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Lean Management from reactive leadership to proactive with standardized routines in glass manufacturing

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Abstract

This thesis was commissioned by NSG, Pilkington Automotive Finland Oy. Primary aim was to develop management routines for the three different management layers in the production line management. Lean principles were followed while creating these routines as well as lean six sigma technical tools was in use. Change management played important role in the design and implementation phase. Secondary aim of the thesis was to offer clear model for the lean management change that can be used as guideline to improve operations of other production departments in the company or in any other manufacturing environments altogether.

For the thesis, theory related to the topics that were included in the preliminary plan was studied. This included change management, lean six sigma, observation, and study techniques. After theory studies were conducted to gain more perspective on the current situation. Time usage of the first and second layer of the line management were studied and analyzed. Internal interviews as surveys were done to establish service level of the layer one of the production line management. Then came the development phase guided by the principles of change management. Lean six sigma tools were used with co-operation of the production line management and development personnel. In the implementation phase coaching theme was used with the guidance of the change management theory.

With the team effort and proper use technical tools provided management routines based on current situation. These routines implemented and monitored by documented audits gave transparency and possibility to understand any further development points. Management of the issues became lean, which gave efficiency to direct more resources to proactive side of the activities.

Systematical approach presented in the thesis made possible to develop new routines and justify existing ones. As a conclusion this thesis provides usable model to be used as guideline to improve management from reactive side to proactive side.

Key words
Change management, Lean Six Sigma, Management standard work

CONTENTS

1 INTRODUCTION

Reason for the project is to go from reactive “firefighting” to proactive Lean Management. Where there is routine checks every day to keep aspired level of standard work. This reactive approach seems to be far more popular approach and it is time consuming. Money is already wasted. Resources (leaders in the organization) are not properly aligned to do the work towards company goal. Resource time is going too much into yesterday vs tomorrow.

Goal is to save money and make people have more satisfaction of their work since this type of responsiveness is highly frustrating. Some parts of lean have been implemented in the past but after a while the results are fading. Systems / processes have not been self-sustaining, nor they will ever be. Deterioration starts immediately and only way to stop that is to have iron clad activities which support processes so that level stays above desired level.

Purpose of the thesis is to determine departmental tasks that are important for the company strategy to succeed. Develop standards and systems for surveillance and to implement routine checks that keep the work level above required standards. Figure 1 shows that all the actors are connected straight to standard work in the middle but there is connection as an arrow that represents the idea of routine checks from group leader to team leader and from team leader to first operator. Shop floor standard work determines part of the success in the company and everyone in the operational side should be involved someway.

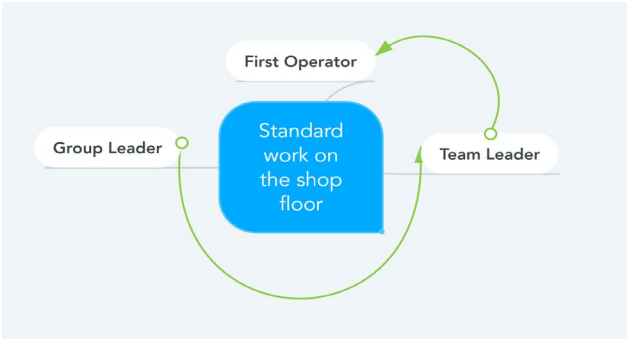

Figure 1. Structure of leadership in relation to standard work

1.1 Boundaries

Project is limited to one production department (shaping), although theory and actual development process produced can and will be implemented to other production departments in Laitila. General process model presented in chapter 2 can be used in other manufacturing processes.

In this project, Group Leader current time allocation will not be studied even though standardized work development phase will undoubtedly bring some changes into daily routines. This project will concentrate on the perspective of the company / departmental yield as part of strategy and will not concentrate on uptime of the furnaces which of course is important aspect for the success of the company. However, yield itself is major factor in productivity altogether so while project is trying to improve yield through management standardization it will have effect on productivity also.

The scope of the thesis on the technical side from the chapter 5.3 onwards will be concentrated on three possibilities to make improvements even though the actual work is done with much wider angle. This is to keep the thesis work within the appropriate length.

1.2 Commissioner

NSG (Nippon Sheet Glass) is one of the world's largest manufacturers of glass and glass products. Manufacturing sectors include architectural glass (Building glass and applications for solar energy), side and windshields for various vehicles in automotive manufacturing (trains, cars and combine harvesters) and technical glass such as thin glass for displays. The company has sales in more than one hundred countries and employs more than 27,000 people. (Website of NSG 2020.)

Figure 2 shows business segments. Company main segments are architectural and automotive and for the last five years automotive has had highest revenue.

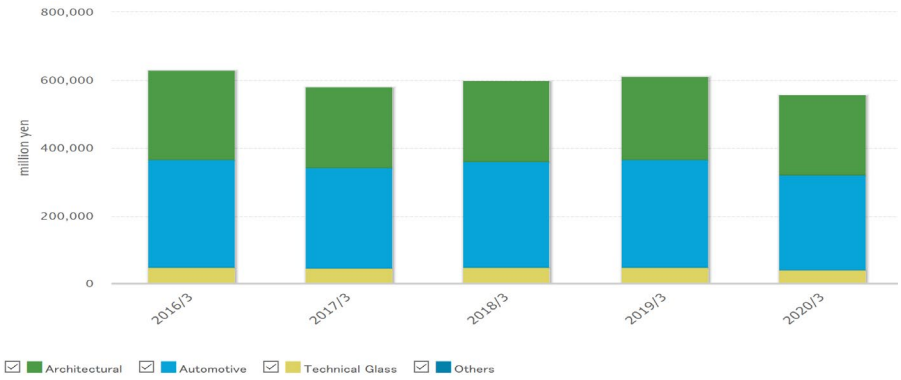

Figure 2. Revenue by business segment (Website of NSG 2020)

At the Finnish level, NSG's operations are divided into three areas: Espoo spare parts sales, in Tampere tempered glass manufacturing and in Laitila laminated windshield manufacturing. In figure 3 yearly turnover in millions for the last four years shows that trend is upwards. 2019 was a good year and has the highest revenue in Finnish operations.

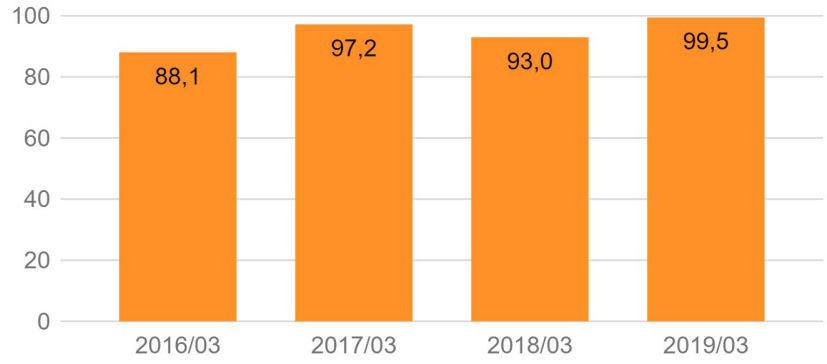

Figure 3. Turnover (M€) of operations in Finland (Website of Finder 2020)

Commissioned work will be done for Laitila manufacturing site. There are approximately 270 persons working there. Current capacity is 150k manufactured windshields. Normally plant operates in 15 to 21 shifts in week. Laitila implements approximately hundred new products every year. Product portfolio contains over 5000 products and active yearly sales over 2000 different products. Biggest customers are in Europe but Laitila site has sales in USA and Asia also. Evobus, MAN, John Deere,

and Case New Holland just to name a few biggest customers. (Website of Pilkington 2020.)

1.3 Production process

Manufacturing site in Laitila is divided into four different departments. Each department has its own purpose of adding value to the product. Production starts from pre-process, then shaping, after that is lamination and ends into final inspection. Short presentation of the all processes and deeper introduction into shaping in this chapter for the reader to be able to understand environment where and with whom the project is being done. Figure 4 shows transformation from raw glass template to processed glass waiting for shaping process.

Figure 4. From endcap to pre-processed glass

Pre-process starts with glass template coming into factory. It is cut into right size and shape. In some models there are holes for the windshield wiper(s). These, if required, are done in this process area. Next step is silk printing where the black band is applied to the processed windscreen. Last step is to apply silica powder between each glass pair to prevent paired glass attaching in the furnacing process.

Some of the requirements for this process:

- Right sized product, according to customer (shaping) specified size
- Edge quality within specifications, no cracks in the edge or scratches
- Black band within specifications, no holes or transparency
- Silica powder, sufficiently and 100% coverage for the glass

Figure 5 shows how the shaping process changes glass. In the figure 10 mold for the shaping process is presented which enables the form change from the flat template to the shaped glass.

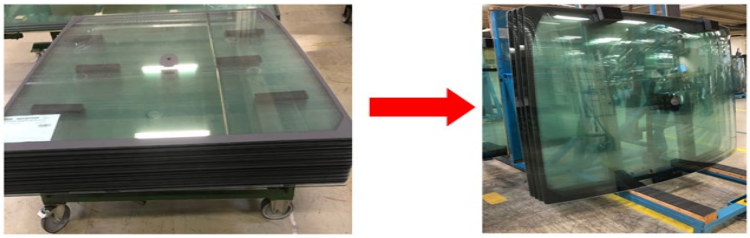

Figure 5. From pre-processed to shaped glass

In the furnacing process pre-processed glass is loaded to the steel mold. Mold is driven into bending furnace where glass is shaped by the heat and gravity (gravity bending).

Some of the requirements for this process:

- Size, according to customer specifications
- Form according to customer specifications, edge form and surface form
- Visual failures according to customer specifications (mold marks etc.)
- Glass pair not attached

In the lamination process shaped glass is processed. Glass pair is separated from each other and silica powder is removed from the inner surfaces. Customer specified PVB (Polyvinyl Butyral resin) interlayer is installed and the pair is joined. Excess trim from the PVB is cut and vacuum ring is installed around the pair as can be seen in figure 6.

Figure 6. From shaped glass to laminated (pre-autoclaved glass)

Some of the requirements for this process:

- Humidity and temperature of the PVB according to specifications
- Clean room conditions to prevent contamination

Before autoclave process glass is vacuumed for a predetermined time to remove excess air from between the glass pair. After the wait time glass pair with the PVB is placed pressure container. With the heat, outside pressure for the glass and vacuum at the start of the process cycle PVB melts and is fastened to glass pair. Within this process PVB is turning from grey to transparent. Windscreen is now achieved laminated safety glass status. Figure 7 has transparent safety glass on the right side.

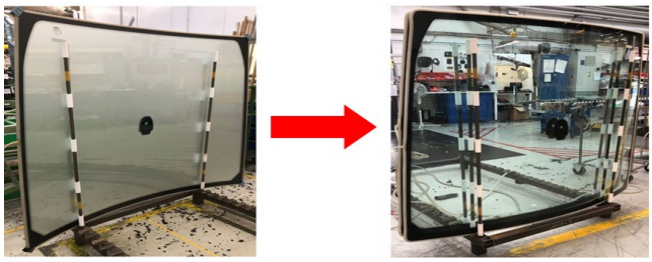

Figure 7. From laminated (pre-autoclaved glass) to autoclaved glass

Some of the requirements for this process:

- Attachment of PVB
- Glass optical properties according to specifications

Final inspection inspects the glass for visual failures. Value-added operations include lane detector bracket, rain sensor bracket installment and edge sealing with sealant. Glasses are packed into wooden crate and shipped to the customer. Figure 8 has wooden packing crate which sizes vary depending on the product it is used.

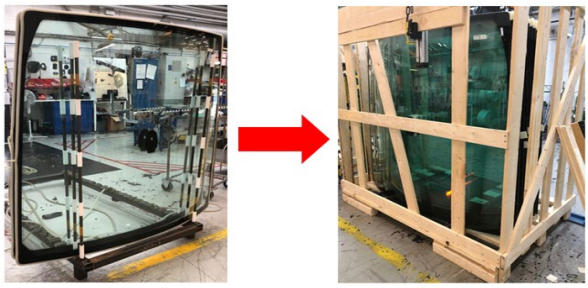

Figure 8. From autoclaved glass to inspected, value-added and packed glass

Some of the requirements for this process:

- Glass optical properties according to specifications
- Visual failures according to specifications

1.3.1 Shaping process

Figure 9 shows “Top Hat” bending furnace. This model has two wagons and electrical heating system. Wagon is moved to under chamber and moved up. Actual shaping can be monitored from the windows and controlled with the side panels. One wagon in the furnace and other can be prepared for the next cycle which is more cost-efficient energy wise and in terms of productivity.

Figure 9. Bus windshield glass bending furnace (Website of Tradekorea 2020)

Shaping process can be divided into three categories. Preparatory work, furnacing phase and finishing actions. Preparatory work contains glass checking before loading, checking the bending mold and the bending furnace setup. Furnacing phase starts from loading the glass into the bending tool (mold). Mold is driven into the heating chamber. Preheating stage begins after loading and stops when phase for shaping of the glass starts and after there is cooling cycle where tensile stress and compression is formed. Finishing actions phase starts with unloading the glass from the bending tool then there are measurements and making glass ready for the next phase. Figure 10 shows typical structure of steel mold. (Karisola 2008.)

Figure 10. Shaped glass on a bending mold (Karisola 2016)

Mold has fixed center and movable sides. Sides will start moving when the glass becomes elastic from the heating effect and amount of weight determines timing and speed for the movement. (Karisola 2016.)

1.3.2 Performance indicators in shaping department

Since production is planned for the daily and weekly pieces manufactured then the most important thing is to keep that plan. If weekly pieces are under planned level, then it can create delays for the customer shipments which is unwanted.

Production quality as in each department / line needs to be measured as in good pieces vs scrapped pieces (Yield) to make sure that we can place corrective actions in the

right places. Quality improvements are easiest way to improve cost efficiency and for this project this is the metric to be used.

Cost efficiency measured as man minutes against manufactured piece. This metric of course takes into consideration the good pieces and yield as in how much was scrapped against how many persons / hours were in the cost point in selected period.

These three metrics are equally important and for example productivity which is measured against actual hours, could be in a good level but still as outcome there is insufficient number of pieces due to high absenteeism rate.

1.4 Leadership structure and stakeholders

Blue box in figure 11 represents leadership structure in production. Production department has Team Leader and First Operator. This structure is similar in all production departments. Outside the box are the departmental contact points (stakeholders).

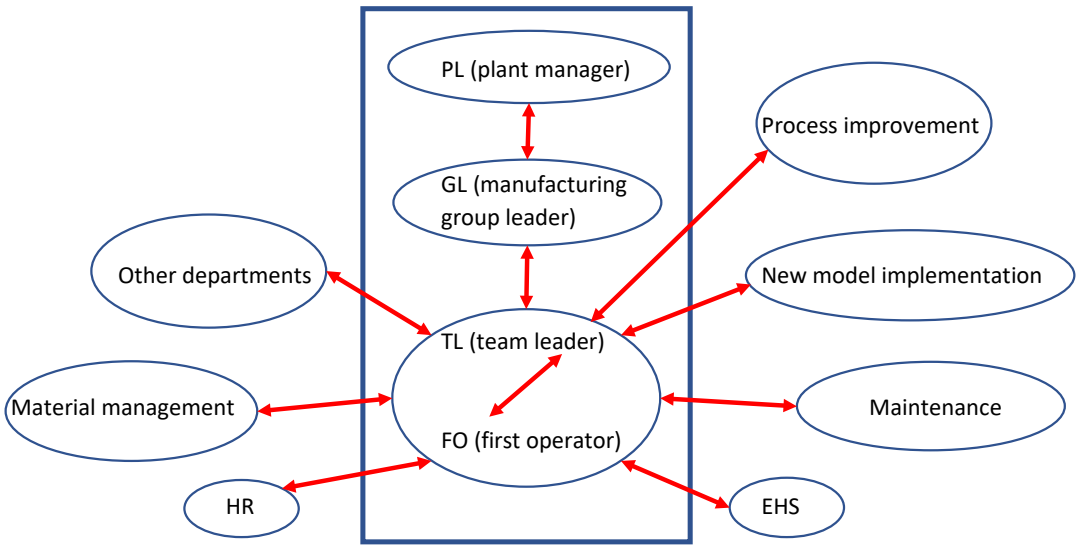

Figure 11. Visualization of the leadership structure and stakeholders

1.4.1 First Operator in the shaping department

First Operator (FO) is experienced operator which is working shift work. FO is the main point of contact in the evening or in the night shift in case of absenteeism and quality issues. Safety notifications, if something happens during the shift FO has obligation to report accordingly and make sure that all the work done is according to safety regulations. Maintenance requests for the breakdown of the machinery is done by the FO and if any material shortages in the shop floor then FO will retrieve more materials from central storage. However mainly FO is operating as one of the production operators and operating bending furnaces.

