ADVICE SUPPORT SYSTEM

Research and development of an advice support system for optimizing the back-end processes of semiconductor assembly for Fico Trim & Form Integration Systems B.V.

B.A. Mentink

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Thesis Industrial Engineering and Management

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B.A. Mentink, Haaksbergen, 2006

MANAGEMENT ABSTRACT

The presented report describes the research that has been done to design a tool that can be used to support sales person during the advice generating process, by providing recorded knowledge outer his/her expertise. It describes why this tool is required, its required function, the expected performance, the design of the different components, maintenance issues and preconditions that need to be met with to guarantee the maintainability of the tool.

The goal of this research was to develop a concept for an "advice support system" that supports sales agents of the different divisions, with information, necessary to generate an advice about optimizing the back end assembly process of a semiconductor product, while taking the customer's situation and preferences into account.
The initiator of this research, Fico Trim and Form, is a division of Besi Semiconductor Industries, which is a leading manufacturer of high-performance equipment and integrated systems for the semiconductor industry's assembly process operations.

Value of the advice support system

Using an advice support system has only sense, when it is able to add a certain value, by supporting Besi in pursuing its mission, in its current organizational structure and in its current environment.
The ability to pursue its mission is influenced by a company's environment and its organizational structure. Therefore, to find out what gave rise to the development of an advice support system, research have been done into characteristic properties of Besi's current organizational structure and the suitability of this organizational structure in relation to its mission, and environment. From this, the following can be concluded:
Because of the ongoing trend of increasing complexity and decreasing product size, a simple change of one process step in the overall assembly process could affect all the following assembly process steps. Therefore it is crucial to have insight into the "overall" assembly process when generating advice towards customers about arranging or optimizing a combination of sub processes.
The following restrictions of Besi's current organizational structure and environment, regarding the advice generating process have being revealed:

- Some process-function groups are accommodated in more than one division of Besi, both offering alternatives, resulting in non-objective comparison between optional alternatives.
- A risk of having a divisional structure is that sales agents from one division are unaware of developments in other divisions
- Because of the wide range of different process techniques available to use in the back end industry, it is impossible for the sales departments of the various divisions, to have thoroughgoing knowledge of processes outer their specialization, and of the interrelation between these processes. This lack of knowledge-exchange and cooperation between divisions while finding an optimal solution for customers can lead to incomplete or contradictory advices

The following opportunities of Besi's current organizational structure and environment, regarding the advice generating process have being revealed:

- A divisional structure is suitable for fast change in an unstable environment
- Normally, each product group should be accommodated in a separate division, so customers are able to directly contact the correct division, and achieve satisfaction by getting detailed advice directly form specialist of the concerning group.

The last opportunity have been violated by accommodating alternative techniques, in more than one division

From the second and third restriction mentioned above, it can be concluded that the advice support system will be valuable when it is able to perform the following main functions:

- Collecting and sharing information across the divisions.
- provides sales agents with detailed information about aspects that need to be taken into account when combining their processes with other processes outer their discipline.
- Providing insight in which product specifications indicate the necessity for certain process steps

Since Besi highly values the "understanding of customer's requirements and desires". This requires structural analysis of the customer's problem before generating advice. The value of the advice support system increases when it is able to perform the following functions.:

- Providing a list of questions that should be asked, to determine the customer's current situation, his preferences and his requirements.
- Providing insight in process information about the suitability of processes in relation with customers situation and preferences.

Design of advice support system

Research has been done in revealing which information is need to be provided by the advice support system. From this research it appeared that there are multiple restrictions that need to be dealt with, when generating advice about arranging and optimizing an overall assembly process of a specific semiconductor product. It has been investigated, which restrictions need to be taken into account when generating the advice. It appeared that the extent to which the overall assembly process can be optimized, is mainly limited by restrictions deriving from the following factors:

- Semiconductor product requirements
- Preconditions and characteristics of Processes and techniques
- Customers situation and preferences

To find out when, which information is required when, research has been done into the current advice generating process. The advice generating process can be split up into following eight different stages which are subsequently settled:

1) Determining product group
2) Inventory of product specifications
3) Inventory of customer's situation and preferences
4) Inventory of the process functions which are subject of the advice.
5) Determination of optional techniques for the process functions
6) Determination of optional process combinations*
7) Judging the suitability of process combinations when taking the customers' situation and preferences into account

8*) When no optional or suitable process combination is found: Adapt the product-design, or specifications, in order to find a suitable process combination.

Databases

At each stage, the sales agent can be supported by providing him/her the for this stage required information. By studying the characteristics of the required information, six different subjects can be distinguished, namely:

- Product - related information
- Customer - related information
- Product in relation with process-functions - related information
- Product in relation with process - related information
- Process combination - related information
- Process in relation with customer – related information

For maintenance purposes it is decided that all knowledge should be classified by subject, and each subject should be accommodated in its own type of database. Each database type consist multiple

sections in which a defined sort of data need to be stored in a consistent way. It is very important that the information, presented by the databases, is easy to read and clarifying. To secure intelligibility of databases, templates are provided for each database, showing which data, should be recorded in which format, in each field of the database.
Because the users of the advice support system are operative all over the world, and the main communication language of the users is English, all information should be recorded in English.

Before the advice support system can be used for generating advice, it should be taken care of that each databases is filled with all available knowledge. All knowledge about existing processes and techniques that could lead to a more complete advice towards the customer should in some way be transferred from the heads of the experts into the databases.
Knowledge can be collected by interviewing process engineers, or can be provided by the process engineers themselves.
Because an advice has less or no value when it is based on incomplete or incorrect data, all data should be controlled by experts before it is approved.
Once a database is filled or updated and it is approved to be correctly updated, it should be marked with the date of approval, so the user can notice that data is changed since the last time he used the database.

Users guide
Next to the availability of databases, it is required to have a users guide. The main function of this user guide is to give instructions along all stages of the advice generating process about:

- Which databases should be used?
- Which data need to be inventoried?
- How should the collected data be processed?
- What need to be done with the result of each stage?

This users guide is designed with use of results of the research that has been done to reveal the current advice generating process.

With us of the designed databases and users guide, it is possible to generate a complete and correct advice about optimizing the back end assembly process of a semiconductor product, while taking the customer's situation and preferences into account.

Preconditions for successful implementation

Unfortunately, there are some restrictions that need to be coped with in order to be able to implement the system in the overall organization, and to make sure that the implementation leads to a successful use of the advice support system.

Appointing a support group
For maintenance and updating of the advice support system, the same counts as for filling the databases for first use. This is, that it should be prevented to store incomplete or incorrect data.
In contradiction to filling the databases for first use, maintenance and updating is a process without an end.
Directly after implementation of the advice support system, all databases are exposed to an aging process, influencing the correctness and completeness of data. This is caused be new developments and insights. The Following situations can be distinguished as a trigger for updating or maintaining the advice support system:

- Technology changes
- New technology
- New insight in process combinations.
- New insight in product process relations

- New insight in process performance in relation to customers' situation and preferences

Since maintenance is not a temporary action, Appointing a support group, dedicated to manage maintenance of the advice support system, is a requisite for correct implementation of the advice support system. This a special group should be formed by persons who are in possession of technical skills, which makes them capable to:

- Collect new knowledge
- Judge correctness and completeness of knowledge
- Category knowledge
- Record knowledge in correct format in correct database

Neglecting the precondition of appointing a support group, will lead to a inconspicuous death of the advice support system. Because when the use of the advice support system leads to incomplete, or incorrect and thus unsatisfactory information, due to lack of maintenance, it is not unlikely that the tool will be degraded as a worthless and incompetent in performing its function.
Because changing the of organisational structure is not part of this research, it is recommended to spend some more research in how to realize this support group.

Create willingness to share data

The existence of the advice support system depends more than anything, on the internal cultural environment of an organization concerning the willingness of employees to share knowledge. To be able to maintain of fill the database with the most update information, it is a requisite that experts are well willing to share their knowledge. Therefore they need to be encouraged to share their knowledge. According to interviews with process engineers and sales engineers, most of them where aware of the fact that a kind of advice support system could improve communication of explicit knowledge within and between the different divisions. During the interviews with process engineers, all interviewees gave the impression that they where well willing to share their knowledge

Arrange technical infrastructure

An other requisite precondition concerns the following. In order to be able to use the advice support system throughout the organization, a technical infrastructure should provide the connection between the users of the advice support system, as well as the access to the available knowledge stored in databases.
At the time of this research, there was no suitable network available for testing the system. Therefore, before implementation of the advice support system can be performed, it is a high priority to arrange a network that is able to communicate available knowledge which is stored and provided by the advice support system. Next to this, there is little experience in working with a networked environment. It is highly recommended to perform research in how the technical infrastructure should be arranged and how the employees can be trained to be able to use the advice support system, after implementation.

Support by senior management

When implementing the advice support system, strong support from executives is a critical factor in succeeding. The types of support that are helpful include the following:

- Sending messages to the organization that knowledge management and organizational learning are critical to the organization's success
- Providing funding and other resources for infrastructure
- Clarifying what types of knowledge are most important to the company.

A strong personal orientation to knowledge may not be absolutely necessary for a senior manager to champion knowledge management, but it surely helps

Addition to the advice support system

Use of product group databases

Additional to the design of the advice support system as described above, research is done in the possibility to use the results of already generated advice, for supporting future advice generating processes.

This research lead to the use of an extra database, additional to the advice support system that is described above.

The products specifications restrict the use of certain combinations of techniques for each product. A product group is a group of products that can be processed with the same combination of techniques. With use of the advice support system, it is possible to find all optional combinations of techniques, and with this, also all product groups that can be processed with currently available techniques.

The results of the advice generating process for all product groups can be recorded in corresponding product group related databases.

When a product can be classified as member of a known product group. All information about optional process combinations with their pros and cons can be presented at once.

Decision Tree

A decision tree is a visualization of all optional process combinations.

The name decision tree is chosen because of its structure. because each branch represents a process choice. Each choice leads to an other process decision, until all process functions are determined. Because this three is generated with use of the advice support system, the decision tree can be used to test the advice support system on the following aspects:

- Correctness of advice about process sequence
- Correctness of advice about process combination
- Correctness of the advice about product process relation data

An example of the decision tree is provided on the to this report attached CD

Conclusion and recommendations

The advice support system can be used to provide sales agents with information outer their expertise about restrictions by product specifications, restrictions by process combination, and restrictions by customers situation and preferences. With this information, the sales agent is able to generate more complete and correct advices about arranging new or optimization of the overall semiconductor assembly back end processes. which is highly appreciated by the customer and therefore it may be assumed that the implementation of the advice support system contributes to Besi's corporate organization in reaching its mission.

With use of the additional product group databases, marketing is able to see, which products groups are able to be produced with current technologies, and with this, also which product groups are not able to be produced. This insight increases the ability to take action on improving -or extending the number of -available techniques.

The advice support system as described in this report is should be seen as a concept, and can be used as an example in building an organizational wide advice support system. In order to create the situation that the advice support system can be implemented, it should be improved on some points. All product and process related databases need to be filled with new and perhaps corrected knowledge.

Next to this, it should be assured that all preconditions mentioned in chapter 9 of this report are settled.

- The preconditions with the most impact on the business are:
- Creating required technical infrastructure
- Appointing a support group
- Create willingness to share data
- Create a link to industry value
- Find Appreciation and support by senior management

Without arranging these preconditions, the implementation of any knowledge management system such as the advice support system, is doomed to failure.

Next to the results of this research, some recommendations are found on the organizational corporate structure, concerning an improvement of service toward the customer.
Some process-function groups are accommodated in more than one division of Besi, both offering alternatives, resulting in non-objective comparison between optional alternatives.
It can be useful to create impartial sales or advice department for each process function, accommodating all available alternatives within this process function, because this will offer the customer a better, more objective advice, increasing customer's satisfaction. When deciding to do this, it should be paid attention, that the level of detail of process information will not be negatively affected.

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APPENDIX LIST

PREFACE

In September 2004, I started my final thesis for my study Business Management and Technology. For this thesis I performed a research project at Fico Trim and Form Systems in Duiven. The aim of this project was the research and development of an advice support system for optimising the back end semiconductor assembly process for Besi Semiconductor Industries.
I ended op in the Process and Technology group under supervision of Han van Egmond and Mike Krabben.
I would like to thank my supervisors at the University, prof.dr.ir. J.J. Krabbendam and dr.ir. P.C. de Weerd-Nederhof for the support during the writing of my final thesis, which was not without barriers and therefore took me longer than I hoped. Thanks for your patience and confidence.

Furthermore, I would like to thank Besi for giving me the opportunity to accomplish my thesis at their company. Mike and Han, thanks for the support in the practical part of this thesis. I would like to thank all my colleagues from Besi, for the nice time I had during those months.
And last but not least I will thank my friends and family but especially Anouk, in supporting me to finish this report.

1 INTRODUCTION

Knowledge functions as a basis of each well considered decision. The more complete and accurate the available knowledge, the easier it is to make a well considered decision, and the higher the certainty of correctness of that decision.
Knowledge is a precious resource within each company, but often not fully exploited. Gaining knowledge is often a costly and time consuming process. Knowledge can be purchased, can be gained by doing research or can be obtained by experience. Gaining knowledge is one thing, but putting all the effort in getting this knowledge has only sense, when this knowledge is being exploited as much as possible, in order to increase the return on investment on this knowledge. This can only be realized, when knowledge is stored correctly and becomes accessible for everyone who needs it.

Besi Semiconductor Industries, is a leading manufacturer of high-performance equipment and integrated systems for the semiconductor industries assembly process operations. Besi, consists multiple divisions. Each division is specialised in a one or more techniques that can be used for performing a specific process step in the customers assembly process.
Because of the ongoing trend of increasing complexity and decreasing product size, the physical boundaries of both processes as product are being challenged. The interference between the independent process steps in the overall assembly process is becoming a growing issue. An improvement of one process step could influence other process steps negatively, causing a worsening of the overall assembly process. Therefore, when determining the performance of a certain sub process, it is important to know how this process influences the product and the suitability and performance of the other sub processes. Knowledge of bilateral influences between processes, can be obtained by close cooperation and exchange of knowledge between the different divisions/ disciplines of Besi.
Unfortunately, the different divisions within Besi, operate mainly individually and the exchange of knowledge between them is moderate. Next to this, currently, there is no unambiguous method for storing knowledge about the bilateral relation between process parameters their influence on product specifications. This has lead to the situation that the quality and completeness of an advice depends mainly on the experience of the sales agent. To cope with this, an information system should be developed that can be used to collect, organize and share knowledge, necessary for generating advice towards customers for optimising their overall back end process.

This report presents the results of the research that has been done to design a concept for an advice support system. Which can be used to collect record and shear knowledge between the different divisions of the company. Chapter two presents the research approach. Containing a description of the company profile, the background of this research, the objective, the project boundary and research questions, that need to be answered and deals with the research steps that need to be performed, in order to be able to develop the required Advice Support System. Chapter three gives an introduction in the semiconductor industry, by describing its products, processes and Besi's customer, which is the producer of semiconductor products. In chapter four, the motive for development of the Advice Support System is revealed. Chapter five provides insight in the difficulties that need to be coped with when generating advice. From this, it can be concluded which information will be valuable as advice support. Chapter six divides the advice generating process into different stages, each indicating a different sub-function of the advice support system. In chapter seven, the required databases used to perform the different sub-functions of the advice support system, are described. Chapter eight completes the advice support system with the users-guide, that directs the user through all stages of the advice generating process, when making use of the advice support system. Chapter 9 deals with rules for maintenance of the advice support system. Chapter 10 provides recommended additions to the advice support system. Finally, in chapter 11, all conclusion that can be extracted from the research results are presented. Next to this, recommendations are given for future continuation in the optimisation of the developed advice support system.

2 RESEARCH APPROACH

2.1 COMPANY PROFILE

Besi Semiconductor Industries, is a leading manufacturer of high-performance equipment and integrated systems for the semiconductor industry's assembly process operations. Their equipment is used principally to produce semiconductor packages. These packages provide the electronic interface and physical connection between the chip and other electronic components and protect the chip from the external environment.

Besi's innovative systems offer customers high productivity and improved yields of defect-free devices at a low total cost of ownership.

Besi's customers are leading US, European and Asian semiconductor manufacturers and packaging subcontractors including; Agere, Amkor, ASE, Atlantic, AVX, Conexant, IBM, Infineon, Intel, Lucent, Micron, Motorola, NSEB, On Semiconductor, Philips and STMicro-electronics. Besi's equipment performs critical functions to their customers "semiconductor assembly operations" and in many cases represents a significant percentage of their installed base of packaging and plating equipment.

Besi's business has benefited from close long-term relationships with their customers, many of whom have been purchasing Besi equipment and services for over 30 years. These customer relationships have contributed to a leading position in each of their principal product lines.

Besi was incorporated in May 1995 and is publicly listed since December 1995. Besi shares are listed on Nasdaq and Euronext. A more detailed profile can be found in Appendix A.

2.2 BACKGROUND

Understanding the customer, and offering the customer the best solution for optimizing its process, strengthens the relationship between Besi and its customer.

The back end assembly process of a semiconductor product contains a chain of many different sub processes that have been developed and optimized mainly independently of each other. Because of the ongoing trend of increasing complexity and decreasing product size, the physical boundaries of both processes as product are being challenged and it has become more and more difficult to successfully optimize the overall assembly process. A simple change of one process step in the overall assembly process could affect all the following assembly process steps. Therefore it is no longer possible to optimize the processes individual without taking into account the effects of this change on other processes. This means that the back end assembly process needs to be optimized as one overall process. And therefore it is crucial to have insight into the "overall" assembly process

At this moment, there is no firm cooperation between the independent Besi divisions, when generating advice for selling a certain sub-process to a customer. The ability to obtain insight into the "overall" assembly process is constraint by the fact that there is no information system that provides information about and the interdependence between the sub-processes within the overall process..

2.3 OBJECTIVE

The objective of this research is to develop a concept for an "advice support system" that supports sales agents of the different divisions, with information, necessary to generate an advice about optimizing the back end assembly process of a semiconductor product, while taking the customer's situation and preferences into account.

2.4 PROJECT BOUNDARY

To be able to develop an advice support system that fits to the company in which it is used, research need be done in Besi's mission, its environment and its organizational structure. With this information, the value and the eventually required functions of the advice support system can be determined.

Research need to be done, to obtain understanding of product-parameters, process parameters and the bilateral relations between these parameters. This requires thoroughly analysis of product specifications, and back end assembly processes. To limit the extent of this research, it is decided to base development of the advice support system on one specific product type. The product type that is used as pilot in this research will be a QFN (Quad Flat No-lead) type semiconductor. [1]

Although this is only one product, a broad spectrum of processes is available which all can be used in the back end assembly process of a QFN type product. Therefore, these processes, the process parameters, the relations between processes and products and the mutual relations between processes, are not expected to become completely cleared during this research. With use of the obtained knowledge, a concept for a pilot system will be developed.

2.5 RESEARCH QUESTIONS

The research is divided into answering four main questions, and related sub questions.

1. What is the motive for the need of an advice support system?
   - What is the current situation?
   - What is the desired situation?
   - What is the value of an advice support system in reaching the desired situation?
2. What insight is required for optimizing the back end assembly process?
   - What are the restrictions in optimizing the back end assembly process?
   - Which information is required to judge the ability to optimize?
3. How should the advice support system look like?
   - In what context will the advice support system be used?
     - ***Who uses the advice support system?***
     - ***When will the advice support system be used?***
     - ***Who provides the knowledge that is sheared by the advice support system***?
   - Which functional components are required in the Advice Support System?
     - ***Which steps can be distinguished when generating advice about how the back end assembly line can be optimally arranged?***
     - ***Which information is required at each step?***
     - ***What is the information source?***
     - ***How can this information be grouped?***
   - How can the different sub-functions within the Advice Support System be linked?
4. How can the Advice Support System be maintained?
   - Who maintains the Advice support system
   - When should the Advice support system be maintained.
   - Which preconditions are required in order to be able keep de advice support system up to date?

[1] ***According to JEDEC standards, the QFN is also called MO-220***

2.6 STRUCTURE OF THE RESEARCH

This research is actually built up out of more stages. There is a certain sequence between the stages caused by the fact that the stages are based on the results of preceding stages.

The first stage of the research deals with the first research question, to find out the motive for the need of an advice support system. In order to find an indication of the motive, Besi's corporate organizational structure is confronted with its mission and the environment in which it operates. Next to this, the corresponding analysis shows, in which context the advice support systems will operate and eventually reveal contradictions within the current relative context of organization structure, environment and mission, which could influence the advice support system. This part of the research also reveals by whom the advice support system is used, when it can be used and what value it adds to the current situation.
Information used for this stage of the research is distilled from literature, Besi's annual report, from the Internet, Besi's intranet and interviews with sales-agents.

The second stage of the research is to gain insight in the semiconductor product and processes. The main goal of this stage is to find relations between product parameters, processes and process parameters. Having knowledge about these relations is a requisite for developing the advice support system. Information is obtained from interviews with process engineers, internal documentation and internet research. To limit the amount of information, information is restricted to a specific product type and the for this product type available processes.

The third stage is about answering the question: "What insight is required to optimize the back end assembly process?" Therefore the most important aspects that need to be taken into account when optimizing the back end assembly line, were traced and extensive research is done in the influence factors that affect the ability to optimize the overall process line.
To find which insight should be provided by the advice support system, research is done in the way how advice towards customers is currently generated. Therefore, the advice generating process is split up into different stages which are analyzed separately. The required insight at each stage, can be regarded as the output of the different sub-functions of the advice support system. Combination of all sub-functions provides the desired performance of the advice support system. The required information for this stage of the research is collected by interviewing sales-agents and process engineers of different divisions within Besi, but also by studying process literature and browsing the Internet.

The fifth and fourth stage are concurrently performed. These stages are separated because one deals more with the contents of the system, and the other with the performance.
The fourth stage is about designing the advice support system. Research is done into preconditions of the advice support system in order to keep the system working. The different sub functions of the advice support system are analyzed and specified and an indication is given how the sub-systems could be designed in order to perform their function. All sub functions together should operate as one advice support system. With use of data flow diagrams, it is determined how data flows between the databases users and customer. This is used to develop a users guide. During this stage, information is obtained from literature about information systems, and design processes.
The fifth stage deals with the maintainability of the system and the preconditions that should be met with in order to be able to maintain the system usable. For this stage, Research is done by reading literature about structuring, implementation and maintenance of knowledge systems.

The final stage is to develop extra optional features that could improve the functionality of the advice support system. These are presented as recommendation in further development of the advice support system.

3 INTRODUCTION INTO SEMICONDUCTOR INDUSTRY

3.1 INTRODUCTION

The meaning of this chapter is to give an introduction into the semiconductor back end assembly equipment industry. Consecutive the semiconductor product, the back end assembly process and Besi's customers are described. Information is obtained from interviews with sales department and from the Internet[2]. Appendix C shows an interview scheme used for interviewing sales agents.

3.2 SEMICONDUCTOR PRODUCT

To prevent misunderstanding when reading this report, it is important to know that a strict distinction needs to be made between Besi's product and the semiconductor products or IC's. Therefore it will be cleared for once and for all, by a schematically overview given in figure 1. The word "product" in this research will only be used, for an integrated circuit component. The word "process" in this research will be used for the equipment and its function, required for production of IC components (products). This process equipment is manufactured by Besi, and so a product of Besi. But because this research, deals with optimizing the customers process, and therefore optimizing the use of this process equipment, Besi's product will be considered as a process. The customer in this research is the person who buys the equipment to process a product.

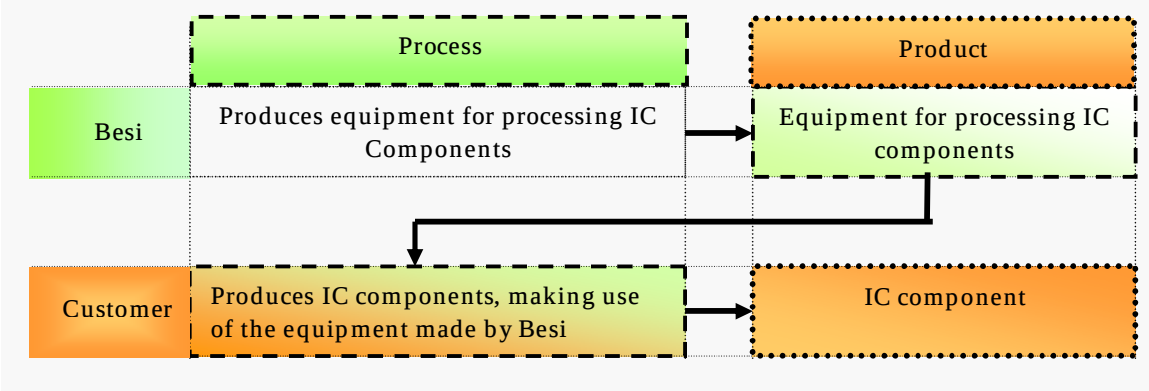


Figure 1: schematically overview to distinguish the difference in definition of "process" and "product" in this research. Besi's product is equipment for processing IC components. The customers product is the IC component, and uses Besi's product for processing. This report regards the IC component as product and the equipment as process, that needs to be optimized

[2] *Advanced packaging (http://ap.pennnet.com)*

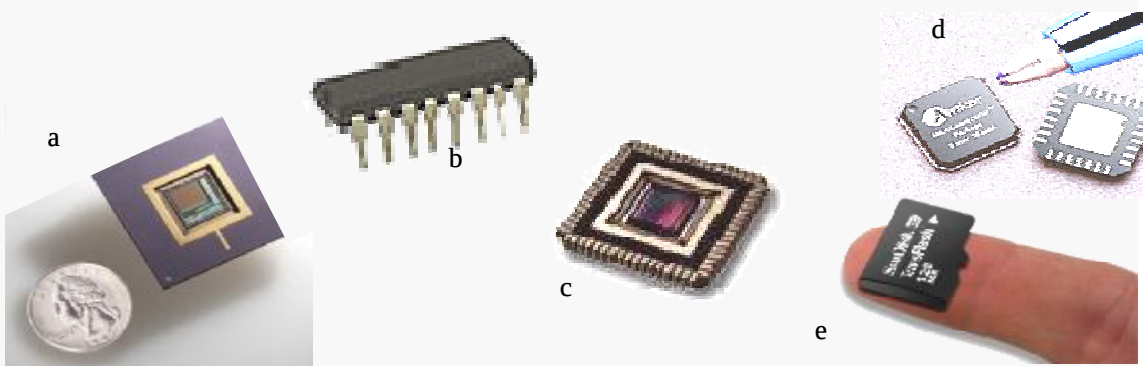


Figure 2: Example of semiconductor products: (a and c) Sensor of a camera, (b) DIP IC, (d) QFN product [Amkor], (e) Trans-flash Memory card [Sandisk]

3.3 BACK END ASSEMBLY PROCESS

The objective of this research is to design a tool that gives insight in product and process parameters that need to be taken into account when optimizing a customers' back end assembly process. The definition of a "back end assembly process" will be treated in this paragraph.

A process is a series of related activities designed to convert a certain input into the desired result. By definition, a process has several key characteristics:

- It has specific standards which determine how the process should perform, and which let it be repeated by others;
- it consumes resources such as time, money or energy
- It responds to control mechanisms that can help the process be done more efficiently.

A more efficient process might result in things being done faster, cheaper, or result in the creation of a better product or service[3].

