IMPLEMENTING TPM AT METAL WORKING COMPANY

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Bachelor's Thesis
June 2009

School of Engineering and Technology

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JAMK UNIVERSITY OF APPLIED SCIENCES

JYVÄSKYLÄN AMMATTIKORKEAKOULU	KUVAILULEHTI 08.06.2009

Tekijä(t) Iina Auvinen	Julkaisun laji Opinnäytetyö	
	Sivumäärä 38+16	Julkaisun kieli Englanti
	Luottamuksellisuus Salainen ____________saakka	
Työn nimi Implementing TPM at Metal Working Company		
Koulutusohjelma Degree Programme in Logistics Engineering		
Työn ohjaaja(t) Olli Salmijärvi		
Toimeksiantaja(t) Kennametal Widia GmbH		

Tiivistelmä

Lopputyöni on toimeksiantaja on saksalainen metallialan yritys Kennametal Widia. Lopputyöni tarkoituksena on tehdä Kennametalin jakelukeskuksen työympäristöstä tehokkaampi, tuottoisampi, puhtaampi ja turvallisempi. Suunnitelmana oli arvioida ja ottaa käyttöön tuottava kunnossapito (engl. total productive maintenance) sekä nostaa se seitsenportaisessa taulukossa tasolta yksi aina tasolle viisi. Teoria pohjautuu ammattikirjallisuuteen, internet artikkeleihin sekä Kennametallin intranettiin. Tuottavaa kunnossapitoa on perinteisesti käyttäneet tuotantoon ja valmistukseen painottuneet yksiköt. Tämän vuoksi tuottavan kunnospidon käyttöönotto varastoympäristössä oli haastavaa.

Välttääkseen suunnitelematonta seisokkiaikaa, laitteille tulisi luoda huolto-ohjelmat sekä viikoittaiset puhdistuaikataulut. Tämä tulisi lisäämään jokaisen koneen käyttöikää. Turvallisuutta parannettaisiin merkkaamalla varaston kulkureitit ja lastauspaikat.

Varaston työpisteiden paikkoja tultaisiin uudelleen organisoimaan, jotta työntekijät pystytään paremmin ohjaamaan heille kuuluville alueille sekä lisätilan saamiseksi. Lisäksi työprosessit tultaisiin arvioimaan uudelleen paremman tehokkuuden saavuttamiseksi. Varasto ja toimistotilat järjestetäisiin ja siivottaisiin kokonaisuudessaan kaikesta turhasta materiaalista.

Avainsanat
Total Productive Maintenance

Muut tiedot

JYVÄSKYLÄ	DESCRIPTION
UNIVERSITY OF APPLIED SCIENCES	08JUN2009

Author(s) Iina Auvinen	Type of Publication Bachelor´s Thesis	
	Pages 38+16	Language English
	Confidential Until____________	
Title Implementing TPM at Metal Working Company		
Degree Programme Degree Programme in Logistics Engineering		
Tutor(s) Olli Salmijärvi		
Assigned by Kennametal Widia GmbH		

Abstract

This Bachelor's thesis was commissioned by Kennametal Widia GbmH. The aim of this thesis was to make the Kennametal Logistics distribution centre more productive, efficient, clean and safer place to work. The plan was to implement TPM and bring it from level one to level five. The theory part of this thesis is based on the information found from the professional literature, Internet articles and Kennametal Intranet. TPM has been used in production and manufacturing units already for a long time. This meant that the implementation of traditional TPM in a warehouse environment was going to be a challenge.

The machines should get maintenance plans and weekly cleaning plans to avoid unplanned downtime and to increase the lifespan of each machine. The safety of the warehouse should be improved by painting the floors with signs to show in which areas pallets are stored, where the main truck traffic is and what are the places should not be blocked or where to be extra careful when driving.

The layout of the warehouse should be modified to keep the unwanted truck personnel out of the working areas. Also more space should be cleared for storing the incoming goods. The work process would be planned carefully and reorganized to optimize to work flow. The warehouse and the office should also be thoroughly cleaned and all the unnecessary items, folders and pits and pieces would be thrown away, recycled or put away to the safe place away from the useful working area.

Keywords

Total Productive Maintenance, Warehousing, Reliability

Miscellaneous

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1 Introduction

Kennametal Value Business System (KVBS) defines the six core business execution processes, which are to create value for their stakeholders, shareholders, customers and employees. One of these six processes is called Lean. Lean manufacturing, also known as Toyota Production System (TPS) (appendix 12), was developed in Japan in 1940s'.[1] The Western way of manufacturing was trying to keep the machines running failure free as long as they could. Instead of the aim for those long production hours, the idea of lean was to concentrate only on a small part of the total time to create value to the customer.[2]

The aim of Lean is to produce the maximum amount of sellable products or services at the lowest operational cost by reducing inventory levels and improving productivity. Ideally, the low-return assets, meaning inventory and capital will be converted to productive assets, which are cash and capacity. It is also important to improve the quality of the products and this way the customer satisfaction is increased. Efficient Lean manufacturing also enhances the employee involvement and work morale by creating a positive working environment.[3]

Total Productive Maintenance (TPM) is an expansion of the Lean enterprise culture. The goal of TPM is to optimize the delivery time, service level and productivity to fulfil the customer needs and expectations. It has been acknowledged that to achieve those goals the employees are in a key role in the success of TPM project. With the help of proper training and autonomous preventive maintenance (PM), companies have been able to increase the equipment effectiveness and to reduce the machine breakdowns. The working environment is also much cleaner and safer than before. But most of all, there has been a significant improvement with worker and customer satisfaction.[4]

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[1] Borris, 2006, p.340
[2] Kennametal Intranet
[3] Kennametal Intranet
[4] Blanchard, 2004, p.36-37

1.1 Company Profile

Kennametal Widia GmbH consists of two Metalworking companies: Widia and Kennametal. Widia (**Wi**e **Dia**mant = Like a diamond) was a product of Krupp, which has been producing innovative metal-cutting tools in Essen, Germany since the late 20's. They were also the first ones to introduce carbide that would be used in this manner. The product range of Widia covers tools for turning, milling, and hole making. In the early months of 2002, Kennametal acquired Widia and added it as a part of Kennametal's product range.[1]

Kennametal is the leading supplier in the tooling, engineered components and advantaged materials market. They are the market leader in North America and hold the second position in Europe and worldwide. They are providing complex metallurgy and tungsten carbide powders to their customers, as well as high-speed steels, ceramics and industrial diamonds. The intention and philosophy of Kennametal is to design and manufacture tools which are capable of resisting extreme heat, erosion, high pressure and wear in order to fulfill the customer's requirements.

Kennametal's product range serves clients from various industrial backgrounds. The different industrial solutions can be divided into six categories, which are:

- Aerospace & Defense
- Energy resources
- Earthworks
- Transportation
- Durable goods
- Specialty applications

The Kennametal headquarters are located in Latrobe, Pennsylvania. The company was founded by a metallurgist, Philip M. McKenna, in 1938. At the beginning of the business McKenna had twelve people working for him. At that

[1] www.widia.com

time their annual sales were only reaching up to 30 000 US dollars. Nowadays Kennametal is led by Carlos M. Cardoso, the chairman, the president and CEO of the company. After the Second World War the US company expanded their business to over 60 countries and currently they are employing approximately 14 000 people all over the world. The annual sales revenue of the year 2007 reached up to 2.4 billion US dollars.[1]

Kennametal Logistics Essen (appendix 1) is responsible for storing in the warehouse goods received from their production plant in Essen, or from the suppliers located all over the world. The stored goods will be later sent either to the customer or to the internal subsidiaries. The inventory is continuously controlled by using a cycle count program of the Kennametal SAP - information system. The personnel consists of eleven employees, of which seven are working in the operational sector their responsibilities including the receiving of goods, stockpiling, picking, packing / securing, and finally the shipping of the consignment. In addition to the seven storage workers the warehouse has its own manager, group leader, shipping coordinator and customs specialist.