1.4.2 Team Leader

Team Leader is working day shift and is responsible of the key results in the department as well as well being of the workers in the area. Personnel deployment planning and daily issues are the main focuses. During the day shift same tasks apply as in previous chapter 1.3.1 mentioned tasks for the First Operator.

1.5 Research question and sub-questions

Main question as a research question is *What should be standard work in the production for the leading personnel in different levels?* In this project this is the question to be answered to achieve the goal. There are several sub-questions that needs to be answered in conjunction with the main question.

- Where is the management putting their time?
- Is it reactive or proactive?
- And how are we able to define standard work as in terms of management actions?
- How we can monitor those agreed standard routines?
- Implementation of the routines, how and when?
- Are we sure that we have right routines?

Bottom line is that this type of change that involves people and has monetary effect for the company, so we really need to understand that we acquired desired change for better and if we didn't then we need to evaluate our process again.

2 CONTENT OF THE RESEARCH

Generic improvement model presented in figure 12 is showing the process to be used in this thesis work. This model can be implemented to different surroundings and into various processes. Critical point is that improvement as itself is ongoing never-ending cycle. There is always room for improvement and money to be saved, so any process in question needs to be evaluated periodically. Period depends on the process in question since some processes are more prone to failures, so the chosen period needs to be shorter. Key features of the model are to understand current situation and to be able to define desired goals and what tools are chosen for the development phase. After comes the evaluation which is the important part since that is the only way to define if the work done was successful or failure.

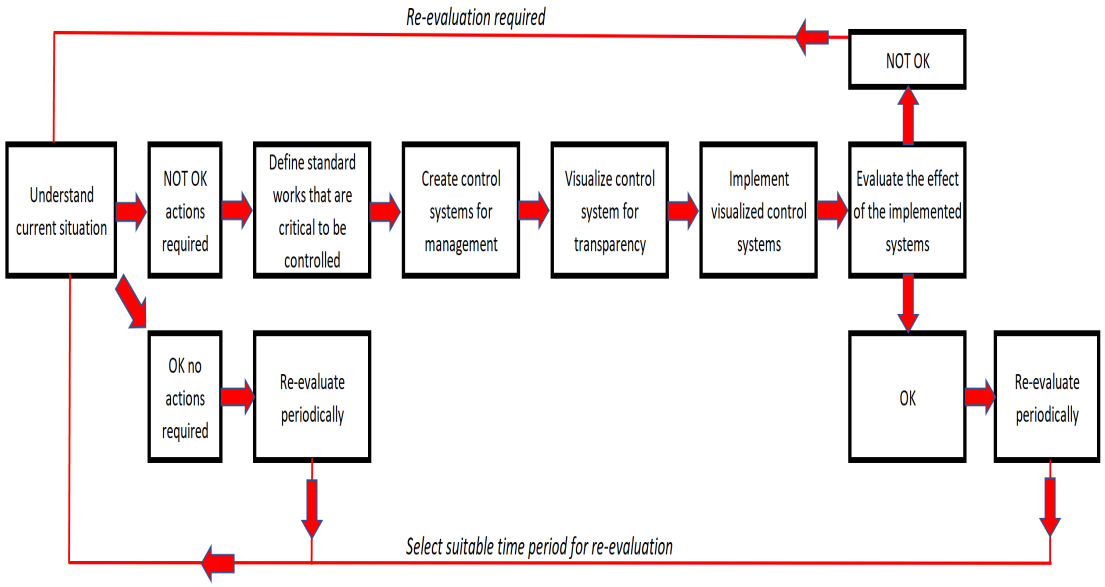

Figure 12. Process chart for continuous improvement cycle used in the thesis work

2.1 Research approach

Empiric qualitative and quantitative research approach is applied. All the data collected is quantified if possible. In the interview section questions are answered so that it will give numerical value as well as all the audits. This makes it easier to make

comparison before and after. In the study and development phase all the people involved can have influence on the outcome and this will make resistance to change and new concepts little bit less than if they have no say in the matters. This can be arranged because author also has worked in the department in question and all the participants are familiar persons. Also, it is possible when the practical part starts to have daily meetings with the persons involved and have because of that better communication. Practical part will be team effort from start to finish as it should be in any lean project. In the implementation phase discussion back and forth is crucial and if there is a need to change already adhered task it will be result of team decision.

2.2 Data collection

Data is collected from several different sources.

1. Personnel questionnaires (interviews) and experienced colleagues
2. Personnel time studies (worktime diary)
3. Enterprise resource planning data (selected KPI's for the thesis)
4. Internal auditing (selected targets)

2.3 Research methods

Several interviews will be conducted by the author to have a softer feel how the shaping department and its actor's actions are perceived in the surrounding departments. Time studies as in work time diary are done for the departmental leadership personnel to gain factual understanding of the time use and from the gathered data analyse how big of a portion is in reactive and how much time is used in proactive activities. Enterprise resource planning system (SAP) contains production data which will be used via Tableau software to analyse and present process data. Internet via google is used for the additional bits of content for the thesis and library services and books is for the factual theory part. Predetermined internal audits with third party auditor to make sure that evaluation of the work is impartial. Group work within in the study and development phase will make sure that all the experience on hand is taken account.

3 THEORETICAL FRAMEWORK FOR LEAN MANAGEMENT

Selected theory for the thesis contains both concept level theory and practical level theory. Concept level meaning that some of the theory presented here is only to open the concept for the reader and it is not being used in practical level within this project. One of the cases being for example standard work in chapter 3.3 which is presented to the reader for basic understanding of that concept. Practical level theory meaning that it is applied in the project and this type of theory is presented more thoroughly. Furthermore, selected theory takes into consideration both human interaction and technical development tools for this type of project.

3.1 Reactive and proactive leadership

Reactive and proactive as in a concept level differs in their approach for the management issues. Reactive approach as the word suggests is based on reaction on an incident or issue after it has already happened. Proactive, then again tries to plan in the future and recognize the potential inputs for the negative outcomes. Furthermore, controlling or preventing those negative inputs are the key motivator in proactive approach. In all environments both approaches are present and needed. It is impossible to predict all outcomes and sometimes reactive approach for the issues is needed. The thing is that when reaction is needed then evaluation is made for the root cause and if possible, it is negated with some proactive action. In organizations and in the leading positions capabilities for both approaches are needed but the ratio in operations should be more on the proactive side. On the positive side for the reactive leadership organization are that managers develop excellent problem-solving skill due constant "fire-fighting" and are especially protective against criticism to the team members. On the other hand, in the proactive environment it is easier to avoid problems than to tackle them which creates more productive atmosphere and is in managerial point of view less stressful. Employees feel appreciated and this creates job satisfaction. (Website of IBuzzle 2020.)

Table 1 presents differences of proactive and reactive organizations with few samples. As in lean continuous improvement is the focal point, and in some traits, organization

can be reactive and in some then again proactive. In the organizational level it is important to recognize these organizational traits and make assessment and determine if there is a need for change.

Table 1. Sample differences in reactive and proactive leadership (Website of IBuzzle 2020)

Reactive	Proactive
Concentrates on crisis handling	Continuous reviews for workplace improvement
Leadership manages with dictatorial attitude	Team is involved in decision making
No time for planning	Short and long term plans are made with contingencies
Innovatism is not supported	Personnel initiatives are valued and rewarded
Problems solved without data analysis	Rational approach with data on hand before actions
Tasks as in emerging crisis changes team orientation daily basis	Projects are planned and have clear responsibilities
Minimal documentation	Detailed documentation with easy access is available

3.2 Lean management

Lean management consist of four separate interdependent concepts and figure 12 represents closed-loop system for the first three of the concepts which are driving force for process improvement. All the four concepts work in conjunction and lean management process will not work if one the four concepts is missing. First one is leader standard work. Second one is visual controls and the third one is daily accountability. Fourth, the one that is not shown in the figure 12 is discipline. (Mann 2005, 19-20.)

Figure 12. Closed-loop system management system with process focus (Mann 2009, 22)

If lean would be a car then leader standard work could be considered as engine in the lean system. It becomes structure and routine for the leader to concentrate both on the processes and results. This is helping to recognize the daily improvement needs for the process and furthermore gives upper management better visibility for evaluation on leader's own job expectations. Defined leader standard work also helps continuity issues. Leaders work is process dependent not person dependent and when there is good structure as standard leadership routines then the change of personnel goes much smoother and training of the individual is faster and results from new leader can be expected sooner. (Mann 2005, 25.)

Mann (2005, 32) refers to layered approach which was also presented in figure 1 in page 4. Layers should be developed from bottom up. Mann has named the three layers as Team leader, Supervisor and Value-stream manager but as for the purposes of generalising in this thesis these will be referred as layer 1,2 and 3 since job names differs with the organization in question. Layer 1 as in first management level and being closest to operations should be concentrating on 80% of their work time on key performance metrics as takt time or something that is equivalent and standard work. Second layer management should be concentrating 50% of their time to monitor and support first layer of management and similarly for the third layer of management to use their time 25% to monitor and support second level. Table 2 presents time allocation and task examples for the different levels of the leadership.

Table 2. Time allocation and task examples (Mann 2005, 33-34)

How often	Management level	% / work time	Minutes / workshift	Examples of tasks
Every shift	Layer 1	80 %	384	Daily improvement tasks, respond to abnormalities, shift audits and training the personnel
Daily	Layer 2	50 %	240	Shift manning allocation, review daily tasks and results from yesterday, assign new tasks
Daily / weekly	Layer 3	25 %	120	Weekly gemba walks, daily accountability meetings

Second one is visible lean controls. In lean car this would be the transmission. Visual frequently updated results that are compared against actual targets give leader the possibility to react to the results that was not in target with better accuracy and speed. (Mann 2005, 41.)

In figure 13 sample departmental meeting area. Accessibility and visibility for everyone from operator to plant manager creates wanted transparency for the operations which improve processes accordingly. One can choose what items are monitored in this type of meeting area.

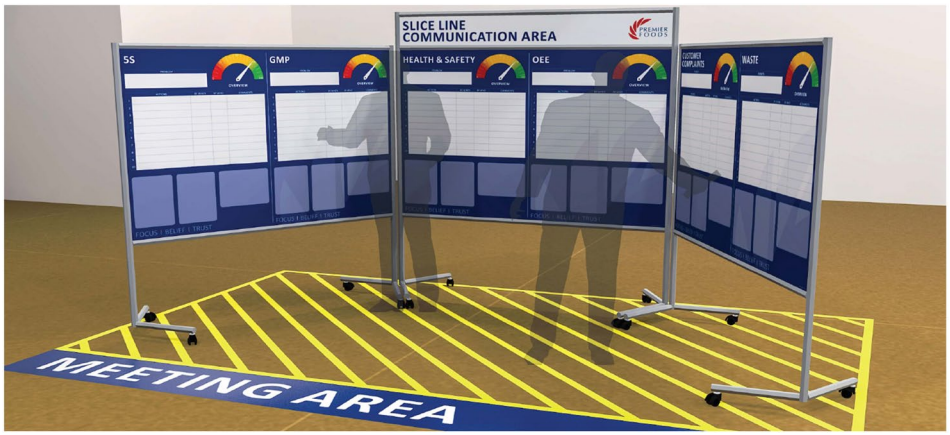

Figure 13. Sample meeting area (Website of clarity visual management 2020)

Important aspect with visual management is that you choose the right items to be monitored and it doesn't matter if the visualization is high-end or little less classy but as long as the results can be estimated with a glance then it will do the job it was intended. (Mann 2005, 42-43.)

Third one is daily accountability. In the lean car this is steering wheel and gas pedal. Major difference in lean when compared for the batch production is that in batch production daily mission stays the same, do whatever you need to meet the schedule and in lean management the question is that, "What caused the problems that interrupted the processes and who is doing improvement actions and when?" (Mann 2005, 69-70.)

Daily meetings in any manufacturing area should be on the shop floor and as presented in figure 13 type of team meeting areas. These meetings are done standing to increase efficiency. It is much easier to spot the problems and see if all the required reporting from the shifts are done accordingly. Table 3 describes length and content of the meetings. LXM refers to management layers and L1M being management layer 1 and so on. (Mann 2005, 70-71.)

Table 3. Sample meeting itinerary and agenda (Mann 2005, 70-71)

	Who attends	When	Lenght of meeting	Location of the meeting	Agenda for the meeting
First tier meeting	L1M and shift operators	Start of the shift	max 10 minutes	Visual display board, shop floor	Visual board issues
Second tier meeting	L2M, L1M and support groups	Daily 08:00	max 15 minutes	Visual display board, shop floor	Visual board issues
Third tier meeting	L2M, L3M and support groups	Daily 08:30	max 15 minutes	Visual display board, shop floor	Visual board issues

Important factors in the second and third tier meetings are assessment based on visual data. Assignments for corrective improvement actions and accountability for the previous day´s actions. (Mann 2005, 71.)

Fourth item is discipline. Again, in the lean car this would be the fuel and as we know every car needs some type of fuel to move, so does lean. Poor discipline makes even good systems to stop delivering good results. This is the hardest one to accomplish and requires everyone involved to actively engage and support the agreed systems. Standard leadership routines to support lean production will keep the lean engine running. (Mann 2005, 21.)

3.3 Standard work in lean

"Detailed definition of the most efficient method to produce a product (or perform a service) at a balanced flow to achieve a desired output rate. It breaks down the work into elements, which are sequenced, organized and repeatedly followed." (Website of I Six Sigma 2020.)

Standard, by definition, gives impression that by standardizing work something is set in stone and cannot be changed. This is the wrong impression. In lean thinking this can be the first step. With standardization first level is achieved and this makes further improvement possible. Lean is a journey and to simply put one needs to take the first step before second step and second step before third and so on. Everything is continuous improvement and the enemy is the satisfaction for the current procedures which stops the progress. (Fredendall & Thürer 2016, 119-120.)

Standard work brings efficiency and reduces variation from the process. Training new personnel is faster when there are detailed instructions. Instructions should contain tasks in detailed level so that in operations there is no doubt what needs to be done, who is doing it and how it is done. Supervising the work is easier for the management when there are boundaries for the procedures. Failures in the process can be seen better rate and rectified. One example being here that new operator has problems to achieve required target and team leader recognizes the situation and can give help for the recruit. (Fredendall & Thürer 2016, 120-121.)

3.4 Change management

Change management is one of the most important skills in organizational level. Companies need to be prepared to change whenever there is necessity or some might say opportunity. These types of agile organizations thrive even in worse circumstance. So, what is causing some organizations succeed and some to fail? In the thesis work concentration is in the managerial change in attitude to gain lean leadership mentality and only briefly commenting on basic change management theory.