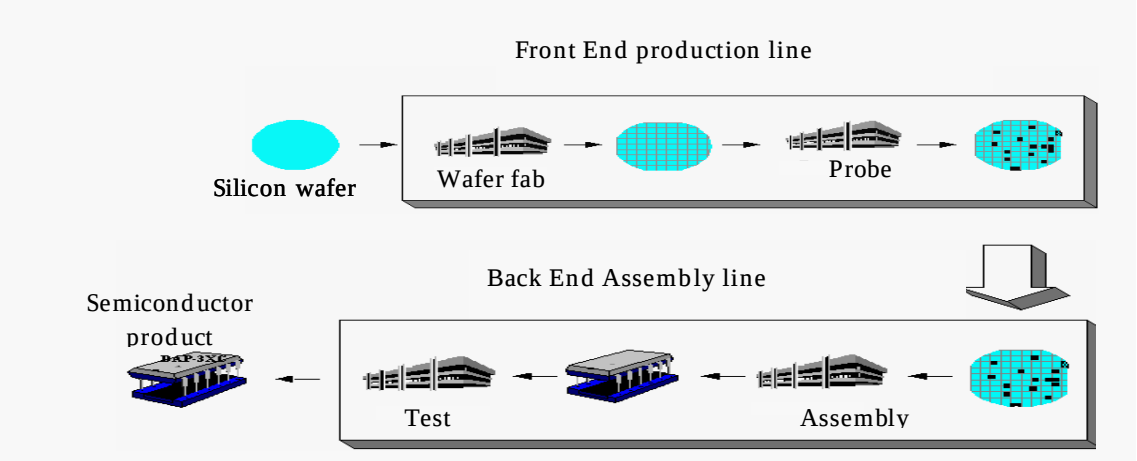


Figure 3: "Front end" and "Back end" process. (The front end generates the die on wafer scale. The back end process integrates the die into a package and performs tests.)

The back end assembly process is a collection of all activities that are required to perform the packaging of a semiconductor chip (also called "die"), resulting in an Integrated Circuit component (IC) ready for use.

[3] ***http://www.nonprofitbasics.org/TopicAreaGlossary.aspx***

Generally known process steps in the back end assembly process of an IC are:

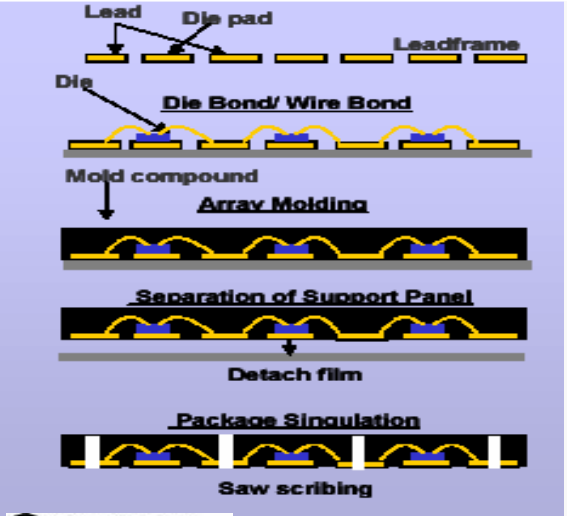
- Die attach
- Wire bonding
- Molding
- Cleaning
- Marking
- Lead isolation
- Singulation
- Testing
- Packaging.

An example of different process-steps in the back end assembly process line is given in figure 4. Each process step has its specific process function which can be performed by different techniques.. In this report, a group of different techniques that can all perform the same process function is called a "process function group".

For example: Separating the semiconductor products (singulation) after molding can be done by punching, by sawing, as well as by laser cutting. These are different techniques performing the same process-function.

It depends on the product type, design and specifications Which process function groups are required in the overall assembly process. Which technique to choose, for each process function, depends as well on the product specifications, on the customers specification as on the techniques used for performing other process functions.

A description of the process functions and the techniques that are used to perform these process functions can be found in Appendix B. It is advised to view this appendix for better understanding of the rest of this report.



- Wafer mount
- Die attach/bonding
- Tape/Film attach
- Wire bonding
- Visual inspection
- Array molding
- Detach tape
- Post mold cure
- Laser Marking
- Cleaning
- Isolation
- Singulation
- Visually and functionally Inspection

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3.4 CUSTOMERS

The advice support system is going to be used to support the advice generating process towards customers. Besi's customers are manufacturers of semiconductor products, and are using or are planning to make use of back end assembly equipment provided by Besi. Besi's customers are leading US-, European- and Asian- semiconductor manufacturers and packaging subcontractors including Amkor, IBM, Intel, Micron, Motorola, NSEB and Philips[4].

According to the interviews with sales agents, customers can be distinguishes into "***subcontractors***" and "***manufacturers***". The definition of these two types is given below.

Subcontractors produce components, like transistors, capacitors, and other IC products to supply manufactures of electronically devices, like mobile phones, computers, audio video apparatus, and so on. Their production consists of many orders of many various products. Their market is subjected to heavy competition of other subcontractors. The product requirements and specifications are forced by their customers and leave minimal play to adapt the product for process optimizing purposes. Subcontractors need a highly flexible production process to be able to adapt to the demand.

Manufacturers produce end-products, like memory cards, phones, audio/video devices, for own distribution. Because they have more influence on product design and are less influenced by customers, their process may be less flexible.

[4] ***Besi company profile (http://www.besi.com / Company profile)***

4 VALUE OF THE ADVICE SUPPORT SYSTEM

4.1 INTRODUCTION

This chapter deals with the question: what gives rise to the development of an advice support system? The ability to pursue its mission is influenced by a company's environment and its organizational structure. The advice support system should add a certain value, by supporting Besi in pursuing its mission, in its current organizational structure and in its current environment. Therefore, before developing the advice support system, it is required to do some preliminary research into Besi's mission, its environment and its organizational structure.
By means of literature, the characteristic properties of Besi's current organizational structure and the suitability of this structure in relation with Besi's environment and mission are determined.
Next to this, the restrictions and opportunities of Besi's current organizational structure and environment, regarding the advice generating process is revealed. With this information it can be concluded which function and value the advice support system should have in order to support in accomplishing Besi's mission.

The following paragraphs subsequently treat Besi's Mission, Besi's environment and Besi's corporate organizational structure. With this, the suitability of Besi's organizational structure in relation with its mission and its environment is determined and can be concluded which adjustments to the corporate organizational structure are recommended and how the advice support system supports Besi to reach it's mission.

4.2 BESI'S MISSION

Besi aspires to be marked leader as supplier of "Semiconductor Back End Assembly process systems" based on high tech solutions. Besi especially wants to exceed competitors on the next values: [5] [6]

- Good relation (of trust) with customer by:
  - Fully understanding customers' requirements and desires.
  - Advice generating and knowledge based service
  - Process optimization advice
  - Good (After sales) service
- Without doing concessions to quality and reliability, more than ever, the Fico equipment range is focused on competitive initial investment.

Being a market leader, as supplier of "Semiconductor Back End Assembly process systems", Besi possesses a portfolio that includes a wide spectrum of "semiconductor back end assembly process systems".

[5] ***Besi's mission can be found in its annual report.***

[6] ***Besi internet site: http://www.besi.com***

4.3 BESI'S ENVIRONMENT

A characteristic of the semiconductor industry is its dynamic environment. The rapid development of advanced semiconductor applications requires semiconductor manufacturers to continually improve their core technology and manufacturing capabilities to remain competitive[7].
Besi's environment is most influenced by semiconductor manufacturers, its competitors and the tendency of available and required technology. These influence factors will be treated in the following paragraphs.

4.3.1 Customers

Semiconductor manufacturers continually improve their core technology and manufacturing capabilities to remain competitive. Due to increased requirements for complexity, miniaturization and customization, semiconductor manufacturers demand highly sophisticated, cost-effective equipment from semiconductor manufacturing equipment suppliers, of which Besi is one. Therefore, the Besi holding and its subsidiary companies are expected to be highly innovatory.

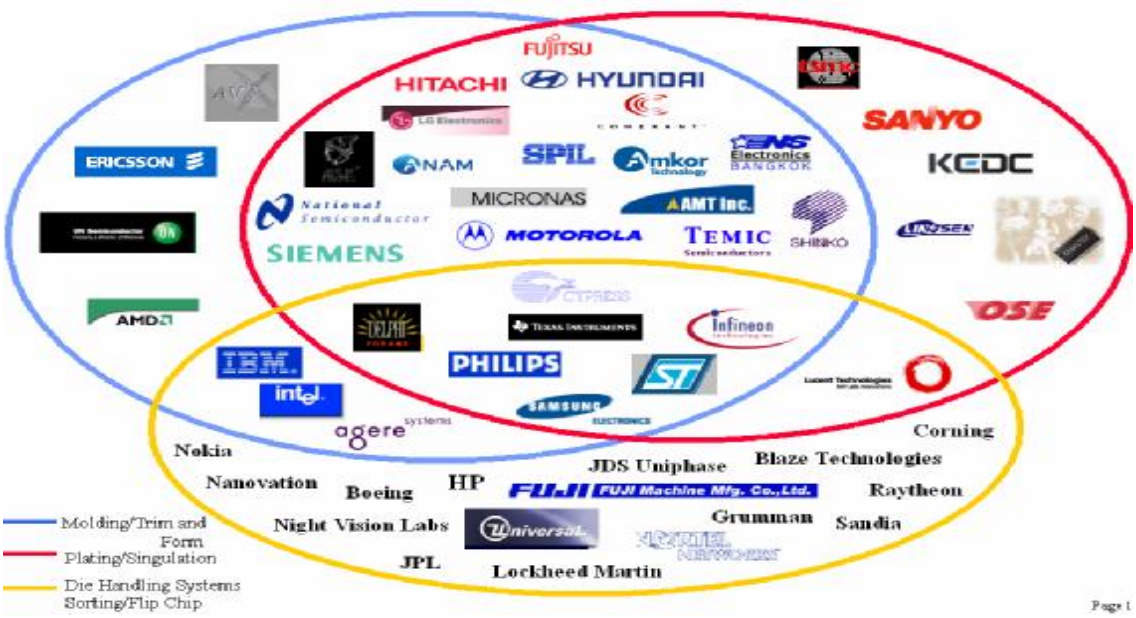

Figure 5 Customers within the different divisions of Besi

For a semiconductor manufacturer it is important that equipment suppliers fully understand his processes and process requirements. Therefore a strong confidential bond between equipment supplier and semiconductor manufacturer is usual, and it is therefore hard to penetrate competitors market.
Due to Besi's wide portfolio, it is common that a customer is served by multiple of Besi's divisions. (See Figure 5) The stability of Besi's position improves, when it has (many) different machines located at a customer's plant, especially when this equipment influences each other in a certain way. When substituting Besi equipment, or equipment that is influenced by Besi equipment, the customer could be forced to (re)purchase Besi equipment, because the support infrastructure for the installed equipment is already in place. Next to this, good experience with Besi's equipment, operating- and maintenance training, spare parts inventory, and familiarity of vendor technicians with the processes and procedures, may all favor the incumbent vendor.

[7] http://www.Besi.nl , ***Industry Back ground***

4.3.2 Competitors

Besi is a pioneer, and therefore always trying to take the lead in new developments. The threat of substitute is therefore often towards Besi's competitors, instead of the other way round. Besi is number three in the top of worldwide assembly equipment suppliers with the highest market share[8]. It depends on developments of both competitors as Besi, to stay in this position.

As vendor with a large market share and market presence, Besi represents a low risk choice for new entrant customers because of its history and reputation. Competitors with relative lower market share must provide a strong argument, to overcome the inherently larger relative risk to the customer in dealing with them. On the other hand, Besi is not the market leader, and therefore needs to compete with suppliers with higher and equal market share. Besi tries to compete these competitors by differentiating, through focusing on customers that value high quality, reliability, good advice and service and are willing to pay for that. (Besi equipment is in average 20% more expensive than that of competitors.)

It has been said that the demand for capital equipment in the semiconductor industry is "inelastic" [9]. That is, it is claimed that the market for semiconductor manufacturing equipment (SME) would not be markedly increased or decreased by changes in the price of such equipment. The argument behind that claim is that semiconductor manufacturing is a highly concentrated industry, with a substantial set of barriers to entry.

4.3.3 Tendency of Technology

Until recently it was usual to optimize the different process steps individually, when optimizing the overall back end assembly process. But because of the growing demand for smaller and more compact and complex semiconductor components, physical boundaries of the back end processes are being challenged.

Because of the high performance that is being asked from the individual back end process steps, they become more sensitive for interferences by preliminary processes. A simple change of one sub-process in the overall assembly process could affect all the following assembly processes. Therefore it will show up more frequently that it is no longer possible to optimize a process individually without taking into account the effects of this optimization on other processes. This tendency will have big consequences for parties involved with optimizing the assembly process of a semiconductor product.

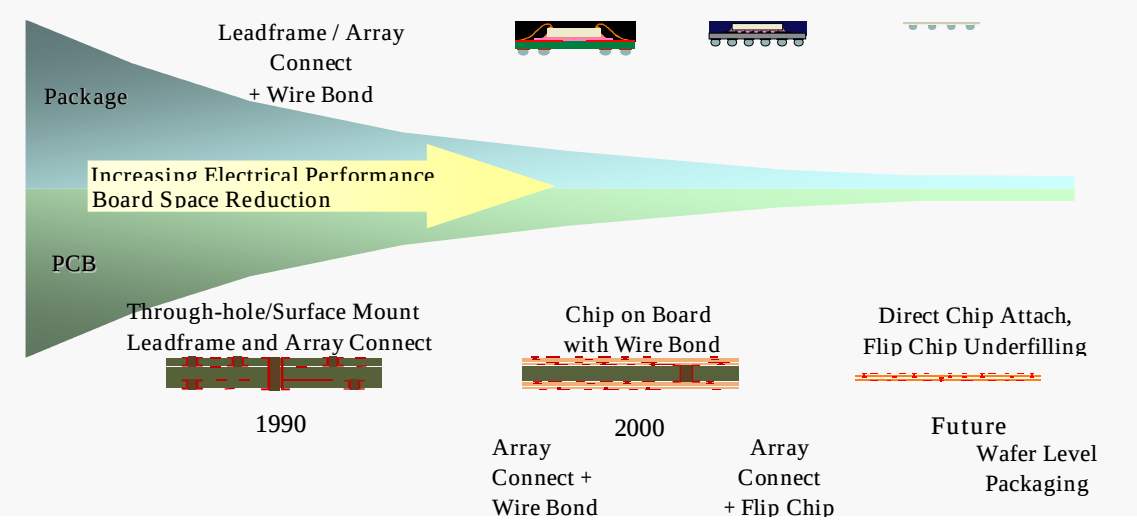

Figure 6: Tendency of technology

[9] *Joseph A.Verderber: A different view on demand elasticity for semiconductor capital equipment,(www.questteam.com)*

4.4 BESI'S CORPORATE ORGANIZATIONAL STRUCTURE

For judging the suitability of Besi's organizational structure to pursue its mission and to operate in its environment, the organizational structure of Besi is analyzed. Information about Besi's organizational structure is found by studying its annual report and its homepage.
Besi is a holding company, consisting of shareholdings in a variety of separate business operations. Besi is horizontal integrating by investing in companies that are complementary to Besi's present activities. That is, they all supply equipment for the semiconductor "back end assembly process". Besi operates primarily through wholly owned divisions, which are summarized in table 1.
Although part of a parent company, the different businesses operate mainly independent.

Division	Processes
Besi Die Handling[10] (Laurier & RDA)	Die Sorting systems (Laurier) Flip chip die bonding systems (RDA)
Fico Molding[11]	Automated molding systems
Fico Tooling	Molding tools Trim & Form tools
Fico Trim & Form[12] (Fico)	Trim and form systems Test systems Marking systems Laser singulation systems
Besi Plating[13] (Meco)	Plating systems
Fico Singulation[14] (Meco)	Saw singulation systems
Datacon[15]	Multi chip die bonding systems Flip chip die bonding systems

table 1: Overview of Divisions with corresponding processes

4.4.1 Divisional structure

Besi can be categorized as a company with a divisional structure, in which, the divisions are organized according to product groups[16] [17]. An overview of the different divisions is given in Figure 7. The different divisions are represented by (combinations of) independent businesses.
From literature, can be found what the characteristic properties of this concerning structure are in relation with Besi's environment and its mission. Strengths and weaknesses of a divisional structure are summarized in Table 2. To find out if these strengths and weaknesses are also

[10] ***http://www.besidiehandling.com***

[11] ***http://www.besimolding.com***

[12] ***http://www.besitrimform.com***

[13] ***http://www.besiplating.com***

[14] ***http://www.besisingulation.nl***

[15] ***http://www.datacon.at***

[16] ***http:/ www.besi.com->company profile (http://www.besi.com/index.asp?p=11)***

[17] ***H.Mintzberg;1979;"The structuring of organizations"; Prentice Hall, Englewood Cliffs***

Figure 7: Besi's corporate structure

Strengths of a divisional structure -Suited for fast change in an unstable environment -Leads to client satisfaction -Involves high coordination across functions -Best in large organizations with several products -Decentralized decision making
Weaknesses of a divisional structure: -Eliminates economies of scale in functional departments -Leads to poor coordination across product lines -Eliminates in depth competence and technical specialization -Makes integration and standardization across product lines difficult

Table 2: Strengths and weaknesses of a divisional structure, according to R.L.Daft,"organizational Theory and Design" 7th edition page 100

4.5 SUITABILITY OF BESI'S CORPORATE ORGANIZATIONAL STRUCTURE IN RELATION WITH ITS MISSION AND ENVIRONMENT

After studying Besi's organizational structure, Besi's Mission and its environment, it can be determined to what extent, Besi's organizational structure fits in its environment.

A divisional structure is suitable for fast change in an unstable environment [18]. The rapid development of advanced semiconductor applications requires semiconductor manufacturers to continually improve their core technology and manufacturing capabilities to remain competitive[19]. This quick response to changes in products, also demands a quick response to change in development of assembly equipment. Therefore, Besi is expected to be highly innovatory. In this point of view, the divisional structure would fit to the environment it operates in.

Another advantage of a divisional structure is that each product group is accommodated in a separate division, so customers are able to directly contact the correct division[20], and achieve satisfaction by getting detailed advice directly form specialist of the concerning group.

[18] ***R.L. Daft, "Organization Theory and Design" 7th edition page 100***

[19] ***http://www.Besi.nl -> Industry Back ground***

[20] ***G. Johnson and K. Scholes, "Exploring Corporate Strategy"***

When a customer needs to choose between two alternative products, it is very important to have an objective comparison between these alternatives. Unfortunately, at this point there are some problems concerning the current arrangement of Besi into different divisions. That is, that some process-function groups are accommodated in more than one division of Besi, both offering alternatives. [21]

For example: Punching and Laser cutting are complementary techniques, but are both competitive for Saw singulation. Unfortunately, The punching and Laser cutting equipment is provided by Fico-Trim & Form and the Sawing equipment by Fico Singulation.

Both companies (divisions) are aiming to survive and therefore the chance of competing each other is possible. As a result, they are not objective when advising a customer about which singulation option suits best to the customers' process preferences. A consequence of this is that, when a customer is looking for a singulation solution, he needs to visit both companies, with the possibility that he receives two contradictory advices concerning which process to choose.

To avoid this problem, it is useful to create an impartial sales- or advice department, representing all available techniques within a certain process-function. This will offer the customer a better and more objective advice, increasing customer's satisfaction

A risk of having a divisional structure is that sales agents from one division are unaware of developments in other divisions. This could frustrate customers[22], especially when process systems of different divisions are combined and interfere with each other at the customer's plant. For Besi, this is also the case. As can be read in the in Chapter 4.3.3, it is a tendency, that sub processes in the back/end industry are more and more affecting each other, due to the higher performances that are being asked from the individual back end process steps, and so become more sensitive for interference by other processes. Because of the wide range of different process techniques available to use in the back end industry, it is impossible for the sales departments of the various divisions, to have thoroughgoing knowledge of processes outer their specialization, and of the interrelation between these processes. This lack of knowledge-exchange and cooperation between divisions while finding an optimal solution for customers can lead to incomplete or contradictory advices.

For example: The molding process influences tool wear in the punch process. The complete molding process consists of molding and post mold curing. Placing the post mold curing after the punch process decreases tool wear in the punch process, but because lack of knowledge of each others processes and lack of influences in each others advices, could lead to a solution with post mold curing before the punching process, leading to unnecessary tool wear.

To eliminate this problem, taskforces and other linkage devices are needed to coordinate information across the divisions[23].

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[21] According to Interview with sales managers of Besi T&F, Besi Molding, Besi Singulation.

[22] R.L.Daft, "Organization Theory and Design" 7th edition page 101.

[23] R.L.Daft, "Organization Theory and Design" 7th edition page 90, 101.

4.6 CONCLUSIONS

The following two subsections describe the conclusions that can be distilled from the analysis results above. The first subsection describes the recommended adjustments to the corporate organizational structure. The second subsection describes in which ways the advice support system ads value to the organization in reaching its mission.

4.6.1 Recommended adjustments to the corporate organizational structure

Concluding from the previous analysis, it is useful to create impartial sales or advice department for each process function, accommodating all available alternatives within this process function. This will offer the customer a better, more objective, advice, increasing customer's satisfaction. This may only be done under the condition that the level of detail of process information will not be affected. The next conclusion is that there is indeed a demand for taskforces and other linkage devices in order to coordinate information exchange across the separate divisions. These taskforce can be composed of representatives from divisions of which their processes affect each other. How the adjustments ,mentioned above, can be realized, will not be dealt with by this research and may therefore be considered as an recommendation for further research. In addition to the taskforces, the advice support system could function as a linkage device for sharing information across the divisions. The value of this advice support system is clarified in the following subsection.

4.6.2 Value of an Advice Support System for Besi

The rapid development of advanced semiconductor applications requires semiconductor manufacturers to continually improve their core technology and manufacturing capabilities to remain competitive[24]. For them it is important to get a well considered advice, containing information about all suitable processes, process combinations and their pros and cons.

The requisite of certain processes depends on the product design and corresponding product specifications. An extensive analysis of the product can reveal all required processes, and eventual restrictions on these processes. The advice support system can be used to find all required processes, by selectively inventory product information that indicates the necessity for certain process steps.

According to chapter 4.3.3 (Tendency of Technology), it will show up more frequently that it is no longer possible to optimize the processes individually without taking the effects of process choice on other processes into account. Therefore, generating advice about a certain process choice, requires a wide orientated knowledge about all other processes that interfere with the process that is dealt with. Unfortunately it is not feasible for a sales agent to be acquainted with updated technical knowledge about all these processes outer their discipline, because this would only reduce the level of detail in knowledge about their own specialization. The advice support system provides sales agents with detailed information about aspects that need to be taken into account when combining their processes with other processes outer their discipline.

Besi tries to compete its competitors by differentiating, through focusing on customers who value high quality, reliability, good advice and service and are willing to pay for that. Therefore, Besi highly values the "understanding of customer's requirements and desires". The advice towards customers about how to optimize their process should therefore be adapted to the customer's situation and preferences. This requires structural analysis of the customer's problem before generating advice.

The advice support system could function as guide when determining the customer's current situation, his preferences and his requirements. Next to this, it provides insight in process information which is required to judge the suitability of processes in relation with customers situation and preferences. With use of the advice support system, the sales agent is able to generate high quality advice, which is highly appreciated by the customer and therefore it may be assumed that the advice support system contributes to Besi's corporate organization in reaching its mission.

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[24] ***http://www.Besi.nl -> Industry Back ground***

5 REQUIRED PERFORMANCE OF THE ADVICE SUPPORT SYSTEM

5.1 INTRODUCTION

In order to assure that the advice support system can be used in an optimal way, the required performance of the complete system should be investigated.
Next to the corporate organizational structure in which the system is used, there are two other important aspects that influence the required performance of the advice support system which should be taken into account when designing the advice support system. The first aspect is a user related, concerning the required usability of the system. For example: language, access to information and required knowledge of technology.
The second aspect is the expected functionality of the advice support system. The function of the system prescribes which parts of the advice generating process should be supported, and with this, the contents of the expected support. Generating advice about optimizing process, requires a continuous confrontation with restrictions that need to be taken into account. These restrictions play a principle role in the advice generating process, and thus will be a main part of the contents of the advice support.
To make sure that the contents of the support are useable, the characteristics of the advice needs to be taken into account. Information about the aspects mentioned above where investigated by studying Besi's annual report, and by interviewing sales engineers.
will be treated subsequently in this chapter.

5.2 USERS

One of the most important characteristics of an information system is the ease of operation. Therefore it is very important to adjust the advice support system to the user characteristics. The system needs to be accessible by two types of users. The first group of users are sales agents who need to advice their customers and therefore require information and knowledge provided by the advice support system. The second group users are process engineers, and R&D engineers. Both experts on processes that are used in the back and assembly process and therefore provide all kind of information required by the first group.

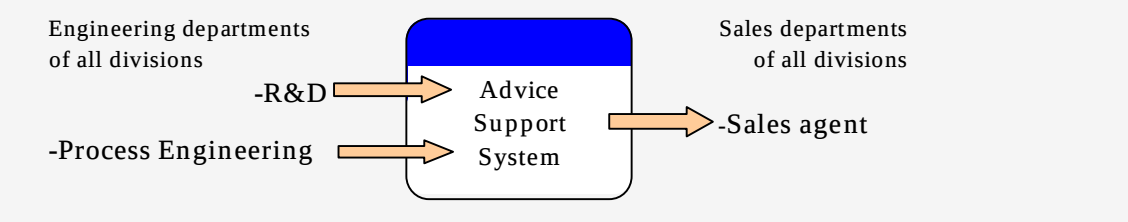

Figure 8: Two types of users can be distinguished: Users that provide information and users that require information

Research is done in the characteristics of these two user groups, by studying their skills, and their situation. Most information used for this study is gained by interviews and conversations with people within the two user groups.
The users of both groups can be characterized with the following properties which need to be taken into account when developing the advice support system:

- The users are active at different divisions of Besi. This means that level of knowledge each user has about certain processes, differences. It may be expected that the users have basic knowledge about the main function of processes outer their specialization, meaning that they are able to make distinction between the different processes that are available within the corporate organization of Besi.

- The users are stationed in multiple countries all using English as communication language.
- The users are situated at multiple locations. This requires a system that is also accessible at multiple locations. This is a strict requirement, but how the system can be accessible at multiple stages is not investigated in this research.
- Not all users are continuous stationed at a fixed location. Using an intranet connection to access the system could be required. (This will not be treated in this report, but is recommended to invest in more mature stage of developing.)
- The users are well educated and familiar with using a computer.
- Because the advice support system is new, the users are not familiar with the new system, and do not yet know how to use it. To make sure they are going to use the system, they need to be motivated and taught to use it. This will not be treated in this research, but need to be taken into account when designing the users guide)

These fundamental user criteria should be taken into account when developing and implementing the advice support system

5.3 EXPECTED FUNCTION OF THE SYSTEM

The main function of the advice support system is to provide sales with information outer their expertise in order to increase the quality of advice, and thereby offering an extra value towards customers. To find out which information is required, and by this, who should provide the information, the content of advice towards customers is analyzed by interviewing sales engineers and by attending consultations between sales and customers.

5.3.1 Content of the advice

For the most customers, technology choice is a relative long-term issue. It can have significant effect on the operation's strategic capability. The acquisition of new process equipment will have impact on the intrinsic constraints and capabilities of the customers' plant.

According to "Nigel Slack et all"[25], A customer evaluates proposed technology on basis of the following questions:

- What effect does the proposed equipment have on the operation's ability to service its markets?
- How does the proposed equipment help to build the operation's resource capabilities?
- What are the financial consequences of investing in the proposed equipment?

The answers on these questions give an indication on the grade of optimization of the back-end assembly line. A sensible approach to evaluate the impact, of any proposed equipment, on an operation's ability to serve its markets, is to assess how it affects the quality, speed, dependability, flexibility and cost performance of the operation.

The cost of "back end equipment" is assessed by the cost of ownership. These are the cost of machine depreciation, wear-parts and consumables per product.

Although the back end assembly line is mainly optimized by weighting the perspectives that come forward when answering the questions above, weighting the different perspectives only makes sense, when it is clear, which techniques/processes (and combinations of processes) are actually suitable to be implemented into the customer's overall assembly process. Therefore, the determination of suitability of processes and the ability to combine suitable processes is an important part of the advice generating process. The generated advice should give the customer an overview of suitable options with pros and cons in relation with the customers situation and preferences. How the optimization of the process is restricted will be treated further in the following paragraph.

