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A Lean Transformation Journey

An Insulation Manufacturing Case Study

Master Thesis in the Master's Programme
Quality and Operations Management

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Abstract

Elimination of waste in internal activities is key in improving operations in organizations. Tailoring and implementing Lean tools in order to focus on customers and achieve flow efficiency is the beginning of a Lean journey. For organizations to remain competitive they are continually searching for cost reduction, decreasing the lead-time in production and increasing productivity. This master thesis project is developed at an anonymous insulation manufacturing company, referred to as Insulation AB. This company has undergone a very abrupt change due to a high investment to increasing operations in the production department. The purpose of this master thesis is to investigate the present Lean implementation and the future steps that need to be taken in order to improve the production processes at Insulation AB. Implementing change requires following clear guidelines and adhere to time frames. For this reason it is important to understand management goals and sequences towards lean implementation. As the implementation will generate interaction between the shop floor and managers, it is important to identify the next step for improvement and the possible hindering factors that might rise in becoming a Lean company. Insulation AB managers, production supervisors, the continuous improvement team and shop floor workers were interviewed and observed in order to gather data to support the purpose and the research questions of this paper.

This research outlines the importance of understanding the differences between the process manufacturing and assembly manufacturing industries for Lean implementation. This difference will affect the way of using Lean tools, implementing standardization and visualization, and analyzing product portfolio at Insulation AB. In order to identify the type company and operating conditions the product, manufacturing and production planning and control characteristics were identified and analyzed. The data collected from interviews and observations was organized between the Lean levels of interpretation to understand the path that Insulation AB is following. The Lean tools 5S, standardization, visual systems, total productive maintenance and continuous improvement were identified as the first steps of Lean implementation at Insulation AB. The framework showed that the company was following Lean tools, which supported the principle of elimination of waste. The next step identified for Insulation AB with their Lean implementation is to implement the principle: *creative involve of the workforce* and connect the company at all levels. An interactive Quality Management System (iQMS) is suggested to link the communication, documentation and strengthen the Lean implementation at Insulation AB, but requires cross-functional collaboration and communication to build a stronger Lean thinking culture.

Key words: Lean tools, Lean principles, eliminating waste, TQM, process industry.

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1. Introduction

The following sections outline the theoretical and company background including the research questions to be answered for this paper.

1.1 Theoretical Background

Nowadays, organizations understand the importance of beginning the journey towards lean operations in order to eliminate waste in their internal activities. In order to implement and deploy innovation and improvements organizations need structures in order to standardize, stabilize and achieve flexibility in their activities following lean methodology. Efficiency and flexibility are powerful drivers that can motivate companies to change their way of working towards a lean management system (Raisch and Birkinshaw, 2008).

A lean operations strategy can guide organizations to manage, eliminate and reduce variation in their processes. This allows companies to focus on flow efficiency towards customer satisfaction. Also, this will help to increase efficiency and focus on the values an organization should have, the principles that will guide how the organizations should think and the required tools that an organization should have. Also visualizing information will allow companies to see the actual situation and the reallocation of the operations if the activities are not following that of the firm. Organizations can be controlled through visualization tools in order to identify and use the deviation to trigger the required improvement (Modig and Åhlström, 2016).

The main objective of implementing Lean within organizations is to increase productivity, decrease lead-time and reduce costs. However, Lean is also important to enhance quality, performance and workflow. Lean principles will change the firm's internal activities towards the desired goal (Åhlström, 1997).

Business transformations are a long-term journey, since change requires implementing new habits and sustaining these changes to avoid returning to the old ways of working. People can be resistant to change and Lean operations are a powerful tool that will help to inspire, involve and work more efficiently. One critical step toward lean implementation is to analyze the firm's current state, helping to understand and identify the organization’s weaknesses and strengths. This step also can open up managers to be involved and to be part of the change (Sedam, 2010). It is important to understand what an organization can gain when developing a Lean Operations strategy. One of the cornerstones of Lean thinking is to focus on the flow efficiency rather than resource efficiency (Modig and Åhlström, 2016). At the same time, firms can understand their internal processes and identify what is value for the customer and what is waste (Sedam, 2010).

According to Slack and Lewis (2002) operations are very important since they manage firm’s resources and processes. Further, a strategy sets the goal objectives, planning the future and long-term vision of the company and gives a clear overall picture of what the company wishes to achieve. From this definition the operations strategy is very important for organizations since it gives a strategic perspective on how the operations resource and processes should be managed. Similarly, an operations strategy is a long-term journey that requires a high level of analysis.

The operation strategy can be described both from top down and bottom up activities. Top down reflects what the organization wants to do and the bottom up focuses on building a strategy by experience. Operation strategies involve translating the market demand inside the operations and move the operations capabilities towards targeted markets (Slack and Lewis, 2002). Organizations set their processes according the demand of the product or services. Therefore, it is important to analyze the four V’s (volume, variety, variation and visibility) in order to manage the processes correctly. The four V’s are the output of an operational strategy decision and can be linked to a Lean operations strategy, which focuses on having a high volume output with low variety, variation and visibility in order to increase flow efficiency (Slack and Lewis, 2002).

1.2 Company Background

Insulation AB Group is an international insulation manufacturer. They have manufacturing plants and sales departments in a number of international locations. Their brand offers solutions within the building, technical and marine industries, including meeting insulation and acoustics requirements. Some of the brand characteristics include saving energy, re-utilization of products, high-level safety &

quality and an environmental commitment to sustainability. The customer segments are within the construction development industry and industrial manufacturer industries for both producers and distributors.

Over the last few years there has been a relocation of production from an international factory to a production location within Sweden (Insulation AB). This investment was completed at the end of 2016 at a cost of around 7 million euros. The headquarters decided to move production (including a large number of machines) due to the experience, equipment and production plant facilities at Insulation AB in Sweden. This has led to a number of improvement initiatives to increase the efficiency and effectiveness at the company.

The production at the location in Sweden, Insulation AB, is divided into three main areas of production: Production area 1 (Product A & B), Production area 2 (Product C) and Production area 3 (Product D & E). Each production area is independent from each other and each contains different operational stations.

1.3 Purpose

The purpose of this master thesis is to identify the current situation of Lean implementation at Insulation AB and the next steps for their Lean journey. The research aims to identify potential hindering factors for the continued implementation of Lean within this company. The research also aims to add further contributions to the scientific literature of Lean culture and implementation in a real situation.

1.4 Research Questions

According to Åhlström (1997) processes can be categorized as logical explanations of independent and dependent variable relationships, organization and individual actions and a sequence of events, which describe change over time.

By these definitions, a process can be explained as a sequence of events or orders that happen during a certain time. Sequences are the order that firms use to implement lean principles. Likewise, sequence is the outcome of managerial decisions and actions. During the adaptation to change, such as the implementation of Lean, firms can face issues that can be sensitive for managers, creating threats that inhibit implementing the new processes (Åhlström, 1997). This has led to the following research questions to be answered from this study:

RQ1: How is Lean implemented at Insulation AB today?
RQ2: What is the next step for improving Lean operations at Insulation AB?
RQ3: What possible hindrances could be encountered in taking this next step?

1.5 Delimitations

The focus of this thesis will be the current Lean implementation at Insulation AB. Although Insulation AB is part of a larger organization, the Insulation AB Group, the research will be limited to the location researched within Sweden. This limits the direct applicability of the findings to the location in Sweden, but may have implications to other departments and locations outside of Sweden.

2. Theoretical Framework

The following chapter outlines the areas of literature to form the basis of knowledge required to begin fulfilling the purpose of this master thesis.

2.1 Process or assembly manufacturing

It is important to establish the differences between the process manufacturing industry and the assembly manufacturing industry, sometimes referred to as discrete manufacturing, as they do not have the same inherent characteristics in their products or processes (Figure 2.1).

Assembly manufacturers build individual and component parts that the operator assemble together to generate a finished product (King, 2009). Some examples of these are computers, televisions, automobiles and motorcycles. The process manufacturing industry creates products that are characteristically components to the manufacturing and other industries. This industry includes those works with mixing, blending, extracting and chemical reactions in order to create a product (King, 2009). Some examples of the process industry are the paint, food and drinks, plastics, pharmaceutical and insulation industries. Lyons et al. (2013) outline three factors that need to be considered to establish the difference between process and manufacturing industries: *the structure of the product, the manufacturing process characteristics and the production planning and control methods.*

Factor	Discrete (project, job shop, batch and repetitive)	Process (job shop, batch and continuous)
Product and product structure	Solid	Solid, liquid, or gas
	Deep product structure	Shallow product structure
	Assembled bill-of-materials	Blended formula or recipe
	Primarily convergent product flow	Primarily divergent product flow
	Countable and distinguishable	Measurable and indistinguishable
	Many input raw materials/components	Few input raw materials
	Limited shelf-life constraints	Frequent shelf-life constraints
Manufacturing processes	Fabrication-based	Fabrication-free
	Predictable material grade	Variable material grade
	Process sequence precedence constraints	Flexible process plans with fewer precedence constraints
	Minimal regulatory involvement	Changes may be governed by regulatory constraints
Production planning and control	Item tracking and control	Lot tracking and control
	Planning of residual products unnecessary	Residual products regularly produced as part of the production process
	Predictable yield expected	Often variable yield
	Post-process equipment cleaning unnecessary	Equipment cleaning requirements accounted for in planning
	High degree of process control automation not necessary	Often highly automated process control

Figure 2.1 Discrete versus process manufacturing industries (Lyons et al., 2013, p.481).

The material flow also plays a key part when defining these two industries. Within the process industry, the variety of the product increases the further it travels in the production process. In the assembly industry the different types of parts join as the material flow goes deeper in the production process (King, 2009).

The raw material can also help to understand the difference between these industries since in the assembly industry the manufacturing procedure begins with a large variety of raw material. The further it travels in the production flow, the number of finished goods products decrease. In the process industry the raw material work in the opposite way, in the beginning of the process the raw material is less and the further along it travels in the production flow the larger number of products are created (King, 2009).

2.2 The Four V's (4Vs) of Operations Management

Operations Management principally focuses on how an organization can produce services or products. Firm's internal processes are different and they need to be handled according to the demand of the products or services. The 4Vs (volume, variety, variation and visibility) have a substantial consequence on how organizations can handle their processes. Focusing on the 4Vs will help the organization to connect their operations and management strategies (Slack and Lewis, 2015).

The 4Vs help to take the suitable strategic decision depending of the type of operation. Likewise, it helps to develop and analyze the volume, variety, variation and visibility in order to achieve the required manufacturing costs (Slack and Lewis, 2015). According to Yuan (2013) the volume, variety and visibility directly affect the product or service costs. The cost of the product or service will be affected depending on where the operation is situated on the 4Vs scale (figure 2.2).

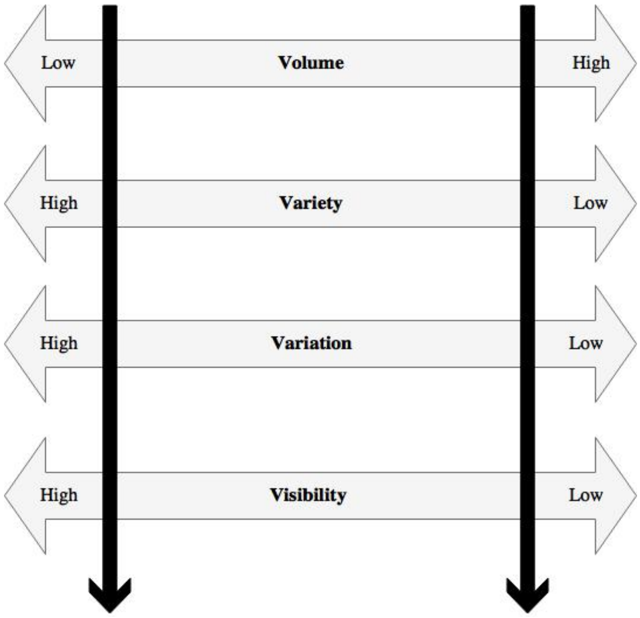

Figure 2.2. The Four V analysis. Redrawn by the researchers from Slack and Lewis (2015).

According to Slack and Lewis (2015) the 4Vs are defined as:

Volume

The output of the process can be categorized between high and low volume. High volume follows in a repeatable process, requiring systematization and specialization in order to achieve a lower cost per unit. Meanwhile, low volume implies lower work repetition, increasing more job tasks and a higher unit cost.

Variety

Manufacturing high product variety indicates having a lot of activities and having a lot of changes among each activity. High variety increases complexity and flexibility in the processes increasing the cost of the product. Low variety means that the process can be produced in a standardized and well-defined way, creating process routines and reducing the unit cost.

Variation

Demand plays an important role in the process variation. If the demand is low, the process is steady, foreseeable and forecasted plans can be followed. Meanwhile, high variation will require adjusting the resources to meet the changes in capacity, seasonality and flexibility. High variation requires having safety capacity to meet the variation in demand increasing the unit cost of the product.

Visibility

The visibility can be described as the operational value added by involvement and interaction with the customer. Low visibility means that the time interval among production and consumption can be measured in days. Low visibility lowers the unit cost of the production. High visibility implies that the customer contact skills and perception need to be high, increasing the unit cost. Also, the waiting time is shorter from production to consumption.

In order to decrease cost in the operations, management needs to have a combination of high volume with low variety, variation and visibility. If the operation performance is low volume and high variety, variation and visibility the operational costs will increase (Slack and Lewis, 2015).

2.3 What is Lean?

Since the success and durability of Toyota and their dominance in their industry, researchers have been trying to decode their success compared to their competitors in the rest of the world, leading to the research of Lean. This led to much conjecture and the debate of what Lean is and what it is not. Researchers during the 1980s suggested that Lean was a number of tools at shop floor level of the manufacturing operations that were implemented that focused on improving the efficiency of operations within the automobile industry (Hines et. al, 2004). Krafcik (1988) suggested that organizations, which had successfully implemented the Lean concept into the operational management policies, could be more successful than their Japanese counterparts. These organizations achieved this by focusing on adding value to the customer and reducing waste in their operations. This suggested that Lean was much more than a set of tools used on the shop floor level of operations. Lean continued to evolve and in the 1990s was implemented by a number of repetitive manufacturing industries outside of the automobile manufacturing industry. This led to the focus of Lean to include reducing waste within the entire value stream from suppliers to the end customer (Hines et. al, 2004). Liker and Meier (2006) add that Lean cannot be directly copied by applying tools from another organization, such as Toyota, into the operations of another company. They explained that a much higher level of interpretation is required to bring lean culture and lean thinking from the shop floor into all areas of the organization.

One of the issues with defining Lean as explained by Modig and Åhlström (2016) is the level of abstraction at which Lean is described. The authors categorize three main levels of abstraction. At the highest level of abstraction Lean can be viewed as a philosophy, culture or way of thinking. At the lowest level, and an area that Modig and Åhlström (2016) suggest has the most research, Lean is described as a tool, such as which is used to eliminate waste in some process or operation. In between these two extremes Lean can be viewed as, a way by which to improve, such as quality or production systems. This forces companies to consider their level of Lean understanding and the level of abstraction that they will implement within their organizations (Figure 2.3).

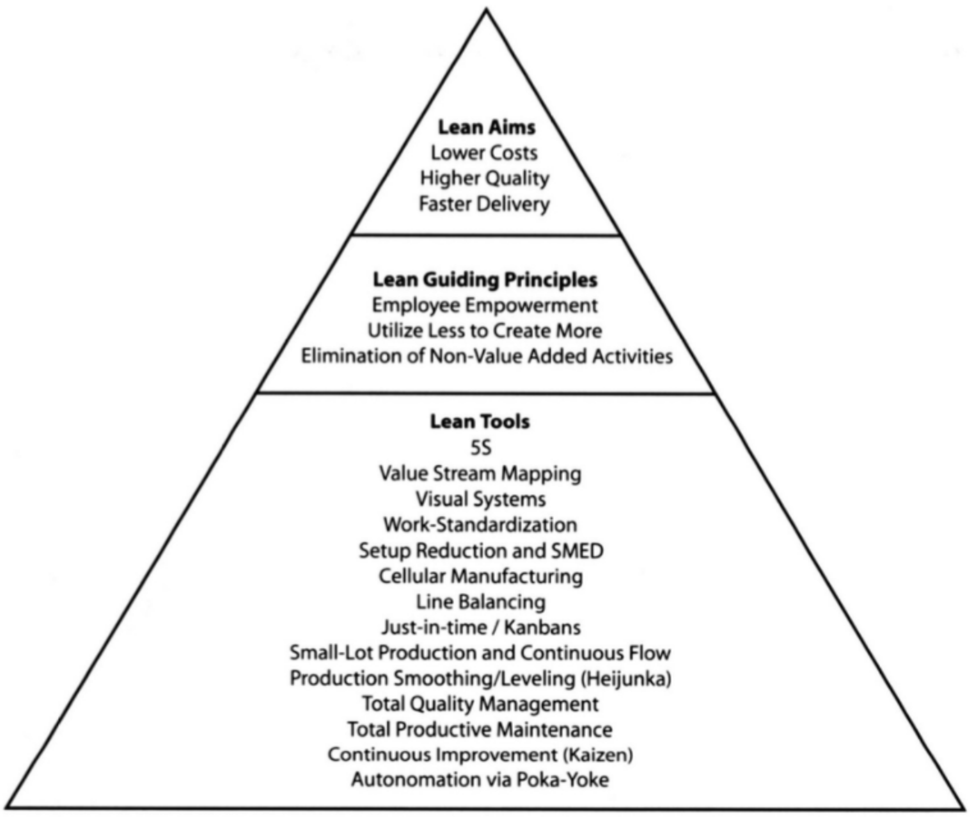

Figure 2.3 Levels of Lean interpretation (Abdulmalek et al., 2006, p.16).