Basic change management according to Hiteshi (2018) includes 4 stages

- Denial
- Resistance
- Exploration
- Acceptance / commitment

In denial stage personnel have not yet understood that the change will happen. Manager can point out the reasons for a change, encourage participation and discussion. Making sure that all involved are doing the tasks that has been agreed. At resistance stage personnel has accepted that there is a change but are resisting openly or in secrecy. At this point manager should listen the concerns an openly courage people to voice out the concerns about the change. Motivate the employees to do the change work and recognize their fears and ease the fears with training and information sharing. Explorations starts, personnel have accepted that there is a change and they need to cope with it. Manager should now give positive feedback and have discussions with personnel for individual needs as training and competitive career changes etc. Then comes the acceptance stage and both managers and personnel are being productive with the new changes which creates commitment through seeing that own actions give positive effect on the change. (Hiteshi 2018.)

Bleistein's (2017, 4) theory suggests as seen in the figure 14. From the top (leader position) it seems that organization is reluctant to change but that is not the case, at least it is rare. Leader starts the change and it emanates through different layers of the management. In some occasions change is deflected, refracted, or completely dissipated. This gives impression that the change resistance in the organization is in high level even though the change message is distorted or reflected by the mid-level manager layer which in most of the cases is the crucial one. According to Bleistein (2017, 5) the first mission is to understand this and take care that different refraction layers are behind the change and after this change can succeed.

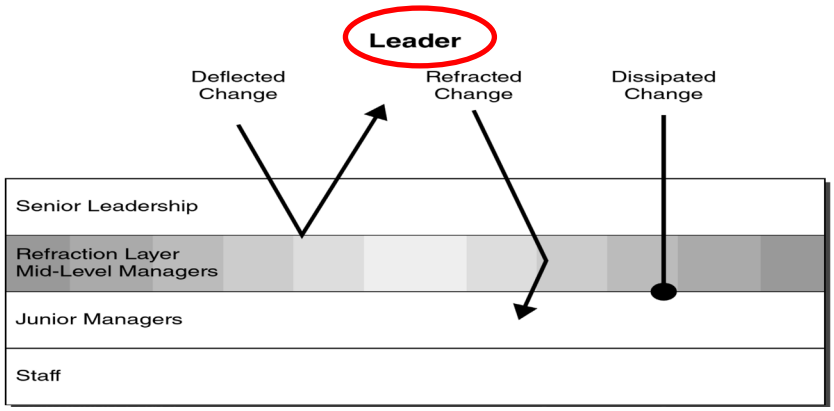

Figure 14. Outcomes of the change process (Bleistein 2017, 4)

Company culture and the company leaders are responsible creating these refraction layers. Some items generating layers of refraction.

1. Overprotection of labour, non-performing managers get to continue at their job or are side lined to a least demanding but similar position which prevents other professional and talented to rise in the ranks of the company. (Bleistein 2017, 8.)
2. Seniority based promotions, where the effect can be the same as in the first item. Young talented and better performing managers are repressed, unmotivated and possibly moving on to different company. (Bleistein 2017, 9.)
3. Leadership fear of the staff, leader might accept that manager does differently as have been agreed for the fear of manager leaving the company. (Bleistein 2017, 10.)
4. Rewarding lack of failure as success, this meaning that from the failures comes the possibility of learning and growing. This does not mean to promote recklessness, incompetence, or negligence but value risk taking capacity and capability to learn from those experiences. (Bleistein 2017, 11.)
5. Lack of leadership bench, internal capability to produce mid-level managers is non-existent and this creates need to raise in the ranks personnel that has less potential and that creates bottlenecks for the reasons laying in the capability of the managers. (Bleistein 2017, 12-13.)

How to eliminate and keep this refraction forming? Growth oriented thinking is key according to Bleistein (2017, 35). Characteristics of this type of thinking includes action over perfection, viewing failure as learning, desire for personal growth and comfort with ambiguity.

Action over perfection means that there will be never perfect opportunity in business and there are always risks some identified and some are hidden. There can be huge amount of data and need to collect more. The question is what for? And is there a need for extra data and will it help to make better decisions? Sometimes answer is yes and sometimes the opportunity just slides by while company profits decrease. It is better to act today and have possible success than no action and not even possibility for success. (Bleistein 2017, 35-38.)

Failures happen even if every precaution is taken. Opportunity rises on these occasions and it can be used as advantage. In the organizational level failure may present need or opportunity to change something from mindset to organizational chart. In the personal level the question is that is the risk evaluated from the personal perspective or organizational perspective. Does the personal risk of failure outweigh the organizational need for growing? (Bleistein 2017, 38-41.)

Learning is the key to any managerial position to be successful and to keep up with the new candidates. Without the desire to learn the progress is stopped. In the personal level and for the ones that are under persons leadership. Company wise it would make sense to hire persons which are interested in the personal growth or at least do everything to inspire managers to acquire new skills. (Bleistein 2017, 41-43.)

Self-confidence is important trait for everyone but especially for the managers. In the managerial position there is seldom a day where you have all the information available and you can make the best decision without hesitation. Comfort in ambiguity meaning that one needs to be able to reason in the thickest of the situations and carry on with decisions just based on what is available at the time. (Bleistein 2017, 43.)

How to close gap in the performance of the managers? There are three different reasons to create gap between desired performance level. Lack of professional skill, wrong king of attitude and some stopping barrier. (Bleistein 2017, 106.)

Education as treatment in the table 4 not meaning classroom teaching or some high-end courses from third party consultant. It means couching and daily accountability. This takes time as investment, but it is well worth it. Enlightenment contains four R's. These are respect, recognition, renumeration as incentives and responsibility. These can be used to motivate unmotivated manager. Empowerment requiring three aspects. Authority to act and will to use it. Sufficient resources for the outcome and visibility of the outcome for the customer. (Bleistein 2017, 120.)

Table 4. Performance gap treatments (Bleistein 2017, 107)

Cause	Illustrative Statement	Treatment
Skill deficit	"I don't know how to ..."	Education
Attitude problem	"I don't want to ..."	Enlightenment
Roadblock	"Even if I wanted to, I can't ..."	Empowerment

3.5 Lean Six Sigma

Lean Six Sigma is continuous improvement philosophy which combines tools from lean and from Six Sigma. These both when combined gives excellent possibility to make improvements faster rate.

Six Sigma combines techniques and tools for reducing variance from the process with empirical, statistical methods. Originally Six Sigma was created by Bill Smith in 1986 for the Motorola company. Later in the 1995 Jack Welch made it business strategy for General electric. This philosophy is based on DMAIC process which stands for define, measure, analyze, improve, and control. These steps each have systematical approach with various quality improvement tools. (Website of Wikipedia 2020.)

Lean method was derived from Toyota production system created in 1930's and introduced by John Krafcik in 1988. Method bases on the five key principles. Define the value desired by the customer. Analyze the value stream and get rid of the waste. One example of waste being here like wasted time because of unnecessary movement for the product which does not add value for the product and increases lead time. Make product flow continuous and increase pull systems to decrease inventory level. Make continuous improvement on the takt time and lead time so that the customer is served with improving rate. (Website of Wikipedia 2020.)

Combined systems as lean Six Sigma contains tens of tools and in this thesis work some of those will be introduced. Criteria being that ones, that will be used will be explained. Noteworthy is that if one is about to launch a similar project then all the tools should be considered and the most suitable should be chosen.

3.5.1 Cause and effect diagram

This quality management and process development tool can be used as root cause identification tool. It was created by Dr. Kaoru Ishikawa in 1968 and for this reason this tool is sometimes referred as Ishikawa diagram. Figure 15 shows the model of the diagram and it is in the form of the fishbone. As said model should be used as rooting out potential causes and important idea behind this is not to leave nothing out. There are six branches which act as possible causes for one effect. (Nankana 2005, 10-16.)

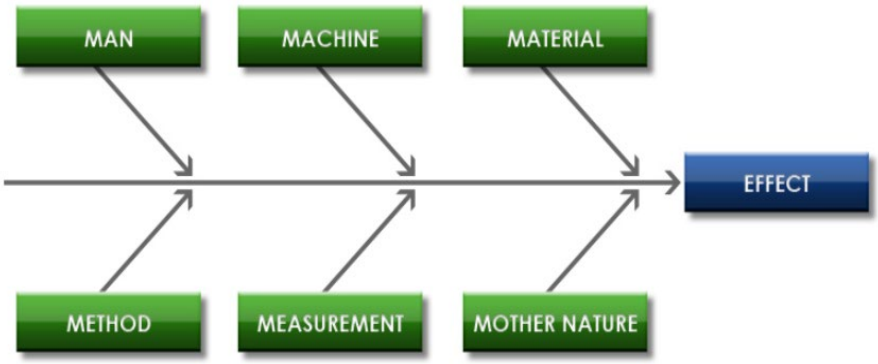

Figure 15. Cause- and effect diagram (Website of Six Sigma Daily 2020)

This tool is teamwork tool and needs professionals of the process in question to the team so that the approach can be comprehensive. There are six branches, but the actual number can change depending of the effect in question. Man referring to human interaction in general for example operator in automated line who can cause various causes for undesired effect like not paying attention to product quality. Machine like automated line which can cause harm for the product quality if there is lack of scheduled maintenance. Material variation can have quality issues. Mother nature as in environmental causes, this can be like in very cold weather circumstances around automated lines surroundings and temperature drops for a few degrees and this has effect on the product quality for the reasons of the machine is working little sluggishly. Measurements like are all the process controls in place and are there right controls. Last but not the least is the methods, are the operating procedures dated or is there need for update or is something missing. (Nankana 2005, 10-16.)

3.5.2 Cause and effect matrix

Cause and effect matrix which is also called X-Y diagram is a prioritization tool which can be used to prioritize root causes for example what was found with the cause and effect diagram mentioned in the chapter 3.4.1. Within this matrix inputs and outputs has correlation value determined by the team of professionals of the process in question. Common values are from one to ten and zero can represent as no correlation value. Bigger the total value is then bigger the correlation to the undesired effect is. Total value in percentage of sum of total value gives the prioritization order. Figure 16 presents five steps of how to use this type of quality management tool. (Website of Six Sigma Study Guide 2019.)

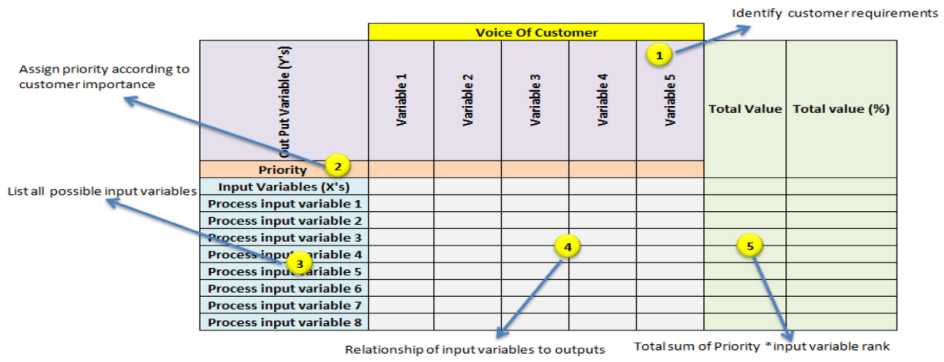

Figure 16. Sample of cause- and effect matrix (Website of Six Sigma Study Guide 2019)

Step 1 is presented here as voice of customer and it represents Y's as effects in the cause and effect diagram. Y's can be what ever effects team chooses process outputs and one example being general product yield (scrap %) from the process and in that second level scrap outputs as Y1, Y2 and so on. In step 2 priority for Y's need to be assigned in numbers from one to ten where one being less important and 10 being extremely important. Following the prior example for the second level scrap team should valuate the Y1 and Y2 from the effect to the total scrap %. Step 3 identifies X's which are process inputs. Bigger this list then better job the team did in the cause effect diagram phase. Step five is the crucial one since it needs the true knowledge from the process. Team evaluates X1's correlation Y1, Y2 and so on. Same principal in valuating as before from zero to ten. In this phase valuation numbers are suggested to be geometric like 0, 1, 3, 9 giving four level to the correlation. Zero is no effect, 1 is low effect, 3 is medium effect and 9 is high effect. Rest is just simple mathematics (X1*Y1+X1*Y2…+X1*Yn) to get the total value and when this total row value is compared to total value for all the rows then we get our effect in percentage. After this most critical X variables can be picked for the next phase. (Website of Six Sigma Study Guide 2019.)

3.5.3 Failure mode effect analysis

Team has identified in the first phase described in chapter 3.4.1 huge amount of potential root causes and then the team has applied XY-matrix described in the chapter

3.4.2 for the ranking of the causes. After these two phases there are smaller amount of chosen root causes to handle which makes the task easier. Process wise all the possible root causes need to be identified and removed or if that is not possible then controlled.

Failure Mode Effects Analysis (FMEA) is a tool that helps us anticipate what might go wrong or has already gone wrong with a product or process as well as identify the possible causes and probabilities of failures. This is a quality management tool to be used to understand seriousness of the cause, how often the cause presents itself and how well it is detected when the failure mode is happening. These three attributes give risk priority number (RPN) which gives deeper understanding to where the team should direct the resources to make improvements. This tool has direct link as can be seen in the figure 17 to actions. Process FMEA can be used as action list where all the planned actions are prioritized, and responsibilities of the actions are clear. This is the tool which transforms issues from reactive side to proactive side. (Geitner & Bloch 2007, 136.)

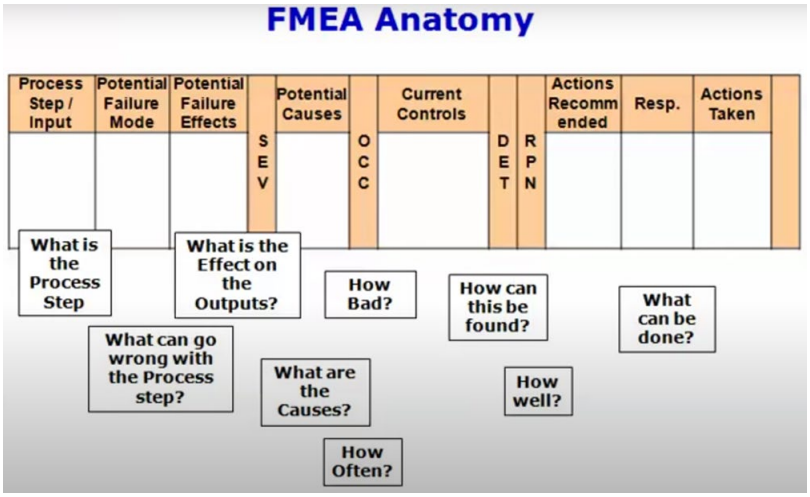

Figure 17. Sample of failure mode effect analysis (Hessing 2013)

The most critical part in using this tool is identifying potential causes and in chapter 3.4.4 5 times why which is a useful tool for the team to help with this is presented. Noteworthy to mention is that current controls and actions taken should be derived from potential cause. FMEA can take greater amount of time when used and it is recommended to be used with the cross functional team. This team should include at least

members from quality, production, and maintenance in case of production related process FMEA. (Geitner & Bloch 2007, 137.)

3.5.4 Five times why

This is purely root cause identification tool and very simple to use. Important aspect for using this is to dig deep enough to find the actual root cause. General idea is that there is problem to be dealt with. In figure 18 example outcome is positive one. Low Work in progress (WIP) which is target for all lean organizations. First question is why there is a low WIP? Because of no stock. Second question is why there is no stock? Because of short manufacturing time. This question to answer continues so long as there is need but in most cases five times is enough to be on the root cause. In the sample case to this fortunate low WIP situation to continue company should keep suppliers happy actively. (Andersen 2007, 132.)

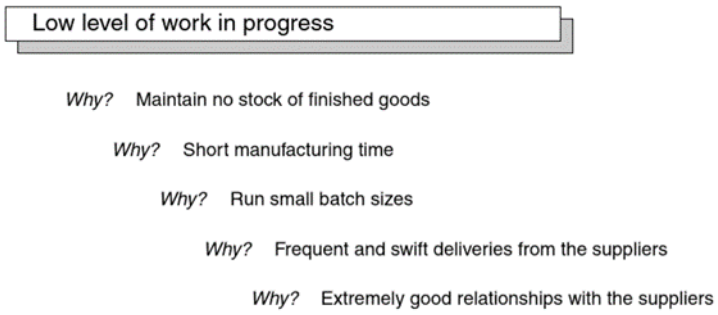

Figure 18. Sample of 5 times why (Andersen 2007, 133.)