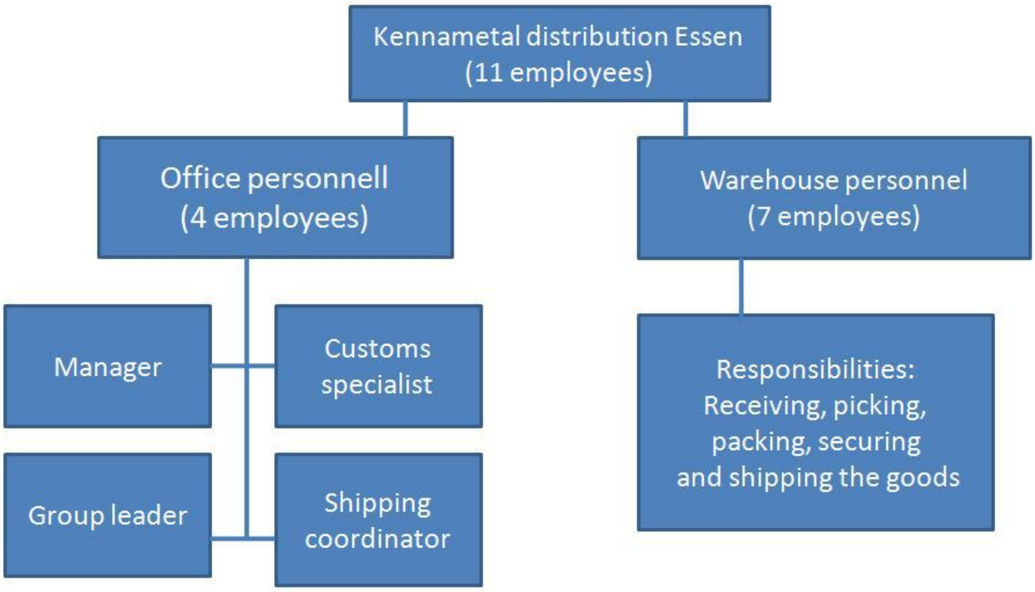

Figure 1. Worker structure

The warehouse has a volume of 1500 m^2 and it has been divided into two parts: The shelf-storage system is for storing metal shafts and pre-packed in-

[1] www.kennametal.com

serts. Tools for mining and construction and the powder are packed on EU-RO- and US- pallets and are they stored in the pallet shelves. There are around 2000 storage places in the shelf- storage system, and 900 places for the pallets. Kennametal Logistics is using a random orientated storage system to have the maximum use of the warehouse capacity. This means that incoming goods are put away into any free storage place without any particular categorization. The only requirement is that the package fits its chosen location from its measurements, which are length, height and weight. The average total volume of packages shipped yearly is around 3000 tons / 16 500 shipments, which are divided into 59% for Europe, 37% domestic and 4% others.[1]

1.2 Goals of the Project

The aim of this project was to make the Kennametal Logistics distribution centre more productive, efficient, clean and safer place to work. The plan was to implement TPM and bring it from level one to level five.

The machines should get maintenance plans and weekly cleaning plans to avoid unplanned downtime and to increase the lifespan of each machine. The safety of the warehouse should be improved by painting the floors with signs to show in which areas pallets are stored, where the main truck traffic is and what are the places should not be blocked or where to be extra careful when driving.

The layout of the warehouse should be modified to keep the unwanted truck personnel out of the working areas. Also more space should be cleared for storing the incoming goods. The work process would be planned carefully and reorganized to optimize to work flow. The warehouse and the office should also be thoroughly cleaned and all the unnecessary items, folders and pits and pieces would be thrown away, recycled or put away to the safe place away from the useful working area.

[1] Darda, 2007

1.3 Research Methods

The theory part of this thesis is based on the information found from the professional literature, Internet articles and Kennametal Intranet. Since the TPM is a widely used and well known maintenance theory, it was easy to find multiple reliable sources and suggestions on how to implement the TPM in practice. TPM has traditionally been linked to Japanese companies, Toyota and Nissan, but it has also been successfully executed in companies like Ford, Texas Instruments, Harley Davidson and Kodak.[1]

The personnel of the Kennametal Company have their own TPM experts and ongoing TPM projects, which have also provided useful information on how the goals and objectives have been achieved in the other units of Kennametal Company. Multiple interviews, meetings and discussions with the personnel, both the workers and management from the distribution centre and productions side have been utilized.

[1] Roberts, 1997

2 Definition of Total Productive Maintenance

The literature defines TPM in multiple ways. According to Peter Willmott "total productive maintenance is the enabling tool to maximize the effectiveness of our equipment by setting and maintaining the optimum relationship between people and machines". [1]

Terry Wireman[2] has a similar definition of the TPM to the one Willmott has, but instead people and machines he enhances the maximization of assets used to produce goods and services.

Benjamin S. Blanchard introduces TPM as being a productive maintenance method, which needs involvement from all levels of personnel to reduce unplanned downtime and inefficiency. On the other hand, Bill Carreira[3] talks about personnel involvement being essential in the definition of TPM. "Everyone in the organization is responsible for and involved in our success. We will all work together, as our individual skill sets dictate, and we'll keep our mechanical resources in outstanding condition, to promote an environment of superb total quality - - ".

In some of the books total productive maintenance has also been divided into two different approaches, which are the Western approach and the Japanese approach. The main difference between these two approaches is that the Japanese approach requires the full contribution of all the employees; either working in teams or in small groups is vital for the success. The Western approach sees the relationship between the equipment and the operator being the solution.[4]

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[1] 1994, Preface
[2] 2004, Preface
[3] 2004, p.279
[4] Pomorski, 2004, p.4

2.1 History of TPM

During the early years of industrialization in the 1920’s the factories emphasized mass production since it was said to keep the prices low. To make the batch sizes large, the engineers started to look for methods to increase the production levels. The first plan was to make the employees work harder. Soon after that the assembly lines were invented to make sure our employees did not need that many skills and were still able to perform the task. Even though the employees were working as effectively as they could, the factories were facing problems, this time with their machines. Due to little or non-existing maintenance, the machines were broken down easily and the wanted increase in output was not reached.[1]

Being aware of the problems the production was facing in the 1920’s, new maintenance strategies were introduced. The early form of TPM was introduced in the United States during the late 1940’s. It was called productive maintenance (PM), which basically meant that maintenance actions were planned in advance to increase the machine reliability and to decrease unplanned downtime. In the 1950’s, after finding out about this new maintenance strategy, several Japanese companies sent expects to the United States to perform a study about the PM. After the research done in the United States, the Japanese car company Toyota implemented their own maintenance strategy - TPM, which was defined as productive maintenance with total employee participation. This led to the division of TPM into the Western and Japanese approach in the 1980’s. During the early years of TPM, it was mostly used only in car industry, but nowadays this has been used also in the other areas of industry and manufacturing.[2]

2.2 Basic Concepts of TPM

As we can see from the definition of the TPM, there are many different approaches and points of view to understand it. This also means that we have

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[1] Borris, 2006, p.2
[2] Pomorski, 2004, p.10-15

various opinions on what the key issues are behind the concept of TPM. Pomorski[1] mentions in his essay four key elements of the TPM, which he thinks are the most vital. Those are:

- Structured continuous improvement process
- Optimized equipment effectiveness
- Team-based improvement activity
- Participation of employees across all levels of the operation hierarchy

Most of the times we see that the TPM actions are divided into five or eight pillars, depending on whether we are talking about the Japanese approach (eight pillars) or the western approach (five pillars). Borris and Pomorski mention the eight pillars model in their book, which covers the following elements:

- Initial phase management
- Health and safety
- Education and training
- Autonomous maintenance
- Planned maintenance
- Quality maintenance
- Focused improvement
- Support systems

Since Kennametal is a western company it uses the definition of the TPM with five pillars[2] (appendix 11), or sometimes a model known as “Yoemans and Millingtons Model”.[3] This theory enhances the following issues:

- Improve equipment effectiveness
- Autonomous maintenance
- Planned maintenance program
- Training for operation & maintenance skills
- Early equipment management

[1] 2004, p.15
[2] Kennametal Intranet
[3] Pomorski, 2004, p.18

The most important issue when thinking about TPM is to improve the equipment. Each machine has a particular task it is supposed to fulfil. In addition to performing the task, it has to do it with the designed speed with the right standard in terms of product quality and it should not endanger the operator or the environment.[1] To make sure that the machine is working at its full capacity, the TPM pursues to detect the minor defects, which themselves do no harm, but in the long run can turn into major defects. A major defect impairs the whole machine and it will be shut down. According to the TPM, the machines should be run each day as if it was their best, and only changed when it is not technologically up-to-date.[2]

The aim of the autonomous maintenance is to involve the operators of the machines to perform the routine maintenance tasks. This gives the operator a chance to increase their skill level and makes them responsible for how the machine is operated. It will also decrease the cost of maintenance since we do not have the expensive maintenance service to perform an easy maintenance task.[3] In the book of TPM Western Way, Peter Willmott[4] highlights an important issue dealing with the autonomous maintenance - although the operator will perform the routine maintenance, the tasks should not exceed their technical skills. Willmott mentions that the maintenance routine of the operator could involve for example some of the following tasks:

- Performing the primary cleaning
- Reading the counter-measurements
- Developing standards for cleaning and lubrication
- Performing small maintenance tasks autonomously (such as adding oil, changing a sealing etc.)

