BACHELOR THESIS IEM

INCREASING INSIGHT INTO MANUFACTURING OPERATIONS BY DEVELOPING A REPORTING STRATEGY

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UNIVERSITY OF TWENTE.

Increasing insight into manufacturing operations by developing a reporting strategy

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Acknowledgments

Dear reader,

You are currently reading the start of what is my bachelor thesis in order to complete my Bachelor of Industrial Engineering and Management. This is the result of working the last half-year on a single assignment, something I was not used to from the years before during this bachelor. Starting in February 2022 with almost no description at all of what is expected of you, was very challenging and required a lot of self-motivation. In the beginning I really struggled with this and the lack of hard deadlines, but luckily, I kept improving myself over this period. In this preface I want to acknowledge the people that have helped me in finishing the assignment.

I want to start by thanking everyone at the company. Not only did they help me with working on the assignment, but I also immediately felt welcome when being there. All people I spoke with for the assignment were very welcoming and willing to talk about their tasks, even though sometimes we quickly noticed that we might not be able to help each other. Also, all other employees made the overall working environment a very pleasant place to work. Special thanks go out to my company supervisor, because he was always willing to help me problems and also actively asked me how I was doing when he did not hear much from me for a few days.

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August 2022, Nick Boer

Management summary

Problem definition

To keep a good competitive position in this market, they acquired a new Business Intelligence tool. The goal of this development is to improve the performance of the production plant. This should ease decision-making by having one central environment with validated information. This will help the company to spot problem and take decision quicker, which should improve the efficiency of the production plant. Especially the production departments that do extrusion and injection moulding are interesting for expanding the report environment, since they are the biggest producers and have a lot of recorded data already. For this research, the idea is to support working towards this centralized environment in Power BI a structured way. This resulted in the research question below.

How to develop an effective performance measurement dashboard to make optimal use of data for the production department of a plastic pipes manufacturer?

Because not all features that are preferably wanted by the company are possible now, the dashboard is not the sole deliverable. The focus of the research is also about the process towards building a dashboard and the way to improve the dashboard in the future. There a roadmap will also be delivered to help the company expanding the environment in the future.

Plan of approach

First, the stakeholders that are most important should be determined. Due to the limited time of the research a right scope of the research has to be chosen and this has to be linked to the right stakeholders. After that the goal the dashboard should serve should become very clear. Now a list of criteria for the dashboard could be created by performing literature research and conducting interviews. Here input was going back and forth from the research and stakeholders. After a few times of repeating, the list was finetuned. Due to limited data availability, not all desired analysis can be realized. Here, the list will be filtered to a mapping of what to actually put in the dashboard now and a roadmap. The rest of the research can be spent on building the report and processing the information in the research.

Results

An operational dashboard has been created. Due to data availability not all desired analysis can be performed yet, but according to the evaluation in contains useful information and it is a good start for a dashboard that can be implemented and used after the summer. After the evaluation, some changes have been made to improve the dashboard.

The other developments with Power BI are put onto a road map. One plan is created for the manufacturing dashboards and contains all desired contents by the company that cannot be executed yet. This can be worked out by the company when sufficient data is available for the analysis. Development in adding information of other departments to the Power BI environment have been discussed with the managers that are concerned, so a clear explanation could be given of what has to be added to the data base. This will help the company to improve the central data environment in the future.

Recommendations

The recommendations for the company for actions after the research are:

- Implement the last four steps as described in the research implementation
- Focus on increasing data availability for the manufacturing dashboards
- Keep discussing possible changes of the dashboard to improve the functionality
- Transfer data from other departments to the central data base

Contents

List of abbreviations

PVC = Polyvinyl chloride

PP = Polypropylene

BI = Business Intelligence

KPI = Key performance indicator

OEE = Overall Equipment Effectiveness

MES = Manufacturing Execution Systems

ERP = Enterprise Resource Planning

GFHL = Goed/ fout/ hoog/ laag (in English: OK/ not OK/ high/ low)

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1. Introduction

In this chapter an introduction of the assignment will be given. Firstly, a description of both the company and the assignment is given. Then an approach to execute the assignment will be given. For this, the core problem has to be found. Now an attempt can be made to solve this problem by formulating research question that have to be answered. Lastly, a description of the contents of the deliverables will be given.

1.1 Company description

Dyka BV is a plastic pipes manufacturer in the Netherlands. The company originated in 1957 from a collaboration between A. van Dijk and J. Katers. Together, the plumber and plastics expert joined forces and created this new production company. Nowadays DYKA BV is part of Tessenderlo Group, a Belgian chemical company that operates all over the world. Over the years the company has become an international supplier of solutions for sewerage, water, air and gas networks. It has 21 locations across the Netherlands and the headquarters are in Steenwijk. At these locations, products can be bought, but the majority of DYKA's products is delivered on command to construction companies. The location in Steenwijk is also the place where the assignment will be executed.

The location in Steenwijk has both an office and production facilities. Two big halls are used for the two most important production processes, injection moulding and extrusion. Extrusion is being used for producing the less complicated products, like straight pipes. Extrusion is a process where a material undergoes plastic deformation by the application of a force causing that material to flow through an orifice or die. There are two types of extrusion: hot extrusion and cold extrusion. At the production facilities of DYKA, hot extrusion is being used. Materials like being heated before being forced through a die. DYKA produces three types of tubes here. Firstly, they make tubes of PVC. This is a cheap material that is relatively strong and therefore ideal making products like this. Another used material is PP. This is more heat resistant than PVC, but does score worse on strength and costs efficiency than and is therefore not used as much. A third type produced is the U3-tube. This consist of three layers. The inside and outside layer are from newly used material, while the middle layer is a combination of scrap material, chalk and foam. This product is almost as strong, but does not contain as much new material. This is great for making the product more sustainable and will also help with a cost reduction to be realized. At the extrusion department, relatively big amounts of materials are being processed.

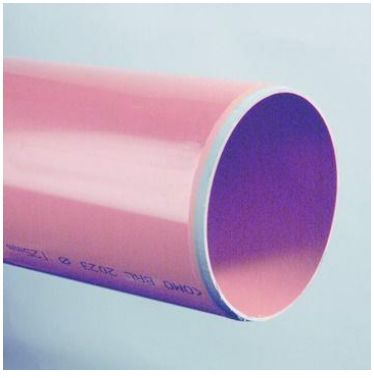

Figure 1: U3-tube

Injection moulding will be used for more special parts, like corner pieces and merging and splitting pieces. With injection moulding, plastics are injected at pressure into a mould cavity, which should be filled up entirely. After cooling down, the production will be in solid form and can be removed from the mould. Sometimes the mould has to be made from a lot of pieces, so the mould can be removed without damaging the product. This process takes more time than extrusion and therefore lower amounts of material are being processed here in absolute values.

These two main production departments are being supported by other departments, which will be explained shorty below.

Department	**Function**
Compounding	Supplies material for the production department in a unique recipe for all products.
Quality control	Tests the products on certain norms to ensure a good quality.
SPS/ Prefab	Assembles parts of systems containing products from extrusion and injection moulding. This is mainly used for building houses.
Warehouse & logistics	Manages the inventory of produced goods and also manages the transports of the orders.
Maintenance	Ensures everything is the production facility is up and running.
General engineering	Manages projects to improve the performance of the production departments.
Tooling	Makes some of the mould cavities for injection moulding.

Table 1: Supporting departments of production plant

In the office many different disciplines are being performed. The most important departments here are sales, supply chain management, finance and marketing.

1.2 Problem definition

Last year Dyka BV acquired a new BI-tool, namely Power BI. In the tool one has access to a data lake, which is connected to the operating systems of the company. This makes data easier and faster accessible than before. A few basic reports have already been made. Their goal for the future now is to expand these reports to create new information for supporting management decisions. The ideal state would be that all available information would be available in a central environment, so everyone within in the company is making decisions based on the same validated data. They want to work towards an effective report portfolio in a structured way, so the working method can be re-used for other departments. This assignment will be focused on the production department. This department is concerned with both the injection moulding and extrusion processes, as well as with the departments supporting these department.

The market DYKA is acting in is the plastic tube market. Only in the Netherlands, multiple actors are active in this market, so it important to keep a competitive position in the market. Currently, there is plenty of work in this sector for all companies operating in this market. On the short-term this means DYKA, and his competitors will have enough work to do. However, if the construction sector will not have as much work anymore, it is important to also have enough demand for products. This is very realistic at the moment, since a lot of discussions and currently going about the construction sector. In the Netherlands, the emission of nitrogen should be drastically reduced and therefore construction projects might be postponed. Therefore, the competitive position is important and improving the performance of the production facilities can help with that.

1.3 Core problem

In figure 1 the problem cluster based on the assignment can be seen. The assignment is formulated, because the production department is unable to maximize its performance based on the data that is available. The company wants more data-driven decision making and to realize this, insight in the data from the different source should be quicker and easier.

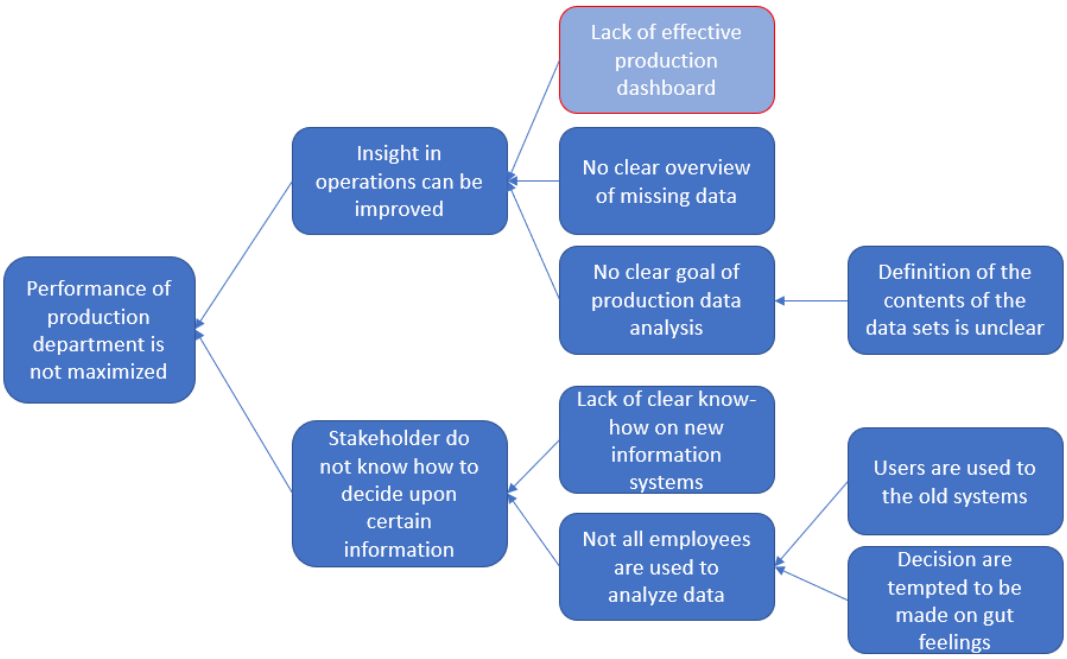

Figure 2: Problem cluster

Two causes can be found for not using as much data-driven decision making are:

1. Not enough insights can be retrieved from the reports that are currently available
2. Decision-makers do not have the knowledge to decide upon the current reports

The second cause can be a result of not having enough training or support during the transition towards this new form of decision-making. This seems more of a management issue and is therefore less relevant for this assignment.

The first problem is divided in three root causes:

1. There is currently no effective production dashboard for day-to day analysis.
2. There is no clear overview of what data is missing. This is important, so this can be communicated to higher levels of the organisation.
3. The definition of the datasets is unclear. This can result in problem, because employees that are starting to work on the datasets need to rediscover what the contents of the dataset are.

The core problem in this assignment is that there is no clear structure in the report portfolio. This seems like the problem what has to be solved first before starting with solving other problems in this cluster. The lack of a goal with the production data is also a problem that is integrated in this bachelor assignment, but this is something to worry about when the core problem is solved. As

mentioned before, developing more KPIs for the portfolio will make it even harder to create a good road map for constructing the portfolio. This should always be the main concern for the assignment, because the structure of the portfolio is most important to the company.

1.4 Knowledge problem and research questions

The main questioned is related to the core problem. The goal is to develop an effective performance measurement dashboard. It has to be effective, because it should be easy to use and expand the dashboard without making it too complicated. Therefore, the structure of the portfolio is essential. This dashboard should make optimal use of all data available from the production halls. This optimal use is essential to create the best overview of the situation, which will then result in the highest chance that it will improve the business of the production department of the company.

Main question: How to develop an effective performance measurement dashboard to make optimal use of data for the production department of a plastic pipes manufacturer?

To answer the main question, it has been divided into smaller sub-questions. This will help to get to the actual goal in smaller steps. The first sub-question is to investigate in what way the portfolio should help to improve the performance of the production department. This is important for guidance during the remainder of the assignment. It will show in which part of production they are looking for better solution and hopefully narrow the scope of the assignment.

After that, two questions are about the desired shape and structure of the portfolio. Discussions with the stakeholders and literature studies should make it clearer what the desired KPI's are for the production department. In the end, it is important the dashboard will contain the information that they think is useful to improve the performance of the production department. Also, other criteria with regards to the structure of the portfolio are important to make sure it is easy to use it and also not too complicated to expand in the future.

The fourth question is about the useful analysis that can be performed to improve the performance of the production department. After the structure of the portfolio is right, this is the first thing to do. A structured portfolio is nice, but without any useful information in it, it is useless after all.

Lastly, it is important to look into the future. Since the time that is scheduled for the actual assignment is quite short, it is nice to have a glimpse into the future. Especially when the portfolio is working well at the moment, it is useful to see what possible expansions are and what are the limits of the possibilities. This all results into the following five sub-questions:

1. How can the reporting strategy help to improve the performance of the production department?

First, the usefulness of the new reporting strategy should be discussed. Who should benefit from the new reporting strategy and in what way? If it turns out a dashboard is not the right tool for this, the project would be a waste of time and effort in the first place and therefore it is important to do this analysis.

2. What are important criteria the reporting portfolio has to meet?

For the portfolio to be useful, it has to serve the purpose of that portfolio. Very advanced analysis can be made, but these are useless if they do not display the right information that is needed for decision making. Also, which person will see which information is an important factor, since all employees within the company have different tasks and therefore will require other information. This will have to be discussed with the stakeholder and decision here can be supported by literature studies.

3. What are the most relevant KPIs for the production department?

If the type of desired information is known, it is important to make this measurable. The right KPIs have to be chosen to give the right information at a glance. This will have to be discussed with the stakeholders, because they are the ones that will use the dashboard (or people close to them, for example employees from their department)

4. What quantitative analysis in Power BI will give added value to the production department?

Now the analysis will have to be added to Power BI. The right visuals have to be chosen to create a quick insight into the current situation at the production department and problems can be detected quickly.

5. In what ways can the portfolio be expanded in the future?

Because it is a short assignment, not everything can be realised to make a perfect functional dashboard. Therefore, making a road map is also part of the assignment. This part is as important as the dashboard, since it will provide the desired structure for future development.

1.5 Research design

The research design below has been made to show in a structured way how the steps that will be taken during the weeks of the execution of the assignment will help to solve the main problem. The end goal is to improve the performance of the production department by creating more insight in the daily operations of the production department. This will be done by developing an effective production dashboard. This dashboard can only become effective if it suits the needs of the people within the organisation that are actually going to use it. In the steps below in the design is shown how it is made sure that the dashboards will contain the exact situation that is wanted by the users.

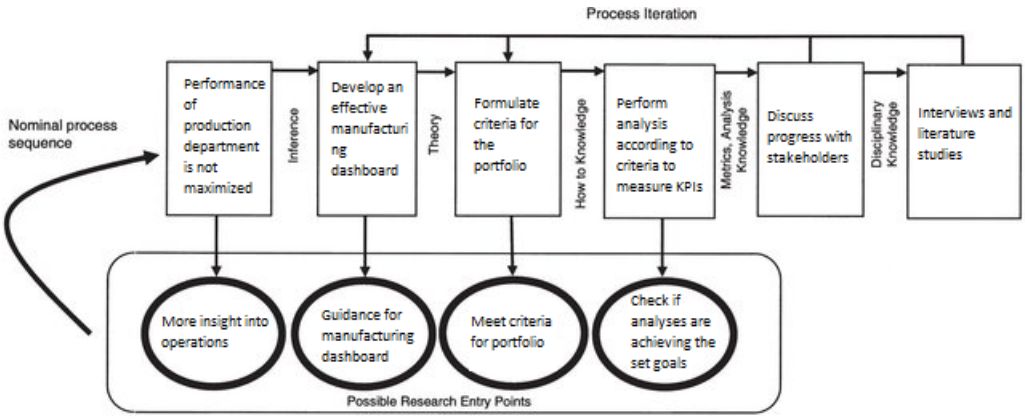

Figure 3: Research design according to design science methodology

1.6 Deliverables

After answering all research questions, this assignment will have to provide the following,

- A production dashboard that is useful for the production departments on a daily basis.
- A list with KPI's that have to added to the dashboard once the data is available.
- A list of data that has to be made available in the upcoming period to support people using Power BI in the organisation with developing their own reports.
- A description of the contents of the current dataset, so working with this will be easier for other users in the future

2. Background

In this chapter, more information will be provided that will be necessary to work towards a solution for the problem the company is facing. Firstly, the current state at the company will be explained. This is necessary to show what problems the company is facing. Also, an explanation of the tool Power BI will be given and the data set that is currently being used for this will be explained. Lastly, in section 2.4 information from literature studies will be provided that is needed to answer the different research questions.