3.5.5 Plan do check act cycle

Continuous systematic improvement with small incremental steps. This is where Lean and Six Sigma collide. Overall target can still far away and a bit hazy but with this tool and thinking process there is a possibility to close the gap every day little by little which in turn starts save money from day one for the company. Various Six Sigma tools can be implemented with this project tool. Figure 19 presents A3 reporting sheet which uses for root cause identification the cause and effect diagram mentioned in the chapter 3.4.1.

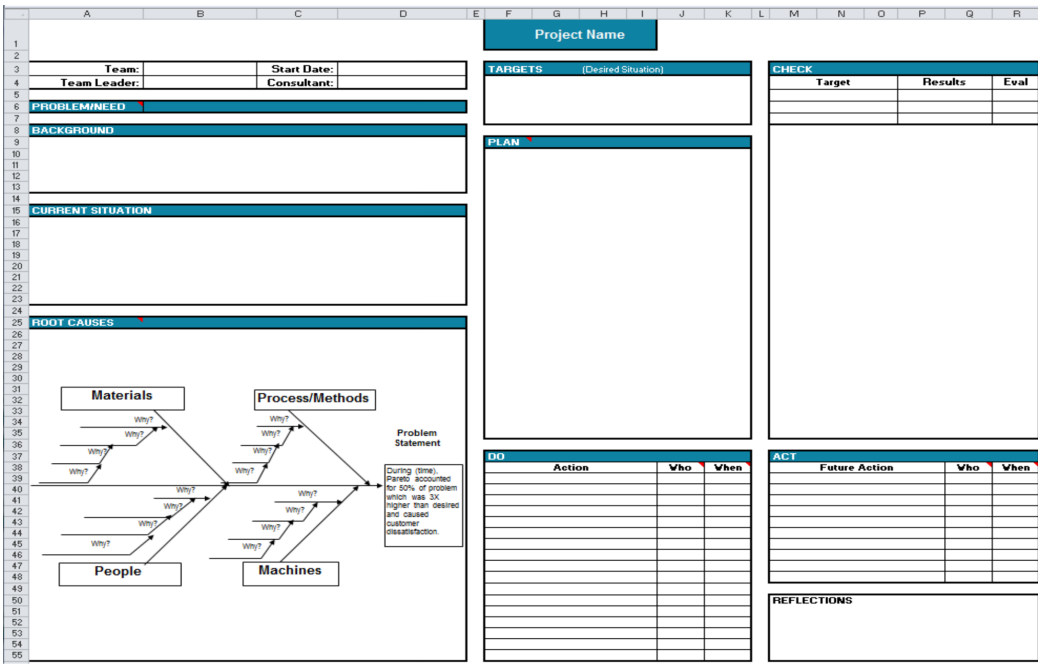

Figure 19. Sample A3 report (Website QIMacros 2020)

PDCA process has four phases and one that can be referred as pre-phase. In a pre-phase important point here is to identify point of cause. This will help to understand what is happening, where it is happening, when it is happening, with whom it is happening, why it is happening and how it is happening. Figure 19 these are expressed as problem/need, background, current situation, and root cause diagram analysis. With all this data in hand gives possibility to define first target. Without this pre-phase it is impossible to have clear targets and project will get side-tracked. Clear target will make first phase easier. “A problem must be stated clearly, accurately, concisely, and in a such way that it can be measured.” (Wilburn & Obara 2012, 79). In Planning phase overall plan and how to achieve target is devised. Within do phase PDCA team should aim to include actions with simple steps towards the main objective, define clear responsibilities and agree on regarding timetable. Smaller and faster actions to implement are suggested to be used since for the third phase these will be easier to interpret as results. This is very important aspect, to understand what was the effect of the countermeasure? Now team has planned actions and timetables. Executed as planned and collected the results. It is time for the fourth phase which is act. What did the team

learn during those tests and if the countermeasures were effective then how will the team to standardize the results? (Wilburn & Obara 2012, 71-91.)

3.5.6 Kaizen

Kaizen roughly translates to change for better and is continuous improvement philosophy. The idea in kaizen philosophy is to be more productive and to have better quality with what resources there are. When new machinery and extra resources are off limits as productivity improvement options and there is necessity for improvement then there is need to concentrate on the how the work is done and improve from that point. Target is to make work simpler to be executed and reduce waste from the process which are also goals of lean manufacturing. There is a slight technical difference when compared to other continuous improvement tools like PDCA, in kaizen everything can be working in standard level but there is still room for improvement in efficiency or quality. (Wilburn & Obara 2012, 93-94.)

There are six steps for kaizen model. First step is to discover the improvement potential. These come from observing and understanding the process. It is not enough to know or ask what is going on, but important questions are why something is happening and how it is done. Best situation is when shop floor operators who has the knowledge of why and how are making improvement suggestions. Rest steps are similar as with the PDCA tool which is described in chapter 3.4.5. (Wilburn & Obara 2012, 101.)

3.6 Observation and study techniques

This section of theory deals with how to observe people and process with systematic approach. For the process observation internal auditing has been chosen and with management observations the work time diary study is used as primary source of information. Overall performance in quality related issues of the departmental management is studied with the interviews of the colleagues and subordinates.

3.6.1 Diary study

Diary study aka EMA, ecological momentary assessment, collects qualitative information from the participant. Aim is to collect data from the everyday working life and record it in a log. This type of collection is called longitudinal technique which involves repeated observations over periods of time. (Website of Wikipedia 2020.)

Five phases in this type of study as can be seen in the figure 20. First phase is a planning and preparation phase. In this phase study focus, participants, how long is the recording period, what tools are to be used are determined. Written instructions for the study are produced. Second phase concentrates on meetings with participants to make sure that everything is understood correctly and if there are any questions from the participants this is the phase where they can have answers. Third phase is actual logging period with the use chosen logging system during which person in charge of the study should observe that everything is proceeding as planned. Fourth phase concentrates on participant experiences and feedback to get the whole picture. In the final, fifth, phase data is analyzed and presented for all the stakeholders. (Flaherty 2016.)

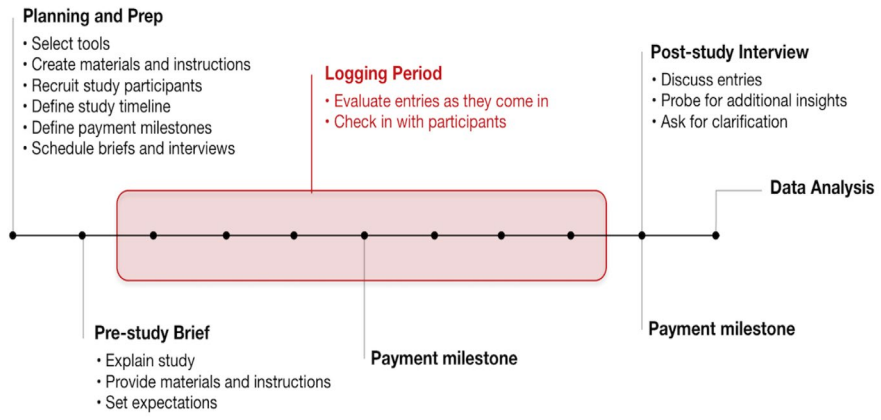

Figure 20. Typical diary study timeline (Flaherty 2016)

3.6.2 Survey

Key issues in surveys are cost, time, resources, and validity of the information gathered. These determine type of the survey to be chosen. For large scale information gathering the questionnaire is better and if in depth information is needed then interview face to face or long distance can be chosen. Long distance interview is more impersonal than face to face interview. Depending on the topics in the interview these should be compared and one best suited to purpose is to be chosen. Questionnaires are not so easy to do well and it is impossible to know, what is the thinking pattern in the reply given or was there deep thought used in the answers. Even if the topics in the questionnaire are clear and gives definable results it gives only to where deeper study as in interviews should be directed. In case that topics in the questionnaire are not so clear the data gathered from the questionnaire is bad and cannot be used as factual data for further research. Then again in the face to face situation interviewer should be impartial and not to lose objectivity. (Gilham 2005, 3-6.)

Interview is a qualitative research technique where interviewer and interviewee are engaged in a conversation. Personal nature of the situation demands tactfulness of the interviewer. As a technique this is easier for the interviewee when questions are related to opinions and impressions. (Website of Wikipedia 2020.)

Structured interview also known as recording schedule combines face to face interview and questionnaire with closed questions. With this type of interview method there is a possibility to use in the interview situation open questions as sub-questions which makes answering to closed questions simpler. Answering bases on simple records as in letters or numbers so the interviewer needs not to use lot of time in the recording which makes the interview sessions cost efficient and consumes lot less time for both parties. It is much easier to interpret structured interview since results are already in the simpler form. (Gilham 2005, 80-87.)

Question forming for the interview / questionnaire should be done with a group of professionals to have wider range for topics and questions. Delphi method is recommended for this type of qualitative research. First some should be leading the question

generation process and gather the professionals for the session. Then, in the brainstorming phase all the ideas concerning the topics are written down. This phase can be repeated couple of times since every time new question is recorded it may raise another question from someone else. Categorize and fine tune the questions after the brainstorming session and when this is done there is need for couple of trial runs to see how the package is working before actual interviews start. (Gilham 2005, 18-23.)

3.6.3 Internal auditing

"Internal auditing is an independent, objective assurance and consulting activity designed to add value to and improve an organization's operations. It helps an organization accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the effectiveness of risk management, control and governance processes"(Website of Wikipedia 2020.)

Target of the audit procedure should follow the SMART performance measure model which produces realistic and useful internal audits for the organization. S stands for specific single item. M is for measurable as in data is already available or it can be acquired with low cost. A is action oriented and can lead to continuous improvement actions. R stands for relevant and this means that all the internal departmental auditing complements each other and are part of the whole audit plan. T is for timely and this implies to realistic expectations in achievable time frame. (Pitt 2014, 36-37.)

Important aspect for internal auditing from the managers point of view is the auditing team members professionalism level and groups cohesion. There should be ongoing process to improve members from then current stage to the next stage of their professional level. Four stages are recognized. Forming, storming, norming, performing. The forming stage starts with orientation to the group and leads to testing the boundaries for the tasks and dependency for the other members in the group starts to form. Second stage, storming, emphasizes interpersonal issues within the group and emotional responses for the task sphere. In the third stage group has overcome resistances and are adapting to new roles and norms. At performing stage structure of the group supports the tasks and roles are flexible and functional. (Pitt 2014, 175; Tuckman 1965, 396.)

3.7 Indicators

Parmenter (2015, 3) recognizes two levels of indicators, result- and performance indicator. Both have two layers as in key level and normal level. Table 5 explains in more detail of this indicator concept and what each of the items is measuring.

Table 5. Four types of indicators (Parmenter 2015, 3-11)

Concept:	Measures:	Example:	Category:	Comments:
Result Indicator (RI)	Combined performance of teams	Weekly sales	Financial	Weekly sales is combination of logistics, quality, production performance
Key Result Indicator (KRI)	Overall summary of performance	Net profit before taxes	Financial	Combination of sales vs all costs
Performance Indicator (PI)	Performance of team	Departmental yield	Non-financial	Daily output in relation to daily losses in process
Key Performance Indicator (KPI)	Critical to success team related	Truck capacity used	Non-financial	On time deliveries resulting to half empty trucks in deliveries

Key performance indicator should be developed so that it is clear what it measures. What the target is. Data comes from what source and what is the measuring frequency. (Olsen 2016.)

Good example from table 4 from the section key performance indicator. Dispatch was making sure that deliveries left on time and the result was that there was frequently empty space in the trucks. Daily monitoring of truck capacity as cubic meter fill ratio was established. After deeper understanding actions could be taken. Truck space was optimized with deliveries so that in some cases customer was asked to take delivery of product before or later actual delivery date. This increased cost efficiency in the target company by lowering transportation costs. (Parmenter 2015, 11.)

Certain issues to be considered when creating and implementing organizational key performance indicator. Parmenter (2015) mentions seven founding stones and six stages for this type of project which can be seen in figure 21. Commitment, capability and change management as in any project are important factors to have success and reach determined goals. However, there are few items of interest to be raised, first

organizational critical success factors need to be determined (stage 4) and then from these KPI's can be sourced (stones item 4). Pick measures that suits organizational culture (stage 5) and make sure that measures taken and reported have significant value (stones item 3). After these phases there are valid measures and reports which should affect the performance as driving force (stage 6) and this can be achieved by empowering the first line of management (stones item 2). From this it is evident that foundation stones and stages are interlinked and should not be considered as separate aspects. (Parmenter 2015, 108.)

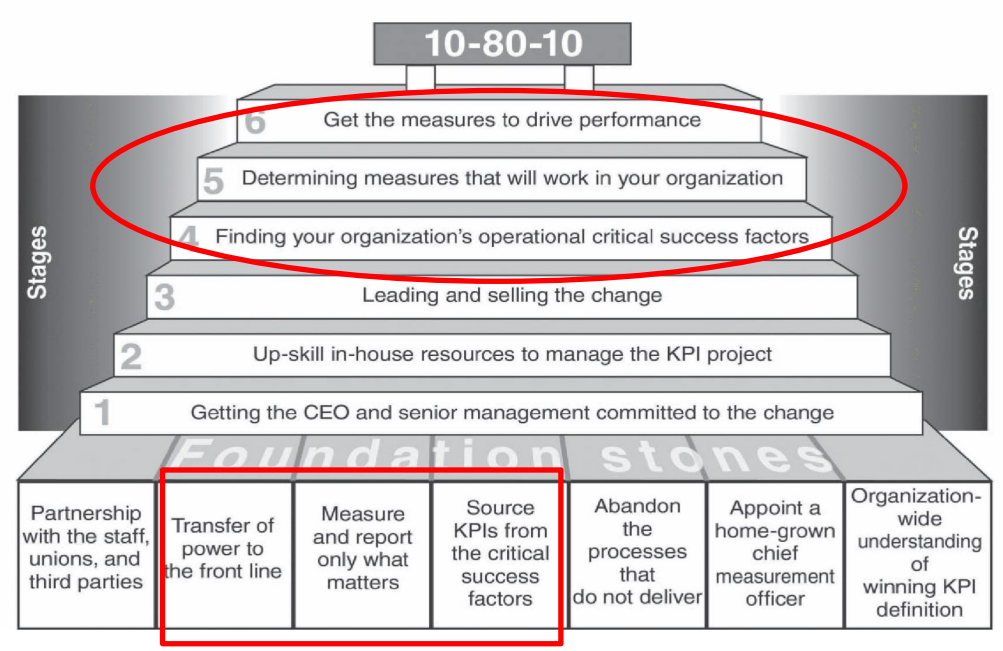

Figure 21. Foundation stones and stages of KPI project (Parmenter 2015, 108)

4 STUDY PHASE

Studies were made to understand current situation and the tools chosen were diary study technique and interviews. Both techniques can easily give information that is unusable due to depending on the feelings of the participant and not mirroring the actual situation. Therefore, preparation is crucial for the success. Furthermore, company ERP is providing extremely important material for the success of this project.

4.1 First operator diary study

In the preparation phase several issues were addressed by following theory suggested in the chapter 3.6.1. First one in the series was to address chief shop steward and explain the reasons for the study to gain permission. This is mandatory policy in the corporate environment. After permission draft of release were composed and HR representative was consulted to gain insight for the proper contents of this type of release and then area team leader was briefed on the release for the approval. This was based on theory of the change management mentioned in the chapter 3.4. Idea is to get the team leader involved in every step of project and that way reduce the change resistance to minimum level to ease the implementation phase. Release contained instructions for the diary study so that all the participants had the same information in the written form. Same time logging form to be used in the study was made by the area team leader which was sign of involvement and good contribution for the project. The pre-study brief was done by the author and the team leader with the participants and at this stage they had all the information available and possibility for the questions. The main questions were concerning why are this being done? and would it have effect for the current workload of the first operator.