Planned maintenance, sometimes called preventive maintenance, is intended to abolish the equipment shut downs.[5] The goal of the planned maintenance is

[1] Mäki, 2008
[2] Kennametal Intranet
[3] Borris, 2006, p.9
[4] 1994, p.15
[5] Wireman, 1998, p.23

to reduce the total maintenance cost of a machine. Pre-planned maintenance will also lower the possibility of an unexpected failure and increase the theoretical lifespan designed by the engineers.[1]

When starting the TPM project it is necessary that the entire personnel, including the management level participate in training, which teaches them the basic skills and knowledge needed to implement the TPM. Without proper training it is impossible to execute TPM, it would not work. As the operator will be responsible for the machines, an accurate training session is required to explain how the machine works. It is also important that the employees and the management communicate with each other. The management may have the power to make changes, but most of the time the employees hold the real knowledge of the things that ought to be changed.[2]

Early equipment management makes sure that when making the investment in buying a new machine the TPM issues are fulfilled with the new design.[3] This method makes sure that the new equipment has a good maintainability and operability. When these factors are taken into account at the early stages of its lifespan they will increase the reliability and the equipment performance of the machine.[4]

[1] Hockney, 2006
[2] Wireman, 2004 p.3-4
[3] Kennametal Intranet
[4] Wireman, 2004, p.23

3 Benefits of the TPM

In the books of Terry Wireman the use of TPM shows remarkable changes made in productivity, quality, cost, inventory, safety and morale. The productivity has been increased by 100-200% and the shut downs have been reduced by 500%. The number of defects has gone down by 100%, there are also 50% less client claims. Labour costs have decreased by 50% and maintenance costs and energy costs have been both reduced by 30%. The inventory turnover has doubled and, at the same time, we have 50% of reduction on the inventory levels. There have been fewer safety and environment violations and the employee participation in small group meetings has increased.[1]

The increase in productivity will lower the cost, when we are cutting down the unnecessary workers movements, transportation and waiting times. It is also important not to produce more products than what is really needed since the right amount of inventory will enable funds, which will then be invested in the growth. The products which are produced should have the minimum number of defects and they should not be overproduced, since they will again add up the cost. The improved quality enhances customer loyalty and cut-downs in lead-time allow better customer service.[2]

As already mentioned above TPM has not only increased the productivity and efficiency, it has a positive effect on the employees; especially on their working morale and motivation. Since the machines are personalized, each worker has a better understanding and knowledge of their working area and they feel proud and gratified from the work that they are delivering. There has also been less fluctuation among the staff and the teamwork and working environment have been reported to improve.[3]

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[1] Wireman, 2004, p.5
[2] Borris, 2006, p.340-353
[3] Kennametal Intranet

4 Challenges and Barriers

When making any major changes to the company culture and to the working processes the implementation might have to face some challenges and barriers before being a success. If the management is aware of the possible pitfalls they are to expect, they can better identify the starting problems already at their early stages and act on them. Here is a list from Pomorski[1] of some of the most common problems TPM has encountered:

- Lack of time
- Wrong attitude
- Resistance to change
- Lack of commitment
- Management expects finding “a quick solution”
- Unwillingness to make investments
- Employees are not willing to take responsibility
- Planning / training has been neglected

As seen from the list, a lot of them are closely related to human factors. The implementation of TPM can cause fear and conflicts among the workers. Since TPM is highly cost driven people have been afraid to lose their jobs. The maintenance personnel may think that now that the machine operator is doing the maintenance they might not be needed at all.[2] The employees have also expressed their frustration by saying that they do not have enough time to do it, or that they never do it this way. They might also claim that they are not appreciated enough even though they would do things differently. There may be also common opinion that the management is always deciding who does and what.[3]

The managers and the supervisors are in a key role to make TPM a success. It is important that they value the workers’ efforts to make the TPM succeed. In case there appears to be any problems the management should actively try

[1] 2004, p.89-93
[2] Willmott, 1994, p.184
[3] Borris, 2006, p. 112

to solve them when they are still acute. They also ought to inform the workers about the common goals and purpose of the project. The workers might also have some suggestions and ideas for improvement, which it is important to take into account when making the changes.[1]

[1] Wireman, 2004, p.172-173

5 Maintenance theories

Maintenance has changed dramatically over the last 30 years. Traditionally it has been perceived as an action that is performed to repair the broken machine, but also as an action to fix the machine to keep it running properly. These tasks can include things like re-adjusting, replacing parts or components, changing the oil, lubricating and cleaning.[1]

Maintenance literature often presents the changes in maintenance habits with a Three-Generations model, starting from the time before the World War II. The First Generation of maintenance did not follow any particular maintenance plan, downtime did not matter and failure prevention was not considered important. This basically meant that the machines were kept running till they failed.[2] The machines were not that complex so the maintenance tasks were pretty easy and did not require high skills.

The Second Generation changed the maintenance strategies radically. The ongoing war required large amounts of supplies, but the manpower was limited, which meant that the machines had to do even more complex tasks. When the industry was increasingly dependent on the machines, it was highly important to keep them running without shutdowns. This created the first concept, preventive maintenance, during the 1960’s. The main idea of the preventive maintenance was to increase the lifetime of the machines and to keep the operation costs down.[3]

The Third Generation of maintenance noticed the link between equipment failures and the operation cost. The reliability and the availability of the machines was a vital issue for the production. The production was also moving towards the just-in-time production, where the machine failure would have a huge impact on the production and this way on the success of the supply chain in total.[4]

[1] Sullivan, 2004
[2] Mäki, 2008
[3] Moubray, 1997
[4] Moubray, 1997

TPM can be perceived as productive maintenance combining the maintenance theories from both the second and third generations. All the employees from top management to operators try to eliminate the shutdowns, losses in speed, defects, rework and breakdowns by having preventative maintenance programs for each machine.[1]

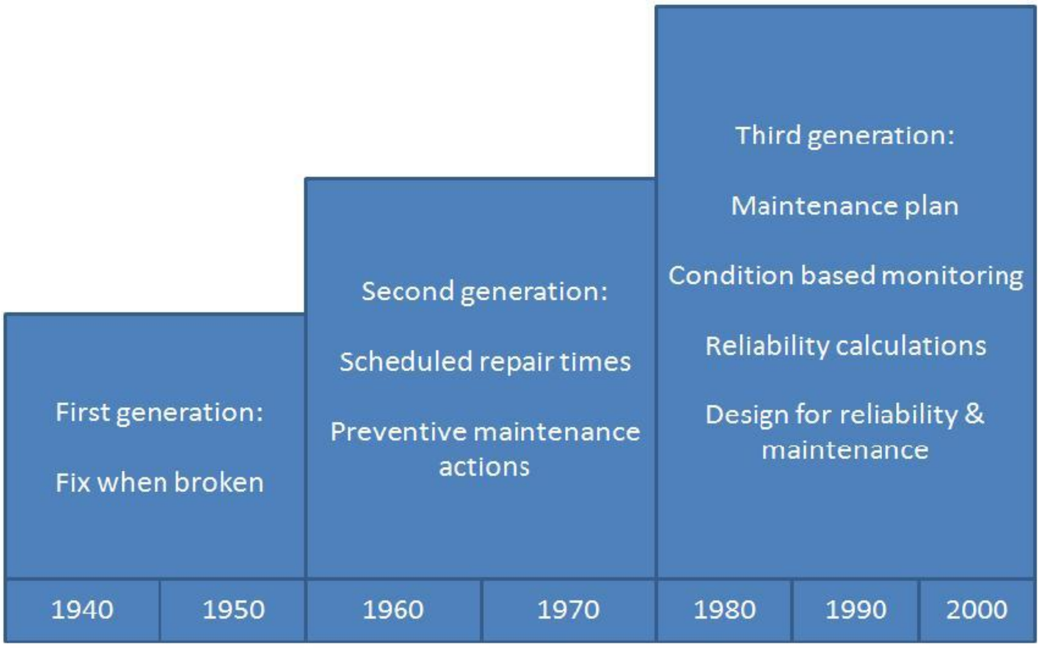

Figure 2. Maintenance history

[1] Blanchard, 2004, p.36-37

6 Reliability

The amount of unplanned downtime and shutdowns will go closer to zero when high reliability is achieved. Reliability can be defined as “the probability of a system or product will perform in a satisfactory manner for a given period of time when used under specified operation conditions”.[1] Within that definition we address the key issues of reliability: function, operation conditions and time.[2] Each machine that we use has a function it has to fulfil. This means that the machine should produce a particular amount of products with the manufacture specified speed and quality. The operation conditions define in which environment the machine has to operate: the operating temperature, humidity, vibration, handling, storing etc. The most important issue, time, gives us the expected lifetime of a machine and the probability it should run failure free. In TPM the reliability is measured most of the time with mathematical terms: mean time between failures (MTBF). We also need another mathematical term, mean time to repair (MTTR), to calculate the total availability of the machine. In addition to the MTBF and MTTR, we also need to calculate the overall equipment effectiveness (OEE).[3]

6.1 MTBF

Mean time between failures (MTBF) presents us the average time between failures. The larger the MTBF, the more reliable our machine is. But when we are calculating the failure occurrence we always have to remember that the result which we get is only an estimation and the formula for MTBF is assuming that the failure rate is constant.[4]

The mean time between failures will be calculated with the following formula:

$$MTBF = \frac{TOTAL\ RUNNING\ TIME}{NUMBER\ OF\ FAILURES}$$

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[1] Blanchard, 2004, p.33
[2] Smith, 2003, p.40
[3] Blanchard, 2004, p. 33-35, 80
[4] Nicholas, 1998, p.216

6.2 MTTR

Mean time to repair (MTTR) measures the time that has been spent on repairing the machine. This can tell us information about the quality of the maintenance work. Like, how skilled our repairs personnel are, the level of difficulty in the maintenance work and the availability of the spare parts.[1]

When we are interested to calculate the total availability we can combine these two formulas as follows:[2]

$$AVAILABILITY = \frac{MTBF}{MTBF + MTTR}$$

6.3 OEE

Overall equipment effectiveness (OEE) measures the improvement of the TPM by providing the rate of improvement. This will be calculated by using the following formula:

$$OEE = A \times P \times Q$$

The availability in this case is:

$$A = \frac{TOTAL\ LIFESPAN - DOWNTIME}{TOTAL\ LIFESPAN}$$

The total lifespan is the lifetime that the designer or the manufacturer has set for the machine. The downtime is the time when the machine is not working as a result of a breakdown, setup and maintenance.

