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Product Quality Control in Lean Organization

Case: Work method standardization

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The aim of this study was to bring improvement to product quality and product efficiency to a Lean company by standardizing methods. A team combining members from different areas affected by this improvement study had been organized to carry out the study. Data was collected by the members of this team from existing documents and from workers, mostly assemblers, because the pilot case was targeted to the assembly area. Data was analysed in a weekly meetings in order to choose the best method based on data analysis. Finally work instructions were created based on the best methods and implemented as a pilot to a selected scope.

A questionnaire has been carried out at the start and the end of the study to state the workers attitude and understanding of standardization. Also a workshop was held just before the pilot implementation to give workers a chance to comment and give improvement suggestions on the created work instruction. A work study had been also carried out during the pilot time to observe how well workers followed the instructions and to map out if the workstations' equipment support the methods.

The results revealed that this study has offered a good understanding of standardization to the workers which implies the success of implementing standardised methods in the future. The literature review on the topic brought out clearly the impact of standardization to the efficiency of Lean manufacturing.

Keywords	Quality control, Lean, TQM, Standardization, continues improvement

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Tämän tutkimustyön tavoitteena oli tuoda parannusta tuotteen laatuun ja tuotannon tehokkuuteen menetelmien vakioinnin avulla. Tämän tutkimuksen läpiviemistä varten koottiin tiimi tutkimustuloksen vaikutuksen piirissä olevilta tahoilta. Tiimin jäsenet keräsivät tietoja olemassa olevista asiakirjoista ja työntekijöiltä, enimmäkseen tuotekokoajilta, joiden alueelle pilotti oli tarkoitus suorittaa. Kerättyä dataa analysoitiin viikoittaisessa palavereissa ja sen perusteella valittiin paras menetelmä. Lopuksi parhaista menetelmistä luotiin toimintaohjeet, jotka toteutettiin pilottiina rajatussa laajuudessa valitulle alueelle.

Sekä tutikmustyön alussa että lopussa tehtiin kysely, jonka avulla kortoitettiin työntekijöiden ymmärrystä, asennetta ja suhtautumista vakiointia kohtaan. Järjestettiin myös työpaja juuri ennen kokeiluhetkiä, joka antoi työntekijöille mahdollisuutta kommentoida ja antaa parannusehdotuksia luodulle työohjeelle. Myös työntutkimusta suoritettiin pilotin aikana, jolloin tarkkailtiin kuinka hyvin työntekijät noudattivat luotua ohjetta ja kartoitettiin työpisteiden varustuksen vastavuutta vakioituun menetelmään.

Tulokset paljastivat että tämä tutkimus on antanut hyvän käsityksen työntekijöille vakioinnista, joka merkitse onnistumista vakioidun menetelmän toteuttamisessa tulevaisuudessa. Aiheesta tehty kirjallisuuskatsaus puolestaan selkeytti vakioinnin merkitystä Lean tuotannon tehokkuudelle.

Avainsanat	laadunhallinta, Lean, TQM, vakiointi, jatkuva parantaminen

Contents

1 Introduction

The main purpose of this paper is to produce (introduce) information regarding product quality improvement by studying the literature concerning this field and through the case study dealt with in this paper. The company dealt with in this paper is world's leading industrial company, Metso, which provides products and related services to the mining, aggregates, recycling, oil, gas, pulp, paper and process industries worldwide. Its product selection include mining and aggregates processing equipment and systems, and industrial valves and controls. [About us 2015.] Metso's valve manufacturing plant in Finland where I have been working in for over 10 years now, is where this paper case focuses on with the issue of *work method standardization*.

Back ground and problem statement

The intent is to intervene to the problem that have been causing a lot of deviation in the working methods making different development works like quality improvement harder to execute. This has been also one of the main reasons for the arising of high amount of disturbance hours daily. The purpose of this study is to bring improvements to the current product quality problems and to the quality control system through standardizing work methods. There is also the belief that this work method standardization will make the current Metso's management system, Lean, more effective.

Scope and objectives

The objectives of this work standardization study attempting at the valve assembly and testing area is to create standardized work methods together with the assemblers and people working in assembly-related departments. The intention for now is to plan a pilot case for which instructions will be created based on the current best practices and then implement it in a selected scope. Quality and product structure related issues, creation of SOPs (Standard Operating Procedures) excluding Pilot case, manufacturing and warehousing of parts or other components and internal and audit testing process are not included in this work development study. The main expected achievements from this study are to:

- reduce the number of butterfly valve related disturbance hours by 50 %

- improve butterfly valve yield in pressure testing by 20 %
- reduce butterfly standard hours by 10 %.

The expectation is that those improvements will lead to improved efficiency and reduction of lead time.

Content of this study

The second chapter starts with a short introduction to the total quality management and ISO as introduction to the main theoretical framework. As Lean is the widely used strategy in Metso this chapter deals largely with the knowledge of Lean system: what it means to a company and its supply chain. It also contains brief introduction to some of Lean tools related to this study. Chapter three contains introduction to the case company Metso and its quality control strategy. The present situation of working method is also stated in this chapter. The work standardization case study is covered in the fourth chapter. Also the results of this study are shown as last issue of this chapter. Then comes the conclusion in the last chapter before summery.

The study is being done by organizing a team to study the current situation, analyze collected data and choose the best method based on them. It is aid by weekly meetings to discuss on the issue and by arranging questionnaires, work study and interviews with concerned workers as well as by studying existing data on this matter. I have also got the chance to be one of the team members and thus able also to observe things in the whole process.

2 Quality control and Lean management system

2.1 Total Quality Management (TQM)

The emphasis on quality started in the early 1900s when F. W. Taylor ('Father of Scientific Management') included product inspection and gauging in his list of fundamental areas of manufacturing management. World War II caused a dramatic increase in emphasis on quality control and the strategic approach to quality which linked quality to productivity and profits emerged in the late 1970s. This approach also increased the importance of consumer satisfaction and the involvement of all levels of management and workers in a continuing effort of improving quality which gave rise to the term 'continuous improvement'. As Bhat [2010] puts it at the end of the twentieth century, business organizations were involved in the so called quality revolution which began in Japan and has spread to other parts of the world. W. Shewhart, Deming, Juran, Crosby and A.V. Feigenbaum are some of the quality gurus who have been developing the principles of Total Quality Management over the years. TQM includes both the techniques of quality assurance and the approach of Total Quality Control. [Bhat 2010: 2, 53; Greasley 2007: 96.]

The following paragraphs will deal with a short description of some TQM related terms. The terms included here are quality, quality control, total quality control, total quality management, inspection, quality assurance, audit and quality cost.

Quality is the main term behind TQM. All definitions of quality found from different sources used for this paper includes at least the fact in the next definition. "The quality of product or service is a customer's perception of the degree to which the product or service meets his or her expectations" [Aswathappa & Bhat 2008: 388]. As far as the approach of a produced goods and services is to meet customers' needs also the concept of quality should be related to how well these needs are met from the customer's point of view. Eight quality characteristics which the customer looks for in a product defined by Garvin are performance, features, reliability, conformance, durability, serviceability, aesthetics and other perceptions. The customer contrasts these quality characteristics against the cost of the product. Since quality is a measure of the conformance of the product to the customer's needs, the quality of a product is high enough when the customer is happy enough about the product. [Greasley 2007: 95–96; Bhat 2010:1.]

In spite of the fact that all customers want their needs met consistently changes in raw materials, worker morale, process parameters, customer expectations, conditions of use, employee abilities, legal restrictions, weather and so on causes that the same products produced are not necessarily exactly the same. Three important steps to cope with such changes are to understand variation and its effect on performance; reduce variation where possible and design the product or service to perform consistently in the presence of variation. A strong communication tie with customers allows companies to know and emphasize the critical features and characteristics of their products based on the customer's use and expectations. Kumar [2008] presents quality also as a measure of how closely a good or service conforms to specified standards. Quality begins with the design of a product in accordance with the customer specification involving established measurement standards. The design stage includes also among others material and suitable manufacturing process selection. [Walker et al. 2012: 3; Kumar 2008: 131–132.]

Kumar [2008] puts *QC* as a system used to maintain a desired level of quality in a product or service stating also that it is a systematic control of various factors that affect the quality of the product. Juran's definition as in Kumar's [2008] book goes as follows: "Quality control is the regulatory process through which we measure actual quality performance, compare it with standards, and act on the difference". The aim of quality control is to prevent defects at the source by relying on effective feedback system and corrective action procedure. Inspection is one the main tools of quality control. As Aswathappa & Bhat [2008] states it Quality Control system integrates the quality development, quality maintenance and quality improvement efforts of the various groups in an organization enabling them to come up with production and service at the most economical level allowing also customer for full satisfaction. [Kumar 2008: 137–138; Aswathappa & Bhat 2008: 389.]

Quality enables organizations to achieve positions to compete on the market. According to Bhat [2010] the effort organization do to improve its products quality is often referred to as *Total Quality Control (TQC).* Feigenbaum's definition for TQC as in Bhat's [2010] book is:

> Total Quality Control is an effective system for integrating quality-development, quality maintenance and quality improvement efforts of the various groups in an organization so as to enable marketing, engineering, production and service at the most economic levels which allow for full customer satisfaction. [Bhat 2010: 51]

Customers are demanding these days products/services with greater durability and reliability at the most economic price. This is forcing industries to provide a product or service at the most economical costs ensuring also full customer satisfaction in order to be able to compete on the market. The achievement of economical products and services with full customer satisfaction can be assured through *Total Quality Management (TQM)* because quality is a systemic process extending throughout all phases of the business like marketing, design, development, engineering, purchasing and production operations. As Bhat [2010] states it TQM is a total, company-wide effort through full involvement of the entire workforce and a focus on continuous improvement that companies use to achieve customer satisfaction. TQM is a comprehensive managerial philosophy. The three principles of TQM are: customer satisfaction, employee involvement and continuous improvements in quality. [Kumar 2008: 155; Bhat 2010: 47, 56.]