Actual study had five first operators from the six possible involved. Study period was defined to be forty hours work period which is five working days. Since first operators are working as furnace operators there is knowledge that only part of the eight hours shift is contributed to first operator assignments. With this knowledge it was easy to exclude all the furnace operator work from the study and concentrate only for the first operator ones. In the study first operators were asked to collect time data for all other

assignments daily during the work week. There would have been possibility predefine possible tasks but the decision of not to limit outcome of the study was made in co-operation with the team leader. During the logging period couple of checks were done to see that has the participants encountered any difficulties and was the study going on as planned. Study was conducted successfully and gave plenty of data to be analyzed.

First goal for the study was to understand, how much is going into proactive and how much into reactive actions. Figure 22 shows proportions for the proactive, reactive, and operator work from the study period including all five participants. Variance as in first operator assignments differed from 9,9% of the worktime to 15,5% giving the average of 13,3%. Level of proactivity and reactivity differs only 0,6 units.

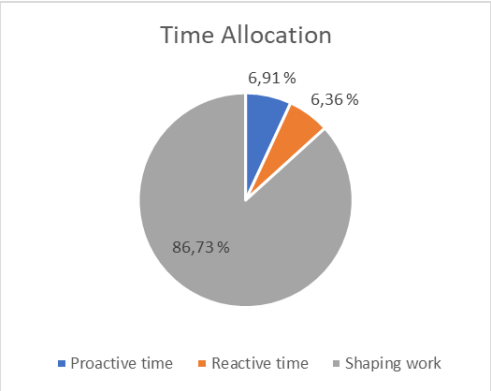

Figure 22. Time allocation of the first operator study

Second goal for the study was to understand, where is the resource time allocated? Figures 23 and 24 presents components found in the study. Component list from the study had more elements and these have been gathered into groups represented here to make simpler interpretation. X axis giving time in minutes allocated to the tasks in the Y axis. Blue bar representing total time used into the activities and operator time used below blue bar.

Figure 23 has proactive components including tooling and measurement audits, 5s cleaning and organizing activities, shift change activities and standard operating procedure (SOP) training. SOP training had no time allocated but it was included in the component list since it should be essential part of the proactive company's strategy.

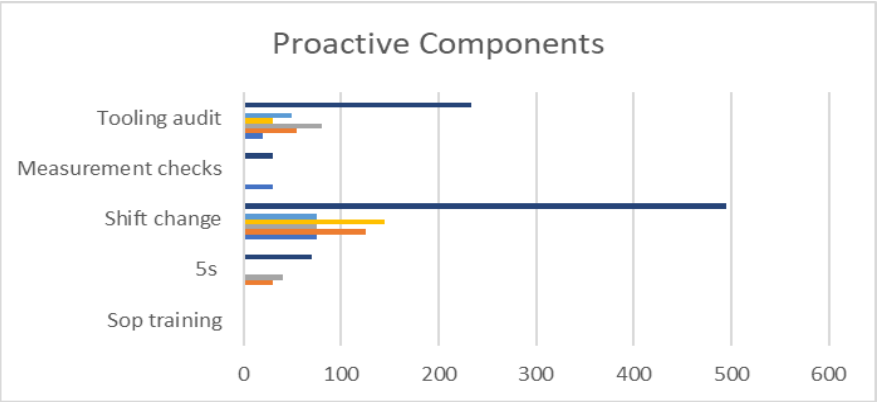

Figure 23. Proactive components of the first operator study

Figure 24 lists the reactive components from the study. Tooling issues, maintenance issues and problem solving could have been under problem solving altogether but for the development purposes these were kept separate. 5s in the reactive side meaning that something in the flow or process has gone wrong and there is a need to organize (react to situation). Central warehouse runs refer to the situation that some item which should have reserves in the shop floor and has been depleted then first operator needs to go and fetch the missing item. Data collection meaning manual data gathering from the shift and reporting it forward to the team leader.

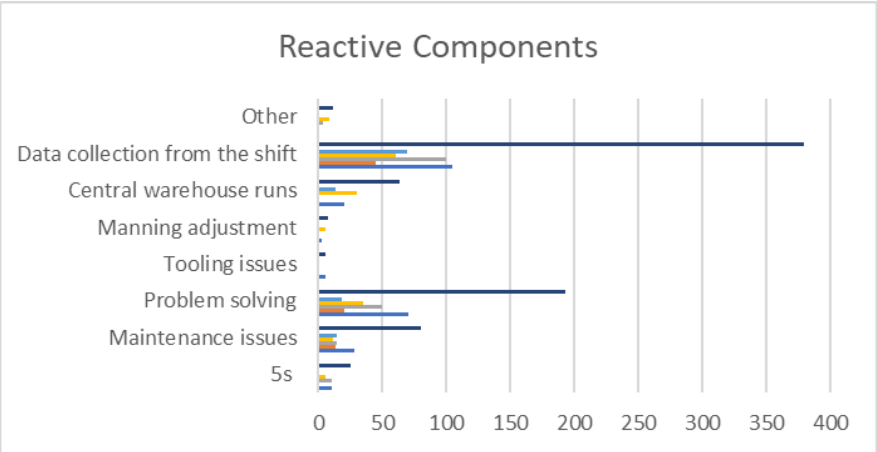

Figure 24. Reactive components of the first operator study

Post-study brief was done with the participants to make sure that data gathered is representation of the current situation and clarify some issues with the presented data.

Some of the components were grouped to have simpler view for the presentation purposes. For instance, problem solving had several sub-categories which were combined. Participants were acknowledged for this change and they had possibility to challenge the data. All five participants accepted this data presentation.

4.2 Team leader diary study

This followed the same principles as first operator diary study. As stated in chapter 4.1 team leader was onboard and participating as active operator in the first operator study so this study was made right after and results were as follows.

Team leader is single type of work containing only one role and first operator is dualistic type containing two roles. Therefore, data presented contains all workhours done during the study period. Study was for forty hours period and team leader used categorization to ease the recordings and this made data easier to present. Figure 25 shows the ratio of the proactivity against reactivity for the study period. Proactive has slight advantage according to the study.

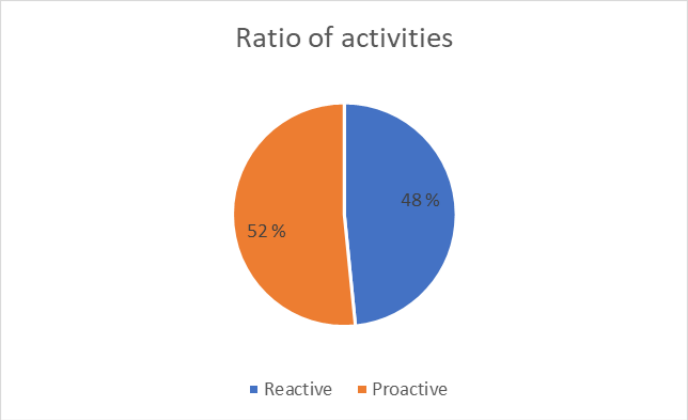

Figure 25. Ratio of proactivity against reactivity

In the figure 26 study components can be seen. As before Y axis contains components and X axis shows allocated time to the component. Green bar is total sum for the week and bars below the green bar represents allocated time during weekdays from Monday to Friday. P and R in the figure 26 presents classification to P as proactive and R as

reactive component. Eight categories in total and distribution is equal for the reactivity / proactivity. Categories contain components which have both proactive time and reactive time. For instance, meetings can be both depending on the purpose. Meeting to create training plan for the personnel is highly proactive activity and on the other hand meeting to discuss yesterday's problems is reaction to what already has happened. Esmikko in the activity list is referring to personnel time logging software and other activities are self-explanatory.

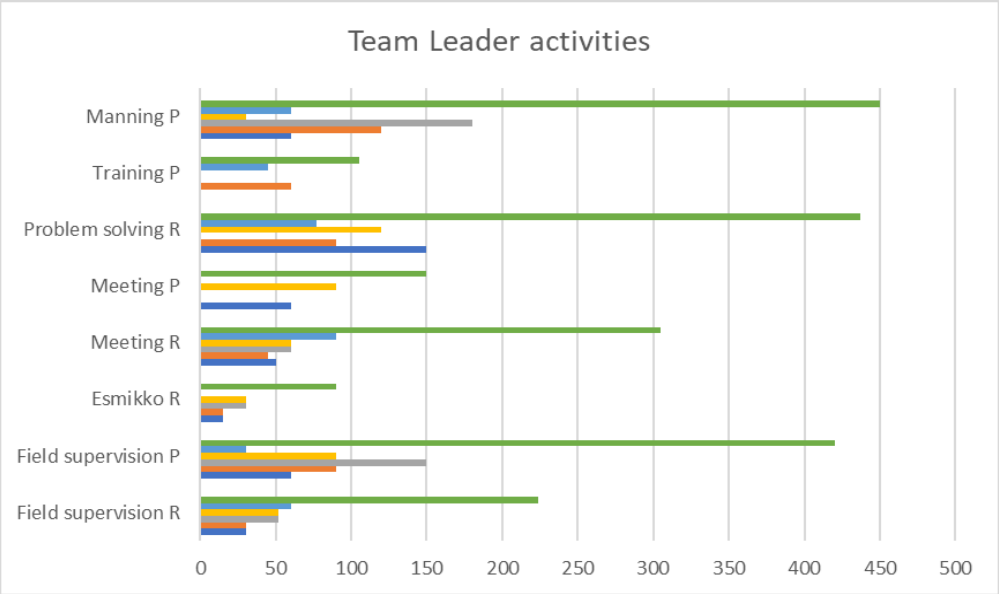

Figure 26. Team leader activities

Post-study meeting did not make any changes for the collected and presented data. As a footnote worth to mention is that manning as in biggest time consumer is not normal situation. In that sense company was having abnormal situation due to Covid-19 pandemic.

4.3 Internal interviews

Purpose of the internal interviews in this study is to act as soft indicator for the activities done by layer one of the management layers as presented in chapter 3.2 in the table 2. Interviews also give guidelines for the possible development points. Interviews will be done for both internal supplier direction and to internal customer direction. Internal

customer as in next departments of production and personnel in the shaping department. Goal is to establish current level of professionality for the first operator as feedback giver and feedback taker.

For the purposes four different interview populations is selected that work in conjunction with the target group. Selected team of professionals from the company devised set of questions for each of the target groups. Total amount resulted to 33 questions. Some questions are valid to all target populations and are repeated for that reason. Internal supplier questions are eight, internal departmental customer questions are thirteen, external departmental customer questions are twelve. Comparison between now and in the future would be extremely difficult in this type of interviews if the questions are only in the written textual form. So, questions are devised with the mechanics that makes the answer directed with boundaries and that way it can be quantified. Sample question can be seen in the figure 27. This makes comparison easier in the future and the actual interview is faster because it requires less writing for the interviewer. Data management from this type of interview is also much less time consuming and results can be presented much faster. All the scores are ranked so that one is the worst score and five is the best score. Overall evaluation and score are depending on the number of interviewees. Plan is to interview fourteen co-workers. So, that gives minimum score of 133 and maximum score of 665. Ratio between result score and maximum score gives the professionalism level as in percentage of the maximum potential. Since this is based on opinions, feeling and memory of the subjects there needs to be exercised healthy criticism for the results. All the persons interviewed were asked to think shaping first operators as a group and not to concentrate on an individual person.

		1	2	3	4	5	1	2	3	4	5
1	Level of interest when internal customer feedback is given	Ignorant		Feedback taken and pushed forward		Very interested					

Figure 27. Sample of the model question

4.3.1 Inner supplier

Table 6 presents questions and results from the target group survey. Overall score 3,19 from the inner supplier (preprocess) interviews rises above 3,0 average. Approachability has the strongest score from the targeted group. This is a good thing since it is basis for an open discussion and through discussion any issues can be overcome. Development point for this direction is to increase active discussion concerning areal and functional interface between preprocess and shaping. Clarification of the responsibilities and setting meetings between first operators from both departments concerning these issues in a situational basis is required to make improvement on that notion.

Table 6. Inner supplier questions and average results

		1	2	3	4	5	
1	Level of interest when internal supplier feedback is given	*Ignorant*		*Feedback taken and pushed forward*		*Very interested*	**2,75**
2	Amount of customer feedback from shaping to pre-process	*Never*		*Weekly basis*		*Every shift*	**3**
3	Professionalism level of the feedback from shaping to pre-process	*Sketchy*		*All the necessary details*		*Top of the line*	**3,25**
4	How often shaping FO approaches for the purposes of the 5S	*Never*		*Weekly basis*		*Every shift*	**2**
5	What is the first operators general attitude	*Ignorant*		*Neutral*		*Very interested*	**3,5**
6	Reaction time of the first operator	*Never*		*Inside the shift*		*Under one hour*	**2,75**
7	What is the first operators attitude towards feedback giver	*Belittling*		*Neutral*		*Appreciative*	**3,5**
8	How approachable are the shaping first operators	*Hard*		*Neutral*		*Easy*	**4,75**

4.3.2 Inner customer

Table 7 presents questions and results from the target group survey. Overall score 3,63 from the departmental operator (shaping) interviews rises also above 3,0 average. This is excellent score from the most important target population for the first operator. Reaction time and approachability scores the highest average which tells that in problem situations operators inside department can easily ask help and response time is fast. On the other hand, key development point from this survey is customer feedback information to the operators from level one and two customers. This can be accomplished by using the meeting area continuous improvement / kaizen action lists mentioned in the chapter 6.1 as information distribution center.

Table 7. Department operator questions and average results

		1	2	3	4	5	
9	FO comes to help when assistance is required	*Never*		*Weekly basis*		*Every shift*	**4,2**
10	Can FO help and solve problems	*Don't know how to help*		*Sometimes can help*		*Often can help*	**3,8**
11	Is FO actively questioning for the shift results	*Never*		*Weekly basis*		*Every shift*	**3,6**
12	During FO audits do you get feedback	*Never*		*Weekly basis*		*Every shift*	**3**
13	Is there a feedback from other departments	*Never*		*Weekly basis*		*Every shift*	**2**
14	What is the FO general attitude	*Ignorant*		*Neutral*		*Very interested*	**3,6**
15	Reaction time of the first operator	*Never*		*Inside the shift*		*Under one hour*	**4,6**
16	What is the first operators attitude towards feedback giver	*Belittling*		*Neutral*		*Appreciative*	**4,2**
17	What type of example FO sets	*Ignorant*		*Neutral*		*Very interested*	**3,8**
18	In neglect behavior how often FO acts accordingly	*Never*		*Weekly basis*		*Every shift*	**3,4**
19	Does FO give positive feedback	*Never*		*Weekly basis*		*Every shift*	**3,8**
20	How approachable are the shaping first operators	*Hard*		*Neutral*		*Easy*	**4,6**
21	How often FO has work related discussion	*Never*		*Weekly basis*		*Every shift*	**2,6**

Table 8 presents questions and results from the target group survey. Overall score 3,5 from the first inner customer level (lamination) interviews are also above 3,0 average. Approachability and reaction time again in very good level and development point is upstream information to lamination first operator from the recognized shaping issues. Situational meetings inside the shift with the departmental operators about the issues risen that can be of concern for the next department needs to be arranged.