2.4 Lean thinking

The concept of Lean as described by Motwani (2003) is a methodology that aims to reduce waste in all areas of a company's operations and can be applied to almost any industry. This allows the focus to be on specific flows of information, materials or products and understand which activities add value to the customer and which do not. Lean also values an organization's ability to respond when required to changes from both internal and external factors on the organization. Womack and Jones (2003) suggest that the very core level of Lean is based on four principles; to specifying the value, identifying the value stream, creating product flow and letting the customer pull. The four principles interact to continuously improve with the goal of perfection in operations and all business activities.

2.5 Lean Implementation

Since implementing lean principles requires discipline and standard procedures it is necessary to let everyone in the organization be involved. Involving many levels within the organization aims to gain management commitment and create a clear goal to guide the change. This new way of working will require resource and time utilization, as the change needs to be supported with training and top-down commitment (Cole, 2009). Lean management needs to structure the workflow. 5S (sort, set in order, shine, standardize and sustain) lean methodology can help the organization to decrease the chaos and set a new structured way of working (Cole, 2009).

One of the difficulties with Lean implementation is the context in which it is applied within organizations. As discussed by Liker and Meier (2006) simply taking tools that have been adapted in one organization and applying them in another manufacturing setting will not be a successful strategy. King (2009) agrees stating that Lean has generally been more discussed within the assembly manufacturing industry, but when applied to the process manufacturing industry has its own complexities, stressing the importance of implementation context. This leads to process manufacturing organizations requiring different approaches to Lean implementation due to these inherent differences between industries. This can lead to organizations not fully understanding the reasoning (the 'why') behind the implementation of the tools (Liker and Meier, 2006; Modig and Åhlström, 2016).

Liker and Meier (2006) suggest that the implementation of Lean can be conducted following a number of different strategies. One such approach is 'X production system' strategy that is implemented across the manufacturing operations with *"conceptual models, training modules, lean assessments, lean metrics* (and) *standard procedure manuals*" (Liker and Meier, 2006, p.395). This type of strategy has the advantage of a consistent message of implementation due to the common language and vision that it creates for management through standardized practices (Liker and Meier, 2006). But warn that it can be an expensive and slow process that requires a greater level of understanding at a higher level of abstraction (principles, culture and thinking).

The way in which Lean is introduced within companies can have significant impacts on the success or failure of the implementation. According to Ballé et al. (2015) companies implementing Lean through operational programs based on the introduction of tools to optimize processes for cost reductions are less likely to be successful. Following Lean as a strategy, by developing all employees by gradual continuous improvement initiatives for building a Kaizen culture, delivers far better business results (Ballé et al., 2015). Lyons et al. (2013) offer a broad framework for the implementation of lean thinking (Figure 2.5). The authors also outline that the differences in manufacturing context also affect the potential usage of lean tools between the industries. Practices such as 5S and visualization are more applicable between different manufacturing settings. Process industry manufacturers do generally implement the principles of elimination of waste, followed by the creative involvement of the workforce but are lacking in the other areas (Lyons et al., 2013). This is also supported by Abdulmalek et al. (2006) who found that the implementation of Lean through 5S, visual systems and work standardization were universally adapted practices in both types of industries. Abdulmalek et al. (2006) add that the process industry is not a good candidate for JIT due to the industry's low process flexibility and specialized equipment types.

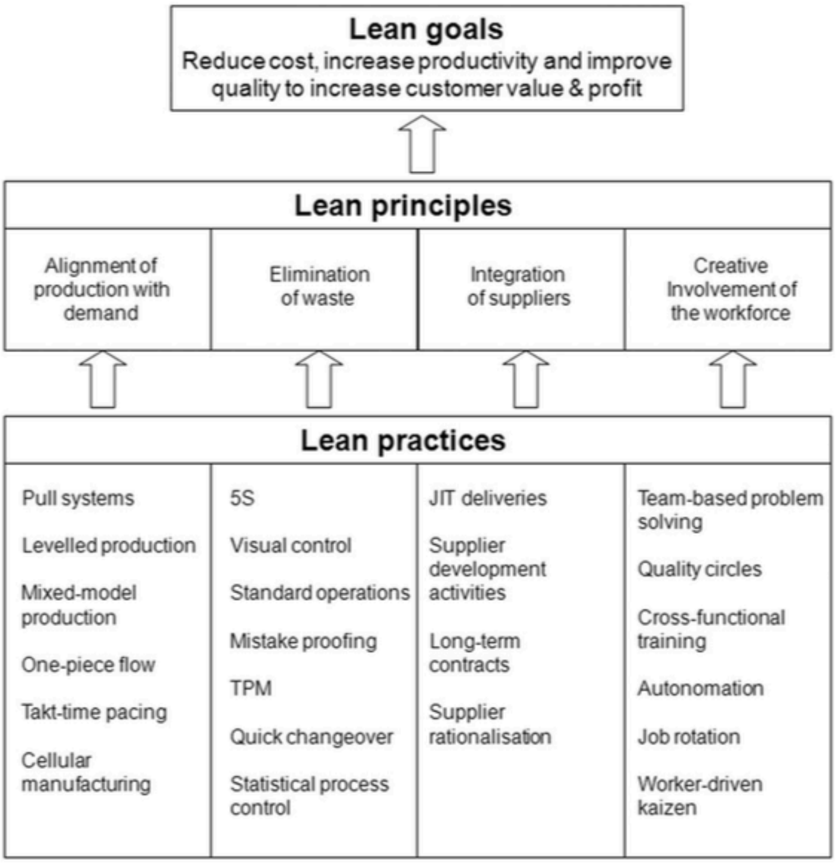

Figure. 2.5 Lean thinking implementation framework (Lyons et al., 2013, p.477).

2.6 The importance of Leaders

One of the most critical factors towards a successful Lean implementation is the Lean understanding and commitment of the leadership (Emiliani and Stec, 2005). Implementing lean will require a long-term commitment, investment and resource utilization. Lean will drive the organization to understand the value of their employees (Liker and Meier, 2006). Working with a Lean mentality will require an open leadership style with skills to inspire and support the implementation challenges (Trenker, 2016). Liker and Meier (2006) support the importance that leaders should focus on the 4P's model of implementation (Figure 2.6). Leaders need to provide the suitable methods to implement and continually work within a Lean system. Leaders will help to implement the required lean tools to support waste reduction and continual improvement (Dombrowski and Mielke, 2014).

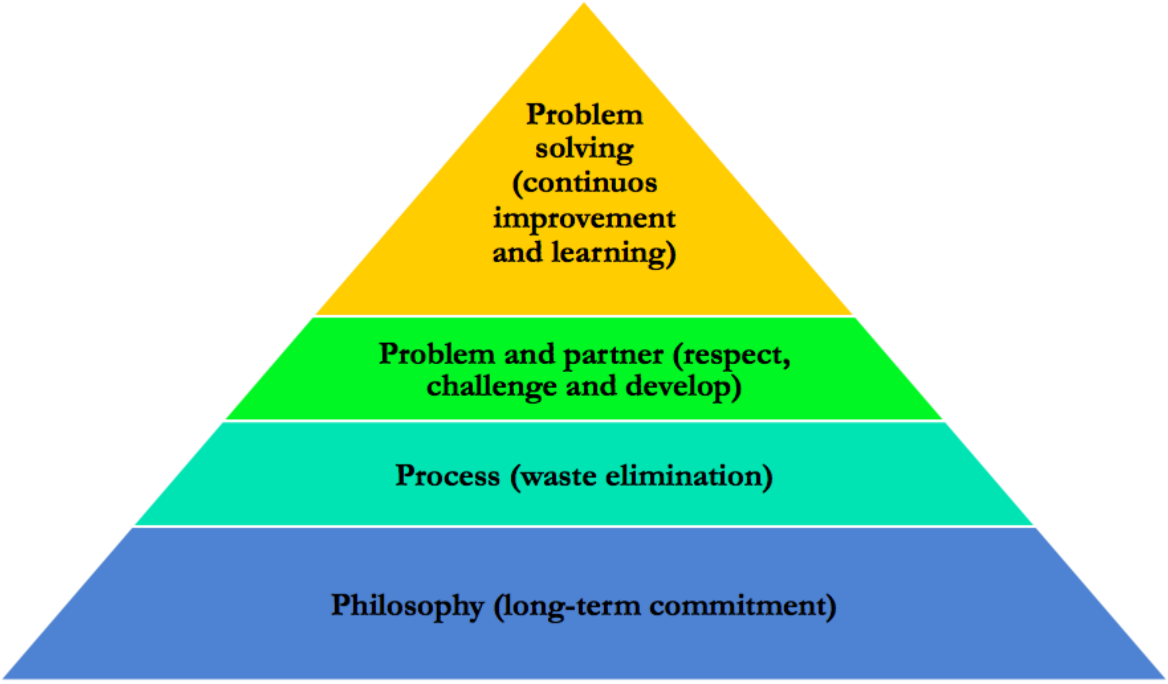

Figure 2.6. 4p's Model (Redrawn by the researchers from Liker and Meier, 2006)

Leadership Model

Lean leadership requires representation from top, middle and bottom levels of the organization to fully support the implementation (Trenker, 2016). According to Liker and Convis (2012) the Toyota way relies on five values that are the foundations of Lean leadership: kaizen, genchi genbutsu (going to the source), respect, change willingness and teamwork. According to Liker and Meier (2006) the Toyota model to lean leadership consist of four steps:

1. Improvement personality: lean leaders need to improve themselves and others. A lean leader usually observes at the source to understand and solve the challenges.

2. Motivation and Training: Lean leaders should be capable to identify the staff's weaknesses and strengths. This skill helps leaders to support people and create stable working and learning conditions.

3. Kaizen Process Support: Lean leaders will develop visual management and ways to analyze the facts, which will help to follow instruction and enhance accountability and responsibility from their employees.

4. Coordination towards the company vision: Lean leaders maintain an environment for continual improvement by focusing on processes and develop their employee's skills. They should also set the objectives and outline the plan to achieve the vision.

In the beginning of the Lean implementation process it is important to train and develop skills while the individual and organization move higher within the 4P's model (Trenker, 2016). Firms need to select the correct leader that will mentor, train and educate to open opportunities for staff to change. Also, the leader needs to provide support and tools to develop people and make the foundation for the change (Liker and Meier, 2006). Poksinska et al. (2013) state there is leadership in all the levels of the organizations. The researchers add that leaders and managers can work together. Liker and Meier (2006) support this statement that leaders can be found in the top, middle and bottom levels of the organization. Eklund (2000) explains that organizational activities and quality are dependent on people. Lean involves staff by trying to change the behavior and attitudes towards a waste elimination mentality, making a connection between people and productivity (Eklund, 2000).

Top Level Leadership

Top-level leaders need to understand and see the reality in order to coach, teach and be committed. Top-level leaders have the resources that organizations require to sponsor and lead the change (Liker and Meier, 2006). Bergman and Klefsjö (2010) point out that the top management has to create a vision and give direction towards the change. A successful top leader understands the importance of a holistic approach to supports the change throughout the entire firm. Top Leaders are important since they can give support and ask for results in order to make things happen (Liker and Meier, 2006).

Middle Leadership

The middle leadership is important since they utilize and channel the resources that are provided from the top in order to support the bottom of the organization. Also the middle leaders are the implementers from the top since they translate top ideas more tangible for the bottom in order to deliver results (Liker and Meier, 2006). Middle leaders are important in order to develop and support the continual improvement work so they need to be involved and committed throughout the implementation (Trenker, 2016). In a Lean implementation the middle leaders are key, since they run the implementation and improvement projects. They have the power to make things happen (Liker and Meier, 2006).

Bottom Leaders

According to Halling and Renström (2014), firms are network systems, where information and relation connections take place. Firms have bottom level leaders that are natural and have an important opinion and influence inside the organization. Bergman and Klefsjö (2010) pointed out that these natural leaders have a lot of connections and they have to be involved in order to have a smooth implementation. A way to include this natural leader, as suggested by Liker and Meier (2016), is to break the shop floor into smaller groups (Kaizen groups) and let this natural leader be the lead implementation projects.

From Change Behavior to Change Culture

Firms can change employees' behavior by sharing information and training to influence daily activities. In order to change behavior and gain commitment, organizations need to explain, instruct and give feedback (Liker and Meier, 2006). In order to impact organizational culture lean leaders need to work and share the experience with the staff. In order to change and ensure transferability in firms, Lean managers need to be commitment and involve and interact with employees to share experience (Liker and Meier, 2006). According to Liker and Meier (2006) one way of starting a change culture of within the organization is by working with a pilot project where the leaders and staff can work together, share knowledge, learn working routines and creating a training program. This will help to bring the external knowledge inside the organization by teaching, driving and pushing the knowledge (Liker and Meier, 2006).

Firms need to focus on the change effort that will drive the desired implementation result. The efforts should be focus on the staff participation and sense of ownership. Other key ingredients are to be committed and have knowledge and leadership inside the organization. Also, within the firm's structure it is important to have the suitable roles and responsibilities and the correct documentation and visibility to share information. (Liker and Meier, 2006)

Process Management

Process management is key in firms' productivity and quality improvements. Leaders focus on improving quality, effectiveness and adaptability of the process. By improving quality, leaders will ensure to meet and satisfy their customer requirements. Also by improving process efficiency leaders can utilize the organization resources to produce the target results. Likewise, by improving processes adaptabilities leaders can increase flexibility by changing prerequisites easily inside the processes. (Bergman and Klefsjö, 2010)

According to Bergman and Klefsjö (2010), there are key roles for process management, which include:

- Process Owner: in firms all process should be assigned a process owner to ensure having responsibility in the process. This owner needs to ensure that the processes have all the required resources to operate in the best conditions. Ownership will avoid having internal power conflicts. (Bergman and Klefsjö, 2010)

- Process Manager: the process manager is the leader for the improvement teams. Also, the process manager takes all the decisions for the operations process such as resources and reevaluating priorities for the process if it is required. If the process locations are physically divided then firms need to have process managers for each different type of process. (Bergman and Klefsjö, 2010)

- ·Process Supplier: the process supplier ensures that the process operates with the required resources and within the optimal conditions (Bergman and Klefsjö, 2010).

2.7 Lean principle – Elimination of waste

One principle in Lean is to identify and eliminate waste in the organization. Waste can be defined as everything that does not add value for the customer (Ålström, 1997). These non-value adding actions can be applied to the office, product development, production, planning and purchasing departments (Liker and Meier, 2006).

According to King, (2009) in order to find waste organizations should identify the value. The value can be set to customer requirements and then used to eliminate the activities that consume the organization’s resources such as staff, time and material. Liker and Meier (2006) outline ‘7+1’ types of waste:

1. Overproduction.
2. Waiting (time on hand).
3. Transportation or Conveyance.
4. Overprocessing or incorrect processing.
5. Excess Inventory.
6. Unnecessary Movement.
7. Defects.
8. Unused Employee creativity.

Excess inventory usually hides problems through buffers and inhibits staff and managers in solving problems. Another type of waste is overproduction. Overproduction describes producing more quantities than is required. This type of waste stresses the organization and generates other types of waste such as increased transportation, inventory and hiring more personnel. Waiting (time on hand) is another types of waste due to organizations failing to plan effectively. This can capacity utilization issues such as not having the required work, raw material, available machines (downtime), or from processing delays. Unnecessary movement can be in the form of materials or employees moving between locations during the process that generates a waste that does not add value for the customers. Any unnecessary movement that workers have to do in order to complete the work is considered a waste that should be avoided. Having poor tools, product or process design will create extra work and generate waste. This type of waste is called the overprocessing or incorrect processing. Having to repair or redo the work due to defect means wasted time and resources for the organization. A new type of waste suggested by Liker and Meier (2006) is when firms do not use the staff creativity in an effective manner to find new improvements ideas. If organizations do not involve personnel to utilize their knowledge and skills they will not be engaged and organizations will be wasting a valuable asset. This may lead to high staff turnover causing lost knowledge for the organization (Liker and Meier, 2006).

