MSc Program
Engineering Management

Improvement of Big-Bag fertilizers Filling Station and its relevant logistics

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Affidavit

I, **Christophe Krauth**, hereby declare

1. that I am the sole author of the present Master Thesis, " Improvement of Big-Bag fertilizers Filling Station and the relevant Logistics ", 97 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master Thesis as an examination paper in any form in Austria or abroad.

Vienna, ________________ ______________________________

Date Signature

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The future belongs to those who believe in their dreams.

Eleanor Roosevelt

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ABSTRACT

This master thesis was undertaken at Timac Agro Austria, a producer of fertilizers with a capacity of 250.000 tons per annum. Timac Agro Austria belongs to the French Roullier Group.

The first goal with this master thesis was to focus on a machine and to analyze the possible improvements in order to increase its effectiveness. This would be achieved through a method that concentrated on finding losses. This method is called Overall Equipment Effectiveness (OEE) which is part of the so called Total Productive Maintenance (TPM), a maintenance process developed for improving productivity by making processes more reliable and less wasteful.

This master thesis gives a practical approach on how the method should be implemented on the Big-Bag fertilizer filling station. Thus this approach focuses on defining: the necessary measurements to follow the effectiveness value of the machine; developing a data collection form; suggesting a training plan for operators and managers; managing the collected data; and giving feedback to the team and upper management.

A description on how to implement this method in the company and a sequence of solutions to improve the big-bag filling station effectiveness is the outcome.

The next goal was to suggest ways to improve the packaging system comprising the big-bag filling station, the bordering machines and vehicles. Due to the location of the big-bag filling station, implementation of some solutions can have an impact on the entire system and vice versa.

The outcome is a general layout representing the position of the different machines and the traffic of vehicles. This shows the current state and the future state which is achievable if some improvements are made.

1 INTRODUCTION

1.1 Production plant

Timac Agro Austria is located next to the Danube about fifty kilometres west of Vienna. It has been a fertilizers production plant for 80 years. The plant employs today approximately sixty employees spread in different departments for example production, logistics, maintenance, and so on. About thirty employees are engaged to sell fertilizers in Austria. There are also several trading companies belonging to the Roullier Group selling fertilizers abroad. As a result, the production plant in Austria is supplying fertilizers to over sixteen countries. The annual production is approximately 250.000 tons of fertilizers. The goods are mainly composed of phosphate, potassium and nitrogen. They are sold in bulk, 600 kg big-bags[1], 50 kg bags and 5, 10 and 15 kg bags.

1.2 Background

I have been working in the company as Head of the mechanical Department for longer than three years, during which time I have noticed that the strategy changed due to the so-called financial crisis. At the beginning of my experience, we produced fertilizers continuously with varying rates of production and the amount of fertilizers in storage was higher than today. This was necessary to be able to respond to some peak demands, in autumn and in spring. Nowadays, fertilizers are produced to order, with minimal storage. Fertilizers are produced and then immediately sent to the corresponding packaging line.

Due to the crisis at the end of 2008, the market demand decreased. As a result the production was running in a stop and go manner for more than one year. During this phase of stop and go, it was important to get the necessary availability of the machines on the packaging line in the Logistic Department to be able to deliver and satisfy the customer’s orders.

[1] The definition of a big-bag is given in the chapter 4

Since the beginning of 2010 market demand has increased again. The lower demand of the market, the greater the pressure on the business management side.

On the one hand, the sales force from the Roullier Group is strong and well organized in order to supply each production plant with orders. This allows for steady or increasing profit. On the other hand, the production plants are not able to produce as many orders as the Sales Department is able to sell. Currently, the Roullier Group is focusing on increasing the effectiveness of its production plants. This means increasing productivity not only in the Production Department but also on the Packaging lines. As a result the Logistic Team has greater pressure to efficiently organize the daily jobs and to find solutions to improve performance and availability of the machines. This should allow in the future the customers orders to be satisfied with less delay.

I am interested in the packaging line because the handling of material is greater than anywhere else in the plant. It is related to numerous different issues for example inventory, movement of product, maintenance, safety, time and service, and cost. It interacts with many departments within the company and its effectiveness is also dependent on the effectiveness of the other departments. It is a real challenge to deal with the current situation and to improve it.

The machine I selected in the Logistic department is the big-bag fertilizer filling station[1].