[25] ***Nigel Slack et all, "Operations Management", 3rd edition, page 257***

5.4 RESTRICTIONS ON THE OPTIMIZATION THAT NEED TO BE DEALT WITH

The most ideal situation for a customer, when arranging and optimizing its assembly process, would be, that the product and the assembly process could be fully adapted to each other, without any restrictions. Unfortunately this is not the fact in most cases. By interviewing sales-agents and process engineers of "Besi Trim and form", "Besi Molding", "Besi Singulation" and "Besi Plating" , information is gathered to analyze out with which restrictions need to be dealt with during the optimization of an overall back end process. (See appendix C "Interview schema sales department").
It appeared that the extent to which the overall assembly process can be optimized, is mainly limited by restrictions deriving from the following factors:

- Semiconductor product requirements
- Preconditions and characteristics of Processes and techniques
- Customers situation and preferences

An introduction about how these factors influence and limit the extent of optimization is given in the next paragraphs. The information in these paragraphs is mainly based internet research and on interviews with process engineers and sales functionaries[26,27]. Appendix C and D show an interview schemes which are used for all interviews.

5.4.1 Restrictions by semiconductor product requirements

Semiconductor products can be distinguished into a wide range of different types, varying in shape, size and material. These product specifications and the variations between product specifications can be attributed to the product function and variations between product functions.
Product specifications that are of interest, when generating advice about optimizing the overall back end process, are those that indicate the need for certain process functions, and those that determine usability of techniques for performing the required process function. These product specifications determine the level of "restriction in process optimization in relation with product requirements" and should be taken into account when arranging the back end assembly process.

When finding the best solution for a customer, it frequently reveals that all product specifications cannot be met simultaneously, or cannot be met with a single solution. A Conflict between specifications, or an opportunity to improve the overall assembly process, may be a reason to revise and change these specification or requirements. Trade studies must be done, which means that requirements and/ or specifications must be compromised. Therefore, it is very important to have insight in the importance of each specification, and the flexibility to adapt them.
An example of a conflict between two product specifications could be: A product design with a non linear circumference of the package, (making it attractive to make use of matrix molding and laser singulation), in combination with use of material that can not be easily cut by laser. Therefore it can be decided to change this material or the thickness of this material, so laser cutting can be used. Other options are changing the shape, or changing the molding process, so other singulation techniques can be used. Which option to choose depends on the priority of the product requirements.
According to the interviews with the different sales departments, product requirements can be distinguished into "strong requirements", "interchangeable requirements" and "weak requirements".
Strong requirements are those specifications that are strictly necessary to fulfill its function, e.g. temperature resistance, input output transformation, etc.
Interchangeable requirements are allowed to interchange with other requirements provided that the product functionality is maintained. For example: the plating material on the leads may be changed, on the condition that the specified solderability is maintained.

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[26] ***See appendix C and D (interview Scheme)***

[27] ***For results, see the files stored in folder "Interview results" on the CD attached to this report.***

Weak requirements or specifications are not really required and should be adapted when they are in conflict with stronger requirements. For example a round edge that has only aesthetical function, should be changed into a sharp edge, when this could reduce production costs.

A similar way of approaching requirements is described by Ian Sommerville[28]. He categorizes requirements by priority, using the following categories:

- "Essential" requirements are those that must be included in the system.
- "Useful" requirements are those that would reduce system effectiveness if left out.
- "Desirable" requirements are those that are not part of the core, but make the system more attractive to the users.

According to Sommerville, it is very difficult for an engineer, or supplier to prioritise a customer's requirements, because he does not have insight in the deeper thought behind each specification. Therefore, the prioritising should be done by the customer himself , eventually supported by the supplier, who knows which specifications are of interest.

Analyzing the purpose of the product and the with this purpose corresponding functions is required to get insight in the importance of each specification.

A (semiconductor) product can be unraveled into many functional parts. A product can be specified by describing the sub-functions together with the ranges within where the values of those sub-functions should be. This can be translated into product design specifications.

For example: The function "electrical connection between the die and the leads" can be specified with the values of "maximum signal interference", applied current and applied voltage. This can be translated into:

- Required way of connecting (Wire bond/Flip chip)
- Area of connection
- Pitch between connections
- Isolation material
- Isolation dimensions

A product needs to perform those functions necessary to fulfill the purpose of its existing. The specifications that are related to such a required function, may restrict the product design and indirectly the optimization of the back end assembly process. A product specification may be adapted as long as the required main function is preserved. An example of specifications that are related to the main function of a semiconductor product are listed in table 3

Next to the main function, support functions can be distinguished. These support functions are preconditions that depend on product design and environmental influences, like the climate in which it is used. Also these functions restrict the play in adapting product specifications and with this could restrict the optimization of the back end assembly process. Important support functions and the corresponding product functions of a semiconductor product, are listed in table 4

[28] *I. Sommerville, P. Sawyer ;Requirements Engineering A Good Practice Guide; John Wiley and Sons, West Sussex, England: 1997*

Requirements	Product specifications
In and output signal	
Number of Input and Output signals	
	• # Of lands
Power of in and output signals	
	• Dimension of leads
Maximum signal interference	
Isolation value of package	
	• Dimension of package • Material isolation properties • Lead Pitch
Connection between IC and leads	
	• Length + cross-sectional surface • Wire bond or Flip-Chip connection
Connection between leads and PCB	
	• Surface area of the contacts • Wear resistance

Table 3: example of specifications that are related to the main function of a semiconductor product

Support Function	Sub-support function	Performance	Product specification
Heat control		Heat sink from chip to Printed Circuit Board	***Surface area*** ***Heat transfer***
Protection from external environment	Chemical protection	Plating on leads	***Oxidation resistance***
		Compound (molding)	***Oxidation resistance*** ***Water resistance***
	Mechanical protection	Leads (Plating)	***Tensile strength of solder connection***
		Compound (molding)	***Hardness***
			Stiffness
User friendliness	Manageable	Package	***Shape***
			Surface roughness
			Burr free
			Flash free
Discrimination	Fit only in purposed device	Package shape	***Dimensions*** ***Shape*** ***Tolerances***
		Land geometric	***Pitch*** ***Dimensions***
	Recognizability	Vision	***Compound color*** ***Labeling*** ***Marking***
Trace-ability	Identification code	Marking	
Aesthetics	Package design	Vision	***Compound color*** ***Labeling*** ***Marking***
Quality	Functionality	Tests results	***Test specifications***

Table 4: Important support functions and the corresponding product functions of a semiconductor product

5.4.2 Restrictions by required processes and techniques

As already mentioned before, the back end assembly process consists of many different sub-processes. Each sub-process performs a certain process function, that is necessary to give the product the required properties.

The sub-processes used for assembly of a semiconductor product are mostly sequential, meaning that the output of a sub process, is the input of the following sub process. The output of a sub-process can be seen as a stage of the product in process, somewhere in the overall assembly process, in which it has certain properties obtained by preliminary processes[29]. Each process step has certain input criteria, on which a product in process should meet with, before entering that process step.

Because each process step requires a specific input, it restricts the accepted output of preliminary processes, and so determines the required-, the optional- and the non-optional preliminary process steps[30].

For example: Lead Isolation may not be done before the plating step, because the plating process requires an electrical connection between the leads and the lead-frame.

Although two process steps can be combined in a certain sequence, it could occur that the optional techniques for both process steps are in conflict, because the output of a certain technique in a preliminary process step, restricts the use of an optional technique for the following process step.

For example: One precondition of punch singulation is, that the material is suitable to be punched. Compound is not advised to be punched, because of negative side effects like tool wear and cracks.
One molding technique is “MAP molding. This MAP molding covers the complete “lead-frame“ with compound, also the places where the products should be separated or “singulated”. Therefore MAP molding can not be combined with punch singulation.

Also indirect restrictions due to the presence of both restriction on combination as restriction can be found.

For example, When decided to use a bare Leadframe, the consequence is that post-mold curing should be done before the singulation process. (Since the plating process requires post mold curing of compound material and should be done before the singulation process.) Post mold curing negatively influences tool wear of punch tools. -> An indirect negative effect of using bare leadframe material is an increase of tool wear at the singulation process when using punch isolation.

From what is mentioned above, it can be concluded that restrictions on the sequence of process steps, and the restrictions on combinations between optional techniques used for process steps, have a significant influence in optimizing the layout of the back end process.

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[29] D.E.Vaughan ,S.H. Jacobson., D.E.Armstrong;2001; Discrete manufacturing process design optimization using simultaneous generalized hill climbing algorithms; University of Illinois at Urbana-Champaign

[30] Jozsef Vancza and Andras Markus; A constraint engine for manufacturing process planning; computer and automation institute, Hungarian Academy of Sciences Budapest

5.4.3 Restrictions by customer's situation and preferences

Optimization is done by weighting pros and cons of different options. The weight of each pro and con, and thus which option is the most optimal for the customer, depends on the customer's situation and by customers preferences. Concerning the customer's situation, two aspects are important to take into account, namely required flexibility and the already installed equipment.
As mentioned in chapter 3.4, two types of customers can be distinguished, namely "sub contractors" and "manufacturers".
According to interviews with sales engineers, subcontractors are interested in advice about how to arrange its back end production line as flexible as possible. Therefore, knowledge about, relations and possible combination between different sub-processes, within the required process function groups is very important for these customers.
Manufacturers, on the other hand, value knowledge and advice about how product design influences the production process, and vice versa. Consequences for their back end process line and influences on product design for both types of customers are given in table 5.

	Sub contractor	Manufacturer
Process line arrangement	Flexible	Optimized for production
Product design	No/less influence on product-design.	Design optimized for production and functionality
Know how of back and process technology	Differences per customer	
Advice	Process optimization Flexibility of processes	Product in relation with process optimization

Table 5: Differences between sub contractor and manufacturer in relation with: Product design, know how of process technology and advice subject.

Next to the differences mentioned above, distinction between customers could also be made by the amount of equipment that is already installed, and the type of products that are already in production at customer's process line.

Minimal restrictions are expected when the customer installs a complete new process line that is only used for one new product. This situation occurs mostly at manufacturer, when they decide to launch a new product. Manufacturers are free to adapt the product design and processes as long as the most important product functions are remained.
In contradiction to manufacturers, subcontractors have minimal play to adapt the product in order to optimize the overall assembly process. Besides this, subcontractors generally produce a high variety of products on the same line. Therefore, subcontractors need a flexible production line that is able to adapt easily to the demanded products. The required flexibility restricts the amount of optional techniques suitable for the required process functions and therefore could limit optimization of the overall process.
Customers prefer low cost price of the product, which is a build up of a number of variables. Besides the cost of the materials used, also the machine cost are calculated in the cost of ownership for a product. It depends on the customer's situation which option will offer the lowest cost of ownership.
Another point of attention, when analyzing the customer, is the customer's preference for, or aversion against certain techniques or certain product specifications. Preferences exist due to: habits, (un) familiarity, (bad) experiences, preconceived opinion, et cetera. They could limit the process choice, and therefore limit the ability to optimize the overall assembly process.
For example: The customer prefers to use single cavity molding. This preference limits both the choice in isolation and singulation techniques, as the flexibility of the process line

It is important to know the underlying thoughts on which customer's preferences and requirements are based.[31] This knowledge can give insight in invisible underlying requirements or preferences that should be taken into account, but which eventually can also be met by other techniques or other product specifications.

For example: A customer prefers to use single cavity molding because this give the ability to create a certain package shape. The reason for this package shape appeared to be detecting the correct orientation of the product. The same function can also met with laser marking. It could be proposed to adapt the product, in order to be able to use other process techniques to optimize the assembly process.

5.5 IMPORTANT CHARACTERISTICS OF THE ADVICE

According to interviews with sales agents, the criteria on which the advice is valued by the customer are: applicability, correctness of data, completeness of data, eye opening, and uniqueness.

The advice needs to fit into the customer's situation and requirements. Therefore it is very important to examine the customer's situation and the intention behind the stated requirements, at the beginning of the advice generating process. For gathering this data, it is important to know what questions need to be asked to the customer.

It has no sense to base the advice on incorrect information. It is therefore necessary to have a strict control on the correctness of data, used for generating the advice.

The advice should be as complete as possible. A complete advice contains clear solutions with corresponding pros and cons. When not enough information is available to generate a complete advice, it should be completed with a list of uncertainties which require more effort to study. In order to generate a complete advice, it should be taken care of, that the information that will be provided by the advice support system, is as complete as possible. This requires the system to be suitable for regularly updating and completion of information.

According to interview with sales, an advice has extra value, when it confronts a customer with new opportunities or threads, which normally would escaped from their attention. The ability to provide this kind of advice can strengthen the relation between the customer and the company that provides the advice. When the advice is based on information that is only available within the advice providing company, the advice can be seen as unique. Advice can also be unique by the way it is generated, and therefore, exceeds competitors with the criteria mentioned above.

5.6 CONCLUSION

A summary of the most important aspects that influence the required performance of the advice support system is given below.

The system is intended to support sales engineers who need to advice their customers and therefore require information and knowledge provided by the advice support system. The required information will mainly be provided by process engineers. Both, sales engineers as well as process- engineers are users for whom the system need to be accessible. The future users are not familiar with the system, but are well educated and familiar with using a computer.

The advice support system will be used as information source when generating advice about the suitability of optional processes with corresponding pros and cons.

[31] ***Prof. dr. Ir. H.H. van den Kroonenberg, Methodisch ontwerpen 1st edition, chapter 3***

The main part of the information concerns restrictions that need to be taken into account. Concerning these restrictions, the following can be concluded.

From product kind of view

- The product design determines which techniques can be used in the back end process.
- The higher the ability to influence the product design, the lower the number of restrictions.
- The higher the variation in products that needs to be produced at the same process line, the more restrictions from product point of view need to be taken in to account when optimizing this line.

From process kind of view

- Not all techniques can be (easily) combined
- The smaller the amount of already installed processes, the less restrictions from process combination point of view need to be taken in to account when generating advice.

From customer kind of view

- The higher the required flexibility in production, the more restrictions that need to be taken into account when optimizing the overall process.
- Customers preferences and requirements should be analyzed in order to find out the underlying thoughts on which these are based. This could give the opportunity to advice the use of techniques which where formerly disapproved.

An impression about the combination of the number of products, the proportion of new products, and the proportion of new equipment, in relation with the extent with which the overall assembly process can be optimized, is given in figure 9.

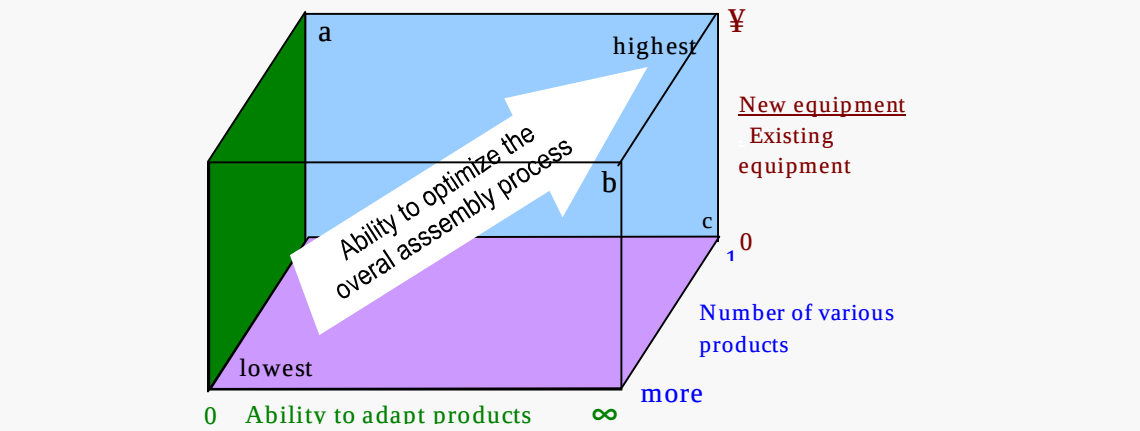


Figure 9: Impression about how the extent with which the overall assembly process can be optimized in relation with:- the ability to adapt products, total number of products in the line -the proportion of new equipment in the line,

a) mainly product design related restrictions
b) mainly product process related restrictions
c) mainly process combination related restrictions

Information has only value when it is correct and therefore need to be checked before it may be recorded in a shared database. The system need to be updated and maintained when new information is available.

6 ANALYSIS OF THE ADVICE GENERATING PROCESS

The main function of the advice support system can be described as: "providing information, necessary to support the sales agent, during the advice generating process about optimizing the back end assembly process of a certain semiconductor product." This main function does not describe the process of generating advice and also does not describe the information that is required at each stage in the advice generating process..
According to "Kroonenberg et al[32]", the main function should be split up into sub-functions in order to get more insight in the performance of each sub-function.

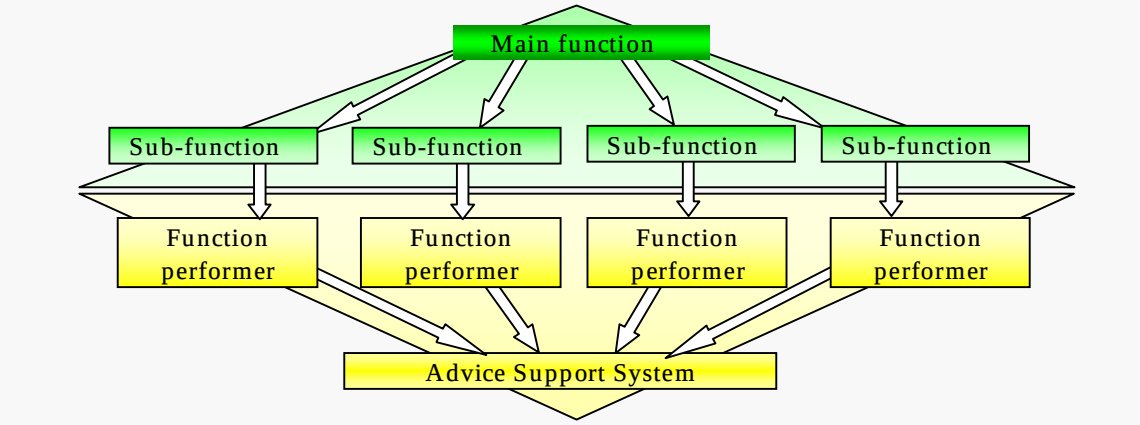


Figure 10: Design-process of the advise support system. The main function is split into sub-functions that can be overseen. For each sub function, function performer(s) is found. These function performers are combined into one system.

To determine the sub-functions of the advice support system, the advice generating process is split up into different stages that are separately analyzed. Providing the required information, necessary to support the advice generating process during a certain stage, can be seen as a sub-function of the advice support system.
After revealing and analyzing the sub functions within the advice support system, the "sub systems" for performing these sub-functions can be designed. These sub-systems can be described with: the required output, the required input and the transformation of the input into the required output.
Subsequently, these sub systems need to be combined into one system covering the main function of the advice support system.

Figure 11: Schematically design of a function, or sub-function

In the following paragraph, the advice generating process is split up into different stages. By means of the result of analysis, the required function of the advice support system is determined.
After revealing which of information is required during all stages of the advice generating process, the information is categorized in such way that each category of information can be assigned to specific stages of the advice generating process and in such a way that redundant information can be prevented.

[32] ***Prof.dr.ir. H.H. van den Kroonenberg et al, Methodisch ontwerpen, 1st edition,***

6.1 ANALYSIS OF CURRENT STAGES IN THE ADVICE GENERATING PROCESS

To gain a structured insight in the advice generating process and to determine which information is required at which moment, each stage of the advice support system is investigated by interviewing sales employees of Besi Plating, Fico Molding, Fico Trim & Form and Fico Singulation. According to that, the advice generating process can be divided into the following stages:

8) Determining product group
9) Inventory of product specifications
10) Inventory of customer's situation and preferences
11) Inventory of the process functions which are subject of the advice.
12) Determination of optional techniques for the process functions
13) Determination of optional process combinations*
14) Judging the suitability of process combinations when taking the customers' situation and preferences into account*

8) When no optional or suitable process combination is found: Adapt the product- design, or specifications, in order to find a suitable process combination.

To complete each stage, certain knowledge is required. Currently, this knowledge is mainly based on experience of the involved sales employee. Providing the sales employee with knowledge not known by him/her, can be seen as a sub-function of the "Advice Support System". Information that supports the sales employee at a specific stage can therefore be seen as the output of the corresponding sub-function. For each sub-function, a certain input and a transformation process is required to generate this specific output. Each sub-function is analyzed in to find out how these sub-functions can be performed, what input data is required, how this data can be collected, and how the input data can be transformed into output data. In the following paragraphs each stage of the advice generating process will be described, to find out the functions that could be performed by the advice support system.
For each stage a summary is given of the following:

- The required input of the sub-function
- The required sub-function
- The transformation of the stage
- Output of stage

The input data is information that should be available in some way at the beginning of the concerning stage and is required for completing the stage.
The transformation of the stage describes what should be done in order to generate the output.
The sub-function describes the information that is required to support the sales agent with generating the output. The required output is the intention of the specific stage.
The total information flow between the different stages are schematically described in Chapter 6.2

Stage 1-Determining product type

Semiconductor products can be divided into many different types varying in function, shape, and application. During this first stage, the advice support system can be used to provide an overview of known product types with their corresponding properties and specifications, to be able to identify the product as a certain type.

Because products of the same type have almost similar properties and product specifications, it may be assumed that a certain type of product requires the same process functions and has its specific points of attention that need to be taken into account. Knowing, what type of product is dealt with, gives the opportunity to reuse experience and knowledge that is gained by similar product types which are dealt with before.

In the case that a product can not be identified as a known product type, it can be concluded that this product type has not been dealt with before meaning that some more effort need to be invested in the following stages.

During the design of the first concept of the advice support system, the only known product types of which the processes are investigated, is the QFN. Because this is only one product type, this stage will not be included in the pilot advice support system. Making use of already known product types will be considered as an extension of the pilot advice support system. The to this stage corresponding sub function can be presented as:

Input: -Product function and specifications (customer)
Sub-function: -Give insight in product type in relation with product function and product design
Transformation:-Determine of product type by analyzing the product function and design
Output of stage:-Product type

Stage 2-Inventory of product specifications that could influence the back end assembly process

The influence factors, that need to be taken into account when generating advice, were already mentioned in preceding chapters. An important part of these influence factors are the product specifications, which therefore need to be collected.

During this stage, the sales employee could be supported with lists, containing all possible product specifications that could be important when generating advice about processing any product.

When the product type is already known, a more compact list, containing only those specifications important for generating advice about processing that specific product type can be used.

Both lists function as guide when collecting specification values, which are required for generating advice.

The collected specification values should be recorded and stored in such way that this information can be used at any following stage in the advice generating process, by anyone involved in the advice generating process. The to this stage corresponding sub function can be presented as:

Input: -Product type (Results of stage 1)
-Product specification values (customer)
Sub-function: -Give insight in all important product specifications belonging to the corresponding product type.
-Provide a database in which product specification values can be recorded.
Transformation:-Collecting and recording important product specification values
Output of stage:-Organized list with product specification values

Stage 3-Inventory of customer's situation and preferences.

As Mentioned before, advice has only value when it helps the customer to find a suitable and optimal solution for arranging its process line. One important influence factor on the suitability of the advice is customer's situation.

The customer's situation depends on the environment in which it operates and has a large influence on the process choice. Examples of customer's situation are:

Already installed equipment: Already installed equipment restricts the number of suitable techniques, that are available for acquisition.

Requirement for High process flexibility. This often requires processes that are less efficient, resulting in a decrease of the level of achievable process optimization

Next to the customers situation, also the customer's preferences play a large role in the choice of process. This could cause that certain sub-processes or product specifications are preferred or excluded as optional. From this it can be concluded that, getting insight in the customer's situation and preferences, is an important step in the advice generating process.

During stage 2, the sales employee can be supported with a questionnaire, containing questions that are helpful for discovering important details, about customer's situation and preferences. When using the advice support system during this stage, the corresponding sub function can be described as:

Input: -Details about customer's situation and its preferences. (customer)
Sub-function: -Provide a questionnaire, containing questions necessary for acquiring important details about customer's situation and preferences
-Provide a database in which customers' situation and preferences can be recorded.
Transformation:-Collecting and recording details, with use of a questionnaire
Output of stage:-Organized list of details about customer's situation and its preferences

Stage 4-Inventory of the required process functions.

During stage 4, it will be determined which process steps are required. the Each process-step in the back end assembly line is intended to add a certain value to the product. In this report, the intention of a process is called the "process function". Each process function can be performed by one or more techniques. A group of processes with similar process functions is called a process function group. The need for certain process functions is determined by the product design and specifications.

For example:

- There are a total of 8 process functions that can be distinguished ***(Process Function A to H)***
- Each process function can be performed by a number of different techniques
- Due to product specifications, a total of 6 Process functions are required in the overall back end assembly process. (Process Function ***A to F***)
- Process Functions that are not required, will not be taken into account in the advice generating process.

Required process function	Optional techniques for performing process functions			
Process function A	Technique A1	Technique A2		
Process function B	Technique B1	Technique B2	Technique B3	
Process function C	Technique C1	Technique C2	Technique C3	Technique C4
Process function D	Technique D1	Technique D2		
Process function E	Technique E1	Technique E3	Technique E3	
Process function F	Technique F1			
~~Process function G~~	~~Technique G1~~	~~Technique G2~~	~~Technique G3~~	
~~Process function H~~	~~Technique H1~~	~~Technique H2~~		

To find out what process functions are required, it can be helpful to have an overview of all possible product specifications that are related to a certain process functions. By comparing the product specifications with the specifications on this list, it can be determined what process functions are required. These process functions should be recorded. After determining the required process functions, distinction should be made between process-functions for which the best optional techniques need to be determined, and those for which the techniques are already set. (For example, because equipment is already installed at customers plant.) Because the process functions of the second group could influence the suitability of optional techniques that perform process functions in the first group, techniques used in the second group should also be recorded.
For inventory and recording of the process functions which are part of the advice, the corresponding sub-function of the advice support system, can be described as:

Input:	-Product type (Results stage 1) -Product specifications (Results stage 2) -Organized list of details about customer's situation and its preferences (Results of stage 3)
Sub-function:	-Give insight in all required process-functions, that need to be used for back end assembly process of the product-type in question -Provide a database in which process functions which are subjected to the advise can be recorded.
Transformation:	-Inventory and recording process functions that are part of the advise
Output of stage:	-Structured list with process functions that are subject of the advise including the corresponding techniques.

Stage 5-Determination of optional techniques for required process functions

With the inventory of the process-functions that are subject of the advice, and the inventory of product specifications, all data is available to find suitable techniques for performing the required process functions. During stage 5, only the product specifications are considered as constraint when judging the suitability of available techniques. The customer's preferences and influences of other processes are considered in a later stage.

To support the involved sales departments, each process function should have a list with the suitability of techniques in relation with the known product specifications. With this lists, all techniques that are suitable to be used as performer of a required process function can be found.
Next to finding optional processes, it is also handy to record why other processes are not optional. (This will become clear in stage 6.) During this stage, the advice support system requires the following sub process:

Input: -Product type (results of stage 1)
-Product specifications (Results stage 2)
Sub-function: -Provide insight in the suitability of techniques in relation with the known product specifications.
-Provide a database in which the suitable techniques can be recorded.
Transformation: -Determine and record optional techniques for the process functions that are subject of the advise
Output of stage: -List with optional techniques for the process-functions that are subjected to the advise.
-List with excluded processes, combined with the reason why they are not suitable.

For example:

- Due to product specifications, part of the available techniques are not suitable.
- This leaves a set of 5 process functions with the remaining suitable techniques

Required process function	Optional techniques for performing process functions			
Process function A	Technique A1	Technique A2		
Process function B	Technique B1	Technique B2	~~Technique B3~~	
Process function C	Technique C1	~~Technique C2~~	Technique C3	Technique C4
Process function D	Technique D1	Technique D2		
Process function E	~~Technique E1~~	~~Technique E3~~	Technique E3	
Process function F	Technique F1			

Stage 6-Determination of optional process combinations.

An optional combination is a set of techniques that can all be combined with each other and which performs all required process functions. At stage 6, all possible combinations of techniques that perform the required process functions will be determined.

To find out if two techniques can be combined, the required input for each process is considered as a constraint on the ability to be combined with other techniques.

