Project of Production Process Improvement in Company "SAAS TEKS INVEST" Ltd

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MASTER'S THESIS ASSIGNMENT

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Thesis Guidelines:

Introduction

Define the objectives and the application methods used in the Master thesis.

I. **Theoretical part**

- **Compile literature review focused on research related to Production Process Improvement.**

II. **Practical part**

- **Analyze production process of Company SAAS TEKS INVEST, Ltd and identify the main areas that could be improved.**
- **Prepare a project of improving production process in Company SAAS TEKS INVEST, Ltd based on the results of previous analyses.**
- **Evaluate presented proposals economically.**

Conclusion

Thesis Extent: **cca 70 stran**

Appendices:

Form of Thesis Elaboration: **tištěná/elektronická**

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BURTON, Terence T. Accelerating Lean Six Sigma Results: How to Achieve Improvement Excellence in the New Economy. 1st ed. Fort Lauderdale, Florida: J.Ross Publishing, Inc., 2011, 397 s. ISBN 978-1-60427-054-9.
COX, James and SCHLEIER, John. Theory of Constraints Handbook, Penn Plaza, New York: McGraw-Hill, 2010, 1147 s. ISBN 978-0-07-166554-4.
OAKLAND, John S. Total Quality Management and Operational Excellence. 4th ed. Third Avenue, New York: Florence Production Ltd., 2014, 521 s. ISBN 978-0-415-63549-3.
SALVENDY, Gavriel. Handbook of Industrial Engineering. Volume 2. 3rd ed. Hoboken: John Wiley & Sons, 2001, 2140 s. ISBN 978-0-470-24182-0.
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Contents

ABSTRAKT

Czech abstract

Cílem diplomové práce je analyzovat výrobní proces společnosti SAAS TEKS INVEST, Ltd a identifikovat hlavní oblasti pro zlepšování. Práce je rozdělena do dvou částí, teoretické a praktické. Teoretická část obsahuje informace o základních termínech vztahujících se k oblasti řízení výroby, produktivity, nástrojů štíhlé výroby, měření práce a zlepšování výrobních procesů. Praktická část se skládá také ze dvou částí. První část obsahuje popis aktuálního stavu ve společnosti, struktury řízení, hlavních aktivit, analýzu výrobního procesu a příslušné výpočty. Druhou částí je projekt s řešením pro zvýšení produktivity, založeném na analýze a výpočtech v analytické části práce. Praktická část se zaměřuje na využití nástrojů štíhlé výroby jako eliminace plýtvání, zlepšování procesních toků, standardizace práce, vizualizace, 5S nebo diagram rybí kost.

Klíčová slova: produktivita, zlepšování procesů, redukce plýtvání, teorie omezení, štíhlé řízení, 5S, vizualizace, diagram rybí kost"

ABSTRACT

The aim of this master thesis is to analyze production process of Company SAAS TEKS INVEST, Ltd and identify the main areas that could be improved. The thesis is divided into two parts, theoretical and practical. The theoretical part provides information about terms related to manufacturing, productivity, lean tools to improve productivity and work measurement. The practical part is divided into two parts. First part is a description of current situation at the company, management structure, the main activities, production process analysis and calculations. The second part is a project with solutions based on analysis and calculations in analytical part for an improvement of productivity. The practical part is focused on using lean tools such as waste elimination, creating flow processes, standardized work, visualization, 5S and fishbone diagram.

Keywords: Keywords: productivity, process improvement, waste reduction, theory of constraints, Lean Management, 5S, visualization, and fishbone diagram.

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INTRODUCTION

"We are creating a powerful textile and light industry sector. Moreover, we should integrate in the world market as other developed countries with the finished products excluding raw cotton", I. A. Karimov, President of the Republic of Uzbekistan.

As our president stated, we should pay attention on producing and exporting finished textile products rather than exporting raw cotton. It is no secret that textile industry plays major role in many developed countries as well as in developing countries. Uzbekistan is one of the fast paced developing countries in many areas. Textile industry is one of the areas of rapid development. One of the main reasons for development of cotton and silk traditions in Uzbekistan was Great Silk Road which connected Eastern Asia with Europe. Uzbekistan is the 6th largest producer of cotton in the world and exporting over 1 million tons of cotton a year. There are a lot of opportunities to develop this industry, and the government highly supports this area in many directions. As a result of reforms, yarn and grey cloth production is rising and being exported to mostly Eastern European countries and Russia. Finished textile products are exported to over 50 countries over the world.

As a result of the implementing in the industry of high-performance modern technology, export of textile products increased 120 times and the results of 2014 remained at the level of € 1 billion compared to € 7 million in 1991.

As it was discussed above, development of textile industry is vital for the economy of my country. Therefore, I have chosen one of the developing textile companies for my internship.

In this thesis, I will analyze production process of the company "SAAS TEKS INVEST" Ltd and identify the main areas that could be improved. Then, prepare a Project of Production Process Improvement in the company based on the results of previous analysis. Finally, I will evaluate presented proposals economically.

OBJECTIVES AND METHODS OF MASTER THESIS PROCESSING

OBJECTIVES

The aim of this thesis is to analyze production process and identify main areas that could be improved at SAAS TEKS INVEST LTD., one of the successful textile factories in Tashkent, Uzbekistan. Being more specific, the objective is to increase productivity approximately to 11 % by reducing waste to 38%. Reducing waste is reached through optimization of production machine.

Research questions are:

1. What is current situation in production like in the company?
2. What should be done to improve productivity by certain percentage?
3. How is the goal achieved?
4. What is expected estimated output of the project?

METHODOLOGY

In this thesis, data obtained from different reliable sources was used. Researcher uses different methods to reach the goal of the project. First, method of snapshots is used to understand whole shift procedure. Second, flow diagram is used to describe activities and main problems in the process. Third, visualization and standard work, 5 S, and waste elimination methods are used to improve productivity of operators and machines. Finally, risk, cost, and time analysis are done to evaluate the project. Time analyses are measured using CPM and PERT methods.

I. THEORY

1 MANUFACTURING PROCESSES

1.1 MANUFACTURING TODAY

"The Four Keys of Great Managers: (1) When selecting someone, they select for talent … not simply experience, intelligence or determination. (2) When setting expectations, they define the right outcomes … not the right steps. (3) When motivating someone, they focus on strengths … not on weaknesses. and (4) When developing someone, they help him find the right fit … not simply the next rung on the ladder." -Marcus Buckingham

Today's business world is very competitive. Resources you have for production such as raw materials, goods and other resources are not unlimited. Therefore, using inputs wisely in manufacturing is really important these days. English dictionary defines manufacturing *as making goods or wares by manual labor or machinery, especially on a large scale* (www.ditionary.com). It is a system of "things" that work together to control what is done where, by who, using what set of resources (machines, tools, and materials), at what time, and in what quantity (Kenneth N. McKay, 2011).
Manufacturing is derived from the Latin word manufactus, which in translation into English means made by hand. Nowadays manufacturing involves making products from raw materials through usage of various processes, making use of hand tools, machinery including computers. Therefore manufacturing is believed to be a study of processes which require making parts and assembly in machines. (Kenneth N. McKay, 2011).

1.1.1 History of Manufacturing

Prior to Industrial Revolution most people were busy with making products and goods by use of hands. Industrial Revolution has change manufacturing system totally. The dramatic change was usage of machines in shorter time rather than usage of hands, and using less labor but more machinery. Textile manufacturing, glass making, mining and the agriculture industry all had significant changes in the late XVIII century resulting in a sudden increase in demand which in return allowed manufacturers to open new factories. Rapid development was seen in textile industry in the USA. Factories employed men and women, and some of them employed children as well. However, in 1833 The Factory Act was established to protect children rights and limit their working hours (Jeannine Mancini, 2015). Crucial role in development of manufacturing played Henry Ford and Charles Sorensen who were fathers of automobile industry. They arranged key elements in the manufactur-

ing such as machines, tools and people in manufacturing first automobile called *Model T*. The idea of Ford was to create an assembly line for each employee in the factory to ensure fast and efficient way to make cars. Ford organized all the job and tasks among employees in a very efficient way which helped him to make 15 million cars in 19 years and each of his employees could afford buying his car as they had enough money to do so (Jeannine Mancini, 2015).

1.1.2 History of Lean Manufacturing

The birth of lean was in Japan with Toyota in 1940s when The Toyota Production System value of product to the customer was the main priority. The main goal was to produce continuously only using small fraction of time. The Toyota Production System's way was absolutely opposite to the way Western companies which were using mass production based around materials resource planning (MRP) and additionally they were using complex computerized systems of mass production. Western companies were producing mass production with standardized products with minimum changes in production (T. Melton, 2008). One of the pioneers of The Toyota Production System was Taiichi Ohno who had a considerable share in the development of the system. He spent almost 40 years of this life in developing TPS. The main key elements and techniques such as Kanban (approach which distributes people who are involved in process with full view of process starting from task definition till the end customer), 5S (a method of workplace organization), Visual Control (instead of using text or written instructions, information is messaged using visual signals), SMED (lean tool used to reduce waste in production), and Poke Yoke (an error proofing technique) were main parts of lean system.

The Benefits of Lean Manufacturing

	Mass production	Lean production
Basis	• Henry Ford	• Toyota
People–design	• Narrowly skilled professionals	• Teams of multi-skilled workers at all levels in the organization
People–production	• Unskilled or semi-skilled workers	• Teams of multi-skilled workers at all levels in the organization
Equipment	• Expensive, single-purpose machines	• Manual and automated systems which can produce large volumes with large product variety
Production methods	• Make high volumes of standardized products	• Make products which the customer has ordered
Organizational philosophy	• Hierarchical—management take responsibility	• Value streams using appropriate levels of empowerment—pushing responsibility further down the organization
Philosophy	• Aim for 'good enough'	• Aim for perfection

Figure 1**:** Two production systems compared **(**Source: T. Melton, 2008)

Comparing these two systems, it can be seen that Lean Production has several advantages such as Team oriented approach, where all the members of team help each other to achieve main goal, perfection. Being more varied in terms of products also gives advantages for Lean Manufacturing. Additionally, making production according to volume ordered by customer ensures that all products would be sold out increasing profit of the companies.

1.1.3 Five Types of Manufacturing Processes

Meaning and history of manufacturing processes were discussed above. Now we have some idea of what manufacture is, when and where it originated basically. However, when it comes to types of manufacturing processes, many people have different opinions. Even some engineers working in companies can't say what type of manufacturing their company uses. Manufacturing processes can be divided into five following categories (Bradford L, 2015):

1. Repetitive
2. Discrete
3. Job Shop
4. Process (continuous)
5. Process (batch)

These days most of the companies are using either one of those or using them as combined. Here is a brief explanation of each MP below.

Repetitive manufacturing is saying by its name that it could be used to plan and control production in repetitive manufacturing such as automobile industry, for example. The main goals of this type are to create production quantities on a period and quantity basis and reduce production control effort. This type of MP can be used if the company manufactures the same type of products in the long run, total quantity of products are manufactured, and if the company has the same technique or sequence to produce its goods (SAP AG, 2001).

This approach is very fast and highly efficient thus could be used in medical supplies, food products, electronic appliances, and some automobile assembly lines. Companies can easily change volume of manufacturing depending on market conditions. The core of production stays unchanged while some specifications and adaptations can be changed depending on demand. Repetitive manufacturing is very beneficial for small companies to use as it

doesn't require a lot of production machines to buy. They can simply operate with the same type of machines and produce high volume of production.

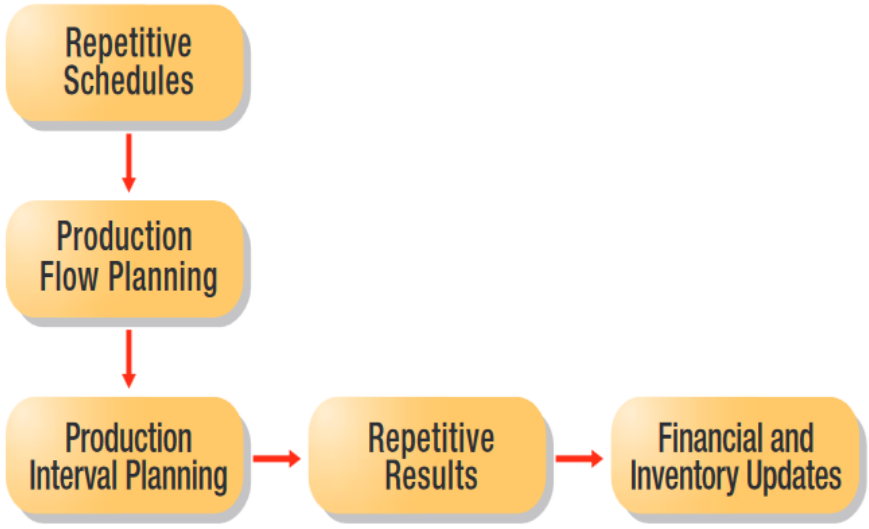

Figure 2: Repetitive Scheduling (Source: www.fujitsu.com)

This Scheduling system can make high volume or continuous flow production very flexible. As a result, this gives opportunity to cut down on lots of paperwork.

Discrete manufacturing is production of distinct items and considered to be very diverse, and it covers from low to high volume of setups and changeovers. The products made using this approach can be highly alike or different (Bradford L, 2015). Automobiles, toys, furniture, smart phones, and airplanes could be very good example of discrete MP. This type of manufacturing is characterized by following strategies (JD Edwards, 2013):

- Make-to-stock or highly repetitive which could be based on work orders
- Make-to-order which requires to make products depending on order
- Assembly-to-order is a model of warehouse operating when order is placed then products are assembled by their components

As it can be seen above, this approach is quite complex and can be used in global companies to produce mass production items. Units can be manufactured in low volume with high complexity or high volume with low complexity (JD Edwards, 2013).

Job Shop manufacturing type doesn't usually have a production line. This method could be used with production areas in the company. The area specified for production may produce one type of product or it could be couple versions, either dozen versions of products

manufactured in the area (Bradford L, 2015). Once job is completed, job shops move to different jobs. For example, making parts to machines, boats, ships, and aircrafts by some companies could be good example of job shop. Individually taken Job Shop manufacturers can't produce complete products. If they need to produce complete products, they usually change into discrete manufacturing (A. Portioli and A. Pozzetti, 2003).

Process (continuous) is similar to Repetitive MP, however, process manufacturing usually produce liquids, powders, gases and such materials in this area. In this method production process could be extremely diverse. This method is also called Continuous production or Continuous flow production because materials that are produced under this method are always under some chemical, biological, mechanical or other continuous process. Some examples of continuous production method are the following (Bradford L, 2015):

- Oil refining
- Chemicals
- Fertilizers
- Gas processing
- Metal industry
- Power stations
- Synthetic fiber
- Pulp and paper

As production workers in this type operate 24 hours a day and 7 days a week, they work in rotating shifts.

Process (batch) is very similar to Discrete and Job Shop MP. It is similar to Discrete when one batch is needed to produce final product. If it takes more than one batch to produce final product then it could be similar to Job Shop. Sometimes production is made in sequence by making one batch after another. Other times, a group of products are finished, and then next group is started. (Bradford L, 2015) For example, a baker can bake first batch of his white bread. After that, he cleans his place and makes next batch of his brown bread. Batch production is really popular in bakery, paints, shoes, and drinks production.

We have discussed five types MP that are used in manufacturing these days. Some companies may use one of them individually; some other companies use them in mixture. This really depends on product type and design of production by management.

1.2 PRODUCTIVITY AND ITS IMPORTANCE

1.2.1 Historical Development of Productivity

Productivity is defined as outputs divided by inputs (Taylor, 1911 and Barnes, 1980). This term was suggested in 1800's, and it has been used in that way since that time. The outputs represent products and goods (and later services) produced or manufactured while the inputs are resources such as labors, materials, and machines. In general, people tried to generate all their inputs efficiently to get more output in the end.

Initially, productivity measurement and analysis focused on the individual level, especially at the assembly and production lines (Takala, Suwansaranyu, & Phusavat, 2006).

There was a high level of pressure for lowering production cost and increasing volume of final products. As a result, the connection with term productivity and business planning was created.

A boom in second industrialization revolution at the end of XIX century created an increase for basic goods such as growth in cotton and textile industry, tobacco and silk trading industry, and building shipping industry, and railway construction.

In the early 1900s there was a high competition among companies which resulted in higher demand to lower production cost. Conditions labors had at that time were not satisfactory with really low wages and unsafe working conditions. Labor union was formed to protect their rights. As a result, companies had to follow new regulations under which they had to pay high wages to workers, but could not increase production price. This was a real challenge for companies at that time. This in turn created a new term called Scientific Management which studied human motions, capabilities and limitations to increase productivity with higher output and lower input.

Productivity became a vital trend during World War II where by using limited resources (labors, materials and facilities) manufacturers had to produce high volume of was machines such as tanks, ships and aircrafts.

The efforts on eliminating the wastes such as waiting time, rejects, returns, rework, and work-in process constantly linked to productivity improvement. (Kongkiti Phusavat, 2013)

1.2.2 Importance of Productivity

Why is productivity important? Productivity is often misunderstood among people. Some people say it is the ways to work better, others say it is to be more efficient or produce

more with less. The productivity can be expressed simply in the following way: with our current resources, what can we produce and how much can we produce. So, relationship between these two (what is produced using what) helps us understand real meaning of it (Bernolak, 2009).

Productivity = Output / Input

For example, how many kg of fabric produced in one working shift? Let's assume that operator produced 200 kg of fabric in 8 hours. So, his productivity is 25 kg/hr.

However, there are many factors should be taken into consideration while talking about productivity. We can look at three following measures about productivity:

1) First measure considers how much of output can be produced using current machines and tools. A case above can be a good example for this.
2) Second one how much of output can be produced using current materials. For example, if a tailor has 20 meter of fabric, how many pieces of shirts can he make?
3) Third measure indicates how much electricity, water, and gas used to produce certain amount of products.

Understanding productivity is beneficial for the company as it generates profit. One way to measure productivity could be to compare current data with past data, and see the change in volume of production (Bernolak, 2009).

One more factor that makes productivity significant is a demand to produce more products using fewer materials. The companies are paying a lot more attention on this as market demand became really unpredictable. Advanced technology, IT, and automation of workplace improving productivity at some point yet there are many researches need to be done to actually measure the level of influence. As a result, multifactor productivity (MFP) term was accepted. This factor contains factors which affect productivity, but it doesn't take into account employees' skills growth. When there is new innovation, or change in processes, capital investment they all have level of influencing on productivity. Companies are using MFP to learn factors influencing productivity and working on improving productivity to be successful in this competitive market (Pritchard, Weaver and Ashwood, 2012).

2 LEAN TOOL BOX TO IMPROVE MANUFACTURING PROCESSES

It is no secret that TPS played a significant role in originating and developing Lean Management and Lean Tools which are commonly used these days. The tools are not difficult to understand and every employee or member of company is responsible in achieving target. Lean Tool Box has areas such as, Tools for Prioritization and Alignment, Tools for Quality, Tools for Seeing Waste, Tools for Eliminating Waste, Tools for Structure, and Tools for Design (Gabow and Goodman, 2014).

This Master thesis work is mostly about improving quality and productivity through Eliminating waste, so some elements of Tools for Eliminating Waste are discussed in this part.

2.1 WASTES AND THEIR ELIMINATION

2.1.1 8 Types of Wastes

For all managers in the organization it is important to understand each and every process, not only concentrating on manufacturing process, and the main aim is eliminate waste in all areas. In manufacturing waste is defined as any process or activity that adds cost to final product, but not value (Moore, 2007). Some managers don't see opportunities and miss them; as a result they lose an opportunity to make profit. This slack in Japanese means *mu da*, this is when the company wastes opportunities such as money, final outputs, time, information and others (Monden, 2012).

There are eight types of wastes recognized in Lean Management (Pereira, 2009):

1. Transportation – when goods or materials are unnecessarily moved within or outside of organization. They are always moved from one place to another, but when moving of such items doesn't add any value for production, then it is considered as waste. When documents or folders are transported from one corner to another corner of office or within departments, it usually causes office transportation waste.
2. Inventory – when organization has excess level of inventory meaning they have more than needed for their activities. For example, knitting factories need yarn to knit fabric, but when they have a lot of yarn which they don't use for a long time, that's a waste.

3. Motion – movement of people which doesn't add any value for production or services. This waste is usually confused with transportation waste. However, this type of waste occurs when people go from one place to another to do some tasks. The main difference from transportation waste is they don't carry goods or materials from place to place. For example, when operator of textile factory goes from one place to another just to sign that he completed a set of tasks, and he does it a lot of times during his shift.
4. Waiting – when people or machines are waiting for some other tasks to be completed. This is one of the wastes which lower productivity. For example, operator is waiting for yarns to be delivered to production floor. Unfortunately, he can't start his work without necessary inventory.
5. Overproduction – when company produces more than needed production. Companies produce high volume of production assuming that all of them would be traded. For example, textile factory produces 200 kg of fabric while only 100 kg was ordered. If nobody buys the other 100 kg of fabric, then it is waste. Companies can create waiting by overproducing as other orders should wait until production is free. As a result, one waste causes another one.
6. Over processing – processing beyond what customer requires. There is a difference between over-processing and overproduction. This waste occurs when company has some activities during process that is not requested by customers. It occurs when there is a change in production, and not all employees are informed about them.
7. Defects – non-confirming products or services. When companies don't meet customers' expectations, it is a waste. For example, a textile company quality department figures out holes or oil marks on fabrics.
8. Skills – not using people's talents and skills. Respect for people is one of the major principles of Lean. Sometimes company's take their employees' abilities, talents, and skills for granted. For example, one idea of a job operator can be beneficial for company. However, some companies don't listen to them. Sometimes employees leave their jobs because they have not been listened to.

2.1.2 Waste Elimination

Wastes exist, but company can take some steps to eliminate them. We can have a look at some strategies to eliminate waste from production.

Using some Lean tools such as SMED, Production leveling, and One-piece flow cells can eliminate overproduction waste. The most important strategy here is balancing between production and needs (Monden, 2012).