Inspection is one phase of quality control and is an essential tool of manufacturing process. It helps manufacturer to assure confidence and aims satisfaction to customer. The inspection and test unit assesses the quality of incoming raw materials and components as well as the quality of the manufactured product or service. Inspection is the most common tool through which standardization, uniformity and quality of workmanship are obtained and defective items are stopped from being sent to further stages. [Kumar 2008: 134; Aswathappa & Bhat 2008: 389.]

Aswathappa & Bhat [2008: 392] present *Quality assurance* in their book as the activity of providing the evidence needed to establish confidence that the quality related activities are being performed effectively. He also mentions that Quality assurance encompasses quality planning, quality control, quality improvement, quality audit and reliability. *Audit* is a systematic, independent and documented process for obtaining objective evidence and for evaluating objectively to determine the extent to which the audit criteria are fulfilled [ISO 9000:2015].

To survive in a competitive business environment organizations have to assure the minimum required quality of their goods and services as extra quality means extra cost [Kumar 2008: 131]. Total quality cost consists of the major quality cost categories. Next is a list of the major *Quality Cost* categories that make up the total quality cost.

- Prevention costs: costs of all activities specifically designed to prevent poor quality in products or services.

- Appraisal costs: costs associated with measuring, evaluating, or auditing products or services to assure conformance to quality standards and performance requirements.
- Internal failure costs: costs associated with product failure prior to delivery or shipment of a product, or the furnishing of a service, to the customer.
- External failure costs: costs associated with failure that occurs after delivery to the customer. [Walker et al. 2012: 6–7.]

Most quality authorities see investigation in defect prevention as the important point for saving money in typical organizations because the ideal place to detect and prevent problems is at their source. Allowing a problem to occur and detecting it internally could be ten times as expensive as the prevention cost and there could come another ten times to be added if the problem is detected by external customers. Suppliers play a great role in assuring the quality of the product or service that an organization provides. So it is important for an organization to have methods (product specifications, standards) to assure that the supplier is capable of providing products with the needed quality constantly. Good understanding of the entire supply chain is also vital for assuring quality. The International Organization for Standardization (ISO) provides a series of standards to make quality evaluations easier. [Walker et al. 2012: 5, 8.]

2.2 ISO 9000 Series

ISO stands for International Organization for Standardization and consists of representatives from more than 90 countries. The ISO 9000 family addresses various aspects of quality management providing guidance and tools for companies and organizations who want to ensure that their products and services consistently meet customer's requirements, and that quality is consistently improved. ISO 9000 standards expect firms to have a quality manual that meets ISO guidelines, documents, quality procedures and job instructions, and verification of compliance by third-party auditors. Here are some of the standards included in the ISO 9000:2015 standard family: [ISO 9000 - Quality management 2016; Kumar 2008: 156.]

- ISO 9001:2015 sets out the requirements of a quality management system.
- ISO 9000:2015 covers the basic concepts and language including detailed explanations of the seven quality management principles and many of the terms and definitions used in ISO 9001.

- ISO 9004:2009 focuses on how to make a quality management system more efficient and effective by providing guidance on how to achieve sustained success with quality management system.

- ISO 19011:2011 sets out guidance on internal and external audits of quality management systems to ISO 9001 helping to ensure quality management system delivers on promise and prepares for an external audit. [ISO 9000 - Quality management 2016; ISO 9001:2015 2016.]

ISO 9001:2015 is the standard that gives requirements for an organization's quality management system and is the only standard in the family that can be certified. It can be used by any organization and it is based on a number of quality management principles that can be used as a foundation to guide an organization's performance improvement. The seven quality management principles of ISO 9001:2015 are: customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision making and relationship management. Using this standard helps ensure that customers get consistent, good quality products and services, which in turn brings many business benefits. It also gives companies confidence that suppliers can consistently provide products and services that meet company's needs and expectations and also that they comply with applicable regulations. [ISO 9000 - Quality management 2016; ISO 9001 in the supply chain 2016; Quality management principles 2015.]

2.3 LEAN

Brief background

The root of Lean thinking leads to Japan and there, to Toyota. The founder of Toyota, Sakichi Toyoda, his son Kiichiro Toyoda and the engineer Taiichi Ohno introduced the Toyota Production System (TPS) during the 1950s. It was a modified version of the company-wide quality control (CWQC) approach to fit their specific environment. Most of the tools used in Lean thinking today including the most important just-in-time and jidoka comes from Toyota Production System. Following the poor condition of Japanese economy and the strong competition from international products after World War Two, Toyota organized and structured their production system to enable themselves to use their resources in the most effective way, cutting the costs. So the key concept in their production philosophy became the total elimination of the three Ms: muda (waste), mura (unevenness) and muri (overburden). These represent activities that do not provide added

value for the customer. As part of that elimination philosophy Toyota listed the seven wastes: overproduction, defective products, unnecessary transportation, manual movements, delay/hold on, WIP (work in process) and manufacturing. [Nicoletti 2012: 7.]

The terms Lean Production, Lean Manufacturing, Lean Enterprise and Lean Thinking were created by Americans who also described and abstracted the TPS to make it understandable and thus applicable in any context. The term 'Lean' was introduced for the first time in a study carried out by MIT (Massachusetts Institute of Technology) by John Krafcik in 1988. American gurus are also the one who provided Japanese organizations the key knowledge for developing their production system. [Nicoletti 2012: 4, 12.]

What exactly is Lean?

Nicolette [2012] presents Lean thinking as a philosophy, a method and a set of tools and techniques that allows to bring processes closer to the customer; to eliminate any activities that do not add value to products, and to produce faster with lower costs and higher quality. Trent [2008] on his behalf presents Lean as business philosophy rather than a set of tools and techniques. He emphasizes that at a broader level lean is the relentless pursuit of eliminating waste across an extended supply chain that applies to any organization in any industry. [Nicoletti 2012: 1; Trent 2008; 4–5.]

Among others the economic crisis, the fall of geopolitical barriers with the subsequent entry of competitors, and the excessive increase of supply over demand have made the competitive pressure so high for an organization to survive only with the traditional production and management model. To achieve competitiveness organizations have to improve quality, reduce cycle time and cut costs. Therefore they have to eliminate wastes. [Nicoletti 2012; 1–2.] There are three kinds of activities in a process:

- *Value-adding activity:* one that transforms material or information into what a customer requests and is willing to pay for.
- *Nonvalue-adding activity:* one that often has to be performed to move or deliver material or information closer to the customer but with no physical value-add taking place.
- *Pure waste:* activities that add neither value nor move material or information closer to the customer. [Trent 2008: 12.]

The aim in Lean system is to constantly improve value-adding activities, minimize non-value-adding activities and to eliminate the pure waste. The value stream map (VSM) helps understand value-added and non-value-added activities in the process. VSM identifies the time required to complete each of these activities and usually starts from raw material and ends with the customer, including flow of materials and information. Lean system also tries to simplify everything and seeks to minimize complexity of something without losing its effectiveness. Simplification of important processes is one way to eliminate waste and nonvalue-adding activities in Lean system. Thus an objective at the start of any product development project should be to simplify product designs. Generally simplified product requires fewer components which affects to the needed amount of suppliers, material, transportation, product cost, inventory and inventory management costs. Also fewer components support higher product reliability which mean improving quality and reducing the cost of poor quality. Santos et al. [2014] lists the three philosophies supporting Lean manufacturing; JIT, kaizen (continuous improvements) and jidoka. Jidoka is a Japanese word meaning ‘‘autonomation’’, a form of automation in which machinery automatically inspects each item after producing it and notifies humans if a defect is detected. [Trent 2008: 11–12; Venkatesh et al. 2014: 342–360; Santos et al. 2014: 9.]

Lean Thinking is a philosophy, which focuses on the systematic elimination of waste. The five principles of the Lean thinking are:

- *value*: define the value from the customer perspective
- *value stream*: identify the value of the flow, all the steps that add value
- *flow*: make the identified flow smooth and let it run
- *pull*: make the flow pulled (allow customer pull)
- *perfection*: seek perfection. [Nicoletti 2012: 12; Venkatesh et al. 2014: 342–360.]

Moore [2006] lists in his book the facts that makes one organization look like a Lean practitioner, the Lean characteristics. Minimum inventory, returns product defects, production losses, variability in production rates and processes are some of those characteristics. Also excellent on-time delivery performance, customer satisfaction and continuing effort for improvement are part of the Lean characteristics. He also reminds that it is not easy to constantly try to balance these for an optimal business solution and also to get the basics in place to assure process and equipment reliability and stability. Hobbs

[2011] supports Moore's [2006] list with his own list of the advantages Lean practitioners have achieved. Some of the advantages frequently reported from manufacturers who have installed a Lean operating system are: Manufacturing lead time reductions (50 - 90%), inventory reductions (15 - 75%), productivity increases (5 - 25%), floor space reductions (5 - 40%) and yield/quality improvements (10 - 50%). [Moore 2006: 138; Hobbs 2011: 6.]