In the past, customer's needs were mainly focused on 50 kg bags. This has changed so that the interest for big-bag of 600 kg has increased considerably. This is due to the progress of the technical system of spreading fertilizer on the fields. The farmers invested in a system adapted for big-bags loading capacity. The big-bag filling station has become crucial in the entire process. The impact that an inefficient idle time and cycle time has on revenues, was greater due to the lower market demand in the last one and a half years. The project is even more important today because it follows the strategy of the Roullier Group: if it is possible to reduce cycle time, then it is possible to increase productivity and revenue.

[1] A statement on how I selected this machine is described in the chapter 5.

It is an interesting project to work on because it covers issues that are new to the scope of my job. This is a good opportunity to add value after completion of the EM MSc Program.

1.3 Goals

The first goal focuses on the big-bag filling station, to analyze the possible improvements, to increase its effectiveness and to measure them.

The second goal is to suggest ideas to improve the entire packaging system comprising the big-bag filling station, the bordering machines and the vehicles.

The master thesis is organized in different chapters:

- Chapter 2 discusses the environment of Overall Equipment Effectiveness (OEE)[1], including Total Productive Maintenance (TPM) of which OEE is a part of
- Chapter 3 describes the way to apply and implement OEE
- Chapter 4 informs about the problems which will be analyzed
- Chapter 5 describes the way OEE should be implemented and measured in the company focusing on the big-bag filling station
- Chapter 6 provides the results of the thesis in form of an improvement plan, and a sequence of solutions to implement to improve the effectiveness of the big-bag filling station
- Chapter 7 summarizes the further works and suggests ideas to implement in order to improve the packaging system composed of big-bag filling station, the bordering machines and the vehicles

[1] OEE is the key metric in TPM. It is described in the chapters 2 and 3.

1.4 Delimitation

- The master thesis is a study based on interviews and a review of the relevant literature, and describes the implementation of OEE in this specific case of the big-bag filling station in order to improve it

- The results of the thesis will not give any cost estimate

2 ENVIRONMENT OF OEE

2.1 TPM Background

Methods related to TPM are often used to improve a process or a machine.

TPM was primarily implemented in Japan within the automotive industry, especially within Toyota and their associated component suppliers (Robinson and Ginder, 1995). Tajiri and Gotoh (1992) describe the situation of the competitors Nissan and Mazda, who soon followed Toyota in implementing TPM at some of their manufacturing sites. Seiichi Nakajima was one of the earliest adherents of this effort and soon became known as the Father of TPM. The earliest Japanese TPM implementations met with limited success and only a small number of companies initiated the effort.

2.2 Key elements of TPM

Nakajima's (1984) Japanese definition of TPM is composed of five key elements:

- TPM aims to maximize equipment effectiveness

- TPM establishes a thorough system of Preventive Maintenance (PM) for the equipment's entire life span

- TPM is cross-functional, implemented by various departments (engineering, operators, maintenance, and managers)

- TPM involves every single employee

- TPM is based on the promotion of Preventive Maintenance through the motivation of management and autonomous Small Group Activity (SGA)

2.3 Principle activities of TPM

The principle activities of TPM are organized as "pillars" (Nakajima 1984; Nakajima 1988). Depending on the author, the naming and number of the pillars can be slightly different. However, the generally accepted model is based on Nakajima's eight pillars:

- Focused Improvement (including OEE)
- Autonomous Maintenance
- Preventive Maintenance
- Training and Education
- Maintenance Prevention
- Quality Maintenance
- Administrative TPM
- Safety and Environmental

2.3.1 Focused Improvement Pillar and OEE

Focused Improvement is characterized by a drive for Zero Losses, meaning a continuous improvement effort to eliminate any effectiveness loss.
"Focused improvement includes all activities that maximize the overall effectiveness of equipment, processes, and plants through uncompromising elimination of losses and improvement of performance." (Suzuki, 1994)
"Maximizing equipment effectiveness requires the complete elimination of failures, defects, and other negative phenomena – in other words, the wastes and losses incurred in equipment operation." (Nakajima, 1988)

OEE is the TPM metric for measuring equipment effectiveness or productivity. "A company cannot make business gains solely by using cost cutting measures because it cannot cut costs enough to become a world-class competitor. Instead it must invest resources in productivity improvement. This generally increases factory throughput and cuts cost at the same time." (Leflar, 2001)

Various methods for calculating OEE are in use, however, most are consistent in identifying three major elements of OEE. In accordance with The productivity press development team (1999), see following a description of these elements:

- Availability – a comparison of the potential operating time and the time in which the machine is currently making products
- Performance – a comparison of the current output with what the machine should be producing in the same time
- Quality – a comparison of the number of products made and the number of the products that meet the customer´s specifications.