The techniques which are already installed at customers plant and meant to be used in the concerning back end assembly line, also need to be taken into account, when determining optional combinations of techniques. These techniques should be part of each suitable process combination.

For example: (***For this example 3 process combinations are presented)***

- Stage 5 leaves a set of 5 process functions with the remaining suitable techniques
- When due to some process constraints, Technique A1 can not be combined with Technique E3, the only possible combinations left, should contain Technique A2 as function performer of process function A. ***(Black and Yellow combination).***
- When Technique C4 is already installed at the customers plant, the only possible combinations left should contain Technique C4. (***The Yellow combination is only possible combination left, The red is not suitable due technique E1)***

Required process function	Optional techniques for performing process functions			
Process function A	Technique A1	Technique A2		
Process function B	Technique B1	Technique B2	~~Technique B3~~	
Process function C	Technique C1	~~Technique C2~~	Technique C3	Technique C4
Process function D	Technique D1	Technique D2		
Process function E	~~Technique E1~~	~~Technique E2~~	Technique E3	
Process function F	Technique F1			

To support the involved sales departments at this stage, they should be provided with an overview in which for each technique is described with which other techniques it can be combined. A combination of techniques is suitable, when all process functions are performed, when al techniques can be combined with each other and when al techniques are optional in relation with the product specifications.

Although a combination of techniques is suitable, each technique in a combination can have direct impact on other subsequent techniques in the assembly process. Next to this, a single technique could also have impact on the performance of the overall assembly processes. It may be concluded that, each combination of techniques has its own pros and cons.

Having insight in these impacts offers the ability to advice the customer about the effect of choosing a certain combination. The advice support system can help the sales engineer by providing information about the impact of one technique on other techniques and about how techniques have impact on the overall assembly process. The to this stage corresponding sub function of the advice support system can be described as:

Input: -List with optional techniques for the process-functions that are subjected to the advise (Results of stage 5)
-List with already installed equipment meant to be part of the new assembly process (results of stage 3)

Sub-function: -Provide insight in the possibility to combine optional techniques.
-Provide a database in which all possible combinations of processes with their pros and cons can be recorded.

Transformation:-Determine and record all possible combinations of techniques with their pros and cons.

In case that no combinations can be formed with the optional techniques, the product-design or product specification should be adapted in order to include “excluded” techniques with which optional combinations can be created. This will be settled in stage 8 and needs to be completed before stage 7 can be executed.

Stage 7 -Judging the suitability of process combinations when taking the customer's situation and preferences into account

Stage 7 of the advice generating process, verifies the suitability of the optional process combinations by taking the customer's situation and preferences are into account.

All optional process combinations should be compared and confronted with customer's situation and preferences. To give an advice towards customers about how they could optimize their back end assembly process, the next questions need to be answered [33].

- What effect does the proposed equipment have on customer's ability to service its markets?

(Quality, Speed, dependability, Flexibility, Costs)

- How does the proposed equipment help to build the customer's resource capabilities?

(New technology, lead to new opportunities.)

- What are the financial consequences of investing in the proposed equipment?

(Financial value of investment)

It could occur that the optional process combination are in some way in conflict with customer's situation or preferences. It could be chosen to accept this and choose the best alternative. Another option is to adapt the product specifications in order to create new optional process combinations. This will be settled in stage 8.

To support the involved sales agent at this stage, they should be provided with data that could help with evaluating the suitability of optional process combinations.

Input:	-Optional processes combinations with their pros and cons (Results of Stage 6) -Customer's situation and preferences (Results of Stage 3)
Sub-function:	-Provide Insight in the impact of proposed techniques on customer's ability to service its markets. -Provide Insight in relation between the proposed techniques and the increase of customer's resource capabilities. -Provide Insight in financial consequences of investing in the proposed techniques. -Collect conflicts between optional process combinations and customer's situation and preferences
Transformation:	-Answer questions that indicate the suitability of the optional process-combination in relation with customer's situation and preferences.
Output of stage:	-Report about the suitability of the optional process combinations Description of conflict between optional combinations and customer's situation or preferences.

[33] ***Nigel Slack et all, "Operations Management", 3rd edition, page 256***

Stage 8-Adapt product specifications in order to create new optional process combinations

Stage 8 will only be necessary when that there is no suitable combination of techniques. The first cause of this situation can be the fact that no combination of the optional techniques can be found, in which each technique can be combined with all other techniques within this combination.
The second cause of this situation can be attributed to the customer's situation or customer's preferences. The execution of stage 7 could show that combinations are suitable regarding the restrictions by product specification, but are not suitable regarding to restrictions by customer's situation or preferences.
Both causes are based on the fact that a part of the available techniques are excluded of being optional. It can be imaginable that the reason for excluding a certain technique is based on a specification value that may be adapted without affecting the product function (as can be read in chapter:4.1 Restrictions by semiconductor product requirements") When this is the case, this specification should be adapted in such a way that an "excluded" technique can be included and by this create new suitable process combinations. Therefore the next steps need to be executed:

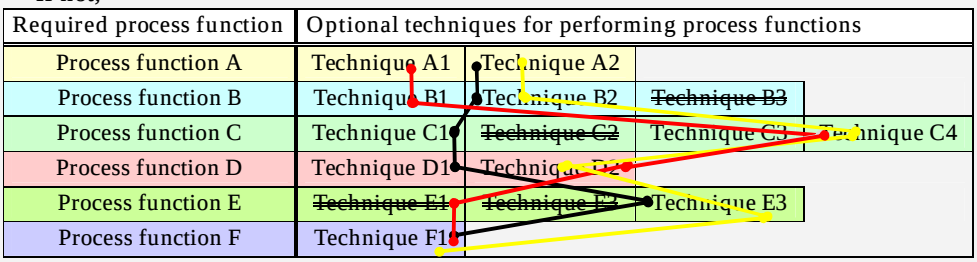
A- List all techniques that are preferred by the customer to be part of the process combination ***(Results of stage 3)***
B- List all techniques that are available for performing the other required process functions ***(Results of stage 4)***
C- Find all suitable combinations that can be made with the techniques listed in step A and B, without taking the restrictions due to product specifications into account. ***(As in Stage 6)***
D- Find the combination with the minimum number of excluded techniques. (***Information from stage 5)***
E- Determine if the product can be adapted in order to include the excluded technique mentioned in D, without excluding other techniques in the specific combination. This may not affect the functionality of the product in such way that it does not suit its required performance anymore.
F1- If this can be done, a suitable combination is available
F2- If not, find a following combination with the minimum number of excluded techniques and repeat step D and E

To support the sales agent in finding suitable process combination, he can be provided with the required list of information which are already generated. Next to this he requires insight in the ability to combine techniques according to stage 6.
A description of the sub function of the advice support system belonging to this stage is given below.

Input:	-Product Specifications (Results of stage 2) -Customer's situation and preferences (Results of stage 3) -List with required process functions (Results of stage 4) -List with optional process combinations (Results of stage 6) -Conflict between optional combinations and customer's situation or preferences (Results of stage 7)
Sub-function:	-Provide the results of stage 2, 3, 4, 6 and 7. -Provide insight in the possibility to combine techniques. -Provide a database in which all possible combinations of techniques with their pros and cons can be recorded
Transformation:	-Replace a technique with an already excluded alternative and create new process combinations.
Output of stage:	-Suitable process combination(s) with corresponding pros and cons.

For example: (***For this example: Assume Technique B1 is required by the customer. Assume that B1 can not be combined with A2 and A1 can not be combined with E3)***

- Because A1 can not be combined with E3, there is no possible combination left.
- A combination with one excluded technique containing B1, is the red combination.
- Because the red combination contains technique E1, it should be determined if the product can be adapted in order to be able to use Technique E1.
- If so, the red combination is suitable.
- If not,



6.2 SUMMARY OF REQUIRED DATA WITHIN THE ADVICE SUPPORT SYSTEM

According to the analysis of the separate stages of the advice generating process, it can be concluded that the main task of the advice support system is "providing insight" in information. This paragraph summarizes which information should be provided by the advice support system.
The required information can be divided into 6 groups, namely:

- Product - related information
- Customer - related information
- Product in relation with process-functions - related information
- Product in relation with process - related information
- Process combination - related information
- Process in relation with customer – related information

Following summary shows what information is related to each group, and at which stage of the advice generating process this information is required.

Stage	Information
	Product - related information
1, 8	Insight in the characteristics of known product types
2	Insight in all important product specifications belonging to the corresponding product type
8	Insight in the relation between product specifications and the intended product function.
	Customer – related information
3	Insight in which details about customers' situation and preferences are required in order to generate a suitable advice
	Product in relation with process-functions – related information
4	Insight in all process functions, which are known to be used for assembly of the product-type in question
	Product in relation with process - related information
5, 8	Insight in the suitability of processes or techniques in relation with the known product specifications.
	Process combination - related information
6	Insight in the impact of the other optional processes performing process-functions outer their specialism and about optional process combinations.
6	Insight in the ability to combine optional processes.
	Process in relation with customer - related information
7	Insight in effect of proposed equipment on customers' ability to service its markets.
7	Insight in relation between the proposed equipment and the customers' resource capabilities
7	Insight in financial consequences of investing in the proposed equipment

At each stage of the advice generating process, information is extracted from the available databases or from the customer, and transformed into output data. The following data will be generated:

- Product type
- Product specification values
- Details about customers' situation and its preferences
- All process functions that are subject of the advice.
- All process functions that are not subject of the advice but are used in the overall assembly process of the specific product.
- Optional processes for the process-functions that are subject of the advice.
- Excluded processes, combined with the reason why they are not suitable.
- Optional process combinations with their pros and cons.
- Description of suitability of optional process combinations.

To keep track of this advice specific data, it will be recorded in an "advice related database".

A schematic description of the provided information and the generated output is given in figure 12. Providing the required information and supporting the ability to record in the Advice related database, are the sub-functions of the advice support system. The design of the required databases and the arrangement of all these databases in an advice support system will be treated in following chapters

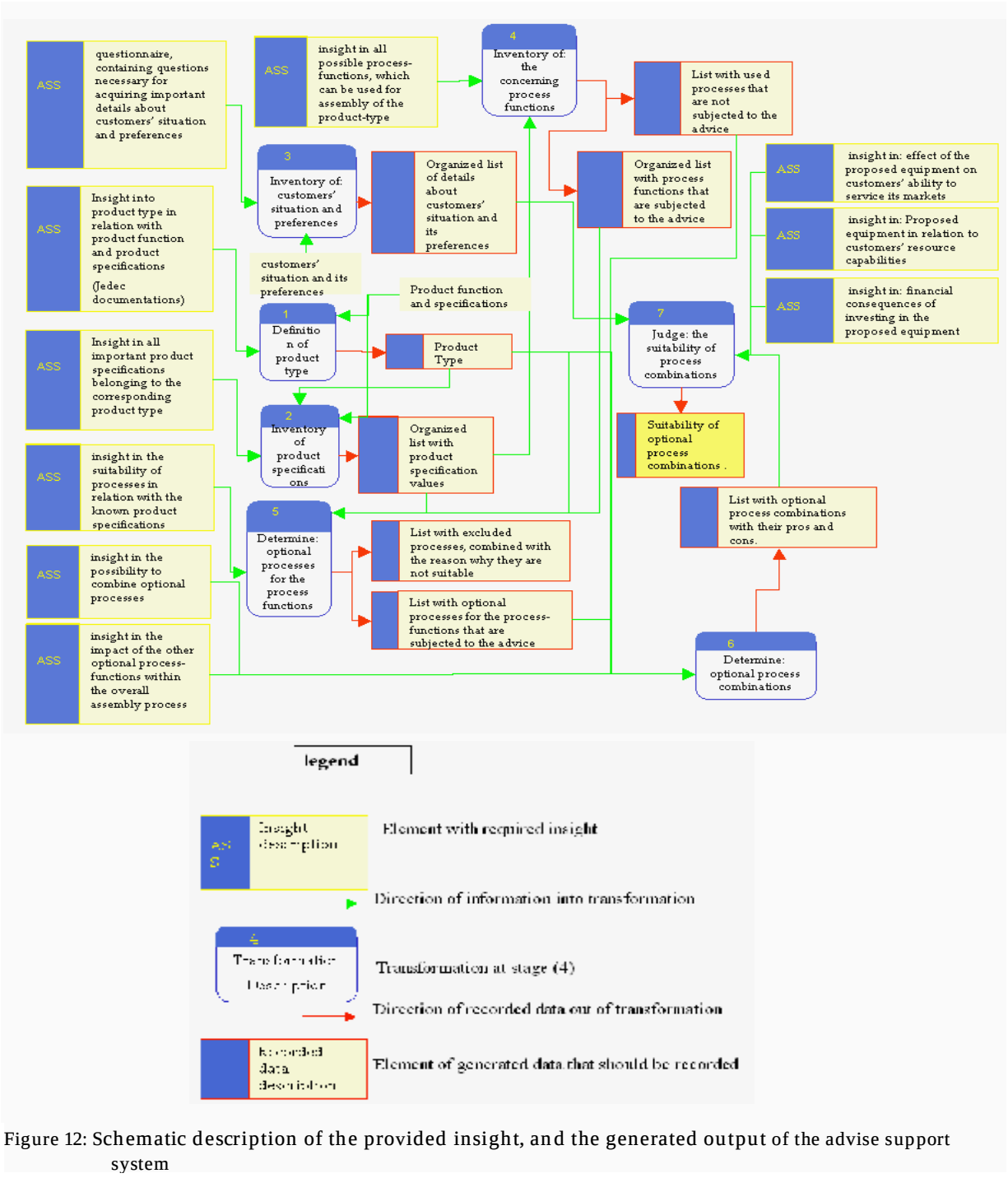


Figure 12: Schematic description of the provided insight, and the generated output of the advise support system

7 REQUIRED DATABASES

According to chapter 6, it may be concluded that the information which should be provided by the advice support system can be divided into 6 different groups, namely:

- ***Product – related data***
- ***Customer's situation and preferences related data***
- ***Product -process function related data***
- ***Process -product related data***
- ***Process combination related data***
- ***Process - customer related data***

It is decided to design a separate databases for each of these groups. Next to these databases, one extra database will be used to keep track of customer specific data. This database will be called, the "Advice database". All databases together shall contain the essential information to provide the required insight for generating an adequate advice. In the following paragraphs, each database will be treated and the contents, structure and data source of each database will be expounded. With use of this information, the databases can be designed. The last paragraph of this chapter deals with general preconditions that need to be taken into account when designing each database.

7.1 PRODUCT RELATED DATABASE

A product can be described by specifying a large number of different features. These features determine which process functions are required and which techniques are optional to perform the required process functions. Therefore, the most important product specifications need to be collected as a preparation to the advice generating process. The product related database will act as guide during the collection and determination of product specifications.

Contents

In the product related database, all important product features and optional values of these features are presented.

To make sure that the collected and recorded values of these features are uniform, the unit of each value and the ranges in which a feature can be categorized are described in the database. Appendix E, shows some example of the definition of value ranges.

For example: The "package thickness" should be recorded in millimeters and the following ranges/ categories are possible: 0mm ≤R1≤ 0.1mm, 0.1mm ≤R2≤ 0,8 mm, R3> 0,8 mm

Next to this it is described which process functions or techniques are influenced by which feature and how.

Structure

An impression of the contents and structure of the product related database is given in figure 13.

The columns of the upper part present all product specifications that have influence on the suitability of sub-processes. The columns are subdivided into columns that are related to optional values or value-ranges.

The classification of product specifications in value ranges is used to have a quick insight into requirement of process function and the suitability of available techniques.

Example 1: For the feature "angle of packaging sides", optional ranges and corresponding restrictions on processes are following:

Ranges	Process restrictions
Tapered	Single cavity molding required
Non tapered	Single cavity molding not possible

Example 2: For the feature “circumference shape”, optional ranges and corresponding restrictions on processes are following:

Ranges	Process restrictions
Curved	Restrictions on singulation techniques (Saw singulation not possible)
Straight	No restrictions on any process

The lower part of the product related database shows a description of all product features and their influence on optional techniques and process functions.

Source

The information presented in this database is an abstract of all product process function related databases, and all process product related databases, which will be treated later in this report.

Maintenance

It may be possible that the boundaries of value-ranges change, because techniques and processes improve or change.

For example: The laser cutting technology improved and made it possible to cut through thicker material. The range within feature “material thickness“ of which the boundary is related by laser cutting will increase.

When a process improves, the to this process related boundaries of the value ranges should be reviewed.

When a new technique is introduced, it should be determined which product features determine de ability to use the new technique. Restrictions of these features on the ability to use the technique should be add to the value ranges as an extra boundary

A new product feature should be added to the product related database, when it appears that it influence the suitability of available techniques.

This update will be done simultaneously with the maintenance of the product-process related databases which will be treated later in this report. More about maintenance of databases can be read in chapter 9.

Version: 1 Date: 31-10-2006 Status: In Progress

Features	Feature A		Feature B			Feature C			Feature D					Feature Z	
Unit	mm		material			#			° (angle)					*	
Ranges/Value options	R1	R2	R1	R2	R3	R1	R2	R3	R1	R2	R1	R2	R3	R1	R2
Concerning product		X			X	X				X					X

Feature definition			
A	Feature A: Thickness of packaging		
	Feature A has influence on:	influence	Remarks
	Technique N1	Only suitable for R1	
	Technique N2	Only suitable for R2	
B	Feature B: lead frame material		
	Feature A has influence on:	Influence	Remarks
	Technique N1	Only suitable for R1	
	Technique N2	Only suitable for R1 or R2	
	process function Y	Required when R3	
Et cetera…			

Figure 13: Example of contents of the product related database: Overview of important product features with Rx represent the values or value ranges of the corresponding feature
The lower part is a description of all product features and their influence on optional techniques and process functions.

7.2 CUSTOMERS SITUATION AND PREFERENCES RELATED QUESTIONNAIRE

One important factor in determining the suitability of a process is influenced by the customers situation and preferences. An important example of this is mentioned in chapter 3.4, where Besi's customers are divided into subcontractors and manufacturers, each with its own process preferences, and abilities of adjusting the product in order to optimize the overall process.
Differences between customers can also be made in the extent of changing current process line: Different situations concerning the extend of this change are:

- The customer has an existing line for a new product and wants to adapt the line to the product.
- The customer wants to ad a new product to an existing line on which he also makes a range of other products, and needs additional processes.
- The customer needs an optimal new line for a new product
- The customer needs an optimal new line for an existing product.

To collect important details about al aspects of customers situation and preferences that could influence the process choice, the customer should be "interviewed". To support this interview, a sort of questionnaire can be used. An example of such an customers questionnaire can be found in appendix D.

Data contents

This questionnaire should contain questions that are important to ask the customer in order to be able to adapt the advice to the situation and preferences of the customer.

Data structure

Which question to ask, depends on the specific customer and his situation. The questionnaire contains general questions to determine the customer type and its situation. Next to this, it contains customer type and situation specific questions.
After answering the general questions, it should be clear which customer specific questions are important to answer. All customer specific questions are related to customer's situation and preferences.

Data source

This database should grow by using the advice support system. To complete the questionnaire, all questions that rise up during advice generating processes, and should be answered by the customer need to be collected. These questions can be put by anyone who contributes to the advice generating process and requires customers specific information.

Maintenance

As mentioned above, the questionnaire will grow during use. Therefore it need to be updated when new questions rise up which are customer type or customer situation related. Updating of the customers questionnaire may only be done by a support group, that is responsible for checking and maintaining the contents of the advice support system. More about maintenance of databases can be read in chapter 9.

7.3 PRODUCT - PROCESS FUNCTION RELATION DATABASE

Each process step in the back end assembly line is intended to add a certain value. This is the function of the process step. Which process functions are required depends mainly on the product design. Next to this, it can also be the case that a process function is initiated by other processes, in order to compensate the output, or to adapt the input for other processes, without actually adding any value to the product. These processes are called secondary processes, or support processes.

The "Product Process-function Relation Database" can be used to determine the required primary process functions that can be derived from the product design and specifications. Next to this, it should also provide information for determining the secondary function groups, which are required due to compensate the output, or to adapt the input for other processes. An example of a Product process function relation database is presented in Appendix G

Data contents

This database will present an overview of relations between product specifications and primary process functions that are initiated by these product specifications.

Next to this it will present the relation between process specifications and secondary process functions that are initiated by these process specifications.

Data structure

For fast overview and ability to track al required process functions, this database will be in table form. The table makes distinction between primary- and secondary processes to distinguish process functions that are influenced by the product specifications, and those that are initiated by the process.

The product properties are in the same row as the corresponding primary process function groups

The process specifications are in the same row as the corresponding secondary process function groups.

Data source

Information about these relations can be collected by interviewing process engineers or will be provided by the process engineers themselves.

Maintenance

The product process related database should be updated when a new process function comes into being. The new process function should be included in the process related database together with the product specification that initiates the requirement for the new process function.

Also when it appears that a process function leads to a required product specification which is not registered yet, this product specification should be included in this database. More about maintenance of databases can be read in chapter 9.

7.4 PROCESS - PRODUCT RELATION DATABASE

This database will be used during stage 5 and 8 of the advice generating process, when the suitability of available processes, within a process function group, need to be determined. The suitability of a process for processing a certain product depends on the specific product specifications and characteristics.

For example: A sawing machine can not be used for cutting circumferences that are not straight. The suitability of a sawing machine therefore depends on the shape of the product circumference.

Each process-function should have its own corresponding "product process related database" containing information about the performance, pros and cons of the different processes and the suitability in relation with product specifications and characteristics.

This information in combination with the known product specifications of the specific product, gives the ability to determine the suitability of available processes, and creates the ability to compare different processes within the same process function group.

Especially in stage 8 of the advice generating process, it is very important to have direct insight into which product specifications influence the suitability of a process. With insight in these relations, it is possible to adapt product specifications, to increase the suitability of a process, or to freeze product specifications to retrain the suitability of a process.

For example when there is no possible process combination, the product specification can be adapted to generate new opportunities concerning process combinations..

Data contents

Each process-function should have its own corresponding "product process related database" containing the following information:

- Available techniques that can perform the concerning process function.
- Product specifications that could influence one or more of the available techniques.
- Relation between these product specifications and the suitability of the available techniques.
- Restrictions or value ranges of product specifications that influence the grade of suitability of available techniques.

Data structure

The data is stored in table form.

The different product features which could influence the suitability of a process are summarized in the first column. The following columns represent available techniques within the concerning process function group, containing restrictions or value ranges of product specifications that influence the grade of suitability of the concerning process

Data source

Information about these relations can be collected by interviewing process engineers or will be provided by the process engineers themselves.

Maintenance

From process side of view, the process-product relation database needs to be maintained when a new technique is introduced or when technical development leads to a change in restrictions or value ranges.

From product side of view, this database needs to be maintain when a product feature that was not important before, is specified due to certain product requirements. More about maintenance of databases can be read in chapter 9.

7.5 PROCESS COMBINATION DATABASE

In stage 6 of the advice generating progress, it will be determined how the different optional processes of the required process functions, can be combined in order to form a complete back end assembly line. The following text will give insight in the problem that is dealt with in stage 6 of the advice generating process and will give an indication of the data that should be provided by the "process combination related database".

It is not a matter of course, that all optional processes are free to be combined with each other. As mentioned in paragraph 5.4.2. the ability to combine different processes is restricted by the required input of each process and the output of processes preliminary to it. Therefore it may occur that some processes can not be combined at all, or that some processes can only be combined when certain preconditions are taken into account.

When it is known which combinations are possible, they need to be judged on different aspects as: costs, flexibility, speed, etc. and compared.

It has no sense to put effort in studying combinations that are not possible. Therefore it is efficient to first eliminate all impossible combinations before studying the combinations in more detail. Taking the following into account, this elimination step can be very simple.

- A combination of processes/techniques, forming the overall assembly process, is only possible when each process in this combination does not exclude the use of other processes in this combination.

With this in mind, all combinations of processes containing at least one technique that excludes an other technique in this combination, can be eliminated. (Figure 14 gives an example about the elimination process.) This limits the number of optional process combinations, and the ability to optimize the overall assembly line.

Contents

The "Process combination related database" should contain information, required for determination of the ability to combine a technique with techniques in other process functions.

A quick overview should be provided for the elimination process, showing which processes are excluded by each process. Next to this, it should contain information required for studying the preconditions . and consequences that need to be taken into account for each process combination.

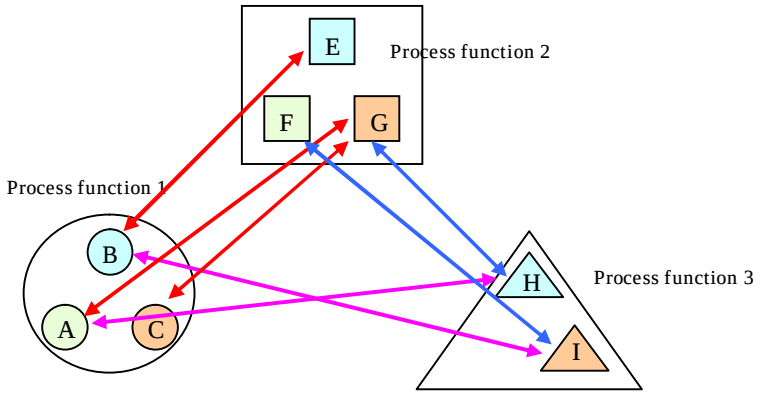


Figure14: This figure schematically shows a situation in which 3 proces- functions are required which can be performed by different processes. For example B can be combined with E and I, but E can not be combined with I, therefore it is not possible to have a combination B,E,I.

After the elimination step, only those combinations remain, that are worth the effort studying. It can be seen that the only possible combination in this example, that is worth putting effort in to study, is combination A,G,H.

Structure

Because of the fact that the need for certain process functions is product dependent, and because each process function can be performed by multiple techniques, it is decided to make use of multiple "process-combination databases". Each corresponding to its own process function group and representing the available techniques within that specific process-function-group.

A process combination database contains a matrix in which each column represents an optional technique for performing a the specific process function. Each row is related to an other process function group. Each cell presents all techniques optional for performing the process function represented by the row and which can be combined with the technique represented by the column.

For maintenance purposes, it is decided to present only combinations of process functions that are by each other. If a combination is not represented in the matrix, this means that there are no restrictions.

The cells within each row present optional techniques in the specific process function group.

For the elimination step, it is important to have a quick overlook on which techniques can be combined.

Because this database also presents the information per process function, subdivided by techniques, this database can be combined with the process-product related database.

Optional combinations with Process Function 1			
	Technique 1.1	Technique 1.2	Technique 1.3
Process function 2	**2,1 and 2.2**	**2.3 and 2.4**	**2.2, 2.4, 2.5**
Process function 3	**3,2 and 3.3**	**3.1**	**No combination**
Process function 6	**6,3**	**No combination**	**6,2**

Figure15: example of a table that records all optional combinations between technique 1.1, technique 1.2 and Technique 1.3 with techniques within process function group 2, 3 and 6. (technique 1.1 can be combined with 2.1, 2.2, 3.2 and 3.3 and 6.3. A combination of Technique 1.2 with process function 6 is not possible. When process function 6 is required, all combinations containing technique 1.2 can be excluded.

Data source

Information about optional and non optional process combinations should be provided by process engineers but also by anyone who knows restrictions or preconditions that need to be taken into account. Before a certain restriction is entered, the correctness of this information should be verified and confirmed by experts of both techniques.

Maintenance

The ability to combine two techniques for the same product, can change due to process improvements. When a process improves, the impact of this improvement on the ability to form combinations with other techniques should be reviewed. When new combination can be made, all related process-combination databases should be adapted. More about maintenance of databases can be read in chapter 9.

7.6 PROCESS-CUSTOMER RELATION DATABASE

When all possible process combinations are known, these can be presented as an advice towards the customer. But to generate a more customized advice, for each combination it should be judged to what range the combination's performance corresponds with the customer's requirements. Important aspects of the performance, on which the customer judges the suitability of a process combination are:

- Reuse of already installed equipment
- Costs of ownership,
- Flexibility,
- Speed,
- Reliability

Contents

A process-customer related database contains knowledge for judging the performance of a technique in relation with the customers situation. For each technique, information about the aspects mentioned above should be available.