2.7.1 Elimination of waste in the process industry

The wastes in the process industries require a different approach in order to be reduced or eliminated than those in the assembly manufacturing setting. However, some of the wastes can be categorized similar between the assemble and processes industries so it is necessary to point out that the root causes and solution will be different between both industries. An example of this difference in the waste is the defects. In the assembly industries the defects are produced by worn out tools and errors in the set up. Meanwhile, in the process industries defects are originated by raw material properties, or a fail in key process parameters (King, 2009).

Overproduction Waste

Overproduction, put simply, is to generate more materials/products than the required from the customer. Having an economy of scale mentality where the focus will be on generating large volumes of products can reveal this type of waste in the process industry. Working with a forecast that is mainly intent to push production creates unneeded products. This leads to having unsuitable productivity measures creating long operations due to incapable process and expensive changeovers (King, 2009).

Waiting Waste

The waiting waste for the process operations can be generated through having many activities and duties at the beginning of the production batch but less throughout the batch (King, 2009).

Transportation waste

This type of waste can be visible due to having dispersed and not well co-located equipment plus large work in progress at the warehouse (King, 2009)

Processing waste

This type of waste can be founded through making, testing, sorting, reworking and preparing defective material. Also, it can be found in preparing defective material to be reused (King, 2009).

Inventory waste

In the process industry, working with a make to stock mentality and different product batch sizes can create overproduction waste. Process industry organizations tend to protect themselves from possible bottlenecks problems and build buffers against variability from the demand and process disturbances. This type of waste can be typically found in non-synchronized material flow and equipment (King, 2009).

Movement Waste

Process industries movement waste can be described when the workers need to search for the necessary tools in order to make their work. Also the layout of the stations and equipment can be located over greater distances (King, 2009).

Defect Waste

Having sensitive processes or very difficult control process parameters, such as raw material, which can be very sensitive and inconsistent, can create this waste. Defects can also arise if organizations do not have standardized work procedures (King, 2009).

Human Potential Waste

The root of the human potential waste is located in a work environment where there is not interaction and involvement from the entire organization. If workers are not capable, trained and involved old habits will arise and the new processes improvement will surely fail (King, 2009).

2.8 Lean practices for eliminating waste

According to Lyons et al. (2013) there are a number of Lean tools that have the goal of, but not limited to, reducing waste within the operations of organizations. These tools can include 5S, standardized work, and visual systems. The next section discusses these tools in more detail.

2.8.1 5S

5S is a methodical approach to organize a workplace. This methodology is used to support waste elimination. Firms use this methodology to ensure cleanliness and order at the working areas (Bergman and Klefsjö, 2010). 5S methodology helps organizations to study workplaces and uncover potential improvement projects. This methodology can be used as the foundation to other Lean mythologies such as Total Productive Maintenance (TPM) and Kaizen to focus on flow. Firms need to plan in advance in order to implement 5S methodology. It is important to involve the employees and explain the new method and what it is the expected input (Durana, 2016). The 5S's are categorized by their Japanese name as: Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seikutze (Standardized) and Shitsuke (Sustain). (Bergman and Klefsjö, 2010).

Sort

The focus here is on eliminating waste by sorting the unwanted and wanted material at the workplace. At the work areas there should only be related work material: This will help to think more effectively and use the space in the most efficient manner (Bergman and Klefsjö, 2010). According to Durana (2016), this first step in the mythology requires a long time for a successful implementation, an inspection of the work place needs to be done and analyze each step.

Set in Order (Straighten)

Tools and working material need to have specially assigned locations. This will help the staff to have better accessibility to pick up and return the tools for the next usage. The arranged position should be labeled and relevant for the area (Bergman and Klefsjö, 2010). Personnel involvement is required in this step to utilize the knowledge of production staff to determine the necessary tools and material resources at each workstation. Discussion and approval are steps that arise during this second step (Durana, 2016).

Shine

The focus here is to establish procedures, routines and documents. This will help to eliminate waste and see potential disturbances in the processes. Creating documentation (preferably including photos) and creating routines (stability) for cleaning are some advantages organizations can gain during this step (Bergman and Klefsjö, 2010). According to Durana (2016), not only the workstations should be 'shined', the employees need to expand this methodology to the machines and any type of equipment or tools

Standardize

This requires staff commitment since everyone needs to maintain, measure and practice a clean environment at their workstations. The staff need to collaborate and categorize with standardized visual colors, for example, in order to bring a common understanding the work area (Bergman and Klefsjö, 2010). In order to standardize, the new procedures or methodology should be easy, comprehensible, use a lot of visualization and less text and should take into consideration the safety and work environment (Durana, 2016).

Sustain

This is a critical step for organizations, as they need to maintain the standards and create new habits. It will require disciple, personnel and external audits in order to maintain the standards Bergman and Klefsjö, 2010). One of the cornerstones in this step is to check and support the new routines. These inspections require a control card check in order to take control and supervise each workstation (Durana, 2016).

According to Durana, (2016) there are some risks to take in consideration when implementing the 5's methodology. Many of the risks are related to the employees. Firms need to involve workers in order to decrease resistance towards the new methodology. Information, training and knowledge play a big role for a successful implementation. This will help to see this new method as an improvement project instead simply cleaning of the workstation/areas (Becker, 2001).

2.8.2 Standardized work

For companies to begin continuous improvement to their processes, activities and operations, the current operations must be understood to begin the improvement cycle. One of the primary tools to eliminate waste and provide focus for organizations is standardized work (Liker and Meier, 2006). It is important to outline the differences between work standards and standardized work as there is a common misconception in this major Lean practice developed from Toyota. Standardization through work standards as explained through Taylorism (Scientific Management) are work practices that have been evaluated to develop the most efficient way to perform a job task based on time measurements (Liker and Meier, 2006). Standardized work focuses on involving a number of employees, such as shop floor workers, shift leaders, engineers and process experts for the implementation of the work standards (Liker and Meier, 2006). This is in contrast to Taylorism, generally developed by specialized engineers, which makes standardized work more likely to be followed to set new standards and build a base for further improvements. *"Standardization is actually the starting point for continuous improvement"* (Liker and Meier, 2006, p.111). Emiliani (2008) agree and add that standardization through financially motivated work standards, which are forced on employees are not sustainable in the long-term, when compared to standardized work which focuses on finding the best practice of the task (Liker and Meier, 2006). Communication is one of the keys to unlocking the potential of standardized work. It requires building relationships and genuine two-way communications (Ingvaldsen et al., 2013) to understand the best way to approach the task. This can be achieved through worker feedback and cross-functional cooperation.

2.8.3 Visual systems

Lean visual management is a way of communication that aims to support processes in real time. This type of management uses tools to increase communication and make easy to measure and understand processes and procedures (Parry and Turner, 2006). Having a shop floor visual management system will shorten communication interaction and provide the required information in a direct and timely way that will allow the manager to monitor and react to issues more quickly (King, 2009). Visual management aims to create a problem free atmosphere in the firm by creating a culture, which reacts to problems and continually improves by using PDCA (Plan-Do-Check-Act) problem solving (Kapanowski, 2016).

Lean visual management can help to make corrections to see the current status of a process and flow, to see improvements and to make visible indicators for improvement. There are some key elements, which include, having a clean working zone, working schedules and function and area visual display information. Firms need to have a quality system that measures the current operating conditions. Also the management needs to communicate with the shop floor through visual channels (King, 2009). Kapanowski (2016) confirms the importance of clean and practical shop floor practices to visualize the manufacturing process and take suitable decisions.
In order to detect and respond to the problems in the manufacturing department, the staff need to develop suitable visual tools (Liker and Meier, 2006). This will help the employees to work on the necessary tasks on time and avoid waste in waiting, unnecessary movement and overproducing. Managers can plan more effectively by visualizing the resource utilization and operational requirements (King, 2009).

Visual working area

One of Toyota philosophies is to increase visibility, as problems and defects can be covered under waste and chaos. Lean uses the 5S tool to achieve order for the workplace both in production and office environment (Liker and Meier, 2006). This helps to increase visibility in the working areas, process flow and will bring the problems to the surface. Likewise, the 5S implementation will raise a firm's' safety standards for their workers and processes (King, 2009). Parry and Turner (2006) state that 5S implemented within production can help to bring order to the company layout since it assigns a place to the entire operation supply chain from raw material to finished good warehouse.

Visual Layout

Firms' layout is important since workers and visitors need to know in which part of the organization they are. This can help to identify different production areas, equipment, color-coding on machines, equipment and walking paths within the factory. The layout can also help visualize dangerous areas and possible safety protection devices that are required (King, 2009).

Visual Scheduling

Kaizen rooms can be used to manage operational areas by implementing display panels or boards. This helps production staff to focus on the daily production, operational takt rate, production schedules, corrections, daily production goals and changeovers schedules (King, 2009). This will help the managers to work with continual improvement when problems arise. Kapanowski (2016) agrees that this will help the production to meet the production schedule, increase flexibility and reduce extra manufacturing cost.

According to King (2009) the visual boards need to be designed, updated and displayed according to the production targets and company values. But the boards should also not have a lot of visual contamination for the workers' environment. This will ensure the acceptability, ownership and development of a standardized communication channel (King, 2009). Busby and Williamson (2000) point out the importance of having a clear objective and vision for the measurement firms want to communicate.

2.9 Total Quality Management (TQM)

Total Quality Management (TQM) is a constant effort to satisfy and surpass customer's needs and expectations at the lowest cost. Continual improvement, commitment and focus on the processes are important activities for TQM. TQM focuses on the values, methods and tools in order to achieve customer satisfaction and allows organization to utilize fewer resources. The quality work aims to prevent, change and improve to create a continual improvement environment (Bergman and Klefsjö, 2010).

2.9.1 TQM Cornerstones

The TQM cornerstones are focus on process, improve continuously, base decisions on facts, let everyone be committed, focus on the customer and committed leadership. It is important to point out that the cornerstones interact actively in organizations creating an environment that focuses on internal and external customers. This allows manager to see the holistic picture and connection between different organizations functionalities (Bergman and Klefsjö, 2010).

Focus on customers.

Since quality is related to customer values. The main focus is on identifying customers' needs and expectations. TQM drives the organization to think about internal and external customers and provides the employees the opportunity to see the entire picture, quality work practices and understand that it is part of the process and to feel satisfied about their deliverables. (Bergman and Klefsjö, 2010).

Base decisions on facts.

It is important for organization to have a logical (well-founded) decisions system. Gathering qualitative and quantitative data combined with knowledge of natural and noise variation will help to make decisions in the organizations. Making decisions on fact requires available, correct and fast information channels. The information channels need to able to gather data in a structured way to support the decision (Bergman and Klefsjö, 2010).

Focuses on processes.

Processes are activities within a network that are repeated over time in order to create value to the customers. In order to have a process it is required to have resources such as equipment, manpower and materials that will be transformed into results such as information, finished goods or any types of services.

Processes can be categorized as a: Main, Support and Management Processes (Bergman and Klefsjö, 2010). The main process focuses on satisfying external customers and improving the products provided by the organizations. The main process consists of a firm's' internal processes such as planning, product development, production and distribution (Bergman and Klefsjö, 2010). Support

Processes focus on other resources and suppliers that are required in the main process. It also supports the internal customer connections inside the main process. Maintenance, information and HR can be part of the support process (Bergman and Klefsjö, 2010). The management process focuses on making strategic decisions. Strategic planning, organizational targets, budgets and audit procedures can be located in this process (Bergman and Klefsjö, 2010).

Improve Continuously

One of the drivers to improve continuously in organizations is to improve their products, processes and working methods in order to achieve better quality and reduce cost. Since mistakes will happen in all organizations, it is important to have a quality strategy in order to improve. PDCA cycle can help to approach problems using a systematic method. PDCA focuses on firstly planning the work, secondly performed the plan, then studying the results in order to identify waste, root causes of the problem and then finally intervene and eliminate or control the variation (Bergman and Klefsjö, 2010).

Plan: the first step when problems are recognized is to find the root causes. In this phase it is very important to break down the problem in order to manage it more effectively. In the planning phase it is important to work with a cross functional team in order to brainstorm and have different opinions from different perspectives (Bergman and Klefsjö, 2010).

Do: after breaking the problem in small causes and effects, the cross-functional team need to pre-establish the next step in order to improve the problem. The team attacks the problem according the predetermined framework. This will require commitment and involvement from the improvement team (Bergman and Klefsjö, 2010).

Study: the study phase will start after the determined improvement steps are realized. This step will ensure that the DO methodology was the correct for improving the problem. If the team's not convinced that the quality and all the problem causes are controlled the re-establish a new improvement step process must be actioned (Bergman and Klefsjö, 2010)).

Act: This is part is where sustainability, learning and keeping the knowledge inside the organization is accomplished by supporting new ways of working and procedures in order to maintain the new level in the organization (Bergman and Klefsjö, 2010).

Let everyone be committed

TQM can help organization to create the necessary conditions to work in a continual improvement environment. Communication, delegation and education/training will ensure creating opportunities for the employees to participate, take decisions, be commitment and continually improve at their workstations. In order to build this culture the staff need to feel committed, that they participate and are recognized. Greater levels of responsibility, professionalism and personal pride through training and recognition can be achieved (Bergman and Klefsjö, 2010).

Committed Leadership

Leadership needs to be continual developed within in the entire organization. Firms need to be clear and have leader visibility in order to create an improvement culture. At the same time, it will ensure that managers take part in the improvement processes (Bergman and Klefsjö, 2010). TQM helps organization to have a complete picture and create win-win thinking. This thinking helps to close the internal process boundaries by showing process interdependencies and interactions (Bergman and Klefsjö, 2010).

3. Research Methodology

This chapter describes the approach that the researches followed to collect and analyze data in order to investigate and answer the research questions.

3.1 Research strategy

The research strategy conducted followed a qualitative research strategy. The qualitative research strategy orientation focuses on gathering qualitative data through inductivism, constructivism and interpretivism (Bryman and Bell, 2015). Inductivism helped the researchers in the observing and finding of quantitative and qualitative data to match with the correct theory. Constructivism was used to support collaboration between the researchers and the workers at Insulation AB. This was achieved through open questioning and collecting opinions in order to represent the social reality at the company. Data interpretation, through an analysis strategy, was used to capture the subjective elements of the research (Interpretivism). The research required a good understanding of the information flow between different departments and administrative structures at Insulation AB. This type of research strategy can be conducted in a number of different ways including interviews, case and panel studies, surveys, observations and focus groups (Yin, 1994). The research conducted for this thesis 28ollowed a qualitative case study.

3.2 Research design and methodology

This research will be grounded on a single case study (Bryman and Bell, 2015). A case study helped point to potentially critical factors when implementing Lean thinking within this company's context. A major focus was on finding articles and cases about lean methodologies, tools and implementation. The literature was focused on building knowledge for research for this case study's context. The research design can be seen in figure 3.2.

As this research methodology followed a qualitative research strategy, it was important to plan and evaluate how data was collected (Bryman and Bell, 2015). The data was collected from two classifications: primary data and secondary data (Yin, 1994). The primary data was collected from sources where no previous system had been used for data collection through interviews, observations (table 3.2) and discussions with staff members from various functions within the organization. The secondary data was collected from pre-existing data sources (company production data, standards, internal documents and publications).

Table 3.2 Data collection methods and participants at Insulation AB.

Data Collection Method	**Participants**
Semi-structured interviews	Interviewee A, Interviewee B, Interviewee D
Unstructured interviews	Interviewee C, Continuous Improvement team and Production Staff, Production Supervisor (see workbook diary – Appendix II)
Observations	Planning, quality, continuous improvement and production departments (see workbook diary – Appendix I)

This research included direct observations, as well as formal and informal interviews. Therefore, it was important to use test pilot studies before conducting the data collection methods (Bryman and Bell, 2015). This helped the researchers to focus and learn how to conduct interviews and observations in an efficient way and observe actual performance at the company. Observations during the interviews gave a clear perspective of the staffs' conduct. Since the research topic focused on the implementation of lean, observations gave a powerful input of practices, methods and language that is actually used in the daily operations (Bryman and Bell, 2015).