The company can take following steps to eliminate motion waste (Tetteh and Uzochukwu, 2014):

- Provide employees with training and improve their skills
- Use 5 S technique
- Increase awareness of their unnecessary movements
- Create regulations and instructions on work procedure
- Design and create U-shaped cells If possible

There are some strategies to remove waiting waste as following (Tetteh and Uzochukwu, 2014):

- Improve company's layout
- Create quick changeover procedure
- Use mistake-proofing systems such as poka yoke
- Regulate procedure for preventive and predictive maintenance

There are several other concepts that support waste elimination and improve productivity (Liker, 2011):

- Create a smooth flow of production. Variability of processes should be cut down. There should be an approach where all activities go in a smooth level excluding possible variations.
- Use pull system which focuses mostly on customer's current demand and market demand in order to avoid overproduction. Meet all expectations on time, not earlier and not later.
- As soon as quality problem is identified, stop production or other activities to avoid waste. Take all steps to solve the issue and then continue with current plan.

- Standardize work procedures to avoid misunderstandings and extra work by job operators. All job operators should know what standardized work they have and follow them as assigned by managers.
- Use more of visual controls to inform all level employees of work orders and procedures. When there is something hidden, that slows down production and create waste.

2.1.3 Standardization

Standard work is essential tool of Lean Elimination waste which provides detailed and concrete work procedures which should be followed by employees. If standard work is not followed or performed by personnel, this leads to generation of waste (Gabow and Goodman, 2014).

This Standard work is a helpful tool for improving and there are following seven steps to make work Standardized (Zidel, 2006):

1. Document reality. Managers usually go to work area or production floor to observe process with necessary documents to take notes, and write down the procedure.
2. Waste identification. After careful observation, using facts obtained, categorize all value added versus non-value added activities.
3. Make a plan. Discuss and brainstorm ideas of how to eliminate waste from production and make work more productive.
4. Implement changes into practice. Inform and train all job operators who are doing the job about changes should be taken to improve their productivity. It is important to be really detailed and concrete in this step.
5. Confirm that changes have positive effect. Visit production time to time to check if changes have been implemented and have positive effect on production.
6. Summarize benefits and advantages. Calculate benefits of changes in money, time or productivity improvement.
7. Sustain changes as standard procedure. Once changes make work place better, ensure that every employee is following them, and make regulations in respecting the changes to formalize them.

2.1.4 Visualization

When companies face with problems, it is really helpful to make it seen, to visualize, so problem could be analyzed. Visualization is a very helpful approach, and it can visualize the problem internally as well as externally (Sehested and Sonnenberg, 2010). For example, drawing machines and the way how they operate in practice is a good visualization process in a textile company. By this way, operators and managers are able to see what part of machine or job process is problematic and take steps to solve it.

There are many methods used in visualization process. One of the most commonly used methods is hour-by-hour production-tracking chart. This chart is very useful in organizations where they have assembly lines with steady production output with flow production implementation (Mann,2005).

Production Tracking Chart

Area: *B211 Assembly* **Date:** 4/27/04

TL: *Tina T.* *Takt: 60 sec.*

Pitch	Goal Pitch / Cumulative	Actual Pitch / Cumulative	Variation Pitch / Cumulative	Reason for Misses
7–7:30	20/20	18/18	-2/-2	10 min. startup mtg. *Meeting long 2 minutes–safety issue*
7:30–8	30/50	30/48	0/-2	
8–8:30	30/80	30/78	0/-2	
8:30–9	30/110	32/80	+2/0	*TL helped at station 5 for 6 cycles to catch up before break*
9–9:30	20/130	20/130	0/0	10 min. break
9:30–10	30/160	30/160	0/0	
10:30–11	30/190	27/187	-3/-3	*Container short three P/N 46230721–notified PIC*
11:30–12	/190	/187		30 min. lunch
12–12:30	30/220	30/217	0/-3	
12:30–1	30/250	30/247	0/-3	
1–1:30	30/280	30/277	0/-3	
1:30–2	20/300	20/297	0/-3	10 min. break
2–2:30	30/330	30/327	0/-3	
2:30–3	30/360	30/357	0/-3	
3–3:30	20/380	21/378	+1/-2	10 min. cleanup washup *TL helped sta 5, 3 cycle–want on-time finish*
3:30–4		2/380	+2/0	Overtime: Minutes, why? *2 min., made up for part shortage @ 10:30 pitch*
Totals	380/380		0/0	*Pretty good shift–external failure and recovered–minimal OT*

Note: Color codes used to indicate at, below, or above goal. In this black and white example, white background represents green for on goal, black represents red for below goal, and gray represents blue for above goal.

Figure 3: Production pitch-tracking chart (Mann, 2005)

The chart above shows production by half an hour, there is planned production, actual production and reason for the difference between them. Management may take some steps to improve productivity when they see what the main reasons are.

2.1.5 5 S Method

One of the popular Total Quality Management's (TQM) philosophy is 5 S. This method helps to analyze processes and their organization in company. Implementing 5 S in the company helps achieve goal towards having high effective, high quality, and clean work-place (Majernik, Daneshjo and Bosak, 2015). The philosophy originated in Japan and has 5 Japanese words meaning (Gabow and Goodman, 2014):

1. Seiri (sort) – sorting and organizing workplace and eliminating unnecessary materials from work area. The idea is only necessary tools and equipment should remain to have productive work.
2. Seiton (set in order) – After sorting all necessary materials, tools and equipment, they should be placed in right order and should not interrupt employees from working, and they should be in easily accessible place.
3. Seiso (shine) – Once all tools and equipment are set in order, workplace should be kept clean. Each employee should clean his work area after his working shift.
4. Seiketsu (standardize) – following regulations and rules for orders, and every worker in organization knows what his or her responsibilities are.
5. Shitsuke (sustain) – after everything is standardized and set in order, it is important to maintain standards and keep work area safe and efficient every day.

5S activities usually require a long term commitment and a lot of efforts. Usually result of 5S being successful or failing depends on management's attitude and initiatives. Job operators might learn implementing this method or importance of the method from their managers (Monden, 2012).

2.2 QUALITY MANAGEMENT

Quality is expressed in different ways by different people. If you ask 10 people, what quality is, you get 10 different answers. The reason is people understand quality in different ways. We can consider the following descriptions of quality:

- *A degree of excellence* – The Concise Oxford English Dictionary
- *How good or bad something is* – The Cambridge English Dictionary
- *Fitness for purpose* – Defoe and Juran (2010)
- *The totality of features and characteristics that bear on the ability of a product or service to satisfy a given need* – British Standard 4778 (British Standards Institutions, 1991)

- *The total composite product and service characteristics of marketing, engineering, manufacture , and maintenance through which the product and service will meet the expectations of the customer* – Feigenbaum (1961)
- *Conformance to requirements* – Crosby (1979)

Dictionary definition of quality means some general meaning of the word, but it doesn't specify areas of expectation. The most common understanding could be meeting expectations of customers. Defoe and Juran (2010) were defining quality in a short way saying that it should match of purposes. British Standards Institutions suggests deeper meaning of quality. Feigenbaum (1961) described that quality relies on different areas of company, and the final expectations of the customer should be met overall.

2.2.1 Quality Improvement Tools

Quality is one of the most important aspects in buying products these days. There are many ways how to improve quality. There is Seven Statistical tools used in Quality Management serve towards improving quality (Charantimath, 2011):

1. Pareto chart
2. Cause and effect diagram
3. Check Sheet
4. Histogram
5. Scatter diagram
6. Graphs
7. Control charts

2.2.2 Pareto Chart

In this part, Pareto chart will be discussed as it is used later in analytical part of the thesis.

The Pareto chart is also called as Pareto Diagram. A Pareto chart is a statistical bar graph, the length that represents frequency or cost, and it is organized with shortest graph to the right and longest to the left. This chart describes relationship between problems or conditions (Charantimath, 2011). Vilfredo Pareto (1848-1923) created this chart, and it was later adapted by Joseph M. Juran (1950) in Quality Management as one of the statistical tools. The meaning of Pareto chart is 20 percent of the causes 80 percent of the problems.

The following steps can be taken to formulate Pareto chart (Charantimath, 2011):

1. Make a list of activities in a table that should be analyzed.

2. Place activities in descending order.
3. Calculate total amount of the entire list.
4. Calculate percentage share of each item on the list from the total amount.
5. Make a cumulative percentage column.
6. Draw a chart with causes on X-axis and cumulative percentage on Y-axis.
7. Place a bar graph with causes on X-axis and cumulative percentage on Y-axis.

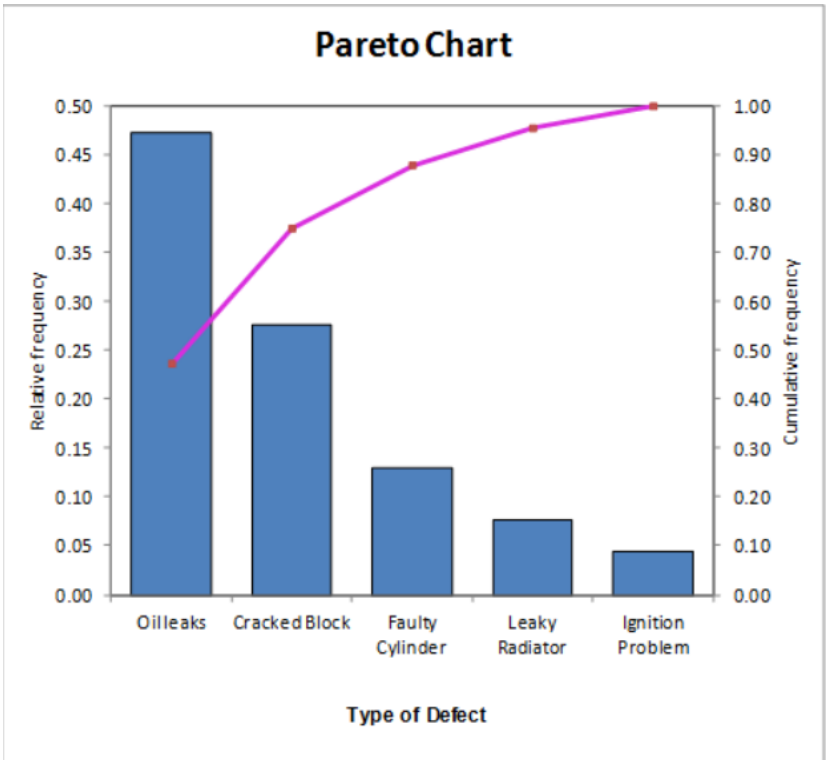

Figure 4: Example of Pareto Chart (Source: Foundasoft, 2016)

Analyzing Pareto charts would give some important information about observed data. Bar graph from the right to the left shows priorities of activities. It is important to recognize objective behind the analysis and use the appropriate measurement (Bagad, 2008).

2.2.3 Theory of Constraints

Every organization faces some difficulties in their operations, or in other words constraints exist and they stop companies from development. Otherwise, all companies would be successful and grow unlimited. Many professional managers struggle with constraints and try to eliminate them from production. However, the problem is not all issues turn out to be constraints. So, the aim is to identify constraints before eliminating it, otherwise, they end up eliminating something useful and make the situation worse. A limit that stops company or entire production is constraint (John Ricketts, 2007).

The Five-Step Focusing Process of TOC (Mandyam Srinivasan, 2014):

1. Identify the system's constraint.

First step in TOC is to identify right constraint that stops system from moving. For example, in a printing company, if a constraint is one of the not properly working printers, this slows down production. It is important to figure out which printer is not working. It could be a worker who is not operating well as he doesn't know all the procedures. Therefore, in this step it is important to identify the constraint. Then move to step two.

2. Decide How to Exploit the System's Constraint.

Second step is deciding how to exploit the constraint. By doing some research it was identified that system slowness in printing office is an old printer which was not working properly.

3. Subordinate Everything Else to Above Decision.

The third step in applying TOC is making sure that non-constraints keep constraints busy – or stay out of the way. We made sure that constraint is only old printer, not a new worker.

4. Elevate the System's Constraint.

The fourth step is to improve or elevate system's constraint because this is the only way to increase productivity. There are several ways how to increase constraint's productivity such as working out of business hours including weekends or switching it with a new model.

5. If a Constraint Was Broken in a Previous Step, Go Back to Step 1.

This final step includes repeating steps if other constraint are identified. For example, by switching old printer to new one, we improved overall productivity. However, if productivity goal is not reached yet, this means there should be another constraint. This requires repeating all the steps (John Ricketts, 2007).

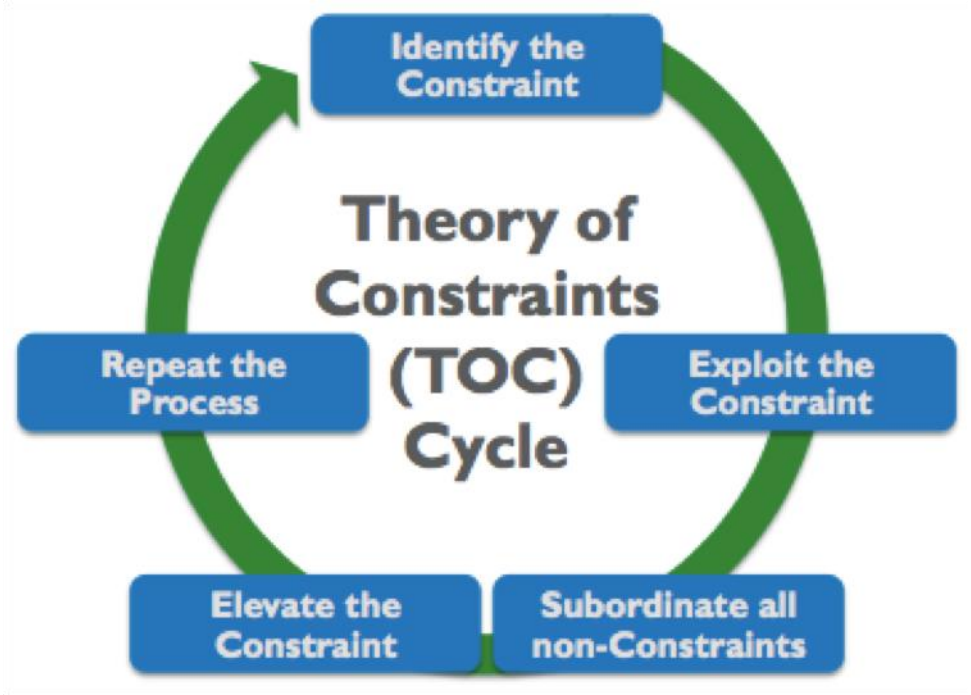

Figure 5**:** Theory of Constraints Cycle

(Source: Rod Baxter, 2015)

So, using TOC successfully would result in the following outcomes (Cox and Schleier, 2010):

- Increase in profit – most companies see TOC as their primary goal towards profit
- Fast improvement – identifying constraint and eliminating it, would result in a quick growth in many areas
- Improved capacity – once constraint is removed, this gives more space to produce more in long run
- Reduced lead times – faster product manufacturing is result of using right TOC approach
- Reduced inventory – identifying and eliminating bottleneck which stops production or slows it down, would reduce WIP

2.2.4 Drum-Buffer- Rope

Drum-Buffer- Rope is TOC application for operations Eliyahu M. Goldratt in the 1980s (John Ricketts, 2007).

We can look at the differene between traditional manufacturing system and DRB below:

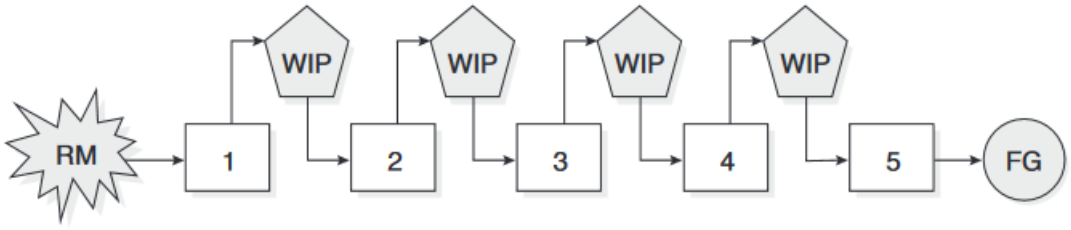

Figure 6**:** Traditional Manufacturing System (John Ricketts, 2007)

RM – raw materials, WIP – Work in process, FG – finished goods

First problem with traditional manufacturing system is a lot of inventory before, during, and after production. In every company inventory is considered to be highly sufficient investment which generates profit. Second problem is when there is a lot of inventory on the production floor; it becomes harder to identify which inventory goes first for the production. Third problem is connected with difficulty to identify which tasks are completed first, and there might be a lot of tasks finished later than expected (John Ricketts, 2007).

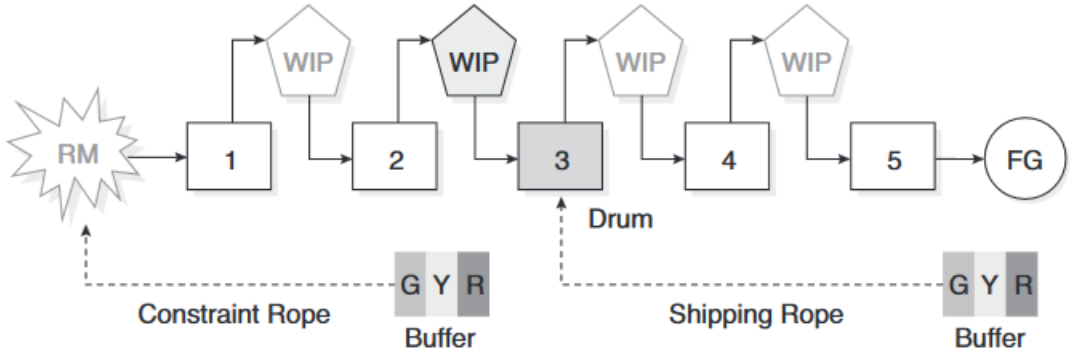

Figure 7: Drum-Buffer-Rope (John Ricketts, 2007)

Solid line – product flow, dashed line – information flow

This chart shows us that there is a constraint in step three of production (it is called drum as it sets pace for the rest of steps), and it can't produce as many items as it was planned, sometimes it is hard to identify this step. However, some detective work can identify it. Knowing constraint will avoid it to be full of work, and previous steps and further steps could be balanced working as they are waiting for the buffer to be complete. When this becomes stable, constraint might have high utilization, as a result, WIP will disappear, and orders will be completed on time. This method of production ensures that production is stabilized and could even be produced more than traditional manufacturing system (John Ricketts, 2007).

2.2.5 Cause and Effect Analysis

Cause and effect analysis were used by Kaoru Ishikawa in 1953 for the first time. This method is also known as Fishbone Diagram. The main reason for this is that it looks like fishbone (Hartung, 2010).

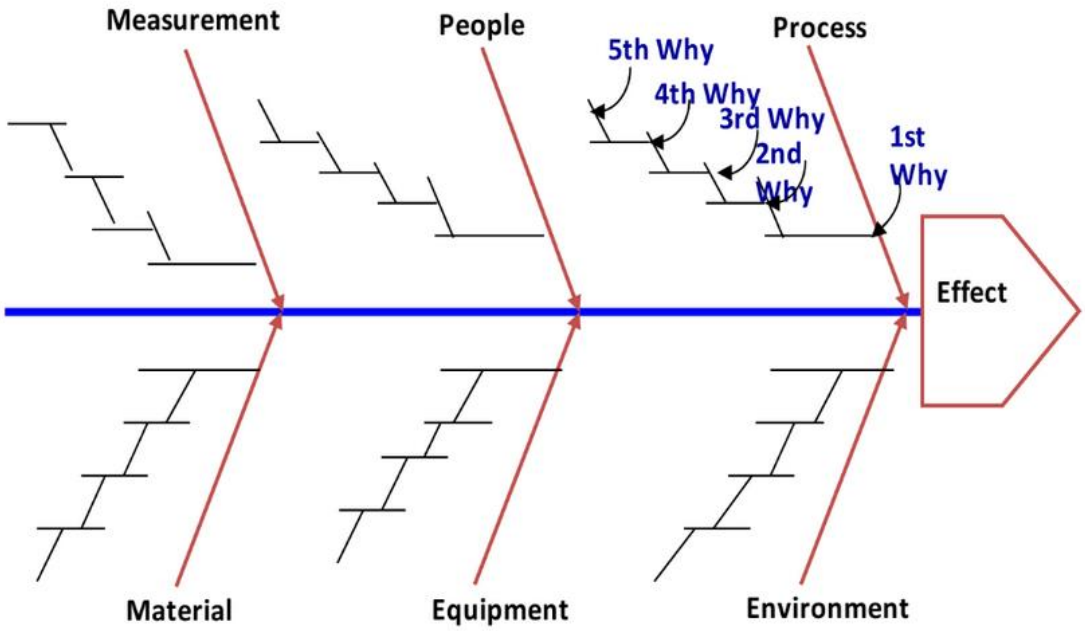

Figure 8: Fishbone diagram (Source: Hartung, 2010)

As it can be seen from the chart, head of the fish shows effect, and each skeleton shows causes. In the chart, there are 6 major causes such as process, people, measurement, material, equipment, and environment.

In the Figure below, we can see that main effect is product quality doesn't meet quality standards. There are 4 main areas need to be analyzed, workers, machines, raw material, and other problems. For example, there are 3 reasons for the problem with raw materials. First is, low quality raw materials result in law quality end product. Second, due to not well organized storage, some materials are wasted. Finally, not delivering materials on time either by supplier or dealers cause lowering productivity.

The biggest advantage of this diagram is that it can show a lot of causes leading to one general effect. Then each cause is analyzed by sub-causes. This gives a clear picture of the process as in general as well as in details.