Structure

The performance of a process combination is build up by the performances of the independent techniques within the combination. The information in which the customer is interested and should be provided by this database is very extensive and therefore hard to present in a single overview.

It is therefore decided store the data of each single technique in its own process-customer relation database. The information will subdivided per aspect mentioned above. An abstract of the customer related data, can be presented in the process function related database.

Data source

New data and knowledge necessary to update, and maintain this database, should be provided by process engineers of the concerning techniques.

Maintenance

This databases should be updated when changes in the performance of a process lead to changes in the aspects mentioned above. The information will be provided by process engineers. More about maintenance of databases can be read in chapter 9.

7.7 ADVICE DATABASE

As mentioned in the introduction of this chapter, all information that is collected during an advice generating process will be recorded in a corresponding database. This database can be seen as a project map that is used during the whole advice generating process and acts as a shared information source for anyone who requires this advice related data. The Advice database prevents that departments put a lot of effort in inventorying information that is already known by other departments. An example of an advice support system is presented in Appendix K.

Contents

This database will be filled with all input- and output data of all stages of the advice generating process. This advice related database will function as kind of project folder during all stages of the advice generating process.

Structure

The information in this database, can be structured into the different data groups that are mentioned in paragraph 6.2, namely:

- Product - related information
- Customer - related information
- Product in relation with process-functions - related information
- Product in relation with process - related information
- Process combination - related information
- Process in relation with customer – related information

Each of these data groups are represented by different sections of the database.

Data source

This database will be filled with all information that is collected during the advice generating process. This means that the data is partly extracted from other databases and partly supplied by the customer. This database is maintained by all sales agents that deal with the specific case for which this database is intended.

Maintenance

Because this database is case related, it will only be maintained during the advice generating process. When the customer is advised, it will not be maintained, unless the advise toward the customer is not sufficient and need to be reviewed. This database can be stored as archive, and eventually be used during communication with the customer about a new cases.

7.8 STANDARDIZING OF DATABASES

Each database consist multiple sections in which a defined sort of data need to be stored in a consistent way. Because the main function of the advice support system is to provide clear and quick insight in shared knowledge, it is very important that the information, presented by the databases, is easy to read and clarifying. To secure intelligibility of databases, it should be defined, which data should be entered in which database, in which section and in which format. Therefore, for each database, templates are provided, with corresponding instructions, how the data should be recorded in each field of the database.

Part of the consistency is based on vocabulary. When information is shared, across multiple divisions, it is important to have some vocabulary control, in order to prevent miscommunication. It is often useful to employ a thesaurus to connect the terms by which users search for knowledge to those used in categorizing it.

Because the users of the advice support system are operative all over the world, and the main communication language of the users is English, all information should be recorded in English.

7.9 CONCLUSION

The previous paragraphs treated the contents, structure and data source of the databases, that will be part of the advice support system.

The information for all databases, except the advice database will be provided by sales agents and process engineers. Together with the users guide that is treated in the next chapter, these databases form the basis of the advice support system.

For the first concept of the advice support system, each database will be separate, but for maintenance purposes it could be decided later to combine some databases.

To complete and maintain the databases mentioned above, data can be collected by interviewing the experts on corresponding subjects. Unfortunately, interviewing is a very time consuming work. Therefore when the Pilot of the advice support system works, it will be more attractive to instruct the experts how to provide information for updating the databases them selves. To prevent, false or incomplete data, the maintenance of a database should be placed under responsibility of a support group.

Standardizing databases is a precondition to support the maintenance of them. Important issues on standardizing are

- Intelligibility of databases by consistency of contents, structure and format
- Consistency of vocabulary

More about maintenance of databases can be read in chapter 9.

8 USERS GUIDE THROUGH THE ADVICE GENERATING PROCESS

The best way to generate advice, is by performing the different stages of the advice generating process as mentioned in chapter and concurrently using the advice support system. The user guide will instruct how the user is expected to use the advice support system. For the user, two aspects should be clear when using the advice support system. For the users it should be clear when an interaction between the user and the advice support system can be helpful.
For each required interaction between a user and the advice support system it should be clear how this interaction should be accomplished by the user, in order to be sure that the correct data is retracted from the advice support system or that the data is correctly recorded in the advice support system.
Distinction can be made between interactions required for generating advice and interactions used for maintenance purposes. The first group of interactions can be determined by studying the advice generating process steps treated in chapter 6. The second group op interactions are related to the updating and maintenance of databases which are treated in chapter 7. The maintenance of the advice support system will be treated in chapter 9.
This chapter treats the users guide for generating advice. All interactions are determined, and for each interaction it is instructed how to deal with the data exchange between the user and the advice support system.

8.1 INTERACTIONS

Interactions between the user and the advice support system concerning actually support of the user are:

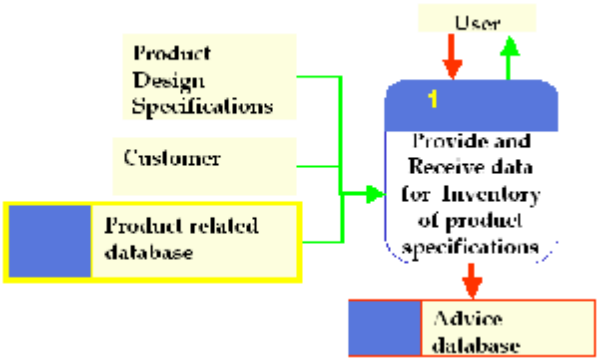
- Inventory of product specifications
- Inventory of customer's situation and preferences
- Determination of required process functions
- Determination optional techniques for performing process functions
- Determination of optional process combination
- Judging suitability of optional process combination
- Revise requirements for adapting optional process combinations.

For each of these interactions with the advice support system, Dataflow diagrams will be presented, and it is described which data is processed and which , databases, sources and sinks are involved.

8.2 INVENTORY OF PRODUCT SPECIFICATIONS

Required databases
- Product related database
- Advise database Section 1

Information sources
- Customer
- Product design specifications



Actions

The product related database presents a list with features of which the specifications are required. In the lower part of the product related database each feature is defined. For each feature it need to be determined in which value ranges it is specified by studying product design specifications or request information from the customer. The customer information is recorded by checking off the corresponding value ranges and copying the product related database into section1 of the advice database.

Checking off the corresponding value range

	Version: 1	Date: 31-10-2006	Status: In Progress
Features	**Feature A**	**Feature B**	**Feature C**	**Feature D**		**Feature Z**
Unit	mm	material	°	° (angle)		°
Range/Value options	R1 R2	R1 R2 R3	R1 R2 R3	R1 R2	R1 R2 R3	R1 R2
Concerning product	X	X	X	X		X

Feature definition

A	**Feature A: Thickness of packaging**		
	Feature A has influence on:	influence	Remarks
	Technique N1	Only suitable for R1	
	Technique N2	Only suitable for R2	
	Feature B: lead frame material		
	Feature A has influence on:	Influence	Remarks
	Technique N1	Only suitable for R1	
	Technique N2	Only suitable for R1 or R2	
	process function Y	Required when R3	
Et cetera…			

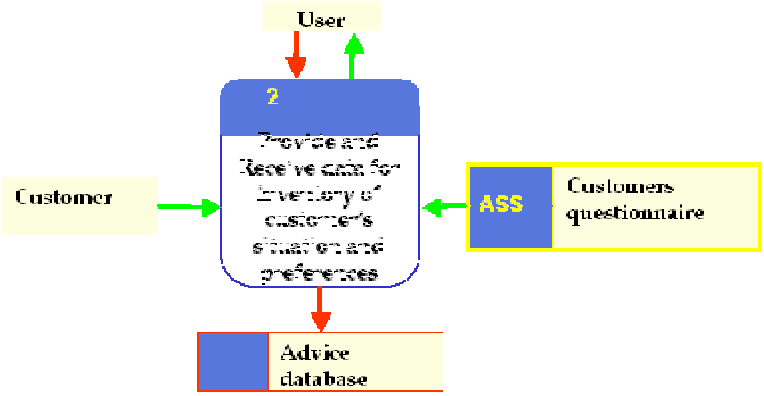
8.3 INVENTORY OF CUSTOMER'S SITUATION AND PREFERENCES

Required databases

- Customers questionnaire
- Advice database section 2

Sources:

- Customer



Actions

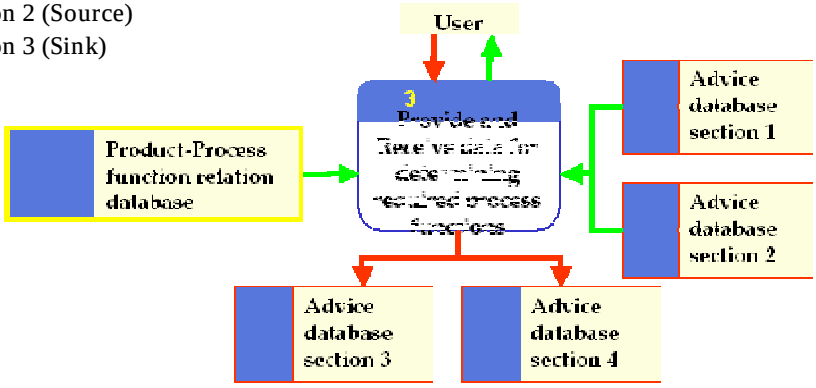
The Customer's questionnaire presents a list with questions to ask the customer in order to gain information that is required in following stages of the advice generating process.

The answers on these questions combined with the corresponding question number should be recorded in section 2 of the advice database.

8.3.1 Determination of required process functions

Required databases

- Product process function related database.
- Advice database/section 1 (Source)
- Advice database/section 2 (Source)
- Advice database/section 3 (Sink)



Actions

The product process function relation database presents a list of product specifications that indicate the need for specific process functions. With use of the product specifications recorded in section1, it can be determined which primary process functions are required. With use of the required primary process functions, and other product specifications listed in section 1 of the advice database, it can be determined which secondary process functions are required.

With use of section 2 in which the customer's situation and preferences are recorded, it can be determined which process functions are already available, and how these process functions are performed.

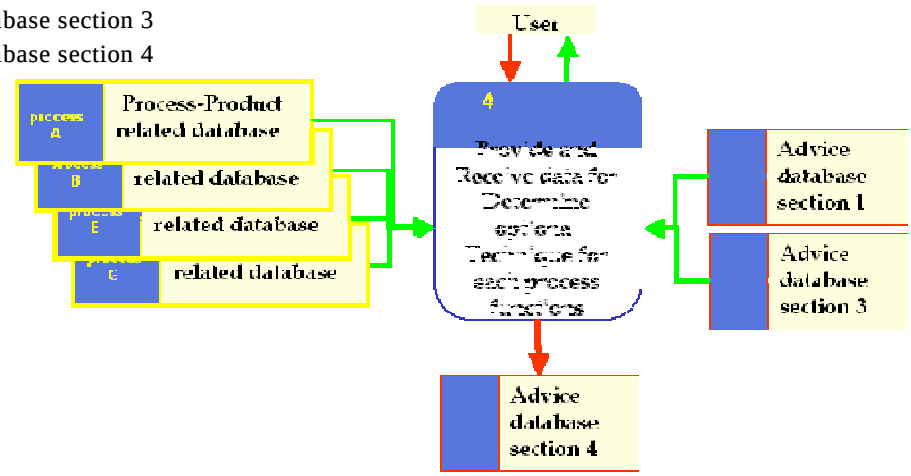
Two lists, one with required process functions which are not available at the customer and one list with already available process functions, should be recorded in section 3 of the advice database. The already available techniques should be recorded in section 4 of the advice database.

8.4 DETERMINATION OPTIONAL TECHNIQUES FOR PERFORMING PROCESS FUNCTIONS

Required databases

- Process product related databases
- Advice database section 1
- Advice database section 3
- Advice database section 4

.

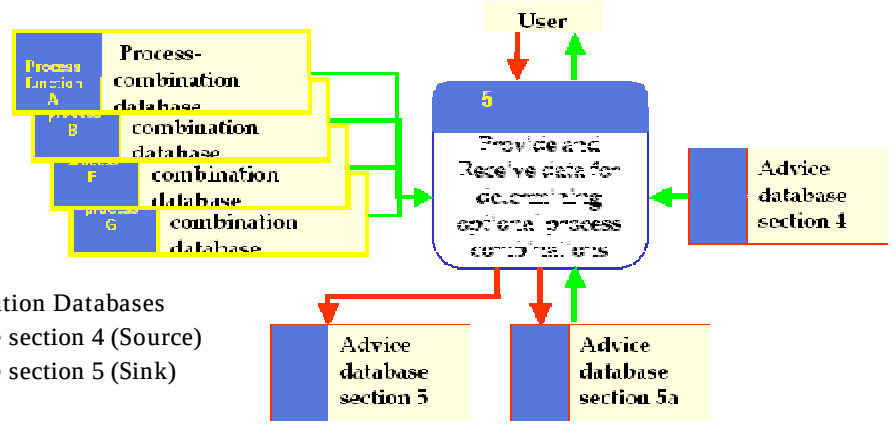


Action

Each process function has its own "process-product relation database" containing all available techniques that can be used for performing the required process functions

With use of a process-product relation database, in combination with the already recorded product specifications in the advice database section 1, it can be determined which techniques are suitable for performing a process function. In this way, it should be determined which techniques are optional to use, for performing those process-functions, of which it is not known yet how they are be performed. All optional techniques should be recorded in section 4 of the advice database.

8.5 DETERMINATION OF OPTIONAL PROCESS COMBINATION



Required databases

- Process combination Databases
- Advice database section 4 (Source)
- Advice database section 5 (Sink)

Action

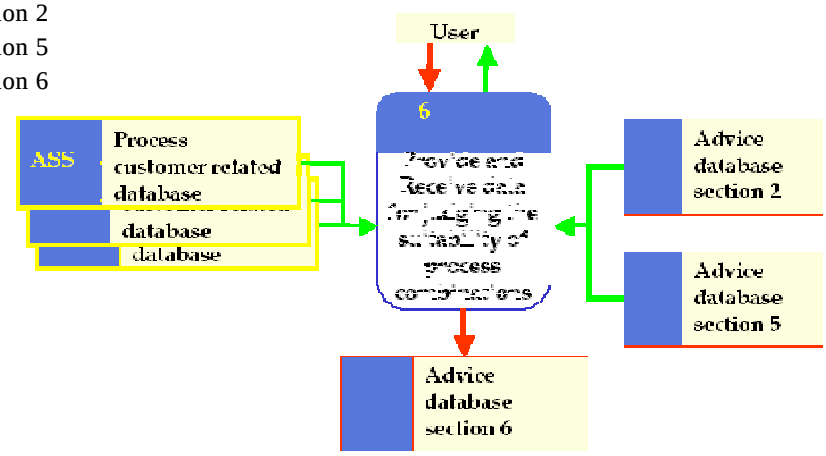
For each required process function, al optional techniques are stored in advice database section 4, all combinations between these techniques, covering all process functions, need to be recorded in a temporary database (Advice database section 5a). When a process combination contains a combination of two techniques that can not be combined according to a process combination database the whole process combination should be eliminated.

With use of the process combination databases, for each technique in a specific process function, it can be determined which techniques can not be combined with techniques in other process functions. with this information, all non optional combinations can be eliminated, leaving only those combinations that are really optional. These combination are recorded in the advice database section 5.

8.6 JUDGING SUITABILITY OF OPTIONAL PROCESS COMBINATION

Required databases

- Process-Customer relation databases
- Advice database section 2
- Advice database section 5
- Advice database section 6

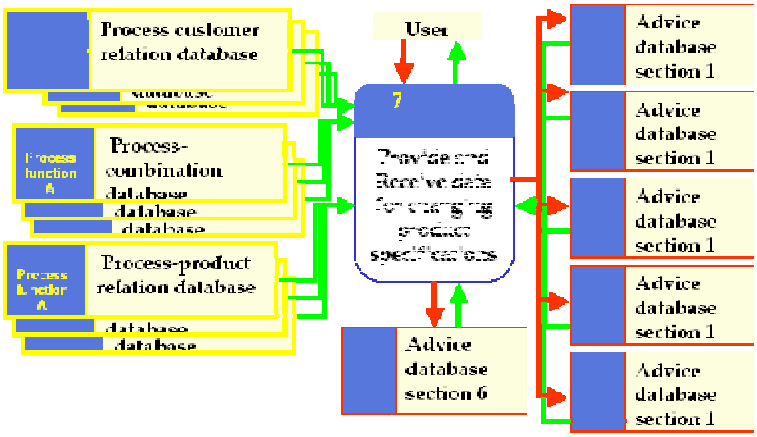


Action

All optional process combinations are recoded in the Advice database/section 5 and it should be judged if any of these combinations is suitable according the customer's situation and requirements which are recorded in Advice database/section 2. The performance of each technique can be found in the to this technique corresponding "process-customer related database". The customer's requirements should be compared with the performance of each technique in a process combination. By this, it can be judged if a process combination is suitable for the customer or not. A report about the suitability of each process combination in relation with the customer, will be stored in section 6 of the Advice database.

8.7 CHANGE PRODUCT SPECIFICATION FOR ADAPTING OPTIONAL PROCESS COMBINATIONS.

When none of the optional process combination suits the customer's situation or preferences, or when no optional process combination can be found the product specifications can be revised in order to include other optional techniques which makes it possible to create a new optional process combination.



Required databases

- Advice database section 1
- Advice database section 2
- Advice database section 3
- Advice database section 4
- Advice database section 5
- Process combination database
- Product process database

Actions

A- All preferred process functions for which the customer has a preference concerning choice of technique, including the preferred techniques, can be found in the advice database/section 3.
All techniques including the excluded techniques, that are available for performing the other required process functions can be found in Advice database section 4.
With use of the process combination database, all optional combinations with all techniques mentioned above need to be determined according to the process mentioned in 7.1.**5**. (without taking the restrictions due to product specifications into account.)
B- Find the combination with the minimum number of excluded techniques. (***Information from stage 5)***
C-With use of the process combination database, it can be determine if the product can be adapted in order to include the excluded technique mentioned in B, without excluding other techniques in the specific combination. This may not affect the functionality of the product in such way that it does not suit its required performance anymore this can be checked by the customer process relation database .
-If this can be done, a suitable combination is available
-If not, find a following combination with the minimum number of excluded techniques and repeat step C
When a product is adapted, All sections of the advice databases should be adapted

9 MAINTENANCE OF THE ADVICE SUPPORT SYSTEM

The right of existence of the advice support system is related to the value it provides toward the organization in which it is used. But before the company can harvest this value, it is required to put some effort in it, to establish the conditions, to actually leverage knowledge to a level where it can actually create value[34].

A characteristic of the semiconductor industry in which Besi operates, is its dynamic environment. The rapid development of advanced semiconductor applications requires semiconductor manufacturers to continually improve their core technology and manufacturing capabilities to remain competitive[35]. A consequence of this is an accretion of knowledge about existing and new technologies.

To be able to generate a complete advice, it is required that the available information is complete. Next to completeness, it is necessary to have a strict control on the correctness of data.

The continuous accretion of knowledge requires regularly updating and extending the advice support system. As can be read in chapter 5.5, maintenance is crucial for the use of the advice support system. When the need for maintenance is neglected, the advice support system will not be able to provide the required information and by this, it will fail to pursue its intention, leading us back to the begin of this chapter. To find out how to maintain the advice support system, the following research questions where answered:

- When should the advice support system be maintained?
- Who should maintain the advice support system?
- Which preconditions are required in order to be able keep de advice support system up to date?

Paragraph 9.1 deals with the first questions, revealing all situation that trigger the maintenance, or update actions.

Paragraph 9.2 proposes options about who should maintain the advice support system.

To assure that maintenance of databases is done consistent, correctly and complete, some preconditions need to be fulfilled. These preconditions will be revealed in paragraph 9.3

9.1 MAINTENANCE ACTIONS

All knowledge about existing processes and techniques that could lead to a more complete advice towards the customer should be recorded in the advice support system. The Following situations can be distinguished as a trigger for updating or maintaining the advice support system.

- Technology changes
- New technology
- New insight in process combinations.
- New insight in product process relations
- New insight in process performance in relation to customers situation and preferences

The following sections will clarify these situations. Table 6, shows which databases need updating at each situation.

Once a database is updated and it is approved to be correctly updated, it should be marked with the date of approval, so the user can notice when data is changed since the last time he used the database Old database revisions should be marked as obsolete.

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[34] ***Thomas H. Davenport, David W. De Long, Michael C. Beers;1997; Building Successful Knowledge Management Projects***

[35] http://www.Besi.nl **,** ***Industry Back ground***

9.1.1 Technology changes

A change in technology means an improvement, or new applications of an existing technology. All databases concerning this technology, should be updated in a way that most recent knowledge about this new development will be presented when required.

For example: MAP Molding normally requires a post mold clamping step to undo warpage effects. A new improvement in the molding process eliminated the warpage effect. After adding this information to the advice support system, when using the advice support system for generating advice about the molding process, it will be mentioned that warpage is a disadvantage of MAP molding, but that it can be solved by post mold clamping, or by making use of the new improvement.

9.1.2 New technology

A new technology could mean a new technique that can be used for an existing process function, but also a new technique that ads a value to the product that can not be performed by any other existing technique, and with this performs a new process function.

For example: A new type of product requires a polished surface for optical purposes. Therefore a new technique is developed to polish the product surface.

To be able to share knowledge about this new technique, new process function and process related databases should be added to the system. Also existing databases need to be updated. First the product related databases should be extended with product features and value ranges that indicate the requirement for this new technique. Next, the process combination relation database need to be updated, because it could be possible that the use of the new technique is restricted by other processes or restricts other processes.

9.1.3 New knowledge about process combinations

It may appear that research into certain process problems leads to new insight in relations between processes parameters, which could improve the advice towards customers.

For example: It is known that the wear of punch tools is related to the hardness of molding compound. This insight could lead to an overall assembly process with less tool wear, and thus cheaper production.

Part of the savings earned by the customer will float back to Besi in the form of loyalty of the customer towards Besi. Process combination related data, should be added into the involved process combination related databases.

9.1.4 New knowledge about product-process relations

Although most product-process relations are already known for existing processes, higher product requirements could require some more investigation into product-process relations.

For example: A lot of problems where dealt with concerning shortcut of leads as a reaction to a specific plating process (called whiskering). It took a lot of effort to find out the root cause. Namely: the growth of crystals due to an unstable material structure.

New insight that is gained by these investigations, should be recorded and shared in order to exploit the invested resources as much as possible. This knowledge should be recorded into the concerning process product related database.

9.1.5 New insight in process performance in relation to customer aspects.

When deciding between two optional process combinations, the customer need to be informed about pros and cons of each option. As can be read in chapter paragraph 5.3.1, this information concerns the following questions:

- What effect does the proposed equipment have on the operation's ability to service its markets?
- How does the proposed equipment help to build the operation's resource capabilities?
- What are the financial consequences of investing in the proposed equipment?

New information that could help answering these questions above should be stored in the process-customer related database of the concerning process.

Situations \ Data base type	Product – related database	Customer's situation and preferences related database	Product -process function related data	Process -product related database	Process combination related database	Process - customer related database
Technology changes	X		X	X		
New technology	X	X	X	X	X	X
New insight in process combinations.					X	
New insight in product process relations	X		X	X		
New insight in process performance in relation to customers situation and preferences		X				X

Table 6: overview of requirement for database updating at each situation. Each cross means that all databases in this type concerning the situation need updating.

9.2 APPOINTING A SUPPORT GROUP

Once the advice support system is implemented, all databases are exposed to an aging process, influencing the correctness and completeness of data. Because an advice has no value when it is based on incorrect data, it is necessary to have a strict control on the correctness and completeness of data, used for generating the advice. This means that all data should be controlled by authorized persons who are in possession of certain technical skills, that makes him/her able to:[36]

- Collect knowledge
- Judge knowledge
- Category knowledge
- Record knowledge in correct format in correct database.

Doing this for all divisions is a time consuming and responsible job and is not likely to be done in addition to a regular full time process engineering function. It is therefore advised to establish an organization wide group whose members have the means and skills to perform the to the maintenance related tasks as pointed above.

Appointing a support group, dedicated to manage maintenance of the advice support system, as mentioned above, is a requisite for correct implementation of the advice support system. Neglecting this precondition will lead to a inconspicuous death of the advice support system. Because once the use of the advice support system leads to unsatisfactory information, due to lack of maintenance, it is not unlikely that it will be degraded as a worthless and incompetent tool.

[36] ***L. Terpeluk Moss, M Abai, S Adelman; "How to Improve Data Quality"; ISBN-10: 0-321-24099-5.***

As mentioned in chapter 4.6 there is a demand for taskforces and other linkage devices in order to coordinate information exchange across the separate divisions. This taskforce can be composed of representatives from divisions of which their processes affect each other. An option is, to combine the role taskforce and support group.
Although new roles are expensive, they can play a main role in communication between different divisions. they mean that any new project can take advantage of them for support and get up and running quickly[37]. Next to maintenance actions, the support group could also perform the following tasks:

- Performing Case study of customer specific problems
- Function as information source for gathering detailed information about processes outer ones expertises.
- Keep in contact with process engineers of all divisions to exchange ideas, problems, updates of techniques.

Since changing the of organisational structure is not part of this research, it is recommended to spend some more research in how to realize this support group.

[37] ***Thomas H. Davenport, David W. De Long, Michael C. Beers;1997; Building Successful Knowledge Management Projects***

9.3 PRECONDITIONS TO GUARANTEE MAINTAINABILITY OF ADVICE SUPPORT SYSTEM

The advice support system can be of great value when it can be uses as presented in this report. But according to literature[38] [39], there are certain preconditions that need to be taken into account in order to assure a successful implementation of a knowledge management system such as the advice support system. The following paragraphs reveal the most important preconditions that should be taken into account before implementing the advice support system[38].

9.3.1 Create a link to industry value

No organisation is interested in implementing an new knowledge management system for the sake of the knowledge management system[39]. It is important to make significant and compelling connections between the advice support system and business strategy. In chapter four, the value of the advice support system in relation wit the business strategy is revealed. The value of the advice support system can be summarized as:

- The advice support system can be used to find all required processes, by selectively collecting product information that indicates the necessity for certain process steps.
- It could act as guide when determining the customer's current situation, his preferences and his requirements. Next to this, it provides insight in process information that can be used to judge the suitability of processes in relation with customers situation and preferences.
- The advice support system provides sales agents with detailed information about aspects that need to be taken into account when combining their processes with other processes outer their discipline

Altogether, the advice support system leads to high quality advice, which is highly appreciated by the customer and therefore contributes to a better strategic position of Besi.

9.3.2 Create willingness to share data

The existence of the advice support system depends more than anything, on the internal cultural environment of an organization concerning the willingness of employees to share knowledge. An organization that has a highly collaborative, team-oriented style will have less challenges implementing the advice support system, versus one that is hierarchical in structure and that rewards only individual accomplishments. At the same time, an organization that is in a growth mode, and already has a reward structure that actively promotes knowledge sharing, will definitely have fewer problems than one that has recently undergone a downsizing process.

Notwithstanding the fact that the encouraging of sharing knowledge can be of great value for a company, it is not uncommon to find negative aspects of organizational cultures with respect to the sharing of knowledge.

According to H. Thomas et All[38], many reasons can be found for employees to be unwilling to share knowledge.

For example: Employees, fearing layoffs, are reluctant to share any information about mistakes or failures even though this knowledge was very valuable to the firm and could prevent others from making the same error.

Another example is: Employees can be reluctant to share positive knowledge feeling that their value to the firm and, therefore, their job security is inextricably tied to their personal knowledge and expertise.

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[38] Thomas H. Davenport, David W. De Long, Michael C. Beers;1997; Building Successful Knowledge Management Projects

[39] F T Liu; August 2003;" How to implement knowledge management in your company, competing in the knowledge based economy"

Employees need to be encouraged to share their knowledge. It should be clearly communicated why introduction of the advice support system is not "the initiative of the month" but the prerequisite for survival and growth in the twenty-first century. There are multiple methods to create a sense of urgency.