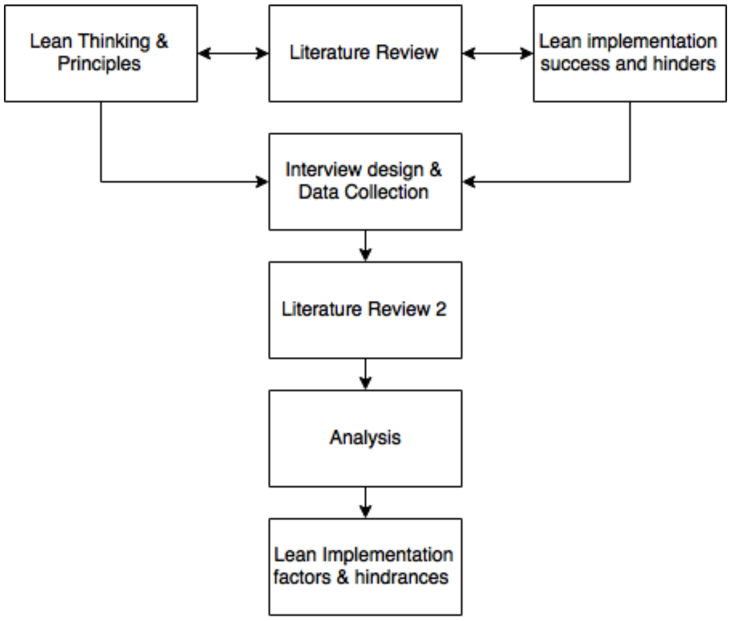

Figure 3.2. Flowchart representation of the Research design.

3.3 Interviews

In order to obtain a broad perspective of the company, all the departments were interviewed. Production Supervisors and shop floor personnel, Managers and the CI team were randomly selected in order to gather quantitative data about how the company is implementing Lean (Bryman, 2012).

The interviews were arranged in a semi-structured and unstructured way allowing the researchers to plan question in advance and asking sequenced question during the interview process. This type of interview format allowed the researchers and the interviewers to have and informal conversations and be responsive during the interview (Bryman, 2012). All interviews were done face-to-face at Insulation AB.

The CI team, manager and production supervisor interviews lasted about one hour each. Meanwhile the shop floor personnel interviews lasted between twenty to thirty minutes due to constraint in daily working time. The interviewees had the opportunity to know the questions before the interviews. The researchers asked if they could record and take notes during the interview in order to analyze the data and to transcript the answers avoiding bias in the data. The interviews were divided into four main stages: the set-up and identification, a small presentation, wrapping up, and transcript of the results (Bryman, 2012) see Appendix I.

3.4 Observations

In order to understand the operations' process flow and lean tools' implementation at the shop floor, the researchers followed a structured observation. Structured observations help to establish pre-existing rules rules and preselect areas to be observed (Bryman, 2012). The observations varied depending on the area to be observed, although the structure was similar at each observation. The observations were required by the researchers in order to describe the current status of the operations. Since the researchers could not be part of or affect the observation (non-participant observation), they were able to illustrate the daily activities on the shop floor accurately (Bryman, 2012).

3.5 Analysis of findings

To develop an understanding of the current state of Lean operations at Insulation AB and answer the first research question the data was divided into two groups of information: information that was related to Lean tools and information related to Lean principles. This was based on triangulation of primary data from interviews and observations and secondary information collected from company documents and literature. To separate the information affinity grouping was used in a number of sub categories and then links between data collection methods to were analyzed to strengthen the findings. The affinity diagram allows visualization of different types of groups of information assessing the similarities of the data (Trochim, 1988) and clarifies concepts, information and interview transcriptions (Bergman and Klefsjö, 2010).

3.6 Trustworthiness and Ethical considerations

To maintain the credibility of observations and interviews it is important to have open dialogue with those being observed and interviewed. In order to ensure the research is credible it will be important to present the findings for validation by the respondents (Bryman and Bell, 2015). The research will ensure dependability in this project by having a record of all the phases in the research process (Insulation AB diary – Appendix II). The researchers in this project will continuously ask if the information has been understood in all aspects of data collection. At the same time, the research will use interviews and observation in order to triangulate information and maintain the objectivity in this research.

In order to maintain ethical considerations, this project will consider the “Four Ethical Principles” (Bryman and Bell, 2015). Since this research will be done primarily at Insulation AB, it is important to consider ethics about the workers at the company.

The research will ensure the following ethical principles:

1. No harming the participants during this research (personnel);

2. Ensure to have informed consent of all the participants involved in this research;

3. Maintain the organization and workers’ privacy and secrecy and;

4. Avoid staff deception by being clear from the beginning and give the opportunity to delete, add and listen to what people want to express (Bryman and Bell, 2015).

4. Lean implementation at Insulation AB

In order to identify the current state of operations at Insulation AB from a broad perspective and understand what Lean tools and principles are used at Insulation AB, interviews with the CIP team, quality staff, managers and production personnel and operators were conducted. Also, to understand the product range, production layout & processes and current state of operations interviews and observations were used as well as formal and informal discussions with operators, production workers and administration staff. Also a wide range of company guidelines, training material and documentation from the local company Insulation AB and from the perspective of the larger organization, Insulation AB Group, was examined.

4.1 Problem definition at Insulation AB

In order to get a general understanding of the current operations a number of interviews, discussions and observations were conducted. Also this study involved understanding the worker's perspective for process change and tool & principle implementation within the company.

The first interviewee (Interviewee A) expressed that one of the major concerns currently are the machines that came from an overseas factory to produce a new product at Insulation AB (Product D & E). The machines changed the production layout of the factory, also affecting the company's management structure. The new reorganization created more chaos in the documentation and information flow. Also this change put the quality and improvement departments under more pressure to implement and train for the new processes that needed to be implemented. Interviewee A expressed that Six Sigma and lean training is taking place in the organization. However, the lack of training and knowledge amongst the shop floor workers, who revert back from these process improvements to continue with old habits, was an area for improvement. This has created unstable procedures within documentation and information. Interviewee A perceived that the knowledge is lost from not having the proper communication channels and also from the staff turnover has affected the entire organization. Also an observation was made that there was a high level of absentee within the production staff. The interviewee added that the HR function is not functioning optimally as new staff are sometimes trained to work with the old pre-established procedures creating a knowledge gap within production.

Interviewee A explained that the organization have been working to establish a 5S environment in the production and office areas for a number of years. However, there have been some difficulties in making the implementations sustainable in the long-term. It was also observed that there was a weak link between documentation and the operations system in the company. Having so many virtual tools has made it very difficult to track the documents since the documents are saved in different locations. An effort is being focused on updating and validating the current documents as an ongoing continual improvement project in 2017.

Another interview was held with a member of the continual improvement (CI) team (Interviewee B). The meeting was held in order to understand the purpose of the team and the core elements and goals for the function within Insulation AB. Interviewee B explained that the cornerstones of this department are to involve people and leadership, to have a structured problem solving methodology, a goal of long-term development and Lean & predictable processes. The interviewee added that these core elements are established in order support the vision of continual improvement within the company. Basic Lean tools such as 5S, standardization, A3, visual methods, and a problem solving culture are used in order to integrate the CI culture within all areas of the company. This includes working with the PDCA cycle and DMAIC (Define Measure Analyze Improve Control) framework in order to effectively frame and solve issues.

An informal interview and discussion was held within a CI functional meeting at Insulation AB. The team expressed that there was a weak connection between machines operating independently of each other adding that there is no current accurate flow chart. The team expressed that they do not have the knowledge about lean tools such as Value Stream Mapping (VSM). The CI team also agreed that the documents that were in some cases not up to date, or missing completely in the new processes was stored in varying digital locations. That added that these documents were critical for implementing visual tools, standardization and 5S in the production. One of the goals for the CI team to have a visual workstation information desk at each major machine. The team does not know how many documents or the type of documents that are available within the organization. The team needs to sort the document depending the operation station in the production. This work has been started recently and an information workshop for the entire organization to was to be held to explain to all production personnel the purpose of this implementation.

A visit was then conducted with the CI team to visit another production location within Insulation AB Group in Sweden. The purpose of this visit was to understand how this facility is currently working with continual improvement projects. The manufacturing process at the sister company is not the same as at Insulation AB. However, there are similarities in processes, procedures and company strategy. An interview was held at this visit with a member of the CI team (interviewee C) at the local facility responsible for implementation of a digital management system to link the shop floor operations with the management. Interviewee explained the importance of having a strategy, staff involvement, discussion workshops, cross-functional teams and communication channels. The interviewee explained some of the key learning's when implementing the management system such as the importance of involving everyone in order to eliminate old habits, to increase communication channels both from top down and bottom up and to enhance information clarity within the organization. Also, pointed out that there were different ways that the company used to create documents. They suggested that this variation affects the communication and information flow as non-standardized procedures resulted in having many documents in different places and formats causing missing information and knowledge in the organization.

An interview was held with a worker within the planning department. The planning personnel explained that the planning department was responsible to handle a number of different software for material acquisition, order processing and warehousing & transportation for the production scheduling. Insulation AB's key suppliers are divided depending on the type of raw material that is required for the different types of products. Activities such as customer order, warehousing level and production and capacity plan are the input that can trigger the planning process. There is ongoing communication between the production maintenance, production planning and shift leader. One of these communications is preventative (autonomous) maintenance is an area that is regularly scheduled for within production by the planning department. The interviewee explained that sometimes the material acquisition is made by an educated guess as the production planning does not follow the orders in a FIFO system as some products require moving forward in the production plan, due to stressed delivery times from the customers.

4.2 Product Portfolio

The products offered at Insulation AB are a combination of insulation solutions that aim to be energy efficient and fire safe through sustainable development with minimal impact on the environment. The products can be used within almost any situation where building or acoustic insulation is required. This is not limited to building insulation solutions but also includes solutions in the area of HVAC (heating, ventilation and air conditioning) where technical solutions are required for production stability within industrial processes. The arrangement of products offered at the site under investigation varies and can be described into five main categories of Product (A, B, C, D and E). The sales percentages of these product categories for 2016 can be seen below (Figure 4.2).

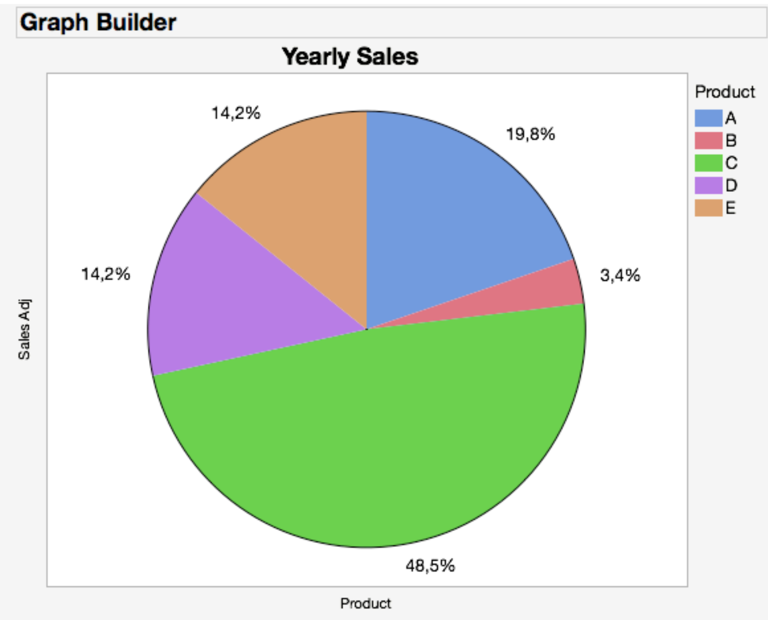

Figure 4.2. Sales by product type at Insulation AB in 2016.

4.2.1 Product A & B

The second largest contributor to the sales in 2016 is from Product A (19.8%). This product has been described as highly profitable and a source of the company's competitive advantage when compared to their industrial competitors. This product is produced in large volumes, with very little variety. Variety is divided into the categories of length, thickness (X&Y), width and density. A large number of Product A variants are kept in inventory. Product A and B can be considered products that require a more complex manufacturing process when compared to the rest of the product range offered. Specialized personnel are chosen and trained to a high level of competence to operate and control the manufacturing line for this product. Product B is considered a specialty product and only produced to customer demands and makes up the smallest percentage of sales (3.4%). No volumes for Product B variants are kept in inventory. It is equally complex as Product A requiring specialized personnel for production, but is produced in much lower volumes. The raw material for both products is supplied from the adjacent factory also part of the Insulation AB Group.

The product structure for both products can be considered solid with the attributes of a divergent product flow, as very few raw materials are processed into a number of end product variants. The manufacturing process for both Products A & B use machines which are highly automated and are expensive to start and stop, requiring approximately 30 minutes for each of these procedures. Also due to the manufacturing processes there are regulatory restrictions placed upon the operators, which work with manufacturing these products. All personnel must adhere to health examinations before and during employment. Product A and B follow the same production process. Also, both production layout are designed so that the products are produced within their own areas. The flow is designated to the particular product that is being produced and has designated production lines for each product (All Product A variants flows through the processes associated with Machine A, whilst Product B flows through all the processes associated with Machine B). Raw material is loaded onto a conveyor where is transported into a heating process, at the required temperature the material is molded and cut at the borders to the designated size. The products are then cut to the required length requirement and then a material is bonded to the main product and travels further to a quality control check (randomly distributed) and then packaged for transportation when the pallet is filled. Both products are more flexible within production planning as there are very few preceding constraints (i.e. the same raw materials and principle processing requirements). In some cases, a change in the product variant requires a setup change within the machinery. The manufacturing output of both products can be considered to have a variable material grade, which is one of the main quality concerns when producing these products. When quality issues are detected there can be implications for a number of products as the production planning and control tracks lots of products (usually pallets) rather than single item tracking. Equipment cleaning and maintenance must also be considered within production planning.

4.2.2 Product C

Nearly half of the total sales volume in 2016 (48.5%) can be attributed to sales of Product C. Product C is produced in very large volumes in a small number of variants. The variants produced can vary in length, thickness and density. A number of standard variants are kept in inventory within the warehousing facility. The product structure is considered solid but is shallow in nature as it is not constructed of a large number parts or materials. Similar to Product A and B, Product C follows a divergent product flow as a number of customer variants are produced from a very low number of production inputs. Also, the production flow is designated to the type of product and passes through all the processes and activities associated with Machine C. The issue of variant material grade is less important with Product C when compared to Product A or B but is still a source of quality concern during production. The manufacturing process requires less complex production activities when compared to Product A and B. Product C production process begins with the raw material being loaded onto a conveyor, where the material is automatically cut to size, then an automated bonding and forming process is conducted and then a final cutting process is done. Finally the product is packaged and in some cases quality controlled. When the pallet is complete it is transported to the warehouse. Controlling quality issues are done taking random samples from a batch or random time frame during production. The manufacturing process can be considered a highly automated process and planning must consider cleaning and maintenance within the production schedule. The raw material is produced from a very closely located supplier that is also owned by the Insulation AB Group.

4.2.3 Product D & E

Products D and E (each making up 14.2% of sales) have similar product properties but can follow very different production processes steps depending on the customer requirements. These products are produced within a the smaller production area within the factory. The location of each manufacturing activity is separated based on the type of operation. This is quite different to products A, B and C as the machinery is job specific (i.e. cutting, shaping, etc.). Very few different raw materials are used in the production process of these products. The product structure is also solid and similar to Product C has the ability for single product tracking and control throughout production. However like all other products produced there are issues with yield quality as the raw material and end product are subject to varying material grades. The processes are less machine automated than the other product range offered and require higher process control from the operators and from production planning. The raw materials can be supplied from a number of internal suppliers located locally from within the Insulation AB Group or from external suppliers.

4.3 Lean tools used at Insulation AB

The interviews revealed that there were a number of lean inspired activities such as 5S, standardization, visual systems, and continuous improvement used within Insulation AB. The following section explores more deeply these areas.

4.3.1 5S

In order to track and find how the 5S tool has been implemented at Insulation AB data has been collected from 5S revisions from June 2016 to March 2017. Also observations have been made of the revision process, the visual transformation of the factory. The data was classified according to different areas: production, administration, warehouse and areas surrounding this insulation firm. The 5S revision is divided into five different question segments. The questions are grouped depending on which area of the 5S (sort, straighten, shine, standardize or sustain) they belong to. The revisions at Insulation AB show that, according to the auditors which are internal members of staff usually from the higher management, the 5S tool is working well in the different areas within the organization.

Shine, standardize and sustain are three areas which are considered implemented very well within the company. Meanwhile, Straighten is on numerous occasions given the lowest level. Sort and Straighten are below 98 % compliance and commonly they have the more detections in the revisions. Sort had 11 failures, whilst straighten had 29 revision failures within the data collected.

Many failures within sort were related to the question:
"Are there any tools, equipment, etc., that do not belong to the area?"

The questions within straighten that gave the most detections of failure were:
"Is the placement marked?"
"Are tools and equipment which are not 'at Work' placed in their positions?" and
"Have cabinets and drawers updated the content card?"