Table 8. First inner customer questions and average results

		1	2	3	4	5	
22	Feedback level from shaping FO	*No answer*		*Weekly basis*		*Every shift*	**3,0**
23	How often FO gives product info for next department	*Never*		*Weekly basis*		*Every shift*	**2,3**
24	What is the FO general attitude	*Ignorant*		*Neutral*		*Very interested*	**3,0**
25	Reaction time of the first operator	*Never*		*Inside the shift*		*Under one hour*	**4,3**
26	What is the first operators attitude towards feedback giver	*Belittling*		*Neutral*		*Appreciative*	**3,7**
27	How approachable are the shaping first operators	*Hard*		*Neutral*		*Easy*	**4,7**

Table 9 presents questions and results from the target group survey. Overall score 3,4 from the second inner customer (final inspection) level interviews are above 3,0 average. Results from this survey are flat and averages are between 3,0 and 4,0. That makes separation of the good qualities and development points impossible to determine. Since, average score is 0,9 points above average score then it can be deducted that the

feedback and functional level of the shaping first operator from the angle of the second customer is in an appropriate level.

Table 9. Second inner customer questions and average results

		1	2	3	4	5	
28	Feedback level from shaping FO	*No answer*		*Weekly basis*		*Every shift*	**3,0**
29	Does FO collect information in the feedback situation	*No*		*Sometimes*		*Most of the times*	**3,7**
30	What is the FO general attitude	*Ignorant*		*Neutral*		*Very interested*	**3,0**
31	Reaction time of the first operator	*Never*		*Inside the shift*		*Under one hour*	**3,3**
32	What is the first operators attitude towards feedback giver	*Belittling*		*Neutral*		*Appreciative*	**3,3**
33	How approachable are the shaping first operators	*Hard*		*Neutral*		*Easy*	**4,0**

4.3.3 Overall result from the interviews

Minimum score from the survey was 133 points. That would have been the case if all the participants would have given one as a result for all the questions in the survey. This presented as percentage would have given 20% professionality level. Total score from the survey was 462 points from the maximum of 665 points. This as a percentage gives 69,5% which was excellent overall result. The survey also revealed weak points which can be developed as mentioned in the chapters 4.3.1 and 4.3.2.

4.4 Yield secondary level components

Designated operators in the production record live performance data to enterprise resource planning system. In this case it is SAP ERP system. From the SAP it is transferred to Tableau servers by data management. In the figure 28 there is 30 weeks period of data from the reject types of the shaping area that are in the top ten. These secondary level reject types of the primary departmental KPI (yield) will be used in the chapter 5.2 cause and effect matrix as X axis voice of customer inputs. Figure 28 also shows rejects as proportions from the whole amount of the rejects which makes weighing the inputs easier. Without secondary level data it would be impossible to target the development actions.

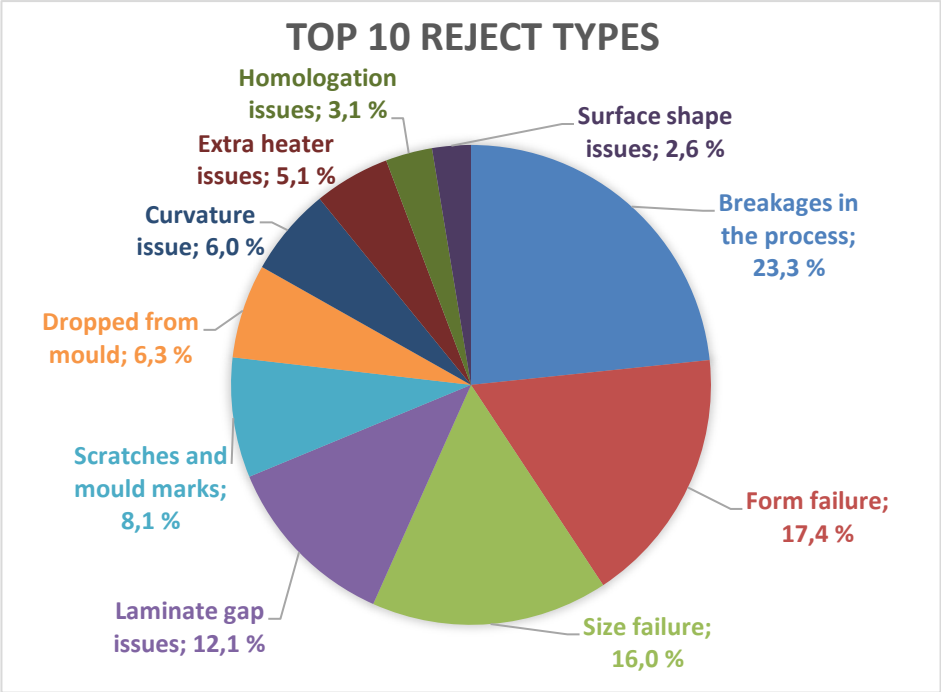

Figure 28. Top 10 reject types and effect level as percentages

5 DEVELOPMENT PHASE

This chapter concentrates more on the technical side of the development project. Aim is to use the tools mentioned in the chapter 3.5 to gain more perspective on the issues and in the end to be able to define preventive proactive actions. The work is done with the team and Bleistein's (2017) theory of the management change is followed. This is to decrease anticipated refraction from the mid-level management.

5.1 Cause- and effect diagram analysis

Cause- and effect diagram is to be used as brainstorming tool as explained in the chapter 3.5.1. Brainstorming team consisted of persons from process improvement and the line management for the area (shaping). Each of the categories from measurement to machine / tool were analyzed separately. Purpose was to record anything related to departmental yield in the six categories chosen. Actual outcome had upper level (category) and lower level (root cause) variables. Category level example is mold failure, which has twelve sub-categories and root cause level example is calibration overdue. Team was able to identify five to eight categories / root causes for each of the branches. For the purposes of the development project this was adequate number.

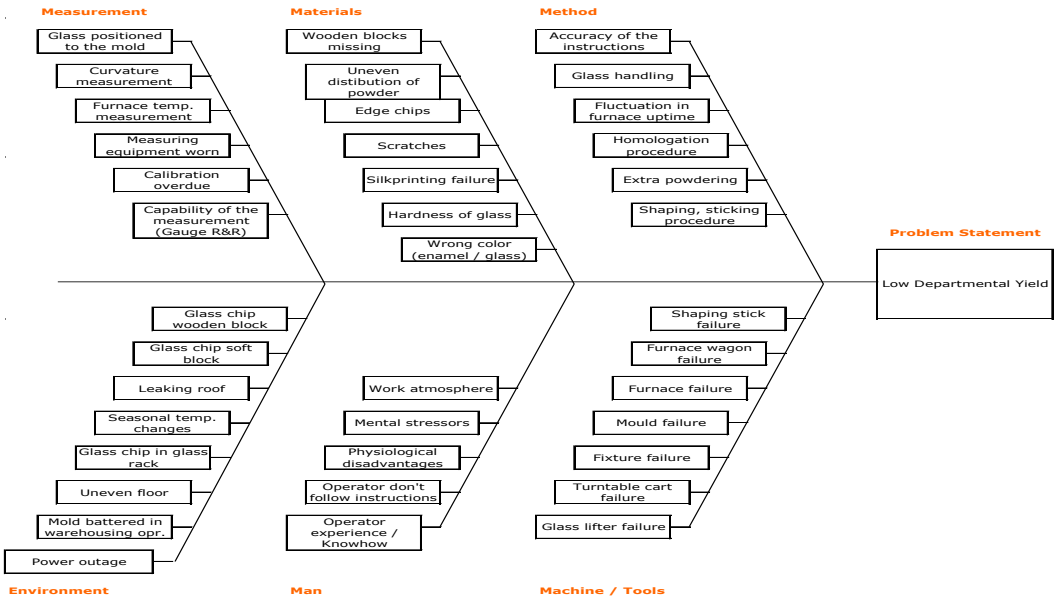

Figure 29. Cause- and effect analysis of the shaping yield

5.2 Cause- and effect matrix analysis

Target is to understand the effect of the different failure modes, found in the chapter 5.1, to the departmental yield. Voice of the customer variables in this case will be secondary level reject types presented in the figure 28. Overall portion for each reject type is calculated and it is simple to give weighing value for the variables. This will assure that even if the team valuates some effects too low still the highest scores will go to highest reject type as in portion of the whole sum of the rejects. Fifty points were distributed as can be seen in the table 10. This number can be any number, but it is easier to have effect if the number is more than ten. Highest value for the breakages in the process and the weighing value is twelve. Lowest value goes to surface shape issues for the value of one.

Table 10. Basis on weighing system

		Percentage of the whole sum	Weighing (50) points
1	Breakages in the process	23,3 %	12
2	Form failure	17,4 %	9
3	Size failure	16,0 %	8
4	Laminate gap issues	12,1 %	6
5	Scratches and mould marks	8,1 %	4
6	Dropped from mould	6,3 %	3
7	Curvature issue	6,0 %	3
8	Extra heater issues	5,1 %	3
9	Homologation issues	3,1 %	2
10	Surface shape issues	2,6 %	1

Same team which was contributing to cause- and effect diagram in chapter 5.1. were also selected for this part of the project. Author had already produced the matrix for the meeting and the next part was valuation of the categories. This is preferred to be done in one session for the reasons, that valuation is made with the same principles. So, several hours were reserved for the task.

Weighing principles and the matrix were explained to the team. Causality effect level between Y and X is to be estimated by the team. Effect was valuated from zero to ten. Zero has no effect and ten has big impact. Numbers, which were agreed to be used were as explained in the chapter 3.5.2. Important thing to keep in mind is that basis for good evaluation is professionals, which are well versed for the process in question.

This makes values more descriptive for the real events in the process. Matrix can be valuated horizontally or vertically. Team chose vertical approach. This meant to evaluate first all Y's against X1 (breakages in the process) and so on.

High impact was estimated on several categories as can be seen in the table 11. Glass positioning, instructions, sticking procedure, experience, following the standards, mold failure, furnace failure. These all scored over 10% in rank column. Couple of these are chosen from this point onward. Sticking procedure is addressed in the chapter 5.3 (five times why). Furnace and mold failure are addressed in the chapter 5.4 (FMEA).

Table11. CE-matrix of the shaping yield

Rating of Importance to Yield (50 points allocation)		12	9	8	6	4	3	3	3	2	1			
#	KPIV	Breakages in the process	Form failure	Size failure	Laminate gap issues	Scratches and mould marks	Dropped from mould	Curvature issue	Extra heater issues	Homologation issues	Surface shape issues	Total	% Rank	
1	Glass positioned to the mold	3	10	7	5	7	10	5	0	0	3	288	10 %	Measurement
2	Curvature measurement	0	0	0	0	3	0	5	0	0	0	27	1 %	
3	Furnace temp. measurement fail	7	7	0	7	0	7	7	0	0	7	238	9 %	
4	Measuring equipment worn	0	1	1	0	0	1	5	1	10	5	63	2 %	
5	Calibration overdue	0	5	5	5	0	5	5	5	0	5	165	6 %	
6	Capability of the measurement (Gauge R&R)	0	10	10	5	0	5	10	0	0	10	255	9 %	
7	Glass chip wooden block	3	0	0	0	5	0	0	0	0	0	56	2 %	Environment
8	Glass chip soft block	3	0	0	0	5	0	0	0	0	0	56	2 %	
9	Leaking roof	0	0	0	0	0	0	0	0	10	0	20	1 %	
10	Seasonal temp. changes	1	1	1	1	0	1	1	0	0	0	41	1 %	
11	Glass chip in glass rack	1	0	0	0	3	0	0	0	0	0	24	1 %	
12	Uneven floor	1	0	0	0	3	0	0	0	0	0	24	1 %	
13	Mold battered in warehousing	0	10	5	5	0	10	3	10	0	3	232	8 %	
14	Power outage	3	7	7	3	0	7	7	7	0	10	246	9 %	
15	Accuracy of the instructions	3	10	5	7	3	7	10	5	7	10	310	11 %	Method
16	Glass handling	3	0	0	0	10	0	0	3	3	0	91	3 %	
17	Fluctuation in furnace uptime	1	7	3	3	0	3	7	0	0	3	150	5 %	
18	Homologation procedure	3	0	0	0	3	0	0	0	10	0	68	2 %	
19	Extra powdering	3	0	0	3	3	0	0	0	0	0	66	2 %	
20	Shaping, sticking procedure	5	10	5	10	10	1	0	10	10	10	353	13 %	
22	Operator experience / Knowhow	7	10	10	10	5	10	7	3	10	10	424	15 %	Man
23	Operator don't follow instructions	7	7	7	10	10	10	10	5	10	10	408	15 %	
24	Physiological disadvantages	1	7	5	0	0	0	5	0	0	3	133	5 %	
25	Mental stressors	0	5	3	3	3	3	3	3	3	3	135	5 %	
26	Work atmosphere	0	3	3	3	3	3	3	3	3	3	117	4 %	
27	Glass lifter failure	10	0	0	0	5	0	0	0	0	0	140	5 %	Machine
28	Turntable cart failure	5	0	0	0	7	0	0	0	0	0	88	3 %	
29	Fixture failure	1	0	0	0	7	0	0	0	0	0	40	1 %	
30	Mould failure	10	10	10	10	10	7	10	10	0	10	481	17 %	
31	Furnace failure	3	7	7	7	0	10	7	10	0	10	288	10 %	
32	Furnace wagon failure	1	5	1	3	0	5	1	10	0	0	131	5 %	
33	Shaping stick failure	7	7	1	1	10	0	0	0	0	3	204	7 %	
34	Wooden blocks missing	10	0	0	0	7	0	0	0	10	0	168	6 %	Material
35	Uneven distibution of powder	10	0	0	0	10	0	0	0	0	0	160	6 %	
36	Edge chips	7	0	0	0	0	0	0	0	0	0	84	3 %	
37	Grinding burned	10	0	0	0	0	0	0	0	0	0	120	4 %	
38	Scratches	5	0	0	0		0	0	0	0	0	60	2 %	
39	Silkprinting failure	3	5	3	7	0	0	3	0	10	10	186	7 %	
40	Hardness of glass	7	7	7	1	5	1	7	0	0	10	263	9 %	
41	Wrong color (enamel / glass)	0	5	3	7	0	3	7	0	0	5	146	5 %	
Total		144	156	109	116	137	109	128	85	96	143			

5.3 Procedure and tooling failure

Shaping process failure, glass surface has been scratched and has visible marks. Table 11 presents these in two categories. The categories are method (procedure, sticking) and machine (tool, bending stick). Effect on the yield is estimated to be 13% from the procedure and 7% from the tool. Five times why technique is to be used if the root cause is not clear.

Shaping team consisting all the essential persons were assembled and brainstorming session started. In the table 12 can be seen the logic behind the use of the five times tool. Problem is that there are scratches in the surface of the glass which are identified as bending tool marks. Logic dictates that glass needs to be pressed which is causing the problem and this is presented in the table 12 as first level WHY1. In the second row there are multiple possibilities for the problem itself and this level is the most important part of the technique because if all the failure modes are known then prevention or controlling is much easier. Level five in this case gives idea where to concentrate effort to make improvements.

Table 12. Five times why of the bending tool and process failure

WHY 1	*1. Bending tool used to press the glass*		
WHY 2	*2. Bending tool surface worn*	*2.Bending tool slipped while being used*	*2. Too much force used with the bending tool*
WHY 3	*3. Change time exceeded*	*3.Bending tool has wrong shape*	*3. New product for the operator*
WHY 4	*4. Bending tool not inspected*	*4. No requirement for the shape of the tool*	*4. Lack of knowhow*
WHY 5	*5. No systematic control*	*5. Not deemed necessary*	*5. Inadequate training or instructions*

Possible prevention and control actions are:

1. Create systematic documented control for the bending tool inspection.
2. Create product related definition system for the documented bending tool shape.
3. Set up sheet definition for the bending tool use procedure to be more accurate.
4. Bending tool use training for the new recruits, better definition to gain deeper understanding for the required shape and understand limits for the use of force.

