Norit leading in purification

Nijhuis

"Once Bitten, Twice Shy"

An analysis of the lean manufacturing implementation attempt of Nijhuis Pompen B.V. in 2007 as basis for a new change program

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"The most valuable talent is that of never using two words when one will do"

Thomas Jefferson

MANAGEMENT SUMMARY

Nijhuis Pompen B.V. wants to become and remain one of the top players in the pump industry through the implementation of lean manufacturing. Lean manufacturing continuously improves the production process by the elimination of *muda* (i.e. waste) through creation of customer pull and production flow.

However, in 2007 Nijhuis already tried to implement lean manufacturing, but this process failed. Before a new implementation can be developed the earlier attempt of 2007 has to be analyzed. This reason has led to the following central research question:

In what way and to what extent does Nijhuis Pompen B.V. best implement Lean manufacturing, taking the first implementation attempt as starting point?

From the analysis of the attempt in 2007 it became clear that the basis for the implementation of lean manufacturing was not well established:

- Nijhuis' production characteristics were not taken into account during the implementation, resulting in friction between the production process and lean building blocks.
- The leadership of the project was not appropriate. The consultancy firm determined direction instead of the change agent. Moreover, communication with the consultancy firm was difficult, which invoked resistance to change.
- Employees' lack of knowledge and their negative attitude were the wrong pillars to build on. Instead of a decrease in the resistant forces to change, they were enlarged, which negatively influenced company performance.

When a sense of urgency is created, employees feel the need to change and are thus motivated. During the new implementation attempt Nijhuis' employees have to be put in the middle, since they possess more than anyone else knowledge about product and production characteristics. The process has to be managed by a change agent, who has the time, will and effort the change Nijhuis.

Two important pillars for Nijhuis' performance are throughput time and product quality, which determine the choice for specific lean building blocks. Nijhuis should start with the development of a VSM to show product flow and areas for improvement. The visibility of the production process and its bottlenecks is furthermore established through organized and clean workspaces: "5s". Along the way Quality at the Source, TPM and *Kanban* are options for performance improvement.

A product is never perfect, nor is the implementation of lean manufacturing. Nijhuis should continuously search for waste elimination opportunities through use of her employees' knowledge.

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MAJOR CONCEPT

Lean Manufacturing A systematic approach to identifying and eliminating waste (non-value-added activities) through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection.

Ch. 1 RESEARCH INTRODUCTION

The research starts with a short introduction about Nijhuis Pompen B.V.. The problem setting and focus lead to the central question. A short description of the research strategy and a visual overview of the research structure complete the chapter.

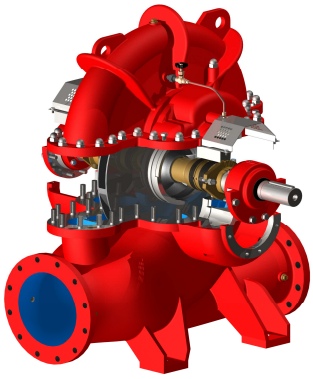

Figure 1 Centrifugal Pump

Nijhuis Pompen B.V. (or Nijhuis) has more than 70 years experience as a pump manufacturer that manufactures high quality centrifugal pumps (Figure 1) and pumping systems according to customer's wants and needs. The company was founded in 1904 by G.J. Nijhuis as a repair shop providing services to the textile industry, before switching to the pump industry. Currently, Nijhuis employs 180 persons divided over 4 locations. The headquarters is located in Winterswijk (NL), where engineering, staff, sales force and application technicians are working to deliver high quality products. Three service divisions in Zevenbergen, Beverwijk and Tynaarlo complete the Nijhuis Company. An overview of the organization is found in the organization chart (App. D).

The mission on the website of Nijhuis reads the following: ***"Nijhuis Pompen B.V. adapts its company to market needs, in order to give the best support to customers and to maintain its reputation "supplier of products with the highest quality"***. Nijhuis is continuously adapting its products to the latest developments in the market, developing pumps with the highest achievable efficiencies and offers a professional after sales service to its customers. The aim of Nijhuis is to be an innovative leader in the pump design, where the pumping system is seen as an integral part of the operating process (e.g. a sprinkler installation). For example, one of the latest developments of Nijhuis is the "fish friendly pump", which allows more than half of the fish to get through unharmed.

Nijhuis is part of the Norit *leading in purification* Group, an international conglomerate of companies with different areas of purification expertise, headquartered in Zenderen (NL). The Norit Group offers products, installations and services in every step of the water and beverage value chain. The Norit Group currently consists of eleven companies located in different continents.

Nijhuis develops, manufactures, sells and services pumpsets for different kinds of water transport purposes. At Nijhuis a distinction is made between blue and red pumpsets (see Figure 2), respectively for water transport and fire protection. The essential item of both types of products is the pump. The quality and performance of a pumpset is determined by the precision of the pump's casting. The foundry of these castings is therefore an essential part of production, which are produced in-house and extern.

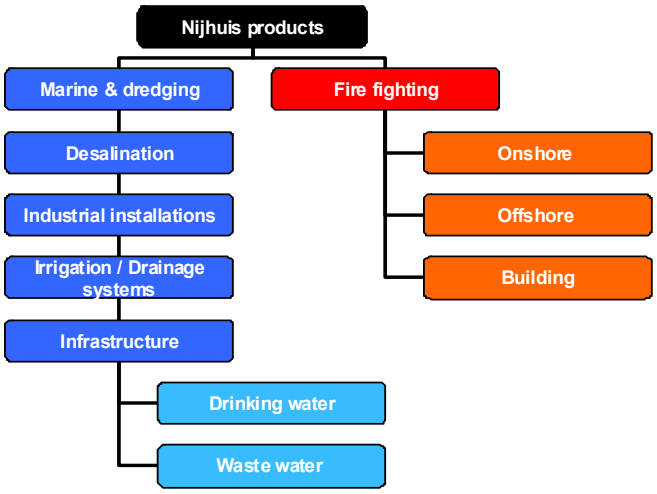

Figure 2 Nijhuis' Products

The *blue sets* are used for all kinds of water transportation purposes. The type of pump is based on the type of material that has to be moved, e.g. certain fans cannot move brackish water, and on the direction of this movement, vertically or horizontally. These sets usually consist of a pump and an electromotor.

The *red sets* are called Nijhuis Fire Protection Compact Units: complete fire pump packages with a pump produced by Nijhuis Fire Fighting. Fire can be extinguished by pumping water to its source. A fire fighting set or fire set is the means to do this. Fire sets are produced for pumps on board of fire-fighting vessels, buildings (stores, offices, etc.) and for offshore oil rigs. A fire set consists of a pump, a diesel or electromotor, a controller and varying accessories.

Complete sets undergo a performance test to see if they comply with customers' specifications. Moreover, the gathered information is used for a maintenance plan, which prevents unexpected failure. This maintenance plan relates to *Nijhuis Services*, which is charged with the installation of pumps, pumpsets, pump rooms, and complete pump stations. In addition to the installation of pumps, pumps are repaired on location or in-house. These installations are performed on turnkey basis. Further services provided by Nijhuis are instant delivery of original spare parts and training of Nijhuis' clients. The production process of a pumpset is shown in Figure 3, with four major departments:

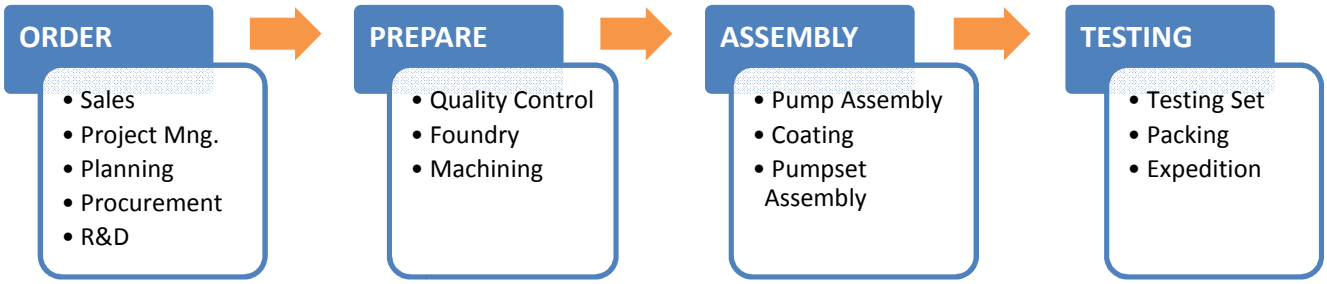

Figure 3 Production Process Pumpset

The management of Nijhuis wants to become and remain one of the top players in the pump industry by production of products that reflect demand in the best possible way. In order to reflect demand, Nijhuis' management has developed a plan, referred to as *Masterplan*, for the production departments, starting in the summer of 2009. The goals of this *Masterplan* are:

- **A rise in capacity efficiency, between 20 and 40 percent.**
- **Delivery dependence larger than 90 percent.**
- **A decrease in throughput time, depending on the type of product.**

Nijhuis' management wants to reach these goals with the implementation of lean manufacturing, starting in the beginning of 2010.

The concept of lean manufacturing is a derivative from the Toyota Production System first occurring in Japan. Womack and Jones (2003) allege that lean manufacturing is the superior way of production, as will be explained in chapter 2.

However, up to now lean manufacturing has not booked successes at Nijhuis. In 2007, Nijhuis faced a large inventory of work-in-progress (or WIP), low delivery dependence and they lacked a clear overview of the production activities. For that reason an external consultancy firm was hired to implement lean manufacturing. This firm promised Nijhuis better delivery of pumps, a flat output and visible bottlenecks. This would be accomplished through a decrease in WIP with at least factor two throughout the complete organization. The reality turned out differently. Nijhuis and the consultancy firm had different ideas about the execution of the plan. Therefore, the project terminated in September 2007. Not only the consultancy firm disappeared from the stage, but most lean manufacturing tools as well. People went back to their old habits of operation and nobody discussed the failure anymore.

§ 1.1 Central and Research Questions

Nijhuis' management is still in favor of lean manufacturing implementation, but they realize that the causes of failure in 2007 have to be addressed prior to a new implementation attempt. The aim of this research is to develop an implementation plan for lean manufacturing that takes into consideration the first attempt and available theory and literature about lean manufacturing. The central question that this research will answer is:

> ***In what way and to what extent does Nijhuis Pompen B.V. best implement Lean manufacturing, taking the first implementation attempt as starting point?***

Lean manufacturing is not only a bundle of activities that can be implemented in a company right away, companies have to adapt their culture as well. Therefore, the following research questions incorporate this dichotomy:

1) **Which aspects of lean manufacturing were implemented in 2007 and what were the major consequences?**
   a) What formed the basis for the implementation of lean manufacturing?

b) Which building blocks were implemented in 2007 and what were the results for Nijhuis?

2) **What is the employee position regarding the change agent role and level of employee participation during the lean manufacturing implementation at Nijhuis Pompen B.V. in 2007?**

The third research question combines the theoretical framework and the results of research questions 1 and 2. This question develops a plan about how to implement lean manufacturing.

3) **How is lean manufacturing best implemented at Nijhuis Pompen B.V.?**

a) Which factors need to be taken into account during a new plan?

b) In what way should Nijhuis Pompen B.V. implement lean manufacturing now and within the near future?

§ 1.2 Research Strategy

This research develops an implementation plan for lean manufacturing, based on exploration of literature and the implementation attempt in 2007. This event took place in the past, which means that data are gathered from available documents and information from employees.

Answers to the research questions are gathered through the use of both qualitative and quantitative research strategies. The data for the technological aspect are gathered through observations and available documents, which is qualitative research. The philosophy data is derived from a small questionnaire (i.e. quantitative research) distributed under and complementing interviews (i.e. qualitative research) with employees. The interviews are semi-structured, based on the results of the questionnaire and aspects surfacing during the course of the interview. Interview data are recorded to assure that no data is lost. The survey data are coded and entered in SPSS to perform the analysis.

§ 1.3 Structure of the research

Figure 4 presents the structure of the report. The preceding paragraphs introduced the research and research strategy. Chapter 2 presents the theoretical framework. This chapter starts with an overview of the principles, building blocks and relevance of lean manufacturing and continues with lean manufacturing implementation. The subject of chapter 3 is the methodology of the research. The type of research is explained and the constructs obtained from the literature framework are operationalized. The lean manufacturing implementation in 2007 is described in chapter 4, based on the gathered data. Chapter 5 presents the new lean manufacturing implementation plan for Nijhuis, in which the lessons from the first implementation attempts are compared with the prescriptive literature. The new change program is based on this comparison. This implementation plan provides the reader with a clear overview over what to do,

how and with whom. Chapter 6 is the final chapter of the research. This chapter starts with the conclusions of the research, both from the analysis as well as the new implementation plan. After that the contribution to the theory is presented. In the final section a few recommendations are discussed, which could form starting points for future research.

Figure 4 Visualization of Research Structure

Ch. 2 THEORETICAL FRAMEWORK

The theoretical framework is divided into two major parts. The first part discusses the technological aspect of lean manufacturing, like the building blocks, principles and applicability. The philosophical aspect of lean manufacturing is discussed in the second part, where the implementation is addressed. Before any company can change it has to know what it is they are changing to and therefore the chapter sequence is appropriate, although the literature often deals with the aspects turned around. The chapter ends with a short concluding section.

§ 2.1 Lean Manufacturing

Lean manufacturing combines the best of pure craftsmanship and mass production (Zijlstra, 2006). Craftsmen possess the skills to produce high quality products according to customer demand, although with low efficiency, since standardization is limited. Mass production recognizes the lack of efficiency and breaks the assembly line into many stages to enhance efficient use of resources by standardization of activities (Womack et al, 1991).

The roots of lean manufacturing are found in early automobile manufacturing. In the 50s, Eiji Toyoda and Taiichi Ohno, managers of the Japanese Toyota, combined the quality focus of craftsmen and the efficiency of mass production in the Toyota Production System. They recognized that only those processes that create value for the customer are useful and result in higher revenues.

The term “lean manufacturing” has been popularized by Womack et al. (1991) in their book: *The Machine that changed the world*. In this book they elaborate on Toyota’s success after the recognition that adding value is the primary concern of an organization. Womack et al. (1991) define lean manufacturing as:

> ***A systematic approach to identifying and eliminating waste (non-value-adding activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection.***

Value, as perceived by the customer, has to be considered during all stages of production to determine *muda* (i.e. waste). *Muda* does not add value to a product and can even negatively influence value. For example, defective products decrease perceived value. Ohno (1988) identified 7 types of waste (Table 1).

Type of Waste	Explanation
Overproduction	Producing more than is demanded by customers.
Waiting time	The time between production activities.
Movement of items	Movement of e.g. paper and material.
Over-processing	Producing products with higher quality than requested.
Inventory	The amount of WIP in stock and spare parts.
Motion of people	Bending, walking, reaching and so on.
Defectives	Products that are wrong, incomplete, defect, etcetera.