2.1 Current state

Currently there are already reports available in power BI to use for analysis. These are mainly focused on the available data on the strategic level. Because of this focus, it is hard to get information that is useful for decisions on a lower level. For production, three apps are available. This is because not everyone in the organisation is authorized to the same level. Also, offline reports are being made by the stakeholder themselves to get insight in data that is specifically relevant for their department. These offline reports can be useful, but do come with the problem that not all decision-maker are using the same reports. This can create information conflicts, because different offline models might be a bit different from each other. Also, reports are still being made in other programs, because it is not possible for all data to be put into the Power BI data base or because this is yet to be transferred.

The data is coming from different sources. Machine data is being recorded via BMSvision (previously BarcoQC), a MES-system. It contains data about the functioning of the machines. It logs the status of a machine, for example when it is running or when it is waiting for a task. Also, it records the speed of the machine when it is running. In this way, the functioning of machines can be compared and problems can be spotted.

Also, SAP is being used as an ERP-system. This is a more general management software tool that is used by all kind of organizations. It can have multiple uses, for example in accounting, supply chain management and procurement. DYKA also uses it for multiple purposes. It tracks order statuses with SAP, but also uses it for budgeting and setting norms for production. Often, this data is the theoretical, which can be compared to recorder value from other data sources.

For data regarding time registration ATPS is used. All employees have a badge which is used when entering or leaving the location. This has two purposes. It can be used in case of emergencies to swiftly know who are exactly in the building. Next to that, the recorded data can be useful for analysis. It logs how many hours an employee has worked over a period. This can be linked to the department where this employee is working, so it provides information per department. When employees are absent, this can also be registered in ATPS. In this way it is visible what are the most common reasons employees are absent and which department suffers the most from absence. This data has to be handled extra carefully, because it contains personal information of employees. Therefore, it can only be in reports where only a few people are authorized to see it.

These data are connected to each other in a data lake, which can be accessed by Power BI.

2.2 Introduction of Power BI

Power BI is a visualisation tool designed by Microsoft. It can be used to design dashboards for management purposes. It has both cloud-based environment and desktop modus. The cloud-based environment is a platform for dashboard to be published on. Users can log on to their business account and can see the published reports that they are authorized to see. When new data is available, it will automatically update the datasets and so the reports. Therefore, it is a nice way to get a look into up-to-date information.

The desktop version of Power BI is the place where reports can be made. Within a company, this will have fewer users, because not everyone that will need the reports will make the reports themselves. To understand the desktop version, more knowledge is needed than for the online version and therefore a company will mostly choose a few people that will invest time and effort into learning these skills. To build a report, a data set needs to be constructed. This can be done by manually adding spreadsheet with information to a dataset, but the most reliable way is to first invest time in a data set and load this later into report. This data set can be designed in a data model, where tables can be linked by certain unique variables, as order ID's. Just like other data models, this can be a one-to-one, on-to-many and many-to-many relationship. With this data model, the structure can also be understood by others that have experience with data analysis and the chance of mistakes in the report are smaller.

When a data set is loaded, it is displayed on the right-hand side in the desktop mode. Now columns of the data set can be dragged onto the pages to create visuals. Columns can be compared to each other and also can be filtered by other variables. Also, slicers can be added, so the user of the report can filter the data in a desired way to get more specific information. This is often used to adapt the time period of a data set.

The current strategic dashboard that is already available is based on a dataset that is called DYKANL_ZPREPCONF_BMS_BARCOQC-ALL_ATPS-Production. This is a dataset made by the Business Information developer and the Data Engineer operations and contains data from all possible sources within the company. The contents of this data set will be explained below in section 2.3.

2.3 Dataset contents

When one wants to start making a dashboard, it is important to understand the data that is used. Because the current data will likely also be usable for dashboards, we will explain the contents of this data set. This will make it easier to build the dashboard and will also help future users of the data set. This will be handed to the company as part of the road map in both Dutch and English. Only the Dutch version is likely to be used in Steenwijk. However, an English version could guide as an example if other locations want to explain their data sets in a document. Because the assignment is made in English and a translation had to be made anyways, this version is also given to the company. The English version can also be found in Appendix B of this document.

In the explanation a distinguishment has been made between dimension tables and dummy tables. The dimension tables contain a lot of data, which will be used regularly for reports and dashboards. These tables are explained per column with a description of the information they contain. From other so-called dummy tables only, a short description is given at the end. These are not important for understanding the data set but are there for specific calculation that are unlikely to be needed in future reports.

2.4 Theoretical framework

To support the steps shown in the remaining of the report, literature reviews has been done to find information about specific topics. First, the criteria of manufacturing dashboard have been researched. After that there has been looked at how to design, how to implement and how to evaluate a dashboard.

2.4.1 Dashboard criteria

The goal of the report portfolio is to improve the performance of the production department at the production facility in Steenwijk. This should help the company to keep a good competitive position in the market of plastic pipe manufacturers. When looking at gaining a competitive advantage, two views are commonly used: the structural approach and the resource-based view. The structural approach focuses on cost leadership, product differentiation and focus, while the resource-based view focuses on creating new, innovative products that are hard to imitate (Dustin, Bharat and Jitendra, 2014). Because the process of producing plastic pipes is commonly known and it is not likely a unique innovative product will take over the function of the current product, the resource approach is not very applicable. Because plastic pipes seem like a quite simple product, the view of the company towards innovation has also been conservative for years. However, innovation following the structural approach can help the company to gain a competitive advantage on competitors. When placing the dashboard in one of the three categories of the structural approach, it should support the cost leadership strategy. In order to do this, the dashboard has to help working on the efficiencies of scale, reduce manufacturing costs or minimize the expenses on sales and administration (Dustin, Bharat and Jitendra, 2014). The last goal will not be achieved with a manufacturing dashboard. However, higher efficiency of scale and lower manufacturing costs can be achieved with help of more insight and therefore these developments are important when working on a dashboard.

The current report is made on the strategic level. Next to this, there are two more levels of control which can be optimized: tactical and operational (McNair and Vangermeersch, 1998). To create an online environment where a complete view of the situation at the company is shown, information on these levels should also be provided.

Figure 4: Three levels of control (Alves, 2019)

The important period for tactical report differs per publication, but is should be between a couple of months and three years. It should inform the management with the right statistics to support and ease their decision-making (Alves, 2019). This can be done by showing trends over this smaller period than the existing report. This for example compares data of multiple years, which is more relevant

for board meetings and not for production managers. The operational dashboard should focus on creating standards and seeing if they are met (McNair and Vangermeersch, 1998). This can be on very short periods and can also be relevant on real-time if this data is available. It can be said that real time data collection through digitisation of operations has become most important for effective operations (Kolberg and Zühlke, 2015). At the company, a project has recently started with a new machine in the extrusion hall. This can track live data of the temperature of the material in the machine and the pressure of the die. This information is visible on a screen on the machine. This means that the information is only visible for the operator when he is standing next to it. To reduce the time from failure occurrence until failure notification, operators should become Smart Operators (Kolberg and Zühlke, 2015). The operators should be notified as soon as possible, which can be done by using for example tablets or smart watches with notifications. An error message should occur with the type of error and the location of the error, so the operator can act quickly. Also, the required action to solve the problem could be shown to make the job of the operator easier.

The notifications can be taken one step further when predictive behaviour of the variables is used. For example, the temperature has an ideal value, but also a range which is a requirement to produce products that will stand the test. If the trend of the temperature is that it is rising relatively quickly, a preventive warning could be sent to operators to check on the situation. This will result in even fewer failures and therefore help with reducing the manufacturing costs to support the cost leadership strategy (Dustin, Bharat and Jitendra, 2014).

	Principle: Just-In-Time	**Principle: Jidoka**
	Method: Kanban system	**Method: Andon**
Smart Operator	Employee gets information about remaining cycle time via augmented reality	Wearable computing systems receive failures and display it in real time to the employee
Smart Product	Smart Product contains information of Kanban to realize an order-oriented production	-
Smart Machine	Machines offer a standardized interface for receiving and sending Kanban	Machines send failures directly to Smart Operators and call other systems for fault-repair actions
Smart Planner	IT systems reconfigure production lines and update Kanban according to the new configuration	-

Table 2: Possible developments in the industry 4.0

So, supported by innovative operators they become Smart Operators who supervise and control ongoing activities. Machines can send failures the operators and asks for fault-repair actions. These options are both part of the Andon method when looking at possible developments to the industry 4.0 (Kolberg and Zühlke, 2015). Implementing solutions like this will take longer than this assignment will last, because only a few machines currently have real-time data. But also with the report, actions can already be taken to give the operators more insight into the current situation. This will give more responsibility to the operators and can help the production managers to focus on tactical decisions.

2.4.2 Data visualisation

When designing a dashboard, it is important to use the right visuals for showing a certain type of information. The greatest display technology in the world is useless if one fails to use effective visual design (Few, 2006). For the manufacturing dashboard, different analysis will be made. This chart can be used to find a useful visual for a certain analysis (Abela et al., 2010). For the manufacturing dashboard, it is expected that the charts for comparisons will be used a lot. Values often have to be compared per production line, article and machine. For this, the bar chart is ideal (Abela et al., 2010). Also, when comparing a value over time a column chart can be used. When comparing occurrence of certain situations (reason of absence, type of failure) , a histogram is normally used. This is also a type of bar chart, but Abela et al. shows it separately, because it shows a distribution of a certain situation. For the histogram to be useful, it is important to have the values in descending order. Now it can be easily seen which option occurs most often. This is also called pareto histogram.

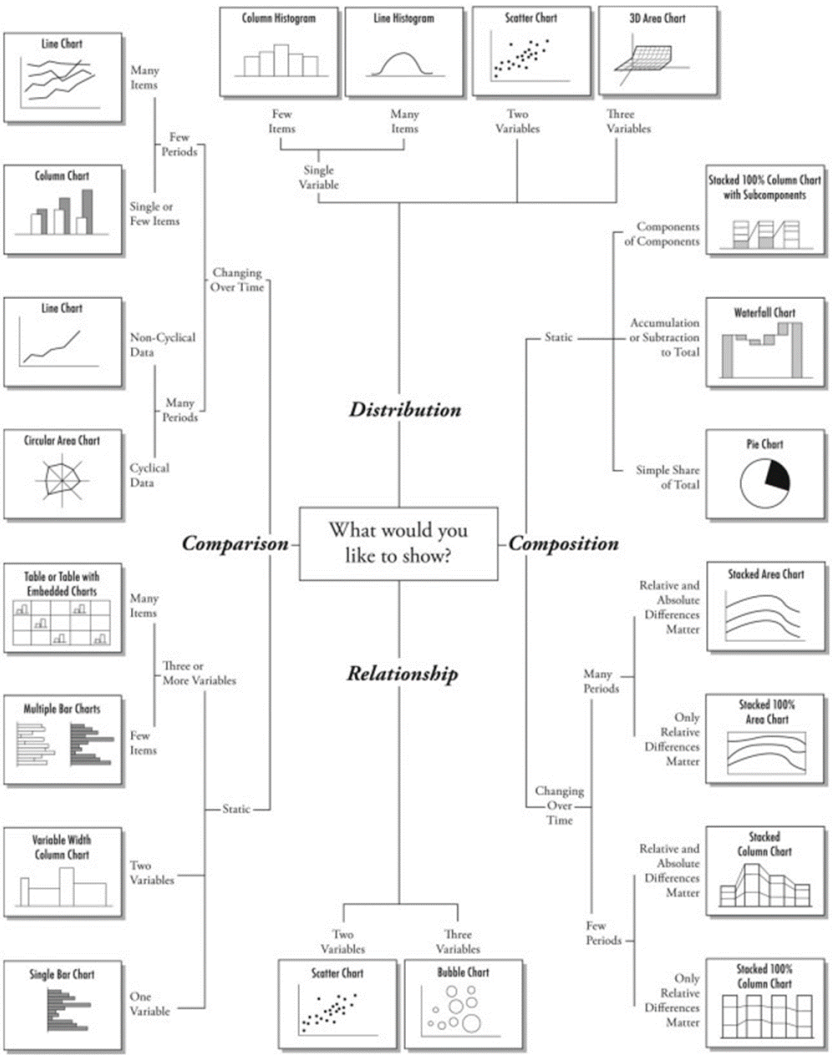

Figure 5: Chart Chooser (Abela et al., 2010)

2.4.3 Implementation of dashboard

After the report environment is finished, it has to be implemented into the daily operations of the company. This innovation will be costly and time consuming, but it is still one of the most important ways to achieve competitive advantage (Dustin, Bharat and Jitendra, 2014). Therefore, it should be done in a balanced way and not impede the daily business to much in order to succeed. Also, some employees might be resistant against the introduction of the new dashboard. Especially older workers with more experience seems to have this aversion in a stronger way (Venkatesh, Morris, Davis and Davis, 2003). There have been many different studies on how to motivate innovation in organizations (Dustin, Bharat and Jitendra, 2014). To do it in a structured way, Kotter made an 8-step approach for leading change to the digital transformation. These steps are:

1. Create urgency: create that the feeling that a change is actually needed in order to keep a competitive advantage.
2. Form a coalition: get enough people on board to support the change.
3. Create a vision: sketch the possibilities when the development has been taken to the next level.
4. Communicate the vision: communicate the idea to stakeholders at the company.
5. Empower to act on the vision: tackle the problems that might slow down the development.
6. Create short-term wins: show the first effects to motivate others.
7. Build on change: keep improving.
8. Anchor the changes: make sure the changes are part of the new culture

2.4.4 Evaluation of dashboard

To test features of a dashboard, four ways of testing are possible: automatically, empirically, formally, and informally (Nielsen, 1994) Empirical methods are the main way of evaluating user interfaces, with user testing probably being the most commonly used method. However, in such a short period it is hard to deliver a dashboard that can be tested by users. Therefore, the best way to test the dashboard is by making a survey. Question that can be asked in a user experience questionnaire can be divided in six categories (Schrepp, Hinderks and Thomaschewski, 2017):

- Attractiveness: Overall impression of the product. Do users like or dislike it? Is it attractive, enjoyable or pleasing?
- Perspicuity: Is it easy to get familiar with the product? Is it easy to learn? Is the product easy to understand and clear?
- Efficiency: Can users solve their tasks without unnecessary effort? Is the interaction efficient and fast? Does the product react fast to user input?
- Dependability: Does the user feel in control of the interaction? Can he or she predict the system behaviour? Does the user feel safe when working with the product?
- Stimulation: Is it exciting and motivating to use the product? Is it fun to use?
- Novelty: Is the product innovative and creative? Does it capture users' attention?

Making questions based on these categories will result in an overall complete view of what is good and bad about the dashboard, although it would be better to use the empirical testing approach as described by Nielsen.

3. Criteria for the reports

In order to make a dashboard that is useful to increase insights into the operations of the company, a few steps have to be taken. We will not only look at the dashboard that will be produced during the assignment, but also at the bigger picture of developments with Power BI within the company. In this chapter we will go through this process. Firstly, in section 3.1 we will perform a stakeholder analysis to find out who has to be directly involved into the production of the manufacturing dashboards, who will only play in designing the road map for future developments in Power BI and who will not play a role in this project.

3.1 Stakeholder analysis

3.1.1 Introduction

Before determining KPI's and other criteria of the portfolio, it is important to know what goals the stakeholders want to achieve with the new information. A data engineer could make extremely advanced analyses, but if they do not suit the goal, they are not of great use to the company and its managers. An introduction talk will be held with all employees that could possibly be relevant for the project. This talk is not yet part of the process of interviewing about the desired contents on the portfolio, but more to get to know the different processes in the production halls. Without knowing this, it is hard to know who are the persons that will be able to give me the right information.