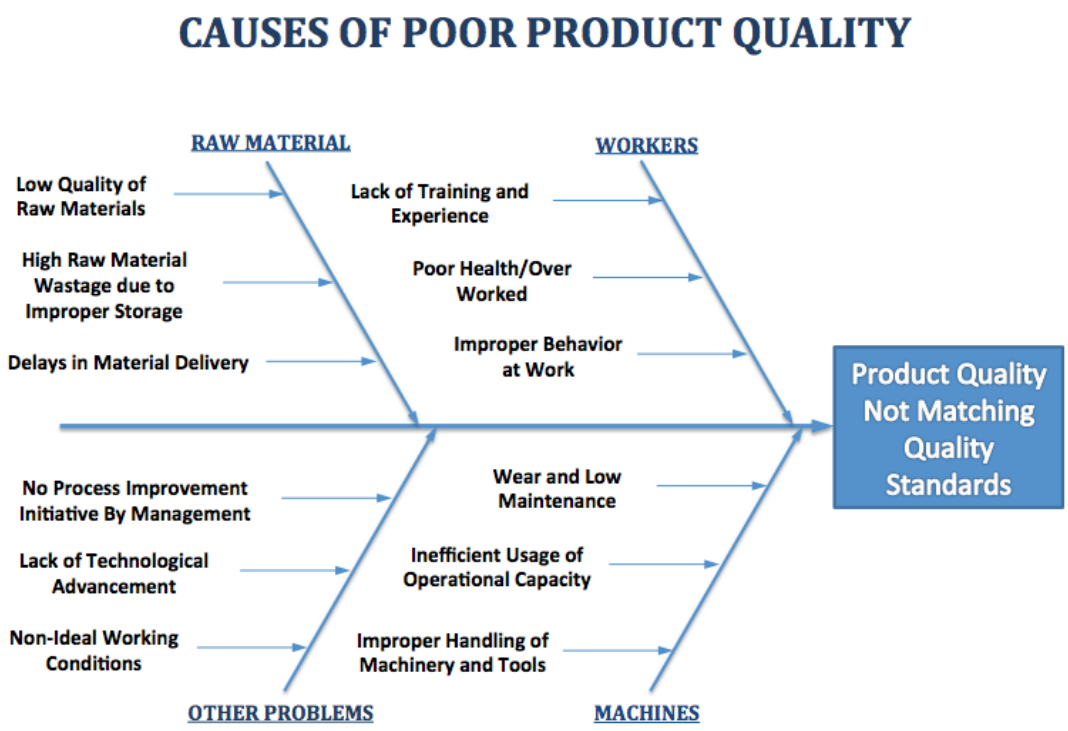

Figure 9: Example of fishbone diagram

(Source: http://fishbonediagram.org/example-1-poor-product-quality/)

2.2.6 Deming Cycle

The Deming Cycle is one of the basics of Continuous Improvement, and it was originated from a business model developed by Walter Shewhart (1891-1967). It was originally called Shewhart cycle, Japanese renamed (1950) it into The Deming cycle as Edward Deming played a crucial in making it more famous and popular among companies (Evans and Lindsey, 2011). The Deming Cycle (PDCA) is a series of activities pursued to achieve continuous improvement in some part and as well as in the whole organization (Charantimath, 2011).

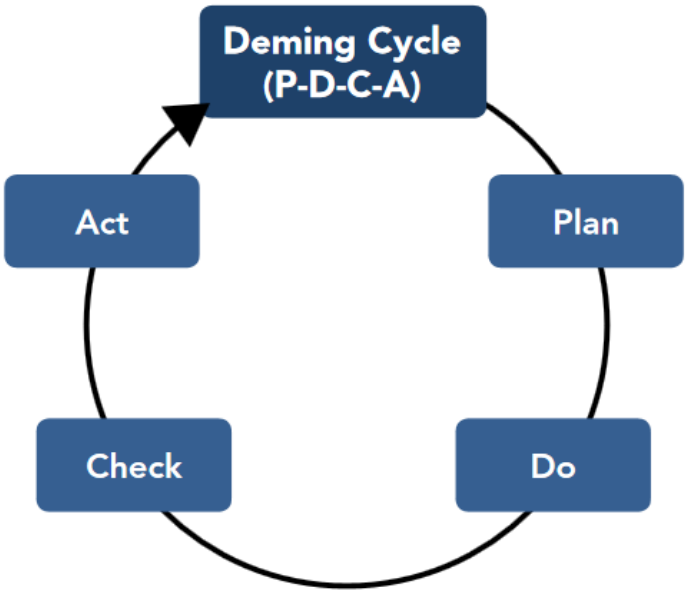

Figure 10: Deming Cycle (Newton, 2015)

The Deming Cycle has following four steps:

1. Plan – identify areas which should be improved and assign tasks, objectives, and processes towards achieving company's goal.
2. Do – once plan made and objectives set, start implementing it into practice.
3. Check – once tasks are complete, check quality and if plan is going towards previous plans. If tasks are not successfully completed, re-organize plans and tasks.
4. Act – after comparing actual and planned results, make plans to correct root causes of differences. Determine areas that should be improved.

Deming Cycle is a simple and easy to use method of continuous improvement. It is important to note that, not only job operators participate, but this cycle requires managers of all levels to take in part in process (Newton, 2015).

2.3 SWOT ANALYSIS

SWOT is a Strategic Management tool that is used to analyze four in areas of functionality, strengths, weaknesses, opportunities, and threats. SWOT analysis focuses on both internal and external factors. Some managers consider SWOT as outdated management tool. However, this method remains to be really efficient in analyzing factors influencing the company's performance (Chermak, 2011). Some researchers believe that SWOT outcomes and results are not taken into serious consideration or dealt properly (Chermak and Kesshanna,

2007). One key factor that leads to success in using SWOT is to successfully use information obtained from analysis. Sometimes, managers use SWOT analysis only with internal factors, and for this reason SWOT is misused (Chermak, 2011). There are two major benefits to using SWOT, it shows current situation of the company in areas analyzed, and it gives a clear picture of how to formulize strategy to obtain main targets.

Strengths	Weaknesses
• **Knowledge:** Our competitors are pushing boxes. But we know systems, networks, programming, and data management. • **Relationship selling:** We get to know our customers, one by one. • **History:** We've been in our town forever. We have the loyalty of customers and vendors.	• **Price and volume:** The major stores pushing boxes can afford to sell for less. • **Brand power:** We can't match the competitor's full-page advertising in the Sunday paper. We don't have the national brand name.
Opportunities	**Threats**
• **Training:** The major stores don't provide training, but as systems become more complex, training is in greater demand. • **Service:** As our target market needs more service, our competitors are less likely than ever to provide it.	• **The larger price-oriented store:** When they advertise low prices in the newspaper, our customers think we are not giving them good value. • **The computer as appliance.** Volume buying of computers as products in boxes. People think they need our services less.

Figure 11: SWOT analysis example (Source: www.bplans.com)

2.3.1 Internal Factor Evaluation (IFE)

Internal Factor Evaluation Matrix (IFE) is believed to be one of the important tools of project management in evaluating strengths and weaknesses areas of the company, and this method helps to identify connection between areas evaluated (Bhandari, 2013). IFM matrix uses weight from 0.0 to 1.0 to evaluate company's strengths and weaknesses, and at the same time weight from 0.0 to 4.0 is used to rank according to the level of strengths and weaknesses (Katsioloudes, 2009).

This method shows key strengths and weaknesses of the company, and highlights the significance in company's performance. At the end of the evaluation, we can see organizations overall score regarding strengths and weaknesses (Bhandari, 2013).

The following table demonstrates an example of IFM matrix:

Internal Strengths	Weight	Rating	Weighted Score
1. Largest manufacturer in the market	10 %	4	0.40
2. Supplies major airlines	12 %	4	0.48
3. Good reputation and image	4 %	3	0.12
4. Close proximity to the airport	8 %	4	0.32
5. Strong management team	4 %	3	0.12
6. Increasing cash flow	5 %	3	0.15
7. Loyal employees	4 %	3	0.12
8. Access to cheap and reliable financing	3 %	4	0.12
9. History of minimal service complaints	4 %	3	0.12
10. Financial ratios	5 %	4	0.20
Internal Weaknesses			
1. Saturated market	10 %	1	0.10
2. Sensitive to oil prices	15 %	2	0.30
3. Little diversification	8 %	2	0.16
4. Absence of strategic partner	4 %	1	0.04
5. Limited access to international markets	4 %	1	0.04
major weakness (1), minor weakness (2), minor strength (3), major strength (4)			
TOTAL WEIGHTED SCORE	100 %		**2.79**

© Maxipedia

Figure 12**:** IFE Matrix (Source: Maxipedia)

2.3.2 External Factor Evaluation (EFE)

This method is used to evaluate external factors, opportunities and threats, which come from outer sources. Most of the times, these external factors are economic, cultural, demographic, political, and legal environment changes that influence the company in many areas (Bhandari, 2013). If the company wants to make EFE Matrix, it is important to list at least 10 to 15 external factors. Then, each opportunity and threat should be evaluated according to their importance to the organization with weights starting from 0.0 to 1.0. In this case, 0.0 means not important and 1.0 means very important. After that, each threat should be evaluated according to the degree of opportunity and threats. The scale is from 1 to 4. The scale is ordered in following way: 1 – major threat, 2 – minor threat, 3– minor opportunity, and 4 – major opportunity (Katsioloudes, 2009).

Table 1**:** EFE Matrix (Source: Bhandari, 2013)

Key External Factors	**Weight**	**Rating**	**Weighted Score**
Adjacent Property	0.35	3	1.05
Increasing Competition	0.15	2	0.30
Environmental Regulation	0.15	2	0.30
Increase in Golf Popularity	0.15	3	0.45
Population Shift to the South	0.20	4	0.80
Total Weight Score	1.00		2.90
Standard Average: 2.5 *Rating: 1-Major Threat, 2-Minor Threat, 3-Minor Opportunity, 4- Major Opportunity*			

As it can be seen from the table that the company has 2.90 as total weighted score, and standard average is 2.5. This means the company has more opportunities than threats**.**

2.4 SUMMARY OF THEORETICAL PART

Manufacturing process developed rapidly after Industrial Revolution creating a lot of work places for people in big factories. Nowadays companies are paying a lot of attention on improving their productivity in manufacturing. The level of productivity can be simply measured by dividing output by input. However, it is not easy to figure out what factors are influencing productivity. There are several ways that companies can improve their productivity. We will mention two of them shortly. First, they can reduce waste from manufacturing. There are value adding and non-value adding activities. If the activity is non-value adding, this is simply waste. It is important to figure out what types of wastes the company is facing. Once waste is identified, using Lean Tools, strategy in reducing or eliminating waste could be designed. Visualization, Standard work, 5 S, and other tools can be used to reduce waste. It depends on company's activities, management and employees which tool to use. Second, improving quality in different areas of activities would reduce waste. Pareto chart, cause and effect diagrams, histograms, and check sheets would help identify problems. These tools help to determine root cause of the problem, which indeed help to improve quality and reduce waste.

II. ANALYSIS

3 SAAS TEKS INVEST

3.1 COMPANY OVERVIEW

The company where I had my internship is not really old. "SAAS TEKS INVEST" Ltd. - a textile company which was founded in 2007 in Tashkent. It is well-known Uzbek textile enterprise with a wide range of high quality products. The company today is one of the leading companies in the field of cotton cloth and knitwear. "SAAS TEKS INVEST" Ltd. - a modern dynamic company that uses the latest technology of textile fabrics.

Areas of company's activities are production and sale of cotton clothing wear and any kind of fabric as well as ready-made garments. What's more, all products are made from knit-wear. Monthly this knitting factory produces about 200 tons of fabrics, monthly volume of clothing production is 300 000 pieces. The company strives to establish strong business relationships with customers, constantly maintaining the quality of its products at the highest level and applying a flexible price policy.

The main types of knitted fabrics produced in the company are the following: *Kulirnaya* - thin smooth knitted fabric which stretches in width and hardly stretches in length with almost no creases. This product is considered to be the most delicate knitted fabric made of cotton, clothing of it turns out light and airy, good air permeability, which creates the effect of air conditioning and is ideal for the hot and sunny summer. This product is made of 100% cotton.

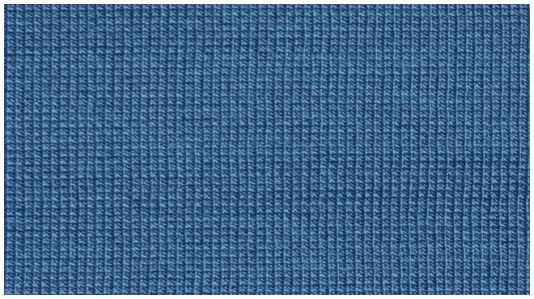

Figure 13: Kulirnaya
(Source: Internal documents of SAAS TEKS)

Ribana - The elastic knitted fabric made of cotton with Lycra, with development in small gum. It is used for sewing summer products and jumpers.

Interlock - knitted fabric has a special structure which is smooth on both sides. It does not fleece, it is soft and particularly comfortable for the body. This product is very resistant to

stretching, gets back into shape, not dissolved, has good insulating properties, and it allows the skin to breathe.

Figure 14: Ribana

(Source: Internal documents of SAAS TEKS)

Footer - It is suitable for bending without forming wrinkles and therefore does not require frequent ironing. Footer is resistant, long and does not lose shape over time. After washing it may shrink, so it is recommended to wash at 30 degrees.

Figure 15: Footer

(Source: Internal documents of SAAS TEKS)

Velour - a fabric with a low, very thick and soft pile. This material is very durable and resistant to abrasion and other serious influences. It remains its original appearance even some years later. This fabric is very good for fall and winter seasons as it has heat keeping functions. This fabric is made of 80% cotton and 20% polyester.

Figure 16: Velour

(Source: Internal documents of SAAS TEKS)

Knitted fabrics have several features that make them highly demanded products these days. The features are simple production technique, low cost in production, and wide production range. Moreover, people always pursue comfort which is the main issue with knitted fabric products. What could be included into the comfort of such fabrics? Moisture absorbing, plenty of stretch, easy care and wear are factors that make knitted garments comfortable.

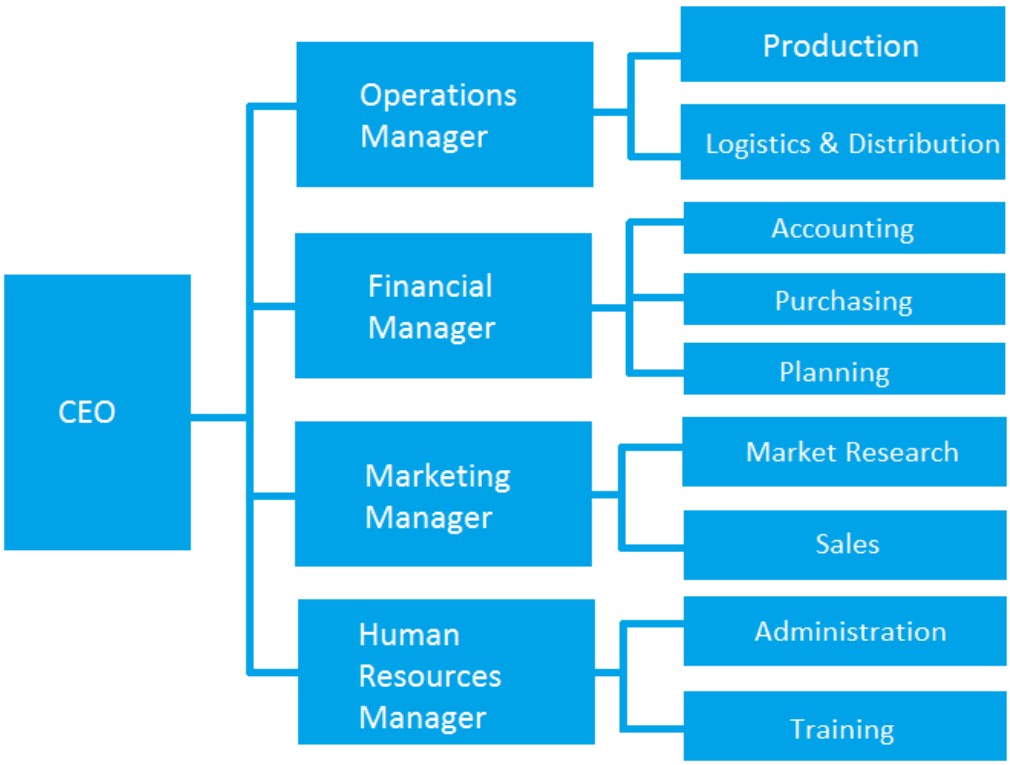

Figure 17: Management Structure of SAAS Teks Invest Ltd

(Source: Internal documents of SAAS TEKS)

CEO of the company – Usmanov Sardor, Production Manager – Avazov Sarvar

There are four departments in the company, Operations, Financial, Marketing, and Human Resources Departments. All those departments have sub departments. There are Production and Logistics & Distribution under Operations department. Three other sub departments such as Accounting, Purchasing and Planning are controlled by financial department manager. Marketing is divided into Marketing and Sales. Human Resources manager controls Administration and Training in the company.

3.2 SWOT ANALYSIS

During my internship at the company, I analyzed different areas of the company. There are some areas in which company is very good at or its strengths. Management of the company is doing a great job by organizing jobs very properly and creating friendly environment. Employees are all willing to help each other. Moto of the company is *Quality is what we constantly improve*. High qualities of products are the main purpose of production. There is also stable development and government support such as low tax benefits, loans with lower interest rates.

However, there are some areas the company needs to develop. One major issue is focusing on research and development. The company is trying to improve its current products, but it lacks of investment to future research in developing new types of product. Employees are good at what they are doing, but they are not very actively participating in offering new ideas, sharing their experience and what needs to be done to develop new trends.

Table 2: SWOT analysis (by author)

STRENGHTS	SWOT	**WEAKNESSES**
Good organizational structure and friendly environment Stable production growth Financial ratios Quality processes and procedures Higher responsiveness to customer demands Local employees On time service and delivery Strategic plan of development for 10 years Selling products directly to customers without dealers		Lack of research and development Lack of initiatives by company's employees Lower productivity High dependence on input suppliers Disability to use machines efficiently Too much stock in inventory and high inventory costs
OPPORTUNITIES		**THREATS**
Create online sales service Current and future economic opportunities by government to support textile industry New countries to export company's products Cooperate with other companies to handle high volume of demand Tax benefits by government Loyal customers Extend portfolio internationally		High level of competition from Turkey and China Increasing number of competing local companies Unstable price of cotton yarn Increasing foreign currency value

Internal Factor Evaluation is a management tool used to evaluate company's strength and weaknesses in different areas of activities.

Table 3: IFE Matrix for SAAS TEKS INVEST LTD (by author)

	Internal Factors	Weight	Ranking	Weighted Score
STRENGTHS	Good organizational structure and friendly environment	6	4	0.24
	Stable production growth	7	4	0.28
	Financial ratios	8	4	0.32
	Quality processes and procedures	7	3	0.21
	Higher responsiveness to customer demands	6	4	0.24
	Local employees	5	4	0.2
	On time service and delivery	5	4	0.2
	Strategic plan of development for 10 years	4	3	0.12
	Selling products directly to customers without dealers	4	4	0.16
WEAKNESSES	Lack of research and development	6	1	0.06
	Lack of initiatives by company's employees	6	2	0.12
	Lower productivity	5	1	0.05
	High dependence on input suppliers	5	2	0.1
	Disability to use machines efficiently	5	2	0.1
	Too much stock in inventory and high inventory costs	6	2	0.12
	Infrequent cash flow system	5	1	0.05
	Weakness of brand image	4	1	0.04
	High rental costs for facility	6	2	0.12
TOTAL WEIGHTED SCORE		**100%**		**2.73**

Weight: 0.0 to 1.0 with the summation equal to 1.0
Ranking: 1-major weakness, 2-minor weakness, 3- minor strengths, 4- major strengths
Weighted score is weight x ranking

IFE Matrix shows that total weight score is 2.73 which is higher for 0.23 than average standard which is 2.5. This indicates that the company has more strengths than weaknesses.

Table 4: EFE Matrix for SAAS TEKS INVEST LTD (by author)

	External Factors	Weight	Ranking	Weighted Score
OPPORTUNITIES	Create online sales service	7	4	0.28
	Current and future economic opportunities by government to support textile industry	10	3	0.3
	New countries to export company's products	15	3	0.45
	Cooperate with other companies to handle high volume of demand	10	4	0.4
	Tax benefits by government	9	4	0.36
	Loyal customers	11	3	0.33
	Extend portfolio internationally	9	4	0.36
THREATS	High level of competition from Turkey and China	7	2	0.14
	Increasing number of competing local companies	7	2	0.14
	Unstable price of cotton yarn	8	1	0.08
	Increase the value of foreign currency	7	1	0.07
TOTAL WEIGHTED SCORE		**100%**		**2.91**

From EFE Matrix analysis, the total weight score obtained is 2.91. Standard average is 2.5, so obtained result is higher than average. This means the company has more opportunities than threats. The management should pay more attention on opportunities and make strategic plan in pursuing them.

It is important to note that main customers are from Russia and Kazakhstan. However, the company can start exporting their high quality products to other European countries. For this purpose, the company must develop Research and Development in export area. There are many benefits and opportunities by government of Uzbekistan to support export of ready products rather than raw materials. Some of the orders are rejected as company cannot handle the volume in time for customers. If the company could cooperate with other textile companies, they can split the order and produce at the amount customer ordering.

Textile industry is developing rapidly in Uzbekistan. There are some other companies which are investing a lot on development of their own brand and products. Some joint companies with Turkish, Bangladesh, Pakistan, and Chinese are the main rivals of the company. The number of such joint companies is growing year by year. Unstable price of cotton causes unstable price of yarn. There are some sudden raises in the price of yarn which makes company to raise their price for final products.

3.3 Order processing chart

The flow chart below describes order processing flow chart at the company. It starts with Executive manager getting order from customer and after several processes; final product is delivered to the customer.