[1] Borris, 2006, p.65
[2] Hecht, 2004, p.15

The performance rate is calculated by using the formula:

$$P = \frac{OUTPUT \times ACTUAL\ CYCLE\ TIME}{LOADING\ TIME - DOWNTIME} \times \frac{IDEAL\ CYCLE\ TIME}{ACTUAL\ CYCLE\ TIME}$$

where, output tells the number of products produced, ideal cycle time tells the designed time needed to produce one product and actual cycle time is the time used to produce one product in practice.

The quality rate uses the following formula:

$$Q = \frac{QUALITY\ DEFECTS + STARTUP\ DEFECTS + REWORK}{INPUT} - INPUT$$

Input tells the number of products produced and defects comprise the products that do not pass the quality control.[1] When improving the OEE there is an increase in both the production performance and quality. Production plants using just in time (JIT) and total quality management (TQM) manufacturing and TPM have found OEE measurements extremely useful for them.[2]

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[1] Blanchard, 2004, p.80-81
[2] Nicholas, 1998, p.222

7 TPM at Kennametal

The Kennametal Value Business System builds an operating system around Kennametal's values, people and code of ethics. The sixth KVBS was Lean. The lean concept itself contains the following methods:

- Error proofing
- Setup reduction
- 5S + 1
- Value Stream Mapping (VSM)
- Total Productive Maintenance (TPM)
- Continuous flow
- Pull system
- Standard work

Kennametal Essen has been part of Lean manufacturing since 2004. The use of Total Productive Maintenance as a part of their business operators started in the summer of 2004.[1] The use of TPM optimizes delivery times, boosts the service level and enhances productivity. All of these efforts aim to increase customers' satisfaction by meeting their demands and expectations for the product and service. The workers of Kennametal are in the key position to achieve these goals. The machine availability is improved by the use of preventative maintenance and the working environment is safer and a more pleasant place to work due to training and close teamwork among the different teams and units.[2]

7.1 Reasons for TPM

The driving factors for the use of TPM at Kennametal are the use of systematic autonomous maintenance and repair plans, which strive for decrease in machine shutdowns and maintenance cost. Co-operation between the workers and other units make it possible to exchange experiences. Training for

[1] Kick-off presentation, 2004
[2] Kennametal booklet

safety and maintenance prevent accidents and enable the employee to take greater responsibility for their work. Process working and standards reduce the amount of defects and rework.

A clean and well-organized office and production site ensure a safe and functional working place. The amount of common waste and the use of non-renewable natural resources have also been reduced. Additionally, efforts have been made to increase environmental awareness and recycling.[1] Although TPM requires time and investments, it is worth the efforts when considering at the benefits that can be achieved with it.

7.2 Five levels of TPM

The TPM can be divided into five different steps or levels as they are called in Kennametal. At the first level initial cleaning and inspection is performed. The aim of level one is to increase the knowledge of the machines and find problems, which have not been found before. Unnecessary items and equipment are also removed and general cleaning is performed to clear away the dirt and dust. At the second level all the sources of contamination, dirt and oil, are eliminated. The places which are difficult to clean and inspect are relocated or re-assembled to allow access.

The third level introduces standards for cleaning, lubricating and maintenance. They are to make sure that the cleaning is performed effectively. Problem areas are taken into closer look to pinpoint the places where lubrication has been inefficient. The process will also be documented for auditing purposes, where we have the situation before the cleaning and after the cleaning. This is an easy way to realise the positive changes achieved by TPM.

At the fourth level the personnel will be trained and advised in the basic functions and controls of the machines they use. This will make sure that they are able to perform easy maintenance tasks on their own and they are aware of the functions of the machine they are working with.

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[1] Kennametal booklet

The fifth level sums up the standards and learning acquired by training at the third and fourth level and it is time that the operator starts to perform the basic inspection and maintenance task autonomously. At this stage we take photographs of the final results and the pictures will be compared to with photographs taken at the earlier stages. Comparing the pictures is very easy and straight forward method used to document the achievements of the TPM project.

7.3 First steps of the TPM

The first TPM meeting divided the Essen location into sixteen areas of responsibility. For example production consisted of different areas and units and the financial department, HR offices and distribution centre had their own locations. After dividing the areas, each team chose a team leader. In many cases the person was already the manager or the head of that particular unit.

As mentioned in the five levels plan, the first step of implementing TPM is to perform the initial cleaning and inspection. Executing the cleaning according to the five levels plan will bring each unit to TPM level one. The deadline to complete the cleaning and this way reach the first level was in November 2004.

8 TPM at Kennametal Logistics Essen

After November 2004 Kennametal Logistics, unlike the other units, did not carry on with the TPM. In the summer of 2008 it was decided to change that fact. The other units at Kennametal carried on by implementing further levels of TPM and managed to get good results with it. The production site was cleaner, safer and more efficient. There was also an increase in machine availability, which was documented by calculating OEE levels.

Carrying on with the TPM all the way to level five brought many positive changes for the production units. This was one factor why it would be convenient to implement it also at the distribution centre. When starting the project, the floors of the distribution centre were cleaned once every two weeks by external cleaning services and a Kennametal cleaner emptied the trashcans from the offices, wiped the floors and dust briefly. The machines did not have any plans for lubrication so they were run until something broke down.

The floors did not have any markings for the areas reserved for forklift traffic. The areas where to leave incoming and outgoing goods where not fully planned either. The drivers of the trucks bringing and picking up goods were walking freely in the warehouse. This was both a safety risk and cause of unnecessary disturbance for the workers.

The layout (appendix 2) of the warehouse should also be reorganized to meet the changed demands: there were large amounts of incoming goods on pallets; there was traffic on the packing table and a growing number of small items arriving from the production on trolleys. So called “dead corners” should be utilized to store cleaning supplies, tool and packing material. There were also extra closets, cupboards and shelves which were not needed for filling the space. Changes in documentation regulation also allowed a big part of the stored picking orders to be thrown away.

The main target of the TPM project would be to bring the distribution centre from TPM level one to level five. This would require maintenance plans for the forklifts, printers and other essential machines used at the warehouse. The floors should be painted to guide in which areas pallets would be stored, where the main truck traffic should be and which places should not be blocked or where to be extra careful when driving.

The layout of the warehouse should be reorganized and cleaned. Offices, the incoming goods area, warehouse and packing area would have their own tidying plans and a team responsible for conducting the procedures. The reorganized entrance area would keep the unwanted truck personnel out of the working area and more space would be cleared to store the incoming goods. The work process would be analyzed to cut down unnecessary movements in the warehouse operations. The warehouse and the office would also be cleared from all the unnecessary furniture, folders, tools and other useless items.

During the initial cleaning, problem areas, faulty machines and other insufficiencies should be listed and later dealt with. This means that some worn parts would be replaced and needed supplies would be acquired. Before reaching the fifth level of TPM all the listed faults should be fixed. Issues which are either too expensive or are not worth repairing should be analyzed to find out if there is any other way to deal with the problem.

8.1 Planning the project

The project of bringing the distribution centre from TPM level one to level five started with a meeting between the management and with the Kennametal TPM specialist in the early days of June, 2008. The meeting discussed issues like what happens at each level, how to calculate OEE, MTTR, MTBF and the cost of production standing still.

In the second meeting all the distribution centre employees were present. The rough plan, of what was going to happen, was gone through and the employees had a chance to discuss what they wanted and expected from this project. After that the employees had to be divided into teams and each team chose a team leader for them. Three teams where formed (appendix 5). Team number one was responsible for the front part of the warehouse, where the goods were coming in. The second team was responsible for the storage area and the third team had the two offices as their responsibility.

8.2 Initial cleaning

As in the official plan, TPM always starts with an initial cleaning and this project was not an exception. The employees were also advised to take pictures and write down a list of the issues that should be repaired, replaced, modified or that were otherwise causing a risk if not dealt with (appendix 4, 6&9).

The first team who were responsible for the incoming area were advised to clean the loading ramp and the working desks where incoming goods are received, booked, labelled and sorted. The packing desk, the shelf next to the packing desk and the sink would also be their responsibility. The second team who had the storage areas as their responsibility were guided to clear all the corners and side paths from all the trash (pieces of wood and metal laying around the storage area) and to wipe floors with a broom. The shelves in the warehouse and the shelves for packing materials were also went to through and cleared from all unnecessary items, folders and trash.

The office team tidied their desks, shelves for the folders, radiators and drawers under each desk. Every team member cleaned their own desk and the common coffee table, cabinets and folder shelves across the office were cleaned together. A lot of the paperwork and documentation for the customs and for the tax department was collected together and brought to safe place in the other side of the company.