Measurement is essential to Lean's continuous journey and to the continuous improvement. Measurement helps identify for e.g. areas that are most in need of improvement and rates of performance change. Measurement provides a picture of performance over time that managers can use to mirror into the future, thus allowing managers to base their decisions on objective rather than subjective analysis. The relationship between measurement, motivation, effort and performance is also obvious to most managers. Measurement also makes conveying requirements between supply chain members more explicit. There are numerous measurements that can be used in Lean system and measurements can be also created to meet the organization's objectives. The best way to approach a measurement is by identifying organization's lean objectives and then creating or choosing the metrics that align directly with those objectives. The importance of right physical layout is also important to notice. As also research with many companies and extensive personal experience reveals many advantages can be achieved through physical layout improvement. Some of the advantages are reducing production cycle times, work-in-process inventory, floor space requirements and material handling. It also creates a stronger ownership among employees, improves product quality and enhances operating flexibility. So taking a comprehensive review to ensure the physical layout supports lean objectives is essential. [Trent 2008: 83, 122, 128.]

Lean Thinking model should simplify the whole organization and its way of working but Lean concepts are not as easy to apply to the day-to-day flow of work as in theory. The challenge comes from the change the concepts demand to the existing organizational culture: the change to employee's cultural approach and the adoption of a continuous improvement culture. So it is important that the methods and tools of Lean system should involve everyone in the organization and all should be trained. [Nicoletti 2012; 12–13.]

Just-In-Time (JIT)

Toyota's production difficulty and the inspiration of the American production methods led the Japanese gurus' to the creation of JIT (Just-In-Time). The progress achieved so far by JIT convinced managers that this philosophy was going to be successful. They also realized the needed efficiency was possible to achieve by changing work methods. As a result seven main wastes were identified. The identified wastes were overproduction, inventory, transportation, defects, processes, operations and inactivities. [Santos et al. 2014: 8–9.] The basic idea in JIT is to produce only what you need, when you need it and the three core elements of the JIT philosophy are eliminating waste, the involvement of everyone and continuous improvement. [Santos et al. 2014: 5; Greasley 2007: 76.]

JIT encompasses the successful execution of all manufacturing activities required to produce a final product, from design engineering to delivery. In JIT system customer demand always determines what is right. The primary objectives of JIT are: to produce only the products that customers want (with no extra features than demanded) for the time needed, to have only the required inventory when needed, to improve quality to zero defects, to minimize lead times, to minimize waste, to produce methods that reinforce the occupational development of workers and to accomplish all these things at minimum cost. [Aswathappa & Bhat 2008: 570, 574.]

Waste

Waste is any activity that adds no value to the customer and for which the customer is not willing to pay as part of a product or service package. Also Tuominen (2010) says in his book that waste is an activity that adds no value but increases costs. The core of Lean philosophy is the tireless eliminating of waste. According to Tuominen there is over 90% of waste in many process and only 10% of value adding activity. [Trent 2008: 12; Tuominen 2010.] Table 1 contains a brief introduction to the seven wastes according to Tuominen [2010] and Aswathappa & Bhat [2008: 581].

Table 1. The seven waste types of Lean.

Waste	Meaning	E.g. of cause
Overproduction	to produce more than the market demands	premature purchase of materials, production flow and order disturbance, inventory growth, increases defect rates and the risk of spoiled products
Inventory	to storing of excess material, products, unfinished products and so on	fear of shortage, overproduction
Unnecessary transportation	to transport materials, data and people between different points	excess materials, the more materials there is the more transportation is needed
Manual movements	to do unnecessary processes or work steps	working habits and methods like deficiency in standards and work methods, weak orientation, bad arrangement of workstation
Delay/ hold on	to wait for material, information or processing	delay in next step, production disorder, poor equipment placement, imbalanced operations, someone being late
Defect	to have defected products	belate inspection of parts, insufficient quality and inspection standards, bad work methods, insufficient professional skill, transportation and handling of materials
Over processing	to take place excessive or unnecessary operation or action (unnecessary parts, features or work steps)	stucking in old habits, unnecessary steps, ineffective functioning of process, lack of staff participation in design and development processes

In addition to the seven wastes listed in table above there is eighth waste mentioned in the recent literatures. It is called underutilization of employees which refers to the failure of organizations in utilizing their employees' knowledge and creativity. Wastes can be managed with different Lean tools. The Just-In-Time (JIT) system is however the best way to manage waste for it aims to reduce wastes by cutting excess capacity or inventory and removing non-value-adding activities. [Krajewski et al. 2013: 297]

2.4 Continuous Improvement

Continuous improvement (Kaizen in Japan) is a management philosophy based on employees' suggestions that was developed in the United States at the end of the nineteenth century, but a turning point to important improvements started as this philosophy arrived in Japan. This philosophy combined with other existing Japanese tools created

Kaizen. According to Henry Ford in 1926 to standardize a method is to choose out of the many methods the best one, and use it. He emphasizes that standardization means nothing unless it means standardizing upward. He also adds that standardization is the necessary foundation on which tomorrow's improvement will be based on and it has to be taken as the best method today, but which is to be improved tomorrow. Creating a standard is not a solution but is key to the success of any enterprise as it is a target on which change can be focused. Continuous improvement (kaizen) is based on improvements suggested by employees and thus all employees are expected to participate. [Santos et al. 2014: 1–3.]

Kaizen (kai = change, changing your way of seeing things; zen = good, to the best) means to solve a problem with a different point of view requiring everyone to produce ideas for improvement. The main objective of kaizen is to involve people to improve processes and products. There are many tools and techniques like PDCA-cycle, 5S, standardization and the pull scheduling system to enable continuous improvement. [Nicoletti 2012: 8.]

PDCA-Cycle

PDCA (Plan– Do– Check– Act) has come to be recognized as a critical tool for solving problems. The *plan* and *act* phases are not as easy as the *do* and *check* phases to many organizations. However this can lead to a longer and more difficult way of solving a problem, just like a product with inadequate design stage ending up with unsatisfied customer feedback. [Walker et al. 2012:15–16.]

Plan is a phase where a problem is clearly defined. Steps in solving the problem are to collect and analyze data, consider and analyze alternative solutions, and choose the best solution. These steps can be extremely difficult and time-consuming to execute creating a great tendency to jump to the *do* phase. However adequately executed plan phase is very important. One way of carrying out this phase is to form a cross-functional team representing everyone impacted by the problem to whom the task should be assigned. In the *Do* phase the solution to the problem decided on the plan phase is tested. The test could be done on a small scale in a lab setting or outside the regular production process. It is important to collect as much data as possible in this phase. The information collected during the *do* phase is analyzed in the *Check* phase carefully using valid mathematical

and statistical techniques. Action is taken naturally in the *Act* phase based on the conclusions reached in the *check* phase. If the data show that the proposed correction is good the *act* phase continues with integrating of the solution into the standard work methods. If the solution is not good enough then as the PDCA cycle shows the phase continues to the start point, back to the *plan* phase for better solution searching. This is the continuous improvement journey of solving problems. [Walker et al. 2012:15–16.]

5S

In order to improve (quality, cost, and time) production activities, source of problems have to be identified. Variability in quality and productivity are considered major problems. Standardizing is the way to identify variations. Exception from the standard (value, method) presents a problem. Improvements to processes and operations are the base to production improvements (better quality, less production cost and shorter lead time). Simple improvement methodologies, worker involvement and respect, and teamwork are the key to Japanese success. [Santos et al. 2014: 3–4.] Next is described 5S as shown in Nicoletti's [2012] book:

- Seiri (Sort): Examine the workstation in order to eliminate materials or tools that are not used, clean up.
- Seiton (Set, straighten, store): Organize the remaining articles. A place for everything and everything in its place.
- Seiso (Shine, sanitize, scrub, sweep): Establish a cleaning routine that includes an initial cleaning, as well as a continuous cleaning, and a daily clearing up activities.
- Seketsu (Standardize): Guarantees that the best practices become part of the daily work on the work station. Establish the processes.
- Shitsuke (Sustain, self-discipline): Review the first four S's on a continuous basis in order to guarantee that there are no backward steps, but only continuous improvement. [Nicoletti 2012: 9.]

Some of the reported benefits of successful 5S initiatives are better communication and information sharing; reduced training cycles for new employees; increased levels of product quality and more available plant and office space [Hobbs 2011: 10].

Work standardization

As has already understood, Lean operating system aims to increase competitiveness by providing the highest-quality products at the best price, in the shortest delivery time possible achieving the highest customer satisfaction. To accomplish these goals, a Lean operating system concentrates less on utilization of resources (traditional MRP) and more on controlling the largest part of product cost; manufacturing of products using the least possible amount of non-value-added time. The base to the Lean operating model efficiency in manufacturing processes is documenting the standard work and standard work times for each process. This eliminates individual interpretation by operators and the best operator syndrome and assignment of smaller amounts of standard work at each workstation, and simplifies the training of new operators. It also ensures quality as inspections are completed as part of standard work. Training operators to be certified to do the standard work, at least of three consecutive workstations, ensure that they are able to manufacture all of the models that will be produced on a mixed-model line. This also allows the flexibility to add or subtract labour resources in response to changes in customer demand. [Hobbs 2011: 76, 463.]

Kumar [2008] put standardization as producing maximum variety of products from the minimum variety of materials, parts, tools and processes. A Lean manufacturing line is capable of producing also multiple models that share the same manufacturing processes. Multiple models can be produced on the same Lean manufacturing line as long as the processes needed to manufacture each model differ only by standard work time and appearance. In Lean manufacturing products are grouped based on manufacturing processes; group that share common manufacturing processes. [Kumar 2008: 98; Hobbs 2011: 170–173.]

Predicting time and controlling the efficiency of the processes is hard unless there is a stable and repeatable processes established. Standardization helps to gather all the ability and best practices owned by the today's workers so that all the workers can use them. It is the base of continuous improvement; the new standard is then improved by encompassing even better practices coming from operators (workers). Standardization enables to collect great improvements from individuals for everyone to use that could have otherwise remained only for their individual use and disappeared as that individual moves from that job. [Liker & Meier 2006: 10.] The Lean system uses standard work to:

- establish the cycle time of products
- identify the work required at individual workstation level
- certify operator training requirements
- ensure the quality criteria at task level [Hobbs 2011: 68].