After the talks, we will make a stakeholder wheel to determine the importance of the interviewees. This figure will have 3 levels:

- Level 1: the input of this interviewee is extremely important for the project and will therefore be actively involved in the process of deciding on the contents of the manufacturing dashboard. We will schedule meetings with them over the following weeks to discuss the criteria of the dashboards and later schedule meetings with updates on the progress of the dashboard.
- Level 2: the input of this person is important for the future developments of the Power BI project of the company. However, they do not have to be directly involved in the process of making the manufacturing dashboard. We will make sure the reports the are currently using on their own will be implemented in the future and therefore tables they are using need to be added to the dataset that will be used for the central reports. Also, a list with explanations has to be made for the roadmap, so the employees working with power BI will be familiar with this and the sources can be made available for making reports. One more meeting will be scheduled with them to make sure the needed information for the roadmap will be retrieved.
- Level 3: it can be concluded that the input of these interviewees does not have enough importance for a project that has to be executed in such a short period. The information about these functions and departments can be of use for a better understanding of processes within the company, but these employees will no longer be actively involved in the project. However, if situation occur where specific question arise that could be answered by one of these persons, they can be consulted.

In cooperation with the Business information developer of the company, a list has been made with employees that should take part in this process:

Name	Function
XXXX	Data engineer operations
XXXX	Business information developer
XXXX	Manager injection moulding
XXXX	Manager quality control
XXXX	Manager extrusion
XXXX	Manager SPS and prefab
XXXX	Manager general engineering
XXXX	Manager Compounding
XXXX	Continuous improvement and systems manager
XXXX	Business controller
XXXX	Process engineer extrusion
XXXX	Manager maintenance
XXXX	Manager tooling
XXXX	Manager warehouse and logistics

Table 3: Possible stakeholders for input on developments in Power BI

3.1.2 Structure of stakeholder analysis

A few criteria have been set up to rate which stakeholders will possess the most useful information for this first sub-question:

Department:

the assignment is based on two specific production departments: injection moulding and extrusion. The managers of these departments are of course important stakeholders for making a roadmap towards an effective portfolio. These have already been in scope 1 in the project plan and will be discussed with on a weekly basis.

Affections with injection moulding and extrusion:

in all production companies, the several departments are all dependent on each other. One of the goals of this project is to work towards a portfolio that could benefit the entire production department. That is the reason why I will speak to all stakeholders in the first place. However,

department that have much affection with either injection moulding or extrusion will probably be more important.

Expectations of the project:

Own amount of experience with Power BI: Not all people in the organisation have the same amount of experience with Power BI. This is not essential for defining the importance of the stakeholder, but it can surely help if some stakeholders do have experience with the program. They can explain more about the possibilities and the limits of the program and can therefore help to frame the assignment to the right size.

3.1.3 Takeaways

During the first weeks talks have been held with all persons on the list earlier in this section. The structure of all talks was very similar. In the beginning, we had to explain what we were exactly doing and what was the goal of the assignment. After that, they told what their role within the organisation was and what their tasks and responsibilities. This was of course very useful information to get to know the company the assignment was for better. However, it was essential to get answers on whether the three criteria were applicable on the possible stakeholder. Sometimes the stakeholder started themselves about Power BI and the developments with this, other were more reserved about this topic. In that case we had to use another strategy and ask more directly about this topic.

The takeaways of the discussions have been noted directly afterwards and are put together in a table (Appendix A), so they can easily be compared. Now the stakeholders can be ranked on the levels described earlier this section in a stakeholder wheel, to have a clear overview what are the upcoming activities we have to plan with them. This stakeholder wheel can be found below.

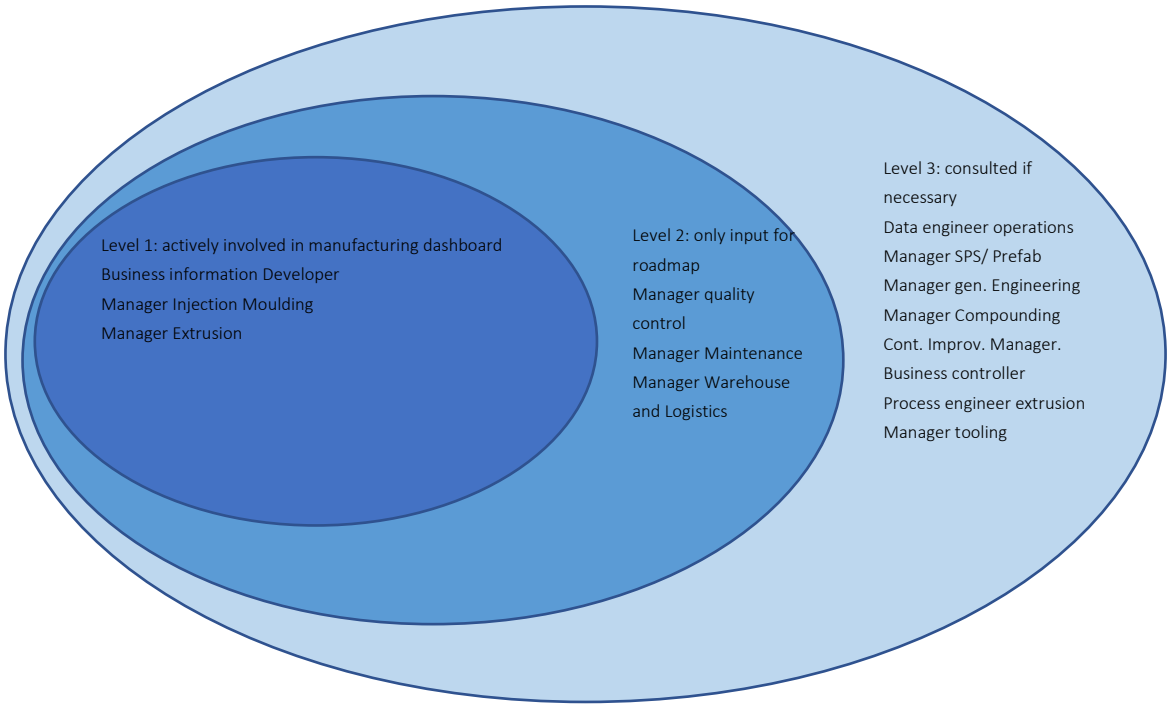

Figure 6: Stakeholder wheel

A conscious choice has been made to keep the number of stakeholders in Level 1 as small as possible. In this way, it is possible to plan meeting where the whole group can be involved at once. If the Level 1 group would have been made bigger, it would be almost impossible to schedule such meeting, especially when looking at the desired frequency of the meetings. The first stakeholder that definitely had to be put into the first level was the Business Information Developer. Not only is he the supervisor from the company that coordinates this assignment, but also does he coordinate all developments around Power BI for the company. Therefore, his input is crucial in order to get manufacturing dashboards. Also, the production manager of both injection moulding and extrusion should definitely be part of the first level. They are not the only users of the reports, but are responsible for the department that is going to use the dashboards. If they do not agree with the information that is shown on the dashboards, they would not want their team to be using it. Therefore, it is essential that they are involved in this process from day 1.

There were thoughts of adding more people to the first level. Firstly, we considered adding the Data Engineer Operations to the first level. He has a lot of knowledge about Power BI and therefore it could be useful to have him involved. However, he does not have direct interest in the functioning of this specific dashboard. He is not going to use it and therefore the contents of this dashboard are not so relevant for him. Also, it has been considered to add the Process Engineer Extrusion to the first level. In the introduction talk he had very clear ideas about Power BI and what it could mean for the extrusion department in the future, both short-term and long-term. The reason he is not included in the more frequent discussions about the contents of the dashboard is that one person per production department should be enough. The manager of the extrusion department and the process engineer communicate a lot and therefore it is expected that his input will still be processed via the manager of the extrusion department. Both the Data Engineer operations and the Process Engineer Extrusion have been added to the third level, so they can be consulted if some more specific information is needed about either the technical aspects of Power BI or about the way of working with certain processes of the extrusion department.

For the second level stakeholders have been added that are needed for working out the road map for Power BI developments in the future. For now, only the managers of a few departments are added, namely the ones responsible for quality control, maintenance and warehouse and logistics. The first reason for this is that these department do already have a significant amount of automated data that is processed in reports in Power BI or does have the potential to be processed. Also, these stakeholders are already more interested in the developments of the company when looking at Power BI, because they are already using it frequently. This makes it easier for them to express their desires of what information they would wish to be added to the reports.

The managers of departments where there is currently lower potential for creating insights with Power BI are added to level 3, as well as the business controller and the continuous improvement and systems manager.

3.2 Criteria for manufacturing dashboard

For the manufacturing dashboards to be useful, it is important that it meets the requirements set by the different stakeholder. Very advanced analyses can be made, but they are worthless if they do not show information that is wanted by the users. Therefore, it is crucial to make a list of criteria the dashboard has to fulfil in order for it to be able to become successful.

Level of control

As could be read in Section 2.1, the current manufacturing dashboard has a focus on the strategic level. It is very useful to make analyses over longer periods, especially if one wants to compare a situation in the current year to similar periods in the previous years. This is very useful information, but the company wants to use Power BI broader throughout the company. Therefore, it is important that the other two levels of control, tactical and operational are also covered. In this way, the right information is available for both executives at board meetings, but also for other employees at the company. The four roles we will be focussing on for the KPI selection in the next chapter are the department managers, their technical assistants, shift leaders and operators. While all dashboards can be made with the same tool, the reports should have very different characteristics. Firstly, the tactical and operational dashboard should be focussed on a shorter time period than the strategic dashboard. This will make certain KPIs more fitting than other. Furthermore, there has to be looked at which data can be made available in the tactical and operational report. The goal is that especially the operational dashboard will have much more users than the strategic dashboard, which means information will be available for more employees. We have to be extremely careful what data can be put in there. Especially data retrieved from the time registration system and the table about employees can be very sensitive, because it gives information about other colleagues.

Simplicity

Because the new reports will be used by more employees, it is essential that the dashboards are not too complicated. Most employees working in the production halls are probably not very familiar with the concept of data analysis. Of course, newly delivered methods at the company with a certain amount of training, but it is preferable that it does not takes ages to be able to use the dashboards. In the end, it should not become a main task for operator to analyse data and it should more be seen as a support tool. More in-depth analyses can be done in the other reports by people who are familiar with data analysis and decision-making.

User-friendliness

For the same reasons as mentioned in the last paragraph, the report should be easy to use. For someone whose job is to run machines, the information given by dashboards should be available without too much effort. One example to achieve this is to minimize the number of filters. For some KPIs it is not necessary to filter manually by date, so at any time the right information will be given automatically. Also, conditional formatting could be of great use here, so the status of a certain value can be spotted at a glance and without much context needed.

3.3 Roadmap for future developments in Power BI

With the end goal of creating one digital environment with all available information in Power BI, an important step is to add data from other departments to the database. Currently, many departments are still using their own offline environment with tables in their own data set. In some cases, this data is already in Power BI, but also other methods of data analysis are still commonly used. This is workable when department managers are working in their own office, but when there is a meeting where multiple managers have to show their findings, it is desirable that all this information is available in the same place. Therefore, the data sets of these departments should be added to the

central data set. For this activity it is not crucial to be finished before the end of this assignment, but it is definitely a task that needs to be done in the near future. Because making a roadmap is part of the assignment and to make things easier in the future, an explanation of the available information in the data sets is given.

Quality control

For quality control, there is already data available in the data set that is used for the strategic report. This gives information about the tests that are performed on the products that are being produced by injection moulding and extrusion. The types of data in this table are elaborated in Appendix B. When something is not right when a test is being performed, a form is being made. This also contains information about the failure, such as the failure type. These are currently only available via Excel. Next to internal failures there are also complaints coming back from customers. These external failures are in a separate data base and available via SAP. In the future, this information should be added to the central data base. This could be the form, or the variables of the form in the format of a table.

Maintenance

Maintenance uses another data set in Power BI than that is used for the manufacturing report. For one part, they are using the same tables. But maintenance also has three table that are exclusively used by them. In the future they should be added to the central data base. The _cado table consists of working order. A new order is creating when a failure occurs somewhere in the production plant where maintenance is needed. This can be either a failure or planned maintenance. It contains data like the type of maintenance and the location or machine where maintenance is necessary. The tables _IW38 and _IW69 connect the financial part of the maintenance to the working orders. They keep track of the budget that is available for a certain type of maintenance and the actual costs of the same action. It also contains data of whether the maintenance is done by own employees or if third parties were involved.

Warehouse and Logistics

The Warehouse and Logistics department uses two data bases in Power BI in an offline environment. In total they consist of 7 tables, which should all be added to the central data base

Table	Contents
Shipment 2022	Shows the history of transports per transporter
YWVR2	Show all deliveries that still need to be done
ZVI12	Shows all transports done in the past
ZVLP	Project with data that is yet to be used
Dode voorraad	Show inventory that has not move for a longer period
Gepickte to (4)	Shows all transport order, internal and external over entire process
LX02 ontvangst	Checks status of buffer location for goods receipt

Table 4: Contents data sets Warehouse and Logistics

4. Development of manufacturing dashboards

Now the criteria are known for the dashboard, the contents of the dashboards should be determined. First, it is important that it is clear what KPIs the company want to be displayed in the reports. Because all employees have different roles within the organisation, it has to be decided who is authorized to do what, so a structure for the reports can be created and is clear what information is wanted in which report. After that, the current possibilities should be discussed in terms of time and data availability. When this is all done, a start can be made to make the first version of the report in Power BI.

4.1 Development of KPI's

After defining the stakeholders, multiple talks have been held with the production managers and the Business Information developer to discuss which KPI's can achieve the goals for the dashboard. This was a process where input was coming from both the research and the company. The meeting was planned either weekly or biweekly and lasted between half an hour and an hour, this depended on the amount of progress that had been made on the project during the period. Between the meetings new input on other dashboards was found by doing research. This input was presented to the stakeholders in the beginning of the meetings. Some ideas would be approved or slightly adapted, while others might not be too relevant for this specific company. Also, the stakeholders might be inspired by this input, which could result in ideas from their perspective as well. This was then added to the research and had to be investigated after the meeting. After repeating this process multiple times, the idea of what was expected from the reports became clearer and more specific. In the end, this resulted in a list of KPIs where all stakeholders could agree on.

Because the dashboard should be used by different levels within the organisation, one list of KPIs would not work very well. If the management level and operational level would have access to the same data, it could result in some problems:

- For both parties, there would be a lot of irrelevant data in the dashboard, which would affect the clarity of the dashboard. The whole idea of a dashboard is that all relevant data can be seen in one glance and one big list of KPI's would impede that.
- The operational level should not have access to certain data of the management level. Especially budgeting data and data about the functioning of certain departments can be very sensitive and it is not desirable that all employees would be able to see this.

In the previous chapter, there is talked about four levels in the organisation that should use the dashboard. Therefore, the next step of the development is to decide which information is needed for which role in the organisation. For all the levels a list has been made with KPIs that should be relevant for them to review daily. This is also done in the talks with the stakeholders. The production managers know best what they expect from each employee and their department and what amount of responsibility comes with that. If this is known, there can be decided what decision should be made by who and what KPIs should be available for that.

Because injection moulding and extrusion are different process, performance is not always measured by the same KPIs. Some performance indicators are used by both departments like OEE and the percentage of employees to be present. These are not connected to a certain production process and could be applied to any production hall at the company, or even at other facilities. Other variables

are more specific for a certain production process and could not be used by other departments. For every KPI, there is stated to which of the production department it can be applied (or both).

Production manager:

KPI	Injection moulding	Extrusion
OEE total	X	X
_Zprepconf tons processed		X
Weight per meter/ savings in material used (Barco qc value– measured weight per meter)(bmsvision – meters)		X
Machine stops (log)	X	X
Labour hours vs. Act labour hours	X	X
Number of failures per production cluster per day	X	X
Percentage of being present, reasons of absence as pareto	X	X
Failure percentage	X	

Table 5: Desired contents of dashboard for production managers

Technical assistants of production manager:

KPI	Injection moulding	Extrusion
OEE Total	X	X
OEEa, OEEp, OEEq	X	X
PressureMelt+TempMeltAct weight per meter/ quality (shown as index number)		X
Savings in materials used per article, production order and production line		X
Number of failures per part of machine	X	X
Pareto internal failures	X	X
Which machine is connected to which silo	X	X
Failure percentage per machine, tool and article number	X	
Screw load/Pressure ration (sign of machine wear)	X	X

Table 6: Desired contents of dashboard for technical assistants of production managers

Shift leaders:

KPI	Injection moulding	Extrusion
OEE per shift (especially last few shifts)	X	X
PressureMelt + TempMeltAct weight per meter/ quality (shown as index number)	X	X
Index number above also from last shifts	X	X
Recorder hours in ATPS	X	X
Pareto internal failures	X	X
Tested/ not tested (shown as percentage)	X	X
Material input/ Material savings		X
Failure percentage per machine, tool and article number	X	
Setup times compared to norm	X	
Work in progress (now in SAP)	X	

Table 7: Desired contents of dashboard for shift leaders

Operators:

KPI	Injection moulding	Extrusion
OEE per production cluster and machine	X	X
PressureMelt+TempMeltAct weight per meter/ quality (shown as index number)		X
Material input/ Material savings		X
Work in progress (now in SAP)	X	
Planning per production line (current and next product)		X

Table 8: Desired contents of dashboard for operators

Because many KPIs are overlapping, there has been chosen to put the desired KPIs for the four different roles in the company in two dashboards: one dashboard on the tactical level and one dashboard on the operational level. This has the advantage that is immediately very clear on which control level you are looking at the data. When making four reports, the report for the shift leaders would have contained analyses on both the tactical and operational level. While it is not uncommon that one person acts on different control levels, it is important that the person doing it is aware of this. Therefore, there has been chosen for the structure with a tactical and an operational dashboard, where the shift leaders will have access to both the tactical and operational dashboard. Naturally, the tactical dashboard will be accessed by the production managers and their technical assistants and the operational dashboard will be accessed by the operators. The KPIs for both dashboards can be divided into four categories, so information on a certain topic can be found easier and quicker. These different categories can be found on a separate page, which can be navigated to from the homepage.