"Tracking OEE provides a relative monitor of equipment productivity and the impact of improvement efforts. Understanding efficiency losses drives the improvement effort." (Dilorio and Pomorski, 2003)

2.3.2 Autonomous Maintenance Pillar

Japan_Institute_of_Plant_Maintenance (1997) describes the critical operator Autonomous Maintenance skills to be:

- Ability to discover abnormalities.
- Ability to correct abnormalities and restore equipment functioning.
- Ability to set optimal equipment conditions.
- Ability to maintain optimal conditions.

2.3.3 Preventive Maintenance Pillar

The objective of Preventive Maintenance is to "establish and maintain optimal equipment and process conditions" (Suzuki, 1994).

According to Japan_Institute_of_Plant_Maintenance (1996), implementing Preventive Maintenance means realizing activities which include:

- Regular preventive maintenance to stop failures (Periodic maintenance, predictive maintenance)
- Corrective maintenance and daily Maintenance Prevention to lower the risk of failure
- Breakdown maintenance to restore machines to working order as soon as possible after failure
- Guidance and assistance in Autonomous Maintenance

2.3.4 Training and Education Pillar

"It is aimed to have multi-skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient know only "Know-How" by they should also learn "Know-why". By experience they gain, "Know-How" to overcome a problem what to be done. This they do without knowing the root cause of the problem and why they are doing so. Hence it become necessary to train them on knowing "Know-why". The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts.

The different phases of skills are:

- Phase 1 : Do not know
- Phase 2 : Know the theory but cannot do
- Phase 3 : Can do but cannot teach

- Phase 4 : Can do and also teach”

(Plant Maintenance Resource Center, Undated)

2.3.5 Maintenance Prevention Pillar

Maintenance Prevention refers to “design activities carried out during the planning and construction of new equipment, that impart to the equipment high degrees of reliability, maintainability, economy, operability, safety, and flexibility, while considering maintenance information and new technologies, and to thereby reduce maintenance expenses and deterioration losses.” (Shirose, 1996)

2.3.6 Quality Maintenance Pillar

In accordance with Japan_Institute_of_Plant_Maintenance (1996), Quality Maintenance is achieved by establishing conditions for “zero defects”, maintaining conditions within specified standards, inspecting and monitoring conditions to eliminate variation, and executing preventive actions in advance of defects or equipment/process failure. The key concept of Quality Maintenance is that it focuses on preventive action “before it happens” (cause oriented approach) rather than reactive measures “after it happens” (results oriented approach).

2.3.7 Administrative TPM

“These departments increase their productivity by documenting administrative systems and reducing waste and loss. They can help raise production-system effectiveness by improving every type of organized activity that supports production.” (Suzuki, 1994)

2.3.8 Safety and Environmental Pillar

Shirose describes Safety as “the maintenance of peace of mind”. (Shirose, 1996) There is no TPM without strict focus on safety and environmental concerns. “Ensuring equipment reliability, preventing human error, and eliminating accidents and pollution are the key tenets of TPM.” (Suzuki, 1994)
Ichikawa (1999) points out that the Environmental Management System “is part and parcel of the work and this implementation should be done through TPM. In concrete

terms, this consists of environmental education, products and equipment development that implement improvements for environmental aspects reduction and give consideration to environmental load, and it is considered to be appropriate to develop these themes along the conventional TPM pillars."

3 IMPLEMENTATION OF OEE

3.1 Hidden potential

"Many companies have simply never considered performance analysis. I am not even talking about complex themes, just the basics. I am unsure if any see it as a waste of resources. The uptime of a tool should be the responsibility of the engineers and should include all sources of downtime. If the engineers create the figures, they will become more involved. It is impossible to say how many companies suffer from the problems in the above examples. In my own personal experience, it is more than 50 percent, although many of them were forced by the demands of competition to make changes. In fact where one issue is seen, there is often a strong likelihood that many others will also be seen." (Borris S., 2006)

Following Steve Borris argument, the concepts of "hidden machine" or "hidden factory" basically describe the "Hidden Potential" to look for when making improvements.