Also an article analyzing the impact of business process standardization on business performance confirms that process standardization provides enormous benefits to firms. The article summarizes the potential benefits of process standardization based on many references used for their study. Process standardization improves process performance through reduced cycle-time, reduced process costs and improved process quality. It also improves customer confidence by reducing probability for process-driven mistakes and by allowing to cope with continuously increasing process complexity which consequently leads to the overall quality and customer confidence improvement. Enhanced readiness is also among the advantages listed. Readiness to outsource business processes, to merge with or buy other companies, to react to regulatory changes, to react to changing compliance needs and to react to market and external change increases significantly. Process standardization simplifies and increases, transparency of process activities and measurability, and communication among departments and different locations. [Münstermann 2010: 29–56.]

Kumar [2008] lists also the possible disadvantages of standardization. According to him it can cause reduction in choice because of reduced variety and consequently loss of business or customer. Standard resist change and could be an obstacle to progress once it is set. It could also become very difficult to introduce new models because of less flexible production facilities and due to high cost of specialized production equipment. [Kumar 2008: 100.]

Both ISO 9001 and Lean need procedures and standardized work instructions as an important part of their system and they both agree on the fact that standardization is the base for continuous improvement. Also Aswathappa & Bhat [2008] put Standardization of components and work methods as supportive tools for achieving the high productivity and low inventory objectives of JIT systems. Liker & Meier [2006] on their behalf point out that instead of as obstacle to innovation, standardizing have to be embraced as launching point for true and lasting innovation. [Micklewright 2010: 32–33; Aswathappa & Bhat 2008: 578; Liker & Meier 2006: 10.]

Pull system

Pull system is one of the fundamental concepts of JIT. Pull system is what enables to execute the JIT system which demands product to be produced just when the customer needs it. A pull system uses signals to request production and delivery from upstream sections to the production stations. Pull scheduling system also called as Kanban is the tool to handle the scheduling system that can immediately and clearly communicate the demands of the customer to the delivery system. Kanban meaning card, uses cards as a means of communicating within work centers. Determining adequate Kanban size and number by properly studying the relationship among the factors that affect Kanban size estimation is essential. Poka-yoke (unnoticed mistake proving) is also a tool part of the JIT philosophy which is used to eliminate defective products generated in production processes. [Aswathappa & Bhat 2008: 572, 574, 584; Venkatesh et al. 2014: 342–360.]

3 Quality control in Metso

3.1 Metso in brief

Valmet was a paper and board machine supplier and Rauma's operations included fiber technology, rock crushing and flow control solutions. The merger of these two in 1999 produced Metso, the equipment supplier to the global process industry. Now Metso is the world's leading industrial company in the mining and aggregates industries, and in the flow control business. [Avenue 2015.]

Metso employs about 12,000 industry workers in more than 50 countries and it has over 80 service centers all around the world in six continents with wide logistics network. Metso's main customers are mining, aggregate and oil, and gas industries. Metso's total net sales in 2015 was 2,923 million euros and 63 % of it came from service business. [Metso annual review 2015.] Figure 1 illustrates the worldwide presence of Metso.

Figure 1. Metso's global presence by location [Metso annual review 2015].

Metso's global locations are shown in numbers in the next figure (2).

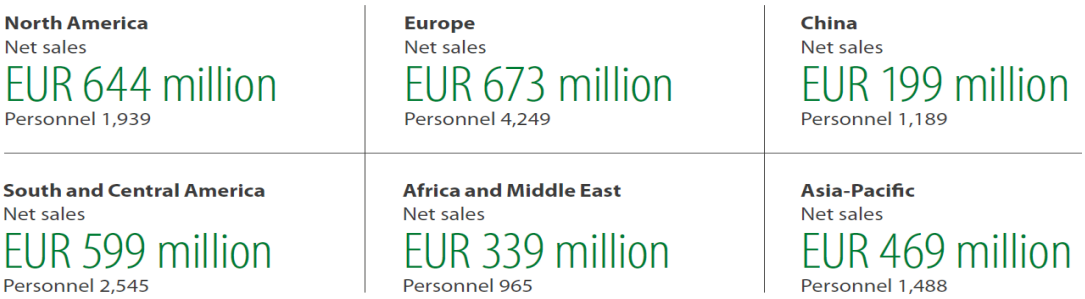

Figure 2. Metso's global presence in numbers [Metso annual review 2015].

Metso offers products, systems, projects and services business. Mining industries' deliveries are mainly large-scale projects while the deliveries to the aggregates and oil and gas industries are individual equipment deliveries and smaller product packages. The services business is essential for all businesses. Metso is a leader in providing mining crushers and grinding mills, aggregates crushing and screening, and services. [Metso annual report 2014.]

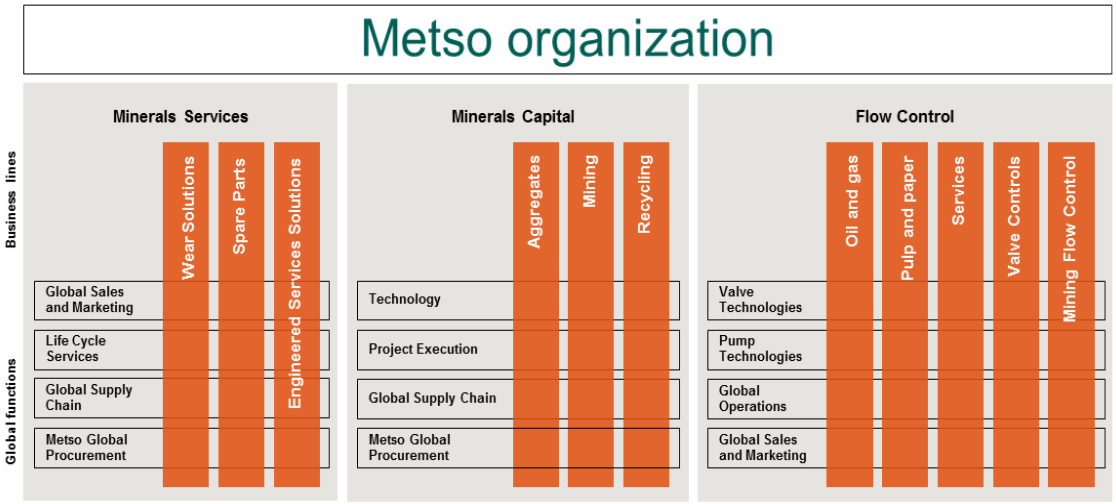

Figure 3. Metso organization chart, modified [Avenue 2016].

As shown in the above chart (figure 3), Metso operates through three business areas: Minerals Services, Minerals Capital and Flow Control (FC). Minerals Services' share of Metso's net sales in 2015 was 47 %, Minerals Capital's 28 % and Flow Control's 25 %. Also received orders shares among the business areas were nearly the same as the net sales. The widely used strategy in Metso is Lean. [Metso annual review 2015, Avenue 2016.]

The Helsinki plant to where this study paper deepen in the next chapter is part of the Flow Control (FC). FC business area serves diversified mix of industries with its product and service that consists of valves and pumps, and related services. The biggest customer industry of FC is oil and gas with 53 % of its net sales share in the year 2015. The rest comes from valves for pulp and paper (18 %), mining and pumps (16 %) and valves for other process industries (13 %). FC's valve technology, slurry pump assembly plants and supply centers are geographically well-spread and are located in Finland, the US, Germany, China, South Korea, India, Brazil, Sweden and South Africa. It has over 40 valve service centers all around those locations. [Metso annual report 2014; Metso annual review 2015.]

FC's main products consists of control valves, automated on-off valves, safety valves and intelligent positioners, and other valve related instrumentation. Its leading valve product brands are Neles, Jamesbury and Mapag. Metso has the industry's widest offering of ball and butterfly valves through Neles. [Avenue 2016.] Picture of different product types are shown in the figure (4) below.

Figure 4. Flow Control products. [Avenue 2016]

3.2 Metso quality control overview

Quality control in Helsinki plant has its own department which functions as shown in figure 5.

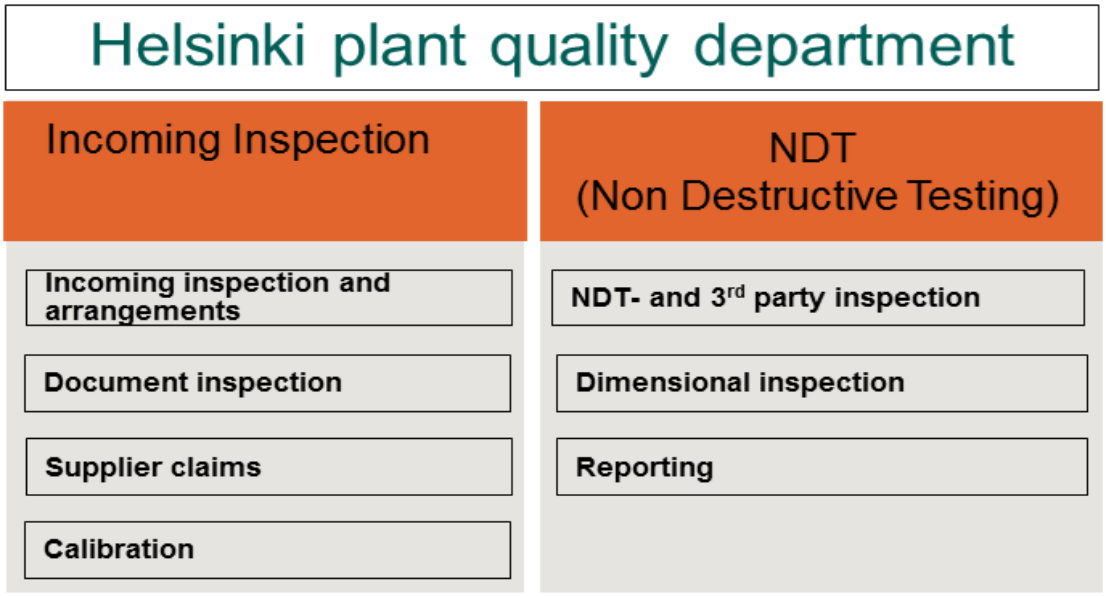

Figure 5. Helsinki plant quality department, modified [Avenue 2016].