Table 1 Seven Wastes (Ohno, 1988)

§ 2.2 Lean building blocks

Lean manufacturing is realized through the implementation of so-called lean building blocks, which together form the "*the House of Lean*" (Figure 5) (Ortiz, 2006). This figure shows that companies can only enter the house by the value stream map (or VSM) stairways. According to Rother and Shook (2003), companies that

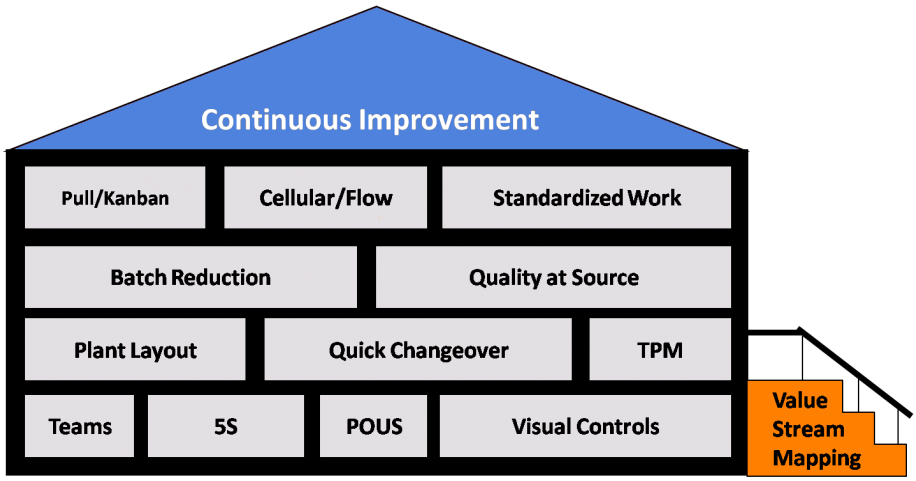

Figure 5 The House of Lean (Ortiz, 2006)

want to implement lean manufacturing or any other continuous improvement program should start with a VSM. A value stream is a sequence of activities required to fulfill a customer's request, either value adding or not. A VSM shows a picture of the complete physical and information flow, both for the current and desired situation. The current value stream shows the state-of-being and the desired situation, without waste in the

process, the future state. The differences have to be solved, because they are bottlenecks[1] in the process. The different lean building blocks in Figure 5 can be used to solve these bottlenecks.

A large number of the tools in Figure 5 enhance process flow (see Section 2.3): 5s, plant layout, POUS (Point of Use Storage), Quick Changeover, TPM (Total Productive Maintenance) and Quality at Source.
5s results in a clean workspace with the major advantage of the chance of seeing improvement opportunities to decrease waste, the prime principle of lean manufacturing.
Storing items at the place they are needed (POUS) increases flow as well. A plant layout with a low number of product movements creates flow as well. Both the production layout as well as the operations at a specific machine must flow.
Quick changeover at a machine can be established through implementation of SMED[2] (Single Minute Exchange of Dies), whereas the total productive time of machinery (TPM) is improved with OEE[3] (Overall Equipment Effectiveness).

Another group of tools positively affects customer pull (see Section 2.3): batch reduction and *Kanban*. In order to use demand as driver, production in batches has to be reduced up to the level of demand. For example, if a customer only demands one product, only one product has to be produced, but if more products are required batch production, if efficient, is required. Complete one-piece production would eliminate WIP inventory, but this is not feasible for all activities (e.g. due to capacity constraints). Companies can achieve inside pull through the implementation of a *Kanban* system. When one department finishes its task a sign is given to the upstream department to deliver a new product (LeanWoordenboek, 2009). A *Kanban* is a card that regulates pull in the system. The cards signal upstream departments that they have to produce/assembly new items to assure that the downstream department can continue its operations.

Teams are another important lean building block. Teams possess more knowledge than an individual and can accomplish more. According to Womack et al. (1991) teams are the "*hallmarks*" of lean manufacturing. Actively involved employees in the search for and debate about improvements feel more motivated and

[1] The meaning of bottleneck in the context of lean manufacturing must not be confused with the meaning in the production management literature. A lean manufacturing bottleneck is a place in the production process where a large level of waste occurs.

[2] SMED = Single Minute Exchange of Dies: setup activities are analyzed and process steps are redesigned to minimize waiting time.
[3] OEE = Overall Equipment Effectiveness: focuses on how effective a machine is running based on the hours a machine is and is not in operation.

develop skills for the elimination of waste. Moreover, teams can come up with more improvement opportunities and by that reach a higher level of perfection.

§ 2.3 Lean Manufacturing Principles

Five principles follow from the definition and lean building blocks of lean manufacturing, along which an organization will evolve and mature (Womack et al., 1991). Organizations need to **determine value** in terms of products with specific characteristics offered at specific prices through conversations with customers (Womack and Jones, 2003). Value is determined by the degree a product complements customer needs. Organizations that exactly know customer needs can continue with the **identification of the value stream** (p. 13). Along the value stream usually three types of actions occur: those that immediately add value, actions that are unavoidable for production (Type I *muda*) and actions that do not create value and are avoidable (Type II *muda*). Type I *muda* requires a lean solution to either make the activity value adding or eliminate the action. Type II *muda* requires immediate elimination, because elimination does not negatively affect product value.

The third lean principle is a counterintuitive hurdle to take. Intuitively, people assume that production in batches is more efficient (e.g. folding everything before stamping). However, they do not realize that throughput time for each product in this case is much higher, as well as the fact that storage space is required which costs money. **Flow production** addresses this issue: one piece production in order to reduce throughput time (Womack and Jones, 2003). The starting point for flow production should be the product or service that eventually ends at a customer. The product has to be ready at a specific moment, which means that departments have to adjust to meet this requirement. Companies have to know which products are required at what time: **customer pull**. Customer pull means that you only produce a product when there is demand, either from the end-user or a department downstream.

The last essential principle of lean manufacturing is the **pursuit for perfection**. There are always improvement opportunities to reduce time, effort, space, costs and mistakes to offer more perfect products to customers (Womack and Jones, 2003), which means that the implementation of lean manufacturing is a never-ending journey. The lean manufacturing philosophy should become embedded in the corporate culture to assure that every employee is searching for waste and thus improvement opportunities.

The five principles can be seen as a maturity model along which the lean manufacturing organization evolves. In the beginning a company has to understand what value is and where in the process value is added and where not. The flow and pull principles increase the performance level, with the result of a more

mature company (in the sense of company performance). However, perfection is an ideological idea, there will always be improvement opportunities.

§ 2.4 Possibilities with Lean Manufacturing

The phrase “lean manufacturing” suggests that the concept is only applicable to production. Moreover, the Toyota Production System (or TPS) was developed in the automobile industry. Yet, lean manufacturing is not restricted to mass production, but also useful for the service, construction and healthcare sector (Womack and Jones, 2005). Lean manufacturing is about finding ways to eliminate waste and through that improve the bottom-line result (Goldratt, 1998). Therefore, lean manufacturing can be applied in any organization, if adapted to company characteristics.

Automobiles are produced in high-volume, while having low-variety. These companies can adapt their production process completely towards *takt*-time, which is calculated the production hours per day divided by the demand per day. Companies with constant demand (cars) can adapt their processes to meet *takt*-time (Womack and Jones, 2003). The case is different with low-volume/high-variety production. Low-volume producers might only have a demand of one product per day or even less, which means that *takt*-time does not have much meaning. And still they can implement one-piece flow by standardization of work activities per group of varieties, which means that throughput time can be calculated up to some point. For example, fashion designers develop customized products with different materials, shapes, etcetera. But every item needs a specific labels sewed onto the item, which takes up the same amount of time every time. A low WIP inventory for high variety producers allows material and information to flow with minimal waiting time.

The production type influences the applicability of lean manufacturing as well, although Shah and Ward (2003) concluded that the implementation of lean manufacturing occurs both in continuous process (e.g. fiberglass) and discrete parts (e.g. bicycles) production, though differently. The output of discrete production is measured in units and the output of process production in volume or weight. Discrete producers are better able to cope with customer pull and JIT (Just-In-Time) production, whereas TPM tools are more often implemented by process producers where capacity utilization is necessary due to expensive and large equipment necessities. The capital investment to change is often smaller for discrete producers than for process producers (Price and Simonin), which makes the latter less flexible to change. Companies have to decide which tools are applicable to them. For example, Kanban cards are useful for discrete, but not for continuous process production. Discrete production occurs in different departments, with each department having its own resources. Process producers’ departments work with and on the same product and therefore flow is already guaranteed.

In summary, the manner of lean manufacturing implementation has to be based on the combination of the following aspects:

- **High/Low volume production**
- **High/Low variety of products**
- **Continuous process/Discrete production.**

§ 2.5 Implementation of Lean Manufacturing

The choice for lean manufacturing implementation has to be carefully discussed, because lean manufacturing alters the production process, which is the source of revenue. The transformation has to make more money with a decrease in the level of inventory and simultaneously decrease throughput time and reducing operating expenses (Goldratt, 1998).

The lean manufacturing implementation continues infinitely, resulting in a higher performance level. Not every change that is made, improves performance immediately, but taking three steps forward and one step back is better than not moving at all (Womack and Jones, 2003). Elimination in either one of the types of waste increases performance level. The following section explains the implementation of lean manufacturing.

§ 2.5.1 Getting started

Several reasons exist for the implementation of lean manufacturing (e.g. throughput time reduction, quality improvement), which makes this choice rather easy. However, actually starting the implementation is difficult. Besides considerations about company characteristics, companies have to keep in mind that lean manufacturing cannot be turned on and off (Flinchbaugh and Carlino, 2006).

Company management has to appoint a **change agent** (Womack and Jones, 2003), who actually causes the change to begin due to an undeniable feeling that there are better and more efficient production ways to strive for (Ortiz, 2006). The change agent may be the person who developed the change or someone appointed to implement the changes. A change agent convinced about the change opportunities is vital for the success of lean manufacturing (Worley and Doolen, 2006). Palmer et al. (2006) developed six images of change, based on the dimensions managing and change outcomes (Table 2). During the process of implementation the change agent performs different tasks and thus adopts different attitudes, as becomes clear in the coming paragraphs. The controlling images require the change agent to enforce the changes on the organization and employees, whereas the attitude in the shaping images is less stringent.

		Images of Managing	
		Controlling	Shaping
Images of Change	Intended	**Director**	**Coach**
	Partially Intended	**Navigator**	**Interpreter**
	Unintended	**Caretaker**	**Nurturer**

Table 2 Roles in the Change Process (Palmer et al., 2006)

The implementation of lean manufacturing involves changes intended to transform an organization (intended changes) and the limited knowledge about lean manufacturing requires management control to move in a certain direction (controlling). The image of the change agent during the planning phase is that of **director**. This image is based on the assumption that a predetermined set of steps at least achieves intended outcomes (Palmer et al., 2006). The change agent leads the change process and determines direction.

According to Womack and Jones (2003) the change agent does not need a detailed understanding of the principles of lean manufacturing; the knowledge may be well found outside the company. Yet, companies have to be careful with external knowledge, since consultants sometimes just implement changes without interest in working together (Womack and Jones, 2003). A *sensei*, or master, helps the change agent and management to obtain the required **lean knowledge**. Companies that decide to gain knowledge otherwise have to study the abundant amount of literature about lean manufacturing, the internet and company stories. Knowledge is required at the technical and social level, to assure that besides the way of operation the culture is changed as well.

A **sense of urgency** has to be established for any transformation (Kotter, 1995). Every involved individual has to understand why the decision for lean manufacturing is essential (Henderson and Larco, 2002). A department in **crisis** is a perfect lever for the implementation, with lean manufacturing as the remedy to the problems. For example, an inefficient layout resulting in high throughput times, affecting the competitive position and consequently revenue, requires a solution, which could be the creation of flow.
However, not all companies face a crisis, which means that the sense of urgency has to be created otherwise. For example, by the use of a **lean supplier/customer**, who demands products according to lean manufacturing principles (respectively pull or flow) and requires your company to adapt (Womack and Jones, 2003). To illustrate this, a lean customer needing 2 pieces of a product each week, will only order 2 pieces each week, meaning that your company only has to produce 2 pieces/week.
And then there are companies neither in crisis nor having a lean supplier/customer. These companies have to create a sense of urgency with a compatible **vision**: what are the major goals for the future (Kotter, 1995), with the focus on the company itself and not on problems in the industry (Womack and Jones, 2003). A clear

vision moves the initiated projects in the same direction. For example, the just in time delivery of products means that procurement, planning and warehouse all have to operate in the same fashion.

The change agent has to start with a thorough analysis of the current situation by drawing a **value stream map** (or VSM). The value stream gives the change agent a good understanding of the current situation and enhances the positive results of lean manufacturing.

Thus, the literature prescribes the necessity of a change agent, extensive knowledge and a VSM but obtaining **quick wins** which your company cannot ignore are also essential. The workforce should see things changing before their eyes, which is essential for the creation of *momentum* in the organization (Womack and Jones, 2003). The easiest place to start lean manufacturing implementation is final assembly, because this is the place where products have to comply with customer demand (Henderson and Larco, 2002). Quick wins can be achieved there, e.g. elimination of accessories not valued by customers.

Communication is the last essential part of the plan phase. After a short period the workforce should sit together to discuss the changes and further changes under way. The change agent should communicate freely about the proposed changes and discuss with employees about their hesitations and questions. Therefore, communication has to appear top-down and bottom-up.

§ 2.5.2 Changing the Organization

Once an environment is created where people understand the necessity of lean manufacturing, a **Lean Transformation Group** (or LTG) is needed for effective implementation of lean manufacturing, both at the organizational and production level. According to Kotter (1995) a powerful – titles, expertise, and reputation – coalition is most successful in any change program. The production level coalition should better consist of employees with all sorts of functions to enlarge the compatibility with the complete workforce (Ortiz, 2006). The LTG reports to the change agent (Womack and Jones, 2003). The role of the change agent moves to the image of **navigator**. The LTG develops and implements ideas, which from the viewpoint of the change agent are unintended. The change agent has the responsibility to navigate the company into the intended direction with taking into account unintended changes influenced by e.g. interests of employees (Palmer et al., 2006).