The office team also helped the storage team to sort out the old picking lists and shipping documents, which were carelessly placed over the storage shelves in the small items area. After the initial cleaning, the photographs taken from the storage and the list of faults were put together and discussed with by the management. The list of faults can be found in Appendix number four.

8.3 The new layout

After the initial cleaning the layout (appendix 3) of the warehouse was taken into closer examination. The number one priority in the layout change was to get the truckers away from the storage room. In the new layout they would not go further than the entrance desk of the shipping coordinator, who would handle the booking of the outgoing goods, print out the labels and attach them on the right outgoing packages. He would also sort out the order lists coming from the printer next to the desk.

Next to the shipping coordinator’s there desk would be two tables serving as a packing table for the smaller packages. The two tables would be opposite each other and the machine tying the packages with a string would be on the other side of the table, where as the machine creating paper bundles from the rolls of paper would be located on the storage side of the table.

The receiving desk would move from the front side of the storage room behind the shipping coordinator. The incoming goods would be collected next to the wall and the shelf from the wall would be moved to the front side of the offices to bring the extra free space next to the cellophane machine.

The desks for packing and shipping were originally placed on the warehouse side of the front area. Moving them closer to the door would free the needed space for incoming pallets and small items on wheel carts. The desks’ to print labels and pack small items would also be removed to new location. The storage had a small space free next to the small items shelves, which was an ideal place to fit the desks. The lifting machine for heavy items was moved to the front of the warehouse, where it would have a larger reaching radius.

The cabinets for tools and cleaning material were moved to the new side of the storage room. Two new cupboards would replace the old crooked ones, which had already become too small to fit all the needed items.

8.4 Markings

One big part of the re-organization was to mark the warehouse with signs showing which areas belong to the incoming and which to the outgoing goods. The storage room floors would also be painted to mark the driving paths for the forklifts. The doors to the distribution centre would get signs to warn from the forklift traffic and the missing signs for fire extinguishers would be hung again.

The cabinets containing the tools and cleaning supplies would be marked with signs, too. These would tell which items belong to the inventory of each cupboard and the right places for them to be found and returned after the use. The plastic boxes holding the paperwork of the incoming goods and the picking area would be replaced with new see-though boxes and they would get new tapings to address the content of the each box.

8.5 Establishing the cleaning standards

The initial cleaning performed at the first level of the TPM would clean the distribution centre from the most acute dirt and dust. After this the cleaning would become a normal routine repeated within pre-planned intervals. The cleaning would follow a plan (appendix 7&8) which contains the following information:

- Who cleans?
- What is cleaned?
- How to clean?
- How often to clean?
- What cleaning products should be used?

The standardized cleaning procedures make sure that everyone can keep the working area they are responsible for clean and in good order. This makes the working environment more efficient and a nicer place to work in when the items are in their right places and everything is tidy. The workers would follow the plan autonomously. If considered necessary, the plan can also involve a printed paper with the dates and a place to write the initials after the work has been done. This way the workers and the management can keep track of the cleaning done and the person who completed it.

9 Results

The warehouse was reorganized and the cleaning standards were established. The initial cleaning brought up issues which needed to be replaced and fixed. The new layout ensured that the truck drivers were not disturbing the workers anymore and a lot of space was cleared for the incoming pallets. Altogether, the new blueprint was able to utilize the previously non-occupied corners more effectively and the warehouse could have a larger potential for growth.

The implementation of the new cleaning standards did encounter some resistance. The job description of a storage worker did not contain any regular cleaning before. Due to this, a couple of workers were worried if they would have enough time to follow the new plans. Some of the workers have had their own desk for a long time and they have been performing cleaning with their own pace. They have not seen much change in the plans made along the TPM. Earlier some workers felt that they were doing most of the cleaning, so after implementing the standards the workload was been divided more evenly and no one has had the feeling that they are only ones responsible.

When thinking about the main focus of the TPM in the production units, it is mostly focused on the machines. The warehouse has forklifts, printers, cellophane machine, a packing machine, a packing material machine and a pressure lift. The first plan was to maintain them autonomously at the distribution centre. Unfortunately the complexity of these machines was too much to implement autonomous maintenance plans. The level of maintenance that the workers would perform would be only to keep the machines clean.

To maintain most of these machines would require intensive training both from the theoretical and practical side. Some of the machines even require a special electricians' certificate from the person maintaining the machine. In this way the TPM project that we managed to carry out was not followed directly according to the plan. Instead, we had to modify it to fulfil the warehouse needs and our purpose was not to train the workers to become fully qualified engineers.

Historical data required for calculating MTTR and MTBF does not exist. We managed to find some maintenance bills but the reasons for the breakdown were lacking in most of them. It was unclear whether the machine was taken into the repairs for inspection or if it was a case of total breakdown. The OEE calculations would have been possible but doing this would not bring the needed information. The forklifts run a couple of meters and are stopped when picking up the goods. They are not even wanted to run all the time. When calculating OEE for machines like this, the rate would not tell the real situation of the machine availability.

The list of faults was examined and all the issues that were worth repairing were fixed and new investments were made. A few of the points, like the brand new working desks and the repairing the uneven floors would become too expensive to fix at the time and they were left out.

The success of the project should not be controlled by using quantitative methods, since the availability and reliability calculating could not have been used. Instead the achievements were qualitative. In total, the project was a success. The work processes were optimized and the new layout along with the cleaner working environment was a positive change. The total capacity for the received goods was increased and there was more space to fit in the incoming pallets. New tapings on the back room shelves were easier to read for the workers picking up the goods. New signs and markings structured the storage room and less time was spent on searching the wanted items.

10 Conclusion

As mentioned earlier, Lean manufacturing contains various approaches to maximizing the efficiency by lowering the operational cost by reducing inventory levels and improving productivity. One good solution hat would be a better solution to the warehouse needs would be to use 5S+1. This means that we sort, straighten, shine, standardize and sustain the wanted processes. In addition to the 5S, safety is also considered. The use of 5S+1 does not require specific knowledge about the machines; instead it is very inexpensive, effective method based on common sense.

The future challenge the warehouse is facing is to decrease the operation cost. Although failure free machine operations are also vital for the warehouse it is not building up the most cost to it. The biggest efforts, instead of the machine breakdowns, should be concentrated on the inventory levels of products and to the amounts of supplies ordered. The use of pull-method (Kanban) was implemented for the distribution centres water bottles. This means that each product that we need to order has a particular limit which tells when to order. If the warehouse supplies (carton boxes, packing materials, papers, pens and etc.) were ordered at pull-system intervals there should not be times when the particular product has been run out or that too much has been ordered. When using pull-method we always have the optimal inventory levels in relation to the money invested.

The financial benefits achieved with this project are hard to measure. We could try to calculate the lead time. Or we could measure the times spend on each working process now and earlier. What is more difficult is to put a price tag on safety. The new chairs will add cost but it will pay back its price when the worker has less sick days and a healthy back. Clean and tidy working place is much pleasant to work in. But it will also be better for the workers health, especially in the working place were we got people who suffer from allergies and illnesses, such as asthma.

TPM has been used in production and manufacturing units already for a long time. This meant that the implementation of traditional TPM in a warehouse environment was going to be a challenge, if not impossible. Due to the lack of knowledge of how to repair and maintain the machines, the TPM plan was made to cover only the cleaning, safety and efficiency issues. Although the common plan of TPM was not exactly followed, the implemented project brought positive changes to the warehouse operations.

11 Abbreviations

JIT	Just-In-Time
KVBS	Kennametal Value Business System
MTBF	Mean time between failures
MTTR	Mean time to repair
OEE	Overall Equipment Effectiveness
PM	Preventive Maintenance, Productive Maintenance
TPM	Total Productive Maintenance
TPS	Toyota Production System
TQM	Total Quality Management
VSM	Value Stream Mapping

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13 Appendixes

Appendix 1.	Kennametal Logistics – Statistics
Appendix 2.	Layout of the warehouse before TPM
Appendix 3.	Layout of the warehouse after TPM
Appendix 4.	Initial clean – The list of actions
Appendix 5.	TPM Teams
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Appendix 7.	Cleaning plan – Control chart
Appendix 8.	Cleaning plan – Action chart
Appendix 9.	Equipment selection chart
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Appendix 11.	The five pillars of TPM
Appendix 12.	Toyota Production System

Appendix 1.

Products

1. Raw materials and supplies
2. HM-Inserts, Rods and Tools

Material to be machined

1. parcels / pallets of inbound shipments
2. Coated and uncoated tungsten carbide tools from production orders

Tasks

1. Receiving, checking, booking of received goods and internally plant distribution
2. Checking, booking, partitioning of finished production orders to Kennametal Distributioncenters and Sales Offices, manual packing

Equipment

Hardware: Computer, Scanner, Labelprinter, scale
Software: SAP, Kennametal Logistic System

Organisation

1 shift operation, KVP, TPM

Metrics

Employees:	2 (10)
Average lead time:	0,2 days
1. 7800 items receiving / year	
2. processed pieces per year	
inserts:	15.000.000
rods:	22.000.000
die & wear parts:	800.000

Appendix 1.