Assuring its product and service quality is essential to Metso. Metso complies with ISO 9001, ISO 14001 and OHSAS 18001 standards. 80% of Metso relevant operations is covered by the ISO 9001 certification, 34% by the OHSAS 14001 certification and 17% by the ISO 18001 certification. Coverage is calculated in proportion of the number of employees working in certified facilities. [About us 2005.]

Metso's sustainability strategy includes all three aspects of sustainability: economical, social and environmental. Metso encourages its suppliers to apply the same sustainability elements as Metso does to ensure supply chain sustainability. Metso supports also its customers to achieve sustainability in their operations. Metso's effort on sustainability and on the importance of it to Metso and its future is illustrated in *Metso sustainability* handbook, which includes also sustainability criteria for suppliers. The aim of Metso's *sustainability criteria for suppliers* is to support suppliers to developing their operations more sustainably and to provide criteria for choosing new supplier. [Metso sustainability handbook 2014.]

In Metso the impact of a product on environment is considered early in the product design stage where environmental aspects of a product are considered along with the other product factors like functionality, quality, cost-efficiency and product safety. Metso quality management is introduced well in the HSEQ (Health, Safety, Environment and Quality) management system guideline (2016) which is continuously monitored through management reviews, audits, assessments, customer feedback, performance follow-up etc. HSEQ management system fulfills also the requirements set by ISO 9001 (quality), ISO 14001 (environment) and OHSAS 18001 (occupational health and safety) management standards. [Metso sustainability handbook 2014; Avenue 2016.]

Metso is committed to excellence and the needs of its customers, as well as to the continuous improvement of quality and reliability of products and services. As mentioned in the introduction the majority of Metso's production units have certified ISO 9001 quality management systems which is a key tool for Metso in managing product quality. Metso assures that products and services are designed to meet their intended purpose along with all relevant standards and directives, and requirements. Assuring the safty of its products is essential to Metso. [Metso sustainability handbook 2014.]

All functions of the company maintain control of nonconformities both in processes and in products in order to meet the customer satisfaction and to preserve the efficiency. Employees are obliged to inform management about nonconformities or take actions whenever possible. All nonconformities are reported and analyzed. As also the following process map shows (figure 6) quality controls are done in all the manufacturing processes. Controls are done also within each function by manufacturers and assemblers. The final quality control test is final audit test (FAT). Metso strives to meet customer requirements, enhancing customer satisfaction and improving operational and business performance by constantly seeking opportunities for improvements. Corrective and preventive actions are taken to remove the immediate cause of a nonconformity and to stop the problem from occurring again. [Avenue 2016.]

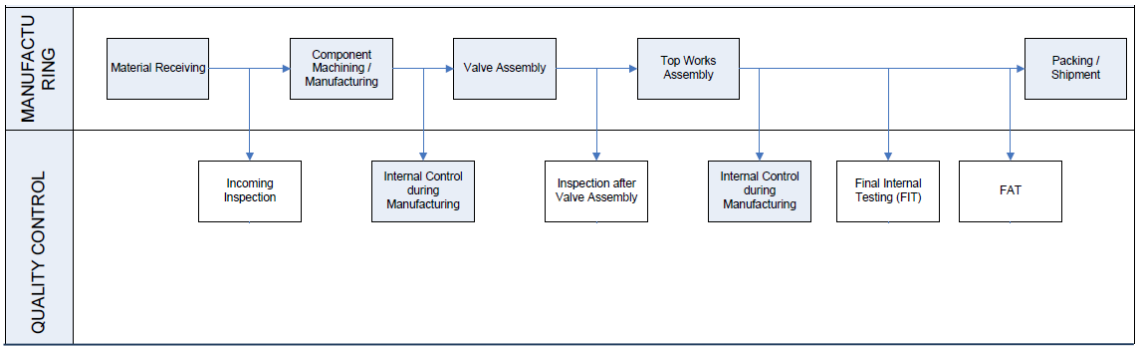

Figure 6. Quality control of internal non-conformities, modified [Avenue 2016].

FC business processes are evaluated regularly by internal and external audits/ assessments. Internal auditing (annual report) is used to verify the quality and efficiency of business processes and their compliance to relevant requirements. Supplier audits are carried out annually and in special needs to assure that suppliers meet the specified requirements and standards. Third party audits are done to maintain the certificates by verifying the compliance of activities to certain standards. Also customers have possibility to audit Metso's facilities on mutual agreement. Reports of all audits are used to correct and improve business processes and activities as well as to make constant adaption to Metso's operational environment changes. [Avenue 2016.]

Metso strongly believes that supply chain sustainability is the way to the product quality. As a way to achieve this sustainability Metso has guidelines and criteria to integrate sustainability throughout its production chain. The aim is to support Metso's supplier network in developing matters related to sustainability and to harmonize the company's internal procedures. Metso expect its suppliers to follow sustainable business practices, to comply with competition legislation, to offer a safe working environment and to assess their own environmental impacts. Suppliers must confirm that their business practices do not contradict the business principles stated in the UN Global Compact or the International Chamber of Commerce Business Charter for Sustainable Development. 98 % of the environmental impact of Metso products comes from the usage period. This makes cooperation with suppliers a fundamental issue for improving the environmental performance of solutions over their entire life cycle. Metso offers products and services that reduce the environmental load and improve the quality of its customers' operations by helping them to improve their energy and material efficiency. [Metso sustainability handbook 2014.]

Metso provides its customers a full life-cycle services along with constant technological improvements and innovations to assure its contribution to a sustainable future. Metso creates solutions that increase the productivity of its customers in a sustainable way by striving to understand their business realities through getting to know to their individual business environment. [Avenue 2016.]

3.3 Continues improvement with Lean

In addition to the different standards Lean management is the widely used strategy in Metso. Lean terms like 5S, PDCA and Kaizen are well known and used all around the factory. A large reformation has been made during the location transformation of the plant in 2010 – 2011. It created good opportunity for implementing e.g. new management strategy and Lean was the strategy in this case. 5S was one of the tools to which this situation created a good opportunity. Detailed information of the participants (employees, bosses, managers, method planners, Lean coordinators and tools personnel) in executing the 5S tools including their roles, rights and obligations has been made. Also enough information of 5S and its implementation has been provided. PDCA continues improvement tool is also widely used and understood. As the next process map (figure 7) shows non-conformities or development issues are gathered from the production cell and are talked over as part of the daily management by supervisors. Also the customer claims and quality control data provided by the quality control department (QCD) are part of this discussion. QCD also produces monthly data analysis on quality issues. Corrective actions are made based on these facts and sent for implementing to the production cell through supervisors. This is an endless process enabling continues improvement. [Avenue 2016.]

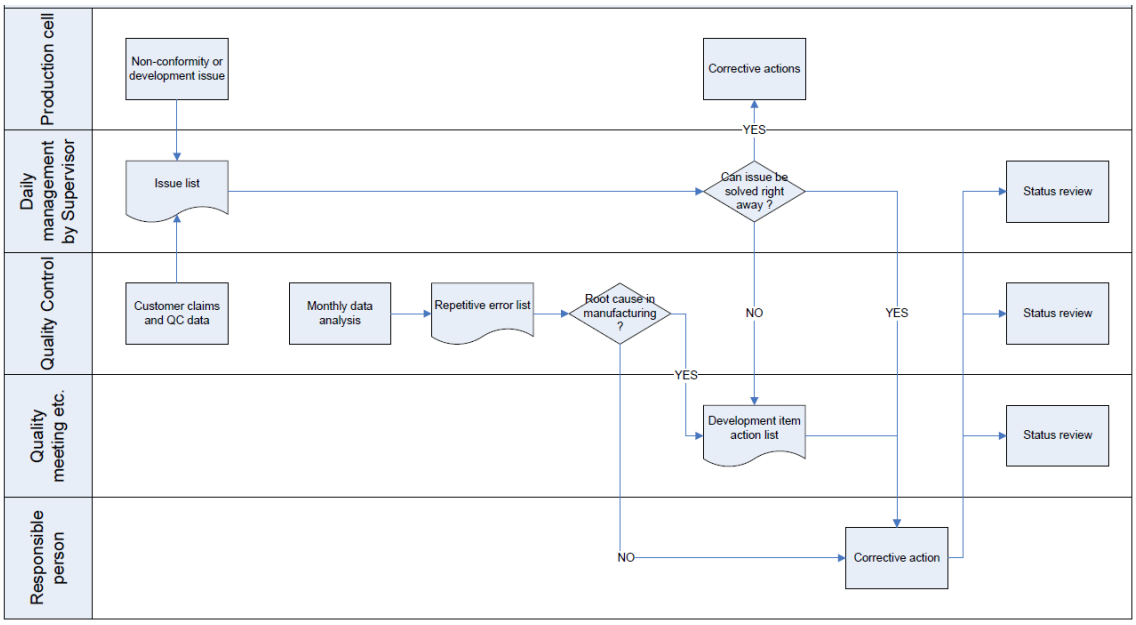

Figure 7. Metso PDCA process map [Avenue 2016].