The extension of lean manufacturing involves **training** for employees about the use of lean manufacturing tools, as well as communication and supervisory training. In combination with the training it is important that efforts are constantly evaluated to prohibit backsliding (Womack and Jones, 2003). Besides the training, companies have to **remove obstacles** that undermine the implementation (Kotter, 1995). Obstacles occur in the form of persons and organizational structure. The change agent has to take away unrest, which means

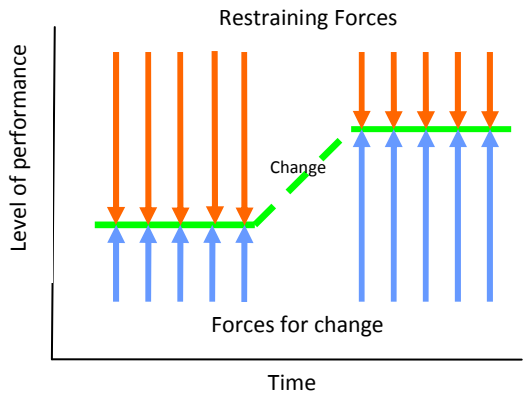

Figure 6 Force Field Analysis (Lewin)

that the organization's surrounding has to be examined to determine the positive and negative forces to change. Lewin's Force Field Analysis (Figure 6) was initially developed in social science to explain the state-of-being of individuals or groups by forces for change and restraining forces. This theory could be extended to the organizational level, an organization is located in a certain position by positive and negative forces. The change agent has to determine these forces and install mechanisms to enlarge the forces for change and decrease restraining forces. The result is a decreased resistance to change and an increased performance. Factors that make employees resistant to change are lack of control, necessity, lack of trust, comfort level, risk, lack of leadership and so forth. Bessant and Caffyn (1997) identified three enablers of employee motivation:

- **Means to change**: access to enough resources (time, money, material) to pursue their ideas up to implementation is required. The commitment and responsibility to a particular change is large and therefore employees are motivated to make it a success. Furthermore, training and learning increase the knowledge and skills of employees, which makes employees feel appreciated and valuable.
- **Authority over the change**: Employees search for problems to solve and implement the solution. Ensure a 'blame-free' environment where everybody is equal when it comes to improvements.
- **Motivational rewards**: appraisals and work objectives plan positively motivate employees to solve problems and come up with new ideas.

As a remark it has to be mentioned here that employees stay subject to company's management and board, since they determine short- and long-term goals. This means that employees cannot act as they please, but should get space within the boundaries of the goals. However, certain employees might become obsolete. The company has to assure employees beforehand that no jobs are lost and above that keep this promise (Womack and Jones, 2003). And still there are employees that will never accept the changes and spread negative messages about the implementation. The inevitable solution for these persons is dismissal.

§ 2.5.3 Encouraging Lean Thinking

The implementation of lean manufacturing requires constant examination of the match between the implemented lean building blocks and company characteristics. Along the way of lean manufacturing implementation the company characteristics might change due to environmental aspects or company change, which might change the usability of specific lean building blocks (Womack and Jones, 2003). In the

beginning it is important to show quick wins by a number of lean initiatives. However, when too many changes are initiated, departments might move in different directions. Thus, the change agent has to **develop a policy** that creates meaning for employees to assure that everyone strives after the same goal. The policy should be a logical interpretation of the lean initiatives. These initiatives will be partially intended (proposed in the initial plan) and partially unintended (developed along the way). The role of the change agent moves from navigator to **interpreter**, where changes are partially unintended and employee behavior is shaped in ways most beneficial for the company (Palmer et al., 2006). For the change agent it is important to realize that his/her task of determining direction is finished.

When the largest obstacles have been removed, the change agent should prevent the company from moving to fast (Womack and Jones, 2003) and backsliding into old habits (Kotter, 1995). Certain employees might see large improvement opportunities in their department, but altering their process might cause disfit with the rest of the organization and therefore improvement has to be postponed. The LTG has to carefully choose a small number of improvements they want to launch in a certain period.
Nevertheless, the company should **extent** the implementation of lean manufacturing *mile wide and mile deep,* which means that every inch of a company and people's thought have to act according to lean manufacturing principles (Flinchbaugh and Carlino, 2006). Companies often celebrate the success of the changes and forget to continue the implementation, with the consequence that changes are subject to regression (Kotter, 1995). Continuous improvement of the production processes is key, which means that the production process is constantly analyzed.

Assessment of employees' dedication (Bessant and Caffyn, 1997) to the implementation of lean manufacturing results in active involvement: employees are reluctant to negative feedback. They feel the necessity to function according to assessors' wishes. During work, employees use skills required for the job, but often employees have more abilities, which could be useful for the organization. The assessments bring out these extra skills and result in improvement. Rewards can be either financial (e.g. performance pay) or non-financial (e.g. naming a change after the developer). In addition of employee assessment it can be argued that employers, or at least the change agent, also should be assessed about their functioning. The change agent is responsible for good execution of the project, which is only possible when they are performing appropriately.

When decisions have been made about new improvement activities, involved employees should receive **training** to obtain the right skills. At the same time working on a project and receiving training assures that employees are *doing the right thing*. Besides the training it is important that the **right tools** are provided,

both for production and for other activities. For example, improvement groups should have a room to discuss, a means to change (Caffyn and Bessant, 1997) (p. 19).

§ 2.5.4 Completing the Transformation

Standardization of successful changes completes the transformation. The changes become "*the way we do things around here*" (Kotter, 1995). Important here is that people know the effect of the change on the performance level. The change agents are responsible for communicating the effect; otherwise the wrong cause might be addressed for the success.

However, during finalization the change agent has to give the floor to others to proactively continue lean manufacturing implementation. The change agent becomes a **coach**, rather than a real boss (Womack and Jones, 2003). After the lean manufacturing implementation the search for waste has become embedded in the corporate culture and employees only on occasion need coaching to become even better (like the coach of a soccer team). A coach structures activities to help employees solve and learn from their problems to achieve desired outcomes (Palmer et al., 2006). Bottom-up initiative is enhanced in the **pursuit for perfection**.

§ 2.6 Conclusion

Thus, lean manufacturing is not merely the implementation of a bundle of tools (i.e. technology), the adaptation of organizational culture (i.e. philosophy) is equally important (Bhasin and Burcher, 2004). The technology encompasses lean building blocks (§ 2.2) and principles (§ 2.3) and the philosophy is the actual implementation of lean manufacturing (§ 2.5). Moreover, lean manufacturing should be seen as a direction, rather than as a state to be reached after a certain time (Karlson and Ahlstrom, 1996). Liker (2004) agrees with this fact stating that the implementation of lean manufacturing should be the correct combination of philosophy and processes. However, a large number of companies forget to adjust their philosophy, which results in a large number of unsuccessful lean manufacturing initiatives (Bhasin and Burcher, 2004).

Therefore, companies have to examine whether lean manufacturing is the appropriate solution to their problems. Besides, one lean building block is more suitable for a certain company than another, which requires examination as well. After that, the journey towards lean manufacturing can start, which requires major adjustments of corporate philosophy. The complete workforce, the board, management and lower level employees are the components of the philosophy, which means that leadership and employee participation need alteration. This chapter has identified the importance of role shifting by the change agent in the process. The change agent is responsible for good execution of the changes through performance of

different roles at different moments. The different roles of the change agent furthermore enhance employee participation, which enlarges the success chances of lean manufacturing.

The choice for lean manufacturing should therefore be based on the production process and corporate culture (i.e. leadership and employee functioning). It is important for a company to determine what needs to change, ensure support and manage the changes and doubts. A company has to get ready for change by an appropriate lean manufacturing technology and philosophy.

Ch. 3 METHODOLOGY

Section 1.3 already outlined the research strategy. In this chapter the methodology is described in more detail. The reasons behind the strategy are explained and substantiated. The chapter starts with the unit of analysis and the choice for qualitative and quantitative research. This section also presents the operationalization of the major constructs. The third and fourth section respectively present the way of data collection and analysis.

§ 3.1 Unit of Analysis

The unit of analysis is the "what" or "who" that is being analyzed in a research. This study developed a plan for the implementation of lean manufacturing, based on literature and the attempt of 2007. Therefore, the central unit of analysis for this research is the implementation of lean manufacturing. The research focuses on the production departments, since they are responsible for actual manufacturing of pumps and most changes took place in these departments. The departments are the warehouse, machining, foundry, assembly pump, set building and test area. However, other departments are included if information is required.

Three constructs were developed that together constitute the implementation of lean manufacturing. The basis for lean manufacturing was first analyzed. The research described the lean building blocks that were implemented in 2007, the reasons behind these choices and the results, which led to information for a new implementation attempt.

The lean manufacturing philosophy covered the path of implementation. Leadership and employee participation are discussed under this heading, since they are important determinants of a successful lean manufacturing implementation.

§ 3.2 Qualitative and Quantitative Research

The following section explains the reasons for the choice to both use quantitative and qualitative research methods.

§ 3.2.1 Quantitative Research

This research used a self-administered survey for the exploration of the lean manufacturing implementation attempt of 2007. A small survey was distributed among production employees to determine the average opinion about the implementation of lean manufacturing. The use of a questionnaire might not sound obvious at first sight, but there are a couple of reasons for this choice. Firstly, during introductory conversations with employees it became apparent that lean manufacturing was experienced negatively,

which resulted in reluctance from employees towards lean manufacturing and this research. The questionnaire assured anonymity, which decreased hesitations to be honest. Moreover, anonymous respondents decreased the influence of personal opinion from the researcher. Secondly, a large sample was reached within a relative short period resulting in a large amount of data. Lastly, quantitative data made it easier to grasp the average opinion from employees due to many analysis possibilities. In order to receive a high response rate the number of questions in the survey was kept small. Moreover, the chance of employees losing focus was smaller, which decreased bias. Before distribution of the questionnaire it was tried out by two employees at Nijhuis to determine whether the questions are understandable and logical.

§ 3.2.2 Qualitative Research

A disadvantage of quantitative research is that the reasons behind certain choices are not explained, which are highly relevant for the research. Much can be learned about the opinion and attitudes of respondents. Qualitative data was gathered through the use of interviews with employees from the test area, warehouse and set building. Diverse case selection presents a variation of the population (in this case Nijhuis' employees) and represents the complete sample more accurately, which positively affects validity (Eisenhardt, 1989)..

Observations from the production floor and document search were used for analysis of the lean manufacturing technology. The observations showed the current flow in the production process and which lean manufacturing technologies were in place. Documents from Nijhuis and the consultancy firm contained explanations about lean manufacturing tools that were implemented in 2007. Observations are a form of qualitative data collection, but the results can be quantified. For example, *muda* is found through observation of employees and the amount of movements they have to make during assembly of a pump. The movements are calculated, which results in quantitative data.

§ 3.2.3 Operationalization

The table below shows the operationalization of the major constructs, deducted from the literature framework. These are:

1. The basis for lean manufacturing.
2. The performance of the change agent.
3. Employee involvement.

The three constructs are the most important issues that appeared throughout the theoretical framework, which means that they are important issues for every company during the implementation of lean manufacturing. These three constructs influence the success of the implementation, although that the list is

not exhaustive. Either one incorporates a critical aspect for the implementation of lean manufacturing. The operationalization of the constructs was the starting point for the development of questionnaire and interview questions, respectively appendix E and F.

Constructs	Operationalization	Reference
Basis for lean manufacturing ***(technology)***	Reason for change	§ 2.2 Lean Building Blocks
	Suitable choice of lean building blocks	§ 2.3 Lean Manufacturing Principles
	Possibilities for lean manufacturing	§ 2.4 Possibilities with Lean Manufacturing
Performance of Change Agent ***(philosophy)***	Act as leader	§ 2.5.1 Getting Started
	Sufficient communication	§ 2.5.1 Getting Started
	Involvement and participation during changes	§ 2.5.2 Changing the Organization
	Policy Deployment	§ 2.5.3 Encouraging Lean Thinking
Employee Involvement ***(philosophy)***	Respect for ideas and opinions	§ 2.5.2 Changing the Organization
	Participation possibilities	§ 2.5.2 Changing the Organization
	Training	§ 2.5.2 Changing the Organization
	Time and Space for idea development	§ 2.5.3 Encouraging Lean Thinking

Table 3 Operationalization of Constructs

§ 3.2.4 Questionnaire

The operationalization of the constructs led to the development of the questionnaire (App. E), which consisted of 11 questions. Question 1 determined the rest of the questionnaire for each respondent. Respondents who have been working at Nijhuis in 2007 had to fill all the questions, whereas others only had to answer four questions. Question 2 and 3 respectively asked at which department they were working then and are working now.

The 4th and 5th question asked employees to explain their knowledge about and familiarity with lean manufacturing, which resulted in an understanding of the level of knowledge among employees. The next 2 questions determined the level of involvement of employees within the change process: participation in LTGs and communication about the changes.

Question 8 addressed the opinion of employees about the performance of the change agent and employee involvement. Respondents had to circle the answer which bests reflected their level of agreement with nine statements. The results of this question gave a good understanding of the employee position regarding the implementation of lean manufacturing.

Question 9 dealt with the future and the possibility of a new change program, in the form of a ranking question. Employees ranked the three statements which they feel are the most important during a new change program. The results of this question were seen as the starting point for a new change program, because it is known what employees value during changes.

The last two questions gave some general information about the different respondents, which were used for further analysis of the results.

§ 3.3 Data collection

The construct operationalization was the starting point of data collection, which limited the chance of irrelevant data collection and thus positively influences construct validity. The sample consisted of 50 employees in production, which all received a questionnaire. The response rate turned out 78 % (39 out of 50). The researcher handed out the questionnaires in person to answer questions employees might have, which increases the internal validity of the research. All respondents received the same explanation about the meaning of the questions and therefore were able to answer the questions in the same manner.
The questionnaire results were the starting point for the interviews. Interview questions were deducted from the results. However, during the interview other questions became relevant, which made the interviews semi-structured.

Relevant to mention here is the fact that the first data was obtained through observations and informal conversations with employees to increase understanding about Nijhuis' pump and production process during the initial days of the researcher at Nijhuis. The researcher spent several days in the assembly and testing area to gain knowledge. During the initial weeks the employees became familiarized with the researcher. The researcher could more easily approach employees to help in the research, because employees already knew the researcher. Moreover, these initial conversations and observations eventually led to the development of the central question.

§ 3.3.1 Triangulation

The reliability of the research is increased through the use of triangulation. Triangulation refers to the use of multiple data sources and methods, with the advantage of overcoming the deficiencies that flow from one observation unit or research method. The use of multiple data sources increased the validity and reliability of the research. This research partially applied triangulation, besides the questionnaire, interviews and documents were used. These documents were developed by the consultancy firm at that time. The data triangulation occurred through the comparison of the results of the questionnaire, interviews and documents. For example, the documents stressed the importance of communication between departments and the consultancy firm, but did employees think there was sufficient communication between parties.

Moreover, the consultancy firm was asked to cooperate in the research as well, which would have increased the reliability. Yet, the consultancy firm refused to participate in the research. This meant that the research

had to be careful with data analysis to avoid subjectivity. Since the research focused on the specific situation at Nijhuis the generalizability among other companies in this industry is low.

The internal reliability of question 8 of the survey is determined through *Cronbachs Alpha* and gave the result of 0.75, which is considered as acceptable.

§ 3.4 Data Analysis

Data analysis started when the questionnaires were received back. Editing detects errors and omissions, which were corrected when possible. A codebook is used for the specifications of the questionnaire (see App. C). The next step involved the establishment of a database with the answers from the questionnaires. This database is the starting point for the analysis of the data (in SPSS). The interview data were used for a better understanding of the questionnaire data and through that improvement of the research's results. The interview data were mostly used for description of the opinions of employee. Reactions to questions could not be perfectly displayed on paper. In order to describe the opinions, quotes were be used and answers are analyzed for comparability. The most striking results are processed in chapter 4.