- Employees can be confronted with current situation by making them aware of the waste of time, energy and opportunities when generating and providing advices towards customers.
- Employees can be positively interested, by confronting them with promising results of other companies after introduction of a similar system. (Unfortunately, I could not find an example of a similar system)
- Employees can also be motivated, either monetarily, or through senior management recognition, through peer review, through competition, etc. As long as any of these approaches are fairly administered, highly publicized, and supported by senior management, they all work. The reward mechanism should also be team-based rather than individual rewards, in order to encourage sharing and creative exchange.

Which of these methods is the best in Besi's situation depends on how it is conceived by the employees. According to interviews with process engineers and sales engineers, most of them where aware of the fact that a kind of advice support system could improve communication of explicit knowledge within and between the different divisions. During the interviews with process engineers, all interviewees gave the impression that they where well willing to share their knowledge, because they have spent a lot of time, patiently explaining all ins and outs of "their" processes. From this it could be presumed that there is less restraint against sharing knowledge.

9.3.3 Technical infrastructure

In order to be able to use the advice support system throughout the organization, knowledge should be accessible for the users.

A technical infrastructure should provide the connection between the users of the advice support system, as well as the access to the available knowledge stored in databases. For communication information, networks are required, such as local area networks (LANs), wide-area networks (WANs), the Internet as well as the Intranet[40]. At the time of this research, there was no suitable network available for testing the system. Therefore, before implementation of the advice support system can be performed, it is a high priority to arrange a network that is able to communicate available knowledge which is stored and provided by the advice support system.

Another aspect of technology infrastructure for knowledge management projects is a set of common technologies for desktop computing and communications. At the simplest level, this means a capable networked PC or briefcase for all users, with standardized personal tools (e.g., word processing, presentation software) so that documents can be exchanged easily throughout a company.

Since knowledge management means collaborating, organizations that are widely networked will find the technical implementation of a knowledge management system less difficult than those organizations with less networked infrastructure. At the same time, employees who are already familiar with a networked environment will have a shorter learning curve and therefore less resistance for a successful implementation of a knowledge management system as the advice support system.

Next to this, there is little experience in working with a networked environment.

It is highly recommended to perform research in how the technical infrastructure should be arranged and how the employees can be trained to be able to use the advice support system, after implementation.

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[40] F T Liu; August 2003;" How to implement knowledge management in your company, competing in the knowledge based economy"

9.3.4 Organizational infrastructure

Building an organizational infrastructure for knowledge management means establishing a set of roles and organizational groups whose members have the skills to serve as resources for individual projects. Although these new roles and structures are expensive, it is a requisite in order to keep de advice support system running. Chapter 9.2 already mentioned the appointing of a special support group. Next to performing maintenance task on the advice support system, this group can also be used for other tasks that increase the overall strategic position of Besi. (As mentioned in paragraph 4.6 and paragraph 9.2.)

9.3.5 Senior management appreciation and support

According to literature[41], strong support from executives is a critical factor in succeeding of the implementation of the advice support system. The types of support that are helpful include the following:

- Sending messages to the organization that knowledge management and organizational learning are critical to the organization's success
- Providing funding and other resources for infrastructure
- Clarifying what types of knowledge are most important to the company.

A strong personal orientation to knowledge may not be absolutely necessary for a senior manager to champion knowledge management, but it surely helps.

9.4 CONCLUSIONS

New product- or process related knowledge, or change in technology, triggers for updating or maintaining the advice support system. Maintenance should be performed when necessary, in a correct way, to guarantee that the provided data is as complete and correct as possible. Neglecting this precondition will lead to the risk that the advice support system provides incorrect, incomplete, and thus unsatisfactory information. Once this happens, it is not unlikely that the advice support system will be degraded as a worthless and incompetent tool.

Because of the extend of data, and high responsibility it takes to maintain knowledge which will be shared throughout the overall organisation, maintenance of the advice support system can not be done in addition to a full time job, like for example process engineering. Therefore maintenance should be performed by a special appointed support group. Next appointing a support group, also the following preconditions need to be taken into account, when implementing the advice support system.

First of all, it is important to make significant and compelling connections between the advice support system and the fact that the advice support system leads to high quality advice, which is highly appreciated by the customer and therefore contributes to a better strategic position of Besi. Strong support from executives is a critical factor in succeeding of the implementation of the advice support system. Therefore it is required to convince a senior manager of the value of implementing the advice support system.

The next precondition is to create the willingness of people to share knowledge. It is presumed that interviewed process engineers are not reluctant to share knowledge. If they are, they need to be encouraged or motivated to share their knowledge.

The advice support system can only be used throughout the overall corporate organization, when some kind of technical infrastructure is available.

Because the employees of Besi are not used to network applications, employees should be trained to be able to use the advice support system, after implementation.

Since changing the organisational structure or technical infrastructure is not part of this research, it is recommended to spend some more research to investigate how to realize a suitable support group, how the technical infrastructure should be arranged and how the employees can be trained.

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[41] ***Thomas H. Davenport, David W. De Long, Michael C. Beers;1997; Building Successful Knowledge Management Projects***

10 ADDITIONS TO ADVICE SUPPORT SYSTEM

The advice support system described in this report, can be optimized and extended to increase the usability of the system. In this chapter, some suggestions are be presented.

10.1 USE OF PRODUCT GROUP DATABASES

In chapter 6, it is described which stages can be distinguished in the advice generating process and how the advice support system could function at each stage.
In spite of the fact that similar problems have already been solved many times before, currently each time when a customer approaches a sales department of one of Besi's divisions, all stages mentioned in the previous paragraphs are executed for every customer request. This is a time consuming job. It is therefore wise to collect and store this knowledge and experiences in such a way, that it can be reused, when dealing with similar products in the future.

All products, of which all specifications are in the same value ranges as presented in the product related database, can be manufactured in the same way. In this chapter, a group of products with all specifications in the same value ranges, will be called a "product group".
When, all optional process combinations for a specific product group have been investigated and recorded, and the pro's and cons of optional processes for a certain product group are analyzed and determined, these results can be recorded into a product group related database.
When a customer requires advice about the assembly process of a product, it can be determined whether the concerning product is member of a "known product group" and if so, all capable process combinations with their pros and cons can directly be presented to the customer and only stage 3 and eventually stages 7 and 8 (which are described in chapter 6) need to be executed to adapt the advice to the customers preferences and situation.
When a product is not a member of a known product group, all stages mentioned in chapter 6 need to be executed. This is still time consuming, but the advice support system will ease this process and the gained knowledge will be recorded and can be reused.

To determine if a product is member of a known product group, the product related database will be extended with a "product group overview". The following subsections will describe the function, structure and data of the product group overview and the product group related database.

10.1.1 Product group overview

A "Product group overview" presents a list with all product features that could eventually influence the requirement and performance of back end processes. Next to this it represents the value ranges of all product features of each product group. After specifying the product features of the concerning product, the product group overview can be used to make a quick scan, to find out whether the concerning product can be classified as member of a known product group.. An impression of contents and structure of an product group overview is shown in figure 17.
The columns, represent all product specifications that influence the suitability of sub-processes. The columns are subdivided into columns with optional values or value-ranges. The value ranges of product features that are used to distinguish different product groups, are defined by restrictions of the corresponding processes. Each boundary of a value range corresponds to a restriction of a process.

Example 1: For the feature "angle of packaging sides", optional ranges and corresponding restrictions on processes are following:

ranges	Process restrictions
Tapered	Single cavity molding required
Non tapered	Single cavity molding not possible

Example 2: For the feature “circumference shape”, optional ranges and corresponding restrictions on processes are following:

ranges	Process restrictions
curved	Restrictions on singulation techniques (Saw singulation not possible)
Straight	No restrictions on any process

The rows of the matrix contain the different product groups that are already investigated. The corresponding values are marked. When the product specifications of the concerning product are known, it can quick be seen which product code corresponds to this specifications.
Figure 18 demonstrates how the product group can be found with use of the product group overview.

Maintenance

When a new product group has been investigated and the corresponding product group related database is released, the overview should be extended with this new known product group.
When a process improves, the to this process related boundaries of the value ranges should be

Type QFN	**Version :1**		**Date:25-02-2005**								Status: In progress		
Product Specificationss	Specification A			**Specification** B				Specification C				Specification X		
Value ranges / PRODUCT GROUP CODE	VALUE A1	Value A2	Value A3	VALUE B1	Value B2	Value B3	Value B4	VALUE C1	Value C2			VALUE X1	Value X2	Value X3
A1B2C2D1…X1	X				X				X			X		
A2B4C2D2…X2		X					X		X				X	
A2B1C1D3 …X3		X		X				X						X
A3B3C1D2 …X2			X			X		X					X	
A3B2C1D3…X3			X		X			X						X
Concerning product		X		X				X						X

Figure 17: Impression of contents and structure of an product group overview

reviewed.
When a new technique is introduced, it should be determined which product features determine de ability to use the new technique. Restrictions of these features on the ability to use the technique should be ad to value ranges as an extra boundary. For those product groups for which a new technology is optional, the product group related databases should be replenished with this new technique as option.

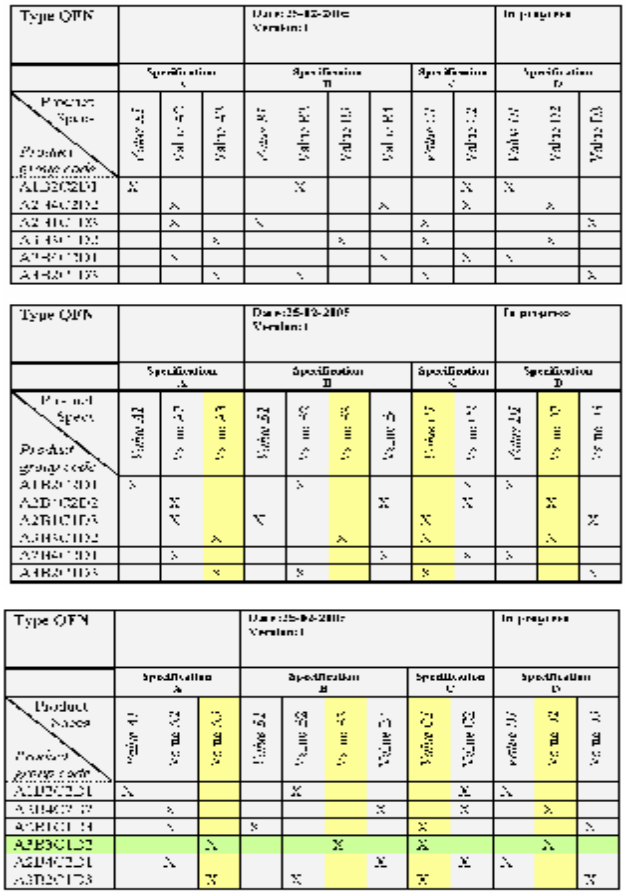

Figure 18: Finding the corresponding product group.

The customer gives the next specifications:
Specification A = value 3
Specification B = value 3
Specification C = value 1
Specification D = value 2,
Then it can quickly be found that the product can be placed into product group with code A3B3C1D2.)

10.1.2 Product group related database

The product group related database will provide all information which is normally gained when a product within the corresponding product group is analysed according to the stages 3 to 7 which were treated in the previous chapter.

Structure

Because of the wide range of different product groups, each with its own specific design, material and function, but also its own restrictions on processing, it is hard to combine all knowledge and information about all different product groups in one database. Therefore, it is decided that once a product group is known, it should have its own product group related database This product group related database is stored together with all other product group related databases.

Because a product group related databases is an abstract of the research results according to the stages 3 to 6 mentioned in the previous chapter, the product related information is mainly extracted from other databases in the advice support system.
The data in the product group related database need to be structured in such way that a sales agent is able to have quick insight in all optional process combinations with their pros and cons, concerning customer's situation and preferences.

Next to this, it should present links to related data in the following databases:

- Product-process function related database.(***Presenting by what the process functions are initiated***)
- Process-product related database (***Presenting how specifications lay restriction on technique choice)***
- Process combination related database (***Presenting how techniques restricts combinations with other techniques)***
- Process combination - customer related database. ***(presenting all pros and cons of optional techniques in relation with customers' situation and preferences.)***

An example of a product group related database is attached in appendix H.

Maintenance

To be sure that the presented data stays up to date, and analogous with the data of its source, maintenance is very important. Because processes are continuously developing, it is not wise to record detailed information about techniques that perform the process functions. It is therefore decided to refer to general databases, which are updated when necessary.

10.2 EXTENSION OF THE PRODUCT GROUP DATABASE

As mentioned in paragraph 5.4.2, the use of specific techniques, can lead to elimination of the ability to use other techniques, which are optional in other process function groups. These relations are recorded in the Process Combination Related Databases.

In previous chapters, the combination related database, is used to find optional combinations between techniques, after eliminating techniques which where not suitable for the specific product.

It is also possible to determine all optional combinations between all techniques, without taking product restrictions into account.

After determination which process combinations are optional, it can be determined which product groups are able to be processed. For these product groups, it is possible to fill all product group related databases, as mentioned in paragraph 10.1. This will eliminate the chance of dealing with an unknown but optional product group.

10.2.1 When a product does not correspond with any of the optional product groups?

With use of the product group overview, a quick insight is shown in all optional product groups, and thus, all optional combinations op product specifications.

It is not in unlikely that a product appears with a combination of product specifications that do not correspond with any of the existing product groups. Then it may be concluded that this product can not be processed by means of the currently existing techniques.

In this case, by going through all stages of the advice generating process mentioned in chapter 6, two basic causes will be found, why there is no potential process combination available. The first can be accounted to restriction of product specifications on available techniques. Leaving no suitable technique. The second can be accounted to restrictions on ability to combine optional techniques. In both cases, it should be determined either to change product specifications, or invest in extra research, in order to find an option to combine suitable techniques or to develop (new) suitable techniques.

10.3 DECISION TREE

All optional combinations can be visualized with use of a decision tree. The decision tree is used to prove the functionality of the advice support system, in generating optional process combinations. The name decision tree is chosen because of its structure. because each branch represents a process choice. Each choice leads to an other process decision, until all process functions are determined. An example of the decision tree for a QFN product is shown in appendix M and available on the CD, attached to this report.
The building of the decision tree is based on data which was recorded in the (pilot) Process Combination Related Databases. The stem of the tree starts with the first process function. For each optional technique, it is determined which process function could follow, when taking preliminary techniques into account, until each process combination chains is suitable to build a specific product group.

10.3.1 Testing the advice support system with use of the decision tree

With use of the decision tree, the advice support system can be tested on the following aspects:

- Correctness of advice about process sequence
- Correctness of advice about process combination
- Correctness of the advice about product process relation data

The process sequence and process combination aspect can be tested, by inspecting all optional process combinations presented by the tree. (A part of a decision tree is shown in figure 19.)
Because the building of the decision tree is based on data in the advice support system, it would present wrong combinations when the advice support system contains the wrong data, or is incapable of providing the correct data about process sequence and combination.

The correctness of product process relation data, can be tested in the following way:

- Take some examples of products, for which already suitable process combinations, are known.
- Inventory the required product specifications with use of the product related database, according to stage one of the advice generating process mentioned in paragraph 8.2.
- At each stage of the decision three , the suitability of each option in relation with the inventoried product specifications should be determined, with use of the to the decision corresponding product-process-function related database of the advice support system.
- Based on the suitability of each option, the correct decision can be taken.

(When at a certain stage, none of the options is suitable, it is required to go back some steps. A suitable technique is not optional because it can not be combined with at least one of the techniques chosen in preliminary stages.)

For each optional product, all optional combination can be found in this way.
To check the correctness of the result, these results should be discussed with process engineers of all related techniques. When it appears that the presented results are correct, it may be concluded that the advice support system is suitable for at least those products groups of which the process combinations are presented in the decision tree, but it may be assumed that is also suitable use on other products.

The process customer related database can not be tested with use of the decision tree. This information is directly related to independent techniques, and should be judged by the corresponding process and sales engineers.

Because, the decision tree, only shows which optional choices are left, and does not give insight in how decisions, eliminate the use of other choices, it is not a tool that can be used on its own.
The decision tree can be improved in user friendliness aspect, by adding references to related databases, at each stage of the decision tree.

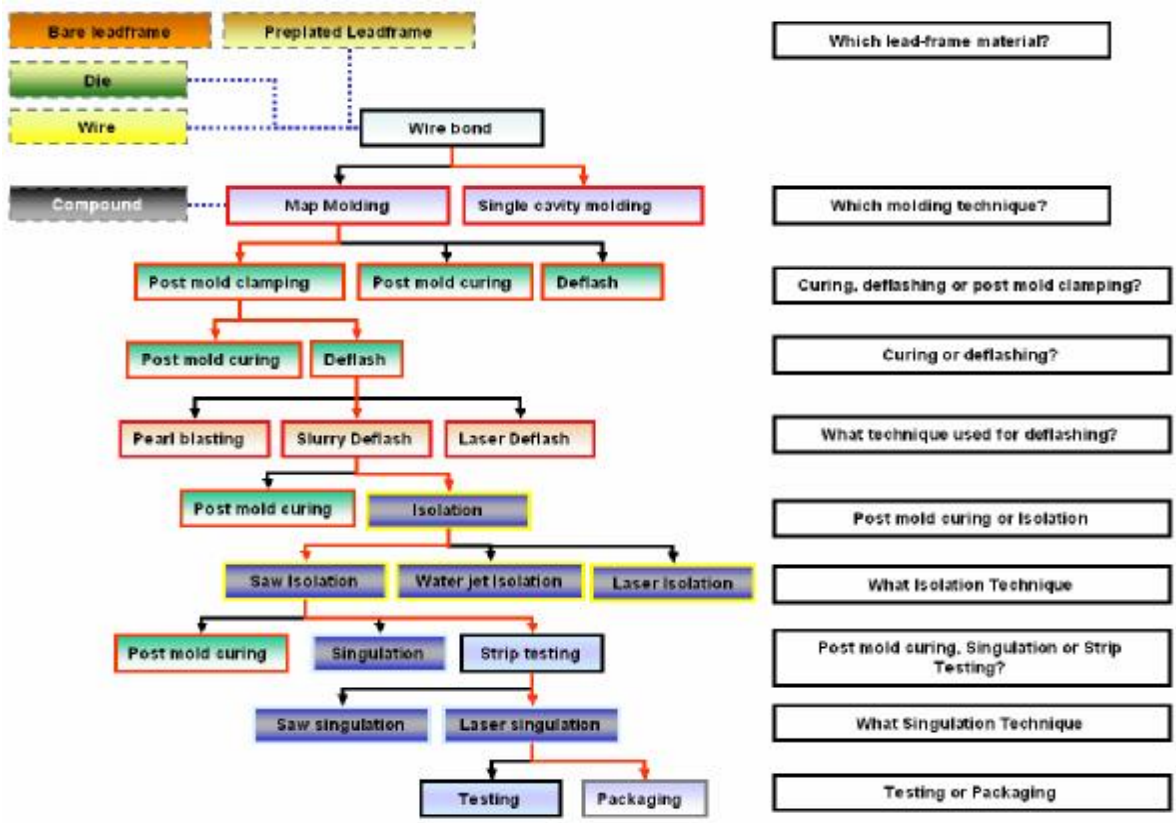

Figure 19: Example of result of making decisions with use of the decision tree. At each choice, the pros and cons of optional decisions need to be considered. After each decision, the following choice is presented. Each decision directly influences subsequent choices. Finally, the techniques linked with the red arrows is one of many optional process combinations.

Maintenance

A disadvantage of the decision-tree is its inflexibility, to maintenance. When a new technique is available, new branches need to be added, for each optional process combination including this new technique.

10.4 CONCLUSION

The use of a Product Group Database is a handy tool to have direct insight in already known product groups that can be processed with currently available techniques. When all product specifications which influence suitability of techniques are known, it can be directly found whether the product is part of an already known product group. If so, this means that only little research needs to be done to optimize the advice towards the customer. If not, the product group is new, and all stages in the advice generating process need to be performed in order to find suitable process combinations.

An extension to the product group database can be obtained, by examining all optional process combinations and concurrently also determine all optional product groups. When each product group has its own product group related database, this will eliminate the chance of dealing with an unknown but optional product group. A product that does not correspond to any existing product group, can not be processed with currently available techniques, and needs further examination how this problem can be tackled.

The decision tree can be used to visualize decisions leading to all optional process combinations and corresponding product groups. Next to this, it can be used to test the performance of the advice support system.

11 CONCLUSION AND RECOMMENDATIONS

The objective of this research was to develop a concept for an "advice support system" that supports sales agents of the different divisions, with information, necessary to generate an advice about optimizing the back end assembly process of a semiconductor product, while taking the customer's situation and preferences into account.
The concept advice support system which has been developed and described in this report, can be used to provide sales agents with information outer their expertise about restrictions by product specifications, restrictions by process combination, and restrictions by customers situation and preferences. With this information, the sales agent is able to generate more complete and correct advices about arranging new or optimization of the overall semiconductor assembly back end processes. which is highly appreciated by the customer and therefore it may be assumed that the implementation of the advice support system contributes to Besi's corporate organization in reaching its mission.

Additional to the design of the advice support system as described above, research is done in the possibility to reuse the results of already generated advice, for supporting future advice generating processes. This lead to the introduction of an extra product group related database.
With use of an additional product group databases, marketing is able to see, which products groups are able to be produced with current technologies, and with this, also which product groups are not able to be produced. This insight increases the ability to take action on improving -or extending the number of -available techniques.

The advice support system as described in this report is should be seen as a concept, and can be used as an example in building an organizational wide advice support system. In order to create the situation that the advice support system can be implemented, it should be improved on some points. All product and process related databases need to be filled with new and perhaps corrected knowledge.
Next to this, it should be assured that all preconditions mentioned in chapter 9 of this report are settled.
The preconditions with the most impact on the business are:

- Creating required technical infrastructure
- Appointing a support group
- Create willingness to share data
- Create a link to industry value
- Find Appreciation and support by senior management

Without arranging these preconditions, the implementation of any knowledge management system such as the advice support system, is doomed to failure.

Next to the results of this research, some recommendations are found on the organizational corporate structure, concerning an improvement of service toward the customer.
Some process-function groups are accommodated in more than one division of Besi, both offering alternatives, resulting in non-objective comparison between optional alternatives.
It can be useful to create impartial sales or advice department for each process function, accommodating all available alternatives within this process function, because this will offer the customer a better, more objective advice, increasing customer's satisfaction. When deciding to do this, it should be paid attention, that the level of detail of process information will not be negatively affected.

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LIST OF INTERVIEWEES

DEVISION	DEPARTMENT	INTERVIEWEE
Fico Molding	Sales	Hugo Claasen
Fico Molding	Sales	Theo Hugen
Fico Molding	Sales	Paul Roodbol
Fico Molding	Engineering	Frans de Fries
Fico (Saw) Singulations	Sales	Gerard Muermans
Fico (Saw) Singulations	Engineering	Wim Brouwer
Fico (Saw) Singulations	Engineering	Rob Foppe
Fico Trim&Form	Sales	Harry Berendts
Fico Trim&Form	Sales (Test equipment)	Joeri van Oosterhout
Fico Trim&Form	Engineering (Punch singulation)	Rob Schoenaker
Fico Trim&Form	Engineering (Laser singulation)	Tonnie Hennekes
Fico Trim&Form	Engineering (Laser marking)	Joost Jalink
Fico Trim&Form	Engineering (handling)	Geert Reulink
Besi Plating	Engineering	Lucas van Brekel
Besi Plating	Engineering	Gus van de Ven
Fico Trim&Form	Engineering Pearl blasting Deflash	Gerard van Grootheest

Appendix A
Company Profile

Fico Trim & Form

Fico Trim & Form is a product division of BE Semiconductor Industries N.V., which is publicly listed as BESI at NASDAQ (USA) and EURONEXT (Amsterdam, The Netherlands) Stock Exchange.

Under the brand name Fico, Fico Trim & Form markets, develops, engineers, manufactures, sells, and services a variety of Trim & Form systems, laser-marking handlers, laser-deflash handlers, laser-singulation and test-handling equipment.

Fico Tim & Form produces a large range of Trim & Form Systems for cutting and forming of the metallic leads of encapsulated semiconductor devices in preparation for placement on a printed circuit board or in other sockets. Trim and Form is the final step in the manufacture of a semiconductor. The procedure requires a high degree of precision, particularly with the increasing adoption of smaller devices with thinner and more numerous leads that can easily be deformed or broken during the process.

For the newer generation of semiconductors using array connect technology in which the molded substrates are singulated into individually packages new cutting techniques have been developed such as cutting by means of laser technology.

For testing Fico Trim & Form has developed strip based test handlers that allows testing with unprecedented speed, positioning accuracy and temperature control.

This equipment is used to manufacture chips for wide-ranging applications, like high-performance microprocessors for the telecommunications industry and sensors for the automotive industry. Chips also find their way into mobile telephones, PDA, modems, computers and similar appliances. Fico Trim & Form creates exceptional customer value by offering ultimate reliability and productivity, excellent customer service, exceptional precision and high production yields.

The sophisticated features of the equipment makes it fully capable of supporting the introduction of new packages and at the same time sufficiently flexible to permit both the high volume production of devices and smaller production runs of specialized chips.

Good is not good enough

The Fico Trim & Form range of Fico Systems has a proven reputation for innovation, quality and reliability. Without doing concessions to quality and reliability, more than ever, the Fico equipment range is focused on competitive initial investment.

Based on experience dating back several decades, each system has been designed to meet the challenges of today's ever more demanding manufacturing processes. The equipment will significantly increase yields, whilst keeping cost of ownership low. On top of this our process knowledge and process support assists you in improving your current processes and help you with the introduction of new packages.

Positioned for performance: Global manufacturing

Fico Trim & Form is headquartered in Duiven (The Netherlands), and operates service centers in Europe, the USA, and Asian markets.

Duiven the Netherlands:

In Duiven, the Netherlands, on an excellent location at the major highway A12/E3, in between Amsterdam and Dusseldorf airports The Besi Trim & Form factory was completed in 2003. The factory is part of a complex consisting of three major production facilities: Besi Molding, Fico Trim & Form and Besi Tooling. Molding and Trim & Form processes follow each other in the Back End production sequence; therefore manufacturing the two kinds of equipment in one location is an ideal combination. Especially since integration and linking of Assembly process and Test equipment into complete production lines has become an area where Besi has been taking a lead

.

Shah Alam Malaysia:

The second production facility in Shah Alam, Malaysia, was built in 1991. Here system assembly of the Fico Trim & Form range of the Fico Systems also takes place.

Appendix B:
Description of Process Functions

Die connection

Die connection is the a primary process function group gives the die a defined place in the total product and that connects the die with the electrical external contacts (by means of wire-bonding or flip chip principle). This process function group is required in all QFN products.

Product properties related to "die connection process" are:

- ***The "die" is mechanically attached and located in a certain position necessary for electrical connection to external contacts.***
- ***Ability to conduct electrical signals in-between external contacts and the die contacts.***
- ***Create a thermal conduction between chip and an external contact (Die Pad).***

Specifications related to "die connection process" are:

- ***Electrical signal conduction requirements.***
- ***Maximum range of signal interference. (Radio Frequent signals)***
- ***Minimum heat conduction.***
- ***Position accuracy of die in relation with support***

Optional sub processes within the Die connection process group are:

- ***Die attach in combination with wire bonding.***
- ***Die attach in combination with flip chip connection.***

Molding

Molding is the product function group that isolates the die and electrical contacts from external environmental influences and creates the ability to handle the product without damaging.
This process function group is required in all QFN products.