Helsinki plant has been working hard to make Lean system implementation successful. The award for Lean development work in 2014 could be taken as indication of this. The positioner factory, part of the Helsinki plant, has been awarded by the Lean Association of Finland. It was ranked 3rd for the Lean Act of the Year 2013. [Avenue 2016.]

3.4 Present state of work methods

The area covered in this study is valve assembly and testing area of the Helsinki plant. The simple fact of the current situation is that there is no standardized work method easily available for workers to use in their daily jobs. In addition the existing work instructions are not the kind of instructions operators are willing to use. There are SOPs (Standard Operating Procedures) that are not even easy to find (location problem) and which are too long and complicated to be used for everyday purpose. The workers were asked at the start of this study to answer the question '*What makes it difficult to follow a standardized work instruction at this moment?'* The result was as shown in table 2.

Table 2. The result of the questionnaire.

Related to	**Frequent**
Work instructions	21
Doing job	13
Attitude	7

5S, tools and workstation	4
Daily management system	3
Guidace management	2
Others	2
Total	**52**

The answers are put to what category they are related to. As we see the categories *work instructions, doing job* and *attitude* makes up the top three which covers almost 80 % of the issues. The *work instructions* category included that *there are no instructions, instructions are in a general level, instructions are complicated and not easily available,* and *unclear responsible owner of the instructions*. The *doing job* category relates with how a worker do own job and the main facts there were *current own way of doing the job* and that *following instructions will slow down the work speed*. *Workers attitude* category on the other hand included *own way is better than instruction, instructions are not important and not trustworthy, losing own freedom* and *no need for change.*

Conclusions made of the current situation based on the answers the workers gave are that there is only little understanding of the importance of work method standardization and its affect to the organization. There is also not enough understanding of relationship between work standardization and orientation. The attitude towards SOPs is that if there is no consciences for not following instructions why follow them, own way is better anyway. SOPs have been made and updated but its assimilation and control have been weak. There is also no clear process for maintaining standardization changes or updates.

First of all developing working methods is difficult if there is no actual common method in use. The operators' assembly methods and their assembly times vary a lot causing ineffective functioning and pure quality. Duration of orientation is long and costing, and also making fast reaction to capacity increase is difficult. The amount of disturbance hours in streams is high and quality issues are difficult to solve. 100 – 200 hours are reported weekly as disturbance due to quality problems in Helsinki plant valve assembly streams and this is only part of the whole truth for absolutely all disturbances are not reported.

4 Work standardization study

This work standardization project is part of the Helsinki plant-wide improvement project. The Helsinki plant-wide improvement program aims among others to:

- reduce varieties and to balance capacity
- assure that the production system is efficient and suitable for single piece/ small series production
- improve flow and implement it throughout the plant
- remove flow and flexibility limits caused by lack of multiskillness
- build continuous improvement in daily work
- increase growth and efficiency, and reduce lead time.

The work standardization study dealt in this paper covers only the Helsinki plant valve assembly and testing area.

Though its name remained Helsinki plant for international operating reasons, it has been situated in Hakkila, Vantaa, since 2011. Its annual capacity is 25 000 valves, 15 000 actuators and 75 000 positioners. It has 393 employees (102 stuff, 291 workers) now (year 2016) from which 61 works in quality assurance, and inspection and testing. [Avenue 2016.]

4.1 Scope and objectives of the study

As mentioned above and also marked in figure 8 process map, this study covers only the valve assembly and testing area. Valve assembly in the process map includes also valve testing which is carried out before the painting stage. A pilot case will be implemented only to butterfly valve assembly and pressure testing.

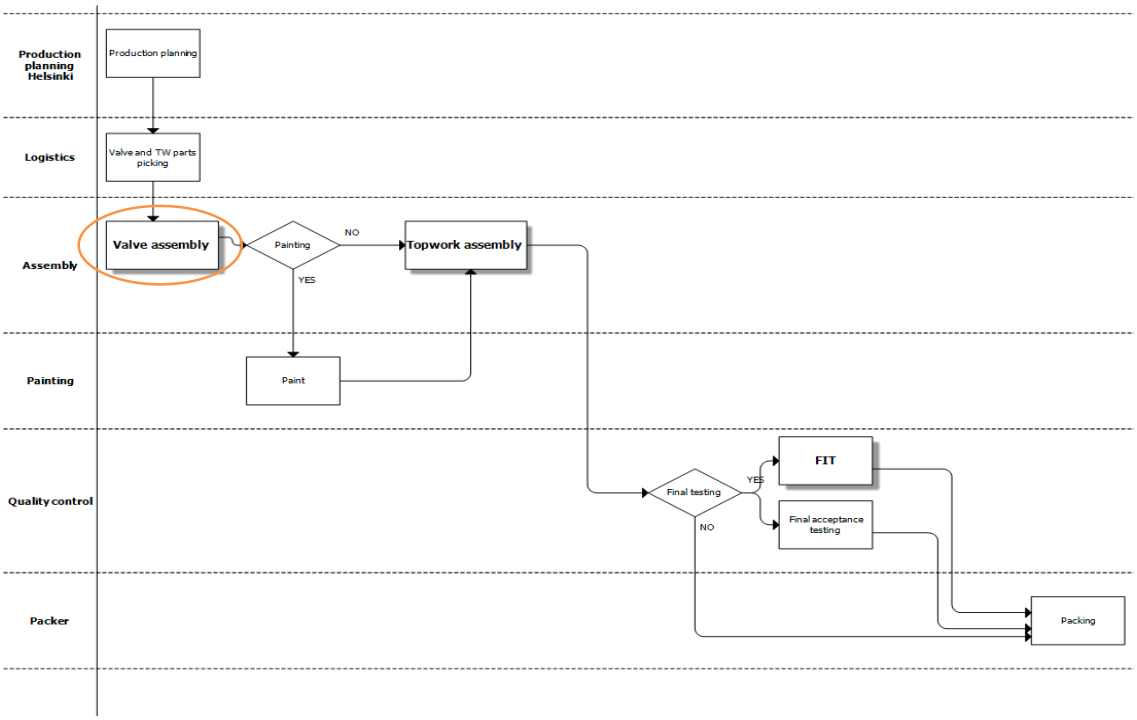

Figure 8. Flow Control valve process map [Avenue 2016].

Quality and product structure related issues, creation of SOPs excluding pilot case, manufacturing and warehousing of parts or other components like actuators, positioners are not included in this work study. The valve assembly and testing study includes:

- defining ownership of working methods and instructions
- creating process of working methods
- standardizing SOP form / layout
- best method selection and improvement process
- measurement of affects
- pilot case planning and implementation in selected scope
- supervision of standardised methods.

The plan is to make work instructions in a standard format which fits to the upcoming documentation system. The intention is to make for one assembly phase one A4 size landscape layout instruction which includes also pictures. Working methods will be standardized for one complete product of butterfly valve as pilot. The aim is to get six critical assembly phases instructed, standardized and implemented as a pilot case. The study acknowledges that employees' professionality should be utilized in method selection. It also considers that improving of the instructions is a continuous process, which contains work study loop and measurement. Also separating job instructions from game

books is as important because current SOPs include too much information including game books making the job instructions too complicated to be followed. Game books study is going to be started soon as own kaizen, not included in this study.

The achievement expected from this standardization study is to reduce butterfly valve related disturbance hours (now 100-200h/ week) by half partly through the reduction of variance in butterfly valve assembly times. Other benefits expected to come out of this study include butterfly valve yield improvement in pressure testing by 20 % and butterfly standard hours reduction by 10%. These improvements will lead to efficiency improvement which means also reduction in lead time. The estimated financial impact of the project only from the disturbance reduction would be the reduction of disturbance expenses by 2500 €/week (130000€/year). Standardized work method is also expected to make future method development and product development projects easier to carry out.

As a result of this study, standard work concept in Helsinki plant valve assembly will be defined and a systematic procedure on how the best method was selected and instructions were created will exist. It will also make sure that instructions are modular, easy to find and maintain, supervisors will be able to observe regularly that SOPs are followed, deviations are interfered and daily management system supports standard work. The aim is also to assure through work flow study that also workstation layout, tools, methods and measuring equipment support standard work. It will also give answers to the other work method standardization related issues arose through the introduction questionnaire that was taken place at the start of this study period. These aims are first of all to create a common understanding on what work standardizing means and its importance, and also a knowledge of the challenges that come along with it. The workers need also to understand that standardized method is the base for a better orientation. It is important also to make clear that standardized work methods are generally accepted methods that are meant to be followed by everyone and improved continuously.

4.2 Flow of the study

As already mentioned, the study started with a questionnaire to map out the current situation of work instructions and their utilization as well as the workers understanding of it and their attitude towards it. Meetings were held once a week for the study core team which included well experienced as well as less experienced assemblers and once in two weeks for the steering group as part of the process of choosing the best method at

this moment. The members of the study core team collects all kinds of information from the assembly area, existing SOPs, designing stuff and other resources to support the study and the selection of best method.

A workshop will be arranged for assemblers with different level of work experience after getting the planned instructions done. The workers will be asked to evaluate the work instruction that will be made. The aim is first of all to give the workers a chance to improve it and to comment on it but also to enhance their commitment to the standard work method through it. Implementation of the work instructions will be the next stage. Also later after pilot case a questionnaire about this new work method will be carried out. The idea here will be to get overall attitude picture of the workers about the standardized method.