Ch. 4 LEAN MANUFACTURING AT NIJHUIS IN 2007

This chapter addresses the lean manufacturing implementation attempt of 2007. This chapter answers the research questions: "How did the lean manufacturing process look like in 2007 and was this appropriate?" *and* "What is the average employee position regarding the change agent role and level of employee participation during the lean manufacturing implementation at Nijhuis Pompen B.V.?". *The reasons for the choice of lean manufacturing are explained, after which the technological aspect of lean manufacturing is addressed. The employee opinion concerning leadership and employee participation addresses the philosophical aspect of lean manufacturing. The questionnaire spread under production employees and the held interviews are the basis for this section.*

§ 4.1 The choice for Lean Manufacturing

In the beginning of 2007 Nijhuis heard the success stories about lean manufacturing from suppliers. One of their suppliers had very recently implemented lean manufacturing with help from a consultancy firm. Nijhuis wanted to become, and stay, the "best pump producer". In order to achieve this, the following problems had to be solved:

- Large amount of WIP inventory: approximately 500 pumps equaling 8 months of work[4].
- A lack of overview of the production process. Departments used different measurements for the calculation of throughput time, e.g. including or excluding foundry hours in the calculation.
- A delivery dependence of less than 19 percent[5].
- A high work pressure due to the constant feeling of being late.

Nijhuis' management figured that lean manufacturing was a good solution for the problems. Conversations with people familiar with the concept, made Nijhuis decide to hire the same consultancy firm, a small national firm specialized in the implementation of lean manufacturing. In March 2007 this firm entered Nijhuis with a presentation of their plan to implement lean manufacturing with the promise of:

- A decrease in WIP inventory with at least factor 2 through the implementation of a new planning system.
- Visible and transparent processes by implementation of tools to be selected.

In this initial presentation it was also mentioned that employees had to be willing to cooperate, think and ask questions. After this presentation the implementation went straight ahead.

[4] The 8 months is the result of the sum of calculated hours per pumpset divided by the total available hours per week.
[5] The delivery dependence is calculated as the numbers of order delivered too late divided by the total number of orders expedited. Orders are too late when expedited on a later date than mentioned in the contract.

However, in the fall of 2007, only six months after the start of lean manufacturing implementation, Nijhuis dismissed the consultancy firm. The decision was based on disappointing results. It became apparent that the process for lean manufacturing, as developed by the consultancy firm, was not suitable for Nijhuis. Nijhuis and the consultancy firm had different ideas about the execution. For example, the consultancy firm proposed the idea to build a new facility for production, but this was far beyond the financial possibilities of Nijhuis. Most lean manufacturing building blocks as developed by the consultancy firm were abandoned. The implementation of lean manufacturing turned out to be nothing more than a "plan", containing the goals of the implementation, the required changes and a bit of "do", the execution of the project. The remainder of this chapter describes and analyzes the technological and philosophical changes that were developed and implemented in 2007.

§ 4.2 Lean Manufacturing Implementation: Technology

Nijhuis' production characteristics are very important for the implementation of lean manufacturing, merely implementing lean building blocks does not guarantee success. The variety of pump types, accessories, environmental conditions and customer wants is very large. A distinction can be made between standard and special pumpsets.

A standard pumpset is composed of a pump that already has been developed plus a specific type of motor and accessories. However, these pumpsets are not produced in advance, because for example customer A might want manometers attached to its pump, whereas customer B prefers an extra manual starter. Production of standard pumpsets is therefore categorized as make-to-order. The throughput time of a standard pumpset can be determined quite accurate, because many actions are the same for every pump. Companies starting with the implementation of lean manufacturing need to examine the standard actions for waste occurrence, since elimination of waste in these activities results in a lower throughput time for every pumpset.

The major difference between a standard and special pumpset is the fact that for a special pumpset throughput time cannot be determined as accurate as for standard pumpsets. Special pumpsets require time from R&D and engineering, who have to determine the specifications of the pump. Beforehand it is not known how much time these activities require and moreover, actual production time is not known either. The production of special pumpsets is categorized as engineer-to-order.

A third critical point in the production of a pumpset is the Quality Department. Critical parts (e.g. the fan and propeller) are examined for quality. If a part does not comply with the standard the part either has to be repaired or replaced, which puts production on hold. The Quality Department influences the flow in production, which results in waste like waiting and inventory (p. 13). For this department the same story

holds, Nijhuis has to examine what is most beneficial for them in relation to WIP inventory and throughput time costs.

R&D and the Quality Department cause throughput times to differ and thus influence the customer pull principle of lean manufacturing. Customer pull requires companies to know how much time is required for every activity, but R&D and quality problems leave only space for estimations. If R&D requires only 2 weeks instead of the estimated 3, the result in WIP inventory. And when R&D requires more time, delivery dependence is influenced. The same holds for the Quality Department. Production is delayed when parts are rejected, resulting in a longer throughput time and/or harmed delivery dependence. Nijhuis has to examine the consequences of using certain estimations of time required by R&D with respect to throughput time and performance. In figure 7 the problems are visualized. The throughput time for a standard put can differ tremendously from a special pumpset requiring R&D and Quality Control. The consultancy firm used the first calculation of throughput time and did not take into account the other three possibilities.

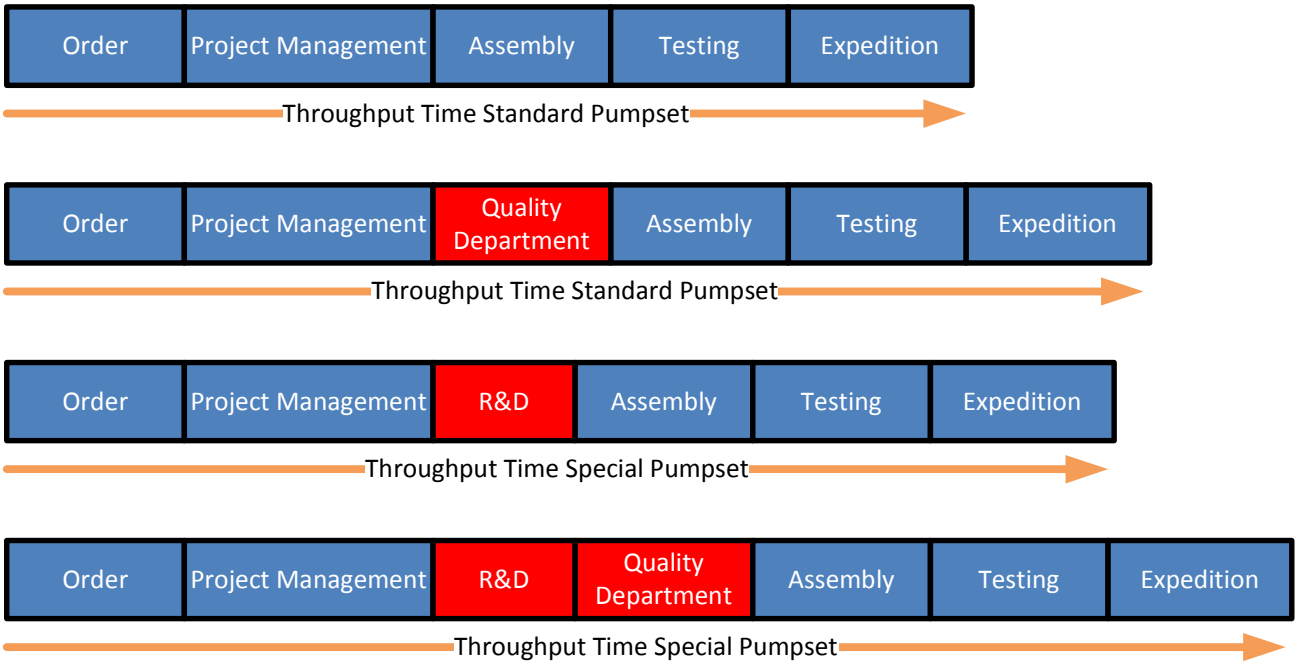

Figure 7 Throughput Time Pumpset

Pumpset assembly can be labeled one piece production, whereas batch production is applicable to the foundry. The foundry of pump castings is dependent on furnace capacity. The ovens are only in function during the mornings, due to electricity constraints. Besides, several types of material can be used for the castings, which affect the use of the furnaces. Certain materials cannot succeed other material, which requires a carefully planned schedule. If material X is only required for a small amount of products these are manufactured in one batch, which is cost efficient but results in WIP inventory costs. Thus, Nijhuis has to

calculate in which situation production costs are minimized. It might be the case that founding of 10 castings is more effective than production of only 5. Nevertheless, attempts should be made to minimize batch production.

The paragraphs above showed the importance of investigating the production process of a company before implementing lean manufacturing. At Nijhuis there are several critical departments which influence flow in production. It is interesting to see that the consultancy firm only established a list with general "rules of the game", which had to be followed by all departments. The differences in production sequence throughput time variances, as mentioned in the prior paragraphs, were not taken into account.

The consultancy firm developed the picture as shown in figure 8, which they thought was feasible in Nijhuis' production process. A finalized order had to be handed over to Project Management who decided what,

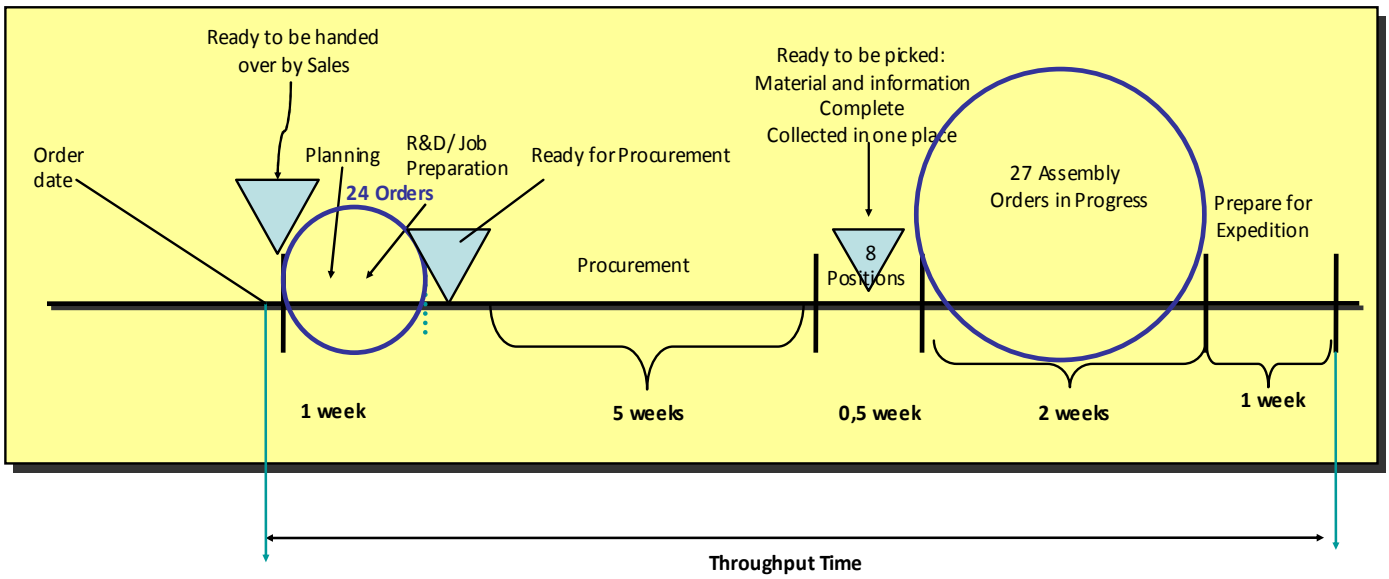

Figure 8 Lean Manufacturing at Nijhuis (proposed by the consultants)

where and by whom had to be done (e.g. R&D requirement), with a maximum of 24 orders in progress (intangible production). The planning only showed one week for R&D, which is too little as mentioned above. Special pumpsets require more development time. After the planning was made the order became visible on the procurement ruler, the guide for Procurement and Logistics. Five weeks were reserved for purchase of all the supplies. In the picture there is no spare time for quality control, which makes the system incomplete. After 5 weeks the parts were picked and put into one of the eight positions, the maximum numbers of picked orders waiting for assembly. Assembly of the pumpset had to be finished within two weeks with a maximum of 27 orders in progress, which contradicts the picking = finishing principle. The testing area determines the level of production, since this department is the critical department due to space limitations

and duration of activities. The testing area does not have space and time to work in 27 orders, which results in WIP inventory, which in turn is a form a waste and thus should be eliminated.

§ 4.2.1 Sales Planning

The major change in the production process was that planning became based on actual sales or the JIT principle, whereas before the available capacity determined production or Management Resource Planning (MRP). The Sales department determined the level of production in other departments. Production capacity for a particular week was derived from the "sold capacity", which is the amount of capacity needed to produce the sales. An Excel sheet with the orders showed which sets had to be produced to reach the due date of the order. However, as could be expected from salespersons, they were selling as much as possible without considering the available production capacity. For example, employee A sold a special pump set in week 12 and employee B sold three standard pumps in week 26, both orders due in week 38. However, production capacity was not large enough to deal with the demand and delivery of the orders is delayed.

§ 4.2.2 Procurement Ruler

Furthermore, a procurement ruler (Figure 9) was introduced at Nijhuis. The ruler in this case was a filing cabinet where orders were listed in such a way that it could be easily seen when which order was due for a particular week. In general, five weeks were reserved for material purchase. However, long lead items[6] needed to be purchased earlier. For example, castings are often bought in China, which at least costs six weeks of shipping. Another example is the motor, which is assembled outside Nijhuis, but fully complies with Nijhuis' customer wishes. New orders were placed on the last row in the cabinet, which were scanned for

Figure 9 Procurement Ruler

[6] A long lead item is a product from which is known that the purchase (or production) time exceeds the scheduled time.

long lead items. During the weeks the orders were updated by Procurement and moved along different rows. Each place in the cabinet contained an overview of the required materials and spare parts for a specific order.

The change in planning and the procurement ruler were linked to a new system of maps that was introduced to move sets through the process, based on the assumption of "one in = one out". Each map contained a bar code which was scanned into a computer to give a sign to other departments. For example, when pumpset assembly finished an order pump assembly received a sign to start the assembly of another pump. Interesting to see is that different colored maps were used to represent a state of an order. For example, the map of a pump was orange during intangible and brown during tangible production. Changing maps is a valueless activity and thus creates waste instead of eliminating it. The flow of the products did not run smoothly, although the system of maps had this intention. Incomplete orders were picked, which made the throughput time higher, because they could not immediately be assembled. The cause of this problem was sought at the suppliers who delivered their products ad hoc and not at the due dates. Nijhuis' should have contacted its major suppliers to discuss the changes and assure that products are delivered at the required date, not too early and certainly not too late. However, the problems in the warehouse could also have been caused by a lack of knowledge from employees, which will be addressed in section 4.3.