As mentioned within the interviews sustaining the level of 5S within all areas has been a major difficulty that the CI function has been trying to combat. To ensure that these changes are sustained the team has one member that also works cross-functionally within the production once a week (20%). This helps the CI team gain insight into the production department and align the goals of both departments. One of the incentives that have been started within the production department is a monetary bonus system (monthly) when they reach the target level of 5S revision. Random representatives from the management department conduct the revisions. Also the revision areas are separated into different areas within the factory. When a revision is scheduled the computer generates the reviser and area to be revised based on a mathematical algorithm, which is also waited so that previous areas that have had issue with non-compliance are more statistically likely to be chosen in the future.

4.3.2 Standardization

Insulation AB has developed a visual workstation (pulpet) in order to standardize the documentation, communication and tasks for the shop floor. The main purpose of this visual workstation is to store instructions and operational documents in close proximity of the operators and working areas. The researchers were present when the first finished pulpet was completed. The instructions and documents aim to show how to complete a working task in the area where the documents are placed. The documentation also follows a standardized template in accordance with the company guidelines for compliance with ISO 9001 standards. The process owner must approve any new document before it can be added to the pulpet.

The information within these areas contains all the potential information required by an operator for the particular machine in production. This is aimed at, not only a standardized visual reference, but also for training new staff members in the future. The instruction documents are simple with pictures and text. These instructions are grouped into the following categories of information: Working Instructions, Training, Quality, Cleaning, Safety and Special and Operator maintenance. In order to improve visualization and standardization for the staff, the organization has decided to use a color system for the frame borders of each document that will be universal throughout all production areas within the factory (Table 4.3.2).

Table 4.3.2 Allocation of visual colors to the different types of documents at workstations.

Instruction Type	Working Instructions	Training	Quality	Cleaning	Safety	Operator Maintenance	Special Maintenance
Color Border	White	Black	Grey	Green	Yellow	Blue	Red

4.3.3 Continuous Improvement (CI) Team

The CI team aims to work in a methodical and harmonized way of improving performance at Insulation AB. The goals for the CI department is to work towards a continual improvement environment in order to reach sustainable and efficient operations. The team works with improvement projects daily to involve personnel, develop a problem solving mentality and create ownership for the workers. The CI team supports and the implementation process for the continual improve projects. Improvement projects can include developing/updating working procedures and training materials, coordinating the required staff for improvement implementations and auditing the implemented processes throughout the company.

In order to translate the organization strategy into a clear plan where actions and priorities are available and clear for everyone the firms creates and updates a master plan strategy. The master plan process strategy is established to involve all plant divisions in order to have common strategies and goals. The master plan is used to help link the organization's strategy to the production goals, key priorities and future plans for the firm. The plan for these performance meetings is to have an overall picture of the current situation and establish corrective actions. The firm has periodical meetings during a shift handover, as well as on a daily, weekly, monthly and quarterly basis.

According to the CI team the meetings have been a good tool to communicate the performance management, continuous improvement projects, identify problems, keep the knowledge in the organization, ensure routine, let everyone been committed, gather quantitative and qualitative data and increase communication at the company. The meetings are usually held within the Kaizen room, which is located in the production floor area. CI, 5S and other types of meeting are conducted within this room. All workers have access to the room, which contains a number of different white boards for visualization of short and long-term goals. The white boards are divided into a number of categories: KPI's long-term, KPI's short-term, short and long-term action plans, ongoing problem solving initiatives both long and short-term (A3) and 5S. The staff and the personnel also have information on the shop floor regarding the firm's performance during the observation period (measure boards): biggest losses analysis (Measure and Analysis boards) and actions to solve the problems (Actions and A3 boards).

Insualtion AB's leadership consists of managers and production supervisors. These leaders are in charge of communicating the organization's goals, vision and the production targets for the week. The continual Improvement team is in charge of motivating and linking Lean tool implementation in the production area. This team also coordinates the 5S internal audits and analyzes all the internal continual improvement projects on the shop floor. The CI team is also in charge of the staff's training in order to ensure that employees follow the instructions and that they have all the necessary tools and knowledge in order to work correctly.

4.3.4 Visual Systems

Visualization is key to provide information for the staff such as KPI's for the production lines, 5S standards, safety areas, shop-floor layout and daily goals for the production. As well as the newly completed pulpet that displays information related to the particular workstation there are also a number of other visual systems at Insulation AB.

Each station at Insulation AB has a monitor with real KPI data that shows the performance per shift. The workers have a daily production schedule that outlines the production for the day. The meeting room shows the current production performance compared to the targets for every shift. The organization has established a color system for the factory layout in order to promote a safer working environment. The system can be seen in Table 4.3.4.

Table 4.3.4 Color system standards for factory layout.

Color	Factory Layout
White	Traffic Lines
Blue	Raw materials, tool carts, spare parts
Green	Finished product for transportation
Yellow	Machines (EU Standard)
Red	Waste, Junk and Scrap
Red/White	Fire fighting equipment

4.3.5 Team Based Problem Solving

Having a standardized problem solving such as A3 and PDCA cycle has helped this firms to find problems root causes and eliminate it. A3 and PDCA problem solving methods are effective to keep the knowledge and teach the workers to do adjustment and fix problems when they arise.

A3 thinking methodology support the PDCA cycle and ensures to keep the knowledge in the organization. The workers plan what they have to do, later they check and implement the modifications. The A3 has increased the internal communication in the firm creating discussing groups that tries to solve an improvement problem.

The A3 layout is used to work in major project and the PDCA is used to solve small day-to-day problems. The CI manager selects the improvement team that will work in these types of projects. A3 enhances working in teams since there is interaction between the sponsor, coach, problem owner and problem solving team.

4.3.6 Maintenance

The maintenance at Insulation AB consists of three main areas: the preventive, project and corrective maintenance. The aim of the maintenance is to sustain and improve the machine’s performance by regular, preventive maintenance. This aims to avoid disturbances in the production lines and identify any problems that will halt the production. The maintenance aims to involve the workers in the maintenance for the machines at each of the production areas. At the same time, training for the workers is key to understand the machine function and for doing the daily maintenance.

5. Discussion

The following section discusses the current state of operations at Insulation AB. The section begins by discussing the type of industry that the company is operating within. This is based on the characteristics outlined by Lyons et al. (2013) of the manufacturing operations (product structure, manufacturing processes and production planning & control).

This is followed by a discussion of the current operational context using the 4V analysis described by Slack and Lewis (2015). Finally an in-depth analysis will be made of the current Lean implementation at Insulation AB.

5.1 Process or assembly manufacturing

All products offered at Insulation AB can be considered solid. They are made up of fibrous compounds from a number of materials that are heated, spun and/or combined in order to produce the final insulation products. The bill of materials is comparatively small when compared with a typical assembled product such as a car or computer. The insulation product is a blended formula rather than an assembled product and has very few raw materials. These characteristics as explained by Lyons et al. (2013) and King (2009) are typical of product structures within the process manufacturing industry.

The manufacturing process at Insulation AB can be considered to be a production that has a variable material grade. This is evident in the quality assurance activities, which are highly focused to target the density and weight of the product to meet customer requirements. The manufacturing process at Insulation AB has very few preceding activity constraints required for production. This allows the processing plan to be highly flexible. For example the production of a car must have many components added as it passes through production (chassis, engine, cab, etc.). At Insulation AB the machines are large, automated and highly flexible allowing small set up changes to produce products with highly varied dimensions to a variety of customers. The manufacturing process is governed by regulatory constraints. A large portion of the production area is regulated by strict health standards. Employees who work in these areas must pass certain health requirements by a registered physician to be deemed approved to work in production. These characteristics are commonly associated with process industry manufacturers (Lyons et al., 2013).

Item tracking & control of products, material yield quality, residual products, equipment cleaning and level of automation are areas within production planning and control which must be considered when evaluating the type of manufacturing industry (Lyons et al., 2013). For all of these areas Insulation AB follows the characteristics of a process industry manufacturer. The item tracking is done in lots rather than single products and the output is measured in cubic meters rather than individual quantities. The material yield quality varies both in output to the customer in the form of finished products and also a varied raw material quality from their suppliers at the beginning of the production process. Within the manufacturing process there are a number of residual products. Some of these residuals are in the form of waste and some are reused in the production. Equipment cleaning is also an area that must be taken into consideration for the production-planning department. The machines have fibrous raw materials and bonding products, which require cleaning to be planned and executed to ensure high reliability of the machinery. Finally, the machines used within production are highly automated requiring highly automated process control, another typical characteristic of a process industry manufacturer (Lyons et al., 2013).

5.2 4V Operational Analysis

The production layout resembles that of a cell layout, as described by Slack et al. (2004). The production is then arranged in either a product layout or process layout within each cell. Product A, C, D and E are all considered high volume. Production of these products follows tasks that are repetitive, systemized and systematic. This a prerequisite for high volume as outlined by Slack and Lewis (2015). The operations follow a pre-determined product flow through the factory, no matter the variant of product that is being produced. Processes, activities and tasks are highly repeatable and can be standardized to develop a best practice through continuous improvement. Product B has not been considered high volume due to the fact that it has significantly less repeatability when compared to the other products (based on volume compared to the other products offered at Insulation AB). However, it is important to note that the unit price is still considered low and tasks can be standardized and documented due to the repetitive nature of production.

The variety for all products manufactured at Insulation AB can be considered to be low. Activities for Products A, B, and C (all considered their own production cells) follow a predetermined flow for all product and product variants and require a setup change within the machinery when there is a product dimension change. This follows a product layout (flow or line layout), whereby the production follows a common predetermined sequence of processes (Slack et al., 2004). The set-up time varies from 15 to 30 minutes (for Product A, B and C) depending on whether the machinery requires a ‘half’ or ‘full’ adjustment. There are dedicated flow of materials, personnel and resources that follow the same pre-determined route for every product. Machinery for Products A, B and C are separated into their own designated production areas. Raw material flows from the inventory warehouse to the designated machines, is processed through highly automated activities and then is packaged and loaded for shipment to the finished goods inventory warehouse to be booked for transport to the customer. For Products D and E (considered its own cell) the activities have been arranged to resemble more of a process layout whereby, resources are moved from one activity to another depending on their needs (Slack et al., 2004). Each product can flow differently through the factory but follows a predetermined and standardized method of working at each station. There are process routines created for working & safety instructions, cleaning & maintenance of the equipment and continuous improvement (which includes 5S standards for the particular area).

The variation of the products at Insulation AB can be considered low to medium, as there is some seasonal variation from products during the period June and July (during the Swedish vacation period in summer). However, the forecast variation is foreseeable allowing for the operations plan to be followed and delivered to the customer, but requires some modification to the production plan and a level of safety stock in some standard products to meet these changes in manufacturing capacity.

The customer involvement required within the operations (visibility) is low. The majority of customers place orders based on catalogued items from a number of prearranged sizes and densities. In some cases, customers may request an item that is not listed as ‘standard’, which may be discussed and then decided whether the order can be met by the production and logistics departments. However, this is rare and uncommon at Insulation AB (but can be accommodated if possible and beneficial for both parties). Lead times range from 2 to 5 days for delivery of products. As described by Slack and Lewis (2015) operational visibility can be described as low in cases where production and consumption can be measured in days. The four V analysis for the product portfolio range at Insulation AB can be seen visually represented in figure 5.2.

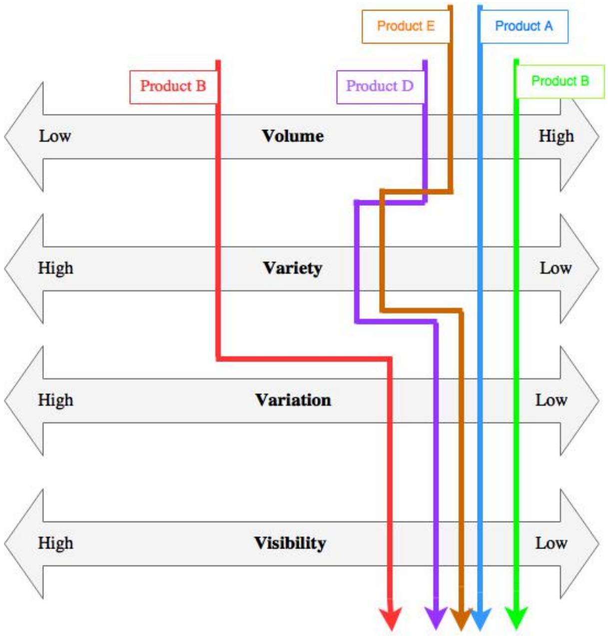

Figure 5.2 Four V Analysis for product portfolio at Insulation AB

5.3 Lean at Insulation AB

The analysis of the data collected for Lean implementation at Insulation AB has been organized in order to follow the different levels of Lean understanding (abstraction) as described by Modig and Åhlström (2016). This has been visualized in a pyramid (figure 5.3) based on the levels of Lean understanding explained by Abdulmalek et al. (2006) and the Lean thinking implementation framework by Lyons et al. (2013).

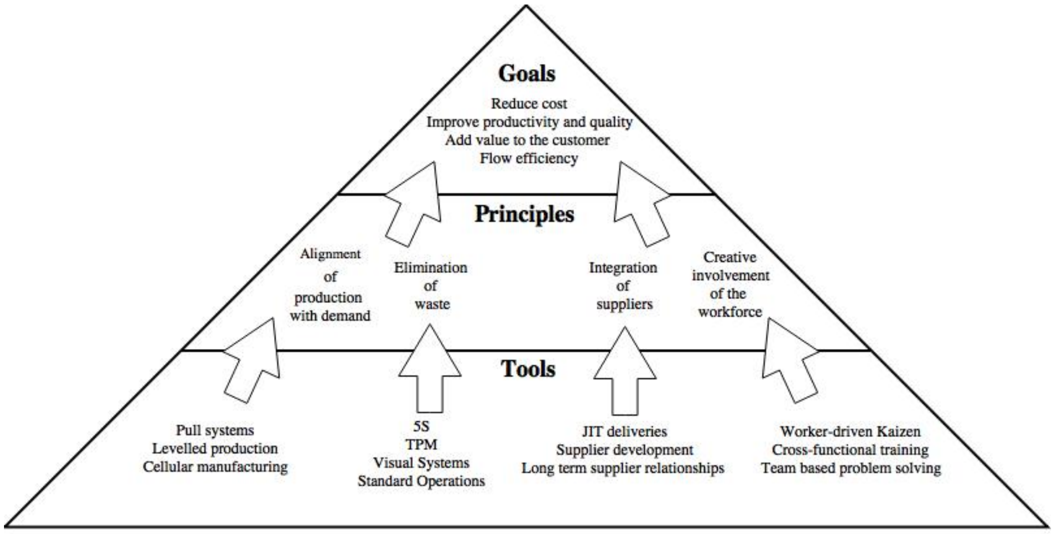

Figure 5.3. Lean implementation. Redrawn image based on Modig and Åhlström (2016), Abdulmalek et al. (2006) and Lyons et al. (2013).

The Lean tools (lowest level of abstraction) used at Insulation AB will be analyzed. These tools include 5S, standardization, visual systems, TPM and team based problem solving. At the principle level (middle level of abstraction) the production and demand alignment, elimination of waste, integration of suppliers and the creative involvement of the workforce will be analyzed.

5.3.1 Lean Tools

As explained by Modig and Åhlström (2015) the tools level of abstraction within Lean is the most commonly understood, as it is tangible and can be physically used and understood within companies. The following section analyzes tool level implementation at Insulation AB.

5S

According to the company's guidelines, 5S is currently considered to be working with an implementation compliance average of 97.67 % for 5S revisions. However, when collecting the data from old 5S revisions, there were varying consistencies within the revision markings. When auditing the same area during different months, the revision could be considered somewhat biased. An example of bias tendencies can be: a production area in November had no mark and in February it had thirteen marks. This tendency is visible in the production and in the office areas. The reviewers and the audit area were randomly selected and followed the same questions but were open to interpretation from the reviewer. There is some evidence here that there was a lack of standardization between the revision team members. Kobayashi, Fisher and Gapp (2008) point out that management promotion, inclusion and training can help the entire company to be aware of correct procedures including conducting revisions that check, sustain and improve the workplace conditions. Xu (2013) agrees that having discipline, a clear implementation plan and following these guides can allow everyone to make revisions in a standard way.

Sort and Straighten were the areas with the most noncompliance marks according to the data. '*Having tools that should not belong to the working area'*, was one area that needed improvement, highlighting that early standardization of what is or is not necessary within these areas needs more attention, in order to be effectively implemented on the shop floor. According to Kobayashi et al. (2008) the Sort, Straighten and Shine areas within 5S need to be implemented closely with cooperation and involvement of the staff at the workstation. These employees are the specialists in their daily working methods & tools and it is critical that they are involved in order to create a safe working environment and enhance process quality and efficiency.

In order to successfully implement 5S in the organization, a reward system has been implemented and shared with the employees. The reward system is a monetary bonus that the workers receive if the revisions are within the performance parameters. Liker and Meier (2006) encourage this method in order to change the behavior of the employees. The authors suggest that the reward system can be tangible such as bonuses or intangible, such as recognition from peers.