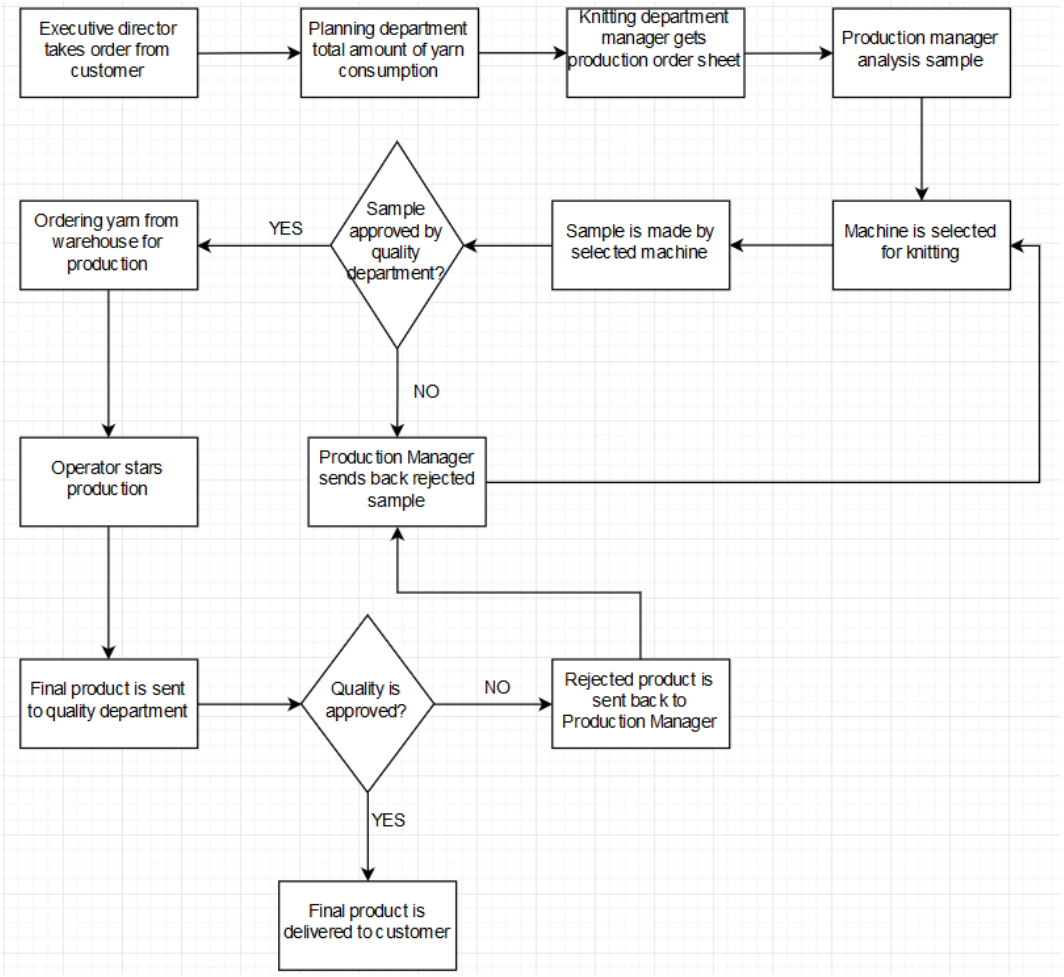

Figure 18**:** Order processing flow chart
(Source: Internal documents of SAAS TEKS)

Company purchases yarn from manufacturers or retailers depending on volume of final production. The most important element in knitting is yarn. Quality of final product depends on quality of yarn. There are 3 types of yarn the company uses to make its final product:

a) Average quality
b) Good quality
c) High quality

Once yarn is brought from storage, operator feeds it to the machine. Then, he sets settings of the machine depending on type of fabric as final product. Once machine knits exact length of fabric, it gives signal to operator. He takes final product out of machine.

The following chart describes the process of knitting from delivery of Yarn from storage to Final product ready to be sent to dyeing.

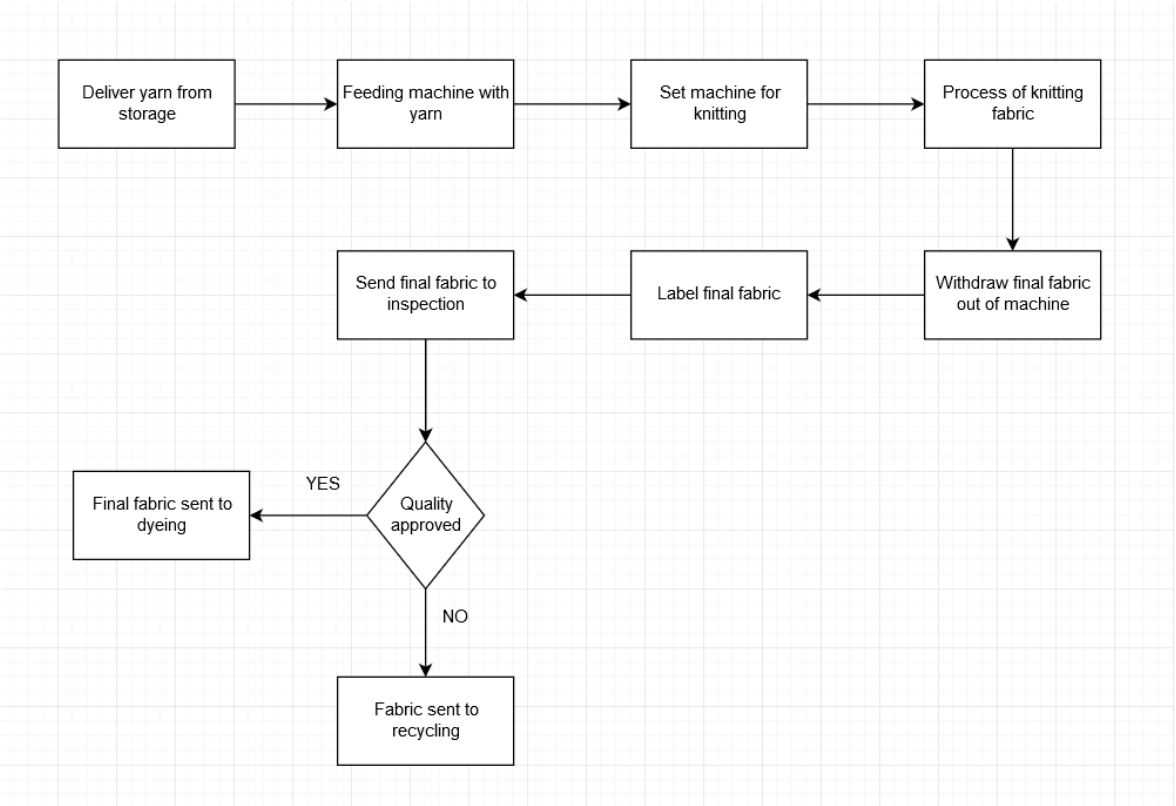

Figure 19: Process Chart for Knitting
(Source: Internal documents of SAAS TEKS)

3.4 Quality inspection

After that, he sends the roll which was labeled to quality check. Quality control people check loop length, fabric width, defects and construction. One of the most important fac-

tors in quality checking is loop length, consumers, producers and retailers are mostly concerned about it. All the final fabrics are checked for quality. We can see a quality control machine below in the picture. Quality control department carries out two types of tests:

a) physical test (Shrinkage, Lycra percentage, Crease Resistance, Strength and others)
b) chemical test (Fastness to wash, Water, Light, Rubbing, and others)

Figure 20**:** Fabric Inspection machine (by author)

(Source: Internal documents of SAAS TEKS)

After careful inspection of fabric, the following defects can be detected:

A) Hole in fabric which is caused by yarn breakage or high tension.
B) Oil mark in fabric which is caused by oil passing through needle trick and reaching fabric.
C) Needle mark which is caused by bad setting of yarn feeders.
D) Pin whole which is caused by curved needle.
E) Loop mark which is caused by improper needle usage.
F) Lycra out which is caused by breakage of Lycra yarn.

G) Yarn missing which is caused by breakage of yarn or using weak yarn.

H) Thin or thick places in fabric which is caused by improper usage of yarn.

The table below shows percentage of defects identified after careful inspection of ready products.

Table 5: Types of defects identified during quality control
(Source: Internal documents of SAAS TEKS)

		Percentage	Cumulative
A	Yarn missing	23	23
B	Hole in fabric	21	44
C	Loop mark	18	62
D	Thin or thick places in fabric	11	73
E	Lycra out	9	82
F	Oil mark in fabric	7	89
G	Needle mark	8	97
H	Pin whole	3	100

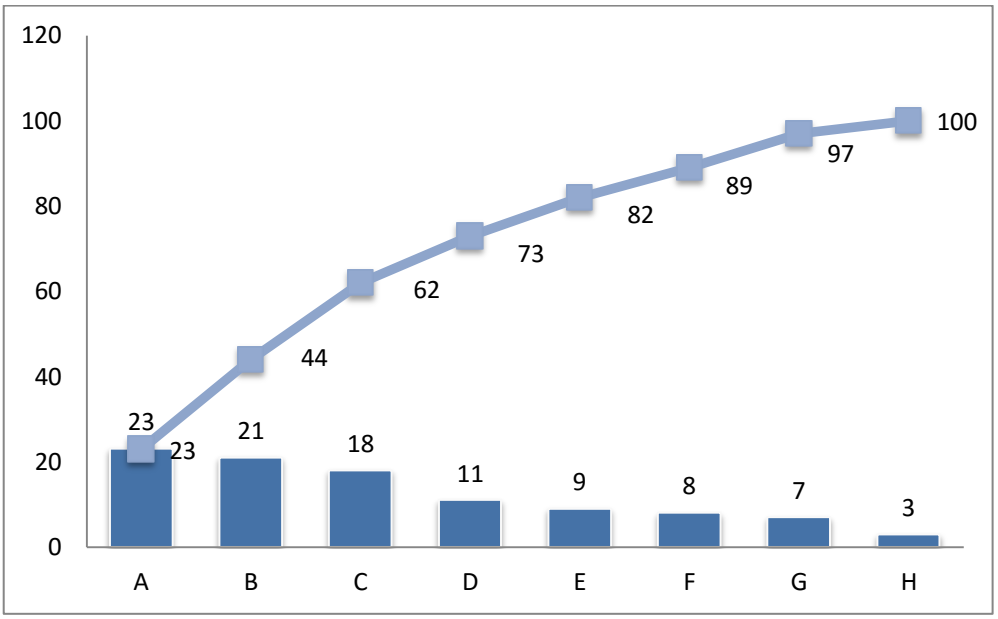

Figure 21: Pareto chart analysis for quality control checking (by author)

According to data provided by the company, the highest portion of defects is yarn missing with almost 23% cases, mostly because of using weak yarn or more frequent breakage of yarn. Following, holes in fabric (19%), loop mark (17%), thin and think places in fabric (10%) are also major defects in fabric knitting. The following are description and images of defects occurring in fabrics in the company. One of the major defects is missing yarn in

final product. This is usually because of breakage of yarn or using weak yarn for production.

Figure 22: Yarn missing
(Source: Internal documents of SAAS TEKS)

A hole in fabric is the second major defect in circular knitting machine. It mostly happens because of breakage yarn or high tension of yarn. Therefore, it is important to use high quality yarn for production.

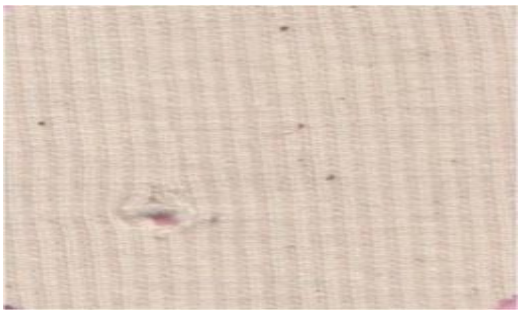

Figure 23: A hole in fabric
(Source: Internal documents of SAAS TEKS)

When operators change needles, they must pay attention to setting it correctly. Otherwise, fabric will have defect of loop mark. Using high quality of needles and installing them correctly onto the machine avoids such defect.

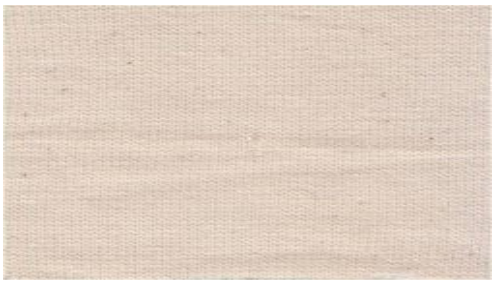

Figure 24: Loop mark in fabric
(Source: Internal documents of SAAS TEKS)

One more major problem with final fabric is thin and thick places of fabric. Operators should be trained to use yarn properly. While choosing yarn, if they use different types for the same fabric, final fabric will have thick and thin places on it.

Figure 25: Thin and thick places in fabric
(Source: Internal documents of SAAS TEKS)

There are some defects that are not major ones, but happen occasionally. One example here is needle mark. This defect occurs due to improper lubrications of needle or defective needles. However, the company usually purchases needle from the same supplier which offers good quality of needles.

Figure 26: Needle mark in fabric
(Source: Internal documents of SAAS TEKS)

When quality control people detect above mentioned defects, they will report it to Production Manager. He will find the cause of defect and fixes the issue not to repeat the same defect in the future.

Once quality control people approve final fabric, it is sent to dyeing department. After dyeing, final product is delivered to customers.

3.5 Circular Knitting Machines

There are 23 circular knitting machines in the factory. Some of them have the same functions and make the same type of fabrics while others have different functions. Depending on type of machines, the length of final product varies.

Below there are specifications, description and final product samples of types of machines used in the company (Mayer & Cie's D4-2.2 II, Relanit 3.2 HS, and SUPREM).

Mayer & Cie's D4-2.2 II is a high-speed circular knitting machine for rib fabrics capable of producing fine quality Lycra fabrics and can also be modified for producing interlock fabrics. This machine is used in variety of manufacturing of sports, leisure wear and underwear products. Additionally, it can be used to produce materials for footwear industry and furnishing materials.

Application area:

- Outerwear
- Sport & Leisure
- Technical textiles
- Underwear & Nightwear

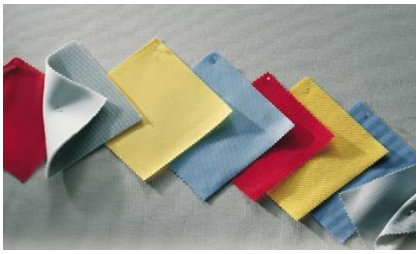

Figure 27: Fabric of Mayer & Cie's D4-2.2 II
(Source: Internal documents of SAAS TEKS)

Figure 28: Circular knitting machine Relanit 3.2 HS
(Source: Internal documents of SAAS TEKS)

The Relanit 3.2 HS knits all single jersey structures reliably with up to four needle tracks. Additionally, high level of yarn supply allows machine to operate in a high level. One more significant advantage of the machine is a low level of energy consumption. This machine has a good reputation in the textile market for its reliability, high fabric quality, and minimum defects. This machine is specialized in making products in the area of Home textiles, Outwear, Sport & Leisure, and Underwear and Nightwear.

3.5.1 Parts of Circular Knitting Machine

There are three major sections of circular knitting machines:

- Yarn supply
- Knitting elements
- Fabric take down

The Figure below shows the machine parts:

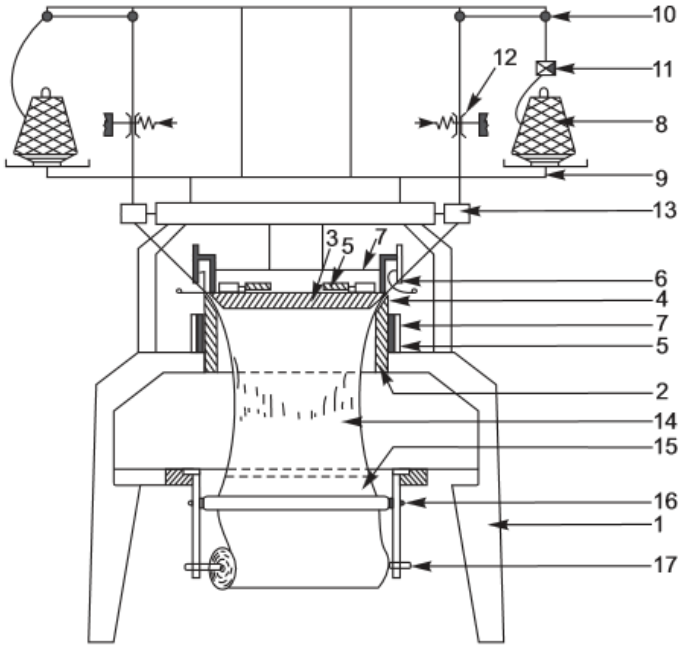

Figure 29**:** Machine parts of circular knitting machine

(Source: Internal documents of SAAS TEKS)

1- Legs	2- Cylinder	3- Dial
4- Needle	5- Cam parts	6- Feeder guide
7- Cam	8- Supply Package	9- Creel
10- Top Stop Motion	11- Anti Snarl Device	12- Tensioner
13- Positive Feeder	14- Knitted Fabric	15- Fabric Spreader
16- Fabric Withdrawal roller	17- Fabric Winding Roller	

Knitting zone supports knitting elements such as needles, sinkers, cylinder, cams and feeders. The knitted fabric goes down inside the cylinder towards the center of the machine, drawn into the take down device and finally collected on a roll winding mechanism.

There are different types of machines used to produce knitted garments such as circular knitting machine, single jersey knitting machine, warp knitting machine, semi-computerized flat knitting machine, hose knitting machine and some other types. All the machines which are described above have different parts. It is highly important to keep all

the parts functioning, maintaining, and effectively monitoring. If machine parts have problems, it has to stop as it cannot operate. As a result, efficiency of machine drops resulting in decrease of productivity of knit production. It is important to calculate efficiency of machines. This could be simply comparing input and output of production. If input is higher than output, then it is not efficient to keep production as machine is not efficient. There are a lot of factors influencing machine efficiency such as power failure, experience and skills of operators, daily, weekly, monthly and yearly maintenance, speed of machine, proper usage of machine, and etc.

In this practical part, I will analyze production process and main areas that could be improved of the textile company, SAAS Text Ltd. During my internship in the company, I observed the following areas:

- Management structure of the company
- Production process
- Layout of production floor
- Circular knitting machine models and specifications
- Material flow
- Order processing
- Operators daily responsibilities

After careful observation of above mentioned areas, I figured out that Production process is the main area that needs improving. Production process is knitting fabric with circular knitting machines. The following are main areas of usage of machines analyzed during my internship in the company:

1. Machine Running Time – machine runs smoothly and knits fabric. This is the time when machine knits fabric using three different quality yarn.
2. Machine Stoppage Time – operator fixes ripped thread to run machine. Machine stops time by time because of ripped thread. When it stops, it is operator's responsibility to connect ripped thread. Otherwise, machine will not run as it needs manual correction.
3. Machine Waiting Time – operator is busy with other machines. One operator runs from two to four machines depending on his experience and skills. Sometimes, more than one machine stops due to yarn ripping. While operator is fixing one machine, the other one should wait for him.

4. Unloading ready fabric – operator withdraws ready fabric out of machine. When machine makes definite quantity of final fabric, operator stops it to take fabric out of machine, and program machine to next portion of product.
5. Feeding yarn – operator feeds yarn once it runs out of it. Some machines have yarn on top, while others don't. This depends on type of machine and function. If machine has yarn on top of it, it runs out of it after some period of time. Then, operator needs to fill new yarn to run machine.
6. Changing needles – operator changes needles when they are broken during production. Needle breakage is one of the issues which stops machine from running. Once needle is broken, it must be replaced.
7. Cleaning workplace – operator cleans his workplace close to end of shift. It is important to clean machine before another operator starts working on it. Operator cleans the machine from dust and other thread left overs.

Main areas of usage of machines were discussed above. Additionally, there are several other activities that are included in operator's daily working shift. The following are the once operators need to operate knitting machines and get ready final product:

- Feed machines with yarn
- Set up machines and selecting right programming before starting knitting process
- Monitor machines and make sure they are running smoothly
- Inspect knitting process to ensure high quality of product
- Report to engineers or management when machine is broken or cannot operate
- Keep their working area safe and make sure the doors are always closed when machine is operating
- Ensure that machines and work order are ready for the next shift

3.5.2 Machine Maintenance

In order to keep machine working efficiently and ensure final product quality to deliver high quality product to customers. Maintaining machine on time and regularly avoids defects and machine stoppage times. There are some maintenance which should be done by mechanics and some maintenance done by operators. Maintenance could be divided into three types:

- Defect preventive maintenance

- Routine or regular maintenance
- Machine breakdown maintenance

Defect preventive maintenance is carried out to prevent machine failure and avoid defects during production. Routine or regular maintenance is done by experts on regular basis to keep machine in optimum condition. Each machine in the company has a schedule of maintenance to follow. Frequency of regular maintenance depends on machine type and how often it is used in production. Routine maintenance is done daily, weekly, monthly and half yearly.

Table 6**:** Routine machine maintenance
(Source: Internal documents of SAAS TEKS)

Maintenance activity	**Frequency**
Each production shift should clear away the yarn fluff on the machine and yarn creel Check automatic stop and safety devices Check the positive yarn feeders, should adjust if any abnormal situation Check oiler glass of base plate and level tube of oil lubricator Check safety gear shields and replace if needed	DAILY
Doing cleaning work yarn feeding speed disk, the inner disk accumulated fly cleaned Check transmission belt tension is normal and drive smoothly Carefully check the functioning of the traction winding mechanism Check the wind and dust removal devices are correct and clear above the dust If fabric is in bad condition, should consider to replace all	WEEKLY
Check whether sinkers and needles have damaged or not, if damaged, replace them as soon as possible Clean all the oil is smooth and clean injection equipment Clean and inspect the positive-type yarn feed mechanism is flexible Clean the fans and check wind direction of fans Clean yarn fluff from all electrical devices Clean needle grooves to stop dirt coming into the fabric with needle Check performance of all electrical devices	MONTHLY
Clean oil lubricator Clean cylinder and dial including needles and sinkers Clean yarn fluff and oil in motor of machine Check the oil waste	HALF YEARLY

Machine breakdown maintenance is type of activity which is done when quality of product drops or machine stops because of breakage. Maintenance is held depending on type of stoppage. If stoppage can be fixed by operators, they don't have to inform mechanics. If operators cannot fix stoppage, then they ask for mechanics' help.