§ 4.2.3 A *Kanban* system

The system of maps can be linked to the concept of *Kanban* cards, where signs are given to prior departments when an activity is finished. The consultancy firm had the intention to apply this system in every department.

Kanban is a method for operationalization of a pull based planning (JIT)[7]. On the other hand there is Manufacturing Resource Planning (MRP)[8], a push based planning. According to the lean manufacturing principle the production process should function as a pull based system, but in practice this is not always feasible. Figure 10 distinguishes between the complexity of flow routings and the complexity of product structures (Voss & Harrison, 1987). The dot in the figure is the position of Nijhuis. Nijhuis produces standard and special pumpsets, which means that product structures are sometimes complex and sometimes not. The routing of Nijhuis' products differs as well. Special pumpsets move through R&D and standard pumpsets not. Both JIT and MRP are useful for Nijhuis. MRP can be used for overall control and JIT for internal control. The

[7] JIT is a planning philosophy that aims to meet demand instantaneously without waste.
[8] MRP is a set of calculations embedded in a system that helps operations make volume and timing calculations for planning to accurately determine throughput time.

internal control includes the requirements for actual materials and the overall control includes everything else. For Nijhuis this means that the use of *Kanban* facilitates the JIT delivery of supplies for production. Other activities, like R&D and purchase of long lead items are served by MRP.

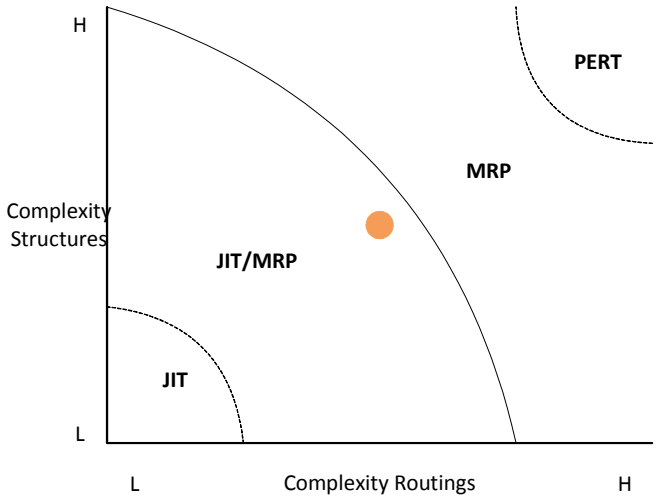

Figure 10 Complexity Positioning Nijhuis JIT/MRP

This analysis results in the following conclusion, the implementation of *Kanban* was not thoroughly analyzed. Complete implementation would not benefit Nijhuis and would mitigate the potential successes of *Kanban.* The consultancy firm did not address the specifications within the production process of Nijhuis.

One way to overcome these problems is to start with a VSM, the entrance to the House of Lean. A VSM of the situation in 2007 was not made. The VSM would have shown the critical departments, R&D, Quality Department and the Foundry. In 2007 only drawings of the situations to be were made, which in combination with a current VSM is good, but without not. Due to the absence of the VSM the implementation of lean manufacturing was based on the wrong assumptions, since it was not clear how the real production process looked like and where the major bottlenecks were found. More precisely, two VSMs should have been drawn, one for a standard pumpset and one for a special pumpset.

§ 4.3 Lean Manufacturing Implementation: Philosophy

The lean manufacturing changes at Nijhuis affected most employees, which made changes in the way of operation, the culture, necessary. This section discusses the changes in the philosophy by the average opinion of employees considering leadership and level of employee participation, which are the results of the questionnaire and interviews.

The lean manufacturing implementation started with an introductory presentation to all employees about the proposed changes from the consultancy firm. Besides the presentation, every employee received a Lego-workshop to get acquainted with the concept. This workshop gave employees an idea about how a production process could flow, i.e. a production process without non-value-adding actions. Each Lego-set represented a pumpset. Employees were placed in groups and together had to build a pumpset. After this short introduction the project immediately started, although playing with Lego is not the same as real practice. The Lego-workshop was not sufficient to get acquainted with the principles of lean manufacturing, as the results of the questionnaire reflect. Question 4 (App. B) asked employees to explain their idea about lean manufacturing. Answers to the question what lean manufacturing was differed: "efficient production", "beginning = finishing", "controlling costs" and "no idea" (Figure 11). Twenty percent of the respondents answered “no idea”, which is surprising since Nijhuis was going to change to lean manufacturing. Interesting to see is that there was only one respondent who clearly defined lean manufacturing: "*Elimination of WIP, elimination of inventory, elimination of waiting time and a focus on quality".* And even more surprising, this person has only been working at Nijhuis since the beginning of 2008, which means that he was not actively involved in the lean manufacturing process. The level of training was not enough to create confidence among employees about lean manufacturing. In addition, it can be argued that employees did not get enough time to adjust to the changes, with a median rating of 4 ("slightly disagree") as shown in appendix I. Employees lacked abilities to perform the tasks as specified. For example, warehouse employees did not see the big picture. An order with assembly scheduled over 8 days was already picked, although not all parts were yet in stock. And still a Warehouse employee said to Procurement: "*Why are there no bolts and nuts of this type in stock, I need them to finish picking this order*". They did not understand the principle that inventory costs money.

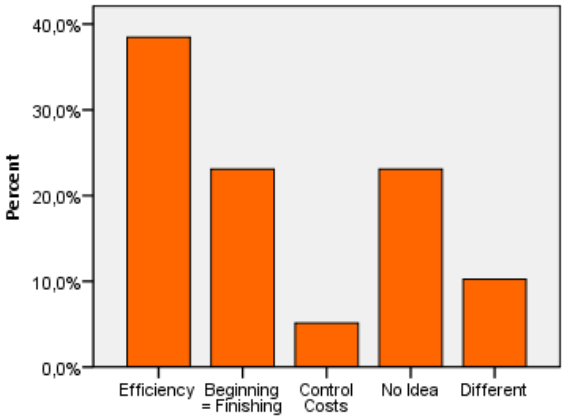

Figure 11 What is Lean Manufacturing?

Besides the short introduction period, leadership during the process was neither appropriate. During initiation a change agent has to act as director, moving the company into a specific direction. This person must be convinced about the predetermined steps and success of the outcomes. Nijhuis' change agent was part of the core group, consisting of two consultants, the change agent, the CEO, Financial Manager and Service Manager (App. E). The core group was in charge of the project’s execution. On paper this group was quite powerful, this suggests that they were able to book successes. However, the influence of the change

agent was limited. He more functioned as a mediator between the consultancy firm and Nijhuis, which could explain the confusion about the leader of the process (App. I). Moreover, the confusion can be explained by the sudden leave of the initial change agent for unknown reasons and the activity of the consultancy firm. The consultancy firm was attracted for the role of *sensei*, with the task to provide Nijhuis with the required knowledge and information about lean manufacturing. However, the consultancy firm did not seem to function as a large information pool, but more as the director of the process. They decided where to go, at what time and how, which gave Nijhuis' change agent more the role of change *manager*, the person with the day-to-day responsibility to oversee the change and report to the *change agent*, at Nijhuis thus the consultancy firm.

It can be argued that it does not matter who the actual change agent was, as long as this person performs the task correctly. This means that the change agent has to communicate the changes, deploy the policies and act upon the changes. Yet, the consultancy firm performed the task differently. An employee from the Warehouse said: "*Right from the beginning I stated that lean manufacturing would fail, but they* (rd. Consultancy firm) *did not listen*". This is quite an oversimplified statement, but it does say something about employee's feeling. The "second" change agent stressed that the consultancy firm did not listen to ideas to make the implementation of lean manufacturing more suited to Nijhuis. The change agent reflects the average opinion about the room for employee initiative. The questionnaire result shows that employees disagreed with the statement that there was enough room for initiative, with a median and mean rating for this variable respectively are 5.00 (“disagree”) and 4.00 (see App. I).

In addition, the small room for initiative made employees feel disrespected (mean 3,69). From discussions with employees it became apparent that the consultancy firm did not listen to the claims made by for example the foundry. One employee: "*Beginning means finishing is not possible in the foundry due to waiting time between activities and besides we can only use the furnaces in the morning*". The consultancy firm did not adjust their initial plan, it pointed their finger to other persons. During the introductory presentation it was mentioned that employees had to be willing to think, cooperate and ask questions. However, communication largely occurred one way; the firm specified the expectations and employees had to follow. The literature prescribes top-down and bottom-up communication to increase the level of trust, create a sense of urgency and make them understand that their personal work is not negatively affected. At Nijhuis there was little communication, which could explain the fact that employees did not feel respected and involved in the process.

Respect for employees goes hand in hand with time and space to develop ideas. Employees' abilities are ideal for the development of ideas to improve performance level. Employees have the best understanding of

the activities occurring at a department and therefore are a good source of information for plan developers. When employees exactly know what is going to happen, their comfort level is increased, which lowers the chance of performing activities moving the company in the wrong direction. However, the time and space to develop ideas was small (mean 3,77) and could explain the negative mean rating of active involvement (3,20) (see App. I).

Besides the core group, three groups were formed representing the different product groups: *Setbouw*, *Pompen* en *Spares*, which could be seen as three LTGs (p. 19). The change groups consisted of employees with different functions, but most employees were working in the office. This made the compatibility with production employees smaller, although most changes took place there. These LTGs developed focus points for the execution of lean manufacturing during daily meetings amongst group members and two-weekly meetings with the consultancy firm. These employees on average gave less negative answers. For example, they did feel actively involved in the process (2,00) and were less negative about the level of encouragement by the change agent (App. I).

The following conclusion can be drawn from the prior section. The basis for the implementation of lean manufacturing was not well established; employees' lack of vision, knowledge and positive attitude were the wrong pillars to build on. The unrest that arose through the wrong start had to be taken away by the change agent and consultancy firm, but the reality was different. The implementation of lean manufacturing was abandoned after only six months, which is too short after the beginning. The implementation of lean manufacturing is a long and intensive journey. According to Womack and Jones (2003) the implementation of lean manufacturing can take up to 5 years. During any change program there are always forces against the changes which have to be overcome. Unrest under employees can even be a positive thing. Discussions between employees and the core group could have enlarged the understanding of lean manufacturing, but conversations with the "omniscient" consultancy firm were difficult. The consultancy firm did not listen to propositions made by employees. Therefore, it can be argued that the choice for the dismissal of the consultancy firm was the right one, since ideas moved in opposite directions. Nevertheless, continuing the implementation of lean manufacturing was an option, since several employees were willing to continue. For example, *Setbouw* saw clear possibilities with the further implementation of lean manufacturing. The *Setbouw* operations are suitable for partial standardization, since certain actions are performed on every pumpset. Furthermore, the layout of the department gave possibilities for the creation of product flow through alterations in the equipment locations. Moreover, this department had (and still has) a large amount of inventory, although that there is Nijhuis' warehouse. This means that opportunities for inventory decrease exist. If this department had prolonged the implementation and booked successes, the implementation could have been extended to other departments. *Setbouw* would then have functioned as

experimental department from which other departments could have learned. Yet, “what if…” is something which will never be known. Therefore, a new implementation plan, adapted to past experiences, is more suitable.

§ 4.4 Conclusion

When reading through the implementation process of lean manufacturing in 2007 some striking results appear. The consultancy firm did not take into account the specific characteristics of the company, which actually are the most important reasons for the early dismissal of lean manufacturing. The specific characteristics of Nijhuis, like the foundry, quality control and R&D were not considered during the development of the lean manufacturing plan. The misunderstanding of the specific characteristics influenced the choice for lean building blocks. The choice for the lean building blocks was not per se wrong, but the wrong implementation did result in problems.

Moreover, problems with the change agent and unmotivated employees are in a way results of the lack of knowledge about characteristics. On the whole it can be argued that the result of a better knowledge about the characteristics would have (largely) increased the chances of successful implementation. For example, employees doubted the changes due to their knowledge about the production process and wanted to communicate this. However, communication was hard and thus employees felt disrespected and unmotivated. If the consultancy firm knew the situation better, they would have been able to see the critical departments and thus adapt the implementation. Then the changes fitted the situation better and leadership seemed more attached to the change process. These "would have..." changes are points to certainly remember during a new implementation attempt.

Ch. 5 IN PURSUIT OF PERFECTION: THE NEW IMPLEMENTATION

The third research question is answered in this chapter. The prior chapters are the basis for the new implementation plan. In contrast to the prior chapters this chapter starts with the lean manufacturing philosophy. Changing the philosophy is the most challenging activity due to past experience. The choice for lean building blocks is presented after the discussion about the philosophy.

§ 5.1 Lean Manufacturing Implementation

The central question of this research was: *In what way and to what extent should Nijhuis Pompen B.V. implement lean manufacturing; taking the first implementation attempt as starting point?* This research actually can be considered as the "check" and "act" of a large PDCA-cycle, developed by Deming (1986):

- **'Plan'** this phase involves the planning of an improvement of the current situation based on the results you want to achieve.
- **'Do'** the plan that has been developed in the first phase will be implemented.
- **'Check'** the changed practices are evaluated against the expected results.
- **'Act'** when the results are as expected the changes are standardized and otherwise the plan is adjusted and the cycle starts again.

Chapter 4 described the lean manufacturing "plan" and "do" of 2007 as well as the "check" of this. Why did certain actions happen and what has to be remembered from this during a new attempt? This chapter develops the new plan, the "act" of the PDCA cycle.

The PDCA-cycle is important for the following reason. Every plan that is developed by Nijhuis, large or small scale, should be considered as a PDCA-cycle. Careful evaluation of the changes is necessary to assure that they fit within Nijhuis and are working for the same result. After a while the change has to be standardized and embedded in the corporate culture. The higher performance level due to the changes is the start for a new PDCA-cycle.

Every change that is initiated has to be dealt with as a PDCA-cycle to avoid failure and increase the profitability of the changes.

Nijhuis wants to become, and stay, the number one pump producer through production of high quality pumpsets adapted to customer needs. This means that Nijhuis constantly has to search for better and more effective production processes. Nijhuis' management depicted lean manufacturing as the means to reach this goal, which has to be transformed into an understandable concept for Nijhuis' employees. Understanding product value is essential for the implementation of lean manufacturing. Nijhuis' customers value a high product quality as well as reliable delivery dependence. These two aspects are major

determinants of Nijhuis' performance, which therefore form the basis for a new lean manufacturing implementation attempt. Thus, the choice for lean building blocks on the one hand has to fit Nijhuis' characteristics and on the other hand has to result in an increase in quality and/or delivery dependence. In contrast to the prior chapters, this chapter starts with the philosophical aspect. The past experience with disadvantageous outcomes makes a new implementation challenging and therefore the support from Nijhuis' employees is essential to success.

A new change program requires a lot of effort from those persons in charge of the project, they have to possess a make-something-happen mindset (Womack and Jones, 2003). A skilled and motivated change agent, and team surrounding this person, is needed for the motivation of employees. They have to increase the forces for change and decrease restraining forces. A major force for change is active involvement of the change agent in the process to show that he/she is committed to the change: "*You are not committed - so why should we be?*" When the change agent *walks the talk,* that is act on what is proposed, employees' imagination about the changes is enlarged, which in turn increases motivation. The change agent has to communicate the change path, both top-down and bottom-up. In 2007 the change agent did not perform the specified tasks, two-way communication and active involvement were absent.