Product properties related to "molding" are:

- ***Isolation of the "die" from environmental influences.***
- ***Create a mechanical connection between the sub-parts.***
- ***Aesthetical properties of the product***

Specifications related to "molding process" are:

- ***Electrical isolation requirements.***
- ***Chemical resistance***
- ***No wire sweep.***
- ***Compound hardness***
- ***Dimensions, Shape specifications. (Degree of warpage)***
- ***Aesthetical properties (Roughness, shape, color, burr free, etc).***

Optional sub processes within molding process function group are:

- ***Single cavity molding (with/ without post mold curing)***
- ***Map molding. (With/without post mold clamping), (with/ without post mold curing)***

Appendix B:
Description of Process Functions

Solderability/ Plating

Plating is the process function group that protects the lands against oxidation and provides solderability.
This process function group is required in all QFN products.
Product properties related to "plating" are:

- ***Protecting lands from oxidation***
- ***Provide solderability***
- ***Preparation of lead-fame for wire-bond and die attach (spot plating or pre plating***)

Specifications related to "plating process" are:

- ***Layer thickness***
- ***Solderability.***
- ***In relation with lead material***
- ***Melt temperature***
- ***Lead free (2006)***

Optional sub processes within plating process function group are:

- ***Pre-plating***
- ***Spot plating***
- ***Post mold plating***

Lead Isolation

Isolation is the process function group that electrically disconnects the lands.
This process function group is required in all QFN productions, which make use of lead-frames in which lands are electrically interconnected for plating or positioning purpose.

Product properties related to "lead isolation" are*:*

- ***Electrically isolated lands***

Specifications related to "lead isolation" are:

- ***Bur free***
- ***Crack free (Delamination)***

Optional sub processes within Isolation process function groups are:

- ***Laser cutting (in combination with singulation)***
- ***Water jet cutting (in combination with singulation)***
- ***Punching***
- ***Sawing***
- ***Peeling***
- ***Etching***

Appendix B:
Description of Process Functions

Testing

Testing is the process function group that performs quality guarantee.

Product properties related to “Testing” are:
Quality guarantee

Specifications related to “Testing” are:

- ***Temperature***
- ***Frequency***
- ***Signal processing***
- ***Certainty***

Optional sub processes within Test process function groups are:

- ***Open short test***
- ***Functional test***
- ***Burn in test***

Each of these optional sub processes can be done either in strip after isolation, or single after singulation.

Marking/Identification

Marking is the process function group that performs trace ability and identification of the product during and after production.

Product properties related to “Marking” are:

- ***Mark for trace-ability and identification***

Specifications related to “Marking” are:

- ***Color***
- ***Text***
- ***Clearness***

Optional sub processes within Isolation process function groups are:

- ***Laser marking***
- ***Ink jet printing***
- ***Pad printing***
- ***Electrolytic marking***

Appendix B:
Description of Process Functions

Singulation

Singulation can be both a primary as well as a secondary process.
Singulation is a consequence of the current way of producing QFN' type products. In order to transport the product as part of a batch, the product makes is connected to a "leadframe". Separation of the product from the leadframe is called singulation. Singulation does not add any function to the product, and therefore it should be seen as a support process, but because this is the usual way of production, and the product package shape depends on the way it is singulated, it may be seen as a primary process.

Product properties related to "singulation" are:

- ***Shape of package sides***
- ***Circumference of package***

Specifications related to "singulation" are:

- ***Bur free***
- ***Crack free (Delamination)***
- ***Surface roughness***
- ***Package length and width***
- ***Package thickness (When map molded)***
- ***Leadframe thickness***
- ***Shape of package***

Optional sub processes within Isolation process function groups are:

- ***Sawing***
- ***Punching***
- ***Laser cutting***
- ***Water jet cutting***

Appendix B:
Description of Process Functions

Deflash

Deflash is a secondary process function group that mends negative side effects of the molding process. The deflash process removes the flash and bleed which is a remaining of the mold process. The reasons for implementing a deflash process are; to prevent wear and fouling of the following sub processes, and aesthetical purposes.

Deflash is initiated by the molding process, and therefore done after, the molding process.

The presence of flash and bleed is undesirable when (and therefore done before):

- ***Plating***
- ***Isolation***
- ***Singulation***
- ***Test***

Specifications related to deflash process are:

- ***Purpose of deflash process***
- ***Kind of flash***

Optional sub processes Deflash process function groups are:

- ***Pearl-blasting Slurry blasting***
- ***Laser deflashing***
- ***Chemical deflashing***
- ***Waterjet deflashing***
- ***Electrolytic + waterjet***
- ***Chemical dipping + waterjet***

Handling

The handling process is a secondary process, accountable for the transport and support of products. Handling is used during the whole back end process. Because of product transformations during the process, and differences between assembly processes, many different ways of handling can be distinguished.

Handling categories

Handling can be divided in 4 categories.

- ***Loading***
- ***Offloading***
- ***Transport during process***
- ***Transport in between processes***

Loading:

Loading means providing the process line with products. The process can be provided with different loading systems.

- Slotted loader (Strip based)
- Tray to tray (Single product or matrix handling)
- Stack (Strip based)

Off loading:

Off loading means taking the product out of the system into stock or buffer.

Different ways for offloading can be distinguished:

- Slotted loader (Strip based)
- Tape & reel (Single product)
- Tray (Single product or matrix handling)
- Bulk (Single product handling)

Specifications related to off loading are:

ORIENTATION OF PRODUCT BEFORE AND AFTER OFFLOADING

- Strip based, single product or matrix handling
- Need for sorting during off loading

Handling during process:

Handling during process is the combination of translation of the product into the process location and support of the product during processing. Specifications related to handling during process are:

- Transformation of product during the process.
- Support requirements for processing
- Translation and rotation speed of product during processing
- Translation- and rotation-axis during processes
- Position accuracy

Transport in between processes

Transport in between processes is necessary when processes are coupled. It takes care of pitch correction from one process to the other, and orientates the product for the next process.

Appendix B:
Description of Process Functions

Differences in product support

Within handling, distinction can be made between strip based handling, single product handling and matrix handling:

Strip based handling

Strip based handling can only be done when the products are rigid connected to each other. This connection is realized by the leadframe, by the compound or by an other kind of support

Specifications related to strip handling are:

- Strip dimensions
- Strip orientation (locating holes)
- Row pitch
- Column pitch

Pros

Makes use of standard non product-related handling tools

Orientation of products are related to leadframe orientation

Cons

Product pitch is fixed

Single product handling

Single product handling can only be done when products are singulated. Normally, the products are only handled as a single product after singulation and during a process where only single products can be processed.

Specifications related to single product handling are:

- Orientation
- Identification
- Product dimensions
- Product relation to pick and place tool

Pros

No fixed pitch

Cons

Use of product related handling tools could be required

Maintaining the orientation of the product in between process steps needs certain arrangements.

Matrix handling
Matrix handling is done when products are singulated, and when parallel processing is required.
Specifications related to matrix handling are:

- Pitch correction
- Orientation correction
- Batch size correction
- Product dimensions
- Pick and place tool product related or not

Pros
Orientation of products after singulation is maintained
No fixed pitch
Cons
Use of product related handling tools could be required

Post mold clamping

This process temporary eliminates the warpage effect of the molding process.
The molded product is clamped under high pressure at low temperature, directly after molding. The effect is that the compound is forced into the desired shape (without warpage). The tensions causing warpage are locked into the cold material, until the compound material is heated up again.
Post mold clamping has therefore only a temporary effect.

Parameters:

- Temperature during post mold clamping
- Pressure during post mold clamping
- Time required for post mold clamping

Pros
Temporary elimination of warpage, provides the following process steps a warpage free semi-finished product.

Cons
Extra process step

Post mold curing

After the transfer molding process, the compound has its final shape. But the material needs a “post curing” for getting its final properties like hardness, rigidity and electrical isolation. Next to reaching its final necessary properties, it also needs post curing for releasing stresses and removing warpage due to shrinkage. The post curing can be done direct after the molding process, but because of the change of material properties it is sometimes chosen to place this process further to the back of the total back end process.
Some technical specifications of post curing are:

Product parameters involved in post mold curing
Hardness before and after curing
Share strength before and after curing
Electrical isolation before and after curing
Compound material

Pros
Improving material properties like hardness, rigidity and electrical isolation.

Cons
Extra process step.

Appendix C:

Interview scheme for interviewing sales agents

•KWALITEIT VAN DE ANTWOORDEN

De antwoorden zijn gebaseerd op de ervaring van de geïnterviewde. De mate van ervaring bepaald de kwaliteit en bruikbaarheid van de antwoorden. Omdat de geïnterviewde personen allemaal minimaal meerdere jaren ervaring hebben op het gebied van sales binnen Besi, wordt aangenomen dat de antwoorden een goede indicatie zijn van de werkelijkheid.[42]

•MOGELIJKHEDEN EN BEPERKINGEN

Aangezien niet alle divisies van Besi binnen een redelijke afstand bereikbaar zijn is gekozen om alleen die sales mensen te interviewen bij Fico Trim & Form en Fico Molding in Duiven en Fico Singulation, en Besi Plating (Meco) in Drunen.

•Duur van interview:

Gemiddeld 1,5 uur.

•INTRODUCTIE VAN HET GESPREK

- Uitleg van:
  - probleemstelling
  - doel van interview
  - Waarom deze persoon geïnterviewd,

•VRAGEN STELLEN

Om zo veel mogelijk informatie boven tafel te krijgen is er gekozen voor het stellen van open vragen.

- Hoe gaat over het algemeen het proces van adviseren van de klant?
- Welke informatie is nodig?
- Wat zijn over het algemeen problemen die worden tegengekomen bij het adviseren van de klant?
- Met welke aspecten moet rekening worden gehouden bij het adviseren van de klant?
- Waar baseert de klant zijn uiteindelijke keuze op?
- Welke verschillen zijn er tussen de klanten en hoe heeft dit invloed op het advies?
- Hoe is de samenwerking met andere divisies wanneer een ander proces van invloed is op het uit te brengen advies?
- Wanneer er een advies support systeem zou komen, welke personen zouden hiervan gebruik maken volgens u?
- Wat zijn de eigenschappen van deze mensen genoemd in het antwoord uit de vorige vraag?

•DOORVRAGEN

- Wanneer er interessante (nieuwe aspecten aan het licht komen.)
- Wanneer een antwoord niet duidelijk is.
- Wanneer blijkt dat er in detail gegaan kan worden.

•STIMULEREN

- Mee praten met de geïnterviewde. Aangeven van onduidelijkheden. Dit motiveert om nog duidelijker en uitgebreider in te gaan op de vraag.

•ANTWOORDEN NOTEREN

steekwoorden opschrijven, schema's schetsen,

Direct na interview uitwerken van steekwoorden naar antwoorden. Bij onduidelijkheden achteraf wordt er weer contact op genomen met geïnterviewde.

•Antwoorden evalueren

Validiteit, volledigheid, relevantie en duidelijkheid

GESPREK LEIDEN

Wanneer wordt afgedwaald, terugleiden naar essentie van het onderzoek

---

[42] ***Literatuur: Interviewen, B.Emans***
Succesvol interviews geven, A. Dogan

Appendix D:

Interview scheme for interviewing process engineers

•KWALITEIT VAN DE ANTWOORDEN

De antwoorden zijn gebaseerd op de ervaring van de geïnterviewde. De mate van ervaring bepaald de kwaliteit en bruikbaarheid van de antwoorden. Omdat de geïnterviewde personen allemaal minimaal meerdere jaren ervaring hebben met het afstemmen en ontwikkelen van processen binnen Besi, wordt aangenomen dat de antwoorden een goede indicatie zijn van de werkelijkheid[43].

•MOGELIJKHEDEN EN BEPERKINGEN

Aangezien niet alle divisies van Besi binnen een redelijke afstand bereikbaar zijn is gekozen om alleen proces engineers te interviewen bij Fico Trim & Form en Fico Molding in Duiven en Fico Singulation, en Besi Plating (Meco) in Drunen.

•DUUR VAN INTERVIEW:

Gemiddeld 1,5 uur.

•INTRODUCTIE VAN HET GESPREK:

- Uitleg van:
  - probleem
  - doel van interview:
    Inzicht krijgen in:
    -proces
    -relatie tussen proces en product
    -relatie tussen processen onderling
  - Waarom deze persoon geïnterviewd

•VRAGEN STELLEN:

Om zo veel mogelijk informatie boven tafel te krijgen is er gekozen voor het stellen van open vragen.

- Hoe kan het proces kort worden omschreven?
- Welke proces parameters spelen een rol bij het afstemmen van het proces?
- Welke product parameters spelen een rol bij het afstemmen van het proces?
- Welke informatie is nodig?
- In hoeverre wordt het proces beïnvloed door andere processen?
- Wat zijn over het algemeen problemen die worden tegengekomen bij het afstemmen
- van het proces?
- Hoever gaat de samenwerking met andere divisies bij het oplossen van problemen?
- Wanneer er een advies support systeem zou komen, welke personen zouden hiervan gebruik maken volgens u?
- Wat zijn de eigenschappen van deze mensen genoemd in het antwoord uit de vorige vraag?

•DOORVRAGEN

- Wanneer er interessante (nieuwe aspecten aan het licht komen.)
- Wanneer een antwoord niet duidelijk is.
- Wanneer blijkt dat er in detail gegaan kan worden.

•STIMULEREN

Mee praten met de geïnterviewde. Aangeven van onduidelijkheden. Dit motiveert om nog duidelijker en uitgebreider in te gaan op de vraag.

•ANTWOORDEN NOTEREN

steekwoorden opschrijven, schema's schetsen. Direct na interview uitwerken van steekwoorden naar antwoorden. Bij onduidelijkheden achteraf wordt er weer contact op genomen met geïnterviewde.

•Antwoorden evalueren

Validiteit, volledigheid, relevantie en duidelijkheid

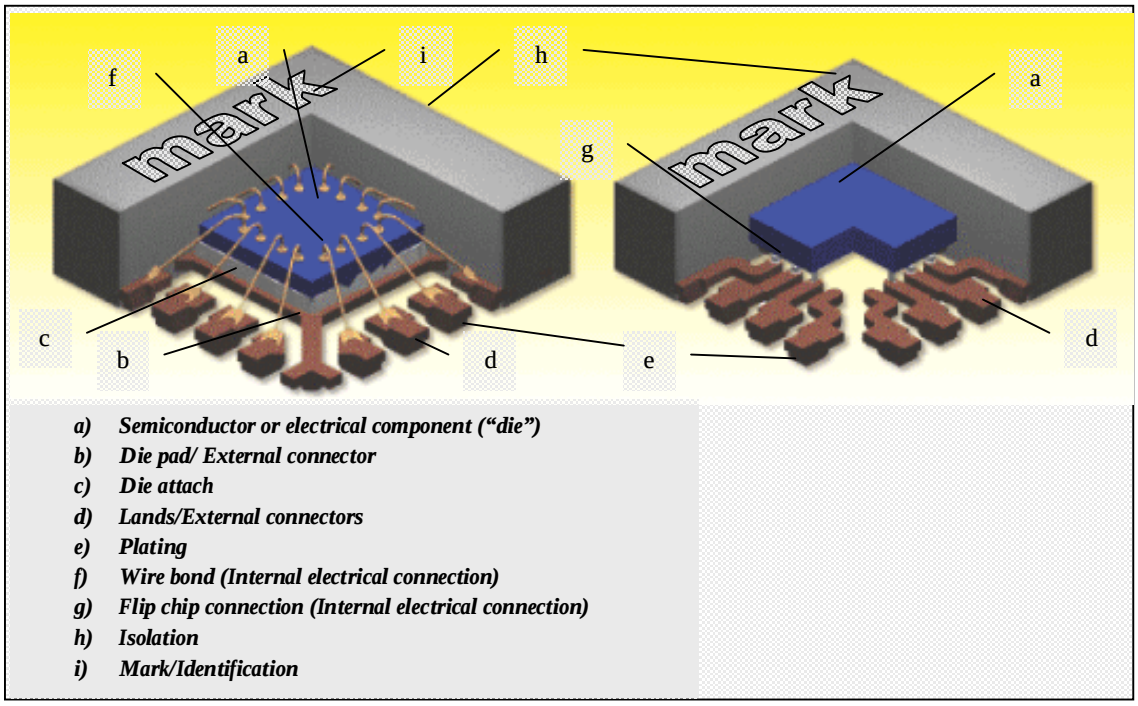
•GESPREK LEIDEN

Wanneer wordt afgedwaald, terugleiden naar essentie van het onderzoek

[43] ***Literatuur: Interviewen, B.Emans***
Succesvol interviews geven, A. Dogan

Appendix E:
Functional components of a QFN semiconductor product

Figure 2Quad flat no leads (QFN)- type packages provide benefits for high speed circuits, including improved co-planarity and heat dissipation. There is a growing need for both the wire bond (left) as well as flip chip (right) versions



a) ***Semiconductor or electrical component ("die")***
b) ***Die pad/ External connector***
c) ***Die attach***
d) ***Lands/External connectors***
e) ***Plating***
f) ***Wire bond (Internal electrical connection)***
g) ***Flip chip connection (Internal electrical connection)***
h) ***Isolation***
i) ***Mark/Identification***

A-SEMICONDUCTOR OR ELECTRICAL COMPONENT

The semiconductor or other electrical component (also called "die") is the main part of the IC and contains the purpose function of the whole IC. All the other parts of an IC are supporting the semiconductor, and take care that the main part can function.

A semiconductor[44] is a material that is neither a good conductor of electricity (like copper) nor a good insulator (like rubber). The most common semiconductor materials are silicon and germanium. Computer chips, both for CPU and memory, are composed of semiconductor materials. Semiconductors make it possible to miniaturize electronic components, such as transistors. Not only does miniaturization mean that the components take up less space, it also means that they are faster and require less energy.

The main part should be mechanically, chemically and (static electrically isolated from the environment. The electrical connections on the semiconductor should be electrically connected with the external connectors. The semiconductor is often connected to a heat-sink at the bottom of a QFN. The chip can be mounted in two different ways. A chip can be mounted with the electrical connection at top and electrically connected to the external connectors with use of wire bonding. Another way is mounting the chip directly with its electrical connections onto the external connectors. The last option is called "flip chip".

B-DIE PAD

The die pad is a support on which the die is attached. For QFN products, the die pad is a special external connector that also acts as a heat sink to conduct the excess of temperature to the outside.

[44] www.nanoelectronicsplanet.com/nanoresources/glossary/article

Appendix E:
Functional components of a QFN semiconductor product

The die is attached to the die pad by soldering or by adhesive. This connection is called the "die attach"

C-DIE ATTACH

Die Attach is the process of attaching the silicon chip to the die pad. (e.g., the lead-frame) of the semiconductor package. There are two common die attach processes, i.e., adhesive die attach and eutectic die attach. Both of these processes use special die attach equipment and die attach tools to mount the die. Die attach materials or adhesives do more than attach the die to the die pad. They also provide thermal and/or electrical conductivity between the die and the package, essentially affecting the performance of the device while operating in the field. As such, proper selection of the most suitable die attach-material for a semiconductor product and application is very important[45].

D-EXTERNAL CONNECTOR

The external connector is the interconnection between the IC and the printed circuit board to which the IC component is mounted. The external connectors are peripheral terminal pads that are electrically connected with the die. The external connectors are provided with a special plating for soldering purposes.

E-PLATING

Plating is done to obtain the right lead frame surface properties, like solderability and chemical resistance.

The plating process can be divided in three types:

- Pre-plating
- Spot-plating
- Post-mold-plating

Which type of plating is chosen has a big influence on the other assembly processes.

Pre-plating

Pre-plating is done before the lead frame enters the "back end assembly process". With pre-plating, a thin layer of Ni Pd is deposit on the lead frame surface. (Ni 2µm, Pd 10nm, Au 5nm).

The gold layer is for sealing the open palladium structure. The pre-plating process is not done by Besi machines, and therefore not treated further in this document.

Spot plating

Spot plating is a locally deposition of certain material (normally silver).

This spot plating is used for wire bonding when the lead frame is not pre-plated.

Post mold plating

With Post mold plating, only the blank land material is plated. Materials used for Post mold plating are: Sn-Pb, Sn-Bi, Sn-Au, Sn-Cu and Sn. This plating is done for both soldering as for chemical resistance purpose.

[45] ***http://www.semiconfareast.com/DA_matls.htm***

Appendix E:
Functional components of a QFN semiconductor product

INTERNAL ELECTRICAL CONNECTION

For providing an electrical connection between the silicon chip and the external connectors, two options are possible. Wire bonding and flip chip connection.

F- WIRE BOND

Wire bonding uses the silicon-face-up chips which are connected to the external connector/lands of the semiconductor device using very fine bonding wires. The wire used in wire bonding is usually made either of gold (Au) or aluminum (Al), although copper (Cu) wires are starting to gain attention in the semiconductor manufacturing industry. [46]

G- FLIP CHIP CONNECTION

Flip chip microelectronic assembly is the direct electrical connection of face-down (hence, "flipped") electronic components onto substrates, circuit boards, or carriers, by means of conductive bumps on the chip bond pads.

Flip chip components are predominantly semiconductor devices; however, components such as passive filters, detector arrays, and MEMS (Micro-Electro-Mechanical-System) devices are also beginning to be used in flip chip form. Flip chip is also called Direct Chip Attach (DCA), a more descriptive term, since the chip is directly attached to the substrate, board, or carrier by the conductive bumps.[47]

H-MOLDING

Molding is used for electrical, chemical and mechanical isolation of the die, from the environment. Another purpose of molding is aesthetics. The molding is one of the most influential parts of an IC. The QFN type product is molded with use of transfer molding. A product can be molded in a single cavity or as part of an array in a combined cavity, respectively called " Single cavity molded" and "Map molded"

Which way of molding is chosen, has a big influence on the other assembly processes.

For example: When chosen for map molding, the use of punching technique for singulation is no option anymore.

I-MARK/IDENTIFICATION

A Mark or identification on the package of an IC is used for trace-ability, and distinguishing purposes. The device name, company logo, date code, and lot identification are examples of information, commonly marked on the IC's package.

There are two common marking processes, namely, ink marking and laser marking with both its pros and cons.

[46] ***http://www.semiconfareast.com/wirebond.htm***

[47] ***http://www.flipchips.com***

Fico Trim & Form

Customers situation and preferences related questionnaire

Questions	General questions	Customer specific questions
	1 What type of customer is dealt with?	
	Manufacturer	
	Sub-contractor	
	2 Will the product be processed on a new line?	
	When answer is No:	
		Which equipment is already installed?
		Which of the already installed equipment is being used for production of the concerning product?
	3 Do you have preferences for using specific techniques?	
	When answer is yes:	
		What is the reason / for preferring this technique
	4 Is the equipment also expected to be used for other products?	
	When answer is yes:	
		Which other products will be assembled by this equipment?
	5 Is the product design already frozen?	
	When answer is no:	
		Rank all product specifications, which are already collected in the advice database, by importance in the following categories. • "Essential requirements (must be included in the product.) • "Useful" requirements (would reduce product effectiveness if left out) • "Desirable" requirements (not part of the core, but makes the product more attractive to the user)

Explaination of questions	
question	Reason for asking
1	The answer wil gives an impression of the customers abilty to adapt its product design, and the required flexibility of the assembly line. A manufacturer is much more flexible in product design, and requires much less flexible production lines.
2	The answer should be taken into acccount when determining the optional techniques and optional process combinations.
3	The answer gives information about the suitability of optional process combinations. It reflects wich aspects of a technique are appriciated by the customer.
4	The answer should be taken into account when determining optional techniques. Techniques are only optional when they are suitable for processing all products that are intended to be produced on this line.
5	The answer gives insight in the ability to change product specifications in order to optimize the overall assembly process.

Appendix G:
Example of:Product-Process Function relation database

	Last updated by: B Mentink
Product - Process function Relation Database	Rev A (In progress)

Primary function groups

Product properties	Process function group
• ***Die mechanically attached to leadframe***	***Die attach***
• ***Electrical connection between Die and Leadframe***	***Wire bonding / Flip chip***
• ***Isolation of the "die" from environmental influences.*** • ***Create a mechanical connection between the sub-parts.*** • ***Aesthetical properties of the product***	***Molding***
• ***Isolation properties of compound after molding do not fulfill requirements, and is improved with post mold curing. (Electrical and mechanical isolation, strength, hardness)***	***Post mold curing***
• ***Protecting lands from oxidation*** • ***Provide solderability*** • ***Preparation of leadfame for wirebond and die attach (spot plating or pre plating)***	***Plating***
• ***Functionality is checked***	***Testing***
• ***Trace-ability and identification***	***Marking***

Secondary function groups

Process specifications	Process function group
• ***Lands are connected during part of the back end process.***	***Isolation***
• ***Internal stresses needs to be locked in the product before it causes warpage. This can be necessary for providing following processes a warpage free input.***	***Post mold clamping***
• ***Products are processed in strip during part of the back end process***	***Singulation***
• ***Flash due to molding, needs to be removed. This can be necessary for providing following processes a flash and bleed free input.***	***Deflash***
• ***Product needs to be fed into be process***	***Load****
• ***Product needs to be taken out of the process***	***Offload****
• ***Product needs support (and translation) during the process***	***Handling during process****
• ***Product needs to be translated from one process to the other***	***Handling between processes****

****These process functions are not treated further in this research, because these functions are subordinate to other processes.***

Appendix H:

Example of: Process product relation database

Function of Singulation	Losens product from leadframe, map or strip			
Per process the different options to choose between are mentioned				
4 options	**Sawing**	**Punching**	**Laser cutting**	**Water Jet cutting**
Variables between different options				
capable materials to threat	Copper, compound, board	copper, metal, thin compound remains	Compound, board, thin copper	all materials
Force on product	Side ways	in Z direction	No force	in Z direction
Warpage	maximal 0,5mm across both the long (x) and short (y) axis	?	?	?
Surface threatment	Smooth, chance on smearing of leads	Smooth	Less smooth than Sawing depends on material	Depends on Speed and material
Wear	controlable wear, depends on material, and cooling	Extrme wear can be caused due to compound	No direct mechanical wear (Cirtain lifetime 15000 hours	Nozlle wear
Temperature	Depends on speed, material and coolant	Neglectable	burning temperature of material	Neglectable
Restrictions for other subprocesses (For all process groups that are restricted as consequence of option choice)				
Molding		Only when single cavity	Only when map molded and thin leads	Only usefull when map molded
Lead Isolation	Is combined with lead Isolation	Also with punching	Is combined with lead isolation	Is combined with lead Isolation
Testing after singulation	In Matrix or single	In Matrix or single	In Matrix or single	In Matrix or single
Handling during singulation	Vacuum chucks, gel pack	Clamping into leadframe and vacuum chucks to pick up singulated product	Vacuum or Adhesive foil. Support needs to be transparant or disperse the light when trough the material.	vacuum chucks with opening on cuttingtrack
Handling after singulation	From vacuum chuck into tray			
Reasons why chosen for option				
Process motivation	Flexibility in product size, high ratio aspect ratio	High speed ,low cost when large batch size	High speed high flexibility	No material, shape and thickness restriction
Flexibility	Flexibility in product size	low flexibility	High flexibility in product geometry	High flexibility in product geometry and material
Cost of Ownership	High (coolant, wear parts)		Lower	
Batch motivation	All batch sizes	Large batch size	All batch sizes	All batch sizes

Relation between singulation in general and

Appendix I:
Example of: Process combination related database

Function of Singulation	Losens product from leadframe, map or strip			
Per process the different options to choose between are mentioned				
4 options	**Sawing**	**Punching**	**Laser cutting**	**Water Jet cutting**
Variables between different options				
capable materials to threat	Copper, compound, board	copper, metal, thin compound remains	Compound, board, thin copper	all materials
Force on product	Side ways	in Z direction	No force	in Z direction
Warpage	maximal 0,5mm across both the long (x) and short (y) axis	?	?	?
Surface threatment	Smooth, chance on smearing of leads	Smooth	Less smooth than Sawing depends on material	Depends on Speed and material
Wear	controlable wear, depends on material, and cooling	Extrme wear can be caused due to compound	No direct mechanical wear (Cirtain lifetime 15000 hours	Nozle wear
Temperature	Depends on speed, material and coolant	Neglectable	burning temperature of material	Neglectable
Restrictions for other subprocesses (For all process groups that are restricted as consequence of option choice)				
Molding		Only when single cavity	Only when map molded and thin leads	Only usefull when map molded
Lead Isolation	Is combined with lead Isolation	Also with punching	Is combined with lead isolation	Is combined with lead Isolation
Testing after singulation	In Matrix or single	In Matrix or single	In Matrix or single	In Matrix or single
Handling during singulation	Vacuum chucks, gel pack	Clamping into leadframe and vacuum chucks to pick up singulated product	Vacuum or Adhesive foil. Support needs to be transparant or disperse the light when trough the material.	vacuum chucks with opening on cuttingtrack
Handling after singulation	From vacuum chuck into tray			
Reasons why chosen for option				
Process motivation	Flexibility in product size, high ratio aspect ratio	High speed ,low cost when large batch size	High speed high flexibility	No material, shape and thickness restriction
Flexibility	Flexibility in product size	low flexibility	High flexibility in product geometry	High flexibility in product geometry and material
Cost of Ownership	High (coolant, wear parts)		Lower	
Batch motivation	All batch sizes	Large batch size	All batch sizes	All batch sizes

Relation between singulation in general and

Appendix J:
Example of :Process Customer related database

Function of Singulation	Losens product from leadframe, map or strip			
Per process the different options to choose between are mentioned				
4 options	**Sawing**	**Punching**	**Laser cutting**	**Water Jet cutting**
Variables between different options				
capable materials to threat	Copper, compound, board	copper, metal, thin compound remains	Compound, board, thin copper	all materials
Force on product	Side ways	in Z direction	No force	in Z direction
Warpage	maximal 0,5mm across both the long (x) and short (y) axis	?	?	?
Surface threatment	Smooth, chance on smearing of leads	Smooth	Less smooth than Sawing depends on material	Depends on Speed and material
Wear	controlable wear, depends on material, and cooling	Extme wear can be caused due to compound	No direct mechanical wear (Cirtain lifetime 15000 hours	Nozle wear
Temperature	Depends on speed, material and coolant	Neglectable	burning temperature of material	Neglectable
Restrictions for other subprocesses (For all process groups that are restricted as consequence of option choice)				
Molding		Only when single cavity	Only when map molded and thin leads	Only usefull when map molded
Lead Isolation	Is combined with lead Isolation	Also with punching	Is combined with lead isolation	Is combined with lead Isolation
Testing after singulation	In Matrix or single	In Matrix or single	In Matrix or single	In Matrix or single
Handling during singulation	Vacuum chucks, gel pack	Clamping into leadframe and vacuum chucks to pick up singulated product	Vacuum or Adhesive foil. Support needs to be transparant or disperse the light when trough the material.	vacuum chucks with opening on cuttingtrack
Handling after singulation	From vacuum chuck into tray			
Reasons why chosen for option				
Process motivation	Flexibility in product size, high ratio aspect ratio	High speed ,low cost when large batch size	High speed high flexibility	No material, shape and thickness restriction
Flexibility	Flexibility in product size	low flexibility	High flexibility in product geometry	High flexibility in product geometry and material
Cost of Ownership	High (coolant, wear parts)		Lower	
Batch motivation	All batch sizes	Large batch size	All batch sizes	All batch sizes

Relation between singulation in general and

Appendix K:
Example of :Advice database

SECTION 1:PRODUCT SPECIFICATION OVERVIEW

			Version: 1			Date: 31-10-2006		Status: In Progress				
Features	Feature A		Feature B			Feature C		Feature D			Feature Z	
Unit	mm		material			?		? (angle)			°	
Ranges/Value options	R1	R2	R1	R2	R3	R1	R2	R3	R1	R2	R1	R2
Concerning product		X			X	X			X			X

SECTION 2:CUSTOMER RELATED INFORMATION

LEGEND
Main question
Sub question
Answer

1What type of customer is dealt with?