3.5.3 Specifications of Single Jersey Knitting Machine

One operator can run 2 to 5 machines depending on their experience and skills. The factory has very friendly environment. Operators are really helpful to each other. In this, management are doing really great job.

The knitting machine usually stops because of defects occurred and then faults are corrected, which causes time loss and efficiency loss. Careful monitoring avoids defects, productivity and quality losses. My main goal is to shorten machine stoppage time and increase machine running time. Among all machines in the company, SUPREM AEN circular knitting machine produces the most important products. Additionally, this machine is used more than other machines in the factory. There are some machine specifications of the chosen machine:

Table 7**:** Machine specifications for SUPREM AEN at SAAS Text Ltd
(Source: Internal documents of SAAS TEKS)

Machine Name	SUPREM
Machine Model	AEN
Machine diameter	30
Machine gauge	28
Count	28
Stitch length	2.5 mm
Efficiency	85%
No. of feeders	96
Machine rpm	40
Finished GSM	140

In textile industry, circular knitting machines yarn count depends on pitch of needle particularly meaning machine gauge. Diameter of yarn might be proportional to its yarn count. This means that there is a relationship between range of optimum counts of yarn which might be knitted on a particular machine and gauge of machine. Machine gauge has a sig-

nificant role in choosing yarn count as it has effect on weigh and appearance of fabric. High machine efficiency depends on balancing yarn count and machine gauge.

Stitch length is measured two different ways — in millimeters (mm) and in stitches per inch (spi). Usually it depends on brand and model of the machine the company uses. There are usually 3 types of stitch lengths used in knitting fabrics:

- The average stitch length for mid-weight fabrics is 2.5 to 3 mm.
- The average stitch length for fine fabrics is 2 mm.
- For heavier fabrics, basting, or topstitching, use 4 to 5 mm.

Feeder is a part of knitting machine where yarn passes through. Number of feeder varies depending of type and model of knitting machines.

Machine RPM – revolutions per minute. There are different numbers of RPM depending on model and types of circular knitting machines.

GSM (also known as gm/2) - grams per square meter and is the metric measurement of the weight of a fabric. For example, a piece final fabric might be listed as 100 or 120 GSM meaning, there is 100 or 120 grams per square meter of the material.

3.6 Time Snapshot analysis

Time Snapshot observation focuses on the whole work shift. It starts with operator's arrival at the workplace and ends with operator's finishing his shift. The aim of this observation is to assess time and percentage share of each individual actions during one shift of operator. Specifically, observing time operator using to operate machine for each activity would give detailed information on machine running time versus stoppage time. Based on data obtained through observations, it will be possible to offer suggestions to improve machine efficiency.

To calculate machine stoppage time a stop watch was used. To compute the calculated production stitch length, yarn count, number of needles, machine rpm, number of feeders, and machine gauge (needles per inch) were identified. Based on machine specifications described in a previous chapter above, there were five Time Snapshot analyses done on a chosen circular knitting machine (SUPREM AEN).

3.6.1 Analysis Of Snapshots

The circular knitting machine was observed 5 different days for the whole shift each time. Observation time was about 8 hours which is about 480 minutes. The whole observations could be divided into two parts, machine stoppage time and machine running time. Looking at these two activities, it can be seen that machine stoppage was very high as there were some stoppages that could be avoided. The following table describes detailed information of the machine observation results:

Table 8: Time snapshot analysis (by author)

Activity	**DAY 1**	**DAY 2**	**DAY 3**	**DAY 4**	**DAY 5**
Quality of yarn	*Average*	*Good*	*Average*	*High*	*High*
Changing broken needles (min)	21	0	0	32	5
Stoppage time %	**4.36**	**0**	**0**	**6.67**	**1.04**
Feeding yarn (min)	63	27	45	53	35
Stoppage time %	**13.09**	**5.63**	**9.38**	**11.04**	**7.29**
Cleaning workplace (min)	35	37	25	31	24
Stoppage time %	**7.27**	**7.71**	**5.21**	**6.46**	**5**
Unloading final product (min)	12	16	8	6	7
Stoppage time %	**2.49**	**3.33**	**1.67**	**1.25**	**1.46**
Operator fixes machine (min)	35	22	37	10	8
Stoppage time %	**7.27**	**4.58**	**7.71**	**2.08**	**1.67**
Machine Waiting Time (min)	20	14	27	10	7
Stoppage time %	**4.15**	**2.92**	**5.63**	**2.08**	**1.46**
Total Stoppage Time (min)	186	116	142	142	86
Total Stoppage Time %	**38.65**	**27.17**	**29.6**	**29.58**	**17.92**
Machine Running Time (min)	295	364	338	338	394
Total Time (min)	**481**	**480**	**480**	**480**	**480**

First day of observation, the biggest part of stoppage time was feeding yarn. 13.09% of total time was spent for it. That was the highest among all observations. After that, fourth day, operator spent 11.04% of total shift while only 5.63% time was spent on second day. Taking into account that the same machine was observed, different operators spent different amount of time to feed yarn. Based on my observations, this activity can be done much faster than time operator spent on it.

Cleaning working area and the machine at the end of shift came second in total amount of machine stoppage time. Operators spent different amount of time on cleaning, however, difference was not really significant comparing to first activity described above. The minimum time spent was in fifth day, 24 minutes with 5% of total shift time whereas maximum time was 37 minutes amounting at 7.71% second day which was almost similar for the first day with only difference of 0.44%. However, operators can spend less time on cleaning as one of them managed to do it in 24 minutes. In this case, company can make regulation regarding time limit to clean, so operators have to follow it to be able to do the task more efficiently.

High quality yarn rips less often than average and good quality ones. Yarn with average quality rips more often than yarn with good quality. From the observed data it can be seen when high quality yarn was used machine stoppage times due to ripped yarn were 10 minutes (2.08%) in fourth day and 8 minutes (1.67%) in fifth days of observations. Yarn with good quality ripping caused 22 minutes (4.58%) stoppage time during the whole shift in day 2. First and third days yarn with average quality was used and it caused machine to stop 35 minutes (7.27%) and 37 minutes (7.71%) relatively. After doing calculations, it will be clear what type of yarn to use. Based on it, it will be possible to suggest some recommendations.

One operator was responsible for at least two machines depending on his experience and skills. While this operator was taking care of another machine and helping another operator, the machine which stopped because of ripped yarn had to wait till operator came to fix it. This waiting time was from 7 minutes (1.46%) to 27 minutes (5.63%) during five days. First day machine waiting time took 4.15 % and second day 2.92 % of whole shift during the days.

One more major reason for stoppage is needle breakage. In this case operator has to find the right needle and change it for the broken one to operate the machine again. Needle broke during three shifts. It is interesting to note that different operators spent different time on this issue even though it was the same for all of them. During first and fourth days operator spent 21 minutes and 32 minutes to change the needle while operator in fifth day spent only 5 minutes which was only 1.04% of total shift time.

The last reason for stoppage is withdrawing ready product out of machine when it is ready to be taken. This machine produces the same type of fabric at the same length. Again it depends on operator's skills and speed how fast he can unload the fabric and set machine for the next portion of production. First and second days 12 minutes (2.49) and 16 minutes (3.33%) time were spent to do this task whereas only 6 minutes (1.25%) and 7 minutes (1.46%) were spent to finish the task.

3.6.2 Calculation of Production Loss Due To Machine Stoppage

According to data observed for the chosen machine (**Table Machine specifications for SUPREM AEN at SAAS Text Ltd.)** production of fabric in kg for an hour can be calculated. There are several steps to calculate production of the machine.

First of all, we need to calculate number of needles. To calculate number of needles, we can use the following formula:

*Number of needles = Machine diameter * Gauge * π* (1)

*Number of needles = 30 * 3.14 * 28 = 2637.6*

Number of needles is always even, therefore, we will take 2636 as number of needles for the machine.

Once we know number of needles, then we need to calculate number of stitches for the chosen machine. We can use the following formula to calculate:

*Number of stitches produced in one revolution = Number of Needles * Number of feeders* (2)

*Number of stitches produced in one revolution = 2636 * 96 = 253056*

The machine produces 253056 stitches in one revolution.

After finding number of stitches, we can use the following formula to calculate Yarn consumption in one hour in yards or meters:

$$Yarn\ consumption\ in\ 1\ hr = \frac{Number\ of\ stitches * Length * R.P.M * 60}{1000\ (convert\ mm\ to\ m)} \qquad (3)$$

$$Yarn\ consumption\ in\ 1\ hr = \frac{253056 * 2.5 * 40 * 60}{1000} = 1518336\ yards \qquad (3)$$

The machine consumes 1518336 yards of yarn in hour of production.

The yarn count is a numerical expression which defines its fineness or coarseness. Additionally, it means that if the yarn is thick or thin. The textile institute gives the following definition to yarn count, "Count is a number which indicates the mass per unit length or the length per unit mass of yarn."

There are two ways to count yarn, either direct way or indirect way. Indirect yarn count expresses the number of length units in one weight unit. Therefore, it is believed that higher the count, finer the yarn would be. The system is generally used for cotton and linen textile. Direct yarn count system expresses the number of weight units in one length unit. Therefore, higher the count, result is coarser the yarn. This direct yarn system is generally used for synthetic fabric and silk.

In International Standards yarn count is defined as the number of hanks **840 yards** per pound.

Now we know yarn consumption in one hour, we can calculate weight of cotton yarn using the following formula as yarn count is known:

$$Weight\ of\ cotton\ yarn = \frac{Length\ of\ yarn}{Yarn\ count * 840} \qquad (4)$$

$$Weight\ of\ cotton\ yarn = \frac{1518336}{28 * 840} = 64.5\ pounds\ or\ 29.25\ kg \qquad (4)$$

The chosen machine for observation works with 85% efficiency. We need to calculate 85% of Weight of cotton yarn to find how much the machine produces in hour:

$$Production\ of\ fabric\ kg/h = \frac{Weight\ of\ cotton\ yarn * 85}{100} \qquad (5)$$

$$Production\ of\ fabric\ \frac{kg}{h} = \frac{29.25 * 85}{100} = 24.86\ kg \qquad (5)$$

Machine produces 24.86 kg of fabric in one hour at 85% efficiency which is very close to the number given by the company production officer 24.9 kg/hr.

We calculated production of fabric 24.86 kg/h for the machine. We can calculate production for each minute dividing it by 60.

24.86 / 60 = 0.414 kg/minute

Based on calculation, the chosen machine SUPREM must produce 24.86 kg in one hour. This means our chosen machine must produce 198.9 kg of fabric in one shift. According to collected data from the observed machine in the company during five day observation, production of fabric in one shift (eight hours) can be calculated. All the data is described below in the chart.

Table 9: Results of time snapshot machine observation analysis (by author)

Activity	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Quality of yarn	*Average*	*Good*	*Average*	*High*	*High*
Changing broken needles (min)	21	0	0	32	5
Lost of production (kg)	**8.694**	**0**	**0**	**13.248**	**2.07**
Feeding yarn (min)	63	27	45	53	35
Lost of production (kg)	**26.082**	**11.178**	**18.63**	**21.942**	**14.49**
Cleaning workplace at end of shift (min)	35	37	25	31	24
Lost of production (kg)	**14.49**	**15.318**	**10.35**	**12.834**	**9.936**
Unloading final product (min)	12	16	8	6	7
Lost of production (kg)	**4.968**	**6.624**	**3.312**	**2.484**	**2.898**
Operator fixes machine (min)	35	22	37	10	8
Lost of production (kg)	**14.49**	**9.108**	**15.318**	**4.14**	**3.312**
Machine Waiting Time (min)	20	14	27	10	7
Lost of production (kg)	**8.28**	**5.796**	**11.178**	**4.14**	**2.898**
Total Stoppage Time (min)	186	116	142	142	86
Total lost of production (kg)	**77.004**	**48.024**	**58.788**	**58.788**	**35.604**
Machine Running Time (min)	295	364	338	338	394
Total Time	**481**	**480**	**480**	**480**	**480**

During five day observation, needle was broken in three of them. Firs time it broke, operator spent 21 minutes to change broken needle which resulted in loosing of 8.694 kg fabric production. When needle was broken on day 4, 32 minutes were spent on changing resulting in loss of 13.248 kg fabric production. However, the last day there was only 5 minutes spent to change the broken needle with only losing 2.07 kg of fabric production.

Once machine runs out of yarn, operators need to feed it. Different amount of time was spent on feeding yarn by different operators. As a result, the biggest lost was on first day with 26.082 kg when operator had to spend 63 minutes to feed the machine with yarn whereas another operator spent only 27 minutes to feed the machine with yarn losing only 11.178 kg of final fabric.

Operators clean their machines and workplace close to the end of their shift. This time, they stop machine to clean it. It is also noticeable that different operators spent different time to clean their work area. The least time was spent on day 5 with only 24 minutes stoppage time of machine, whereas the highest amount of time was on second day with 37 minutes. The difference in production loss was 5.382 kg of fabric production.

When machine knits exact amount of fabric, it stops and light turns on letting operator that fabric needs withdrawing from the machine. During observation time, fabric type manufactured was the same. However, operator on second day spent 16 minutes for this activity resulting of 6.624 kg of final production. The quickest time was spent by operator with 6 minutes losing 2.484 kg production.

Machines stop because of yarn breakage most of the times. Once yarn breaks, operator fixes it by connecting ripped yarn. Operators spend different amount of time to fix the problem. Most of times were spent on first and third days to fix. What is more, fourth and fifth days, operators spent only 10 and 8 minutes to fix the machine.

Due to machine waiting time, about 32.29 kg fabric production was lost during five days. The biggest lost was on third day with 11.178 kg while operator was busy with fixing another machine.

Summing up, during five days of observation out of 994.5 kg of expected production, 278.21 kg were lost due to machine stoppage because of reasons listed above.

Table 10: Total amount of expected and real production (by author)

Activity	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Quality of yarn	*Aver-age*	*Good*	*Aver-age*	*High*	*High*
Production time (minutes)	295	364	338	338	394
Amount of fabric production (kg/ hour)	0.414	0.414	0.414	0.414	0.414
Total production per shift (kg)	122.13	150.7	139.93	139.93	163.12
Expected maximum production (kg)	198.9	198.9	198.9	198.9	198.9

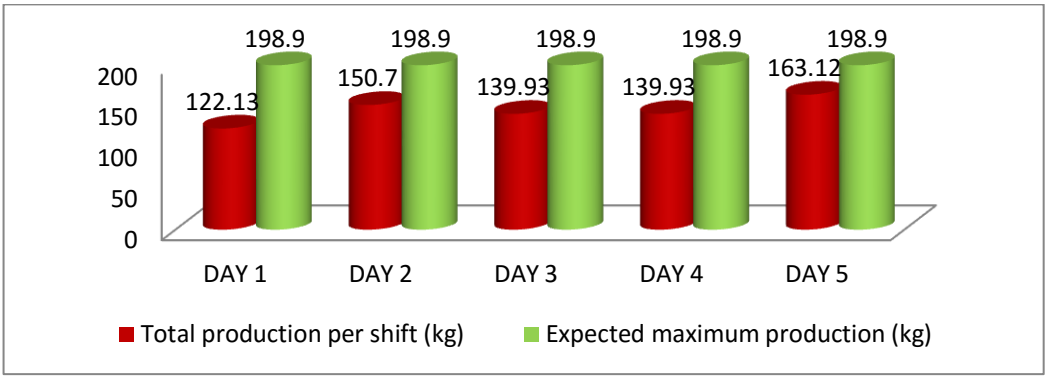

Figure 30: Comparative analysis of productivity (by author)

3.7 Fishbone diagram

We can use fishbone diagram chart to illustrate the main causes of the production loss using all the data and information we obtained.

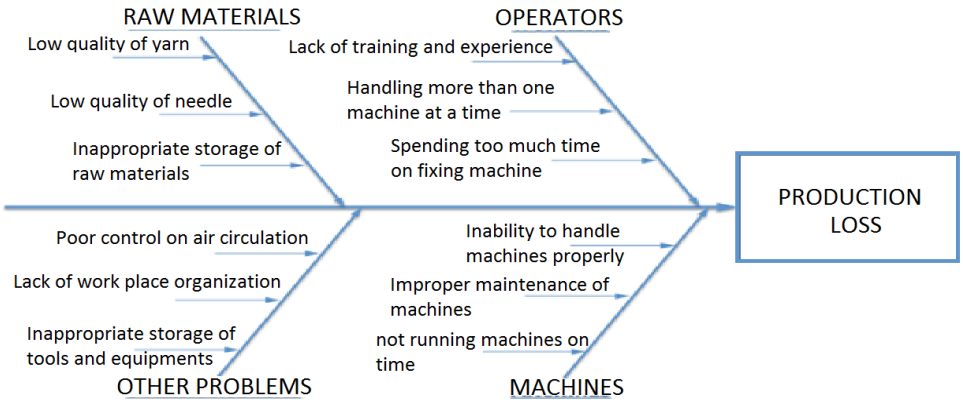

Figure 31**:** Fishbone diagram for analyzing production loss (by author)

The chart shows that there are several causes for production loss as a result of machine stoppage times. Using low quality of yarn, needles and improper storage of raw materials are some reasons of stoppage. When operators cannot handle more than one machine at time, or spend a lot of time on fixing the machine lead to stoppage time of the machine as well. There are some other reasons such as not controlled air conditioning and humidity, poor workplace organization and improper storage of tools and equipment result in productivity loss.

3.8 SUMMARY OF ANALYTICAL PART

SAAS TEKS INVEST Ltd. is one of the developing textile companies in Uzbekistan. The company has several customers in former Soviet Union countries. It exports most of its production volume. It aims to produce high quality products even it has high costs as it wishes to provide customers with high quality products. The company has 23 circular knitting machines, and plans to buy 10 more in near future. The main products of the company are: 1) Knitting production - processing of 300 tons of yarn per month 2) Knitwear clothing - 300,000 units per month 3) Bags and caps.

The company is working successfully in spite of high level of competition in the market. However, as a result of this project work, some issues were identified where company needs improving. Specifically, observation of circular knitting machine gave some evidence of not using it properly with more stoppage times and production loss. After 5 day of observation of the machine, it was figured out that machine running time was 295 minutes in one shift (480 minutes). Third and fourth days machine running time was equal with 338 minutes, and 394 minutes for the last day when the machine was operated by an experienced operator with high quality of yarn. Estimated production was around 198.9 kg of fabric for each day. However, due to stoppage time, expected production was not met. Average loss of production for five days was around 278.69 kg. After conducting a research on reasons for this loss, several issues were identified. The majority portion of stoppage time is due to inexperienced operators who spent around 63 and 53 minutes whereas an experienced one spent around 27 minutes.

All the findings will be discussed in details and proper calculations will be done in proposal part. In the end, some solutions with steps in improving the process will be made. Risk, cost, and time analysis will be conducted.

4 ROJECT FOR IMPROVING PRODUCTIVITY FOR SAAS TEKS INVEST LTD.

INTRODUCTION

The aim of this project is to improve production process of the company SAAS TEKS INVEST LTD. Project will propose improvements on each machine stoppage, and estimated optimization of stoppage times.

More specific goal could be expressed using SMART method as following:

S (specific): Improve the machine's and operators' productivity to certain X by reducing waste from production at Y percent.

M (measurable): Reduce waiting time, defects, and motion at least by 35 % and increase productivity by minimum 10%.

A (achievable): Create and analyze time snapshots for operators of 5 different working shifts in 5 different days. Calculate, analyze and make a solution of proper usage of the machine.

R (realistic): Regular meetings with Production Manager, Job Operators and Supervisor of Diploma Thesis. Ask for information and data, and propose realistic solution by approval.

T (time tabled): Create an exact length of the project in days using Time Analysis methods (CPM and PERT). Propose the project to the CEO of SAAS TEKS INVEST in April, 2016.

The project will include risk analysis, cost analysis and time analysis. Risk analysis will estimate risks associated during and after implementation of the project. Cost analysis will be based on calculations based on current data to calculate approximate amount of the project. Time analysis will give information about length of the project implementation and its anticipated time result.

4.1 CURRENT SITUATION ANALYSIS

It can be seen from analytical part that the biggest problem with machine efficiency is stoppage times. By reducing stoppage time, machine productivity will be improved.

We can rank machine stoppage times according to amount of time from the most to the least in the following order:

1. Feeding yarn – approximately 33.2 % of total stoppage time during observation.
2. Cleaning workplace – approximately 22.6 % of total stoppage time.

3. Fixing yarn breakage by operator – approximately 16.7 % of total stoppage time
4. Machine waiting time while operator is busy with other machines or tasks – approximately 11.6 % of total stoppage time.
5. Changing broken needle – approximately 8.63% of total stoppage time.
6. Withdrawing final product out of machine – approximately 7.29% of total stoppage time.

4.2 PROJECT STEPS OF PRODUCTIVITY IMPROVEMENT

4.2.1 Step 1 Shorten Yarn Feeding Time

The biggest portion of machine stoppage time is feeding yarn. This process takes a bit more time than other processes. The highest stoppage time for 63 minutes because of this reason was first day, and fourth day operator spent 53 minutes. Interesting point here is the same activity was done for 27 minutes by another operator on the second day, and 35 minutes were spent on the last day of observation. After talking to operators about this procedure, it was clear that second and fifth day operators had more experience and worked in the same job in a different company. Two other operators who spent most of the time for this procedure were operators with little experience. The company lost about 15 kg of fabric production for the different time task completion. Production manager informed me that there is always one experienced operator on the shift among 5 or 6 operators. This might be a good strategy to train operators. However, this is not enough to provide help for all operators as this one operator (experienced one) has 3 - 4 machines to operate.