Efficiency	The efficiency page will contain all information about the efficiency of the machines in the production halls.
Material	The material page will contain all information about the input and output of the machines in the production halls.
Labour	The labour page will contain all information of employees and the current activities.
Quality	The quality page will contain all information of the status of produced goods and the equipment in the production halls. On the tactical level, these subcategories will be put on separate pages, because there are too many analyses to be put on one page and it this way they will be placed in a structural way.

Table 9: Different pages on dashboards

For both levels a visual representation of the possible contents of the dashboard has been made. This has been presented to a group of stakeholders (Level 1, people present from Levels 2 and 3 and the site director), so they could give another round of feedback to make sure the contents would be a good representation of what is wanted by the company.

For the tactical dashboard, the efficiency page should contain information on the OEE, as a complete number as well as divided into the factors of the calculation method for the OEE (OEE is the product of OEE-a, OEE-p and OEE-q, these are explained in appendix C). Also, the machine stops should be recorded by a logging system. The material page should contain information about the amount of material processed (for extrusion in tons weight and for injection moulding in number of products), the weight per meter per product and an overview of which machine is connected to which silo. The labour page should compare the hours that are budgeted and scheduled for certain activities and the actual time it takes. Also, the percentage of time employees are absent, and the most common reasons should be displayed. The quality pages contain data on both the quality of the products as well as the quality of the equipment.

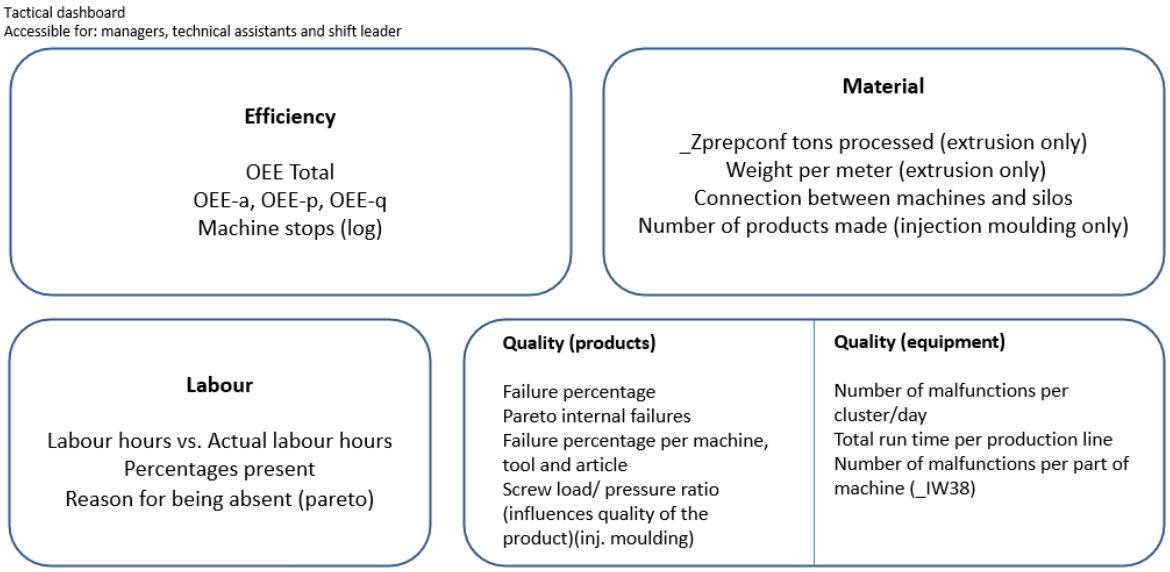

Figure 7: Desired contents for tactical dashboard per category

On the operational level, the pages are planned to be a lot simpler. The efficiency page should show the OEE, as a whole and per shift. From the last 3 shifts values will be displayed, so they can be compared. The material page should show the live status of the pressure and temperature in the machine, as well as the number of materials processed. The labour page will be about the planning and work in progress. Also set up times to switch between produced products will be recorded and compared to the norm. The quality page will show the frequency of failures and the percentage of products that have been tested.

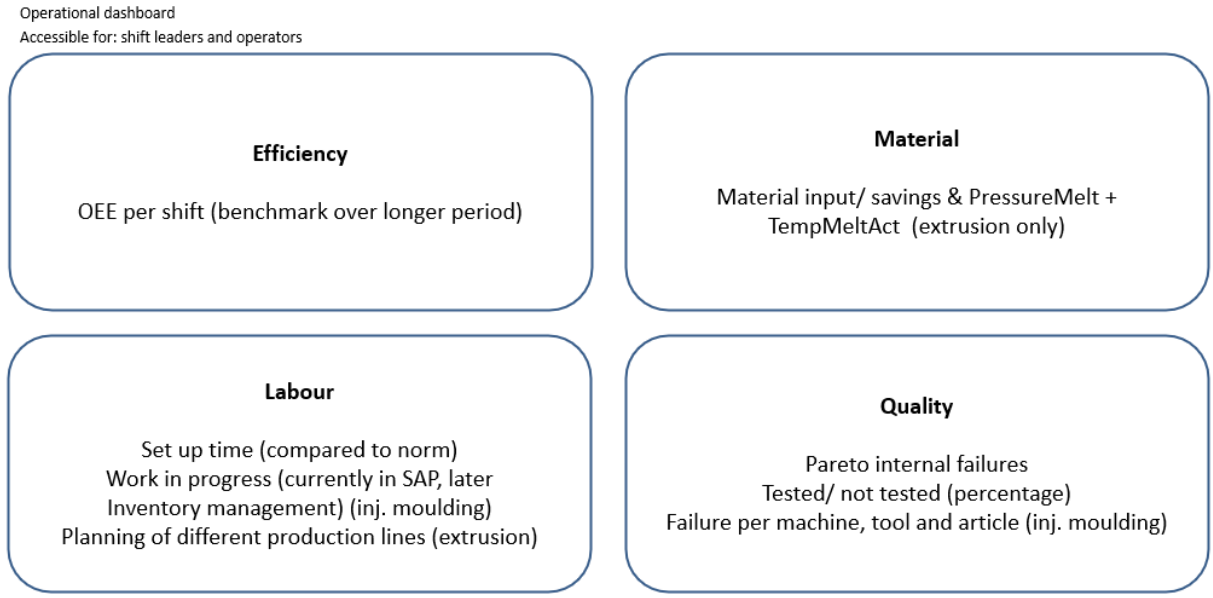

Figure 8: Desired contents for operational dashboard per category

4.2 Data availability

For these KPI's, the availability of the data has been checked together with the Business Information developer and the Data engineer operations. Some desired visualisations are already possible, while other wishes will not be possible for the coming period. This can take some weeks, but in some cases, it might also not be possible this year. The lack of data availability can have different reasons:

- The information is available but not in the dataset. For information to be added in Power BI reports, it must be in the connected data set. Because the company just started working with Power BI last year, a lot of data is still in other locations. There are possibilities to link datasets to a Power BI data, but this often requires the latest version of programmes. For example, with SAP, this is not available and the company. The transition to the newer version will take until at least next year and therefore a lot of data will not be available until then.
- Information must be added manually. When making reports, it is important that all data is up to date. Especially on the operational level it is crucial that new data is added as fast as possible to get to the right conclusions. A solution for this can be SharePoint lists, but the company just started with this and therefore information is currently not available for Power BI.
- Information is not recorded by machines. This is especially a problem for the material pages of the dashboards. Currently the first machines are acquired that can keep track of temperature and pressure in real time, but that is only the beginning when moving towards a production plant where this can be track everywhere. On top of that, calculations to determine the weight per meter seemed more advanced than expected and are not finished.

The current availability of the data is shown below. The fourth column shows whether the data is available at all and the fifth column shows if the data is ready to be used in Power BI.

Variable	**Injection Moulding**	**Extrusion**	**Data available**	**Already in data set**	**Further comments**
_Zprepconf tons processed		X	X	X	
Failure percentage	X		X	X	
Failure percentage per machine, tool and article number	X		X	X	Currently no reason available
Index number PressureMelt + TempMeltAct from last shifts	X	X	X	X	
Labour hours vs. Act labour hours	X	X	In development		
Machine stops (log)	X	X	N/A		
Material input/ Material savings		X	Only from E24 machine		
Number of failures per part of machine	X	X	X	In _IW38	
Number of failures per production cluster per day	X	X	N/A		Only shows machine stops now
OEE per shift (especially last few shifts)	X	X	X	X	
OEE total	X	X	X	X	
OEEa, OEEp, OEEq	X	X	X	X	
Pareto internal failures	X	X	X	In Excel	Can be made available via SharePoint list

Percentage of being present, reasons of absence as pareto	X	X	X	X	
PressureMelt + TempMeltAct weight per meter/ quality (shown as index number)	X	X	X	X	
Recorded hours in ATPS	X	X	X		
Savings in materials used per article, production order and production line		X	X		
Screw load/Pressure ration (sign of machine wear)	X	X	Only from E24 machine		
Setup times compared to norm	X		N/A		Norm is known
Tested/ not tested (shown as percentage)	X	X	X	X	
Weight per meter/ savings in material used (Barco qc value– measured weight per meter)(bmsvision – meters)		X	N/A		Calculatable
Which machine is connected to which silo	X	X	N/A		Connection can be made in the future
Work in progress (now in SAP)	X		X	Only in SAP	Future via live inventory management

Table 10: Data availability tactical dashboard

Variable	**Injection Moulding**	**Extrusion**	**Data available**	**Already in data set**	**Further comments**
Failure percentage per machine, tool and article number	X		X	X	
Index number Index number PressureMelt + TempMeltAct from last shifts	X	X	X	X	
Material input/ Material savings		X	Only from E24 machine		
OEE per production cluster and machine	X	X	X	X	
OEE per shift (especially last few shifts)	X	X	X	X	

Pareto internal failures	X	X	X	In Excel	Can be made available via SharePoint list
Planning per production line (current and next product)		X	X		Works via Power BI
PressureMelt + TempMeltAct weight per meter/ quality (shown as index number)	X	X	X	X	
Recorder hours in ATPS	X	X	X		
Setup times compared to norm	X		N/A		Norm is known
Tested/ not tested (shown as percentage)	X	X	X	X	
Work in progress (now in SAP)	X		X	Only in SAP	Future via live inventory management

Table 11: Data availability operational dashboard

Mapped KPIs

Now the data availability is known, the KPIs and data that will be used in the dashboard can be mapped. This will be for the efficiency, material, labour and quality page.

Efficiency

The recorded data for the efficiency page is all based on the OEE. This is the fraction of time a machine is making a good product. It can be divided in three factors:

- OEE-A: the fraction of time the machine is running
- OEE-P: the fraction of runtime the machine is producing
- OEE-Q: the fraction of produced goods that is good

Along with the total OEE, these are the only four KPIs that are recorded by machines. In the different visuals they are filtered on time, department, machine and article. More about the visuals will be in Section 4.4.

Sum of OEE	Overall equipment effectiveness (OEE-A*OEE-P*OEE-Q)
Sum of OEE-A	Part of time machine is in service
Sum of OEE-P	Part of time a machine is producing when in service
Sum of OEE-Q	Part of produced units that is OK

Table 12: Recorded data used for efficiency page (source: _BMSVISION table)

Material

For the material page, there are currently two ways to measure the size of the production. Firstly, the number of raw materials processed can be recorded. Furthermore, the number of products produced can be recorded. For extrusion, the amount of material processed is more relevant while injection moulding looks more at the number of products produced. However, both graphs give valid data for both measuring ways, so the can both be added to the material page. In the different visuals they are filtered on time, department and machine. More about the visuals will be in Section 4.4.

Sum of Net Weight	Total weight of products
Sum of Production Quantity	Total quantity of products made

Table 13: Recorded data used for material page (source: ZPREPCONF table)

Labour
For the labour page, there is currently no relevant data available for the operational dashboard. Employee data is available, but this is too confidential and should only be put into the tactical dashboard. That is why the labour page will be left blank intentionally for now.

Quality
The quality of the produced products can be measured by two different measurements. The first way to show the outcome of the tests is two have two options: OK or not OK. It could also be shown more elaborately. In this way the item is either good, bad, not tested, high or low. Both options have their uses, so they will be used both on the quality page of the operational dashboard. In the different visuals they are filtered on time, department, machine and article. More about the visuals will be in Section 4.4.

Bevinding Naam	OK/ Not OK
GFHL	Status of product (OK, Not OK, not tested, high, low)

Table 14: Recorded data used for quality page (source: _BarcoQC_Steekproef)

4.3 Roadmap for manufacturing dashboards

Because there is limited time left and there is limited data availability, the choice has been made to focus on making one dashboard as part of the assignment. This will improve the quality and increase the chance that at least one dashboard can already be partly implemented after the summer. Because the data availability is currently better on the operational level, this will be the dashboard that will be produced as far as possible. Where data is missing, we replaced the desired analyses by analyses from the tactical dashboard that could also be useful. When the right data is available, these visuals can be replaced by the desired ones. For the labour page we chose not to replace any analyses, because a lot of data there is confidential and should not be accessed by large amounts of employees. Therefore, this has been left blank intentionally.

For the tactical dashboard, the plan is already in this report and presented to the company. If sufficient data is available, another employee should be able to create the tactical dashboard by following the guidelines of this assignment. However, it is very important to evaluate the current guidelines at the time. A lot can change in this relatively short period and therefore it should be checked if all wishes are still up to date before starting to build the dashboard.

4.4 Designing the operational dashboard

Structure of the dashboard

The dashboard consists of six pages. First, there is the front page. This contains the seemingly most important visuals from all categories. Also, from this page there can be navigated with buttons towards the four pages dedicated to one of the categories. The next four pages all contain information on one of the categories. The last page contains practical information, like the producer and the owner of the dashboard. This is useful when someone does not understand something or there are problems with the dashboard. Data on the different production departments can be

filtered by ticking the right box on the right-hand side of the pages. The top box should be ticked in data from the extrusion department should be visible and the bottom box should be ticked if injection moulding visuals should be shown. Above these boxes, a calendar is placed to change period of the visible data. This does not work for all visuals, because some visuals are locked on a certain period.

Explanation per page

Front page

On the left-hand side of the front, efficiency visuals are placed. A material visual is placed on top of the page and below this one visual and two tables are placed for quality control. They will be elaborated later, because they are exact copies from the other pages.