5.4 Failure mode estimate analysis for the selected development points

Inputs for the failure analysis are chosen to be mould and furnace which are key elements for this type of process. Mould failures scored 17% in the CE-matrix analysis seen in the table 11 and this was the highest rank score for the effectiveness against overall yield estimated through secondary rejects. Furnace related failures had 10% rank score which is also very high effectiveness.

Structural points are as explained in the chapter 3.5.3. Inputs are on the left in the table 13. Furnace and mould have been divided into sub-categories to make evaluation easier for the team. Important thing to note here is that even though these were presented in the CE-matrix as two rows these had thirty-one rows in this phase. Evaluation for the all items from the cause- and effect analysis results hundreds of rows. So, this is no small feat and requires time and resources. Potential failure effects are the secondary level rejects which were presented in the figure 28. Normally in this type of analysis there is one failure effect for one row which and when contemplating severity, occurrence, and detection this makes it easier to evaluate but for this thesis work these are presented as a bundle to have less rows. Potential failure modes contain all the failures for the input. These are known from the history or from the risk evaluations. Potential causes are also presented as a bundle of causes in one row for the same reasons as failure effects. This section of the evaluation requires process experts otherwise it is difficult to understand root causes. Current controls section is self-explanatory.

Severity, occurrence, and detection are evaluated from one to ten and these scores are multiplied to give risk priority number (RPN). This gives RPN range from 3 to 1000. Lower the score is, less the risk is for the failure mode. Detailed instructions for the process FMEA scoring can be found from FMEA handbook from AIAG & VDA, 2019. Level of the RPN what requires designated action can vary depending on the process evaluated. Severity score 9 or 10 always requires prevention or detection action otherwise it is a team decision where to draw the line. Table 13 has three colours green, yellow, red, and actual numbers are hidden. Green requires no action and is considered low risk. Yellow is considered medium risk and action is recommended. Red is high risk and action is mandatory. This is not possible always as can be seen in the table 13, since some of the red ones are without action.

Table 13. FMEA for the furnace and mold as inputs for the evaluation

Process step / input	*Potential failure mode*	*Potential failure effect*	*Potential causes*	*Current controls*	*RPN*	*Actions recommended*	*Responsible*	*Actions taken*
Furnace, wagon	Extra heater power cable grounded	Form failure, size failure,extra heater failure	Insulation of the cable worn out due time from use, misplacement of the cable during loading, insulation caught between two surfaces and breaks	Planned maintenance / 7 week rotation, Error detection system				
	Extra heater power cable broken	Form failure, size failure,extra heater failure	Due long time stresses against the cable from the use, cable caught between two surfaces and breaks	Planned maintenance / 7 week rotation, Error detection system				
	Raw air into furnace from the gap between wagon and hat	Breakages in the process, form failure	Due long time stresses against the insulation layer from the use of furnace, misplacement of the mould tears insulation	Planned maintenance / 7 week rotation		Supervisor periodical audit (documented)	Team Leader	
	Middle support mechanism working improperly	Breakages in the process, laminate gap issues, form failure	Sensor malfunction, failure of the mechanisms motor, gear malfunction	Planned maintenance / 7 week rotation				
	Uneven support for the mould	Form failure	Due long time stresses against the weldings from the use of the furnace, heavy impact from loading	Planned maintenance / Once a year rotation		Create measuring mechanism for the planned maintenance (documented outcome)	Maintenance Team Leader, Process improver	
	Floor insulation insufficient	Form failure, curvature failure, laminate gap issues	Due long time stresses against the insulation layer from the use of furnace	Planned maintenance / 7 week rotation		Supervisor periodical audit (documented)	Team Leader	
Furnace, top	Raw air into furnace from the gap between wagon and hat	Breakages in the process, laminate gap issues, form failure	Due long time stresses against the insulation layer from the use of furnace, misplacement of the mould tears insulation	Planned maintenance / 7 week rotation		Supervisor periodical audit (documented)	Team Leader	
	Pyrometer reading failure	Breakages in the process, laminate gap issues, form failure, surface shape issues	Misplacement of the sensor after maintenace, sensor cleanliness changes during calibration, sensor calibrated and reading changes, electrical failure of the sensor	Planned calibration/ Once a year rotation		Create operating procedure for the calibration checks, calibration twice a year	Maintenance Team Leader	
	Heating resistor working improperly	Breakages in the process, laminate gap issues, form failure, surface shape issues, size failure	Due long time stresses against the resistors from the use of furnace, impact from the sticking procedure	Planned maintenance / 7 week rotation, Error detection system		Test heating pattern used by operator at the start of the work week / documented by first operator	First operator	
	Ceiling insulation insufficient	Form failure, curvature failure, laminate gap issues	Due long time stresses against the insulation layer from the use of furnace, misplacement of the mould tears insulation	Planned maintenance / 7 week rotation		Supervisor periodical audit (documented)	Team Leader	
Mould, Surface	Rim surface scratched	Breakage in the process, Scratches and mould marks	Glass breaks against the mould, during warehousing impact against rim, during maintenance tool impact	Maintenance check at the start of the series		After maintenance daily audits by first operators (documented)	First operator	
	Rim fabric hardened	Scratches and mould marks	Use of tape with the fabric, been in use for too long	Maintenance check at the start of the series				
	Hole in the rim fabric	Breakage in the process, Scratches and mould marks	Use of tape with the fabric, been in use for too long , glass breaks against the fabric	Maintenance check at the start of the series		After maintenance daily audits by first operators (documented)	First operator	
Mould, frame	Welding opened	Form failure	Due long time stresses against the weldings from the use of the mould, heavy impact from loading or in warehousing	Maintenance check at the start of the series		After maintenance daily audits by first operators (documented)	First operator	
	Wing weights moved	Form failure, size failure, dropped from mould	Weight locking mechanism not in use use	Maintenance check at the start of the series		After maintenance daily audits by first operators (documented)	First operator	
	Hinge point uneven	Breakage in the process, Scratches and mold marks, form failure	Due long time stresses against the hinges from the use of the mould, heavy impact from loading or in warehousing	Maintenance check at the start of the series		After maintenance daily audits by first operators (documented)	First operator	
	Hinge point loose	Form failure	Due long time stresses against the hinges from the use of the mould, heavy impact from loading or in warehousing	Maintenance check at the start of the series		After maintenance daily audits by first operators (documented)	First operator	
	Heat shields loose	Laminate gap issue	Due long time stresses against the heat shields from the use of the mould, heavy impact from loading or in warehousing	Maintenance check at the start of the series				
	Glass stoppers wrong distance	Form failure, size failure, dropped from mould	Adjustment failure, graphite tube worn, impact in warehousing	Maintenance check at the start of the series		After maintenance daily audits by first operators (documented)	First operator	
	wrong shape	Form failure, size failure, dropped from mould	Glass breaks against the mould, during warehousing impact against rim, misplacent during installation causing impact to the hat	Maintenance check at the start of the series		After maintenance daily audits by first operators (documented)	First operator	
Mould, extra heater	Wire broken	Form failure, size failure,extra heater failure	Due long time stresses against the wire from the use of mould, impact from the sticking procedure	Maintenance check at the start of the series, Error detection system				
	Herlite separator broken	Form failure, size failure,extra heater failure	Impact in warehousing, impact during loading	Maintenance check at the start of the series, Error detection system				
	Herlite tube dirty	Form failure, size failure,extra heater failure	Been in use for too long	Maintenance check at the start of the series, Error detection system				
	Herlite tube broken	Form failure, size failure,extra heater failure	Impact in warehousing, impact during loading	Maintenance check at the start of the series, Error detection system				
	heater dislocated	Form failure, size failure,extra heater failure	Impact in warehousing	Maintenance check at the start of the series				
Mould, size indicator	Warped	size failure	Impact in warehousing, impact during loading	Maintenance check , each shift				
Mould, insulation	Wool: not white	Surface shape issues, curvature issue, laminate gap issue	Been in use for too long	Maintenance check at the start of the series		Create visualized parameters for wool change , implement and audit (documented)	Process improver, first operator	
	Wool: wrong size	Surface shape issues, curvature issue, laminate gap issue	Insufficient instructions for the wool size for the mould maintenance operator	Maintenance check at the start of the series		Create visualized product related instructions for the wool size, implement and audit (documented)	Process improver, first operator	
	Wool: wrong place	Surface shape issues, curvature issue, laminate gap issue	Insufficient instructions for the wool placement for the mould maintenance operator	Maintenance check at the start of the series		Create visualized product related instructions for the wool placement, implement and audit (documented)	Process improver, first operator	
Mould, glass support	Middle support wrong height	Breakage in the process, form failure, laminate gap issues	Adjustment failure	Maintenance check , each shift				
	Hinge support wrong height	Breakage in the process, form failure, laminate gap issues	Adjustment failure	Maintenance check , each shift				

5.5 Standardized work defined

Chapters 5.3 and 5.4 presents several possibilities what can be chosen for the standardized work. Team decided to go forward with five different actions. Selected work included:

- Monitoring the condition of the bending tool (stick)
- Monitoring the maintenance of the bending tool (mould)
- Monitoring the condition of the furnace resistors
- Monitoring the condition of the furnace (insulation)
- Monitoring of the mould insulation condition

These requires clear set of instructions of when or how often these are done, how this is done, who will do these and what is the criteria to separate good result from the bad. These detailed instructions are not in the scope of the thesis work but are essential for the project to succeed for the parts of training and understanding the results from the audits.

5.6 Management routines defined

During the thesis work first operator job description was updated to 2020 version from the 2004 version. This was made to respond more of the current needs. Chapter 4.1 presented first operator diary study and average time used to these duties was 13,3% of the 8-hour shift. This amounts to roughly 64 minutes. Mann (2005, 33-34) suggests 80%-time allocation for the first tier of management as can be seen in the table 2. This results to 384 minutes. This journey from 64 minutes to 384 minutes takes longer time than with in this thesis work is possible to monitor but with gradual incremental changes in the future this can be achieved.

From the first operator diary study analysis rises shift change as the most time-consuming activity as can be seen in the figure 23. Even though this is highly proactive, still the team considered this daily average twenty minutes time usage to be a bit too much. Furthermore, from the interviews analysed in the chapter 4.3 it is evident that

development toward communicating inner shift issues to shift operators is needed. Agenda for the shift change is revised to contain results from the shift, line break-downs, if there is a need to assist with the upcoming products, yield and safety issues raised inside the shift. Mann (2005, 70-71) suggests shift start meeting for the layer one but the team decided that it would be better if the information from the issues is delivered one on one basis for the purposes of open discussion to be much more fruitful with less participants. Of course, shift start meetings with more participants can be the next step in the lean process. Important aspect here also is that issues are raised on the visual board by the first operators for the follow-up and with this it is easier to assign daily tasks. Routine tasks defined in chapter 5.5 for the first operator includes bending tool audits for the stick and mould maintenance which also takes account the condition of mould insulation and furnace resistor check.

Team leader diary study presented in the chapter 4.2 revealed that there is almost 50/50 split for the reactive and proactive time use. Proactive manning and field supervision had high minutes as well as reactive problem solving. From this point of view the optimal direction is to transfer minutes from reactive problem solving to proactive field supervision containing standard work management audits with the first operator to make sure that the level in the audits are what is required to sustain appropriate level in the work. Daily accountability meetings with the first operators are in an important role to keep things moving forward. Additionally, 24-hour plan for the first operators is revised for assistance need with the upcoming products. Monthly review for the furnace condition with the maintenance personnel needs to be established.

Group leader time usage was not in the scope of the thesis but as Mann (2005, 33-34) emphasizes in the table 2 that 25% of the daily worktime should be allocated to standard management. This amounts up to two hours daily contribution which gives 30-minutes to each production department. In this case this 30-minutes contains daily accountability meeting by the visual board with the team leader. 24-hours result overview and actions if needed derived from these results. Furthermore, as weekly Gemba with the team leader at least one hour is allocated. Safety and departmental 5s as well as selected standard management work audits are included in this walkabout.

5.7 Kaizen efficiency

Performance level measuring as in departmental KPI is more efficient if there is possibility to measure inputs instead of the outputs. As mentioned earlier in the chapter 3.1 one of the markings of the proactive company is the amount and detail of the recordings they keep. So, there are bound to be problems and the need to counter. Efficient organization can tackle the problems as they come but resource allocation and coaching are easier to handle if there is detailed knowledge of the efficiency. Figure 30 shows simple formula that can be used to determine efficiency for the selected period. Kaizen efficiency in this sense can be continuous improvement meter for the first management layer.

Problems countered and recorded / *Problems raised and recorded*	=	*Kaizen efficiency as in percentage*

Figure 30. Formula for the kaizen efficiency

6 IMPLEMENTATION PHASE

Definition of the standard work and management routines has been done and next step is to train the involved personnel to uphold the new activities and standards. Transparency and accountability are the key issues in lean methodology as presented in the chapter 3.2. To accomplish this information center and meeting area is needed. Transparency for the activities and results in this meeting area are the key for successful accountability meetings. Without transparency it would be impossible to uphold discipline to keep activities ongoing.

6.1 Visualization of the new operations

Figure 31 presents meeting area of the shaping department. Shift change and the shift start meetings are done here as well as all the daily accountability meetings. There is information about the shift pieces, yield, productivity, and line uptime. Continuous improvement action lists are separated as maintenance actions, safety actions, and yield actions. Audit results are presented in this area also.

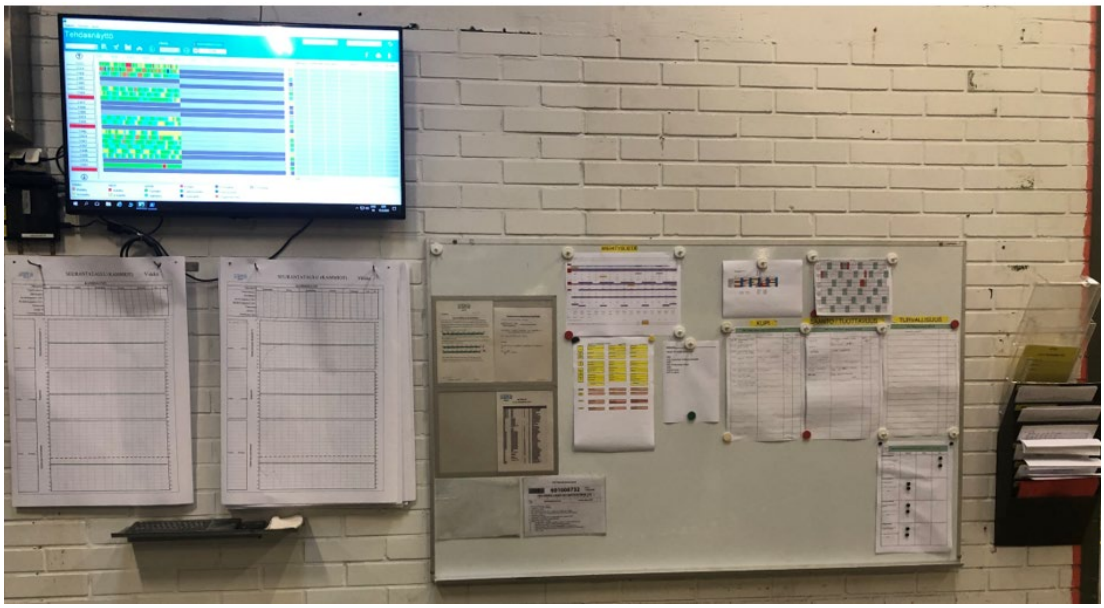

Figure 31. Shaping shift change and meeting area

6.2 Training system

Before training can start there is need to have instructions. Preferably visual operating procedure. This makes training easier and operations standardized. Standardized work gives predictable results as stated in the chapter 3.3. As management wise this makes the management audit results to be trustworthy and therefore results can be used as guidelines when planning new set of actions. Coaching system is used to solidify the procedures and making the change resistance easier to overcame. “A leader is one who knows the way, goes the way, and shows the way.” (Maxwell).