So, employee motivation is increased when they are conciliated in the process and when the change agent or management supports the plans. These conclusions are in agreement with the results from the last survey question (App. J), where employees had to rank their top three of most valued aspects. Clear visions from management and employee conciliation about the changes are clearly most valued[9] (24/40). The aspects that employees value were also seen in the literature framework: authority over the change (§ 2.5.2). Employees want opportunities to develop and implement changes. It can be argued that these answers are based on past experience, since employees did not feel involved in 2007 and did not completely understand the importance of the changes. Therefore, the change agent has the primary task of developing a sense of urgency, which motivates employees. Take for example the changing environmental conditions. Every employee knows that emissions and garbage are sources of environment pollution. Employees feel the need to improve their production process with the focus on less waste, i.e. lean manufacturing. Waste elimination drives production costs down and this nullifies the possible revenue loss due to lower demand. Besides that, the goals in the *Masterplan* have to be reached through waste elimination.

[9] 40 People correctly answered this question in the survey out of who 24 ranked the statement of a clear vision from management and employee conciliation. 24/40 equals 60 %.

In addition to this, employees have to receive the means to change. For example, employees mentioned the fact that they were searching for equipment quite often. The solution for this is the purchase of new tools for their tool boxes. Nijhuis has to invest in this to motivate employees.

In concrete words, the first task for Nijhuis is to create a sense of urgency and appoint a change agent, who has the time, energy and will to involve employees and turn Nijhuis into a lean manufacturing organization.

Change agents have to perform different roles during the implementation of lean manufacturing (see Table 4). The director role is appropriate during the initial phase where the changes are intended and have to be controlled. The change agent has to determine direction for the employees who, during the beginning, do not know exactly what is expected. The 'director' of lean manufacturing 2007 did not perform the task as specified in the literature. Directing does not mean forcing others to act upon the changes, but a director has to straighten the path which employees have to follow. After the initial period the change agent has to move to the less strict role of navigator, where there is room for unintended changes (arrow 1, Table 4). The first (successful) changes have attracted the attention from employees and they start to understand the benefits from lean manufacturing. The implementation should be extended. At this moment unintended changes (e.g. employee initiatives) are mixed with intended changes, which do all need control by the change agent. Along the way employee knowledge about lean manufacturing develops, which results in more ideas. If the level of knowledge is sufficient the role of the change agent can move to interpreter (arrow 2a) where boundaries are developed in which employees can develop ideas (shaping). But is might also be the case that the change agent still has to control the unintended changes and thus adopts the role of caretaker (arrow 2b).

During the completion of lean manufacturing the change agent has to act as a coach or nurturer, depending on the situation (arrows 4a and 4b). The change agent has to provide employees with the resources to change. This means that changes are intended in the broad sense (they fit within the policy) and unintended (beyond the initial plan).

Every change program starts with control over the change to the less strict role of shaping. The status of the changes determines the role of the change agent. The choice for a specific role is the responsibility of the

		Images of Managing	
		Controlling	Shaping
Images of Change	Intended	1 **Director**	**Coach**
	Partially Intended	**Navigator** 2a	**Interpreter** 4a
	Unintended	2b **Caretaker**	4b **Nurturer**

Table 4 Role of Change Agent

change agent.

Around the change agent a group has to be formed which performs the initial changes. Every employee should be given the opportunity to become part of an improvement team. Certain employees are fond of developing and implementing ideas, whereas others are more comfortable with assigned tasks. The results of the questionnaire show that Nijhuis' employees are willing to develop improvements, but they are less willing to implement the changes (App. J). This could be explained by the negative feedback they received during the implementation of lean manufacturing in 2007, when ideas were not respected. The improvement teams can start with discussions about what is waste, for example about the number of movements they are making during an activity. Certain activities immediately become obsolete due to re-ordering, combining or eliminating activities. Teams actively pursuing lean principles and obtaining quick wins attract attention and by that enlarge interest. Quick wins create a psychological sense of flow in the workforce and create change momentum (Womack and Jones, 2003). Along the way teams become more acquainted with the principles of lean manufacturing and therefore can set higher, yet achievable, goals. The largest benefit of goal setting is that employees want to achieve (or win). Knowledge is also obtained through training. Training results in a more efficient use of skills to delivers good results.

To sum up, an improvement team can realize quick wins through efficient use of employees' skills. Small waste elimination efforts enlarge the positive attitude against lean manufacturing.

Not merely the employees in the improvement teams need to be involved in the process. Every employee has to be informed about the changes and his/her remarks need to be heard. Their opinions are just as important as those of the change agent and team members. Moreover, during the change process employees have to be contacted to discuss the results of the change and if necessary adjust the plan. An environment has to be created where employees are willing to cooperate and act upon the changes, which means that the resources (money, space, room, material, et cetera) to perform the changes are present, employees are authorized to perform the developed change and are rewarded for good execution. Nijhuis' employees do not per se want a financial reward, different assessment rewards (e.g. recognition and communication) are valued as well. In contrast to what happened in 2007, when there was little attention for the employee, the new change program has to put the employee in the centre. Employees have to implement the changes and thus have to make lean manufacturing a success.

Nijhuis' employees have to be put in the middle of the change, they have to put the changes into practice and are thus responsible for the outcomes.

The new way of operation has to become a habit, which means that it has to be embedded in the corporate culture. The corporate culture at Nijhuis is composed of different (departmental) cultures. All too often it

seems that employees are not working for the entire organization, but merely for their ówn department. The establishment of a lean manufacturing culture should result in a workforce working for the end product and not anymore for their own department.

§ 5.2 Lean Building Blocks

When the basis for the changes, an informed workforce and willing change agent, is well established, and more important, is sustained through the process, the right lean building blocks have to be determined. The lean building blocks can be found in Figure 5 (p. 13). The choice for specific building blocks is based on the assumption that Nijhuis needs quick wins to motivate employees and make lean manufacturing a success. The attempt in 2007 failed and thus employees have to be persuaded to become advocates of lean manufacturing. Therefore, Nijhuis has to start with building blocks with a clear goal: improvement teams, VSM and 5s. The lean building blocks and time period are presented in Table 5. The benefits and implementation of the different building blocks are elaborated on in the coming sections.

Lean Building Blocks	When	Benefits	How
Improvement Teams	Now	Different people have many skills and ideas to improve company performance	• Search for willing employees • Employ a change agent • Communicate the choices • Training possibilities
Value Stream Map	Now	Clear overview of the production process and its problems	• Walk through Nijhuis' production and determine flow • Determine levels of WIP inventory at every department (e.g. *Setbouw*) • Draw different departments/activities within one department • Mention department/activity specific characteristics
5s	Now	Clean and organized workspaces to show critical departments	• Reserve time for 5s • Start at one department (*Setbouw*) • Follow standard order with drive
Quality at Source	Within 2 years	Improved guarantee of quality, better production flow	• Develop product standards • Communicate standards • Communicate individual responsibility for end product
Total Productive Maintenance	Within 2 years	Better production flow through clear possibilities machinery	• Calculate machinery OEE • Minimize possibilities of disturbance • 5W1H principle
JIT (*Kanban*) + MRP	Within 2 years	Establishment/improvement flow principle	• *Kanban* in actual production • MRP for other departments • Determine possibilities with ERP system

Table 5 Pursuit for Perfection: Building Blocks

§ 5.2.1 Value Stream Map

Every company, indifferent the production characteristics, has to start with the development of the VSM. A VSM shows the sequence of activities in combination with the level of inventory and thus places where improvements are feasible. A VSM can be drawn for the entire production process with reference to the different departments, but also for the different activities within one department.
The improvements will increase quality and/or decrease throughput time, for Nijhuis the two pillars on which lean manufacturing has to be built. The importance of the VSM is visualized in the House of Lean (p. 13), where it is presented as the stairways to enter the house. Nijhuis has to develop a VSM that presents the current situation with the throughput time per activity and the level of inventory before every activity. At the moment the value stream is clearly mapped the implementation of lean manufacturing can continue.

The VSM is the first and tremendously important item that has to be developed by Nijhuis to show production activities, product flow and improvement possibilities.

§ 5.2.2 5s: organized workspaces

However, the current value stream identification might be hard due to the large amount of clutter in the workspace. In every corner, on every shelf and in every casing you can find material, equipment and products, with the result of unsafe working areas, quality loss, waste from searching, moving and inventory. Moreover, an accumulation of waste through unclean workspaces demotivates people. The solution for clutter within the lean manufacturing concept is "5s". The five (Japanese) terms beginning with an "s" together form the basis for a clean and organized workspace, with the result of higher valued products. Each term will be addressed in the following paragraphs.

The first term is "**seiri**" (sort), during which materials, equipment, tools and products are identified which are not used during regular business. Only the bare essentials can be kept around the workspace to enhance throughput and decrease waste. Each item that is not essential has to be labeled red. This label contains the name of the product, the date and location. Red labeled items have eventually be removed, sold or recycled. The second item is "**seiton**" (set in order), puts the essential items into order. The result of removing unused items is space which can be used for a more efficient layout. An efficient layout means that movement of products and persons is minimized as much as possible, determined by the frequency of use and reach of employees. "**Seiso**" (shine) arose around the fact that a clean workspace increases the working morale, safety and quality issues. During cleaning of the workspace improvement opportunities might surface, which otherwise were not seen.

The first three steps have to be continuously carried out and must become embedded in the company activities, which is "**seiketsu**" (standardization). Every employee has to know what is expected from him/her through a clear 5s schedule. The fourth principle should not be confused with "**shitsuke**" (sustaining), which involves the intangible aspect of standardization. 5s has to become embedded in the minds of employees.

The implementation of "5s" provides Nijhuis with a better visibility of value-adding activities and in relation to those improvement opportunities.

This first improvement cycle, the implementation of 5s, is the beginning of a new cycle. As a word of caution, the implementation of 5s throughout the complete organization requires (much) time and effort from employees. Thus, the planning of employee capital has to incorporate time for 5s, otherwise the result is limited. A clean and organized workspace positively influences both product quality and delivery dependence. Clean workspaces cause fewer errors to occur and organized workspaces decrease waste of moving and searching for items and thus throughput time.

After the implementation of 5s in the complete organization, Nijhuis has to decide which lean building blocks are best suitable for them either improving throughput time and/or product quality.

§ 5.2.3 Quality at the Source: faultless production

The guarantee of high quality products is strengthened through "quality at the source". Every product has to be of accurate quality when moved through the production process. This means that every operation has to be performed correctly and without mistakes: Quality at the Source. In traditional manufacturing environments products were inspected after final assembly, whereas in lean manufacturing environments products are controlled continuously. The major advantage of direct control is that mistakes are resolved before they turn into defective products. Inspection of machinery, including cleaning (5s) allows catching of errors which could cause defectives. In practice this means that standards for information and equipment have to be established that present the minimum quality. The operations, for which the standards are not met, have to be monitored and adjusted to meet the requirements. Correction of mistakes requires less time than correction of errors, which positively influences throughput time. Currently, not every employee has enough knowledge to determine potential errors in the product and/or machinery. Mistakes are not discovered immediately, which in the end negatively influences Nijhuis' performance.

Every Nijhuis' employee has to know what quality level is required per product and through that enlarge the quality, which also positively influences throughput time. Appropriate information and equipment enlarge the quality.

§ 5.2.4 Total Productive Maintenance: effective production

Total Productive Maintenance (TPM) can be considered as an extension of the quality at the source principle. The goal of TPM is "profitable PM", the prevention of mistakes should be done in effective ways. Every machine in a production process must be able to perform its required tasks so that production is never interrupted. TPM is suitable for Nijhuis' Machining department. Every employee must feel the responsibility for a smooth process of all machines. This means that they are not only responsible for their own machine, but for all machines.

Disturbances, maintenance activities and changeover time are three example of hidden waste. Employees have to find solutions to minimize the chance of disturbances. The reason behind a disturbance has to be found, which is possible with the "5W1H principle"[10]. Machines need maintenance every once in a while. Maintenance activities performed by employees minimize the downtime of a machine. Moreover, daily maintenance can be considered as preventive maintenance. Five minutes a day for checking and cleaning gives an early sign of machine errors, which increases the overall equipment effectiveness (OEE)[11]. A waste free production process would result in an OEE of 100 %, which means that any machine in function produces products as required, no machine functions infinitely. However, an OEE of 80 % is already very high, because every machine will have disturbance sometimes. Nijhuis has to form a team with mechanics to improve the OEE of each machine. This means that they have to find ways to decrease the downtime of a machine, which exists due to hidden waste. The results of a high OEE is a decrease in throughput time (productivity) and increase in quality.

TPM decreases the downtime of machines, which positively influences throughput time and quality. Nijhuis has to find the causes of downtime to eliminate the waste.

§ 5.2.5 *Kanban*: inventory signalling

The implementation of lean manufacturing can continue with the establishment of a production environment where a pumpset moves through the process without interruptions from the moment an order is picked up to the moment a pump is prepared for distribution.

Section 4.2.3 analyzed the possibilities of JIT and MRP for Nijhuis. JIT by means of cards or empty boxes (i.e. *Kanban*) has many possibilities in actual production. The testing area is the last department before an order

[10] 5W1H means that you have to ask several why questions before you come to the real problem. The answer to the how question is the solution to the problem.

[11] OEE is based on three factors: Availability x Performance x Quality.

Availability	=	Operating time / Planned operating time
Performance	=	(Total Pieces/Operating time) / Ideal run rate
Quality	=	Good pieces / Total pieces

is distributed, which is the starting point for the creation of flow. The date for distribution is the starting point for flow creation. Planning has to determine the demand for a specific day, week, month and according capacities of the different departments. The largest bottleneck for production at Nijhuis is the testing area due to space and equipment limitations, which makes the testing area determinant of the production process. When planning for the testing area is made, *Setbouw* can be planned. They should know when a pumpset is tested and subtract the hours required for assembly to know when to start production. The same story holds for pump assembly and the warehouse.

For the other departments planning should be made by means of MRP. For example, historical calculations of time required by the R&D department can be used for the planning of a new order. ERP systems are the successors of MRP systems. They possess many possibilities to calculate lead times and planning possibilities. Currently, the ERP system is not fully exploited. There might even be possibilities to use the ERP system for *Kanban* activities. For example, scanning a bar code when an activity is finished.
Moreover, the ERP system offers many possibilities for communication and cooperation. When all information is gathered in one system everybody knows what is going on and through that can adapt the working activities to sudden changes. Moreover, transparent information gives employees the feeling that they are all working on the same goal to achieve the best possible result.

JIT and MRP have to be used together at Nijhuis to guarantee production flow. The ERP system helps with the establishment of both systems.