Products
Hardmetal Rods, Mining & Construction, Die and Wear parts

Material to be machined
Tools for distribution

Tasks
Put away and picking of tools, packing and shipping customer orders, cycle count, Import and Export dispatch, customs compliance, freight approvals

Equipment
Winder and strapping machines, scales, serveral fork lifts, computer, scanner, printer and equipment

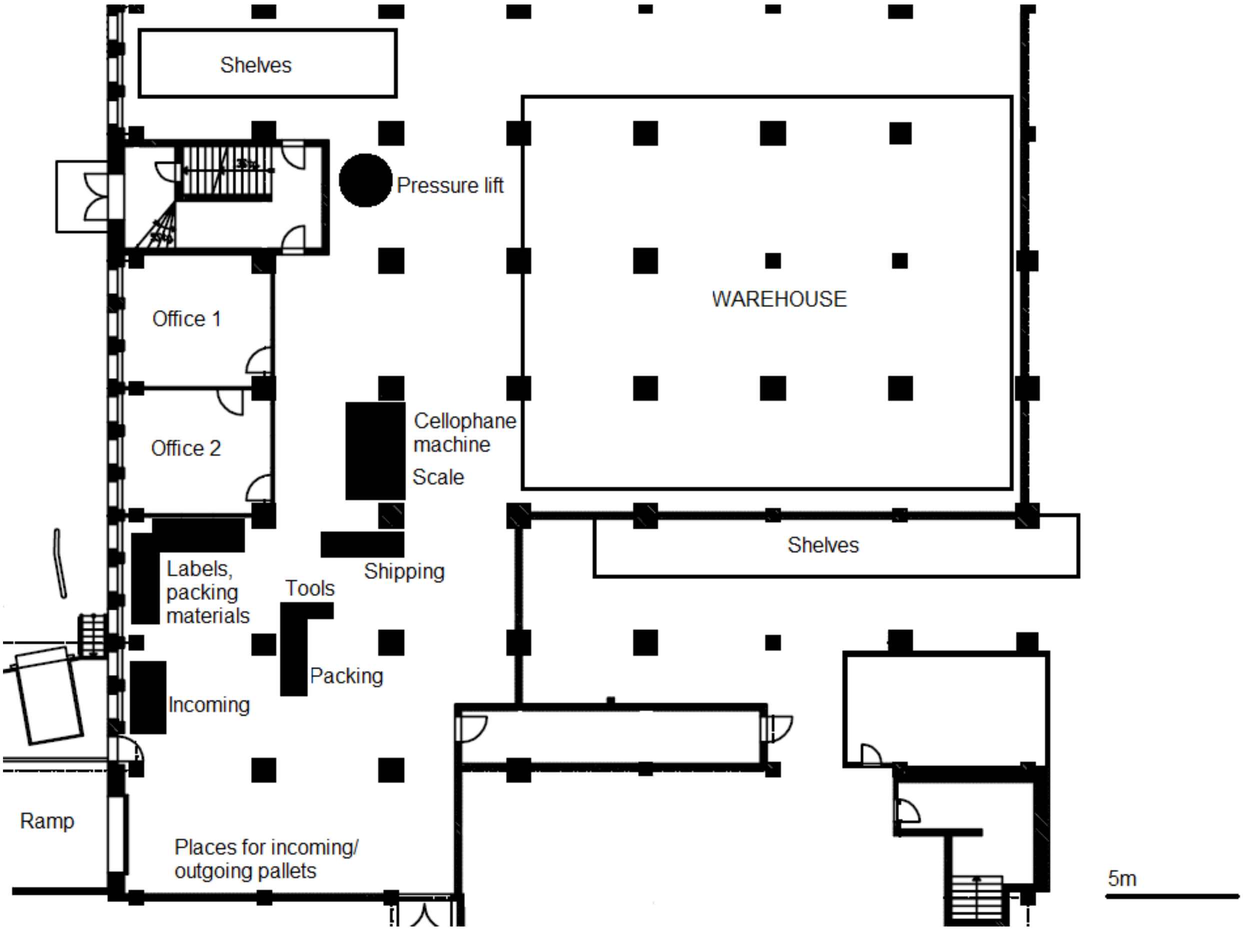
Organisation
1 shift operation, KVP, TPM

Metrics

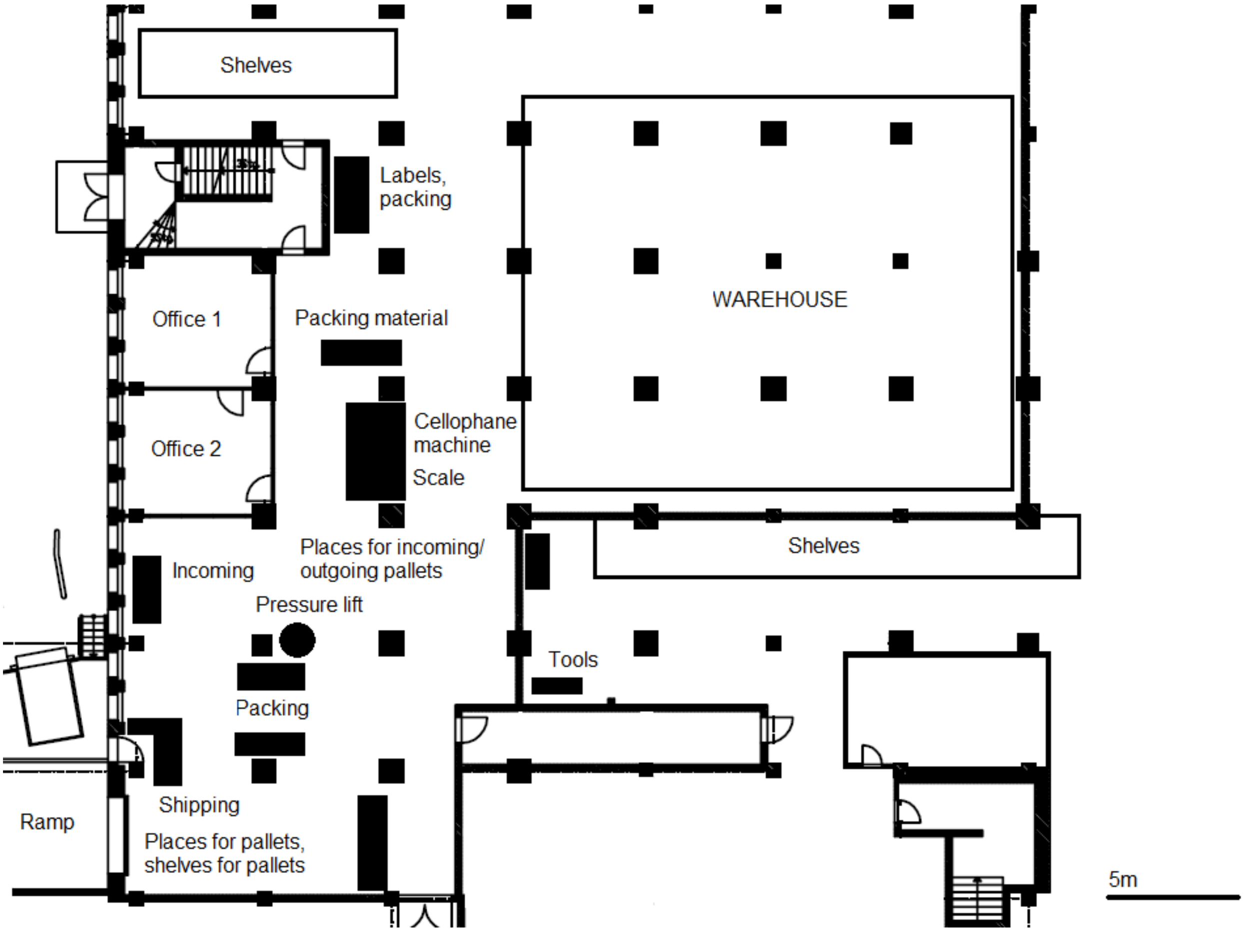
Employees:	8 (10)
Average lead time:	0,2 days
shipments per year:	16.500
freight volume per year:	3000 tons

Domestic 37% / Europe 59% / Others 4%

Appendix 2.


Shelves
Pressure lift
WAREHOUSE
Office 1
Office 2
Cellophane machine
Scale
Shelves
Labels, packing materials
Tools
Shipping
Packing
Incoming
Ramp
Places for incoming/ outgoing pallets
5m

Appendix 3.


Shelves
Labels, packing
WAREHOUSE
Office 1
Packing material
Office 2
Cellophane machine
Scale
Places for incoming/ outgoing pallets
Shelves
Incoming
Pressure lift
Tools
Packing
Shipping
Ramp
Places for pallets, shelves for pallets
5m

Appendix 4.