Standardization

Insulation AB has created standardization for shop floor routines and tasks based on both general and specific production area information. More standardized documents have been produced that are specific to the operators which control, maintain, clean and service the machines. This is implemented through a multifunctional team consisting of quality, continuous improvement, production leaders and shop floor staff. As explained by Liker and Meier (2006) for continuous improvement to be achieved work tasks need to be standardized with cooperation from shop floor employees in order to create a base for best practice development. To store this specific machine information in one area, Insulation AB has began a project to implement visual workstations known as ‘pulpets’, which has been completed on one machining area (figure 5.3.1).

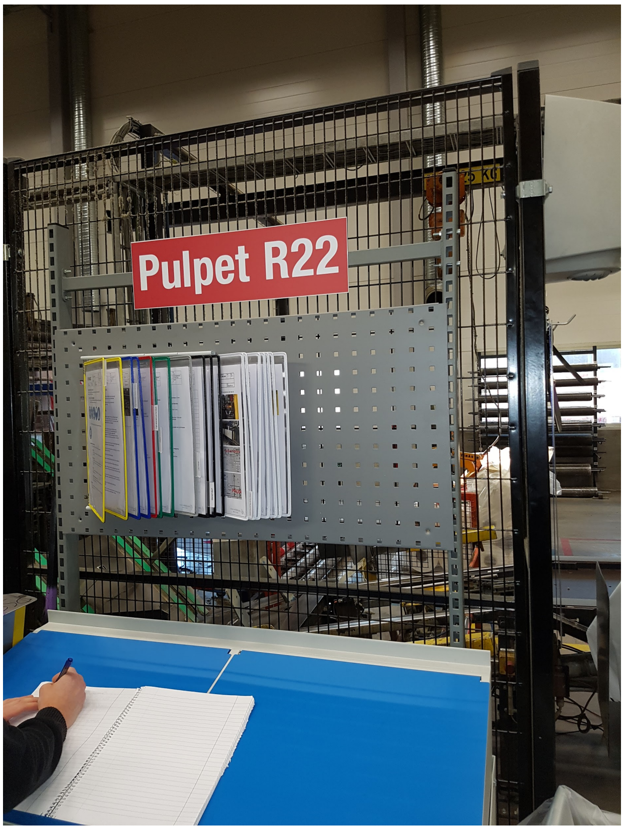

Figure 5.3.1 Pulpet for the first (pilot) production machine area.

The pulpet has a number of documents that follow a color system also adding to the factories visual systems (more on ‘visual systems’ below). The operators can quickly and easily find the necessary documents that are required for instructions in work methods, safety, maintenance, repair and cleaning. These documents also follow a standardized methodology to be approved before being accepted for implementation at the pulpet. Cross-functional teams create documents that follow the Insulation AB Group guidelines, formed on ISO 9001 documentation standards. Before the document is deemed accepted the process owner must approve it. A number of shop floor workers have confirmed the validity and usefulness of the pulpet in the pilot project. The pulpet helps to decrease duplication and excessive document types. White (2003) stated that using color in the document will help develop a logical framework, making it easier to understand for the staff and the supervisor. The authors add that the worker will find the information faster and be more efficient and informed. This prevents the duplication of documents and helps ensure the documents are up-to-date.

Visual systems

In order to create visual systems that support the worker's environment, the insulation company has implemented visual color system for the documents in the pulpet at each major machine (which is an ongoing project) and a visual meeting area – the 'Kaizen' improvement room.

In order to increase safety and promote order in the factory, the factory floor has been marked with lines and areas with a number of different symbols and guides. The visual guidelines have included marking pedestrian and traffic lines (forklift and transport vehicles), raw material, finished goods areas and locations marked for specific tools and machinery. King (2009) explains that having a visual factory layout decreases accidents and improves teamwork. Also, it gives the worker a sense of belonging and supports the small improvement mentality. The workers at Insulation AB are now responsible for maintaining these areas and markings.

To have a visual system that supports the shop floor, the organization has created a Kaizen room located within the production facilities. The Kaizen room has different types of information posted on boards, which include KPI's, overall equipment efficiency (OEE), daily production target, Ishikawa diagrams, A3, PDCA cycles and 5S revisions. However, the information channel is repetitive and sometimes not up-to-date which creates some confusion. Kobayashi et al. (2008) explain that the information should be focused to answer the 5W's and 1H (What, Where, Why, Who, When and How). This will steer companies to focus on communicating what is essential for the daily work and maintain production performance.

The daily production schedule is also presented as a visual document for the employees. This helps to plan the daily operations effectively. The operators have a production plan where they can see production targets in advance at each of the production areas. According to Pool et al. (2011) having recurrent schedules benefits both the operators and the planners. This helps coordinate the production with a fixed plan and decreases or avoids set-up times and production costs.

Total Productive Maintenance (TPM)

Insulation AB has divided the maintenance into three main areas; preventive, project and corrective maintenance. The preventive maintenance aims to work with scheduled maintenance per machine and production area. This type of maintenance allows the firms to avoid downtime that it is not planned, optimizing the performance and working time in the production. The preventive maintenance schedules involve calibration, cleaning, safety inspection, lubrication of the machines and planned overhaul. The preventive maintenance is conducted by the machine's operators, the maintenance department and sometimes when required, external (outsourced) maintenance. Baluch et al. (2012) explain that TPM is a long-term and complicated system to implement. The authors add that TPM can decrease the downtime in production and increase production efficiency. Ahmed et al. (2005) suggest that organizations that implement TPM can improve in their overall efficiency and effectiveness; decreasing the production downtime, quality defects and improving production.

The organization also works with project-based maintenance. This type of maintenance aims at optimizing the working efficiency by planning and investing in special projects to improve and meet safety and production parameters. The corrective maintenance represents an efficiency loss for the organization when machine downtime is unplanned. The breakdown can stop the production and are handled by the maintenance department or outsources externally when required. Ahmed et al. (2005) describe that in order to implement TPM successfully it is necessary to link management and operations and break up the controllable and uncontrolled activities in order to optimize scheduling activities.

Some of the interviews showed that the staff does not follow the company described methodology for preventive maintenance. The employees claimed that their lack of knowledge and skills inhibits them to work in a preventive way. In some cases, the maintenance could not be done since machinery do not stop during shift changes. The maintenance schedule is key, since the maintenance department also belongs to one of the key suppliers within the Insulation AB Group. The researchers found no record of maintenance being documented by the operators, project maintenance or internal maintenance departments. Shukla and Upadhyaya (2010) state that in order to reduce maintenance costs the involvement of the personnel is key. They add that in order to sustain the TPM implementation training and operators' participation can help to predict and prevent any potential machinery problems. Ahmed et al. (2005) support the necessity of having a living documentation system. The authors add that the documentation system should help to trace the maintenance that has been done, staff training, equipment at each station, control checklist activities and safety & environmental policies.

Team based problem solving

A3 problem solving and the PDCA cycle are used at Insulation AB to guide teams that work on improvement projects. The A3 tool at Insulation AB is used for larger improvement projects. There is not much data that supports the level of frequency that A3 problem solving is being used. However, the staff claims that it is mainly used for the managers and that they are not involved in the selection of the teams. According to Liker and Meier (2006), A3 is a communication tool that requires agreement for achieving the improvement. Mohd et al. (2013) point out the importance of having a cross-functional team to gain a better description of the root causes of the problem.

The PDCA cycle at Insulation AB is used for small projects. The employees use the PDCA cycle for improvement in their working area. Small improvement such as changing a tool for the machines and buying new tools that are required for making the product are very common projects within this improvement cycle. Liker and Meier (2006) suggest that the PDCA can be used for short and long-term problem solving countermeasures.

5.3.2 Lean Principles

Lean thinking implementation framework by Lyons et al. (2013) highlights four important Lean principles; alignment of production and demand, elimination of waste, integration of suppliers and creative involvement of the workforce. The following section analyzes these areas of implementation at Insulation AB.

Production and demand alignment

To suffice the condition of a pull system there must be an agreement between two parties (workstations, activities or processes) for the volume, mix and delivery of products or parts (Liker and Meier, 2006). Currently, Insulation AB has no physical pull system within the production facility. Products are produced according to specific customer order signals from within the planning department that are sent to the production floor. Products A, C, D and E, which have much higher production volumes, has resulted in Insulation AB keeping safety stock on hand to meet changes in customer ordering demands.

Elimination of waste

Finding, evaluating and removing waste in the operations is crucial within Lean. According to Tapping (2007) processes consist of three elements: supplementary work, concrete work and waste. The supplementary work is the type of work that is required to be done in order to support the operations such as putting the product on the conveyor or packing and checking a customer report or order. Concrete work is related to the operations task, which adds value and creates goods or services. Waste is all unnecessary activity that does not add value to the product or service.

No type of buffer has been observed in the line production operations (due to the highly automatized production) and there is not a physical Kanban system but rather an electronic system controlled by the planning staff. This type of industrial product differs to that of an assembled product as discussed earlier. The work is very standardized and the transportation system and automated production allow the operators to work on parallel tasks (loading and unloading the product and preparing packaging and transportation) while waiting for the production of products. Liker and Meier (2006) support the waiting time being used to work on other types of activities.

In order to avoid excessive transportation, the insulation company has implemented a conveyor system that allows sending pallets of products to a specific pick-up station in the warehouse. This has decreased the use of forklifts at the end of the process. However, the forklifts are used in the beginning of the operations by moving raw material from their storage area to each station in the production line. Welo and Ringen (2016) explain that firms try to avoid transportation by using conveyor belts to transport the product. However add that the transportation will increase if the production is not leveled.

Overprocessing waste has not been detected, since the customer specification and product specification are clear. The process design is very standardized and each process is independent from the others. This allows setting parameters on the machines according to the product specification. Also, this makes quality control on the product easier, by having specific measures and specific parameters. Tapping (2007) explains that in order to work according to customer requirements, the specifications need to be clear to avoid activities of overprocessing above what is required to achieve customer satisfaction.

According to Liker and Meier (2006), overproduction can be easily detected by observation. Products can be lined up and stored in areas where they do not belong. There are piles of pallets in the warehouse and the surrounding areas at Insulation AB (warehousing inventory data could not be obtained within this study). In order to avoid and control the inventory, the managers and the planning department are currently working on a buffer based on safety stock level calculations. Tapping (2007) suggests that analyzing the customer demand and using a pull system to control the inventory turnover can control the inventory.

In order to have the correct tools and information at each workstation, the firm has implemented the 5S tool and the first workstation information system (pulpet). This aims to eliminate waste (movement and waiting time) searching for tools and walking to retrieve them in order to work. Tapping (2007) describes the importance of having a 5S program and cross-functional training in order to avoid unnecessary movement for the employees while working at their stations.

Liker and Meier (2006) stated that in a Lean environment the operator needs to perform tasks correctly the first time. Rework and quality issues should be checked and identified closer to the beginning of the production of the product. If they are not checked then, it is expensive for the organization to detect failures in the product at the end of the production line. At Insulation AB, the rework and corrections are detected at the end of the process when the product has passed through the production line. The quality complaints document is very simplified and lacks direct connection with the management and management communication system. Also, there is little traceability and quality assurance when a defect has occurred. The only indication is that a complaint document is created and sent to the supplier who takes out the product batch to the laboratory for analysis. Few follow-up indications or documents are available to analyze for how much the product or batch has been defective. Tapping (2007) explains the importance of having a defective rate, a master plan for quality assurance and analyzing the reason for defectiveness at the different stations. This would create raw data on production quality levels for analysis and improvement.

Not using staff to their full potential can be considered as a waste (Liker and Meier, 2006; King, 2009). Insulation AB encourages employee rotation in the production area. PDCA's small improvement aims to let workers change their working area and improve tools and procedures that they think can be used or is necessary at the workstation. Also, employees on the shop floor are encouraged to give feedback on improvements within the entire facilities. Monetary benefits are often employed to encourage and motivate staff members to play a larger role in the company's improvement initiatives, such as 5S. Tapping (2007) suggests that the most important asset the organizations have are their employees. The author adds that motivation to share and improve their working areas can help to support the continual improvement mentality in the organization.

Integration of Suppliers

According to Chun Wu (2003), in order to compete in a global market, firms need to create long-term relationships. The organization's relationships must be based on trust throughout the entire supply chain from the supplier to the customer. Linking the supplier, is an important factor for an effective Lean implementation. Liker and Meier (2006) discuss the importance of inspiring and developing Lean capabilities with suppliers and sub suppliers in order to deliver and supply agreed upon levels of quality, deliverability and cost to meet the demand and maintain the competitiveness of product offerings.

Insulation AB has four suppliers that provide the raw material that is necessary to produce the different types of products. Three of the suppliers are part of the Insulation AB Group. Two of these suppliers are located in different cities in Sweden. One of the suppliers is located at the same operating location as Insulation AB. The fourth supplier is located in another country in the European Union. Lee (2015) demonstrated that in order to avoid hindrances in the supplies, reduce the amount of suppliers and cost and decrease distances, firms have started to source suppliers closer to the production facilities. This is also in accordance with the Toyota Production System, which emphasized the importance of close working relationships with common interests (aligned strategically) and located within short geographical distances (Liker and Meier, 2006)

Liker and Meier (2006) recommend seeing suppliers as a part of the production line. This will help to reduce cost and improve processes, products and flow in the production. The communication with the suppliers, at Insulation AB, is generally when there are issues in product quality, traced back to defects from raw materials. When there are quality defects identified, the communication is rich and fluid. Prahinski and Fan (2007) recommend evaluating and working towards a deeper relationship with the suppliers in order to increase production performance, quality and communication.

Creative involvement of the workforce

In order to involve the workforce, Insulation AB has taken the first steps to develop a quality management system. This system aims to link and control the information flow between the managers and the production staff. Each production station needs to be analyzed in order to establish the types of documents that are required to run, measure and maintain the production at each station. Employee involvement has been suggested to be crucial due to their experience, skills and knowledge within production. Chay et al. (2015) explain the importance of involving the shop floor staff and supervisors in any continual improvement activity in order to understand the current condition to achieve the desired future state. The insulation company's continual improvement team is a cross-functional team that works very closely to the production floor. The implementation of the pulpet has involved the operators and let them work on their own station’s documents. This has allowed specialized sorting of the information and documents that are required from the operator’s perspective.

The improvement projects (A3 and PDCA) have also been used to involve the employees in order to improve their working areas and environment. The 5S revisions have been designed to rotate the staff and create cross-functionality in order to review the working areas in the company. Insulation AB holds educational workshops for information regarding improvement initiatives and company targets and goals led by the different functional leaders. The workshops aim at sharing information of how each function is operates to within the organization. The production workers are present the entire day and have the opportunity to learn how the organizational functions work, their goals and encouraged to give feedback in order to promote staff involvement. Longoni and Cagliano (2015) point out that in order to sustain and integrate Lean, the organization needs to work with vertical and horizontal alignment. Firms need to align the community (social) and eco-friendly goals with the operational goals. Likewise, cross-functionality will sustain managerial decisions and operational involvement and awareness.

The continuous improvement (CI) team works towards improving internal and external processes at Insulation AB. CI is a cross-functional team that focuses on implementation, support, follow-up and feedback in regards to performance management, visual systems, autonomous maintenance and systematic problem solving. CI also ensures that the continual improvement methodologies are implemented within the organization. CI focuses on production efficiency and is the owner of both small and large projects. Imai (1991) point out that in order to succeed towards Kaizen (change improvement), organizations need to focus identifying, reducing or eliminating waste in processes for continual improvement. Martin and Osterling (2007) state that Kaizen events help to change culture within organizations. The authors add that having a cross-functional team and implementing tools ensures a doing and learning mentality. The CI manager makes the decisions regarding improvement tool implementation, strategy objectives and timeline for the projects. The manager also looks after the safety and working environments. The continual improvement manager has also created a cross-functional team in order to link implementation on the shop floor. Imai (1991) agrees that managers are key to guiding the improvement projects. Managers need to support and lead the change towards the implementation. Martin and Osterling (2007) describe the importance of cross-functional teams and the roles these teams play within projects such as coordinators, facilitators, leaders, sponsors and champions. Hirano (1995) claim that tool and principles implementation requires managerial control and cross-functional team support.

5.4 Aggregate view of the Lean implementation at Insulation AB

Building the foundations for operational improvements has been a priority at Insulation AB. This has led to the selection of tools that the company has decided are beneficial and appropriate for their operations. The company has tailored tools that allow them to create a safe production environment by utilizing visual systems and standardization for their situation. 5S, visual systems and standardization have been found to be universally adaptable within both the assembly and process manufacturing industries (Abdulmalek et al., 2006).