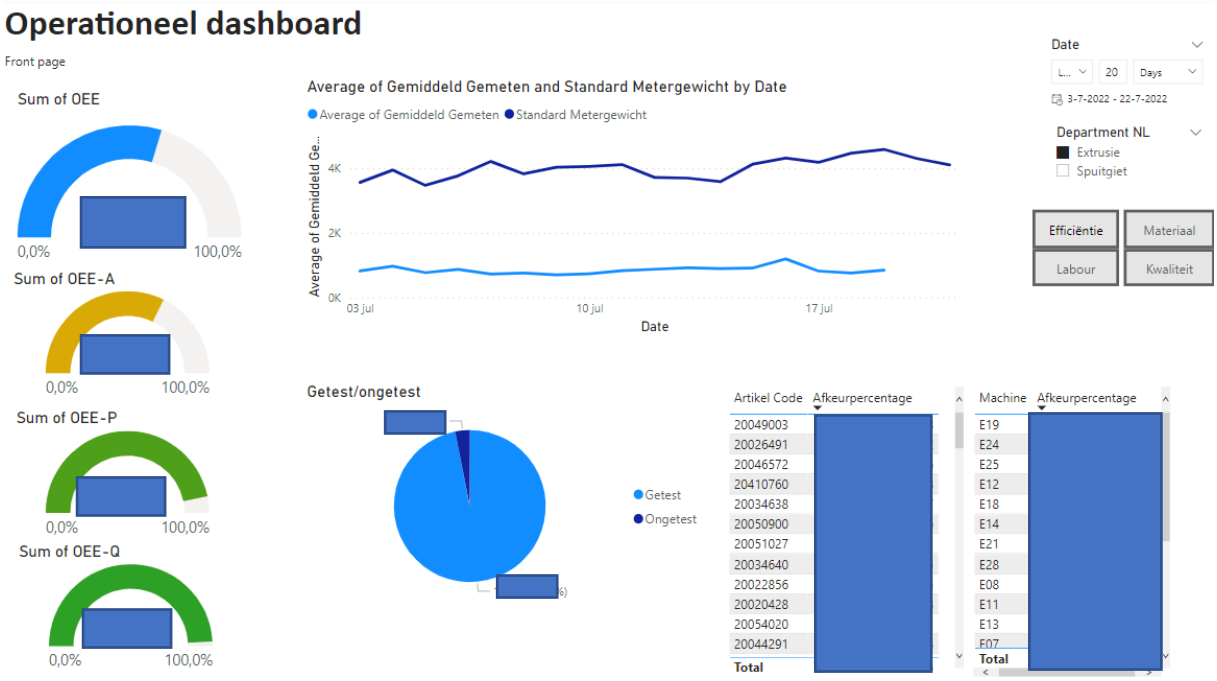

Figure 9: Front page before feedback

Efficiency

In the top left corner, three gauge visuals are placed. Gauge visuals are not in the chart chooser (Abela et al., 2010), but are even simpler to understand a single value. The left one shows the OEE of the last completed morning shift, the middle one shows the last evening shift and the right one shows the last shift. The OEE is the fraction of time when a machine is producing good products. Under these visuals, the OEE of the last 14 days is visible, so a development can be spotted without having to apply the calendar table. This is a fitting visual, because there is a change over time with few periods and only a single variable (Abela et al., 2010). On the right-hand side, two table are added to look at the worst performing products and articles in terms of efficiency. Tables are also not in the chart chooser (Abela et al., 2010), but they seem to be the best visual here. The main reason

for that is that the exact values are important to know is a certain product or machine is performing well. At the bottom, the OEE is divided into the three different factors:

- OEE-A: the fraction of time the machine is running
- OEE-P: the fraction of runtime the machine is producing
- OEE-Q: the fraction of produced goods that is good

The tables and gauge visuals at the bottom can be filtered by using the date slicer. For the other visuals the data period is locked, so it always gives comparable information.

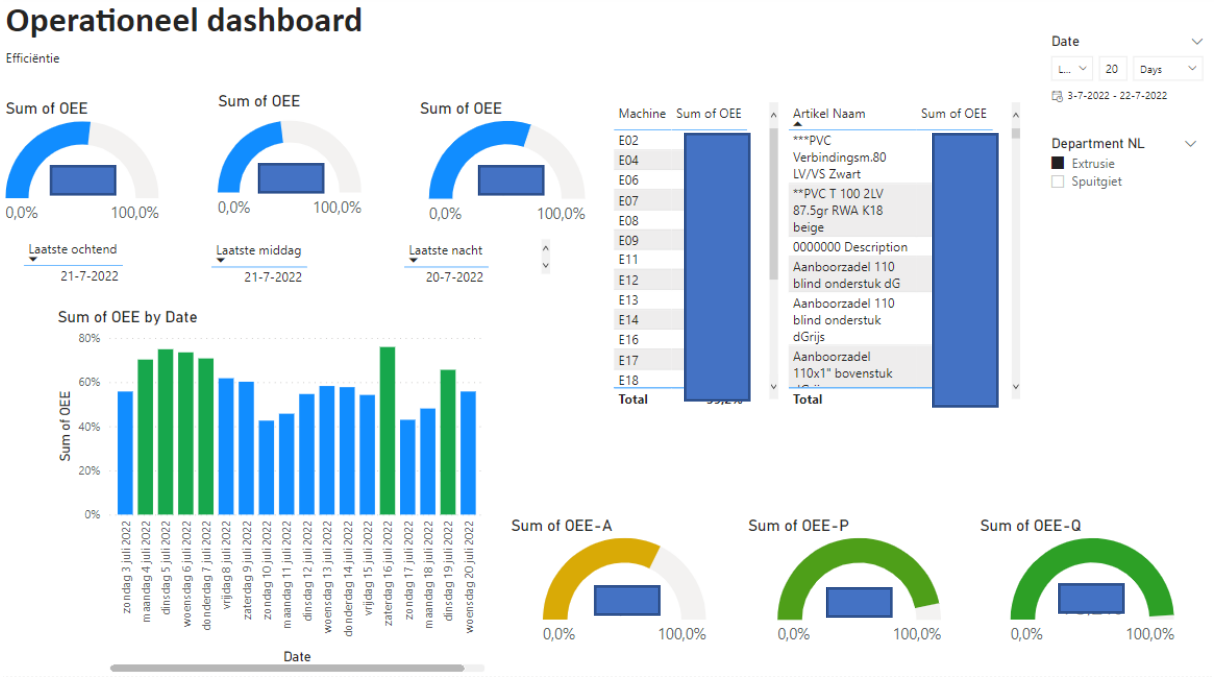

Figure 10: Efficiency page before feedback

Material

The net weight of material processed and the number of products is being filtered per machine. The chosen visual is a bar chart, because there is a comparison between the machines in the production halls. It is not comparing values over time and they both only show one variable (Abela et al., 2010). The values are in descending order, so the machines with the biggest production are always on the left-hand side. However, this does not necessarily mean that this are the best performers, because easier to produce products can always be made at a higher speed and bigger tubes will always process more materials per time period. The time period and department can be filtered on the right-hand side.

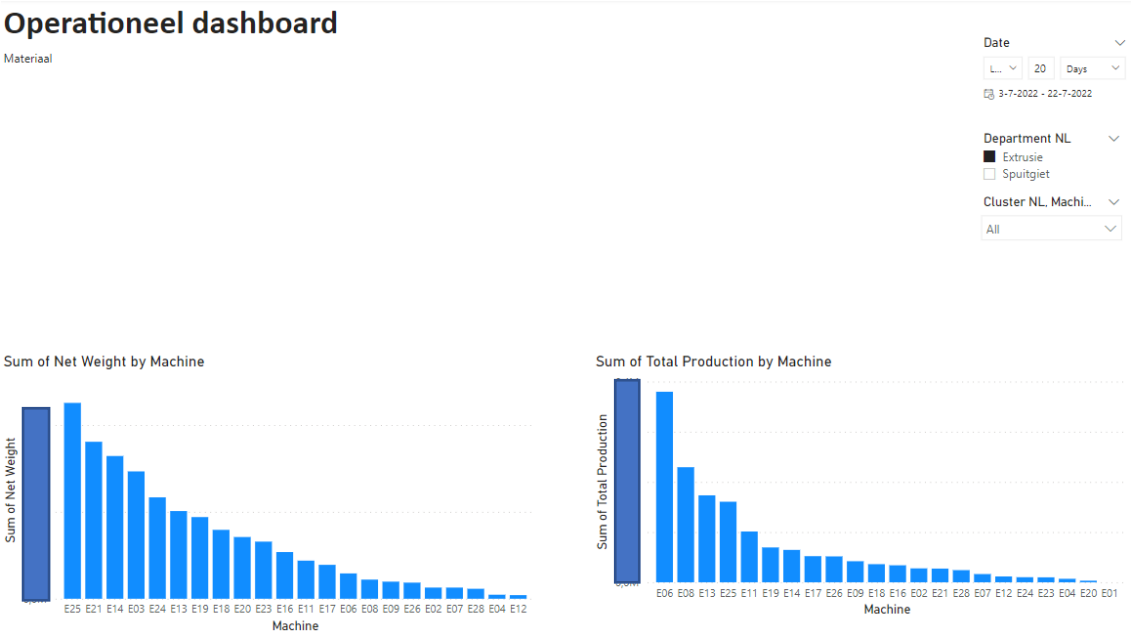

Figure 11: Material page before feedback

Quality

In the top left corner of the quality dashboard the status of the performed tests is displayed. It shows which fraction of the total is a passed test, a failed test, untested, high or low. There is chosen for a pie chart, because a composition of the single shares of the total of products is shown (Abela et al., 2010). Next to the pie chart, two tables are shown with the failure percentage per article code and per machine. There is chosen for tables, because the exact values can be seen in this way. This can be useful when one wants to do calculations on for example costs of a certain failure percentage. Underneath these table are also visualized as a bar chart. This is a good option, because one variable is compared with values not changing over time (Abela et al., 2010). All visuals can be filtered by date and department on the right-hand side.

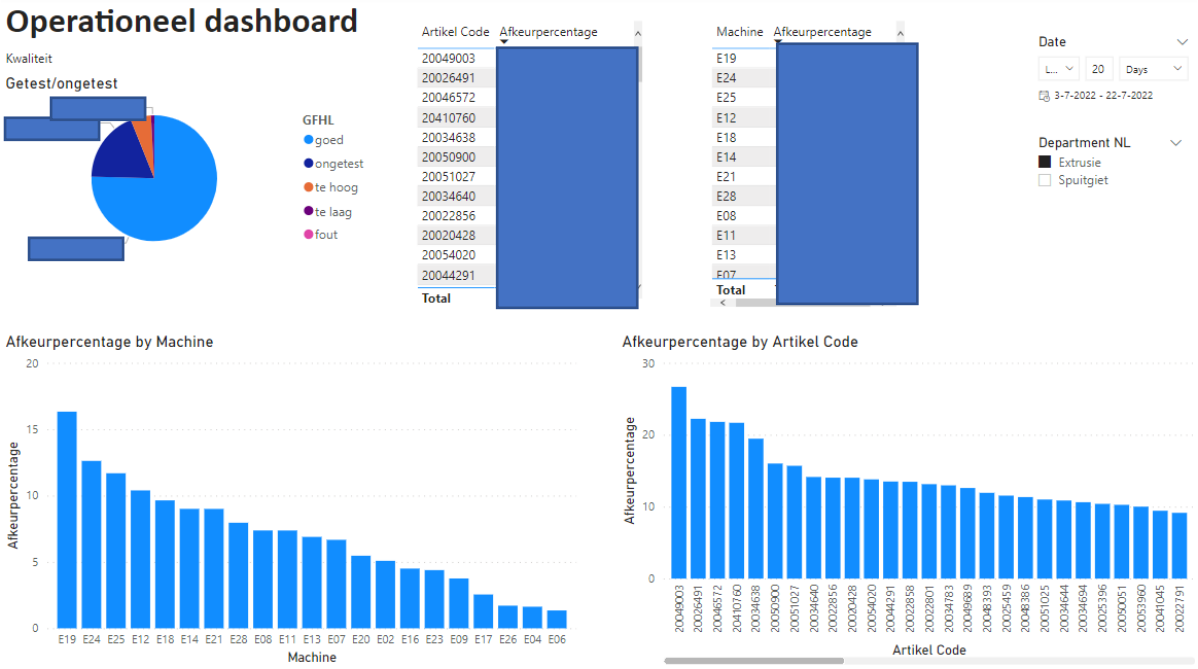

Figure 12: Quality control page before feedback

5. Improvements and implementation

In this chapter a first impression of the operational dashboard will be reviewed by performing a survey. A survey is not the ideal way of reviewing a dashboard, but for this assignment there was no time to test the dashboard by using it. The results of the survey will be processed and a conclusion will be drawn of which area needs most improving. Also, other small improvements will be considered. This feedback will be taken back to Power BI and after the new version is finished, the changes will be explained in the report.

5.1 Feedback

A survey has been made based on Section 2.4.4 to review the first version of the operational dashboard. Questions that can be asked in a user experience questionnaire can be divided in six categories (Schrepp, Hinderks and Thomaschewski, 2017):

- Attractiveness: Overall impression of the product. Do users like or dislike it? Is it attractive, enjoyable or pleasing?
- Perspicuity: Is it easy to get familiar with the product? Is it easy to learn? Is the product easy to understand and clear?
- Efficiency: Can users solve their tasks without unnecessary effort? Is the interaction efficient and fast? Does the product react fast to user input?
- Dependability: Does the user feel in control of the interaction? Can he or she predict the system behaviour? Does the user feel safe when working with the product?
- Stimulation: Is it exciting and motivating to use the product? Is it fun to use?
- Novelty: Is the product innovative and creative? Does it capture users' attention?

No questions have been asked about the stimulation or the novelty of the dashboard, because for now it will not help in improving the dashboard. The phase the current dashboard is in is not advanced enough to really tell if it is stimulating enough to use and the novelty will be more relevant if the visuals containing more live-data are in there.

So, for now, thirteen questions have been asked in four different categories. Firstly, the attractiveness of the dashboard was questioned. Here, a distinguishment has been made between the aesthetic attractiveness and the clarity of the dashboard. They are both about the visual aspect of the dashboard, but very different. It is not only important that it is nice to look at, but also that information is visible in a good way. This is especially important when ongoing activities might be controlled by Smart Operators in the future (Kolberg and Zühlke, 2015).

The next few questions were about the actual information the dashboard displays. For information to be useful it is important that the right visualization is chosen for each analysis (Abela et Al.,2010). Also, should the right filters be chosen and should the visuals be accompanied with the right explanation in the titles and axis. Lastly, a more general question is asked about the potential of the analyses to be actually used.

Then questions are asked about the easiness of use the report, which focuses more on experienced users. Two questions are about the usability for an experienced user, like navigating and filtering data. Next, there are questions about the introduction of new users. Because the reports will also be used by employees that are not familiar with data analysis yet, it is important that it is clear what amount of training will be needed for the implementation of the dashboard.

Also, a box is added for further recommendations and tips. When getting all questions answered, it should give a good image of how the dashboard is currently looking. The entire survey can be found in Appendix C. The survey has been filled in by the stakeholders in level 1 of the stakeholder wheel. This has been done after presenting the presenting the dashboard at the company and explaining all the visuals on the pages. After that, the stakeholder could ask questions on certain visuals. Lastly, they filled in the questionnaire and gave other tips on both the dashboard and the report.

Results

The first three sets as of questions are asked in such a way, that a high rating can be described as the most positive. The last set of questions about the amount of necessary training was asked the other way. Here a low score would be the most positive response.

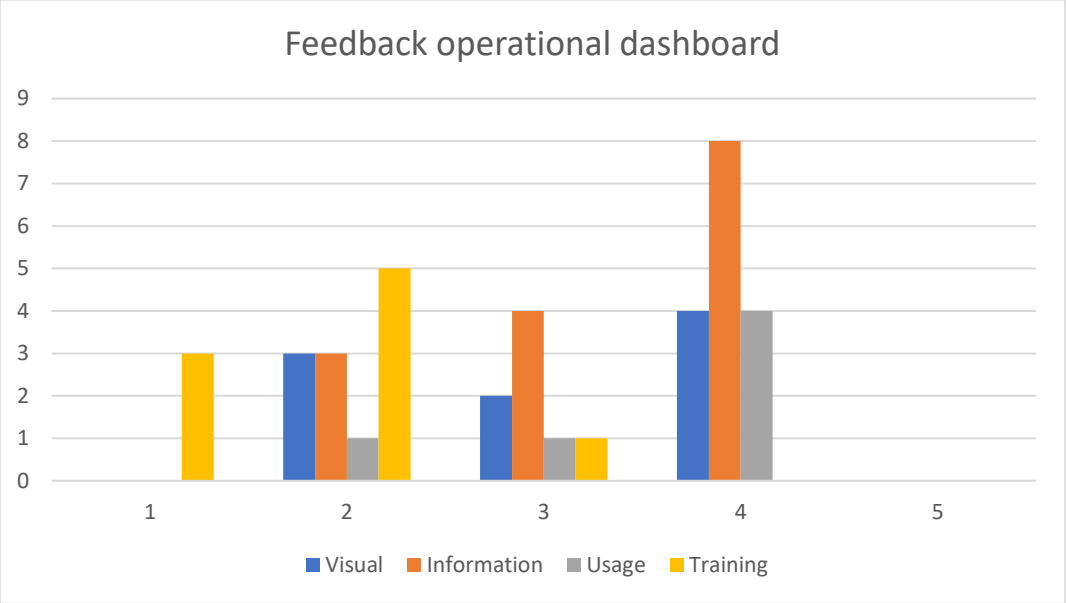

Figure 13: Results of the feedback forms about the first version of the operational dashboard

For all sets of questions, the number of times a certain answer is given can be counted. This results in the bar graph above. Because for one of the questions sets the questions are asked in a different way, calculating the weighted average of the answers per set might give a better representation of the responses. For the last set of question, a column has been added to translate the score in a comparable number.