6.3 Training outlines

Kick off meeting needs to be arranged where all the parties are present. This includes first operators and team leader as well as departmental process improver. This must be done to clarify the target and allow group discussion to dissipate change resistance. So, in this type of meeting everyone can voice their doubts and that gives possibility to explain and to counter those doubts.

Coaching is a journey where there is possibility to have learning for all the participants. Best part for this is that mentoring skills advance by doing and by advancing one’s own skills and the skills of the apprentice advances at the same time. As mentioned in the chapter 5.6 the group leader time allocation contains weekly Gemba walk. This is the best forum to initiate training for team leader concerning the selected standard work management audits. During the Gemba, selected targets are audited, and this makes sure that team leader is on the same level of the execution of the task as well as how the results are interpreted. Repeating these audits, week after week will keep focus on the determined targets. Same time team leader coaches first operators the same way and this will make organizational change and have lasting effect. Discipline as the fourth principle in the lean system is required in this stage and according to Mann (2005, 21) without discipline even good systems will bring bad results. Daily account-ability meetings within the visual board meeting area with the group leader and team leader gives experience to both parties which evolves to more efficient meetings in the future. Team leader can use this gained experience to challenge the first operators with

daily assignments and to gain understanding of the current situation with the given tasks.

7 JUSTIFICATION FOR THE SOLUTIONS

A3 sheet that was presented in the chapter 3.5.5 is not in use as such in this but the philosophy behind the Deming cycle is present for the whole thesis work in a larger scale. Figure 12 showed generic process continuous improvement model and as can be seen in the figure 32 the model divides into clear phases. Planning phase in the thesis includes theory and current state investigation as well as use of lean six sigma tools to define critical standard works. These are presented in the chapters three to five. Do phase includes visualized control systems which are trained to involved personnel. Chapter six presents this and the most important part in any project is the evaluation of the actions done. Justifications done in this chapter counts as check phase. Timetable for the thesis makes this part a bit harder since the timeframe from implementation to evaluation is out of necessity just a few weeks. Although indicative information can be acquired from shorter periods of time and used to define success rate for the project.

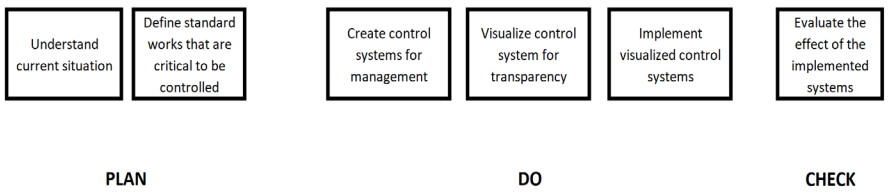

Figure 32. Thesis work PDCA process first three phases

This chapter contains comments on established audits and evaluation of audit results. Comments continuous improvement as kaizen activity, and secondary level yield analysis for the selected period.

7.1 Audits and results

Kick off meeting with all the involved parties was arranged and the initial ideas for the audits presented. In this meeting the internal interview results from chapter 4.3 were presented also for the interview target group first operators. Meeting was done in good spirit and as a result there was agreement for the next steps. Team was able to make

better suggestions within the meeting to improve some of the audit structures and documentation. This meeting had great importance in overcoming the change resistance which is very important aspect in any project and especially in any Lean project.

First item audit for the bending stick condition was decided to be made once in a week per first operator which resulted to be six weekly audit events. Appendix 2 presents audit form for this activity. Audit is to be made by the first operator with the furnace operator present. In one audit event since there is 18 furnaces in the area and twelve operators there is then in one event twelve separate discussions about the conditions of the tools used. Weekly period contains therefore 72 discussions. In one furnace there is four separate bending tools (sticks) and the maximum amount of these tools audited is 72 in one event and when done six times in a week this will result as 432 tools checked. As a learning possibility for the target population and for assured quality of the tools used this amount is sufficient to increase the level of the operator knowledge and keep the quality level of the tools very good. After audits the results are visible in the meeting area board. This transparency creates positive activity towards desired goal since all operators now can see if one area fails in the audit.

Above mentioned figures represent activities done when operating in full capacity however during the thesis work global pandemic was affecting operations and this maximum potential was not achieved in the implementation period. In the selected period, which was roughly five weeks the audit event number reached was 23. During these events number of discussions between first operator and furnace operator was 161. Number of bending tools (sticks) checked were 976 in total. From these 903 were deemed to be in good condition and 73 were in bad shape and operator was instructed to make immediate change. This, when considered whole five weeks period as one entirety means that 7,5% of the time operators are using these tools and it will have negative effects on the productivity and yield. However, during the selected period, the systematical training and audits had the effect of improvement. This means that first two weeks contained most of the rejected tools and then significant improvement were visible.

Second item furnace resistor check was agreed that once a week is sufficient check rate. During the implementation of this process check team had to create check program for this purpose and train it to area operators. At start of the activity this was done at the start of the work week but it was not the best time for this type of activity since if there is failure found then it will take production time as long as the repair time is and this has negative effect on the productivity. This is a good example of the PDCA process since there was a PLAN to do this at the start of the week then in the DO phase team started the activity and in the CHECK phase the team understood that activity timing was not the best possible. Then this was planned second time and the activity time was moved to the end of the week which gave maintenance to plenty of time to make repairs without compromising productivity. Appendix 1 presents audit form for this activity.

This activity was agreed to only for the active furnaces at the end of the week and operators do the test and inform first operators which document the results accordingly. Although maximum check sum is 90 from the period and that is when department is working full capacity, but we reached check sum of 54 for the reasons mentioned in the previously in this chapter. From these 54 furnace checks operator found five times resistor failures giving 9,3% chance that furnace is operating with diminished capability and could affect departmental yield negatively. These failures are much harder to detect without making separate test and since deterioration of the resistor is impossible to measure and resistor failure happens most of the time randomly. So, this was good improvement because it saves material and work costs and department do not lose production time and that way decrease productivity.

Third item mold maintenance as a topic was judged to be that large entirety that team decided to open separate project. Project was led by the process improvement engineer associated to the shaping department. During the project all the operating procedures regarding the maintenance of the mold were audited and revised as needed. Then operators working in this field were trained by the process improver and during the training key points for the upcoming audits were defined. After definition first operators were trained also by the process improver to have proper understanding of the contents of the audit. Coaching method was used in the initial trainings. Twelve items crucial for the mold condition were found and the audit was decided to be from the actual

maintenance while it was done. For the audit interval team agreed that once per week for one operator which results six audit events in a week. Visual A3 sized instructions for the twelve items were laminated and put to the work area to be reminder of the importance. Appendix 3 presents audit form for this activity.

This time frame consisted twelve audit events and therefore 144 items. From these 144 items there was 11 items that was deemed to be outside of operating procedure parameters. This gives 7,6% possibility that in the shaping process there is critical failure with the mold and that can have negative effect on the departmental yield. So, from this it is easy to deduct that there is need for this type of activity to make sure that adequate level of the maintenance is kept, and the work is done properly.

Fourth item was separated project from the mold maintenance concerning condition of the wools installed in the mold. This project was led by the team leader of the area and executed by the operators in the mold maintenance. This included audit for the 150 key product molds with highest sales volume. During the auditing, system of the wool placement and size documentation were created, and this produced 120 document sheets. These are now available for the operators in the work area and documents are also in pdf format in case something happens to paper copies. Also, this brought also mass improvement for the level of this wool quality. This activity as itself was one time but the system to implement document when new high demand products emerge to production needs to be created. Appendix 5 presents audit form for this activity.

Fifth item was furnace condition. This activity started with initial check for all furnaces and during this tour, audit sheet for further purposes was created. People involved here were dedicated process improver, team leader, and representative of maintenance department. It was decided that after these maintenance requirements found in the initial check separate action list was created and after these actions are done then preservation of the acquired level is handled with extra audits. Appendix 4 presents audit form for this activity. Initial action list has been handled and team is ready to start monthly audits. At this point there is no collected data to present within the thesis work.

7.2 Key performance indicators follow-up

Kaizen efficiency follow-up was not implemented within this thesis work. This is one of the development points yet to be implemented in the future. Activity of the shop floor operators gives management good possibility to enforce positive behaviour which in turn has positive effect on the departmental KPI's and just as well for the attitude of the operators.

Time frame of the implementation was seven weeks. During the seven weeks period the actual training for the actors were done. For evaluating this same period is used. Since initial data was from the 31 weeks period and within this section data is only from seven weeks there is need to modify collected data to match. This makes the comparison possible. Seven weeks needs to be multiplied by 4,4 to achieve 31 weeks and this gives matching period. As an example, department had in seven weeks period ten form failures. Now this is multiplied by 4,4 and which makes total 44 form failures. So, now this can be compared to previous data for the ratio and deduct if there was improvement or not. As stated previously in this chapter, this is only indicative information since issues are not that linear to predict.

Overall reduction in the amount of total rejects by the categories presented in the figure 33 were 27% compared to previous data. This means that for every hundred pieces scrapped within this period, 27 were saved and again compared to previous data. Departmental overall yield which was not presented as such in this thesis work had positive upward change and that supports data presented here. Breakages in the process, scratches and mould marks, and surface shape issues are not showing that much improvement. Due to error margin for the interpretation of the data, these can be deducted to be stagnant compared to previous data. However, other items in the figure 33 are having wider gap to previous data and showing good improvement.

	Secondary reject type	*Improvement %*
1	Breakages in the process	7,0 %
2	Form failure	55,6 %
3	Size failure	58,6 %
4	Laminate gap issues	57,3 %
5	Scratches and mould marks	-1,1 %
6	Dropped from mould	67,5 %
7	Curvature issue	53,3 %
8	Extra heater issues	144,6 %
9	Homologation issues	110,6 %
10	Surface shape issues	0,5 %

Figure 33. Secondary reject improvement

8 CONCLUSION

Final phase in the PDCA is act and this stands for the standardization of the routines. New operations have been evaluated and decisions been made. Yet, it is good to remember that standardized routines are only the first step in the lean and continuous improvement journey. In this chapter contemplation of the work done is presented. Questions to be answered are:

- Did the thesis achieve the goal that was set?
- Were all the predetermined research questions answered?
- What was good and what was challenging in the implementation?
- What is the next step in lean journey?

8.1 Outcome of the project

Main question and sub-questions in the chapter 1,5 are the ones that has been agreed with the commissioner. If thesis work deals with the predisposed questions, then outcome should be sufficient for the commissioner. Main question was, what should be standard work in the production for the leading personnel in different levels? This can be answered through answering all the sub-questions.

Diary studies done answered two of the sub-questions. Where is the time used? and how much of that use is reactive or proactive? Studies give clear picture and to these perspectives and if there is need in the future it is possible to make same kind of study to the same target groups. This makes easy to compare studies and see how the time use have changed and if it is positive or negative change. Also, this model can be used similar target groups in the company to determine time use.

Definition done with the lean six sigma tools answered the question of how are we able to define standard work as in terms of management actions? Route from cause and effect diagram to failure mode effect analysis give the tools to define the most important tasks and this way to make sure that every minute counts towards proactive

environment. This serves as a roadmap for everyone trying to achieve the same goals. Easy to implement to another department, only requiring time.

Transparency is one of the cornerstones in Lean method and for this reason one of the questions was how to monitor standard routines. Chapter 6,1 presents team meeting area where audit forms are visible. This makes managing the auditing less challenging since the data is easily available. Added advantage is that all the operators are aware of these audits and results which in turn makes operators to try to be even better with chosen standards. This makes progress easier.

Implementation was planned and training plan was devised. Actual training was done by coaching method and before this all, required operating procedures were audited and updated if there was a need.

At the start of the project one of the questions was that how we can be sure that the right routines are chosen. Chapter 7,1 and figure 33 data presents results, all though indicative ones. These results show that improvement has been achieved. So, from this it can be deducted that we have at least some of the right routines but obviously there is still much to understand.

8.2 Evaluation of the implementation

This project started on early days in June 2020 and in December 2020 it is done. This has been almost seven months journey which has been entertaining and educational time. There is no harder challenge than to get the people see the goal as one sees it. Same time there is no greater reward when one is successful and even greater satisfaction is that when the whole team can enjoy for the success. Superior positivity is the first thing that comes to mind. Everyone involved in these tasks have been committed 100% and with the positive attitude. Active information flow and steady stream of meetings have made change resistance almost non-existent. As have been stated before operators, team leader, and dedicated process improver even gave improvement ideas in the implementation phase. Biggest challenge in this project was global situation due to covid-19 pandemic and therefore departmental workload was significantly less than

within normal year. This made stretches to original thesis time plan and some of the ideas that was originally included in the contents were left out. However, all the items required to achieve goal for the thesis work are present.

8.3 Recommendations for further studies

This project offered narrow view into very wide field. To evaluate all the critical aspects even in one production department is an enormous task. Given the time and resources this is a viable way to define all the pressure points and achieve lasting improvement. Systematical Lean approach from all angles is nevertheless something that should be considered. Small investment in the present can produce better results for the future. There are few aspects that were left out of the scope of the thesis work but still these need to be done. Kaizen efficiency as shop floor activity being one of those and interdepartmental meetings between first operators in the shifts.

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APPENDIX 1

Furnace resistor weekly audit sheet

Week	**Resistors**	
xx	*OK*	*NOK*
Furnace 1		
Furnace 2		
Furnace 3		
Furnace 4		
Furnace 5		
Furnace 6		
Furnace 7		
Furnace 8		
Furnace 9		
Furnace 10		
Furnace 11		
Furnace 12		
Furnace 13		
Furnace 14		
Furnace 15		
Furnace 16		
Furnace 17		
Furnace 18		

APPENDIX 2

Bending tool (stick) weekly audit sheet

Week	**Audit 1 (stick)**		**Audit 2 (stick)**		**Audit 3 (stick)**		**Audit 4 (stick)**		**Audit 5 (stick)**		**Audit 6 (stick)**	
xx	*Good*	*Bad*	*Good*	*Bad*	*Good*	*Bad*	*Good*	*Bad*	*Good*	*Bad*	*Good*	*Bad*
Furnace 1												
Furnace 2												
Furnace 3												
Furnace 4												
Furnace 5												
Furnace 6												
Furnace 7												
Furnace 8												
Furnace 9												
Furnace 10												
Furnace 11												
Furnace 12												
Furnace 13												
Furnace 14												
Furnace 15												
Furnace 16												
Furnace 17												
Furnace 18												

APPENDIX 3

Bending tool (mould) weekly audit sheet

Week	Audit 1 (mold)		Audit 2 (mold)		Audit 3 (mold)		Audit 4 (mold)		Audit 5 (mold)		Audit 6 (mold)	
xx	*OK*	*NOK*	*OK*	*NOK*	*OK*	*NOK*	*OK*	*NOK*	*OK*	*NOK*	*OK*	*NOK*
item 1												
item 2												
item 3												
item 4												
item 5												
item 6												
item 7												
item 8												
item 9												
item 10												
item 11												
item 12												

APPENDIX 4

Monthly furnace audit sheet

NOK - scale: 1 = not that bad, 3 = bad, 5 = extremely bad

Furnace		Wagon floor insulation		Edge insulation top		Edge insulation wagon		Wagon weldings		Ceiling insulation		Furnace windows		Hatches	
		OK	NOK	OK	NOK	OK	NOK	OK	NOK	OK	NOK	OK	NOK	OK	NOK
1	A														
2	A														
3	A														
4	A														
	B														
5	A														
	B														
6	A														
	B														
7	A														
	B														
8	A														
	B														
9	A														
10	A														
	B														
11	A														
	B														
12	A														
13	A														
	B														
14	A														
	B														
15	A														
	B														
16	A														
	B														
17	A														
	B														
18	A														
	B														

APPENDIX 5

Mould wool condition audit sheet

		Wool			Symmetricity R/L		Teared		Darkened	
	Product	*None*	*Middle*	*Edges*	*OK*	*Nok*	*OK*	*Nok*	*OK*	*Nok*
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
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