TPM
Initial clean
List of actions

Kennametal Logistics Essen

Date	Procedure	Responsible	Planned D-day	Ready
17.6.2008	Paint the floor guidedance for the forklifts	Darda/Auvinen	21.10.2008	5.11.2008
17.6.2008	Mark the incoming goods area with signs	Team 2	15.12.2008	
17.6.2008	Mark the outgoing goods area with signs	Team 1	15.12.2008	
17.6.2008	Mark the packing area with signs	Team 1	15.12.2008	
17.6.2008	Fix the printer "WE19"	Blach	10.7.2008	15.8.2008
17.6.2008	Clean the windows	Schmidt	10.7.2008	21.7.2008
17.6.2008	Change the lamellas at the ramp entrance	Darda	28.11.2008	
17.6.2008	Fix the sink	Ripkens	10.7.2008	24.7.2008
17.6.2008	Repair the ramp	Bongards	10.7.2008	15.8.2008
17.6.2008	Buy new boxes for the papersheets	Ripkens	10.7.2008	21.7.2008
17.6.2008	Buy new tools	Ripkens	10.7.2008	14.7.2008
17.6.2008	New signs for the warehouse doors	Darda	10.7.2008	30.10.2008
17.6.2008	Integrate scale to the packing table	Ripkens	10.7.2008	31.12.2008
17.6.2008	Attach back wall to the new shelve	Darda	10.7.2008	30.7.2008
17.6.2008	Fix the new shelve tight to the floor	Darda	10.7.2008	30.7.2008
18.6.2008	Folder tower stands uneven	Ripkens	10.7.2008	8.7.2008
18.6.2008	Clean the coffeemachine	Georg	10.7.2008	4.7.2008
18.6.2008	PC screen higher on the table	Ripkens	10.7.2008	21.7.2008
18.6.2008	The high of the tables should be changeable	Darda	10.7.2008	not implem
18.6.2008	Fix the fax machine	Georg	10.7.2008	14.7.2008
17.6.2008	The floors are partly uneven	Darda	10.7.2008	not implem
17.6.2008	Change the taping at the back room of the warehouse	Auvinen	10.7.2008	15.7.2008

Appendix 4.

17.6.2008	Clue the BT-forklifts dashboards and cap the roof	Ripkens	10.7.2008	15.9.2008
17.6.2008	Food, jackets and other items away from the warehouse	Ripkens	10.7.2008	15.9.2008
22.7.2008	Hang the calenders and watch nicely at the office	Schwedhelm	20.8.2008	15.9.2008
22.7.2008	Buy two new PC's to the warehouse	Darda	20.8.2008	17.10.2008
22.7.2008	Mark the trash cans	Ripkens	20.8.2008	
22.7.2008	Fix the speed dials of the office fax machines	Georg	20.8.2008	
22.7.2008	Headsets to the office workers	Darda	20.8.2008	not implem
22.7.2008	Dispose the old table fan	Schwedhelm	20.8.2008	20.8.2008
22.7.2008	Change the doormats	Ripkens	20.8.2008	
22.7.2008	Introduce cleaning standards to the office	Auvinen	20.8.2008	23.7.2008
22.7.2008	Re-arrange the office	Georg	20.8.2008	10.10.2008
22.7.2008	Bring old documents to the cellar	Darda	20.8.2008	22.7.2008
22.7.2008	Clean the key cabinet	Ripkens	20.8.2008	31.10.2008

Appendix 5.

TPM Teams - Kennametal Logistics			
Where	**Incoming goods area**	**Warehouse**	**Offices**
What	Packing table	Storage shelves	Desks
	Small items shelves	Floors	Cupboards
	Labeling desk	Shelve for packing material	Coffee table
	Incoming desk		
	Shipping desk		
Teams	**Team Hügen**	**Team Mendrina**	**Team Schwedhelm**
Responsible	**Hügen**	**Mendrina**	**Schwedhelm**
Team members	Gunia	Aajour	Darda
	Eulenbach	Jung	Ripkens
		Erenler	Georg

Appendix 6.

TPM - Level One Visual Cleaning Plan

Equipment Identification:	**Team Members:**
Dept. No.-------------------- Date. ----------------	Names:------------------------ ----------------------
Cleaning Frequency..D------W-------M	------------------------ ----------------------
	------------------------ ----------------------
	------------------------ ----------------------
	List of Safety Measures:
	Lockout/Tag Out--------------------
	Confined Space Entry---------------
	PPE------------------------------------
Photo Of Cleaning Standard	
	Required Cleaning Materials List:
	Cleaning Detergent
	Cleaning Rags
Remarks:	Utensils
	Misc.
	List Areas to Be Cleaned
	1)____
	2)____
	3)____

Appendix 7.

Cleaning plan
Where

Inventar Nr.	Machine Nr.	Machine	Account Nr.
			EEE XXX

Team : XXX

Worker — Maintenance guys — External company

Nr. / who	Interval	Calender week 1	2	3	4	5	6	7	8	9	10	11	12	13
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														

Appendix 8.

Cleaning plan

Where

Inventar Nr.	Machine Nr.	Machine	Account Nr.
			EEE XXX

Work division		Interval		Cleaning method	
		t	daily	1	Broom
		w	weekly	2	Wet towel
	Own worker	m	monthly	3	Dust wiper
	Maintenance guys	j	yeatly	4	Water + Fairy
	External company			5	

Nr. / Who	What	Where	Cleaning method	Interv.
1	XXX	XXX	2/3	w
2	XXX	XXX	2/3	w
3	XXX	XXX	2/3	w
4	XXX	XXX	2/3	w
5	XXX	XXX	2/3/4	m
6	XXX	XXX	1/4	t
7	XXX	XXX	1	t
8	XXX	XXX		w

Appendix 9.

TPM Equipment Selection Chart

Machine Type							Date		
AREA	**NUMBER**	**ITEM**	**EVALUATION**				**EVALUATION STANDARD**		**Priority Ratings:**
Production	1	How often is the equipment used?	5		2		EIGHTY PERCENT OR ABOVE	5	
	2	Is there back up equipment available ?	5	4	2	1	NO OR YES BUT TOO MANY MANHOURS REQUIRED (MULTIPLE MANCHINES)	5	A= 30 points or more
							AVAILABLE IN OTHER DEPARTMENTS	4	B= 20 to 29 points
							COVERED BY INVENTORY	2	C= 19 points or less
							COMPATIBLE BACKUP EQUIPMENT IS AVAILABLE	1	
	3	To what extent is the equipment running a deciacted product?	5	4	2		100-75%	5	
							74-35%	4	
							34-0%	2	
	4	To what extent will failure of this equipment affect other processes?	5	4	2	1	WILL AFFECT THE ENTIRE PLANT	5	
							STRONGLY AFFECTS OTHER PROCESS	4	
							WILL DECREASE OUTPUT OF OTHER PROCESSES	2	
							ONLY AFFECTS THIS MACHINE	1	
Quality	5	What is the average value of monthly scrap, or waste produced by this machine?	5	4	2	1	$750-$1000	5	
							$500-$749	4	
							$250-$499	2	
							UNDER $250	1	
	6	How will the process run on this equipment affect the final quality of the finished product?	5		2	1	DECISIVELY	5	
							SOMEWHAT	2	
							NOT SIGNIFICANTLY	1	
Maintenance	7	What is the average monthly cost of repairs to this equipment?	5	4	2		OVER $1000	5	
							$999-$500	4	
							UNDER $500	2	
	8	What is the average time it takes to repair this machine?	5	4	2		OVER 3 HOURS	5	
							1-3 HOURS	4	
							UNDER 1 HOUR	2	
Safety	9	To what extent will a failure of this machine effect the safety of the operator, cause excessive machine damage, produce offensive noise, smoke, heat, leaks, or just constitute an overall safety problem?	5	4	2	1	CAN RESULT IN SERIOUS HARM TO OPERATOR AND OR MACHINE	5	
							EXCESSIVE NOISE/LEAKS/ECT., AND GENERALLY UNSIGHTLY	4	
							CONTAINED TO THIS MACHINE	2	
							NO SIGNIFICANT EFFECT	1	

Appendix 10.

Step 1 - Initial Cleaning Guideline Checklist

☐	**1.** Photograph your equipment before and after you clean it so that you will have a record of your accomplishments. This will also serve as your "Baseline" for all future improvements.
☐	**2.** Observe proper "Lockout/Tagout" procedures when shutting down your equipment for cleaning.
☐	**3.** Systematically clean each part of the equipment using the checklist on the next page. Note: An "abnormal condition" is defined as any condition within, or around the machine that affects the appearance and performance of the machine or production cell. a "normal condition" is defined as a condition in which the machine's appearance and performance is in "like new" condition and no waste is generated in time, resources, or materials. An abnormal condition can be a broken bolt, a leak, a worn or damaged part, it can also be a dirty part. As you document these conditions on your "Abnormality Summary Sheet" try and discover the reasons for them. Ask yourself the following questions: • Why did this happen? • What other problems could this have caused? • ***How can I prevent this from recurring?***
☐	**4.** Correct problems you can deal with within the time constraints allowed. All other problems will be tagged at the conclusion of the training and the team will prioritize them for repairs at a later date either by the Team or by the Maintenance Department.
☐	**5.** Document the cleaning tasks that you complete. Use your camera to take pictures to document the "before" condition of the machine and to document the "after" condition to depict your accomplishments. Began to develop countermeasures for keeping the machine clean.
☐	**6.** Once the equipment is running again observe which areas get dirty the quickest and then go the source of the contamination and eliminate it.
☐	**7.** During the exercise the Team should have a short assessment and planning meeting to assess their previous day's accomplishments and to plan their daily activities. Also, the Team should begin developing their Activity Board.
☐	**8.** Utilize the following checklist to insure you are thorough in accomplishing each task relating to the Initial Cleaning of the machine

Appendix 10.