Question set	Weighted score	6 - (weighted score)
Visual	3,11	X
Information	3,33	X
Usage	3,50	X
Training	1,78	4,22

Table 15: Weighted averages reviews

The criteria that are scoring worst based on the reviews is the attractiveness with a weighted average of 3,11. Especially question 2 if the dashboard gets very bad results. Because the attractiveness is also the easiest part to improve when there is limited time available, there is chosen to focus on improving this part. That the clarity of the dashboard is the main part to improve also show from the other comments given by the production managers. They can be found below.

Business information developer:
"This is a good start. This dashboard can be worked out further so we can use it after the summer break."

Manager injection moulding:
"Think about the layout (width of headers, number of decimals, descending/ ascending order, tables on the same height on the page, et cetera)."

Manager extrusion:
"You should create clarity by simplicity. Titles of figures could be shorter and border around the figures would be nice. Also, there is no navigation button back to the home page."

5.2 Improvements dashboard

To improve the attractiveness and clarity of the dashboard, the most important changes had to be made in the visuals. Titles and axis explaining the visuals were vague and visuals were too big or too small and not in the right location. Also, the number of decimals was not right and the order of values was sometimes wrong. Below can be found the lists of improvements and underneath can be found screenshots of the unimproved and the improved dashboard. Above these figures, the improvements will be explained in more detail. A description of the visuals itself can be found back in Section 4.4.

Improvements that have been to improve the attractiveness:

- Visuals that belong together are the same size and placed on the same height on the page
- Tables are filtered on article code instead of the article name
- The variables in table have been given shorter names to make the column narrower
- Untitled visuals have been given a title
- All values are in the desired descending order

Other improvements:

- Navigation buttons have been added to return to the home page
- Default material visual on front page is replaced by efficiency visual
- Default pie chart on front page is replaced by visual on quality page
- Material visuals can now also be filter per production cluster

Front page:

The first change that has been made is to replace the line chart with a visual from the efficiency page. It did not show valid information and therefore it is better that is removed, otherwise decisions might be based on wrong information. The bar chart with the OEE from the last two weeks is added, because it can be useful to see how the OEE has evolved over the last period at first sight. Also, the formatting of the tables has been changed. The column names have been made shorter and the number of decimals has been decreased to a reasonable number according to the stakeholders. Lastly, the tables have been made smaller and visuals have been placed on the same height for attractiveness.

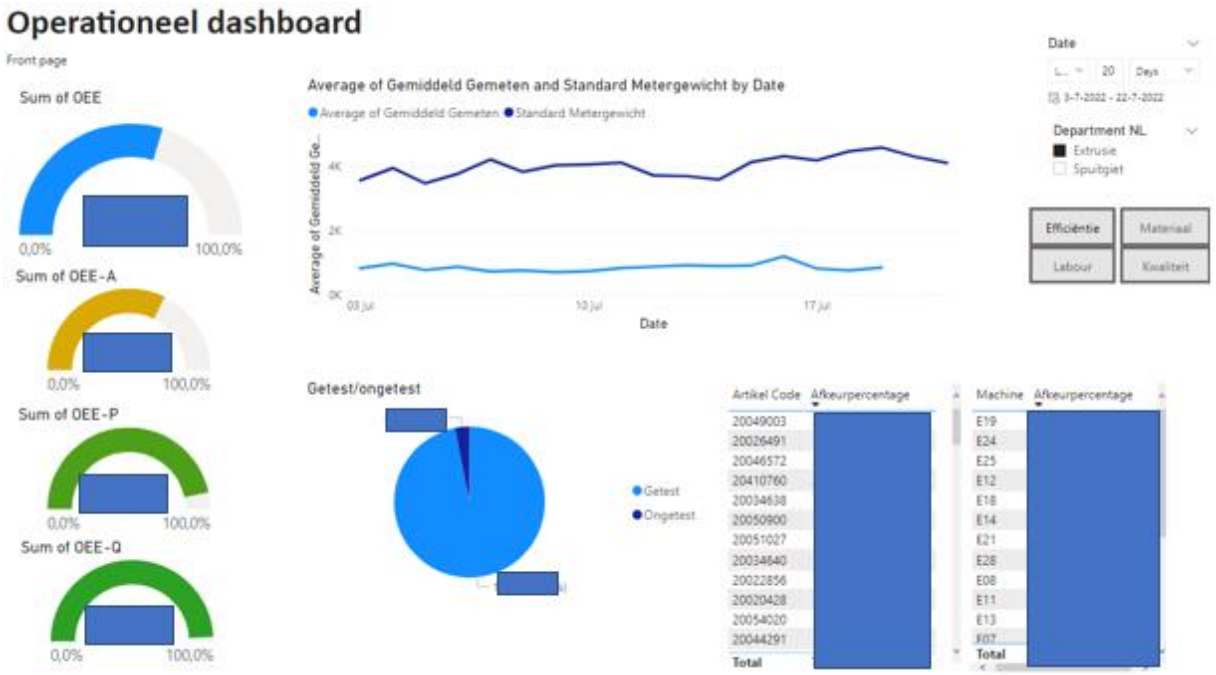

Figure 14: Front page before processing feedback

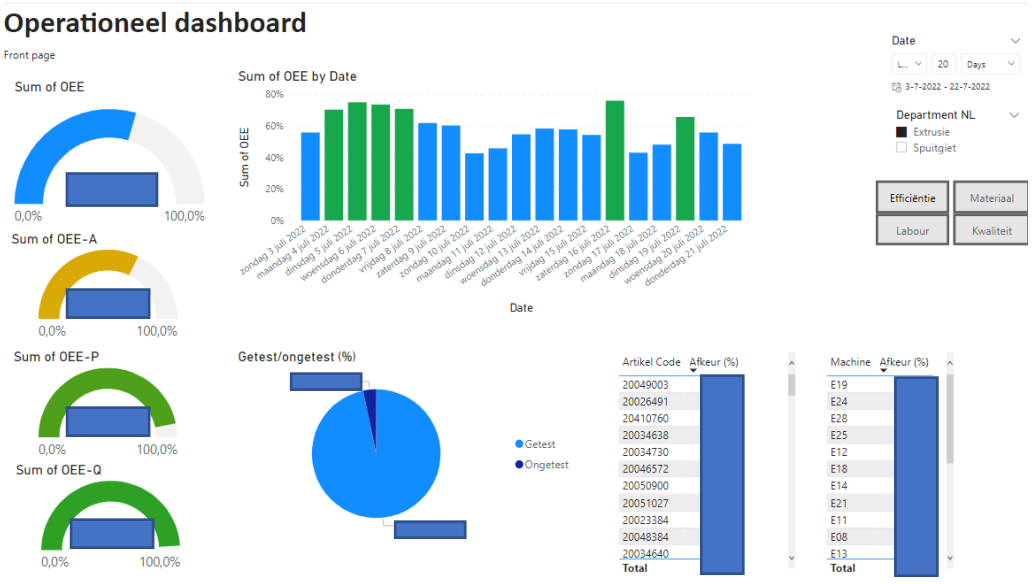

Figure 15: Front page after processing feedback

Efficiency page:

The only visuals that have been here are the tables. Titles have been added to explain what is displayed in them. Also, the input of the right-hand table is changed from the product name to the product code. This name is clearer, because it is always in the same format. Furthermore, a navigation button has been added to go back to the front to improve the usage. Lastly, the tables have been made smaller and visuals have been placed on the same height for attractiveness.

Figure 16: Efficiency page before processing feedback

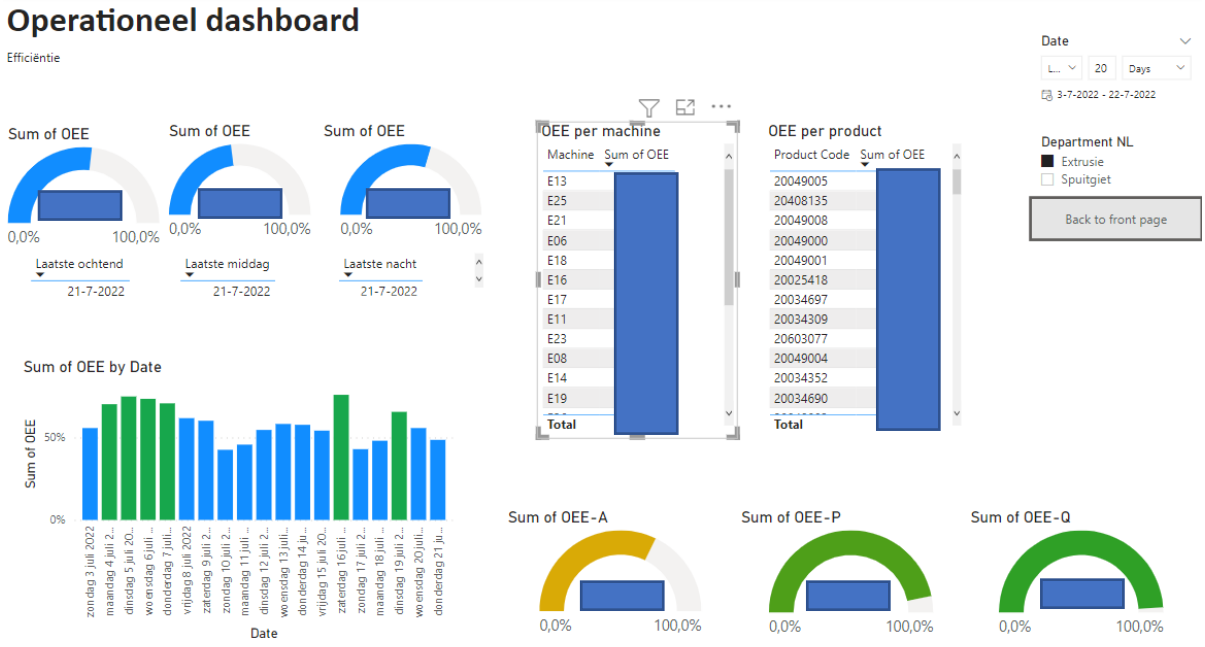

Figure 17: Efficiency page after processing feedback

Material page:

On the material page, not a lot has changed in the improved version. The visuals have been given clearer, translated names to make it easier to use. Furthermore, a navigation button to the front page have been added.

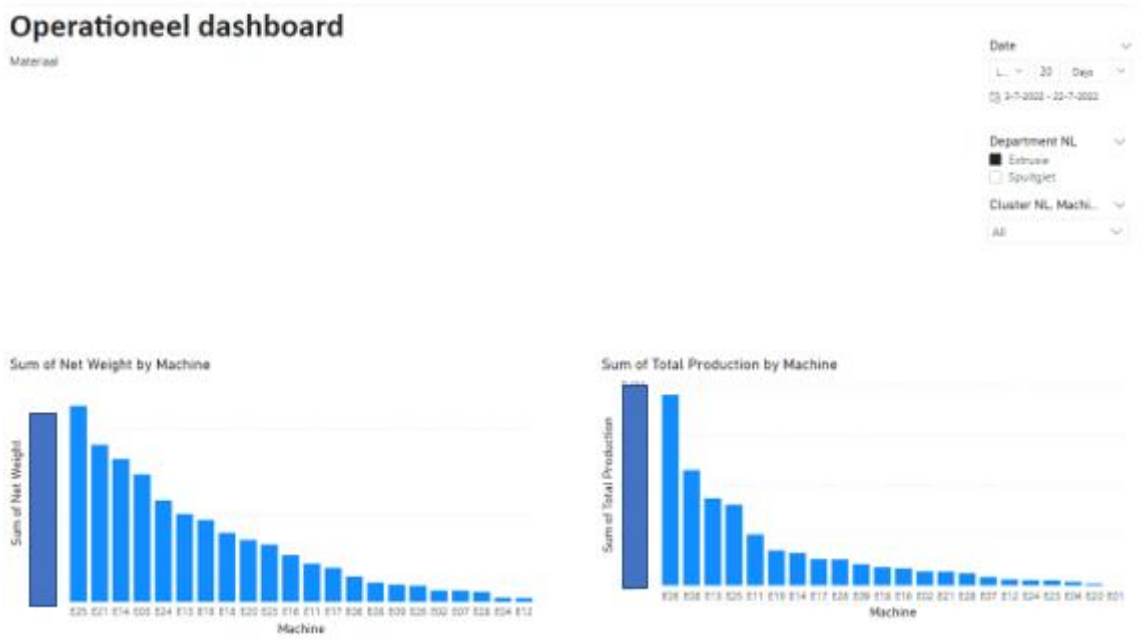

Figure 18: Material page before processing feedback

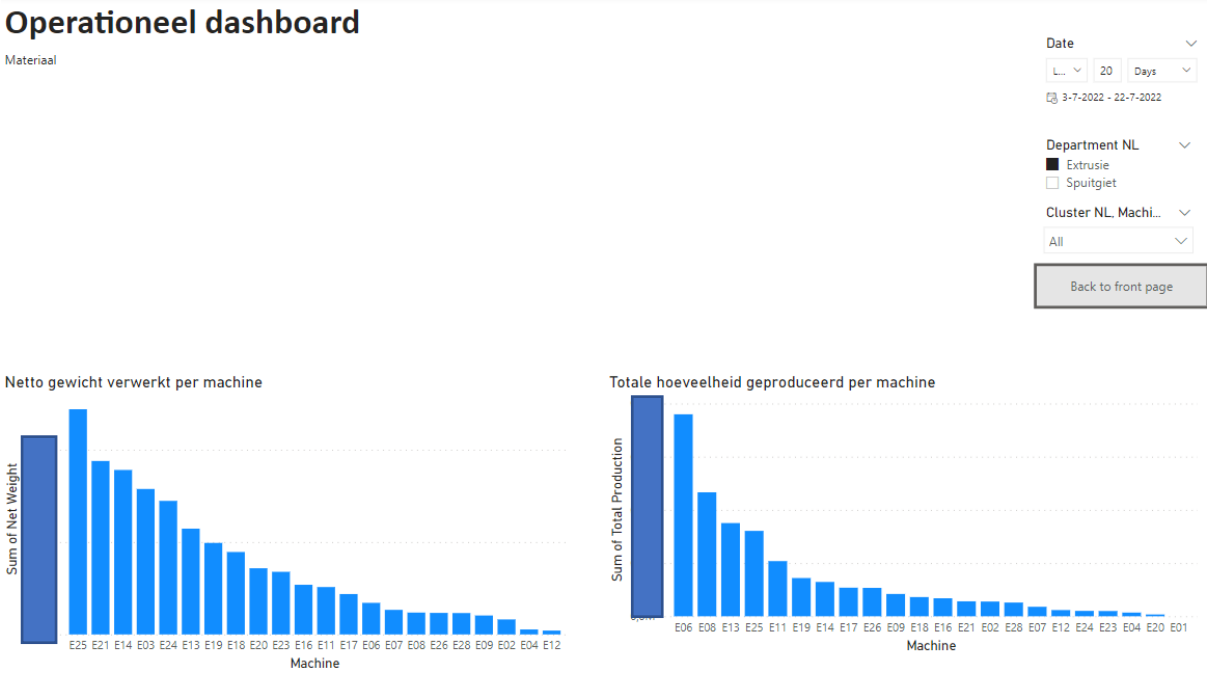

Figure 19: Material page after processing feedback

Quality page

On the quality page, the tables have also changed. Titles have been added, column names have been changed and the number of decimals has been decreased to a reasonable number. The changed column names can also be seen in the bar charts at the bottom. Furthermore, the navigation button to the front page has also been added to increase the easiness of use. Lastly, the tables have been made smaller and visuals have been placed on the same height for attractiveness.