4.3 Implementation of standard work method

Implementation was done to the selected butterfly valves and to pressure testing at the end of the year 2015 almost as was planned too. Also work flow study was done along with it. Products made with the new standard work method were marked differently to make their monitoring easier. The aim was also to gather more comments and improvement suggestions from the assemblers as they actually use it.

First named instructors were well introduced to the new instructions. These instructors will work as link between the workers and the management personnel for the future too. The instructions were tested by instructors, experienced assemblers and also unexperienced assemblers. Supervisors were recommended to emphasize to the assemblers that the instructions cover only basic phases, not special cases, and the question here is to have common method to follow and to make orientation easier for the future. Workers were asked to give comments and improvement suggestions on the new method.

4.4 Results of standardization study

General results

The study until pilot implementation was done almost as planned too, only a short delay occurred. The atmosphere in the workshop was very positive and everyone had something to say on it. Many comments and good suggestions came about the instruction and even some improvements were made based on these suggestions. It was really constructive. However monitoring of the workers to keep following the instructions after the pilot case was weak because of the personnel shortage that came up during that time. It was realized as also expected that standardizing everything is not possible because of the nature of the products and their parts. There are too many product varieties in some product types, which can make standardizing hectic and also uneasy to utilize and gain the advantages of standardization. Also some extra processes have been done in this standardization study. For example workflow study which revealed that the amount of liftings and transferring being too many compared to the number of value-adding steps.

The intended work instructions in a standard format which fits to the upcoming documentation system was made. The instructions are simple, well visualized and structured, which makes them much easier than the old SOPs to be used by the workers in their everyday jobs. The created instruction layout is shown in figure 9. It contains safety notifications, tools and chemicals' use as links. The maximum pictures (4 pieces) and text lines (3 lines) are limited in order to keep the instructions simple and also additional advice is put to second page as link when necessary.

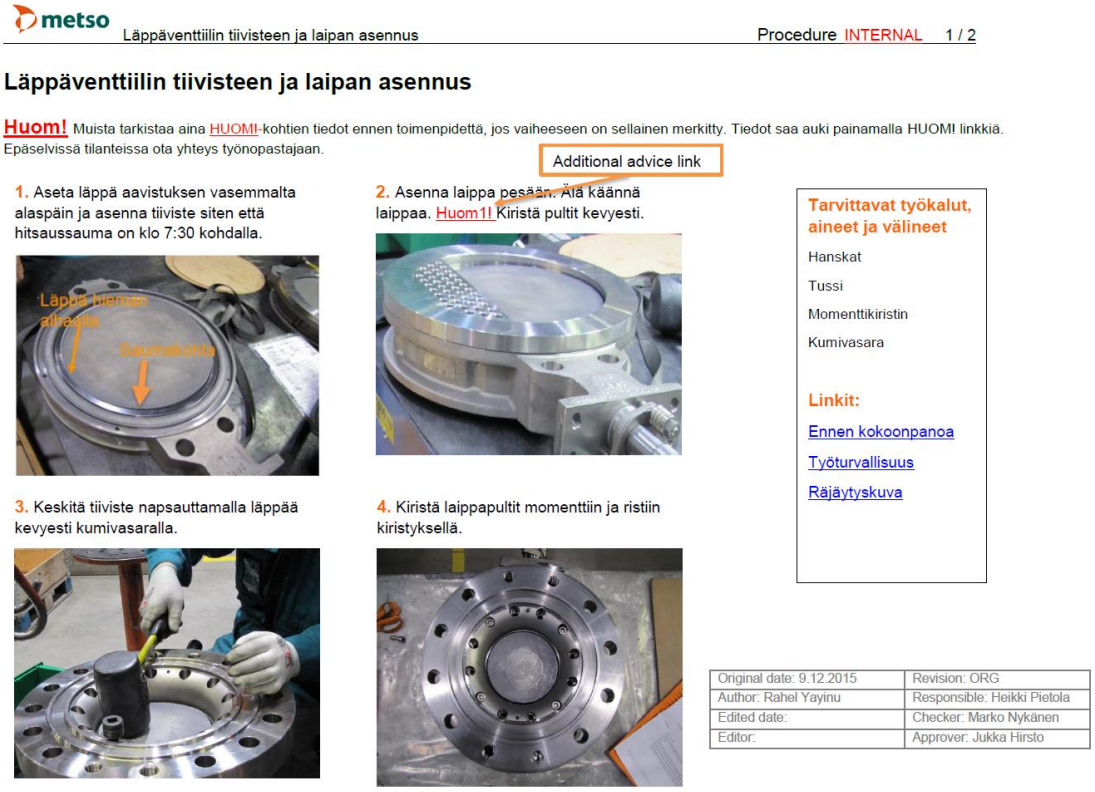

Figure 9. Example of the created instruction layout.

The standardization of working methods for one complete product of butterfly valve as pilot was also successfully completed. Instructions are made standardized and implemented as a pilot case for eight phases which exceeded the original plan to make only for six phases. The professionality of the employees was utilized well as planned and they were the main actors of this whole standard method adaption process.

The idea that improving the standard work method is a continues process is not adapted as in high level as wanted and the shortage of the personnel has a lot do with it. The workers could not get enough mentoring and supervision. Full control including work study loop and measurement was done till the pilot case was completed but after that it didn't continue the way it should.

Results of the work study

According to the work study made during the pilot implementation, assembly time varieties were reduced but the average assembly time remained at the same level. This work study also revealed that there is a need to follow and encourage workers to follow the instructions. Some workers were still doing some step in their own way. In the valve

testing area varieties reduced significantly, many stages were standardized and there was an improvement in the testing yield as well as.

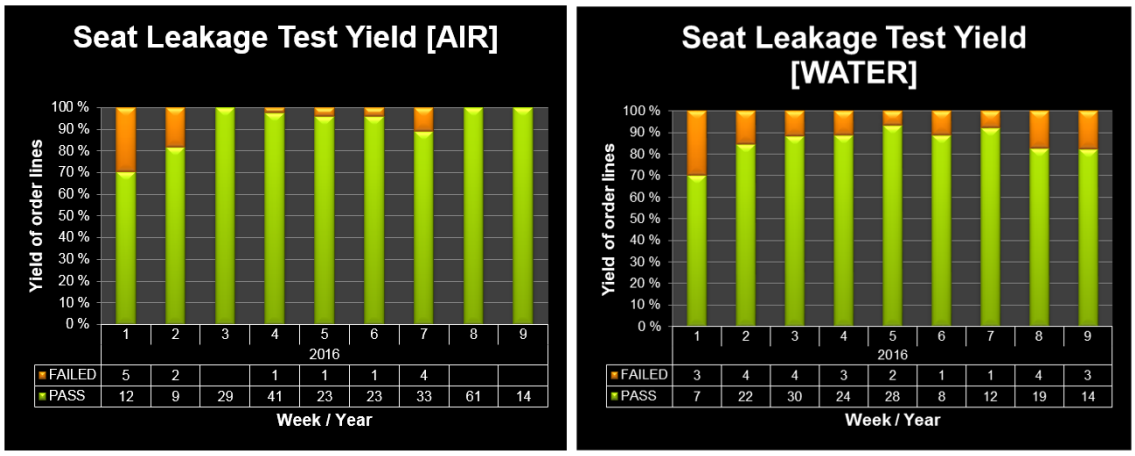

Figure 10. Yield in butterfly valve testing 2016.

The figure (10) above illustrates the results from nine weeks of testing which can be compared to the starting point of yield in the following table (3).

Table 3. Starting point of yield in valve testing by tester.

No standardization at all!

	Rejected	Approved	Approved wth remark	Number of tested valves
Tester 1	77,83 %	16,04 %	6,13 %	212
Tester 2	49,52 %	27,48 %	23,00 %	313
Tester 3	26,28 %	43,74 %	29,98 %	487
Tester 4	59,03 %	38,19 %	2,78 %	144
Tester 5	69,39 %	15,31 %	15,31 %	98
Tester 6	59,76 %	21,95 %	18,29 %	82
Tester 7	17,76 %	48,03 %	34,21 %	152
Tester 8	79,31 %	13,79 %	6,90 %	29
Tester 9	0,00 %	88,57 %	11,43 %	35
Tester 10	0,00 %	100,00 %	0,00 %	10
Tester 11	0,00 %	23,08 %	76,92 %	13
Tester 12	0,00 %	52,94 %	47,06 %	17
Tester 13	0,00 %	31,03 %	68,97 %	58

There was observed that there are some *too old test instructions* on the wall that need to be renewed. Also shortage of some tools was discovered and also got interfered with. Common understanding on what work standardizing means and its importance has become clearer to the workers, specially its effect to a better orientation. A lot is still to be done concerning its utilization as also this work study and the afterward questionnaire revealed.

Result of afterward questionnaire

In addition to the work study a questionnaire has been carried out after the pilot period was over. It revealed that they all agreed with the importance of having a standard method of doing things but then almost all didn't feel the need for changing their way of doing things to the standard one. The obvious advantage of the standardized work method for them was for orientation purpose. The reasons for not wanting to follow the new method was that they are already used to it and that it is easier and faster way to do their job. All said that the new methods don't differ much anyway from their own way of doing the job. Many also mentioned as second reason that it is not required and no one has demanded it after the pilot period. Only three not much experienced assemblers admitted that they follow the new instructions and that it has been helpful to them. Also there was one experienced assembler who said is assembling according to the new method. Unlike the others who have learned the job just by following their instructor's method, this person had got a chance to learn to work according to instructions. The result of the questionnaire were a bit different in the pressure testing area. They believed that standardized method has significant positive affect to their work and are applying it. Some also saw the standardized work method process as a test related to some research works which is not going to continue any more, referring to many studies which have been done and no one has asked about them later. Most of them also said that they don't even know where to find the instructions by themselves.