According to the idea of "hidden machine" from Koch, (2008), the concept of hidden machine is to find, next to each machine in each production department another one which is not visible. The aim of this concept is to find it and to use it. Even if one believes that the production line is doing well, there is always a way to improve production capacity also called performance.

This concept is pretty close from the so called "hidden factory" but it differs by the fact that it relates the concept to quality, thus to the "customer dissatisfaction".

"The theory that a business that does not focus on ensuring quality will engage in wasteful processes and production, leading to inflated costs and decreased profits, largely through production of defective or nonconforming units and resultant customer dissatisfaction.” (Survey Methods Inc., undated)

“The "hidden factory" is a name given to the wasteful and inefficient activities that occur across an enterprise, which can greatly increase costs in time, resources, and money. The effects of the hidden factory are delays, errors, higher inventories, and customer dissatisfaction. The financial consequences are higher costs and lower profits.” (Six Sigma Solutions, LLC, undated)

Timac Agro Austria has existed since the beginning of the 60´ies and has been developed according to the requirements from the former years of the company.

The objective of the Roullier Group in terms of performance is to increase produced tonnage. It is even more important today to find the “hidden machine” or “hidden factory” in order to increase as much as possible the production effectiveness.

The OEE approach focuses on Availability, Performance and Quality. The use of the OEE approach is described in the chapter 5.

The OEE calculation is a measurement that calculates daily the effectiveness of a machine and which loss from the six major losses (described in 3.3) it is related to.

The most common question is how much improvement is possible?

This question relies on many others: how much more output is it possible to achieve? How many more products satisfying the quality requirements is it possible to manufacture? How much is it possible to reduce trouble and stress? How reliable can the process become? With how little stock is it possible to manufacture? How many development and performance improvements are possible? How independent can the production team act?

3.2 Concept of OEE

According to Koch (2008), this method comes from Japan. Seiichi Nakajima wrote a book about “Total Productive Maintenance” in 1984 where the concept of “Overall Equipment Effectiveness” was introduced for the first time.

The OEE method ensures which equipment in the process needs more attention and which activities do not add value are determined. The non-value adding activities need to be eliminated.

Measuring with OEE enables the production team to know how well the machine is performing, thus which part of the process has to be improved. This approach does not give any indication with regard to what could be the cause of the losses. That means OEE determines what is going on and provides a direction to look for in order to apply an improvement strategy in the future.

OEE can be considered a gauge to find out the production losses of a machine.

Defining a loss implies knowing the maximum performance rate of a machine. This is important to know as we need to find out the current performance rate and to compare it with the maximum possible performance rate.

The perfect machine should continuously work at maximum performance without producing defect parts.

Unfortunately, the machines are not perfect, they do not work continuously and cannot keep the maximum performance. The products are partially not at the required level of quality.

3.3 The six major losses

According to The productivity press development team (1999), OEE traditionally consists of six major losses and these are briefly described like this:

Availability: Downtime losses

- Failures or breakdowns
- Setup time or waiting time

Performance: Speed losses

- Minor stops (less than 5 minutes)

- Reduced operating speed

Quality: Defect losses

- Scrap or rework
- Start up losses

See the following description of these losses according to Koch (2008).

3.3.1 Downtime losses

- Failures or breakdowns of the machine are a loss of operational time due to a sudden and/or unexpected breakdown of the machine. The ultimate cause can be technical or organizational. In the case of the Big-Bag filling station it would be for example the breakdown of the conveyor belt bringing the product to the screening machine. OEE examines the nature of the breakdown. According to Vorne Industries Inc. (Undated), the next step would be to apply the Root Cause Analysis (RCA) to solve failures.
- Setup time or waiting time is a loss of operational time when the machine could have been working but is standing still. The machine is standing still when adjustments are made or preventive maintenance is done or when operators go to lunch break or when warm-up time is necessary. According to Vorne Industries Inc. (Undated), reducing set up time is possible in using SMED Method (Single Minute Exchange of Dies).
- Line restrictions results in the machine standing still when problems occur in case of material or operator shortages. It is not usual to find this line restrictions loss in literature because most of the time, it is simply combined with setup time loss. Thus, there are only 6 major losses announced.