Figure 20: Quality page before processing feedback

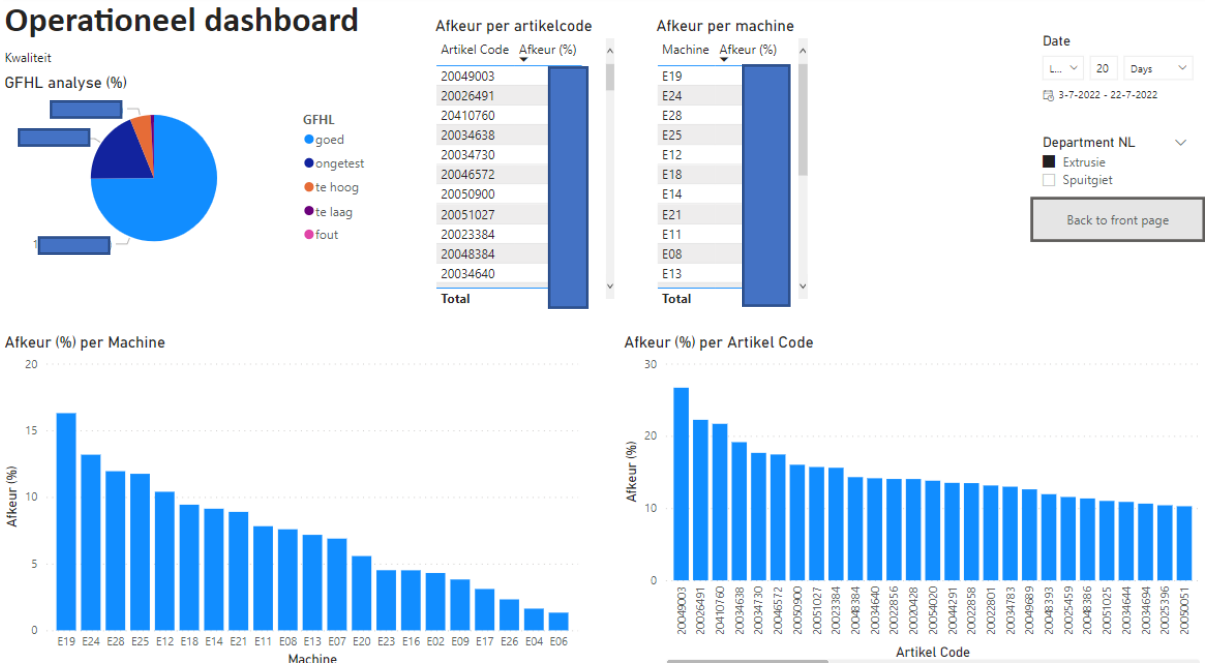

Figure 21: Quality control page after processing feedback

5.3 Implementation

When the dashboard will eventually be ready to use, it will take some effort to implement it into the daily business of the company. This must go in phase, because it is not possible to shut down the plant, adapt everything and start up like nothing happened. This would have big consequences on the amount of produced goods. Therefore, it important to have structure in a continuous transition towards a situation where the reports are being used in both production departments. The eight steps of the Implementation model we are using for this, are: create urgency, form a coalition, create a vision, communicate the vision, empower to act on the vision, create short-term wins, build on change and anchor the changes (Kotter, 2012). This can help to implement the dashboard into the company, especially when one is facing resistance from employees as described in Section 2.4.4.

1. **Create urgency:**
   For people to accept change, they should have the feeling that the change is very much needed. This can be created by explaining the development in the production industry as a whole, where live data analysis becomes more and more important. To keep a good competitive position in the plastic pipes industry, the company should keep improving their efficiency.

2. **Form a coalition:**
   It is also important that enough people are supportive of the change. If not, enough people are on board, the developments will go very slow, if they happen at all. For this dashboard, it is important that the users are part of the coalition. The department managers are on board, it is their tasks to make the other users in the department aware of the urgency of this change. Also, the site director is very enthusiastic about the possibilities of Power BI and therefore he is also supportive of the change.

3. **Create a vision:**
   Especially when the first version of the dashboard will be used, it might not be immediately clear that the dashboard would have a positive effect on the operations in the production halls. A vision has to be created to sketch the possibilities of this new feature when the dashboard is developed more and everything is finetuned.

4. **Communicate the vision:**
   Now a vision is created, it has to be communicated to the people at the company, so they will also be more likely to get on board with the solution.

5. **Empower to the act of vision:**
   In this step, the barriers that are impeding change have to be tackled. This will most likely have to do with the resistance of employees. Here it is very important to be a good listener when employees are seeing problems with the change. Especially older workers with more experience seems to have this aversion in a stronger way (Venkatesh, Morris, Davis and Davis, 2003). In some cases, this attitude towards employees can even lead to new insights. When something can be done with this insight to improve the dashboard. The employees will feel involved and empowered.

6. **Create short-term wins:**
   In the evaluation phase, the adaptions have been the short-term wins, because it improves the functioning of the dashboard. In the first testing phase as recommended in Section 7.4, more improvements could be made. In the case that the performance of the test group will be significantly better than of other shifts, this can also still be seen as a short-term win.

7. **Build on change:**
   During the implementation, improvement points can be found to increase the effectiveness of the dashboard. This should not only happen during the test phase, but should be a continuous process. A dashboard will never be perfect and there is always room for improvement.

8. **Anchor the changes:**
   When the change is completed. It has to be made sure that this will remain the way of working until a request for a new change is there. The new way of working should be part of the new culture at the company. It is the responsibility of the managers and the site director that this culture will be protected. As long as they are satisfied with the new way of working, this should not be a problem.

Timeline for implementation

This assignment is not the start of the development in the company towards a bigger online environment in Power BI. The Business information developer is already focussing a lot on getting more data available and processing this into the online reports. That is why a few steps of the implementation model are already done. The urgency is already created and the coalition is formed. The site director is enthusiastic about the project and most managers are also on board. The Business information developer created a vision and knew well what the opportunities of the BI tool and data analysis are. He communicated the vision with the company as well. That already concludes the first four steps.

Step 5 is not fully done at the company. Department have been involved a long time ago, but this project is not only decision for managers and technical assistants. Shift leaders and operators will use this operational dashboard and therefore the also have be convinced that it is of added value. This should be done after the summer break, when the dashboard will be finished and shown to other employees of the department.

Step 6 should happen shortly after. This does not mean that all employees will use the report immediately, but they could start with one shift leader with his team. In this way the dashboard can be tested for a few weeks and be improved based on their experiences.

Steps 7 and 8 are more continuous processes. The dashboard will never be finished and new opportunities with more live data might come up over the years. Therefore, building on change remains important and no period can be assigned. Anchoring the change should also be done until a solution is on hands that is clearly better. As long as the current site director and managers run the operations, this should not be a problem, because all see a future in the development towards Power BI. They should just control the situation under their management and make sure the situation remains like it is when the solution is implemented.

6. Conclusion and recommendations

Dyka BV is a plastic pipes manufacturer in The Netherlands. It has its headquarters and production facility in Steenwijk. Only in The Netherlands there are multiple competitors in the plastic pipes industry and therefore it is important to keep a good competitive position in this market. To improve the performance of the production plant, they acquired a new Business Intelligence tool. This should ease decision-making by having one central environment with validated information. Currently some reports are already made, but not to the extent that is desired by the company. Especially the extrusion and injection moulding departments are interesting for expanding the report environment, since they are the biggest producers and have a lot of recorded data already. For this research, the idea is to work towards this centralized environment in Power BI a structured way. This resulted in the research question below.

Main question: How to develop an effective performance measurement dashboard to make optimal use of data for the production department of a plastic pipes manufacturer?

Because not all features that are preferably wanted by the company are possible now, the dashboard is not the sole deliverable. The focus of the research is also about the process towards building a dashboard and the way to improve the dashboard in the future.

6.1 Conclusion

In order to answer the research question, an answer has to be given to the other knowledge questions first.

1. *How can the reporting strategy help to improve the performance of the production department?*

   First, the usefulness of the new reporting strategy should be discussed. Who should benefit from the new reporting strategy and in what way? If it turns out a dashboard is not the right tool for this, the project would be a waste of time and effort in the first place and therefore it is important to do this analysis.

   The person that is most involved with this development is the Business information developer. Talks with him made it very clear in what direction the company wants to go with Power BI. Not only the short-term goals were mentioned, but also the goals for over the next few years. For this first sub-question, those might be even more important to serve as a guidance in working towards a manufacturing report.

   The reporting strategy should help in creating an environment without situations where people are not deciding on the same information. The new centralised way of reporting will automatically provide all authorized people with the same standardized up-to-date reports, that can be filtered by the wishes of the users. This will prevent employees from making decisions based on unverified analyses. This will improve the overall insight into operations and therefore improve the performance of the production department.

   The improved performance of the production departments is important to keep the competitive position on the market of plastic pipes manufacturers. More about this can be found in Section 2.4.1.

2. *What are important criteria the reporting portfolio has to meet?*

For the portfolio to be useful, it has to serve the purpose of that portfolio. Very advanced analysis can be made, but these are useless if they do not display the right information that is needed for decision making. Also, which person will see which information is an important factor, since all employees within the company have different tasks and therefore will require other information.

To answer this question, discussions have been held with all possible stakeholders. In this way the scope of the research could be defined. When having a small group of stakeholders left, literature research has been done to find criteria that are usually important for manufacturing dashboard. After discussing this with the select group of stakeholders, it became clear what was expected from the report.

Firstly, the newly added reporting portfolio should display data that is relevant when measured in shorter periods, so it can be used on lower levels of control and therefore complement the existing strategic manufacturing dashboard. Because the dashboard will be used on the tactical and operational level, it is also crucial that the dashboard is simple and easy to use. Employees with little to none experience with data analysis will also use the dashboard and they should be able to get the right information without too much effort. Also, when the dashboard will be displayed on tablets and smart watches, they cannot be too complicated in terms of filters. Details on the dashboard criteria can be found in Sections 2.4.1 and 3.1.3.

3. *What are the most relevant KPIs for the production department?*

If the type of desired information is known, it is important to make this measurable. The right KPIs have to be chosen to give the right information at a glance. This will have to be discussed with the stakeholders, because they are the ones that will use the dashboard, either themselves or people from their department.

Multiple talks have been held with the closest stakeholder to define the lists of KPIs. Proposals from studies have been presented and afterwards the production managers gave their opinion on them. They commented on the existing ideas and came up with new one themselves. After repeating this process a few times, a complete list of desired KPIs came out.

The relevancy of KPIs depends heavily on the function of the user. Distinction has been made between production managers, their technical assistant, shift leader and operators. They all have their own tasks and responsibilities within the organisation, which means they also need different information to do their job well. More on this can be found in Section 3.2.

All KPIs of this production site can be divided into four categories: efficiency, material, labour and quality. Their relevancy depends on the type of analysis one wants to perform. But for managing the production departments in the best way possible, a good balance should be existing between these categories. Focusing too much on a good performance in one of these areas might result in worse performances at other disciplines. For that reason, KPIs of all categories are put together in one dashboard. The desires KPIs per category can be found in Section 4.1.

When looking at data availability, for now the efficiency KPIs are most relevant. Most data are already available and can be used immediately in the report. In the future, more data will be available and a good balance should be found again.

4. What quantitative analysis in Power BI will give added value to the production department?

Now the analysis will have to be added to Power BI. The right visuals have to be chosen, so the data actually provides information. Unfortunately, many data is not currently available. Therefore, the list of KPIs first had to be filtered on availability. The rest of the analysis could be worked out later, just like the tactical dashboard.

For performing the analysis, first a draft version of the dashboard with the help of the tutorials provided by the internet and the company has been made. This has been presented to the stakeholder in combination with a survey. They filled this in and gave other comments, after which the dashboard was improved to what it is now. This can be found in Section 5.2.

In terms of efficiency, the OEE remains the most important value to measure performance. However, there are many different applications for this variable. While on a tactical level the development and factors of this number might be most important, the operational level will only look back a few shifts.

The way of analysing the material use is different for the two production department: while injection moulding focuses on the number of products that are made, extrusion mainly looks at the tons of material that are processed. A huge wish for the extrusion department would be to calculate the savings by reducing the weight per meter, but this is not possible for now.

Labour analysis will be mostly about employees on the tactical level. The amount and reason of absence could become important analyses. For the operational level, this is confidential and there can be looked and the work in progress and planning in the near future. Also, this data is not currently available as can be seen in Section 4.2.

Quality analysis could be divided into the quality of produced products and the status of the equipment. Because of limited data availability, the equipment quality is hard to analyse. The focus with product quality should be on the failure percentage of products and the percentage of the products where quality tests are performed.

5. In what ways can the portfolio be expanded in the future?

Because it is a short assignment, not everything can be realised to make a perfect functional dashboard. Therefore, making a road map was also part of the assignment. This part is as important as the dashboard, since it will provide the desired structure for future development. The roadmap consists of both the work-in-progress that comes with the manufacturing dashboard as well as a list with desired data from other departments that should be added to the data base in order to create a central environment with information.

For answering this question, another talk has been held with the managers of Quality Control, Maintenance and Warehouse and Logistics. It was already clear that they would not get involved in the development of the manufacturing dashboard, but what the missing data was not exactly clear. For the missing parts of the manufacturing dashboard, no more discussing was needed, since a list of desired KPIs is already in Section 4.1.

The development of the report portfolio mainly depends on the speed at which desired data becomes available. A clear visual is delivered which contains the desired contents of both the tactical and operational dashboard. When more data is available, more relevant visuals could be added. The current data availability can be found in Section 4.2

Also, data other departments than injection moulding and extrusion should be added to the central data base in order to create one report environment for the whole company. The first department where this transition could be done are Quality Control, Maintenance and Warehouse and Logistics. The list of missing data is in Section 3.3

After answering the knowledge questions, the main question can be answered:

Main question: How to develop an effective performance measurement dashboard to make optimal use of data for the production department of a plastic pipes manufacturer?

The company wants to make more use of data analysis in order to improve the performance of the production departments at the company. This can be a good tool to do this, because it creates insight in current situations at the company and will make decision-making easier and faster. Currently, many decision-makers have their own local file. This can work, but might result in conflicts between employees where both stakeholders are use different models and values. A central environment with validated data can prevent this from happening. Before investigating what information is exactly wanted in the new environment, it is important to understand the exact way decision-makers are currently working and what their vision is on the development towards Power BI is in the future. After this is known, a step-by-step approach can be followed:

Stakeholder analysis

First of all, the group of stakeholders that is important for the development of the dashboard should be determined. Especially in such a short period it is important that the stakeholders that are giving input are the most important ones. For the dashboard it is crucial to get enough useful input, but too many stakeholders might result into too much information and complicity in planning meeting with them.

Important criteria

After that, the criteria that the dashboard has to meet can be discussed. This is very important, because it has to be clear what goal the dashboard is going to serve. Especially the expected users and the decision that have to be made with the dashboard are important factors for later, when the contents of the dashboard will be discussed.

KPI selection

The next step is to decide on relevant KPIs. They should help in achieving the goals that are set previously. The stakeholder should be asked what they want to see in a dashboard and a list should be made with this information.

Dashboard structure

Because the last few steps have resulted in lists of criteria and KPIs, it is important to filter this information. One of the properties of a good dashboard is that is has to be very clear. When information is shown in a messy way, it will not be effective to use it. Therefore, it is important to decide which KPIs can be put together on the level of reports and later which KPIs should be on the same page.

Data availability

Because not all data will be available in the right format, this has to be checked before starting to work in visualization software. Data not being available is a very common problem when making reports and therefore this has to be checked first.

Now a dashboard can be produced. It is best to keep the stakeholders involved in this process, so frequent rounds of feedback occur and the dashboard can be improved regularly. Ideally, a first version of the dashboard can be tested but due to limited time this was not possible.

6.2 Research limitations

Firstly, time available for this research is very short, which comes with a few limitations. First of all, the scope of the research has to be kept very small. While it might have been good to include a few more stakeholder to add more insight, this would have resulted in a wish list of all stakeholders that would have been way too large to work with. Also, the review of the dashboard could have been done with an actual testing phase if more time was available. This would have resulted in better feedback then when someone's opinion is asked when looking at a dashboard for a short time.

Furthermore, the amount of data that is currently available to work with in Power BI is very limiting. Half of the desired KPIs for the dashboard are currently in other locations than Power BI when connecting to it is impossible, or the data is not available at all. This makes it hard to deliver a dashboard that can actually be used in the near future.

Lastly, it is always questionable if stakeholders give the information about a topic that will benefit the entire company. Production manager will always be looking at the performance of their own department first before looking at the performance of a company as a whole. This might result in other desired KPIs.

6.3 Recommendations

Since I am leaving the company after this research, there are a few things I would recommend for the company to do in the future:

- Focus on data availability: lots of tests are already being done to make data available that is currently not, but still a lot can be done. Especially data that is currently in other systems should be transferred to Power BI as soon as possible.
- Keep discussing possible changes of the dashboard: having frequent discussion on the contents of the dashboard will help improving the dashboard in the long-term. Some analyses might be used a lot and should be expanded, while other are not used in hindsight and can be removed.
- Test an early version of the dashboard on a small group: when testing a version of the dashboard on a small group, real experiences can be retrieved. This will be more useful than letting employees fill in surveys and will therefore lead to a better dashboard in the end.
- For the two steps above, follow the guidelines as in Section 5.3. Step 5 and 6 should be done in the net few months after the summer, while steps 7 and 8 are more continuous processes.