Initial Cleaning Guideline Checklist (Continued . . .)

Check Main Body Of Equipment For: Dirt, Dust, Excess Oil, Sludge, Chips, Or Other Foreign Matter On:	
☐	Moving and/or rotating parts
☐	Locator or product contact parts, mounting surfaces, positioning parts
☐	Frames, beds, oil pan interior/exterior, conveyors, transfer lines, feeders, chutes, rubber rollers, etc.
☐	Reference pins, surfaces, crank plate, back electrodes, bars
☐	Braking apparatus, locking mechanisms, nozzles, paint hoses
☐	Guide surfaces, fixtures, gages, dies, cylinders, tank interiors/exteriors, cables or other devices installed on the equipment
☐	Loose or missing nuts, bolts, washers, etc.
☐	Unnecessary objects on body of the machine
☐	Is equipment firmly seated or anchored to the floor?
Check Auxiliary Devices For: Damage, Dirt, Dust, Oil, Grease, Chips, Sealer, Paint Residue, On:	
☐	Air cylinders, solenoid valves, FRLs, mist lubricators and separators, transformers, etc.
☐	Limit switches, micro-switches, proximity switches, photoelectric sensors
☐	Motors, belts, gear boxes, welding transformers, pumps, propeller shafts, couplings, covers, and surroundings
☐	Faceplates and surfaces of instruments, meters, displays, switches, control boxes, (inside and out)
☐	Wiring, piping
☐	Loose or missing nuts, bolts, washers, locking devices, etc.
☐	Leaks - oil, water, coolant, air, gas, steam
☐	Buzzing or other abnormal sounds on solenoids and motors
☐	Burned out indicator lamps

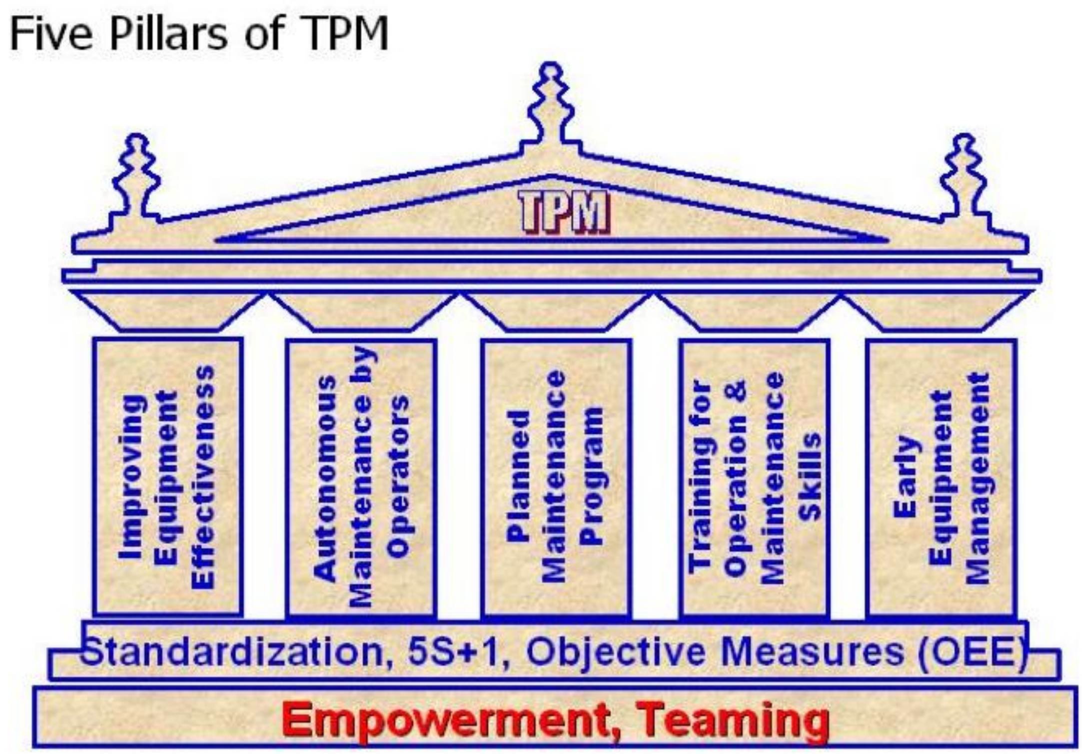
Appendix 10.

Initial Cleaning Guideline Checklist (Continued . . .)

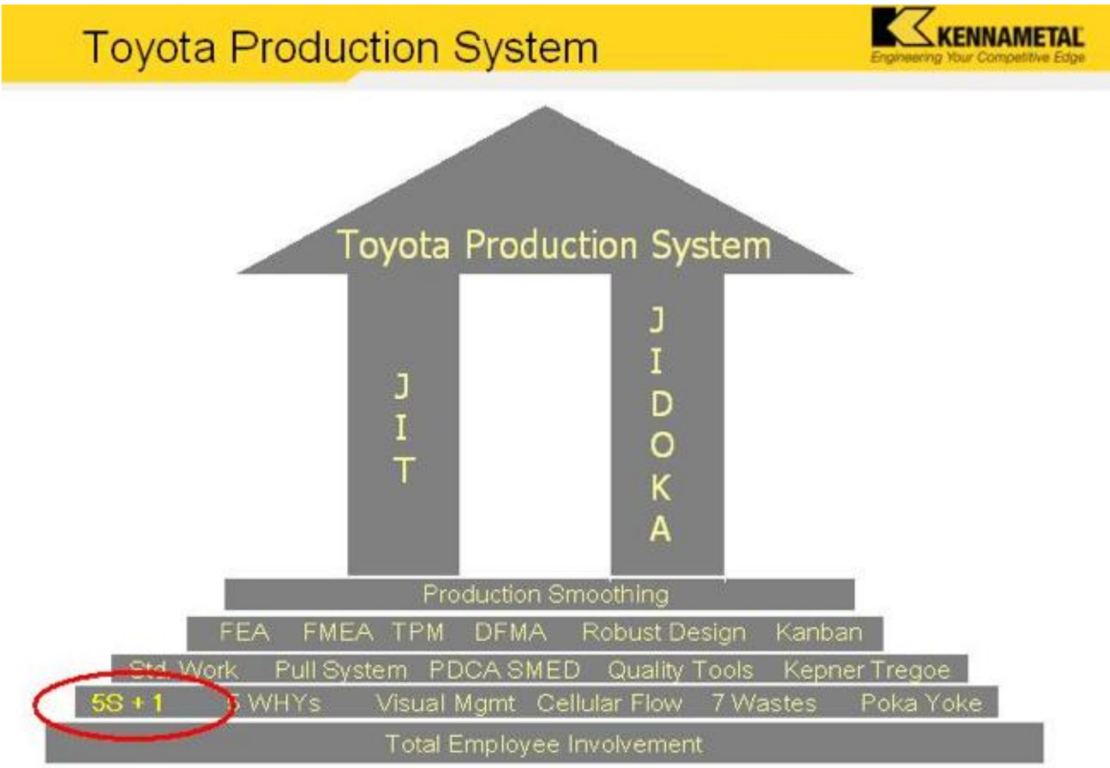
Check Lubrication System for:	
☐	Dirt, dust, sludge, on lubricators, grease cups, lubricating devices, etc.
☐	Proper lubricant levels and drip feeds
☐	Covers on all lubricating supply vessels
☐	Dirt and grease on lube lines
☐	Leaks and seepage
☐	Oil not reaching all intended lubrication points
☐	Malfunctioning devices

Check Area Around Equipment for:	
☐	Tools and supplies in assigned places, missing or damaged
☐	Bolts, nuts, tools, parts, etc. lying on or around the machine
☐	Dirty, illegible, hard to see name plates and labels
☐	Transparent covers, windows, view-plates, and other safety shields, broken, dirty, dusty, or fogged
☐	Dirty, tangled wiring, leaking pipes
☐	Dirt and dust around the machine or falling from top of the machine
☐	Dropped parts, work-pieces, etc.
☐	Defective work-pieces left lying around
☐	Conforming and non-conforming products and scrap not kept separated
☐	Extraneous clutter, cigarette butts, trash, and outdated posted material

Appendix 11.


Five Pillars of TPM
TPM
Improving Equipment Effectiveness
Autonomous Maintenance by Operators
Planned Maintenance Program
Training for Operation & Maintenance Skills
Early Equipment Management
Standardization, 5S+1, Objective Measures (OEE)
Empowerment, Teaming

Appendix 12.



Toyota Production System
KENNAMETAL
Engineering Your Competitive Edge
Toyota Production System
JIT
JIDOKA
Production Smoothing
FEA FMEA TPM DFMA Robust Design Kanban
Std. Work Pull System PDCA SMED Quality Tools Kepner Tregoe
5S + 1 5 WHYs Visual Mgmt Cellular Flow 7 Wastes Poka Yoke
Total Employee Involvement