Control of standard work method

Continues improvement of the methods chosen to be done through work study (PDCA) and evaluating new methods. Deviations and suggestions to the methods to be reported through disturbance reporting and to be utilized in daily management. Supervisors to run daily management by reflecting to the standard work and by collecting feedback by continuous development methods like PDCA. Systematic procedure for standard work has been set as shown in the following figure (11). Also criteria for method selection and creating new instruction is defined to be instruction in current SOP or IMO (Maintenance and Operating Instruction), and effect to safety, quality, cost/ productivity and serviceability. There should be no need to instruct anything that doesn't affect to any of the mentioned criteria.

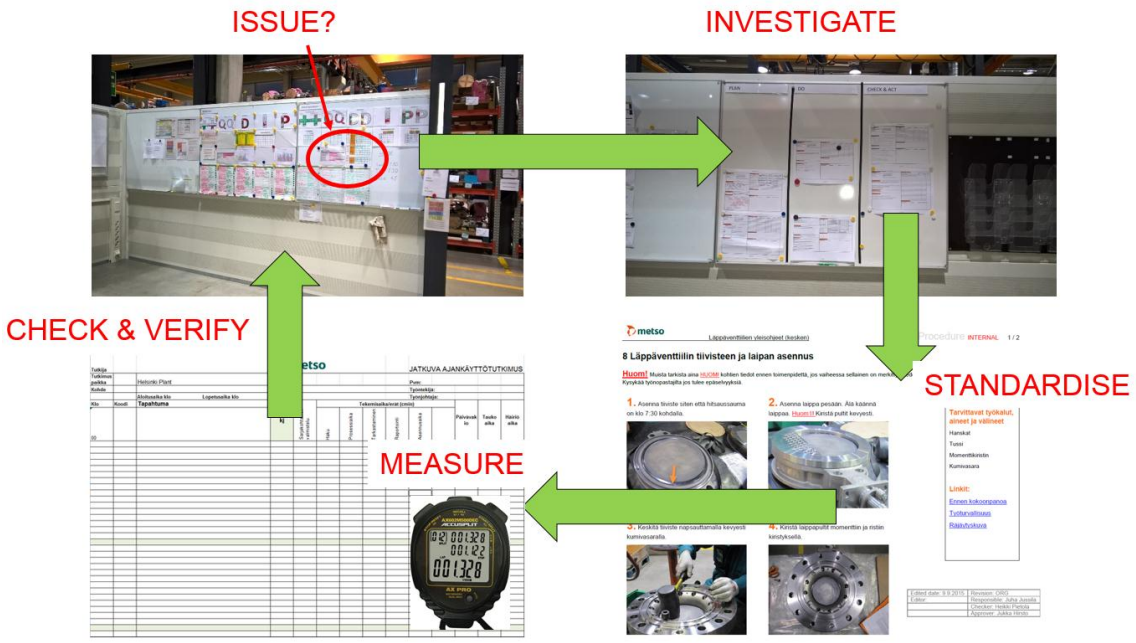

Figure 11. Systematic procedure for standard work.

Management has to be able to use the information for e.g. for determining the need for changing methods. Job instructors have to be trained to the instructions and they shall support assemblers to follow agreed methods. Also job instructors' role needs to be clarified and qualifying system defined for maintain job instructor validity. Weekly meetings are to be held between the foremen and job instructors to discuss on the experiences of the standardized work method and its progress. Development and improvement process has been launched for unclear situations that arose during the method creation and implementation period. Also issues that demand deeper study are included to this process.

The instructions are in a temporary place for the time being and will be easily available for everyone when the actual time for workers to follow those instructions comes. This cause a little bit confusion with the workers as they assumed that the instructions are still not easily available for them. The results of this whole study is put in short in the next table (4).

Table 4. Outline of the standardization study results.

Result of	Positive	Negative (challenge)
Work study	- Assembly time varieties were reduced - Significant reduction in valve testing varieties and improvement in yield	- Not all followed the instructions - Shortage of some tools observed - Average of assembly times remained the same - Need to follow and encourage workers to follow instructions
Afterward questionnaire	- Testers see more clearly the advantage of having common method and are more ready to apply it (are using it) - Having common method for orientation purpose vital for all workers - Unexperienced assemblers already using it and seeing its advantage	- Experienced assemblers not wanting to change their own methods - Not clear for workers if they really have to start applying the new method
Control of standardization	- Ways for controlling it created	- Shortage of employees in proceeding it
General	- Good understanding of standardization achieved - Almost all objectives related to the creation of work methods and the pilot case fulfilled - Professionality of employees utilized well in the process	- Still the need for more work on making it more understood and assimilated - Weak monitoring of workers after pilot case (personnel shortage) - Full understanding to adapt it of it still missing - Works related to some products difficult to standardize

5 Conclusion

The results reveal that this study has given workers a lot of knowledge regarding standardization and it has clearly improved the understanding of it among the workers. Especially the understanding of the importance of standardization to the orientation gives a lot of hope for the future that this standardization implementation could be successful and bring the advantages that were set to be achieved through it.

The fact that all workers that have been asked were ready to apply this new method for orientation purpose and the answer of the one experienced assembler and three less experienced workers gives the messages that the implementation of the standardized method is going to be successful and mostly through the new comers. It has to be considered also that this demands a close control during the orientation of new employees to assure that the inspectors indeed use the new method. The answers of those four workers is significant though the amount seems a bit too small, because those people are the only one with that kind of background and the attitude of all towards the standardized work method was similar.

In addition to the mentioned in the theory, orientation with standardized method will make much easier also from the new comer's point of view, because there will be only one way to learn to get one step done. From my experience of being new worker once, it also makes new worker frustrated and confused when different ways are offered from different people for one step. It could also affect to the atmosphere of the workplace the new comer will have to prefer one's method over the other. Having clear and visible processes affects a firm in many positive ways.

Also bringing the experienced workers to adapt the new method is however important and it seems to be also possible with a little bit more effort on guiding and controlling. To most of the workers the ongoing presence of emphasizing importance of things is a great inducement to take something seriously as also the results revealed. The absence of control could imply less importance to many. The effects of standardization can't be known also till at least the majority of workers start to apply it. So it is important also to get the experienced workers to commit themselves to this.

The attitude of the experienced workers towards their own way of doing things and to the standardized method one gives the implication of a need of more information and

understanding on standardization. First of all they need to understand that own way is better only till they learn the new one and as they also admitted, the difference between the standardized method and own way is little. On the other hand keeping the old way just for not wanting to change couple of habits causes a great difference for data analyzing e.g. to assure product quality. This happens because, the differences are only couple of steps for the worker but when it goes to the data analyzing the difference becomes huge and it makes analyzing much more complicated and hectic, because it is not known for e.g. which method led to a particular defect. When there is one known method of doing that step, taking action on the defect is much simpler and straightforward.

There were difficulties observed in trying to standardized instructions to all jobs related to all products. However it could be more beneficial to concentrate for the time being on the phases and product types that can be easily standardize because the total cost of standardizing all, could exceed the benefits gained from it. Still it is important to standardize all the possible phases that can be standardized with less effort, because it brings a lot of benefits to a lot of departments and to the assurance of product quality by making many processes smoother and less complex as also mentioned in the theory part. What could possibly be done concerning the difficult ones is to first try if there is a way to combine parts and to be able to make products from fewer parts. That way standardization could become possible with less effort also for those products.

The results measured in the work study of implementing this method as pilot were not much satisfactory but as said the good results come with time. The new way has also to get embraced and implemented with the majority. It could even be possible for example that some problems to seem to get worse at the start of implementation, among others learning (adapting) the new method takes time at first. As the result of the work study also showed the reduction in disturbance hours have not been observed. Still it does not mean that the expected 50 % reduction in that could not be achieved. The new method has been applied only for a short limited time.

It has to be taken to consideration that the advantages of standardization could not necessarily be fast and easily visible though its final effect could be significant to a company. Based on the knowledge of standardizing and on common sense it should be clear that standardization offers many benefits.

The next step from this could be the utilization of the created instructions for orientation and defining a responsible person for the execution of continuous improvement in assembly stream with selected scope. Also the expansion of the standardization work to other assembly streams and departments as well as making clear quality standards of different parts and products is important for the execution and utilization of standardization.

6 Summery

The study which aimed at improving product quality and production efficiency by standardizing methods has brought much understanding about standardization to the workers. Especially its importance for orientation has become clear to all which is a great achievement considering the future. The expected numeric results couldn't yet be achieved during this study period for the obvious reasons that a comprehensive participation on the implementation of it hasn't been done yet and standardization results demand longer time to be seen. However the study has given a clear message that the implementation of standardized work method in Helsinki plant in the near future is going to be possible and successful.

It has to be consider though that the success is going to demand hard work on controlling and monitoring of workers till it gets adapted. It has also become clear that especially the experienced workers who already have adapted their own way of doing things are going to need more control and encouragement to get rid of their old habits. Instead, for the future, they have to be instructed to use the continuous improvement process tool to bring up their constructive ideas and improvement suggestions for the creation of even better methods.

The literature review has revealed standardization makes Lean manufacturing and the utilization of its tools more effective through smoothing many complicated processes and supporting the continuous improvement principles. Today's best is the start point for coming up with even better ways which gives a way for better product quality and quality control, and consequently for improved efficiency to different operations and activities.

The utilization of the created instructions for orientation, defining a responsible person for the execution of continuous improvement in assembly stream with selected scope, and the expansion of the standardization work to other assembly streams and departments are among the issues that should be dealt with in the near future.

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