Insulation AB have been using a color system to mark different areas and activities on the shop floor, which has helped identify and separate the three main production areas. Combining the idea of visual systems into the pulpet has been a way to control the information and documents, develop cross-functional teamwork and improve the operator's working conditions, whilst improving waste reduction. This has steered the company to focus on the elimination of waste principle as their lean implementation path (figure 5.4). According to Lyons et al. (2013) this is a typical implementation path followed by companies that operate within the process manufacturing industry. The *elimination of waste* principle, has allowed Insulation AB to focus on the shop floor processes to identify and analyze the activities that add value to the customer and those which do not. 5S has been implemented and refined to keep the operator from having unnecessary movement and waiting time on the shop floor. The pulpet contains information to avoid waiting for instructions, offers guidance as a training tool and contains all the necessary information needed for the operator's day-to-day activities. As explained by Ballé et al. (2015) building a culture of improvement (in this case waste elimination) throughout the entire company is a superior strategy when compared to those that focus on cost improvements initiatives.

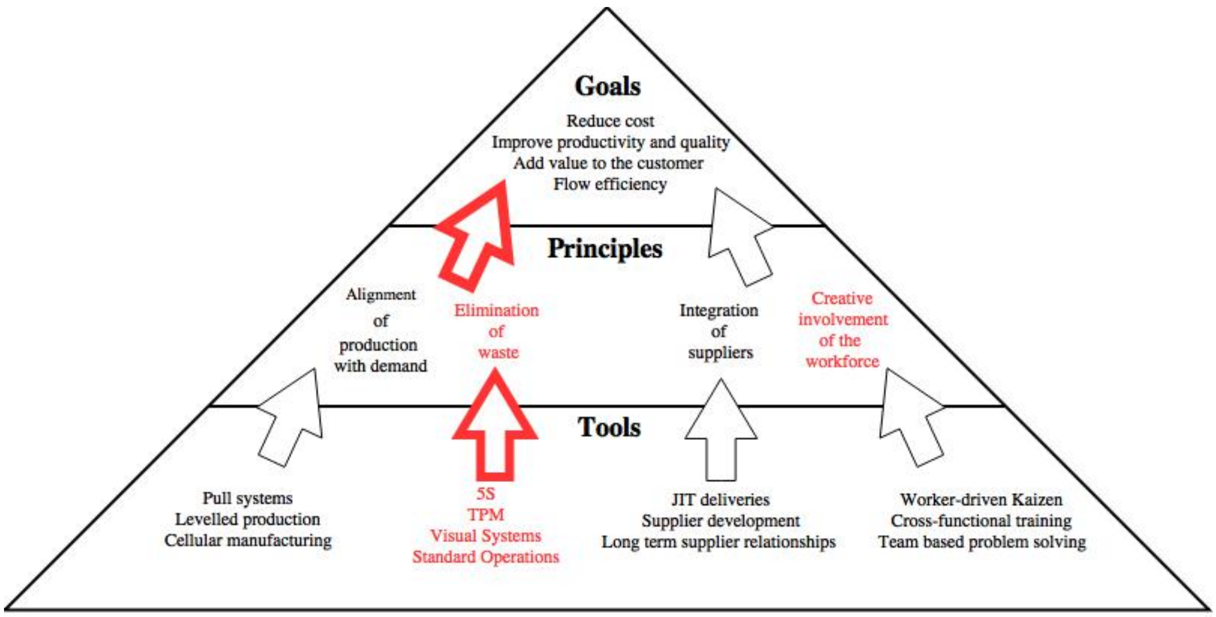

Figure 5.4. The current Lean implementation path at Insulation AB.

For Insulation AB the personnel are key in contributing to and developing improved ways of working. The management aim to educate all levels of the company of the importance of lean tools, but there lacks a genuine connection between the shop floor staff and management to implement the lean principle *creative involvement of the workforce*. Liker and Meier (2006) and Modig and Åhlström (2016) explain that the workforce must understand not only the tools that are implemented but also the reason (the why) behind the implementation. The leadership has been the coordination link for implementing and rewiring the 5S implementation. The CI leadership has implemented standardization and visualization, as this is key to implement, coordinate and support the necessary information that should be available at each workstation. Also, the CI leadership analyzes the necessary TPM information required for the different operations and follows and ensures the team-based problem solving projects are executed. Lean leadership is responsible for implementing, coordinating and following up implementations (Liker and Meier, 2006).

The principles *alignment of production and demand* and *integration of the suppliers* are the weakest implemented at Insulation AB. *Alignment of production and demand* is one of the most difficult Lean principles to implement within process industry manufacturers, according to Abdulmalek et al. (2006). This makes JIT deliveries difficult to accomplish. *Creative involvement of the workforce* has the most potential for improving Lean implementation at Insulation AB and will be discussed in the section below.

5.5 Improving Insulation AB Lean implementation

Insulation AB has been implementing generic (both process and assembly manufacturing relevant) Lean tools based on the principle of waste reduction. So far this has proved successful but going forward it will be important to customize the implementation of tools that are relevant for the company's own situation. Applying the same tools copied from other companies is not ideal, as they must align with the goals and values of the organization (Liker and Meier, 2006). This means that having clear goals for the Lean implementation will help to align the company and develop the road map to achieve it. Further, communicating this goal throughout the company will require top-down dialogue from the leadership (Cole, 2009) and feedback from the production facilities. Lean tools can help give order and structure but if the direction is lacking then a gap in the knowledge between the leadership and rest of the workforce could be created.

In order to improve operations at Insulation AB it is necessary to observe the processes, as was done during the completion of the proposed iQMS. Observation will help to understand and see possible connections within processes. The CI team has focused on implementing and controlling the tools in production. The production managers, supervisors and personnel are key to drive the implementation on the shop floor. The CI team is working on implementing lean tools within the facilities. Not identifying the key players that support, control and check the implementation and give feedback and improvement suggestion is something that can obstruct the lean tools implementation at Insulation AB. Involving a production supervisor or manager in the CI team will increase the knowledge of what it is required on the shop floor. Likewise, it will strengthen the implementation and will increase feedback if something is not working.

The CI team is the only cross-functional team at Insulation AB. However, there are three different production areas where the production layout differs. Having a cross-functional team in production will help to understand and incorporate the workers to analyze and share knowledge from the shop floor. Some staff rotates and has knowledge about two types of operations and their input can give information that can be beneficial for the company. Also cross-functional teamwork will allow the sharing and saving of knowledge that drive internal production improvement projects. According to Modig and Åhlström (2016), cross functionality helps the staff and the organization to gather the necessary information, increase collaboration and work in a dynamic improvement environment.

Insulation AB is focusing on creating value for the customer through elimination of waste. In order to maximize value, other Lean principles should be implemented to gain the full benefits of Lean. One of the advantages that Insulation AB has is that the main supplier is located in very close proximity. The raw material travel distance is short, but communication and synchronizations is not optimized. A major focus for future improvement of the iQMS should be to increase communication between Insulation AB and their suppliers. The company needs to see the suppliers as a part of the production operations and an extension of their own operations.

Insulation AB has implemented Lean by using tools that support the waste elimination principle. The drivers for *elimination of waste* is decreasing cost and identifying the value for the customer, increasing efficiency and effectiveness in the production process in order to meet customer value and increasing quality towards improving customer satisfaction (Bergman and Klefsjö, 2010). Insulation AB has developed a waste elimination culture in order to educate and move the organization towards improved production operations by adding value to the customer by removing non-value adding activities. In order to enjoy the full benefits of Lean, the company must build on the foundation of eliminating waste and implement the other principles for a successful Lean implementation. Åhlström (1998) explains the importance of implementing Lean principles in parallel to achieve the full potential of Lean within organizations. As explained by Lyons et al. (2013), *creative involvement of the workforce* (after *elimination of waste*) is one of the most commonly implemented principles for process manufacturing companies. This is evident already within Insulation AB. The CI team along with the Kaizen meeting room and workshops aim to involve the shop floor workforce. Involving the personnel is one of the main drivers for sustainable Lean implementation (King, 2009; Liker and Meier, 2006). Having cross-functional teams will help to improve and analyze the situation from different perspectives.

The CI team is the only cross-functional team. Currently, there lacks a leader from within the production department that can give important input and feedback about new implementations. In order to develop a Kaizen environment, the personnel from this department need be involved to give feedback, since they have the knowledge of what is really happening and the current status in production. The company motivates the workers to develop skills and be able to rotate between the production areas. However, quality reports and complaints are not available or traceable, making analyzing and identifying problems, trends and possible causes very difficult. Team-based problem handling by the CI team and the interaction with the production requires the company to become more open and transparent.

5.6 Next step implementation at Insulation AB

The managers at Insulation AB have focused on the production operations since it is in production where customer value is affected through the production of waste. To achieve high quality and short lead-times in the process the implementation of other Lean principles is required. Due to the company operating in the process manufacturing industry, it is recommended to begin by further developing the *creative involvement of the workforce* Lean principle. This will require that Insulation AB focus on how to organize their resources, procedures, knowledge and documentation in an efficient way. In order to organize and control the organization and create a strong link between the shop floor operations and the management it is recommended to create a digital quality management system. The system will be used in order to link the management and production to align the implementation of Lean at Insulation AB and strengthen the already existing foundations that have been created through *elimination of waste*. To achieve this, the researchers have created the framework for an interactive quality management system (iQMS). The iQMS was developed based on the cornerstones of Total Quality Management; focus on processes, improve continuously, base decisions on facts, let everyone be committed, focus on customer and committed leadership (Bergman and Klefsjö, 2010). The iQMS is a wed-based system created in SharePoint, within the Insulation Group AB intranet. The system is a framework to store, edit and distribute all documentation associated with the production process. The iQMS aims to help the organization to assign a process owner for the management, support, planning, production and warehouse processes. This will establish responsibilities in the different processes and create stronger involvement of the workforce in decision-making. The process owner will be responsible to approve changes if any requirement is necessary in their own processes (Bergman and Klefsjö, 2010).

According to Modig and Åhlström (2016) flow efficiency is key in a lean environment. Since the operation and production area have expanded recently at Insulation AB, observations were made that information and knowledge of the processes within the production areas was lacking documentation. Following the idea of focusing on processes the researchers started to identify the processes and activities that are repeated over time in order to create value to the customer. In order to have a process it is required to have resources such as equipment, manpower and materials that will be transformed into results such as information, finished goods or any types of services (Bergman and Klefsjö, 2010).

As explained by Bergman and Klefsjö (2010) processes can be categorized as main, support and management processes. In conjunction with the shop floor staff, managers and support staff the main, support and management processes were identified and used as a basis to create the home page of the quality management system (figure 5.6).

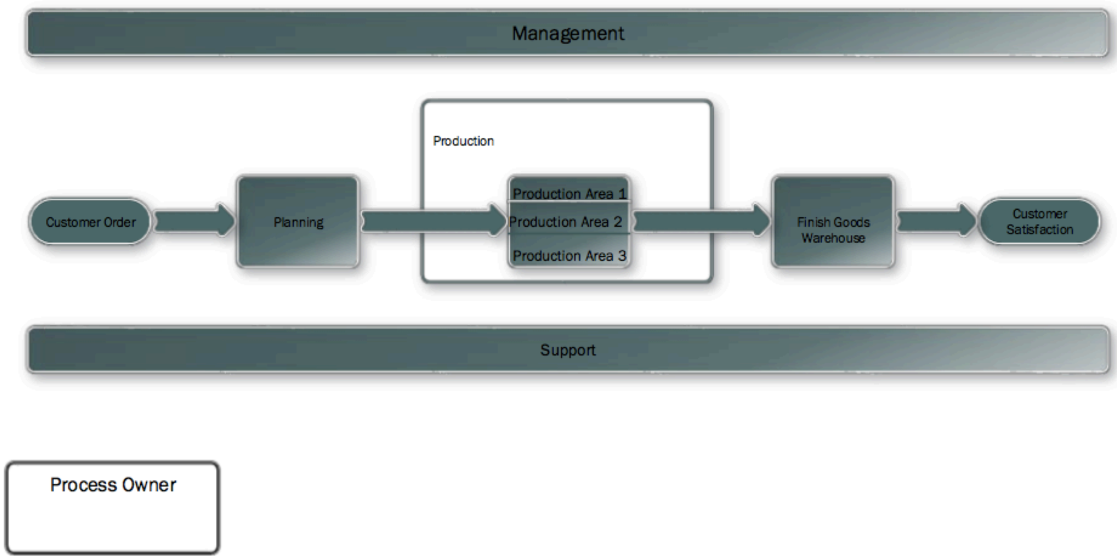

Figure 5.6. Home page for the proposed quality management system at Insulation AB.

At Insulation AB the main processes were identified as: planning (including purchasing), production and distribution (warehousing). The next step was to map the flow in each of these internal departments within the main process.

The planning and purchasing process flow was evaluated (Appendix III) and mapped followed by the production processes. The production area was divided in the three main areas based on product specification types. After organizing the operations that are involved within the production area, each production process flow was mapped at Insulation AB (Appendix IV).

The support processes were then identified and mapped (Appendix V). This area focuses on processes from other resources that are required to support the internal customer connections inside the main process. The support process was divided into two main areas. One area was designated to the local support functions for Insulation AB where the logistics department, continual improvement team, maintenance and quality control was included in order to support the main process of the organization. The second area is designated to the centralized Insulation AB group external support function in order to link the entire group under one management system.

Finally a process map was identified for the management processes (Appendix VI). This area focuses on making strategic decisions. Strategic planning, organizational targets, budgets and audit procedures can be located in this process. Since Insulation AB is a part of a larger group that must also follow centralized company standards it was important to include the environment, safety and health and the organization goals and strategy following the Insulation AB Group standards.

One of the main problems identified was the document handling and storage. The current intranet used for document handling can be unstructured and confusing for users. The documents were sorted and placed in different places within the system. As explained by Singer and Becker (2013) it is ideal to have a document storing system where all documents are stored, edited and updated at the same location, which they refer to as single-source content management (SSCM). The proposed solution for sorting documents within the iQMS follows that of the categories used at the pulpet. This was suggested in order to establish a standard for document sorting throughout the organization for all employee levels within the company.

In order to create an interactive and functional iQMS for Insulation AB, a clickable website was developed within the pre-existing SharePoint intranet in order to visually represent the look and functionality of the future iQMS, the structure can be seen in Appendix VII.

6. Conclusions

The purpose of the research was to understand and identify the current Lean implementation at Insulation AB and evaluate how this company can move forward with their implementation. The research questions will be answered within this section.

RQ1: How is Lean implemented at Insulation AB today?

Currently, Insulation AB have implemented Lean within the company using tools that drive to reduce waste within their processes and build a culture of continuous improvement. Tools such as 5S, standardization and visual systems have been implemented within the production area. Most recently this has lead to the implementation of the pulpet at the pilot workstation to reduce waste and increase education and knowledge within the production area. Implementing these tools has also required the company to begin working cross-functionally. The CI team has laid the foundation for problems to be assessed more collaboratively and bring the voice of the production into the management's decision making at Insulation AB. The implementation of Lean to date has been primarily focused on the *elimination of waste principle* (figure 5.6). This is a typical Lean implementation journey for companies that operate within the process manufacturing industry. These tools have been applied due to their applicability to almost any industry and ability to be implemented within companies beginning their Lean transformations.

RQ 2: What is the next step for improving Lean operations at Insulation AB?

Moving towards "Leaner" operations for Insulation AB requires working in parallel to incorporate the other principles of Lean such as *creative involvement of the workforce* and *integration of the suppliers.* The most potential for implementing the next level of Lean operations at Insulation AB is to improve the *creative involvement of the workforce*. Cross-functional problem solving has already begun and will be essential to improving knowledge transfer within the company. The proposed iQMS can be used to link the strategic message and goals of the management with the shop floor to create feedback and keep knowledge within the company.

RQ3: What possible hindrances could be encountered in taking this next step?
Implementing tools that support Lean principles is an important strategy in building a culture that can adapt to new improved ways of working. To implement the changes discussed above, shop floor workers need to be able to see the advantages of Lean tools in their day-to-day activities. Creative involvement of the workforce is a culture change within the company requiring collaboration of different departments in different levels to solve problems in the best possible way. Communication plays an important part in this Lean principle. Linking the objectives and goals of the management with the everyday activities of the workforce will be a crucial element to further the Lean operations at Insulation AB.

6.1 Managerial Implications

Companies looking to improve their operations must understand their current state of operations to determine the next step of their Lean transformation journeys. It is important for companies to take a step back and take an outside perspective of the operations from a holistic perspective. Analysis from both the operational context (volume, variety, variation and visibility) and type of manufacturing industry has been used in this research to give a clearer understanding of how Insulation AB can take the next step in their Lean implementation.