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Appendix

A. Stakeholder analysis

Function	Affections department with injection moulding and extrusion	Affections with Power BI project	Experience and attitude towards Power BI	Further comments
Data engineer operations	Makes reports in Excel and Power BI for different stakeholder, also for injection moulding and extrusion.	Has many tasks around the Power BI developments, mainly producing reports himself	Not really interested in developments with particular assignments, because he will not benefit from it by using reports.	Probably mainly useful person for the assignment because of knowledge of Power BI
Business information developer	Also building reports for stakeholders within the company	Tasks almost exclusively connected with the Power BI development	Interested in the report, because he is busy with all developments around Power BI.	Also, the supervisor of the assignment.
Manager injection moulding	Runs one of the production departments the assignment is based on.	Developments of the reports related to the department are very interesting, because they will give more insight into operations.	Already uses Power BI a bit, but would love to get more insight	
Manager quality control	Tests products of injection moulding and extrusion. In absolute value the most mistakes are being made here.	Can be interesting, because there is a relatively large amount of data of tests of these two departments.	Likes working in Power BI and sees opportunities for the future, but questions if it fits the scope of this assignment.	
Manager extrusion	Runs one of the production departments the assignment is based on.	Developments of the reports related to the department are very interesting, because they will	Already made his own dashboard in Power BI, but expects that a lot can be added in the future.	

		give more insight into operations.		
Manager SPS and prefab	Uses products from extrusion and injection moulding, but this is coordinated by logistics.	Not a lot of data available automatically, since many things are not automated here.	Not a possible stakeholder in this assignment	Only existing data can be put into a central report, but no real potential short-term
Manager general engineering	Coordinates project over the whole company, so depends on which projects they are currently working.	Some projects are about Power BI, but usually mostly other projects	Not a possible stakeholder in this assignment	Power BI can be useful for status and time spent on certain projects, but probably out of scope for this assignment
Manager Compounding	Processes of injection moulding and extrusion start here, so there is dependency	Currently not using it a lot, only one report about the contents of silos	Would be relevant if more live data was available	
Continuous improvement and systems manager	More general improvements on a higher strategic level	Power BI could help in certain development	Not a possible stakeholder in this assignment	
Business controller	Advises people on financial dilemmas, also the managers of the production departments.	Currently mainly using Excel for analyses	Not a possible stakeholder in this assignment	Would use the reports when finished, but not really involved in development around Power BI
Process engineer extrusion	Supports the manager of extrusion, so definitely works a lot on one of these departments	Is very involved in the transition towards Power BI and already uses this a lot	Has very clear ideas about possibilities with the assignment (section 3.3)	
Manager maintenance	Fixes failures at both at production department, so definitely	Works a lot with Power BI and also sees great potential for this	Has ideas about improvements of his department where Power BI can help, but	Mainly predictive maintenance

	connected with them		seems out of scope for this assignment.	
Manager tooling	Makes tools for injection moulding	Not a lot of data available for analysis (like SPS)	Not a possible stakeholder in this assignment	
Manager warehouse and logistics	Works more with supply chain, not so much with injection moulding and extrusion themselves	Works with power BI, but not really related to production.	Has ideas about improvements of his department where Power BI can help, but seems out of scope for this assignment.	Has clear ideas what he wants with Power BI

Table 16: Stakeholder analysis

B. Explanation dataset

The data set DYKANL_ZPREPCONF_BMS_BARCOQC-All_ATPS-Production is being used for the production of manufacturing dashboards. Currently the data set contains tables from different sources. Some of these dimension tables contain a lot of data, which will be used regularly for reports and dashboards. These tables are explained per column with a description of the information they contain. From other dummy tables only, a short description is given at the end.

Table: _ATPS

This table contains data collected by ATPS, a time registration system. It contains data from the status of employees and the duration of this. This is registered by the badges that all employees have.

Column	Description
Beschrijving	Status of employee (for example present, holiday, sick)
BeschrijvingId	Status of employees displayed as code
Datum	Date
Sum of Duur Aanwezig FTE	Time present in FTE according to transactions in ATPS
Sum of Duur Aanwezig FTE Rapportage	Time present in FTE according to the schedule in ATPS
Sum of Duur Aanwezig Minuten	Time present in minutes according to transactions in ATPS
Sum of Duur Aanwezig Minuten Rapportage	Time present in minutes according to the schedule in ATPS
Sum of Duur Aanwezig Uren	Time present in hours according to transactions in ATPS
Sum of Duur Aanwezig Uren Rapportage	Time present in hours according to the schedule in ATPS
Sum of Duur Afwezig FTE	Time absent in FTE according to transactions in ATPS
Sum of Duur Afwezig FTE Rapportage	Time absent in FTE according to the schedule in ATPS
Sum of Duur Afwezig Minuten	Time absent in minutes according to transactions in ATPS
Sum of Duur Afwezig Minuten Rapportage	Time absent in minutes according to the schedule in ATPS
Sum of Duur Afwezig Uren	Time absent in hours according to transactions in ATPS
Sum of Duur Afwezig Uren Rapportage	Time absent in hours according to the schedule in ATPS
Sum of Duur Overig FTE	Time spent in other way in FTE according to ATPS
Sum of Duur Overig Minuten	Time spent in other way in minutes according to ATPS
Sum of Duur Overig Uren	Time spent in other way in hours according to ATPS
Tot	End of certain status
Van	Start of certain status

Table 17: Time registration data table

Table: _BarcoQC_Steekproef

This table contains data of the tests performed by quality control. A test form is made, of which many parameters return in this table

Aanmaak Datum	Date of making test form
Artikel Code	Code of product that has been tested
Artikel Groep	Product group of products that has been tested
Artikel Naam	Name of product that has been tested
Artikel Naam Code	Name and code of product that has been tested
Average of gemiddeld gemeten	Average weight of measurements (must be filtered per product, otherwise it will return the average of all products)
BatchId	ID of the test
Bevinding Code	OK/ Not OK (as code)
Bevinding Naam	OK/ Not OK
Bovengrens	Maximum acceptable value
Fout	Type of failure
GFHL	Status of product (OK, Not OK, not tested, high, low)
Inspectie Plan	Defined inspection plan
InspordId	ID of made inspection order
Machine Barco QC	Machine where a certain product is being made
Maximum Gemeten	Highest value measured
Meetplaats	Used test location
Minimum gemeten	Lowest value measured
Norm	Desired value
Ondergrens	Minimum acceptable value
Opdracht	Inspection order test on order level
Opdracht type	Type of task (department)
Opmerking	Other comments
Parameter Code	Type of test code
Parameter Naam	Type of test description
Parameter Opmerking	Given comment with measurement
Parameter Status Code	Status test code
Parameter Status Naam	Status test name
Parameter Type Code	Format of result test code
Parameter Type Naam	Format of result test name
Ploeg	Shift that has performed the test
Ploeg Start Datum	Start time of a certain shift
Production Order Barco QC	Production order of tested product
Standard Metergewicht	Average weight per meter according to theory
Steekproef Grootte	Sample size
Steekproef Status Code	Status of test phase as code
Steekproef Status Naam	Status of test phase (not started, unfinished, finished)
SteekproefId	Sample ID
Test Datum	Date of test
Tester	Employee that performed the test

Table 18: Quality control data table

Table: _BMSVISION

This table contains data from the machines at the production plant. It records which tasks are done by the machines and how lang they take.

Average of production Speed	Average of production Speed
Colour	Colour of the order
Custom String	Type of production process
End Date Time	End time of a shift
Job	Task is the production process
Job End Date Time	End time of a task
Job Start Date Time	Start time of a task
Machine BMS	Machine used for order
Period	Hide
Product Code	Code of product
Product Code Name	Code and name of product
Product Ext Length (m)	Length of production (extrusion only)
Product Group	Product group
Product Meter Weight	Weight per meter of product (Extrusion only)
Product Name	Name of product
Product Standard Speed	Usual speed at which a product is being made
Product Tool	Hide
Product Weight	Weight of product
Production Order BMS	Order number according to BMS
Recipe Code	Code of recipe for a product
Record End	Recorded end time of order
Record Start	Recorded start time of order
Required Quantity	Required quantity of a product
Sequence Number	Hide
Shift Sequence Number	Number of certain shifts
ShiftAndSeqId	ID of a shift
Standard Piece Length	Length of a tube
Start Date Time	Start date and time shifts
Stop Number Auto	Hide
Stop Number Change	Hide
Stop Number Decl	Hide
Stop Number Interval	Hide
Stop Number Other	Hide
Stop Number Scrap	Hide
Stop Number Wait	Hide
StopTableId	Hide
Sum of Good Production	Total amount produced that is of good quality
Sum of Loss	Total amount produced that cannot be used
Sum of OEE	Overall equipment effectiveness (OEE-A*OEE-P*OEE-Q)
Sum of OEE-A	Part of time machine is in service
Sum of OEE-P	Part of time a machine is producing when in service
Sum of OEE-Q	Part of produced units that is OK
Sum of OEE.01.Total Time	Total available
Sum of OEE.02.Available Time	OEE.01 – Plant shutdown
Sum of OEE.03.Planned Production Time	OEE.02 – Planned stops

Sum of OEE.04.Working Time	OEE.03 – Downtime
Sum of OEE.05.Net Working Time	Extrusion: Machine speed (m/min)* (Meters produced/ Number of products per cycle) Injection moulding: Cycle time* (Number of product made/Numbers of products per cycle)
Sum of OEE1.Plant Shutdown	OEE.01.Total Time – OEE.02.Available Time
Sum of OEE2.Planned Stops	OEE.02.Available Time - OEE.03.Planned Production Time
Sum of OEE3.Downtime	OEE.03.Planned Production Time - OEE.04.Working Time
Sum of Quantity Good Production (EX)	Number of products produced (OK)
Sum of Quantity Loss (EX)	Number of products produced (Not OK)
Sum of Quantity Total Production (EX)	Number of products produced in total
Sum of Stop Time Auto	Total stop time due to auto
Sum of Stop Time Change	Total stop time due to change
Sum of Stop Time Declared	Total stop time due to declared
Sum of Stop Time Interval	Total stop time due to interval
Sum of Stop Time Other	Total stop time due to other
Sum of Stop Time Scrap	Total stop time due to scrap removal
Sum of Stop Time Wait	Total stop time due to wait
Sum of Total Production	Total amount produced
Tool	Used tool
Unique	Unique ID of a record
User String	Used material

Table 19: Recorded machine data table

Table: _ZPREPCONF

This table contains data from SAP

Act 1	Hide
Act 2	Hide
Act 3	Hide
Base Unit	Unit (m, kg, pieces)
Cancellation Indicator	Hide
Comments	Comments
Confirmation Ctr	Hide
Confirmation Number	Hide
HU-Number	Package number (qr code)
Machine SAP	Machines in production hall
Operation Plan Number	Hide
Plant SAP	Production plant (NL or BE)
Previous Yield Base Unit	Hide
Production Order SAP	Production order
Production Order Unit	Unit (m, kg, pieces)
Reversal Indicator	Hide
Shift	Type of shift
Shift StartDate	Start date of shift
Shift StartDateTime	Start date and time of shift
Shift Starttime	Start time of shift
Sum of Gross Weight	Total weight of product and packing material
Sum of Labour Hours	Total hours worked by employees
Sum of Machine Hours	Total hours of machines in service
Sum of Net Weight	Total weight of products
Sum of Production Quantity	Total quantity of products made
Sum of Scrap Quantity SAP	Total weight of scrap according to SAP
Sum of Setup Hours	Total setup hours
Unit 1	Hide
Unit 2	Hide
Unit 3	Hide
UploadDateTime	Scan moment when order is picked
Weight Unit	KG

Table 20: ERP-system data table

Table: Date

Time is displayed in different formats

Date	Date (weekday + DDMMYYYY)
Day	Day of the month (1 tm 31)
DayOfYear	Day of the year (1 tm 366)
DimDateId	YYYYMMDD
ISOWeek	Week of year (1tm53)
ISOWeekName	Week of year (W1tmW53)
Month	Month number (1tm12)
MonthName	Month name
Quarter	Quarter (1tm4)
QuarterName	Quarter (Q1tmQ4)
Weekday	Weekday (1tm7)
WeekDayName	Weekday (name)
WeekOfMonth	Week of month (1tm6)
WeekOfYear	Week of year (1tm53)
Year	Year
YearISOWeekName	Year + week number
YearMonth	Year + month number
YearMonthName	Year + month name
YearQuarter	Year + quarter

Table 21: Date table

Table: kostenplaats

This table shows different location where costs are being made

KostenplaatsNaam	Location where costs can be assigned (code + name)
KostenplaatsCode	Location where costs can be assigned (code)
KostenplaatsOmschrijving	Location where costs can be assigned (name)

Table 22: Kostenplaats table

Table: Machine Groups (SharePoint lijst, handmatig in te vullen)

Deze tabel filtert productielocaties op verschillende manieren.

Cluster EN	Machine groups in English
Cluster NL	Machine groups in Dutch
Dep.	Department
Department BMS	Department code in BMS
Department EN	Department name in English
Department NL	Department name in Dutch
Department SAP	Department code in SAP
Machine	Machines on location
Machine Description	Machines on location
Plant	Producing plant

Table 23: Machine Groups table

Table: Material

This table shows all products in different formats, so they can be filtered

AVI NL Product Type	Product group
Base Unit of Measure	Units
External Material Group Code	Production processed used (as code)
External Material Group Name	Production processed used
Gross Weight	Gross weight of product (including packaging)
Material Code	Code of product
Material Group Code	Code of product group
Material Group Name	Name of product group
Material Name	Name of product
Material Name Code	Name and code of product
Material Type	Type of product
Net Weight of Item	Net weight of product
PPS Hierarchy L01 Code	Material hierarchy DYKA group level 1 Code
PPS Hierarchy L01 Name	Material hierarchy DYKA group level 1 Name
PPS Hierarchy L01 Name Code	Material hierarchy DYKA group level 1 Name + Code
PPS Hierarchy L02 Code	Material hierarchy DYKA group level 2 Code
PPS Hierarchy L02 Name	Material hierarchy DYKA group level 2 Name
PPS Hierarchy L02 Name Code	Material hierarchy DYKA group level 2 Name + Code
PPS Hierarchy L03 Code	Material hierarchy DYKA group level 3 Code
PPS Hierarchy L03 Name	Material hierarchy DYKA group level 3 Name
PPS Hierarchy L03 Name Code	Material hierarchy DYKA group level 3 Name + Code
PPS Hierarchy L04 Code	Material hierarchy DYKA group level 4 Code
PPS Hierarchy L04 Name	Material hierarchy DYKA group level 4 Name
PPS Hierarchy L04 Name Code	Material hierarchy DYKA group level 4 Name + Code
Weight Unit	G or KG

Table 24: Material table

Table: Personeel data productie

SharePoint list to calculate labour efficiency

Afdeling	Department where employee worked
Datum begin week	First day of the first week (date)
Weeknummer	Week number

Table 25: Personeel data productie table

Table: ProductionOrder

With this table you can filter on product number

ProductionOrder	Order number of products

Table 26: ProductionOrder table

Table: Shift

This table displays shifts in different formats

Shift	Display different shifts (full name)
Shift Abbr.	Display different shifts (abbreviation)
Shift Char	Display different shifts (A, B, C)
Shift Num	Display different shifts (1, 2, 3)

Table 27: Shift table

Table: Time

This table displays time in different formats

DimTimeId	Time (HHMM)
Hour	Hour of the date (00-23)
Minute	Minute of the hour (00-59)
Time	Time (HH:MM)

Table 28: Time table

Tabel: Werknemer

This table displays information about employees. It contains unique codes from badges and employees, but also information about contract types

Afdeling	Department of employee
Badgenummer	Badge number
Chauffeur	Hide
Contractvorm	Type of contract
Employeenummer	Employee number
Kaartnummer	Card number
Personeelsnummer	Employee number
Ploegendienst	Working in shifts (Yes/No)
Reiskostenvergoeding	Travel allowance (Yes/No)
Sector	Department
StandaarweekVakrecht	Number of holiday hours
Startdatum	Start date of employee
Uitbetalen	Hide
UrenVolgensKlokMatrix	Hours in ATPS
VakantieDienstjaren	Holiday according to service years (hours)
VakantieLeeftijd	Holiday according to age (hours)
Variabelwerken	Working variable hours (Yes/ No)
VerlofRecht	Rightful leave hours
VerschovenUren	Hide
WerknemerId	Employee ID
ZiekPercentage	Hide

Table 29: Werknemer table

Other tables:

Table	Description
BMSData	Shows possible analyses for data from _BMSVision
PresenceAbsence	Status of employees (same as data from _ATPS)
PresenceData	Dummy table for presence/absence
SAPData	Dummy table for calculations with SAP-data
TimeData	Dummy table for MTD and YTD
TimeTypeData	Dummy table for time units

Table 30: Other tables with description

C. Survey dashboard evaluation

Visual	1	2	3	4	5
1 The dashboard looks attractive					
2 The dashboard looks clear					
3 The dashboard contains the right number of analyses per page and is not too busy/ too empty					

Information	1	2	3	4	5
4 The analyses display useful information					
5 A logical media display is chosen to show the analyses (graphs and tables)					
6 The data is filtered in a logical way					
7 The analyses come with clear information in titles and axes					
8 The dashboard can be used for analyses on operational level					

Usage	1	2	3	4	5
9 Navigating between pages is easy and clear					
10 The filters used are in a logical place and are easy to use					

Training	1	2	3	4	5
11 There is a lot of training required to understand the dashboard					
12 Experience with Power BI is required to understand the dashboard					
13 Experience with data analysis is required to understand the graphs and tables					

Other comments