Manufacturer

2Will the product be processed on a new line?

Yes

3Do you have preferences for using specific techniques?

yes: Laser singulation

What is the reason for preferring this technique?

Flexibility

4Is the equipment also expected to be used for other products?

Yes: Similar products but with other package shape

5Is the product design already frozen?

When answer is no:

·Try to identify “Essential” requirements

Shape of package due to functionality

Try to identify “Useful” requirements

Identification flexibility

Try to identify “Desirable” requirements

Color

Appendix K:
Example of :Advice database

SECTION 2: REQUIRED PROCESS FUNCTIONS

Overview of required process functions in relation with product specifications

Product group code		Revision: A	
A1B1D3E1F5G2H2I2J2K4		Date of last update: 30-03-2005	
		Summary of revision changes: A: Release of product group A1B1D3E1F5G2H2I2J2K4:	
Summary of product specifications values of this product group			
Function	Specification	Value options	Process function
Aesthetics , discrimination, Manageability	• ***Circumference shape***	***curved***	***singulation***
Electrical connection	• ***Connection between die and leads***	***Wire bonding/flip chip***	***Wire bonding/Flip chip***
Aesthetics	• ***Surface structure***	Flat	
Electrical Isolation Manageability	• ***Total thickness***	0,8-1mm	Molding
Electrical Isolation	• ***Electrical isolation requirements.***	No interference with environment allowed.	Post mold curing
Solderability Manageability	• ***Shape specifications. (Degree of warpage)***	***5 µm / 1 mm***	***Post mold clamping***
Solderability	• ***Solder temperature***	***>230°***	***Plating***
Chemical isolation	• Plating material	No preference	Plating
Conducting signal	• ***Lead thickness***	***<0,1mm***	
Solderability	• ***Geometry of lands***	***Single row***	
Quality check	• ***Before singulation***	***No preference***	***Strip test Isolation***
Heat resistance check(Burn in test)	• ***Temperature***	***200° - 230 °***	***Burn in test***
Signal quality check	• ***Signal processing***	***Yes***	***Functionality test***
Zero defects	• ***Certainty***	Yes	End of line test
Identifications	• ***Compound color***	***Colored***	
Identifications	• ***Flexibility of text***	High flexibility	Marking

Appendix K:
Example of :Advice database

SECTION 4: TECHNIQUES

Overview of optional techniques per process function.

Optional techniques for this product			
	Process functions	Optional techniques	
1	Die Connection	Wire bonding	
2	Molding	Map molding	
3		Post mold clamping	
4		Post mold curing	
5	Solderability	Ni Pd Au	
6	Lead Isolation	Laser cutting, Waterjet cutting, Sawing	
7	Testing	Strip test / Functional test, Burn in test	
8	Identification	Laser Marking, Ink jet printing	
9	Singulation	Laser cutting, waterjet cutting	
10	Deflash	Pearl blasting/ Slurry blasting	

Overview of not optional techniques per process function with reason why this technique is not optional.

Not optional techniques for this product			
	Process functions	Not optional sub processes	Reason for elimination of process option
1	Die Connection	Flip chip	Design of die is already fixed
2	Molding	Single cavity molding	Shape flexibility
5	Solderability	Sn plating	Melting temperature
6	Lead Isolation	Punching Etching	Due to molding process Not chemical resistant material
8	Identification	Pad printing, electrolytic marking	Required flexibility
9	Singulation	Punching Etching	Due to molding process Not chemical resistant material

SECTION 5: PROCESS COMBINATIONS

All combinations start with wire bonding and Map molding.

1. Post mold clamping->post mold curing-> Pearl/ Slurry blasting->Laser marking-> Laser cutting-> Functional test-> Burn in Test
2. post mold clamping-> Pearl/ Slurry blasting-> post mold curing->Laser marking-> Laser cutting-> Functional test-> Burn in Test
3. post mold clamping-> Pearl/ Slurry blasting-> post mold curing -> Laser marking-> Water jet cutting-> Functional test-> Burn in Test
4. post mold clamping->post mold curing-> Pearl/ Slurry blasting ->Laser marking-> Water jet cutting-> Functional test-> Burn in Test
5. post mold clamping->Saw Isolation->post mold curing-> Pearl/ Slurry blasting-> Strip testing-> Laser marking-> Laser cutting-> Functional test-> Burn in Test
6. post mold clamping->Saw Isolation->post mold curing-> Pearl/ Slurry blasting-> Strip testing-> Ink marking-> Laser cutting-> Burn in Test
7. post mold clamping->Saw Isolation-> Pearl/ Slurry blasting-> post mold curing-> Strip testing Laser marking, Laser cutting-> Burn in Test

Appendix K:
Example of :Advice database

SECTION 6: PROS AND CONS OF PROCESS COMBINATIONS

Process combination 1

Pros: Flexibility in product shape due to laser singulation
No force on product during singulation
Post mold curing and clamping can be combined

Cons: Pearl/Slurry blasting will take more time due to cured material,
High temperature on package during singulation.

Process combination 2

Pros: Flexibility in product shape due to laser singulation
No force on product during singulation
Pearl/Slurry blasting will take less time due to uncured material,

Cons: Post mold curing and clamping can not be combined
High temperature on package during singulation.

Process combination 3

Pros: Flexibility in product shape due to waterjet singulation
No high temperatures during singulation
No restriction on material and package thickness

Cons: High forces on the product during singulation
Difficult to clamp during singulation

Etc….

SUITABILITY FOR CUSTOMER

Options 1,2,5,6, and 7 are optional due to use of laser cutting in the process.
Options 5,6 and 7 are less flexible, due to the use of saw isolation.
Saw singulation is required due to use of strip test.
Other way of isolation is etching. This can only be done when material is resistant to etching liquid.

When using coloured compound material, special attention is required when using laser singulation. Colour can change due to high temperatures.

When the color of the product is required to be red, it can be chosen for water jet singulation. This has the same flexibility as laser singulation. For process optimisation point of view, it is better to use laser singulation and do a concession on the product color

Appendix L:
Example of :Product group related database

Product group code			
A1B1D3E1F5G2H2I2J2K4		Revision: A	
		Date of last update: 30-03-2005	
		Summary of revision changes: A: Release of product group A1B1D3E1F5G2H2I2J2K4:	
Summary of product specifications values of this product group			
Function	Specification	Value options	
Aesthetics , discrimination, Manageability	• ***Circumference shape***	***curved***	
Aesthetics	• ***Surface structure***	***Flat***	
Electrical Isolation Manageability	• ***Total thickness***	***0,8-1mm***	
Electrical Isolation	• ***Electrical isolation requirements.***	***No interference with environment allowed.***	
Solderability Manageability	• ***Shape specifications. (Degree of warpage)***	***5 µm / 1 mm***	
Solderability	• ***Solder temperature***	***>230°***	
Chemical isolation	• ***lead material***	Copper	
Conducting signal	• ***Lead thickness***	***<0,1mm***	
Solderability	• ***Geometry of lands***	***Single row***	
Quality check	• ***Before singulation***	***No preference***	
Heat resistance check(Burn in test)	• ***Temperature***	***200° - 230 °***	
Signal quality check	• ***Signal processing***	***Yes***	
Zero defects	• ***Certainty***	Yes	
Identifications	• ***Compound color***	***Black***	
Identifications	• ***Flexibility of text***	High flexibility	

Optional techniques for this product group			
	Process functions	Optional sub processes	
1	Die Connection	Wire bonding	
2	Molding	Map molding	
3		Post mold clamping	
4		Post mold curing	
5	Solderability	Ni Pd Au	
6	Lead Isolation	Laser cutting, Waterjet cutting, Sawing	
7	Testing	Strip test / Functional test, Burn in test	
8	Identification	Laser Marking, Ink jet printing	
9	Singulation	Laser cutting, waterjet cutting	
10	Deflash	Pearl blasting/ Slurry blasting	

Links to concerning process related databases

Appendix L:
Example of :Product group related database

OPTIONAL COMBINATIONS

All combinations start with wire bonding and Map molding.
Optional combinations based on laser cutting
No strip based testing

3. Post mold clamping->post mold curing-> Pearl/ Slurry blasting->Laser marking-> Laser cutting-> Functional test-> Burn in Test
4. post mold clamping-> Pearl/ Slurry blasting-> post mold curing->Laser marking-> Laser cutting-> Functional test-> Burn in Test

Optional combinations based on waterjet cutting
No strip based testing

5. post mold clamping-> Pearl/ Slurry blasting-> post mold curing -> Laser marking-> Water jet cutting-> Functional test-> Burn in Test
6. post mold clamping->post mold curing-> Pearl/ Slurry blasting ->Laser marking-> Water jet cutting-> Functional test-> Burn in Test

Optional combinations based on saw isolation.
Strip based testing optional

8. post mold clamping->Saw Isolation->post mold curing-> Pearl/ Slurry blasting-> Strip testing-> Laser marking-> Laser cutting-> Functional test-> Burn in Test
9. post mold clamping->Saw Isolation->post mold curing-> Pearl/ Slurry blasting-> Strip testing-> Ink marking-> Laser cutting-> Burn in Test
10. post mold clamping->Saw Isolation-> Pearl/ Slurry blasting-> post mold curing-> Strip testing Laser marking, Laser cutting-> Burn in Test

PROS AND CONS OF PROCESS COMBINATIONS

Process combination 1

Pros: Flexibility in product shape
No force on product during singulation
Post mold curing and clamping can be combined

Cons: Pearl/Slurry blasting will take more time due to cured material,
High temperature on package during singulation.

Process combination 2

Pros: Flexibility in product shape
No force on product during singulation
Pearl/Slurry blasting will take less time due to uncured material,

Cons: Post mold curing and clamping can not be combined
High temperature on package during singulation.

Process combination 3

Pros: Flexibility in product shape
No high temperatures during singulation
No restriction on material and package thickness

Cons: High forces on the product during singulation
Difficult to clamp during singulation

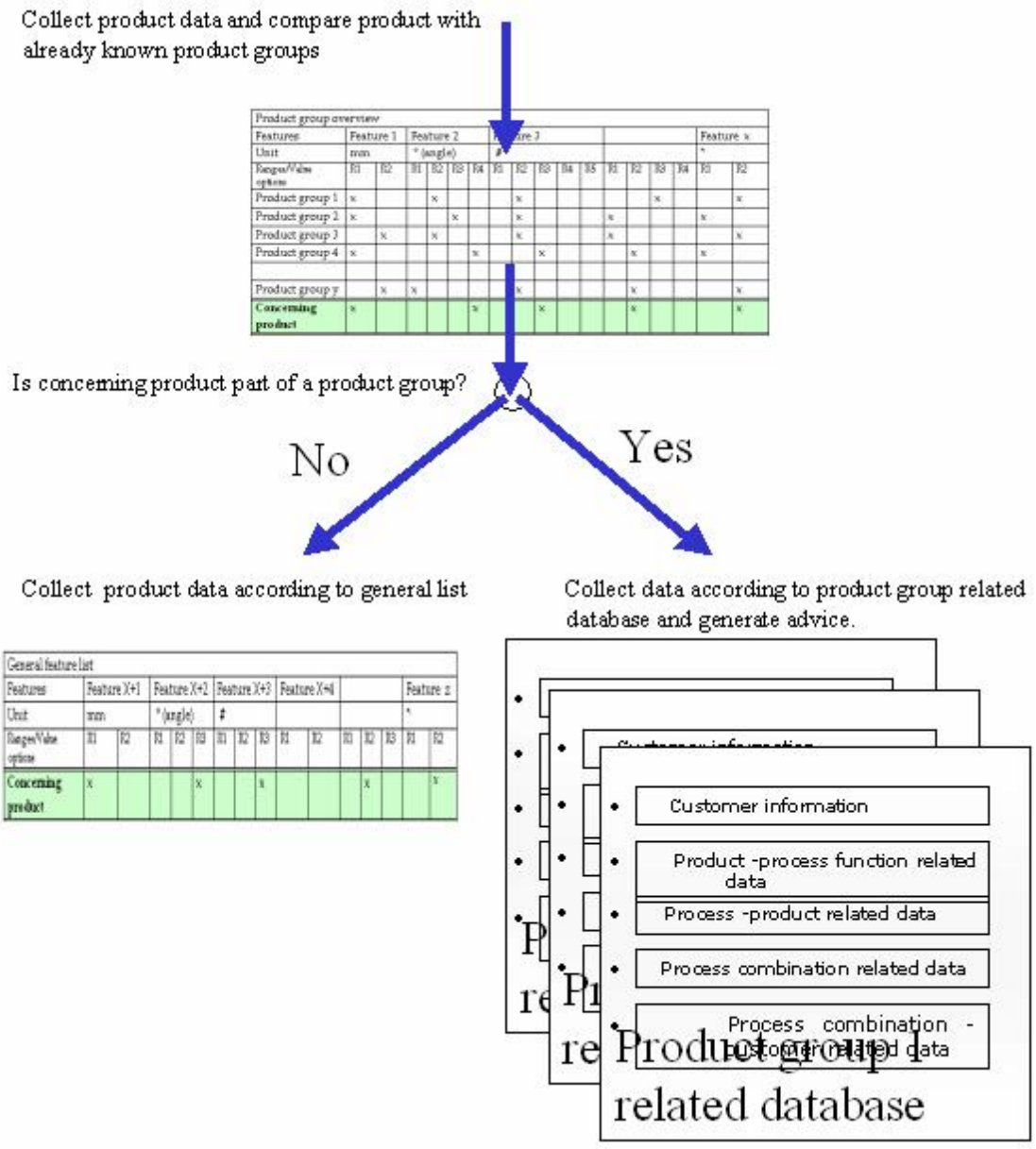
Etc….

TO PRODUCT GROUP RELATED QUESTIONNAIRE

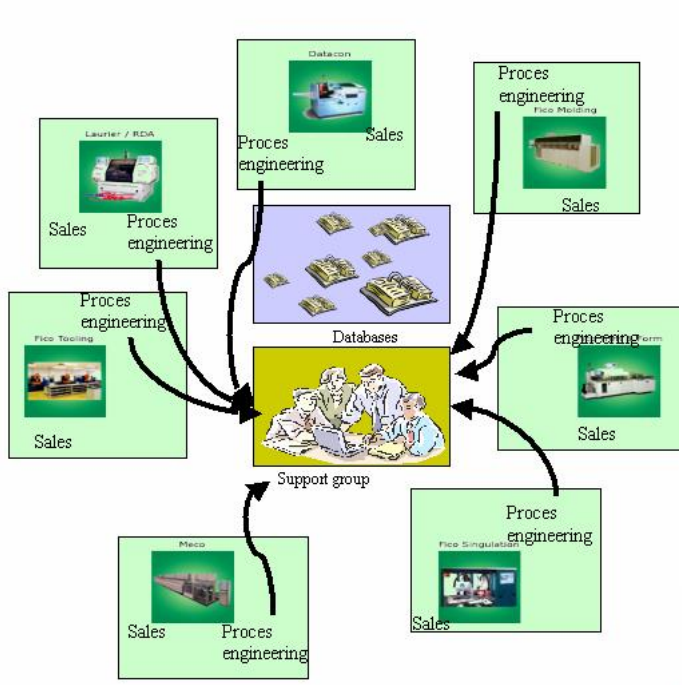
-Is there already installed equipment which is planned to be used for this product?
-Will the processes also be used for other products? If so, which products?
-What is the required tact time[48]?
-What function need to be tested?
Etc…..

[48] ***time needed for manufacturing a unit: the time needed to manufacture one unit of a product, measured as the elapsed time between the completion of one unit and the completion of the next***

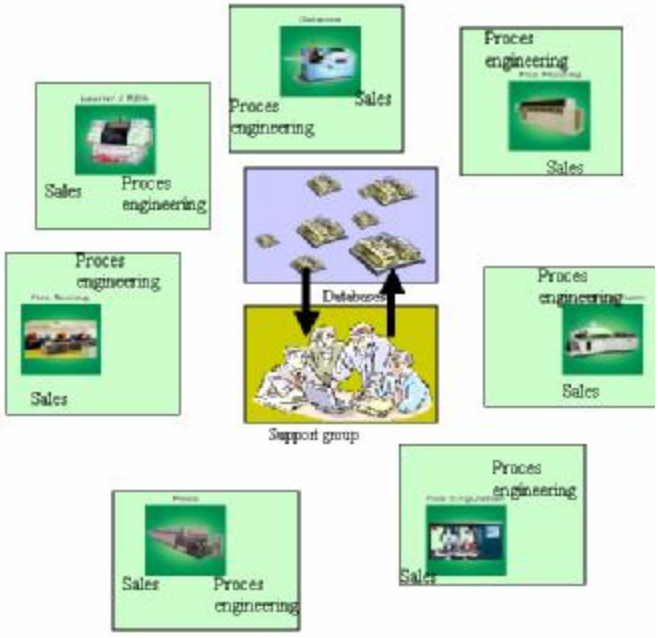
Appendix M
Information flow between users and advice support system



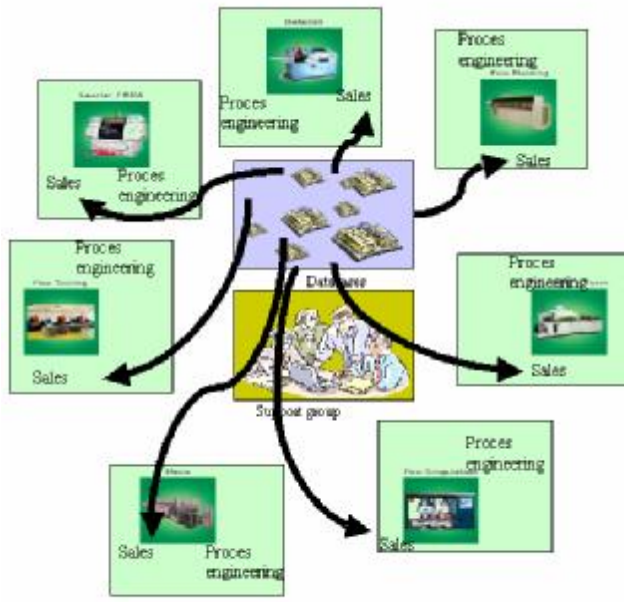
Appendix M
Information flow between users and advice support system



Knowledge is provided by process engineering

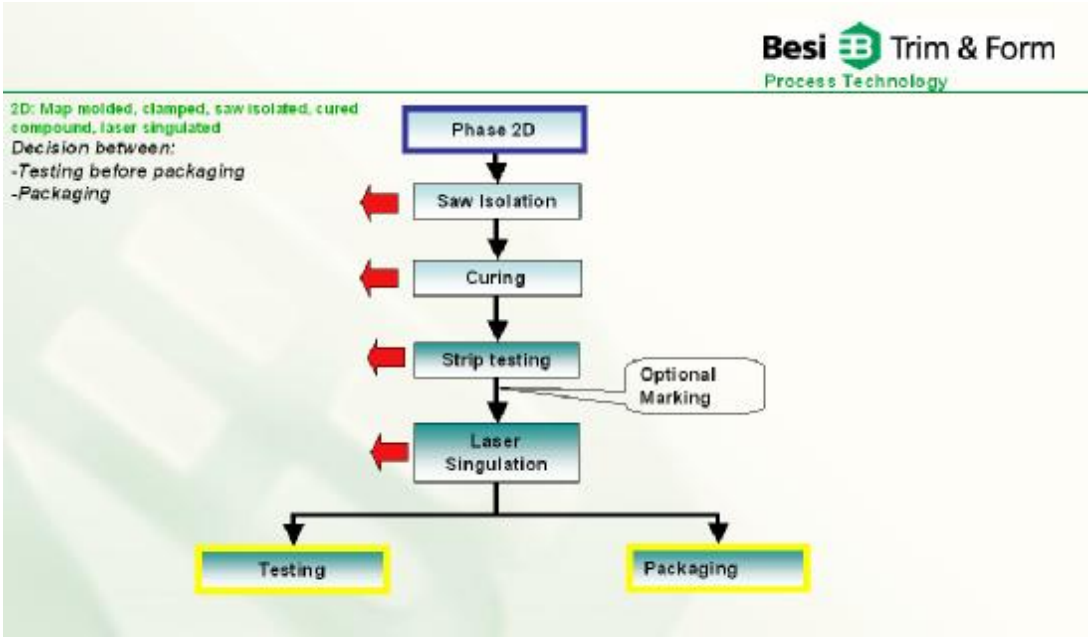


Knowledge is maintained and updated by support group



Knowledge is used by Sales

Appendix O:
Example of decision tree



Part of a decision tree for a QFN product:

Already taken decisions are:

-Use of: Map-molding, clamping, saw isolation, compound curing, and laser singulation.

The following decision need to be taken.

Which process function should follow:

-Testing before packaging

-Packaging

Appendix P

Influence of value range on process choice

Exampe: The use of a certain technique for the Singulation process is restricted by multiple product specifications. When a technique is not restricted by one specification, there is a possibility that it is restricted by an other specification.

Feature: shape of singulation line

Value ranges	Straight edges	Curved edges	Tapered edges	
Singulation techniques	Water jet singulation Punch singulation Saw singulation Laser singulation	Water jet singulation Laser singulation	Saw singulation Punch singulation	

Feature: material at singulation line

Value ranges	metal	Thin metal	compound	Thin compound remainings	Board
Singulation techniques	Water jet singulation Punch singulation Saw singulation	Water jet singulation Punch singulation Saw singulation Laser singulation	Water jet singulation Saw singulation Laser singulation	Water jet singulation Punch singulation Saw singulation Laser singulation	Water jet singulation Saw singulation Laser singulation

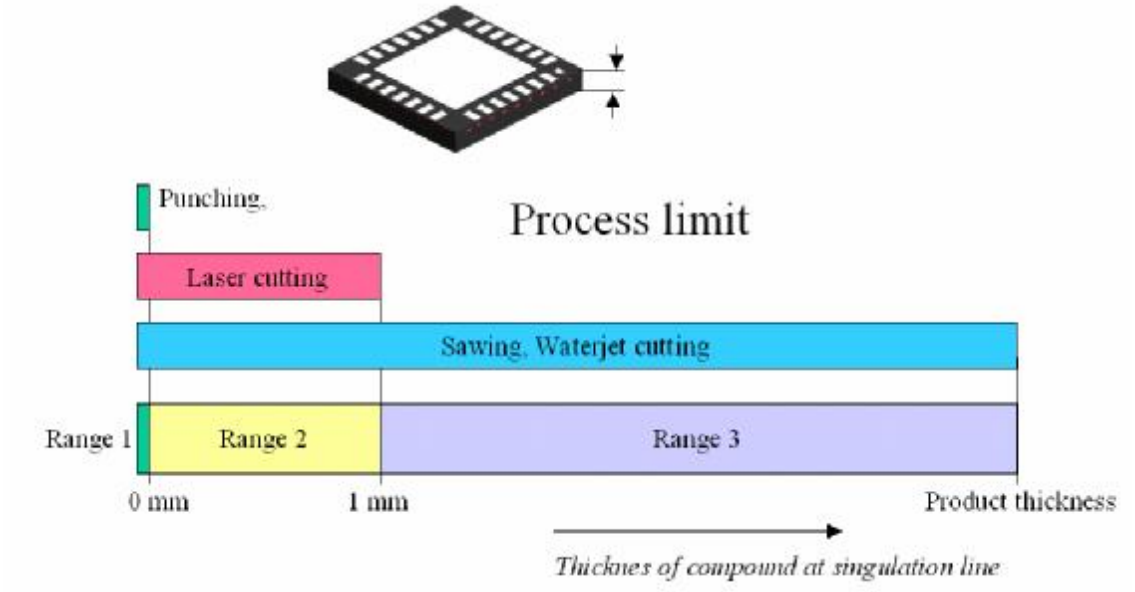
When a product has tapered edges, both saw singulation as punch singulation are optional. But when the same product has board material at the singulation line, punch singulation is not optional anymore.

Appendix Q
Definition of value range

Example to clarify the definition of value range

A technique can restrict the maximum or minimum value of a certain feature. When the value exceeds the admissible value, the restricting technique can not be used for processing the product.
When the suitability of multiple techniques is restrict by the same feature, but with other limits, the values of all limits, in ascending sequence form, the value ranges of the concerning product feature.

Feature: Maximum thickness of compound at singulation line/product edge	
Processes related to the feature:	Value of feature
laser cutting:	0 to 1 mm
Sawing:	No limit
Punching:	0 mm. No compound at singulation line allowed
Water Jet cutting:	No limit



Value ranges
Range 1: No compound at singulation line allowed
Range 2: >0 to 1 mm
Range 3 > 1 mm to maximum product thickness
The concerning feature value in range 1 does not restrict any singulation technique. When the concerning feature value is in range 2, the product can not be singulated by punching. When the concerning feature value is in range 3, the product can only be singulated by sawing and water jet cutting.
This does not mean that the use of a certain singulation techniques may not be restricted by to other feature values.