Figure 32**:** Yarn feeding process by operator

(Source: Internal documents of SAAS TEKS)

There are two suggestions which company can provide to its operators with little experience. First, the company should provide extra trainings on this task. During observation, I noted that if the operator is stuck with one step, it took him some time to realize what to do next. The procedure seems to be easy; however, they might get confused with some steps. The following one week program on daily hour will improve operators' skills on this task.

Table 11**:** Program on improvement operational skills of operators (by author)

Day	Theme	Duration	Estimated output
1	How to feed yarn in right order	60 min	OP are aware of order
2	Watch & discuss video on feeding yarn	60 min	Visual learning of process
3	Feed yarn on time limit by experts	60 min	Practical experience by experts
4	Make competition on feeding yarn	60 min	Improve skills and speed of OP
5	Review & discuss benefits of training	60 min	Self-realization of process improvement

The company can shoot the process of experienced worker or expert feeding yarn to video. Then, provide this video to other operators and use it as manual. So, operators can watch it over and over to get familiar with the task and steps to take. Additionally, the management can make visual pictures with step by step instructions on how to do the activity. Finally, it is said, *it is better to see once rather than hearing hundred times.* Visualizing this activity would definitely make it easier for other operators to catch up with the task. The company can install four monitors in four sides of the production floor, so operators can watch those procedures while they are waiting during machine running time.

4.2.2 Step 2 Work Visualization Method

In order to see production process with facts and evidences, the company can implement hour-by-hour production tracking chart. By implementing this method, operators and production managers will be able to see the difference between planned and actual production.

Table 12: Production Tracking Chart (by author)

Area:			**Operator:**	
Date:			**Shift:**	
Time (min)	**Planned (kg)**	**Actual (kg)**	**Variance (kg)**	**Reason**
09:00-10:00	25	22.7	2.3	Machine stopped due to yarn breakage
10:00-11:00	25	24.2	0.8	Machine stopped due to broken needle

Implementing Production Tracking Chart gives a clear picture of how much production is loss and what reasons are for this loss. They can make daily, weekly, and monthly statistics on production loss, and figure out what can be done to improve productivity. One of the biggest advantages using to this method is its price. It doesn't require any investment to implement into practice. Production manager can walk through the production floor and check how production is going. If he notices some problem with lower productivity, he can take some steps to improve the situation. For example, in case of the company is using lower quality of yarn, he can assign operator with more experience as he can fix the machine as soon as it stops. In case of needle breakage, he can assist or assign someone else to assist operator in fixing the issue. When the machine needs feed yarning, production manager can switch operators who can do it faster to shorten yarn feeding time.

4.2.3 Step 3 Use High Quality Yarn

One of the ways of improving productivity is to use high quality yarn. As it can be seen from snap shot analysis, as quality of yarn is better as breakage of yarn is lower. As a result, machine stoppage time is lower. When high quality yarn was used, machine stoppage times were only 8 and 10 minutes because of yarn ripping. The other days with average quality of yarn, machine stopped 35 and 37 minutes during whole shifts. Finally, yarn breakage time is about 16.7% of total machine stoppage time. When I asked about quality of yarn they use, they highlighted that they are not really into using average quality of

yarn. They stated that this makes their job more difficult as it rips more often than other types. And they spend more time on fixing it. I would suggest to Management to concentrate only on high quality yarn. If high quality yarn was used, machine stoppage time would be cut to roughly 25-27 minutes which has some benefits for the company:

a) Having machine stoppage time of 25-27 minutes would increase productivity 10 – 12 kg per shift.
b) Operators would have more time to do other activities. In their free time, they could help other operators around and help to increase productivity of other operators and machines.
c) Quality of final product would be higher as high quality of yarn is used which increases price of final product.

4.2.4 Step 4 Check Yarn Quality before Production

Quality department plays vital role on productivity and quality procedures. Looking at order processing chart which was discussed in analytical part, it can be seen that there might be some minor changes in the process chart. In the original chart, after sample is made by selected machine, sample is approved by quality department. Then, calculated amount of yarn is ordered from warehouse. However, after yarn is brought from warehouse or supplier, quality department doesn't check it, and it goes into production straight which causes machine stoppages because of yarn breakage. As it was analyzed earlier, when yarn is not high quality, machine stops more frequently resulting in production loss.

I suggest checking yarn quality by quality department once it is brought into production floor before operator starts knitting fabric. Quality department must check all amount of yarn which is brought, not only a part of it. When I talked to production manager about quality of yarn, he noted that not all yarn is the same quality even supplier claims they are the same quality. So, careful inspection would avoid machine stoppages and improve productivity.

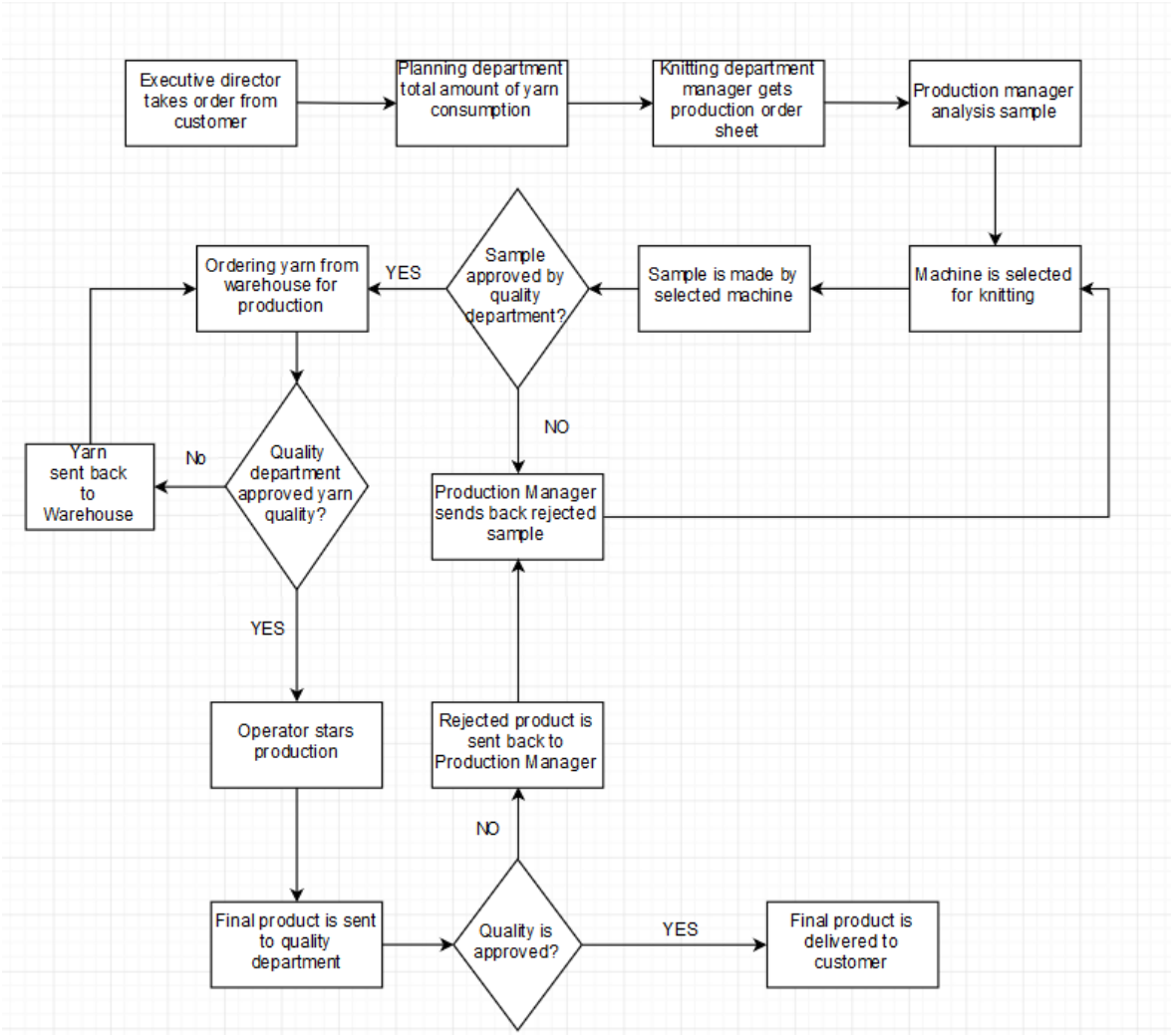

Figure 33: Proposed order processing chart (by author)

4.2.5 Step 5 Standardize Work and Use High Quality Needles

Needle breakage stops machine from operation. However, changing broken needle on time and supplying right quality of needle would quickly return machine into production. During machine observation, needle broke three times. First time it broke, operator had to walk to warehouse to bring a new needle, and it took him 15 minutes to bring a new needle. During this time, machine was stopping and waiting for operator to fix. It took 5 minutes for operator to change broken needle. During 15 minutes of walking time, 6.2 kg production was lost. Fourth day of observation, there was a needle breakage again, and operator had to walk to warehouse to bring another needle to change (it took him 10 minutes to bring it). After he brought the needle, he realized that it did not fit this machine. He had to walk back to warehouse to bring a different needle (it took him 12 minutes). He was not able to change the needle during 5 minutes, and he called another operator to help him

change it. They changed broken needle after 5 minutes of trying. It took 32 minutes to change one broken needle. During this time, company lost 13.2 kg of fabric production.

If this process was standardized, it would be more efficient to operate. When needle broke during fifth day of observation, operator was able to fix it in 5 minutes as he had an extra needle with him which he brought the day before. I would suggest for the company to have cabinets with all necessary tools to fix machine when needed including needles. Needles could be sorted out according to their types. Cabinets should be placed near machines, so operators don't have to walk to warehouse.

Quality of yarn, design of knitted fabric, and some other factors influence life of needle. Using higher quality life extends life of needle, and cuts risk of needle breakage (www.smeda.org.pk). When cams have uneven surface, they leave marks on needles. In this case cams should either buff or replaced by new once. One way to shorten needle breakage is to sort out needles once needle set is changed. Needles with better condition should be placed differently. It is better not to use needles with bad condition. It might only slow down process by more frequent breakage.

High quality needles should be used to maintain machine running time and avoid frequent stoppages. Needles have different life times which depend on their quality. Some of the needles work only for one week whereas some of them may last for 3 or 4 months. Generally speaking, needles in production must be used from 30.000-50.000 kg of fabric production is reached. Therefore, quality department should check all needles bought by the company and return if it finds some of them to be lower quality.

4.2.6 Step 6 Temperature and Humidity Control

Knitting industry is based on quality of yarn and quality of yarn depends on quality of cotton. Cotton is very soft and sensitive product. It easily absorbs liquid including moisture if the air is humid. Therefore, International Standards Organization set standard for temperature and conditions in textile industry. According to ISO standards, moisture content must be 65% ± 2% and temperature must be around 20°C ± 1. Following these standards result in high quality maintenance of yarn. While observing the company's air conditioning system, I noticed that it doesn't work because of cabling damage, and fluff vacuuming system is not working due to broken electrical part. Production manager informed me that this part should be ordered from China. They were not able to find such device in internal market. As a result not working vacuum, fluff which comes out of yarn flies in the air and lands on

yarn which makes yarn thicker than it is. As a result, at some parts yarn is stuck in the hole of needle because of fluff stuck on it.

Controlling air humidity and temperature can increase productivity to 20-25%. Additionally, yarn and needle breakage could be decreased by 50% (Spencer, 2007). As quality of yarn remains high with required air conditions, needle breakage would be lowered. We mentioned that needle breakage occurs because of low quality yarn. What is more, using air conditioning would clean air from dust and fluff providing employees with clean air, and saving machines from fluff. If there is less fluff and dust on the floor, it would be easier for operator to clean his workplace at the end of this shift.

To sum up, implementing air conditioning and fluff vacuuming would result in the following benefits:

- Less breakage of yarn
- Less breakage of needle
- Less yarn wastage
- Better health conditions of employees
- Clean and controlled temperature work area
- Less machine stoppage
- Better final product quality

The company must fix air conditioning by changing broken cable. The broken part of fluff vacuuming must be ordered from China. It might cost money for the company, but it improves productivity and working area conditions in return.

4.2.7 Step 7 Cleaning Work Area

By the end of their shifts, operators have to clean their machines and workplace to prepare for the next shift. Operators don't have exact regulations towards cleaning procedures. What's more, their time is not limited to clean. All operators observed did their tasks differently and spent different amount of time. For example, three of the operators spent 31 to 35 minutes for this task, and two operators spent 24 and 25 minutes. However, all operators did their task fully. The fact is some of them work slower, and some others work faster. Taking into account difference in amount of time which was about 10 minutes, the machine could produce about 4 kg of fabric.

In order to spend the same amount of time and assign the same tasks for all operators, I suggest having cleaning work order procedures in the following way:

Table 13: Suggested cleaning procedures (by author)

	Activities	Time (min)
1.	Clean the wastes around the machine.	3
2.	Clean yarn fluff on the machine and yarn creel	5
3.	Set apart the wastes collected and deposit at the waste bins.	3
4.	Use proper tools for cleaning as instructed by managers.	
5.	Carryout cleaning activities in knitting zone and fabric zone.	5
6.	Ensure the yarn path, knitting heads, machines, and working environment are clean and free of contamination.	5
7.	Ensure safety while carrying out cleaning.	
8.	Ensure the wastes collected are deposited in the respective waste box.	1
9.	Ensure knitting machine area is clean.	3
	Total cleaning time	25

Following these procedures and ensuring all activities on the list are done will standardize operator's job for the cleaning working area. Each operator will know how much they can spend on the process. If operators don't spend more than 25 minutes, loss of production would be cut down.

4.2.8 Some Additional Tips to Improve Productivity

The company uses aluminum tube to supply yarn to the machine. This tube weakens yarn and risk of breakage is high in this case. After learning different sources by knitting experts, I would suggest using plastic tubes to provide yarn a smooth path to the machine and risk of breakage would be much lower than aluminum tubes.

I would also suggest covering machines which are not in operation with plastic, so machine would be free of dust and fluff. As a result, operator would spend less time on cleaning machine.

4.2.9 Deming Cycle

Deming cycle could be used to control the process of the project implementation.
Planning part is designed in project of this thesis. All the tasks and activities are given in order to conduct. Time analysis will show how long it will take to complete the project.

The second stage of the cycle is implementing the project. The CEO of SAAS TEKS INVEST approved the project and agreed to start implementation with the researcher as soon as he is back to Tashkent. He stated that he would be more than happy to implement new ideas into production and supports aims towards improvement of the company.

Checking should be done every hour, shift, day, week and month. Results of the changes should be reported to Production manager, he should report it directly to CEO of the company. Some changes should be made if necessary. Acting stage considers comparing planned and actual results. After analyzing comparison, make changes if needed, if actual goal was met, then keep the process stable.

4.3 PROCESS ANALYSIS AFTER PROJECT IMPLEMENTATION

After making changes, machine stoppage time can be reduced. As a result, productivity could be increased. The following table shows estimated raise in productivity after implementation of suggested ideas. One minute of production was calculated equal to 0.414 kg.

Table 14: Estimated production increase in kg after changes (by author)

	Observed		**Estimated**		**Difference**	
Measure	**Min**	**Kg**	**Min**	**Kg**	**Min**	**Kg**
Changing broken needles	11.6	4.8	5	2.07	6.6	+ 2.73
Feeding yarn	44.6	18.46	30	12.42	14.6	+ 6.04
Cleaning workplace	30.4	12.56	25	10.35	5.4	+ 2.21
Unloading final product	9.8	4.05	8	3.312	1.8	+ 0.738
Operator fixes machine	22.4	9.27	10	4.14	12.4	+ 5.13
Machine Waiting Time	15.6	6.46	5	2.07	10.6	+ 4.39
Total Stoppage Time	134.4	55.64	83	34.36	51.4	+ 21.28
Total Running Time	**345.6**	**143.09**	**397**	**164.36**	**- 51.4**	**- 21.27**

It can be seen from the table when needle breaks, and operator could fix it in 5 minutes as he can find the right needle next to him, and if he gets necessary training on that. This time could be easily managed. Estimated production increase would be 2.73 kg. Feeding yarn which takes most of the time could be shortened after trainings, and with aid of visual materials, and videos. This is one of the most challenging steps, but once operator gets skillful in that, he can manage the time (6.04 kg increase in production). As it was discussed earlier, cleaning workplace is a little bit chaotic activity. The reason for this is lack of instructions and tools necessary to clean around working area. Having the steps clear and how much time should be spent on each step would shorten the time down to 25 minutes as estimated increasing production to 2.21 kg. As company starts using high quality yarn, and air conditioning system would be working on, yarn breakage would be less frequent. And maximum expected time for yarn breakage is 10 minutes. As a result, an operator who is responsible for two or three machines at a time would have more time. This would shorten machine waiting time indeed. As a result of changes, and increasing machine running time, productivity could be increased approximately to 165 kg per shift. Total increase in production could be reached up to around 21.3 kg in one shift. As the machine works in two shifts, the productivity could be increased to 42.6 kg per day.

4.4 COST ANALYSIS

Cost analysis, sometimes called Cost benefit analysis (CBA), are a financial description of the project development. It should give a clear idea of how much are expected costs for the project would be. The following costs will be associated with the project:

Table 15: Cost analysis for the project (by author)

N#	Project expenditure	Pieces	Total
1	One week training program (salary, hours)	5 x 20 €	100 €
2	One week training program (bonus)		200 €
3	4 monitors	4 x 500 €	2000 €
4	Posters with instructions	10 x 10 €	100 €
5	Air –conditioning maintenance	1 x 500 €	500 €
6	Replace Fluff vacuuming part from China	1 x 1200 €	1200 €
7	Installing cabinets for needles and tools	5 x 250 €	1250 €
8	Plastic to wrap machines	23 x 10 €	2300 €
9	Other operational expenses		500 €
	Total expenses		8150 €

As it was described in the table, total expenses of the project are 8150 €. The biggest amount goes to buy plastic to wrap machines. Comparing to other expenses, providing training and bonus money is considerably less. As it was discussed earlier, making air-conditioning and fluff vacuuming is important to keep humidity and air temperature in the production floor. The company doesn't notice considerable impact of those machines on productivity.

After implementation of changes, estimated productivity increase is 42.6 kg a day.

Company makes about 3 € profit from each kg of the fabric produced in that machine. From this, we can calculate estimated increase of a profit for a day, and then for a month.

Estimated profit increase per day = estimated increase in kg x profit per kg

EP = 42.5 x 3 = 127.5 €

Estimated profit per month = estimated profit per day x 30 (cycle day of a company)

EP (per month) = 127.5 x 30 = 3825 €

Payback time of investment for the project is 8150 € / 127.5 € = 64 days

If all changes are made successfully, the company will earn back investment of 8150 € in 64 days due to productivity improvement.

4.5 TIME ANALYSIS

Time analysis is conducted to figure out how long it takes from the submission of the project till its implementation. Length of each activity is measured by days. The project implementation is a set of tasks. Some tasks just follow one another whereas some other tasks can't be started unless predecessors are completed. Therefore, it is crucial to create time analysis using Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT) methods. Using CPM method helps to identify which paths are critical and non-critical, and approximate time of completion time of the project. PERT method provides graphical representation of a project's timeline.

Table 16: Activities with predecessors for project of productivity improvement (by author)

Activity	Description of activities	Length of each activity	Predecessor
A	Submit a project to the management of saas teks invest ltd.	1	-
B	Schedule a meeting with the management upon approval	5	A
C	Present new project to the company	2	A,B
D	Meet with quality manager to discuss orders for high quality yarn	1	B
E	Calculate budget for expenses	3	B
F	Order and fix air-conditioning	7	D,E
G	Order a new part for fluff vacuum machine	30	D,E
H	Prepare curriculum for staff training	5	F,G
I	Prepare instructions for cleaning work area	3	H
J	Conduct training	5	H,I
K	Prepare posters of instructions	3	H,I
L	Prepare hour by hour chart	2	H
M	Buying monitors	10	D,E
N	Order cabinets for tools and needles	14	D,E
O	Order plastic to suppliers	3	D,E
P	Implementation of process changes	10	J,K,L,M,N,O
Q	Evaluate effectiveness of solution and make improvements	7	P
R	Finalization of process into businesses as usual	1	Q

Obtained result from CPM analysis is with approximately 70 days of project duration. The result with possible critical paths is attached in Appendix VII.

The activities are followed in order. The following table represents possible situations with optimistic, most likely, and pessimistic times.

Activity Number	Activity Name	Immediate Predecessor (list number/name, separated by ',')	Optimistic time (a)	Most likely time (m)	Pessimistic time (b)
1	A		1	1	2
2	B	A	3	5	7
3	C	A,B	1	2	3
4	D	B	1	1	2
5	E	B	2	3	4
6	F	D,E	5	7	9
7	G	D,E	20	30	40
8	H	F,G	4	5	6
9	I	H	2	3	4
10	J	H,I	4	5	6
11	K	H,I	2	3	4
12	L	H	2	2	2
13	M	D,E	8	10	12
14	N	D,E	12	14	16
15	O	D,E	2	3	4
16	P	J,K,L,M,N,O	5	10	15
17	Q	P	5	7	10
18	R	Q	1	1	3

Figure 34: Activities with 3 possible times of completion in days (by author)

04-15-2016	Critical Path 1	Critical Path 2
1	A	A
2	B	B
3	E	E
4	G	G
5	H	H
6	I	J
7	J	P
8	P	Q
9	Q	R
10	R	
Completion Time	70.67	70.67
Std. Dev.	3.95	3.94

Figure 35: Critical paths of the project implementation (by author)

PERT analysis resulted in two possible project completion ways, critical paths. The management can consider both paths. Additionally, in both ways project will be completed at the same amount of time, 70 days.

4.6 RISK ANALYSIS

Every company works under certain degree of risks. Some of the risks are known, and the others are hidden. The task of the Risk Management is to identify types of risks and try to avoid them. Risk management analysis risks as a whole in general level, and analysis some risks when project is created. Risks could be classified into three major categories, risks with high level, moderate level, and low level. Identifying level of risks would let managers rank them, and deal according to level of importance. The following table describes risks associated with the project and their detailed explanations.