§ 5.3 A final word

The new way of operation through the changes has to be standardized in the production process. Standardization of activities forms the basis for improvements. Every improvement plan that is thought of is based on the standard activities. Moreover, the standard activities are value-adding activities, since non-value-adding activities have been eliminated through the implementation of the building blocks. After the implementation of lean manufacturing Nijhuis' employees have to remember that a product is never perfect, there are always better, cheaper and more efficient ways of production that result in a higher level of protection. The complete organization has to realize that there are always forms of waste within a company that can be eliminated.

Ch. 6 CONCLUSION & RECOMMENDATIONS

This chapter concludes the research. Section 6.1 summarizes the major findings of the analysis of the 2007 attempt and plan of action for the new implementation attempt. The contribution to theory is addressed in 6.2 .Section 6.3 deals with the limitations of the research and hence the subjects for future research.

§ 6.1 Conclusions

This central question of this research was: "*In what way does Nijhuis Pompen B.V. best implement lean manufacturing, taking the first implementation attempt as starting point?*" The research examined the abundant amount of literature about lean manufacturing, which was used for the analysis of the implementation attempt in 2007. Chapter 5, *the pursuit for perfection,* was based on the result of the analysis in chapter 4. The major conclusions of the research are addressed below.

The basis for lean manufacturing implementation at Nijhuis was not well established. The success story from a supplier gave Nijhuis the idea that lean manufacturing would benefit them as well. They did not realize that lean manufacturing has to be adapted before successes can be booked. An external consultancy firm was hired to help Nijhuis with the implementation of lean manufacturing. This consultancy firm did not start with an analysis of the production process. Moreover, the consultancy firm did not consider the large amount of knowledge that is available among Nijhuis' employees. The production process at Nijhuis cannot be categorized under one heading. Process production (the foundry) and discrete production (pumpset assembly) both occur, as well as engineer-to-order and make-to-order. These categories complicate the calculation of throughput time.

Furthermore, employee participation and leadership level were not accurate. The consultancy firm forced the changes on the employees, which is not effective. Change always causes some level of discomfort, which has to be managed well to prohibit resistance to the changes. The survey showed that employees did not feel respected and through that became hesitant to the changes. The leader of the process did not perform the different roles as prescribed in the literature. The leader did not create an environment where everybody was willing to cooperate, improve and change.

The analysis of the attempt in 2007 formed the basis for the new implementation plan, the pursuit for perfection. Chapter 5 put the lean philosophy first to stress the importance of a committed change agent and workforce. Motivating employees is already hard, but due to the negative experience with lean manufacturing even more. Nijhuis has to create a sense of urgency to motivate employees and appoint a change agent who has the will to turn Nijhuis into a lean manufacturing organization. Moreover, employees

are motivated when they are appointed during the change process. For example, participation in improvement teams with a further advantage of efficient use of employees' skills.

The motivation of employees should also be remembered during the choice of lean building blocks. The motivation of employees is enlarged when quick wins are realized. Employees that see positive results become more enthusiastic. The choice for lean building blocks is furthermore determined by Nijhuis' performance, which is largely dependent on product quality and delivery dependence.

Firstly, Nijhuis has to develop a VSM to show production activities, product flow and improvement possibilities. Secondly, "5s" provides Nijhuis with a better visibility of value-adding activities and in relation to those improvement opportunities. Nijhuis can continue with Quality at the Source, TPM and *Kanban.* If every employee assures the high quality of his/her product when it leaves his/her workspace, product quality is higher and the number of errors in the process is decreased (i.e. lower throughput time). TPM helps to find causes of machine downtime, which positively influences throughput time and quality. The last building block, *Kanban,* serves the JIT and customer pull principle, if partially used. Due to the various production routings and complex product structures complete implementation of *Kanban* is not feasible.

The establishment of the VSM and implementation of 5s are activities to start with immediately, whereas the other lean building blocks are possibilities for the future.

§ 6.2 Contribution to theory

The results of the research have led to the following contribution to theory. Nijhuis can be considered as an example from the book where changes are not correctly implemented. Although there is abundant literature and knowledge to minimize the chance of failure, Nijhuis changed without giving consideration to the effects. The literature presents stories where change programs fail due to a lack of understanding, commitment and management. These aspects are precisely the causes of problems that occurred at Nijhuis.

Moreover, Nijhuis choose lean manufacturing as solution for the problems they were facing in 2007, since the principle worked correctly at other companies. This contradicts the logical order of understanding a problem, deliberating solutions and choosing the most suitable solution. Nijhuis must not make a habit of making decisions this way, because every company has its individual characteristics and thus every change program is different. A solution is never found through implementing "one best way" (theory), but it is created after having a holistic view of the problems. *Thinking before acting!*

These issues result in the following contribution to theory. Managers seem to forget what they have so often heard during their education, which means that there is a gap between the theory about and practical implementation of lean manufacturing. On the one hand the theory might not be practical enough but on

the other hand companies might need to follow the theory more. Further research could address the reasons for this gap.

§ 6.2 Limitations and Further Research

Every research is bound to intended and unintended restrictions. These limitations can be the starting point for further research.

- This research only described, on paper, the implementation of lean manufacturing. The proposed actions were not executed. During the execution new problems might surface, which require alterations of the plan. For example, the execution of dummy runs could be a topic for Action Research. The positive and negative sides of lean manufacturing implementation can be discovered by this form of research.
- Furthermore, the research only focused on the assembly of a pumpset and not the office departments. In the literature there is evidence of lean manufacturing success in the office. Nijhuis should consider the possibilities of extending the implementation of lean manufacturing to the offices. During extension of lean manufacturing the following should be considered. During the research the researcher formed the opinion that an "*afschuifcultuur*" (passing culture) exists at Nijhuis. All too often employees with a problem are driven from pillar to post. Everybody is to blame, except themselves. Nijhuis' employees have to realize that they are all working for the same company and same goal. The goal for every employee should be the delivery of high quality products to satisfy customer needs. When lean manufacturing is extended to the entire organization, employees should cooperate more. Future research could explore the possibilities of lean manufacturing in the offices, both at the philosophical and technological level.
- This research looked at the implementation attempt from the angle of Nijhuis Pompen. The consultancy firm was asked to participate in the research, but they refused. The consultancy firm probable had different ideas about the implementation and causes of failure. Suppliers, advisors and customers are affected by companies that implement lean manufacturing, but are often not the unit of observation in a research. A subject for research could be the degree to which stakeholders of lean manufacturing companies are affected. Moreover, the effects in the complete supply chain can be addressed.
- The last remark for this research is that lean manufacturing is not the answer to all problems. Lean manufacturing should be seen as an ideology, developed by certain authors. No matter in which company lean manufacturing is implemented, adaptation towards company characteristics is required. Besides this, there are many other change programs available in the literature, which might also be applicable to specific companies. Future research could try to combine the best of both worlds to enlarge effects of change programs.

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APPENDICES

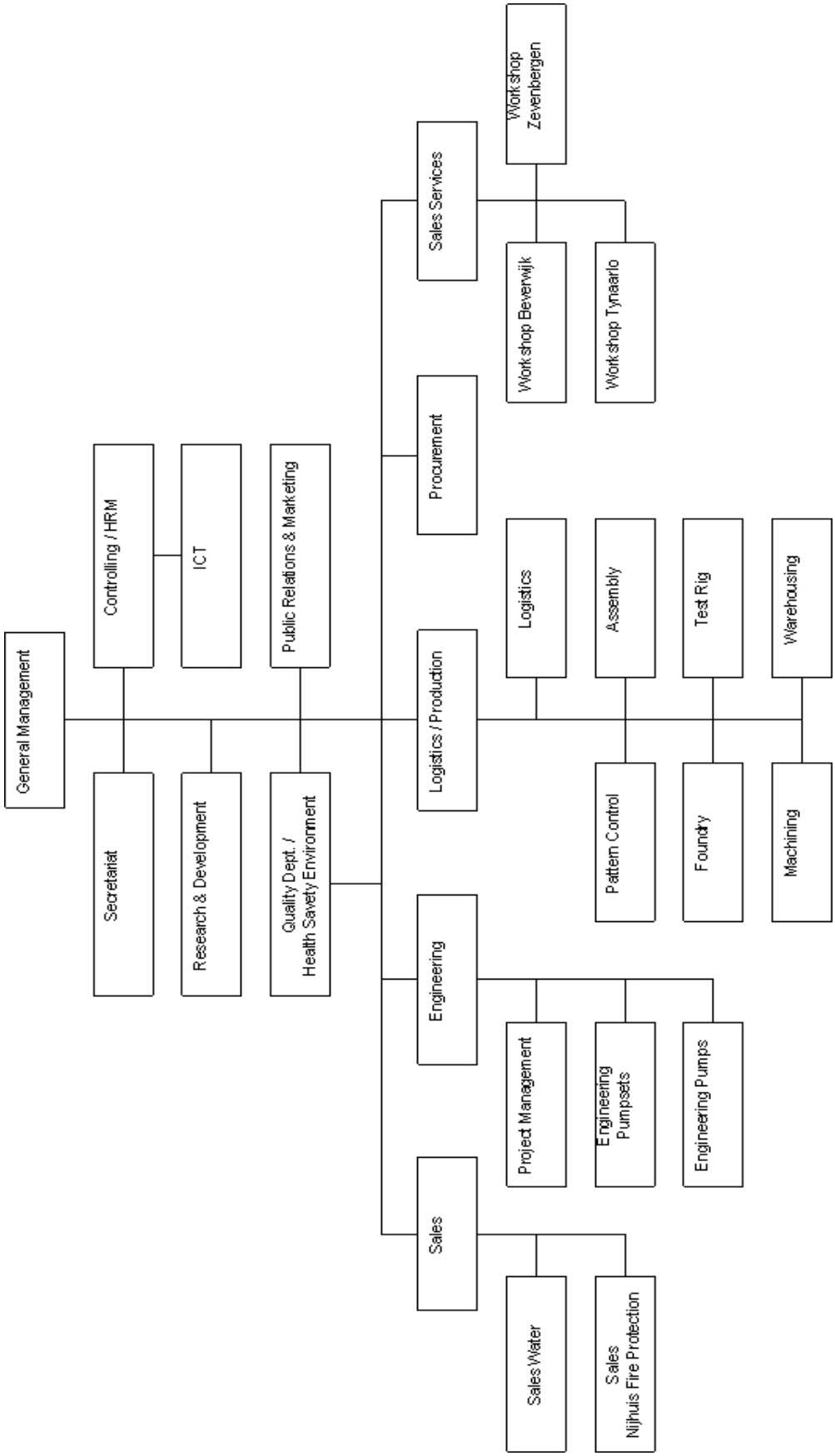
App. A List of Figures

App. B List of Tables

App. C List of Abbreviations

JIT	Just-In-Time
LTG	Lean Transformation Group
MRP	Management Resource Planning
OEE	Overall Equipment Effectiveness
SMED	Single Minute Exchange of Dies
TPM	Total Productive Maintenance
TPS	Toyota Production System
WIP	Work-In-Progress

App. D Nijhuis Pompen B.V. Organization Chart



App. E Questionnaire Survey

Voor mijn onderzoek wil ik jou vragen om deze vragenlijst in te vullen. De vragenlijst gaat over *lean manufacturing*: de veranderingen die in 2007 hebben plaatsgevonden en een mogelijk nieuw veranderingsproces. Jouw mening is van belang voor de rest van het onderzoek! Alvast bedankt voor het invullen!

1. Werkte je in januari 2007 al bij Nijhuis Pompen B.V.?

○ Ja, ga naar vraag 2.

○ Nee, beantwoord vraag 4, 9 en 10.

2. Op welke afdeling was je in 2007 werkzaam?

○ Magazijn ○ *Setbouw*

○ Montage Pompen ○ Proefstand

○ Spuiterij ○ Anders _____

3. Op welke afdeling werk je nu?

○ Magazijn ○ *Setbouw*

○ Montage Pompen ○ Proefstand

○ Spuiterij

4. Wat is *lean manufacturing* volgens jou?

_____

_____

5. Was je bekend met *lean manufacturing* voor de introductie bij Nijhuis Pompen B.V.?

○ Ja.

○ Nee.

6. Zat je in een van de veranderingsteams (*Setbouw*, Pompen, Spares) tijdens de invoering van *lean manufacturing*?

○ Ja.

○ Nee.

7. Op welke manier hoorde je voor het eerst van de voorgenomen veranderingen? Slechts 1 antwoord mogelijk.

○ Presentatie van de directie.

○ Van Mond tot Mond.

○ Email.

○ Prikbord.

○ Geen idee.

8. In hoeverre ben je het eens met deze stellingen? Omcirkel het antwoord dat het meest van toepassing is.

	Eens				*Oneens*
Ik begreep waarom *lean manufacturing* belangrijk was.	1	2	3	4	5
Ik was verward over wie de leider van het proces was.	1	2	3	4	5
De leider van het proces toonde actief leiderschap.	1	2	3	4	5
Ik werd vanaf het begin actief betrokken bij het veranderingsproces.	1	2	3	4	5
De leider moedigde mij aan om te veranderen.	1	2	3	4	5
Er was ruimte voor eigen initiatief.	1	2	3	4	5
Mijn mening werd gerespecteerd en serieus genomen.	1	2	3	4	5
Ik had vrijheid en tijd om eigen ideeën te ontwikkelen.	1	2	3	4	5
Ik had voldoende tijd om aan de veranderingen te wennen.	1	2	3	4	5

9. Welke punten vind jij belangrijk bij het werk? Kies de belangrijkste 3 en nummer de belangrijkste met 1, 2, 3.

a. Tijd en ruimte om ideeën te ontwikkelen. ___
b. De mogelijkheid om ideeën zelf te implementeren. ___
c. Een duidelijke visie van het management voor de toekomst. ___
d. De optie om in teamverband verbeteringen te ontwikkelen. ___
e. Training ontvangen voor persoonlijke en bedrijfsontwikkeling. ___
f. Een beloning voor de ontwikkeling van ideeën. ___
g. Overleg over de voorgenomen veranderingen. ___

10. In welke leeftijdscategorie bevind jij je?

○ < 25 jaar.
○ 25 – 40 jaar.
○ 40 – 50 jaar.
○ > 50 jaar.

11. Hoe lang werk je al bij Nijhuis Pompen B.V?

○ < 1 jaar.
○ 1 – 3 jaar.
○ 3 – 10 jaar.
○ 10 – 20 jaar.
○ > 20 jaar.

BEDANKT VOOR HET INVULLEN VAN DEZE VRAGENLIJST!

Thursday, January 21, 2010

App. F Interview

1. Necessity of Lean Manufacturing

Was there enough communication between the change agent/consultancy firm and employees?

Why do you think the changes were implemented? Did you feel they were necessary?

Do you think lean manufacturing is suitable for Nijhuis? (Explaining LM) Why/why not?

2. Performance change agent

Did you exactly know who was in charge of the project? Who was the leader of the process?

Was the level of communication between change agent and employees enough? Was this communication top-down/bottom up or both?

Did the change leader have a clear vision?

Did the leader encourage you to actively involve yourself in the process?