The Lean implementation path in figure 5.6 has been used in understanding the current state of Lean operations at Insulation AB. The findings are limited to the company in question but are suggested to be applicable to other companies operating within this industrial sector in Sweden. However, it is suggested that more research, such as case studies from a longitudinal perspective where implementation success can be measured, is needed to confirm the validity of the framework used. Also longitudinal research into the implementation success of the iQMS to improve the *creative involvement of the workforce* at Insulation AB should be conducted.

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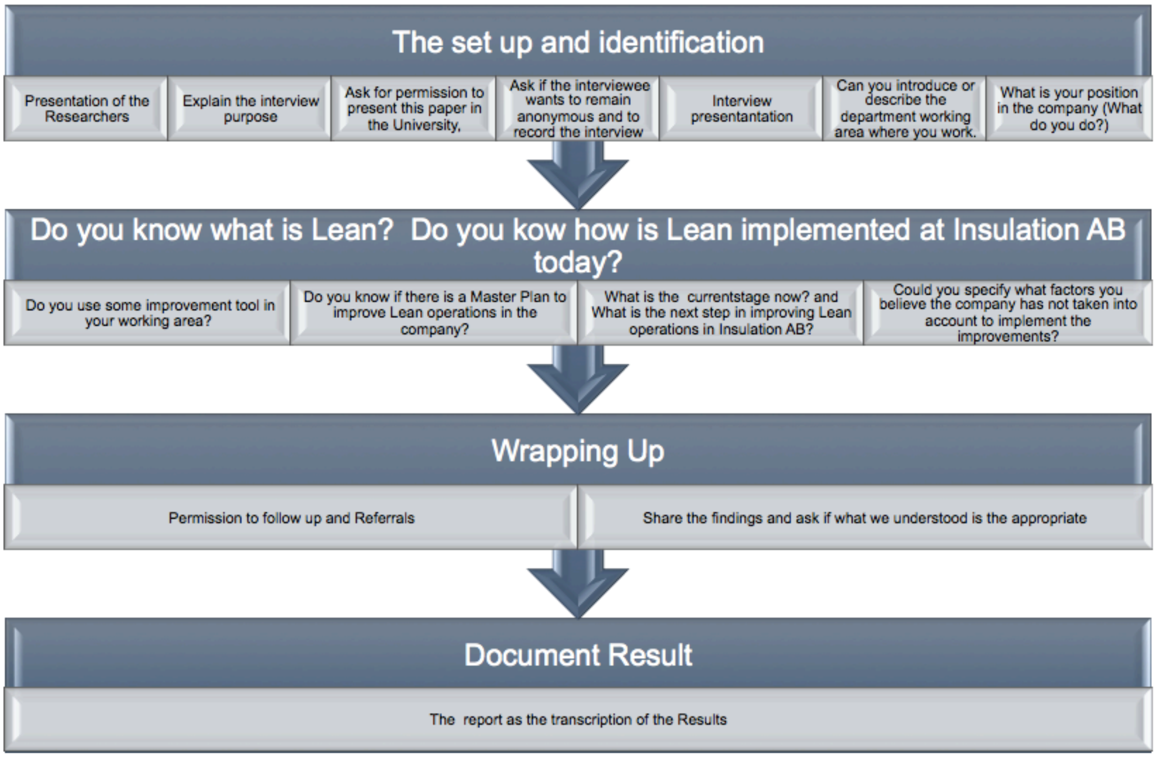
Appendices

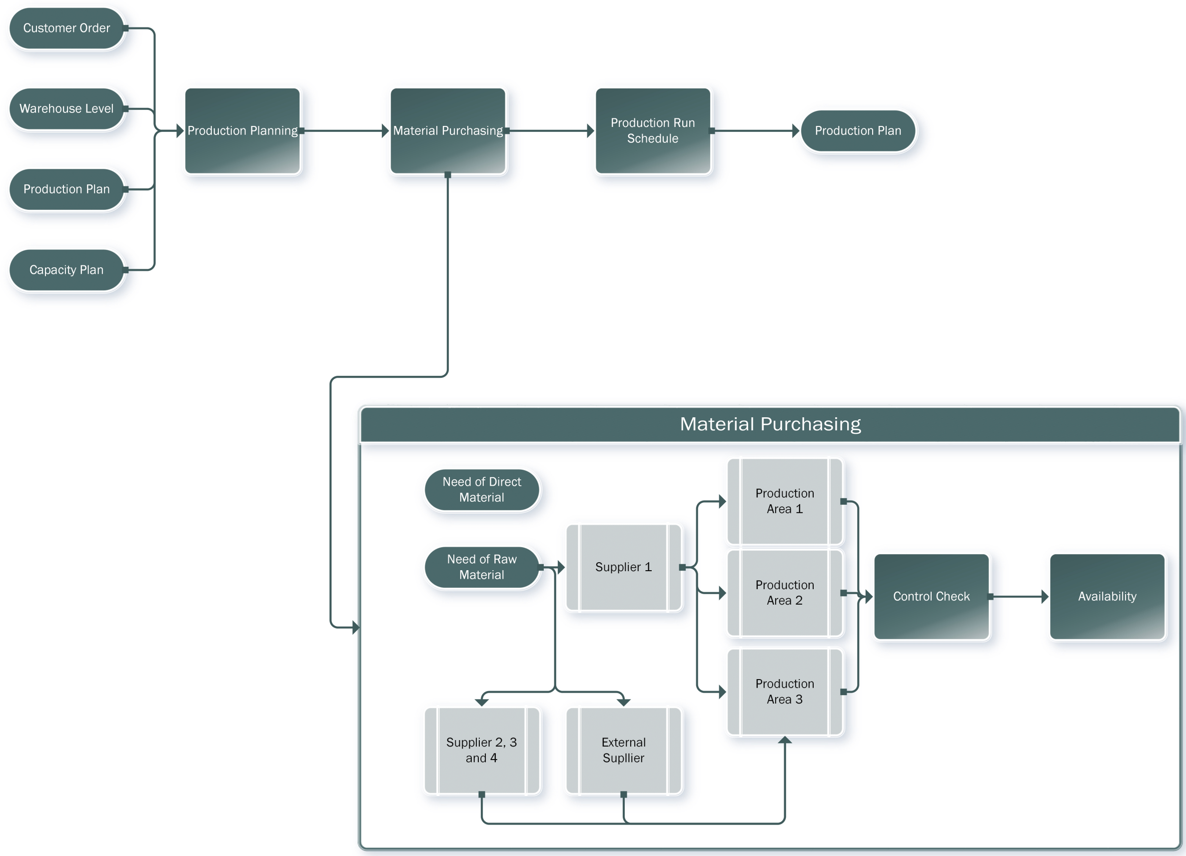
Appendix I – Interview guide for semi-structured interviews



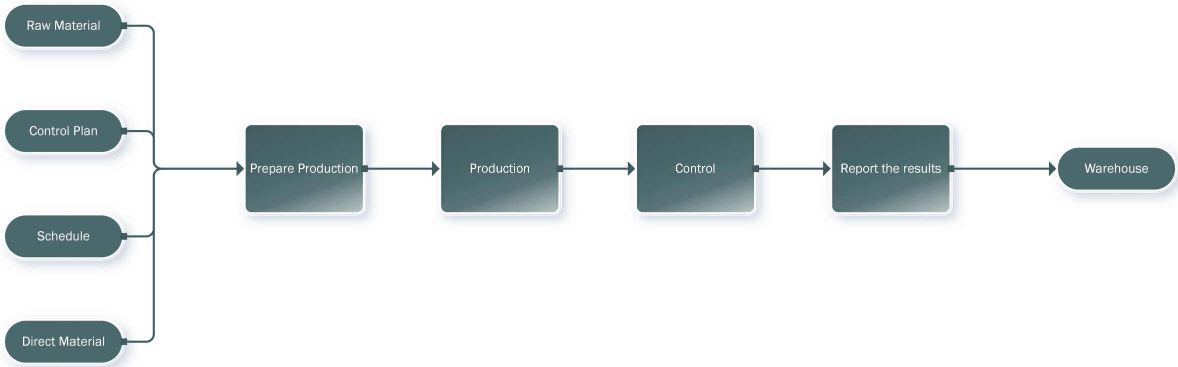
Appendix II – Company site visit workbook

Researchers site visit workbook - Insulation AB				
Month	Date	Time	Hours	Activity
January	13	10AM- 14PM	4	Introduction day
	17	10AM- 14PM	4	Production Plant visit/ First Interview
	19	10AM- 14PM	4	Follow the process in Production/ Second Interview
	23	10AM- 14PM	4	Interview with Continual Improvement Member
	25	10AM- 14PM	4	Interview with Product C Production worker
	26	10AM- 14PM	4	Interview with Product D & E Production worker
	30	10AM- 15PM	5	Operating system visit/ Interviews with Quality Manager
	31	10AM- 15PM	5	Continual Improvement Meeting
February	7	8AM- 15PM	7	Interview with Quality Manager
	8	8AM- 15PM	7	Main Process identification
	9	8AM- 15PM	7	Management Process Flow Mapping
	10	8AM- 15PM	7	Support Process Flow Mapping
	13	8AM- 15PM	7	Planning Process Flow Mapping
	14	8AM- 15PM	7	Production Areas Operations Mapping
	20	8AM- 15PM	7	Warehouse and Sorting Documents by Headlines Mapping
	21	8AM- 15PM	7	First Draft Process Flow Mapping
	24	8AM- 15PM	7	Operations Workshop Day
	28	8AM- 15PM	7	First Draft Meeting With Quality and Capacity Manager
March	1	8AM- 15PM	7	Data collection (product sales, production and planning)
	2	8AM- 15PM	7	Second Draft Process Flow Mapping
	10	8AM- 12PM	4	Purchasing, and Production Operations Flow Mapping
	13	8AM- 15PM	7	5S audits
	15	8AM- 15PM	7	A3 audits
	16	8AM- 15PM	7	Sorting Documents
	17	8AM- 15PM	7	Visual Management color system identification
	20	8AM- 15PM	7	Working on the Operations System Web design
	23	8AM- 15PM	7	Transferring the Visio Documents
	25	10AM- 13PM	3	Acquiring programs to work on the web
	31	8AM- 15PM	7	Acquiring programs to work on the web
April	3	8AM- 15PM	7	Transferring the Flow Processes to share point web design
	5	8AM- 15PM	7	Transferring the Flow Processes to share point web design
	6	8AM- 15PM	7	Transferring the Flow Processes to share point web design
	19	8AM- 15PM	7	Transferring the Flow Processes to share point web design
	20	8AM- 15PM	7	Transferring the Flow Processes to share point web design
	21	11.30AM- 12PM	0,3	Presentation about the New Operational System
	25	12AM- 14PM	2	Meeting about how to Transfer documents in the system
	28	8AM- 15PM	7	Links to central system
May	4	11AM- 12PM	1	Presentation and Thesis Project Closure
Days Total	39	Total Working Hours at Insulation AB	219,3	

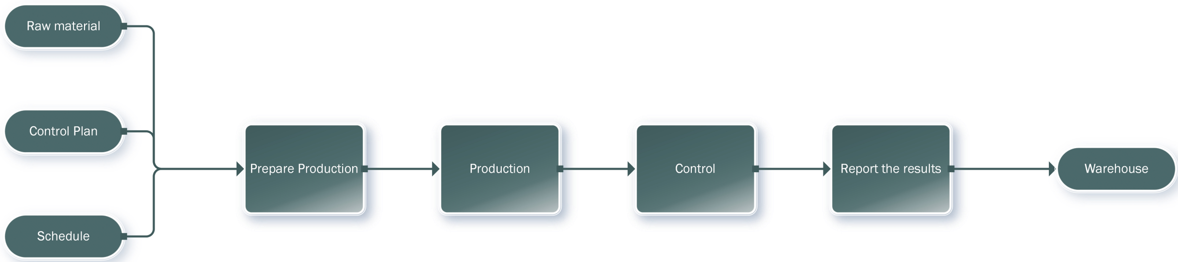
Appendix III – Proposed iQMS Planning process map



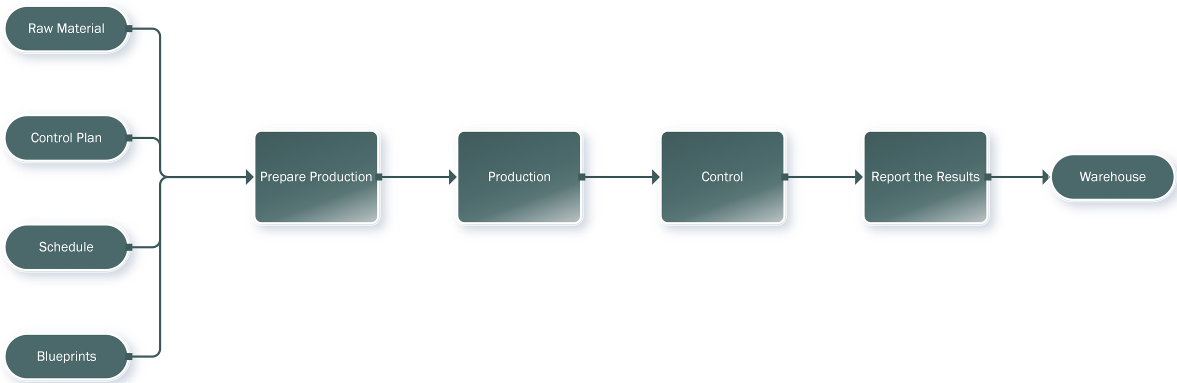
Appendix IV – Proposed iQMS Production process map



Production Area 1

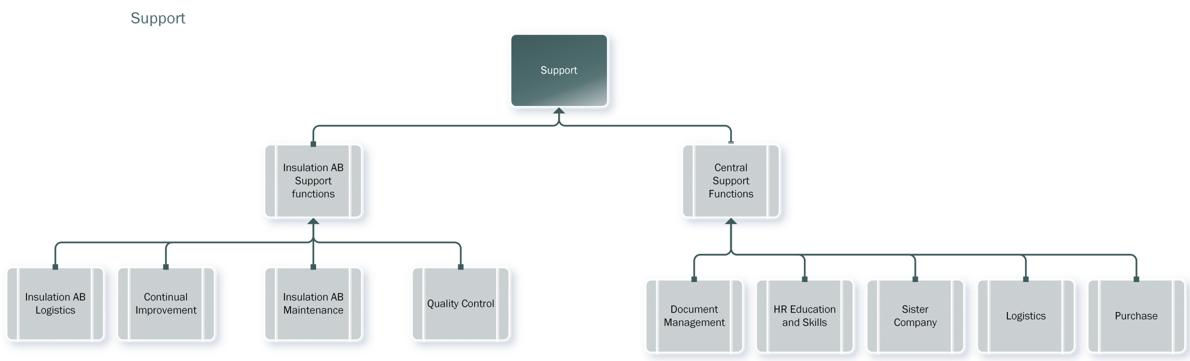


Production Area 2

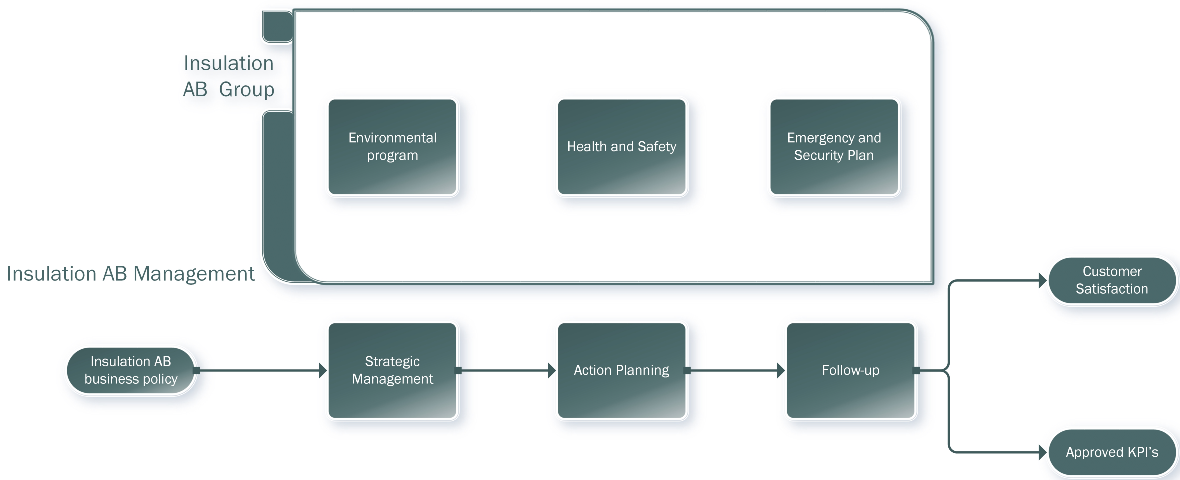


Production Area 3

Appendix V – Proposed iQMS Support process map



Appendix VI - Proposed iQMS Management process map



Appendix VII - Proposed iQMS structure