Table 17: Risk analysis of the project (by author)

Risk area	Risk description	Probability	Impact	Actions	Responsibility
Information technologies	loss of data due to computer breakage	Low	High	Save data in more than once source	Own responsibility / IT specialist
Health and safety	Injury during operation	Medium	Medium	Instruct operators with health and safety regulations, hang posters on health and safety	Safety officer / production manager
Human factor	uncooperative operators and manager	Low	High	More team building activities, rewarding programs, bonus on salary	Production manager/operations manager
Financial	Not providing with funding to project	Medium	Medium	Present project to managers, promote benefits of the project	Own responsibility
Operational	Not operating efficiently	High	High	Educate operators in importance of project	Job operators
Time	Expecting a quick change	High	High	Report to managers about approximate timing of project presenting time analysis	Own responsibility / managers
Price change	Sudden price change for raw materials	Low	High	Regularly check market prices and consulate with financial and planning department	Financial / Marketing managers

CONCLUSION

Uzbekistan is one of the world leaders in cotton distribution to the world market. Cotton trade is a big part of GDP in Uzbekistan. However, as out president stated, we should be better at exporting final fabric made of cotton instead of raw cotton. There are a lot of regulations and reformations in this field which resulted in a sudden growth of textile industry. SAAS TEKS INVEST is also one of the textile companies which was founded in 2007 by its current CEO, Sardor Usmanov. The company's production volume is knitting fabric (300 tons) and clothing garments (300.000 pieces) per month.

During my internship at the company, operators, managers, CEO, and other employees were really cooperative and helpful. I observed company's production system and analyzed which part could be improved. As a result of my observation, I figured out that the main part of productivity is circular knitting machines which operate to knit fabric out of yarn. So, my focus was to improve functionality and productivity of those machines using my knowledge and experience I obtained in Tomas Bata University. Main goal was to improve productivity at certain percent by reducing waste by certain percent through implementing some lean tools to production process.

This thesis is divided into 3 parts, theoretical part, analytical part and project part. Theoretical part includes theoretical background about manufacturing and its history, productivity and its history, lean tools which are used to analyze production processes. All theoretical part was based on reliable sources including books, journals, and web-sites.

Analytical part contains discussion about company's profile, products, organizational structure, and most importantly production process. Different lean tools to improve process were used such as visualization, standard work, 5S, waste elimination, fishbone diagram, TOC, and pareto chart analysis. Based on analysis, it was identified that productivity of the machine could be improved by eliminating waste. Waiting, defects, motion, and skills were types of waste in the production process.

Based on calculations done on analytical and project part, it was identified that production at certain machine could be improved by 11% by reducing waste to 38 %.

Late in project part, risk, cost and time analyses were conducted. Based on risk analysis, there are not any major risks that company might face to. Risks could be avoided if all the implementation is done properly. Cost analysis revealed that 8150 € would be needed to

implement the project into process. Major expenses in the project includes monitors, fixing air-conditioning, and ordering a broken part for fluff vacuuming. Time analysis using CPM and PERT methods indicates duration of the project is approximately 70 days with some critical and non-critical paths.

BIBLIOGRAPHY

1. RICKETS, John. Reaching the Goal: How Managers Improve a Services Business Using Goldratt's Theory of Constraints. 1 st ed. Westford, Massachusetts: International Machines Corporation, 2008, 400 s. ISBN 978-0-13-256541-2.
2. SCHONBERGER, Richard. Best Practices in Lean Six Sigma Process Improvement: A Deeper Look. Hoboken, New Jersey: John Wiley & Sons, Inc., 2008, 290 s. ISBN 978-0-470-16886-8.
3. BURTON, Terence T. Accelerating Lean Six Sigma Results: How to Achieve Improvement Excellence in the New Economy. 1st ed. Fort Lauderdale, Florida: J.Ross Publishing, Inc., 2011, 397 s. ISBN 978-1-60427-054-9.
4. OAKLAND, John S. Total Quality Management and Operational Excellence. 4th ed. Third Avenue, New York: Florence Production Ltd., 2014, 530 s. ISBN 978-0-415-63549-3.
5. COX, James and SCHLEIER, John. Theory of Constraints Handbook, Penn Plaza, New York: McGraw-Hill, 2010, 1147 s. ISBN 978-0-07-166554-4.
6. CRABTREE, Ron. Driving Operational Excellence: Successful Lean Six Sigma Secrets to Improve the Bottom Line. Livonia, Michigan: MetaOps Publishing, LLC, 2011, 338s. ISBN: 978-0-9827871-0-6.
7. ABDELHAMID, Tariq, EL-GAFY, Mohamed, and SALEM, Ossama. Lean construction: fundamentals and principles. American professional constructor journal. 2009, Issue 4, ss. 8-19. ISNN 0146-7557.
8. DELISLE, Dennis. Executing Lean Improvements: A Practical Guide with Real-World Healthcare Case Studies. Wisconsin: ASQ Quality Press, 2015, 287 s. ISBN 978-0-87389-909-3.
9. CHERMACK, Tomas. Scenario Planning in Organizations: How to Create, Use and Access Scenarios. San Francisco: Berrett-Koehler Publishers, 2011, 271 s. ISBN 978-1-60509-414-4.
10. BHANDARI, Arabinda and VERMA, Prasad. Strategic Management: A Conceptual Framework. New Delhi: MacGraw Hill Education, 2013, 674 s. ISBN 978-1-25-902640-9.

11. KATSIOLOUDES, Marios. Strategic Management: Global Cultural Perspectives for Profit and Non-profit Organizations. New York: Taylor & Francis Group, 2011, 375 s. ISBN 978-0-75-067966-4.
12. HARTUNG, Michael. Lean-Six Sigma: Quality and Process Management for Managers & Professionals. QT & T Consulting, 2013, 182 s.
13. MOORE, Ron. Selecting the Right Manufacturing Improvement Tools: What Tool? When?. Burlington: Elsevier Inc., 2007, 359 s. ISBN 978-0-7506-7916-9.
14. CHARANTIMATH, Poornima. Total Quality Management. 2nd ed. New Delhi: Dorling Kindersley, 2011, 573 s. ISBN 978-81-317-3262-5.
15. PEREIRA, Ron. iSix Sigma Magazine: The Seven Wastes. Volume 5, 2009.
16. YASUHIRO, Monden. Toyota Production System: An Integrated Approach to Just-in-Time. Boca Raton: CRC Press, 2012, 520 s. ISBN 978-1-4398-2097-1.
17. JAMES, Morgan and LIKER, Jeffrey. The Toyota Product Development System: Integrating People, Process, and Technology. New York: Productivity Press, 2006, 377 s. ISBN 978-1-56327-282-0.
18. GOETSCH, David. Quality Management for Organizational Excellence: Introduction to Total Quality. Harlow: Pearson Education, 2014, 468 s. ISBN 978-1-29202233-8.
19. GOETSCH, David. Quality Management for Organizational Excellence: Introduction to Total Quality. Upper Saddle River, N.J.: Pearson, 2013, 456 s. ISBN 978-0-13-287097-9.
20. JACKSON, Thomas. Kaizen Workshops for Lean Healthcare. Boca Raton: CRC Press, 2013, 108 s. ISBN 978-1-4398-4152-5.
21. KENNETH and MCKAY. Practical Production Control: A Survival Guide for Planners and Schedulers. Boca Raton, Fla.: J. Ross Publishing, 2004, 269 s. ISBN 978-1-932159-30-4.
22. MELTON, Trish. Real Project Planning: Developing a Project Delivery Strategy. 1st ed. Burlington: Elsevier Ltd., 2008, 368 s. ISBN 978-0750684729.
23. BRADFOR L. Doing Business 2015: Going Beyond Efficiency. Washington: World Bank Publications, 12th ed., 2015, 328 s. ISBN 978-1464803512.
24. SRINIVASAN, Mandyam. Lean Maintenance Repair and Overhaul. Columbus, OH: McGraw Hill Education, 2014, 304 s. ISBN 978-0071789943.

25. RICKETTS, John. Reaching the Goal: How Managers Improve a Services Business Using Goldratt's Theory of Constraint. Indiana: IBM Press, 2007, 404 s. ISBN 0132333120.
26. BAXTER, Rod. Problem Solving for Success Handbook: Solve the Problem Sustain Solution Celebrate Success. Florida: Value Generation Partners, 2015, 92 s. ISBN 978-1-329-52824-6.
27. BAGAD, Vilas. Total Quality Management. Pune: Technical Publications Pune, 1st ed. 2008, 256 s. ISBN 81-8431-237-7.
28. GABOW, Patricia and GOODMAN, Phillip. The Lean Prescription: Powerful Medicine for Our Ailing Healthcare System. New York: Taylor & Francis Group, 2014, 183 s. ISBN 978-1-4822-4638-4.
29. TETTEH Edem and UZOCHUKWU Benedict. Lean Six Sigma Approaches in Manufacturing, Services and Production, 1st ed. Hershey: IGI Global, 2014, 343 s. ISBN 978-1466673205.
30. MAJERNIK, Milan, DANESHJO Naqib and BOSAK Martin. Production Management and Engineering Sciences. Boca Raton: CRC Press, 2015, 622 s. ISBN 978-1138028562.
31. SEHESTED, Claus and SONNENBERG, Henrik. Lean Innovation: A Fast Path from Knowledge to Value. Horsholm: Springer, 2010, 189 s. ISBN 978-3642158940.
32. PHUSAVAT, Kongkiti. Productivity Management in an Organization: Measurement and Analysis. Bangkok: To Know Press, 2013, 214 s. ISBN 9789616914048.
33. ZIDEL, Tomas. A Lean Guide to Transforming Healthcare: How to Implement Lean Principles in Hospitals, Medical Offices, Clinics, and Other Healthcare Organizations. New York: Productivity Press, 2006, 192 s. ISBN 978-0873897013.
34. BERNOLAK, Imre. Succeed with Productivity and Quality: How to do Better with Less. Wisconsin: ASQ Quality Press, 2009, 235 s. ISBN 978-0-87389-771-6.
35. PRITCHARD, Robert, WEAVER, Sallie, and ASHWOOD Elissa. Evidence-Based Productivity Improvement. New York: Taylor & Francis Group, 2012, 317 s. ISBN 978-1-84872-967-4.

ONLINE SOURCES

1. INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. iso.org [online] 2016, Accessed on February 16, 2016. Available at: http://www.iso.org/iso/iso_catalogue/catalogue_ics/catalogue_ics_browse.htm?ICS1=59&ICS2=120&ICS3=40,
2. TEXTILE APEX, Yarn Count Types. textileapex.com. [online] 2015, Accessed on February 20, 2016, Available at http://textileapex.blogspot.cz/2014/01/yarn-count-types.html.
3. Guidelines on Control of Knitting Process, nptel.com [online], Accessed on March 20, 2016 Available at http://nptel.ac.in/courses/116102008/guidelines%20on%20control%20of%20weft%20knitting%20process/productivity%20of%20knitting%20machine.html.
4. REPETITIVE MANUFACTURING, fujitsu.com [online] 2016, Accessed on March 25, 2016 Available at http://www.fujitsu.com/downloads/CN/it/products/repetitivemanufacturing.pdf,

LIST OF ABBREVIATIONS

Ltd	Limited
TPS	Toyota Production System
MP	Manufacturing Process
WIP	Work In Progress
TOC	Theory of Constraints
FG	Finished Goods
DRB	Drum Buffer Rope
OP	Operator
CBA	Cost Benefit Analysis
CPM	Critical Path Method
PERT	Program Evaluation Review Technique
IFE	Internal Factor Evaluation
EFE	External Factor Evaluation
GDP	Gross Domestic Product
MFP	Multifactor Productivity

LIST OF FIGURES

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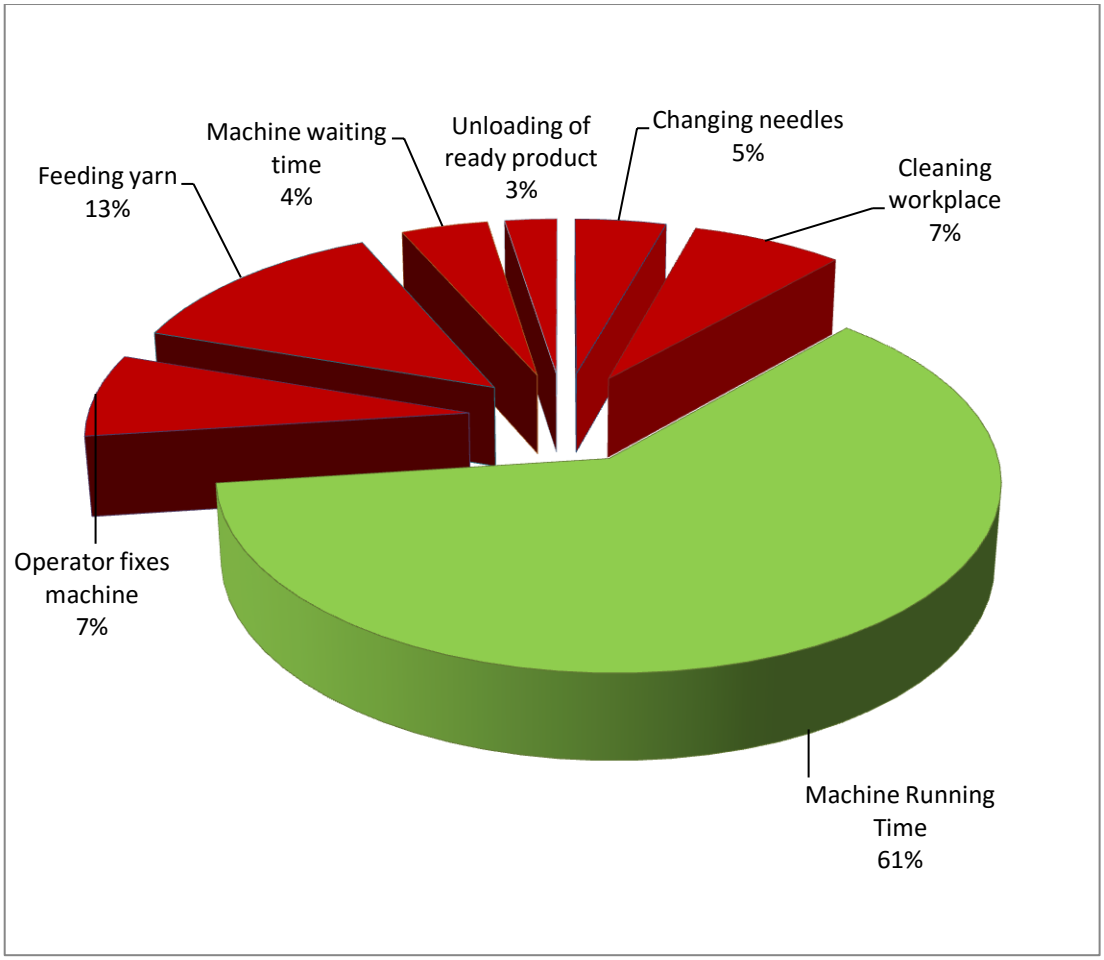
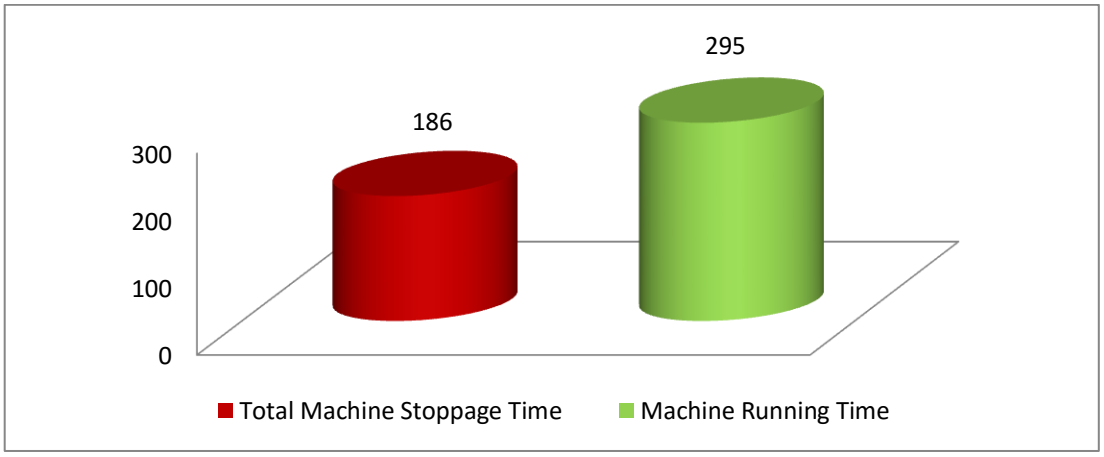
APPENDICES

APPENDIX I: DAY 1 TIME SNAPSHOT: KNITTING MACHINE (SUPREM AEN)

Shift: day Date: December 30th Time: 08:00 – 17:00





APPENDIX I: DAY 2 TIME SNAPSHOT: KNITTING MACHINE (SUPREM AEN)

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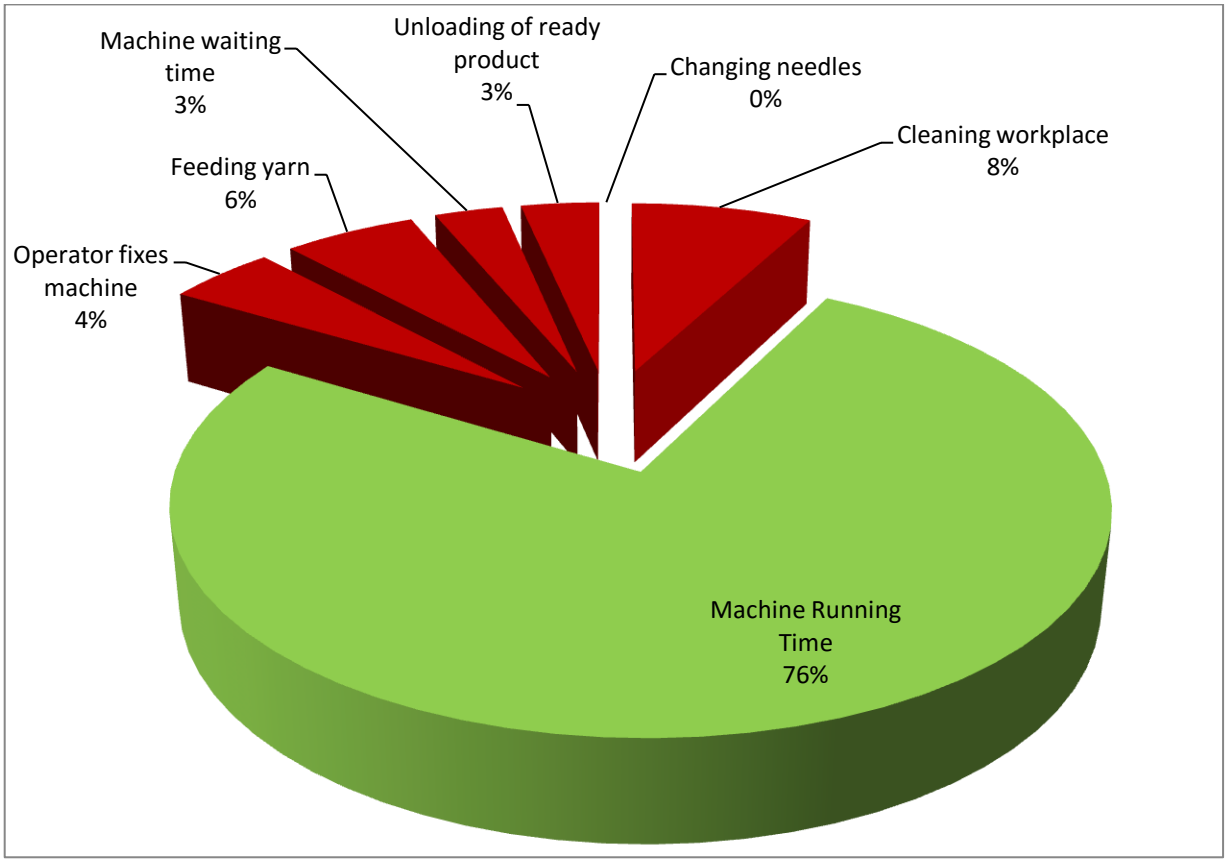

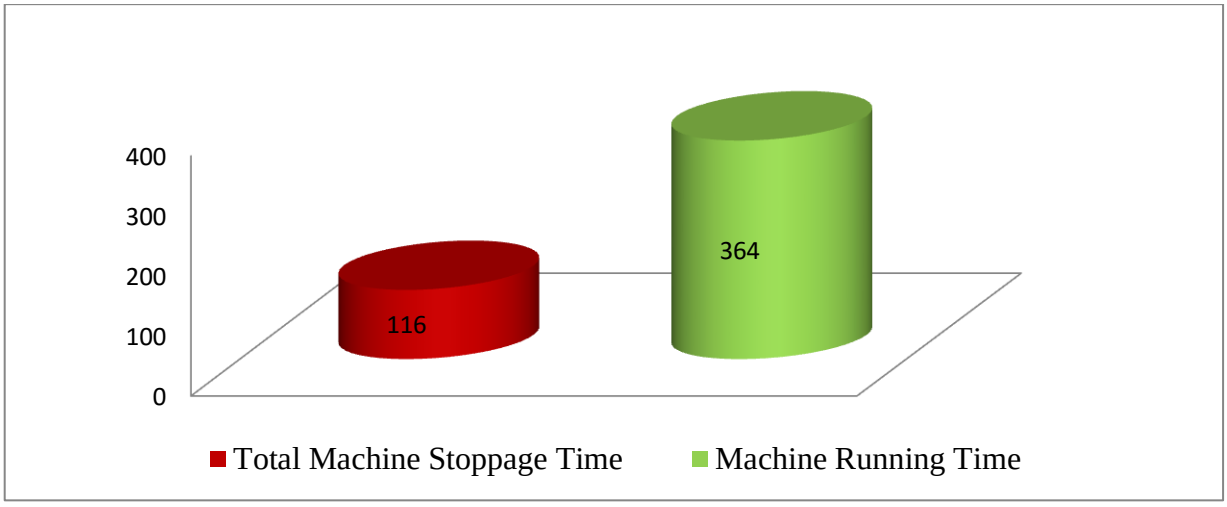

APPENDIX III: DAY 3 TIME SNAPSHOT: KNITTING MACHINE (SUPREM AEN)