3. Employee Participation

Did you get the choice to participate in a change team? Why did you participate/Why not?

Was there enough opportunity to participate and negotiate about the changes?

Were you respected at moments when you doubted the changes?

App. G Codebook

	Variable Number	Code Description	Variable Name
1	1	Werkzaam 2007 1 = Ja 2 = Nee 9 = Missing	Werk2007
2	2	Afdeling 2007 1 = Magazijn 2 = Montage Pompen 3 = Spuiterij 4 = *Setbouw* 5 = Proefstand 6 = Anders 7 = Gieterij 8 = Verspaning 9 = Missing	Afd2007
3	3	Afdeling NU 1 = Magazijn 2 = Montage Pompen 3 = Spuiterij 4 = *Setbouw* 5 = Proefstand 6 = Gieterij 7 = Verspaning 9 = Missing	AfdNU
4	4	Definitie Lean Manufacturing 1 = efficiënte productie 2 = aanpakken is afmaken 3 = kosten beheersen 4 = geen idee 5 = anders	DefLean
5	5	Bekend Lean 1 = Ja 2 = Nee 9 = Missing	BekendLean
6	6	Veranderingsteams 1 = Ja 2 = Nee 9 = Missing	Teams
7	7	Communicatie 1 = Directie 2 = Mont tot Mond 3 = Email 4 = Prikbord 5 = Geen idee 6 = Anders 9 = Missing	Communicatie

8a t/m 8i	8 t/m 16	Vul in Eens (1) t/m Oneens (5)	Stellingen
9a	17	Rangorderen stellingen 1 = genoemd als 1e 2 = genoemd als 2e 3 = genoemd als 3e 9 = niet genoemd	Tijd
9b	18	1 = genoemd als 1e 2 = genoemd als 2e 3 = genoemd als 3e 9 = niet genoemd	Implementeren
9c	19	1 = genoemd als 1e 2 = genoemd als 2e 3 = genoemd als 3e 9 = niet genoemd	Visie
9d	20	1 = genoemd als 1e 2 = genoemd als 2e 3 = genoemd als 3e 9 = niet genoemd	TeamOntwikkelen
9e	21	1 = genoemd als 1e 2 = genoemd als 2e 3 = genoemd als 3e 9 = niet genoemd	Training
9f	22	1 = genoemd als 1e 2 = genoemd als 2e 3 = genoemd als 3e 9 = niet genoemd	Beloning
9g	23	1 = genoemd als 1e 2 = genoemd als 2e 3 = genoemd als 3e 9 = niet genoemd	Overleg
10	24	Leeftijd 1 = < 25 2 = 25 - 40 3 = 40 - 50 4 = > 50 9 = Missing	Leeftijd
11	25	Jaren bij Nijhuis 1 = < 1 2 = 1 - 3 3 = 3 - 10 4 = 10 - 20 5 = > 20 9 = Missing	JarenNijhuis

8a = begrijpen belang Lean
8b = verward leider
8c = actief leiderschap
8d = actief betrokken
8e = aanmoediging
8f = ruimte initiatief
8g = mening gerespecteerd
8h = vrijheid en tijd
8i = voldoende tijd

App. H Lean Transformation Groups composition

Kernteam Team Setbouw
Frank Raben Projectleider setbouw
Jan Willem Winterberg stuurgroeplid
Ron Sieben stuurgroeplid
Wim Hiddink (Setbouw)
Martijn Tolkamp (Testing Area)
Marcel Schutte

Kernteam Team Pompen
Andre Betting Projectleider pompen/stuurgroeplid
Erwin Rietman
Herman Steenhuizen stuurgroeplid
Emiel Koldeweij (Machining)
Jan Nijhof (Testing Area)
Sander Westendorp
Henk Mellink

Kern Team Services
Henny Wonink Projectleider spare parts/stuurgroeplid
Harry Bos Stuurgroeplid
Wilbert Hietkamp (Warehouse)
Gert Jan Sluiskes
Ronald Hogeboom (Foundry)

12-10-2009 1

Overall
Robert Schuuring Voorzitter stuurgroep (CEO)
Marcel Dorst stuurgroeplid (CFO)
Gerard Scholten (Manager Services)
Robert van der Velde (Consultant)
Klaas Kunst (Consultant)
Chris Hengevelt coördinator lean (change agent)

Overleg structuur
Dagelijks bijeenkomst van de kernteams
Elke 14 dagen een implementatie sessie met de kernteams en leanent
2 Maandelijks bijeenkomst stuurgroep

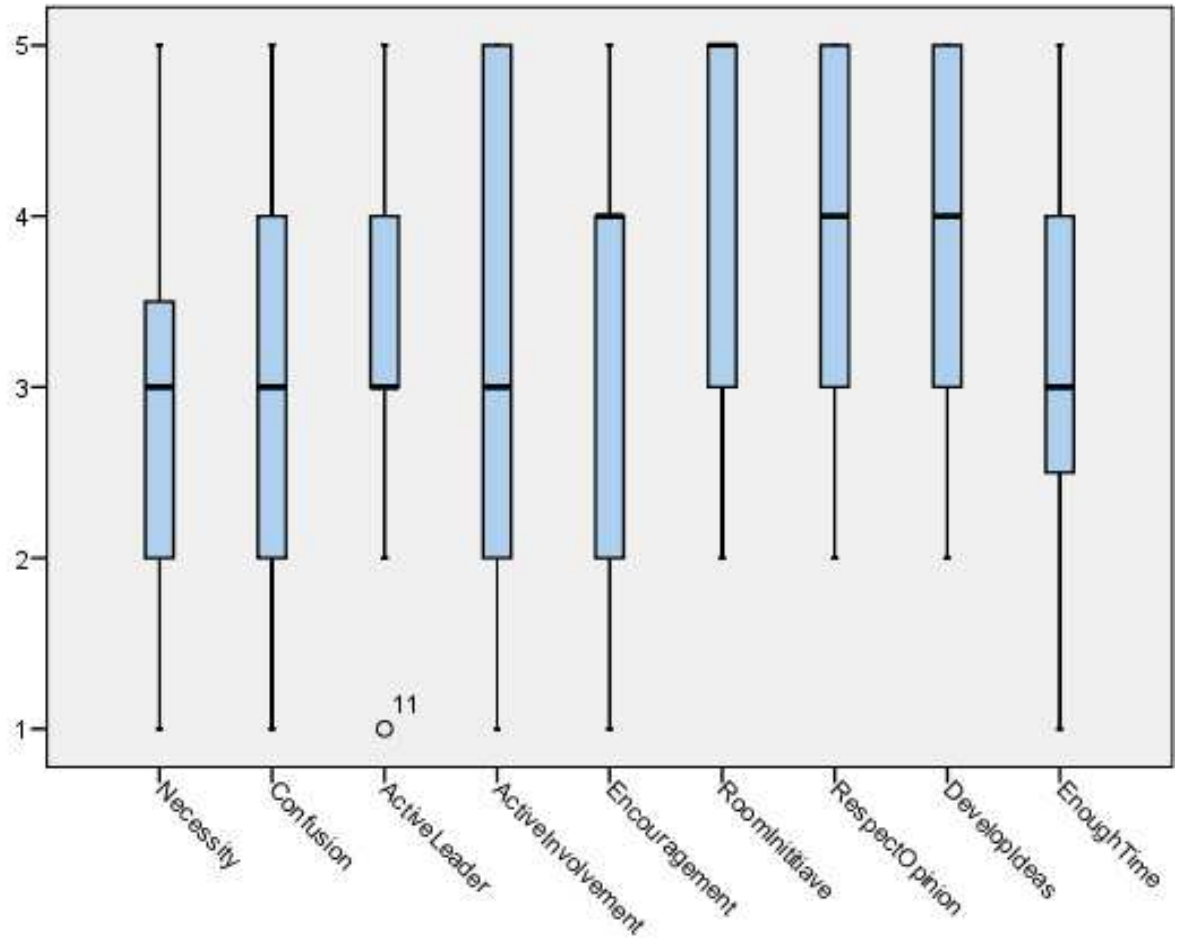
Wanneer je vragen en of opmerkingen hebt omtrent het lean proces kun je deze stellen aan een van de hier bovengenoemde leden.

12-10-2009 2

App. I Results of the Survey

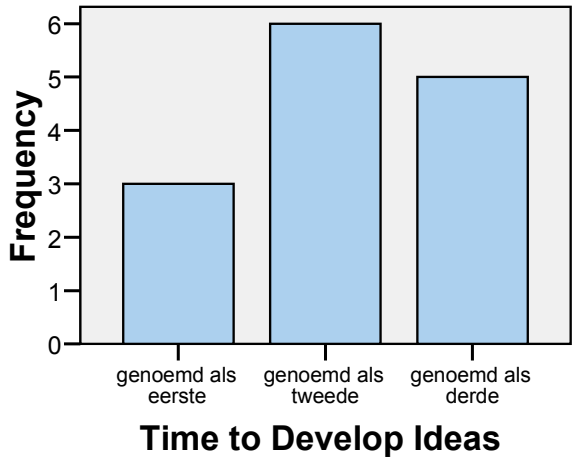
Teams	Necessity LM	Confusion	Active Leadership	Active Involvement	Encouragement	Room Initiative	Respect Opinion	Develop Ideas	Enough Time
Ja	2,71	2,43	2,86	2,00	2,86	3,71	2,57	3,00	3,00
Nee	2,59	3,39	3,55	3,57	3,22	4,09	4,05	4,00	3,43
Total	2,62	3,17	3,38	3,20	3,13	4,00	3,69	3,77	3,33

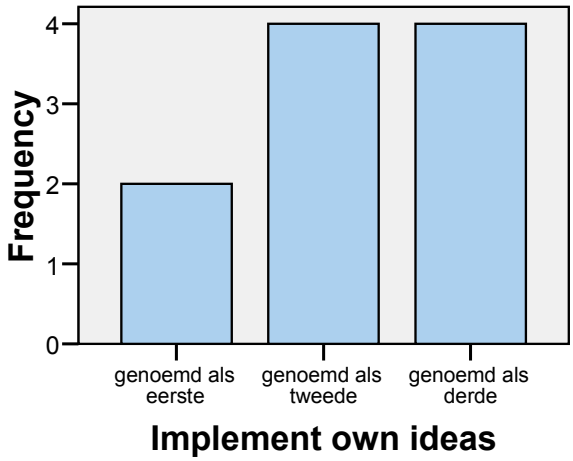
Mean Variables Lean Manufacturing 2007 (Team members and non members)

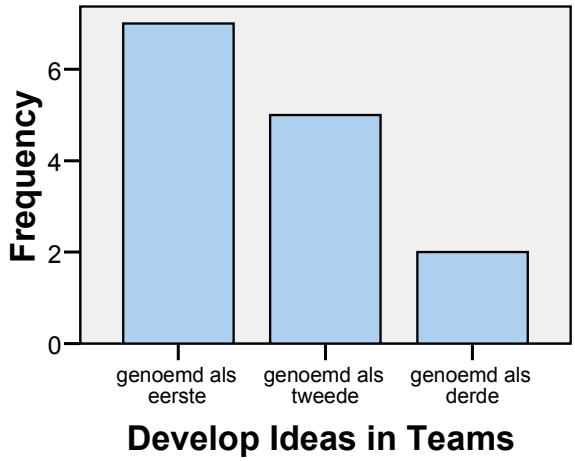


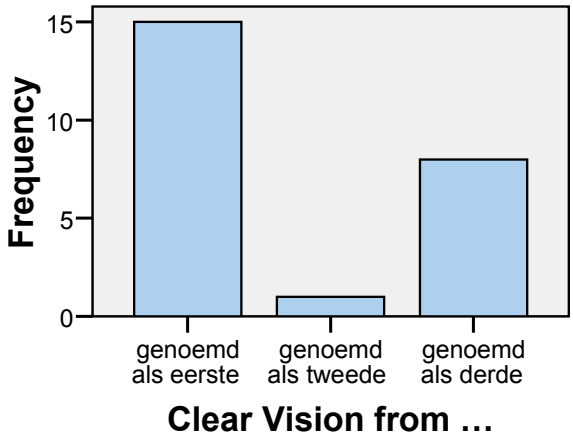
Median Rating Results Questionnaire

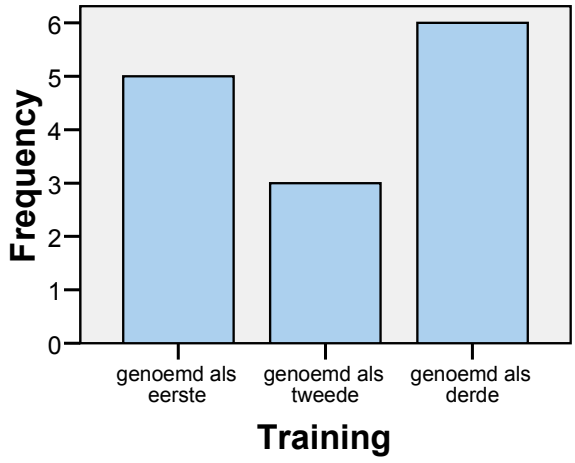
App. J Employee Opinion

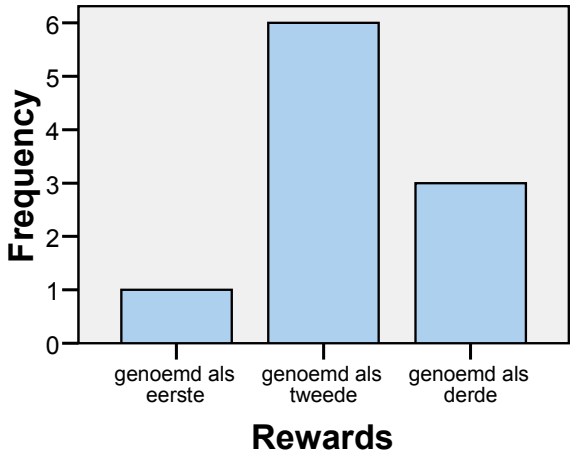


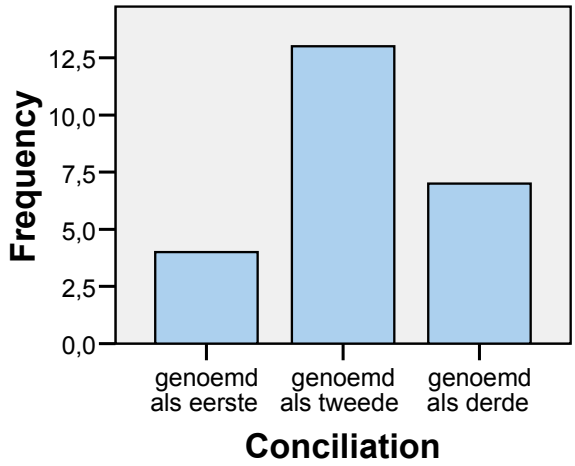












Respondents were asked to rank their top three of statements they value most during a change implementation. Each figure presents the frequencies each statement was picked first, second and third.