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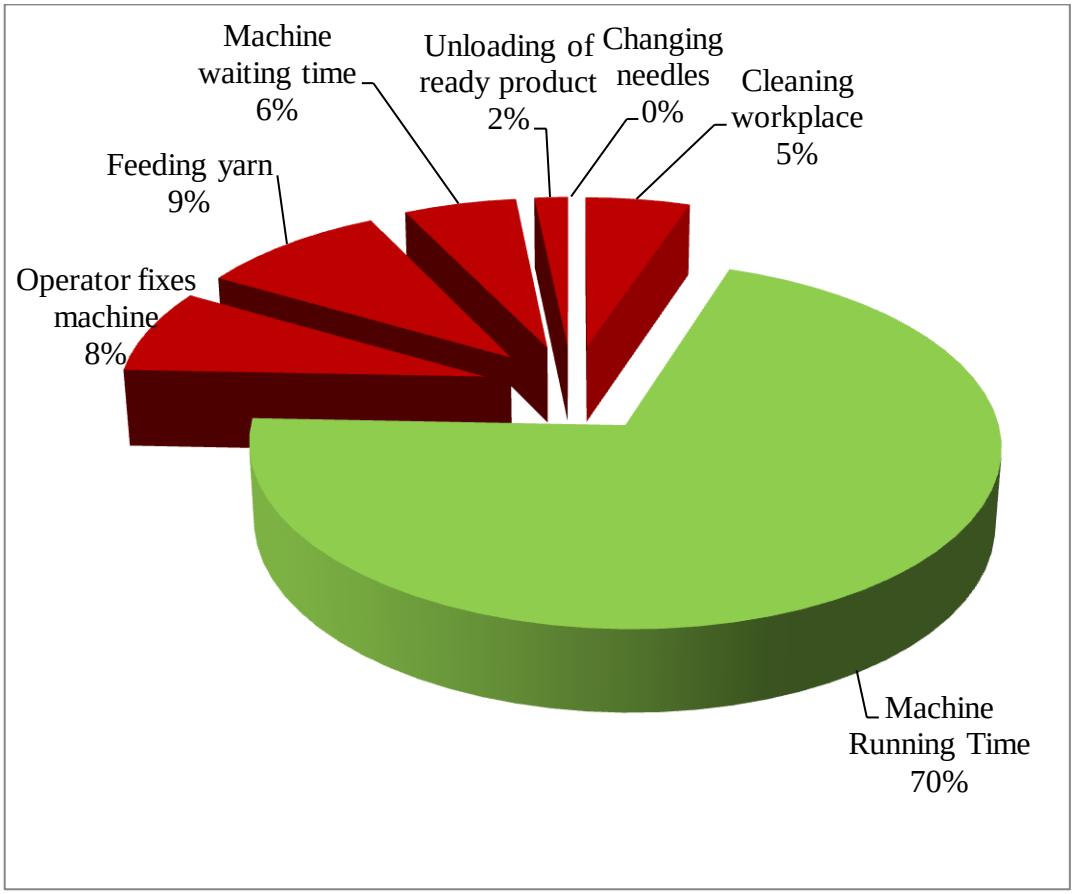

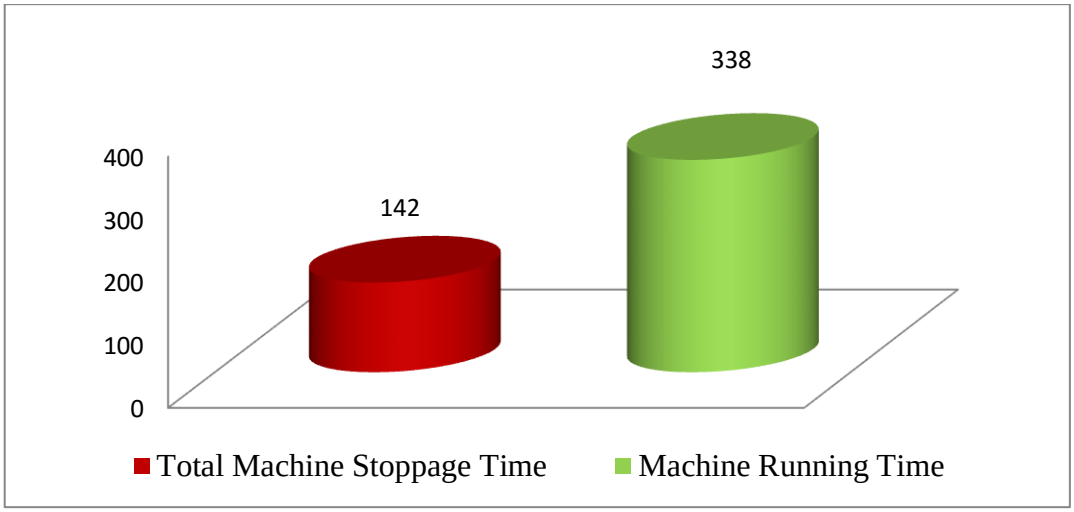

APPENDIX IV: DAY 4 TIME SNAPSHOT: KNITTING MACHINE (SUPREM AEN)

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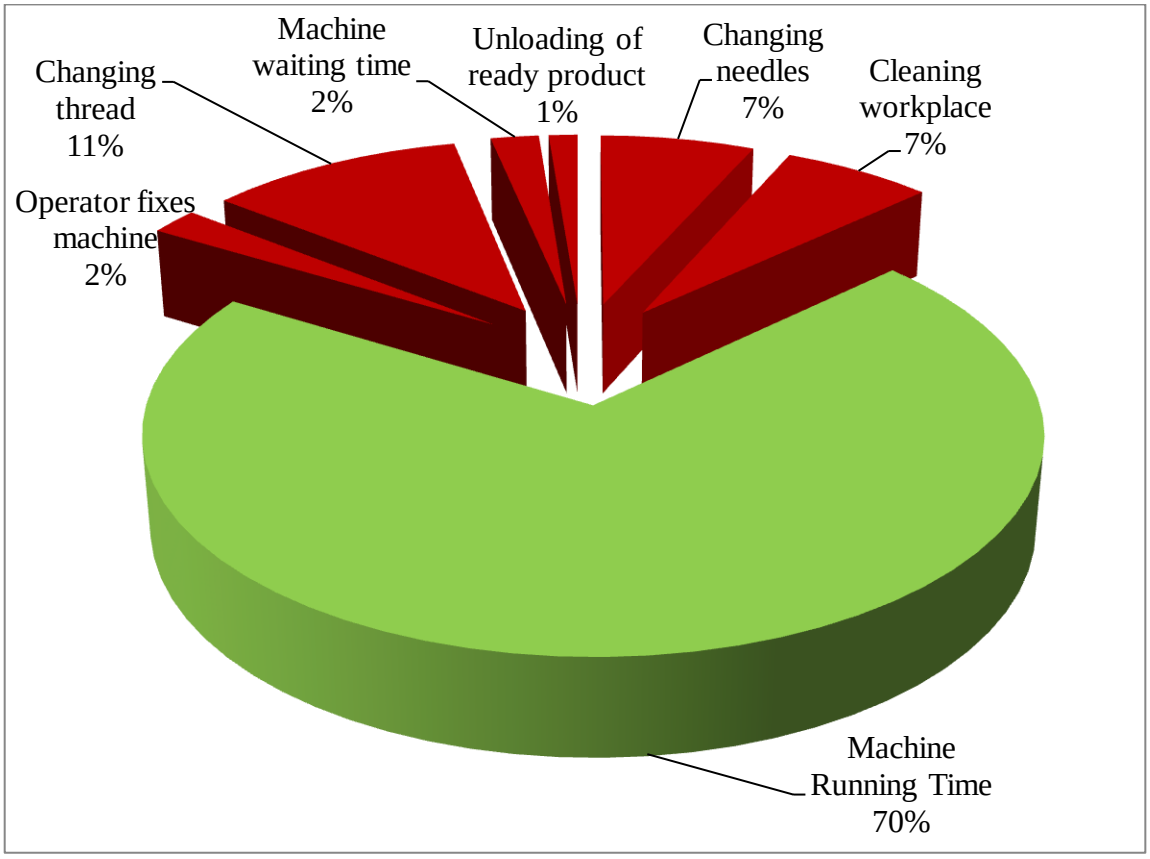

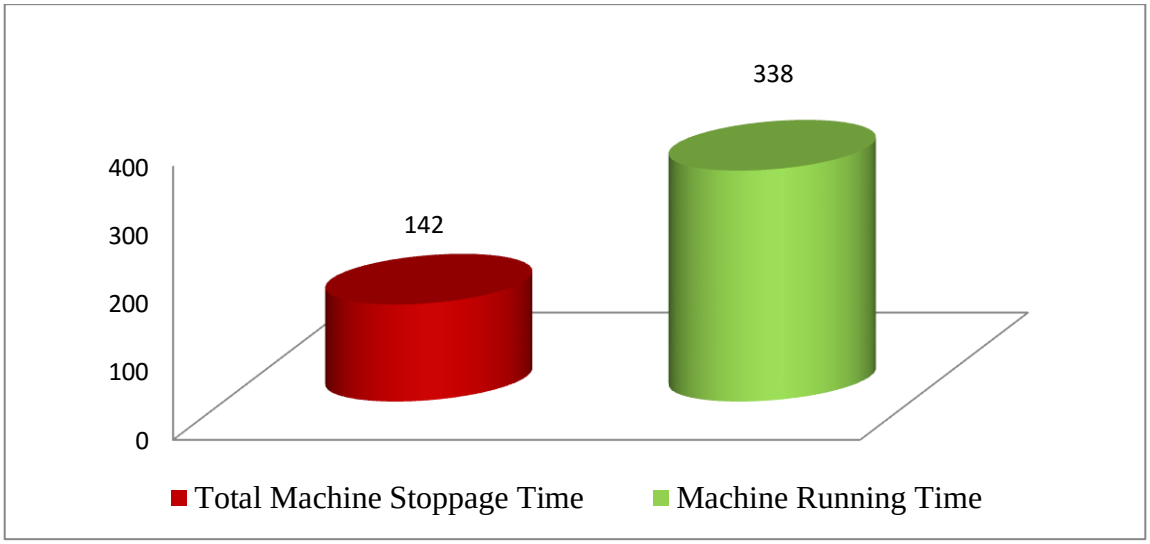

APPENDIX V: DAY 5 TIME SNAPSHOT: KNITTING MACHINE (SUPREM AEN)

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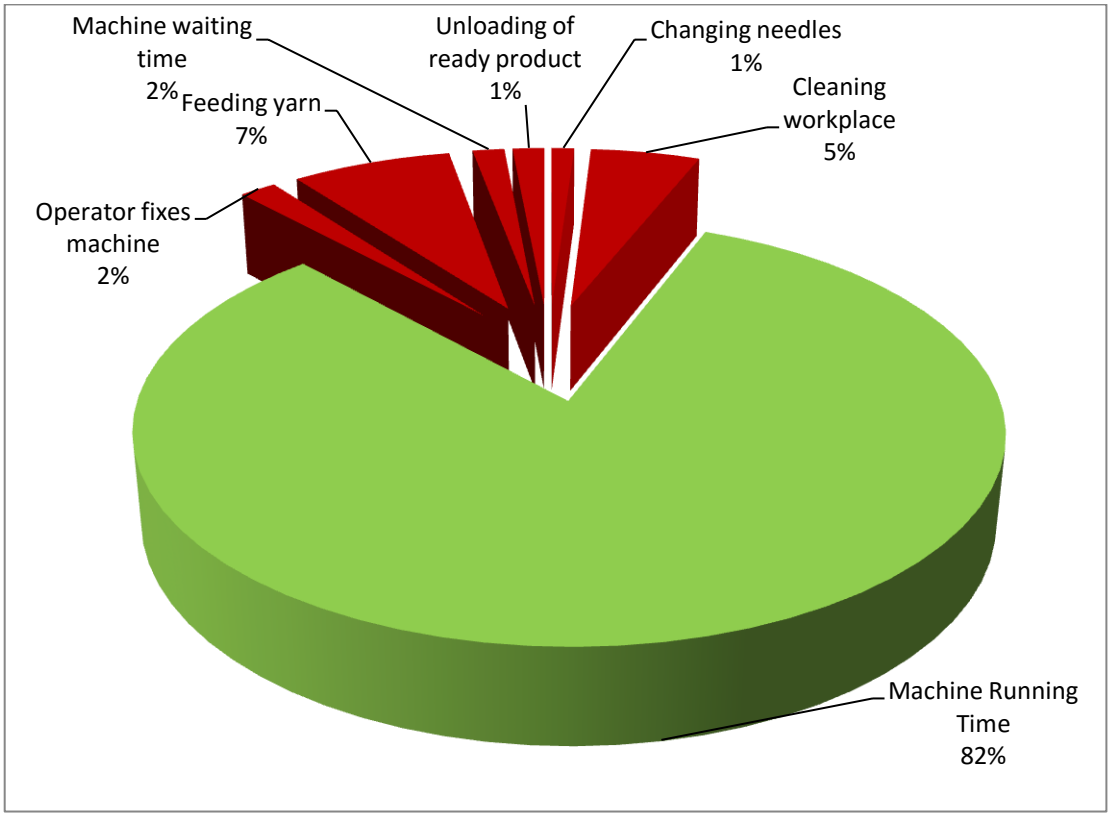

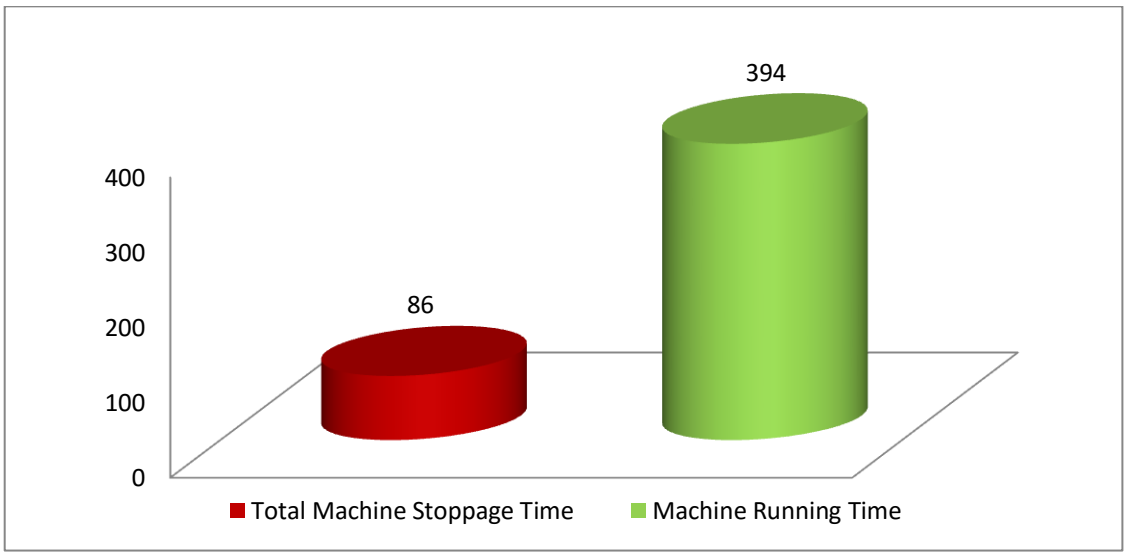

APPENDIX VI: RESULTS OF PERT ANALYSIS FOR ACTIVITIES OF THE PROJECT IMPROVEMENT OF PRODUCTIVITY

04-15-2016 08:42:20	Activity Name	On Critical Path	Activity Mean Time	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack (LS-ES)	Activity Time Distribution	Standard Deviation
1	A	Yes	1.1667	0	1.1667	0	1.1667	0	3-Time estimate	0.1667
2	B	Yes	5	1.1667	6.1667	1.1667	6.1667	0	3-Time estimate	0.6667
3	C	no	2	6.1667	8.1667	68.6667	70.6667	62.5	3-Time estimate	0.3333
4	D	no	1.1667	6.1667	7.3333	8	9.1667	1.8333	3-Time estimate	0.1667
5	E	Yes	3	6.1667	9.1667	6.1667	9.1667	0	3-Time estimate	0.3333
6	F	no	7	9.1667	16.1667	32.1667	39.1667	23	3-Time estimate	0.6667
7	G	Yes	30	9.1667	39.1667	9.1667	39.1667	0	3-Time estimate	3.3333
8	H	Yes	5	39.1667	44.1667	39.1667	44.1667	0	3-Time estimate	0.3333
9	I	Yes	3	44.1667	47.1667	44.1667	47.1667	0	3-Time estimate	0.3333
10	J	Yes	5	47.1667	52.1667	47.1667	52.1667	0	3-Time estimate	0.3333
11	K	no	3	47.1667	50.1667	49.1667	52.1667	2	3-Time estimate	0.3333
12	L	no	2	44.1667	46.1667	50.1667	52.1667	6	3-Time estimate	0
13	M	no	10	9.1667	19.1667	42.1667	52.1667	33	3-Time estimate	0.6667
14	N	no	14	9.1667	23.1667	38.1667	52.1667	29	3-Time estimate	0.6667
15	O	no	3	9.1667	12.1667	49.1667	52.1667	40	3-Time estimate	0.3333
16	P	Yes	10	52.1667	62.1667	52.1667	62.1667	0	3-Time estimate	1.6667
17	Q	Yes	7.1667	62.1667	69.3333	62.1667	69.3333	0	3-Time estimate	0.8333
18	R	Yes	1.3333	69.3333	70.6667	69.3333	70.6667	0	3-Time estimate	0.3333
	Project	Completion	Time	=	70.67	days				
	Number of	Critical	Path(s)	=	2					

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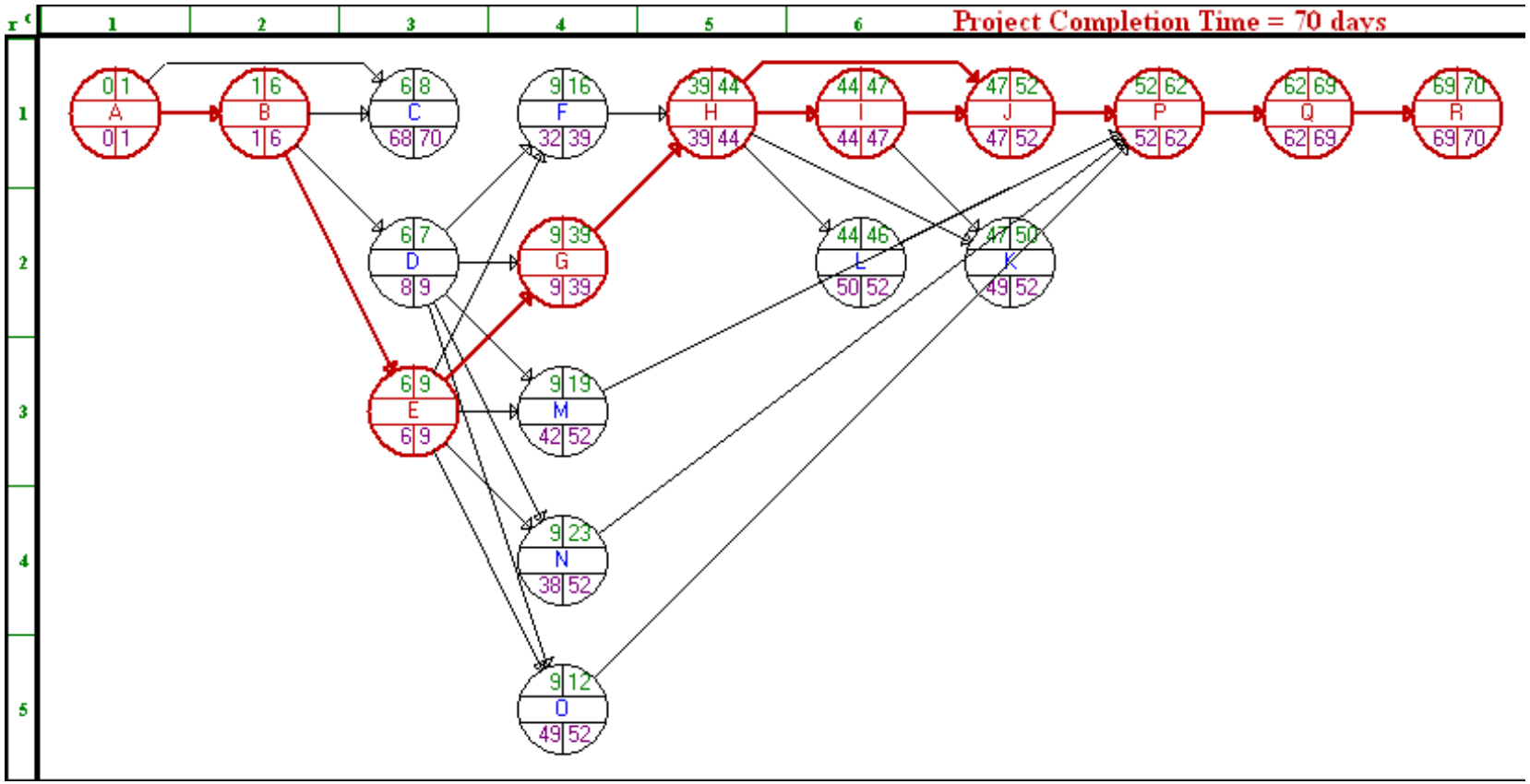
APPENDIX VII: GRAPHIC SOLUTION FOR PROJECT IMPROVEMENT OF PRODUCTIVITY



APPENDIX VIII: GANNT CHART SOLUTION FOR THE PROJECT IMPROVEMENT OF PRODUCTIVITY