3.3.2 Speed losses

- Minor stops describe a machine stopping sometimes and cannot reach a constant speed, thus the production flow can be disabled. These minor stops and the resulting speed loss are mainly caused by small breakdowns, for example in the case of the big-bag filling station because of dust, some sensors are not working on demand and the conveyor belt at the output of the machine does not move the big-bags forward. These recurring breakdowns have an impact on effectiveness of the machine. In theory, these minor stops are part of availability losses but because they are shorter than 5 minutes, they are considered as a speed loss. According to Vorne Industries Inc. (Undated), a Cycle Time Analysis could help to reduce minor stops losses.

- Reduced operating speed is the difference between the current set up of the speed and the theoretical speed which is given by the supplier. Often there is a clear difference between maximum speed perceived by people and the current one. Often the speed is reduced to avoid other losses like for example quality defects or breakdowns. Losses because of reduced operating speed are often ignored. According to Vorne Industries Inc. (Undated), minor stops and reduced operating speed are the most difficult of the Six Big Losses to monitor and record.

3.3.3 Defect losses

- Start up losses represent products which do not meet quality requirements (also if it would be possible to sell them as second choice products or being reworked). The objective has to be zero quality defects. A special type of quality losses are the production start and stop losses because:

  - The production after start of the machines is not stable and the first products are not fulfilling the requirements.

  - The production before the end of a batch is not stable anymore, thus the last products are not fulfilling the requirements.

A specific number of products are not attributed to any production order, thus it as to be viewed as a loss. These are the rules of hidden losses which are often assigned to inevitable losses. The quantity of such losses is sometimes really big.

- Scrap or rework means products which do not fulfill quality requirements. There is possible to get good products by reworking these products. Reworking seems to be a good solution because the products can be sold at the same normal price. If the reworked products are not meeting the quality requirements, it has to be taken as a quality loss, which has an impact on the performance. According to Vorne Industries Inc. (Undated), Six Sigma method is often used to focus attention on a goal of achieving near perfect quality.

3.4 Branches of manufacturing and losses

According to Koch (2008), there are three different branches of manufacturing to consider and losses related to it.

3.4.1 Discrete manufacturing

For example: manufacturing of piece goods like bottles, screws and bolts

Effectiveness losses are most common by piece goods manufacturing based on availability (waiting time and breakdowns) and performance (reduced operating speed and minor stops).

A balance between production, emptying the machine and setting the right speed, is most of the time set by the operators in an intuitive way in order to reduce the number of production failures. The manufacturing equipment is often composed of rotating devices, thus this leads to malfunctions or long breakdowns. The largest proportion of problems is caused by line restrictions issues. Lean manufacturing focuses mainly to handle this problem.

3.4.2 Batch manufacturing

For example: manufacturing of bier and roof bricks

Machines do not produce piece by piece but produce simultaneously in a large quantity. The loss distribution is different: availability (adjusting and waiting), performance (reduced operating speed and the most technically reduced possible batch size) and quality (batch losses as production defects and second choice product quality).

By batch manufacturing, products are manufactured simultaneously and in large quantities. Waiting time, for example filling or emptying or cleaning a production line can last a long time. There is a big impact on performance of the production. Also if the products are not fulfilling the quality requirements, then the batch cannot be sold and is lost due to bad quality.

3.4.3 Process manufacturing

For example: manufacturing of cement or refining of petroleum

There is a constant flow of product coming out of production line where specific losses have to be considered: performance (reduced operating speed) and quality (rework, product out of the quality requirements and mixing by production change).

This is a branch associated with formulas and manufacturing recipes.

The manufacturing equipment for such production is often expensive. Lots of technical features prevent from breakdowns. Most of the time, critical machines are doubled so that in case of breakdown or maintenance, the second machine can operate. Precautions are taken to avoid stop of the production and also to reduce products which do not fulfill exactly the quality requirements. These products are often feed back into the production line.

This kind of production produces large hidden performance losses because the different parts of the process are working with an average speed.

3.5 Framework of OEE

3.5.1 Calculation of OEE

According to Vorne Industries Inc. (Undated), OEE would be calculated like shown on the following figure and described in the sections 3.5.2, 3.5.3, 3.5.4 and 3.5.6.

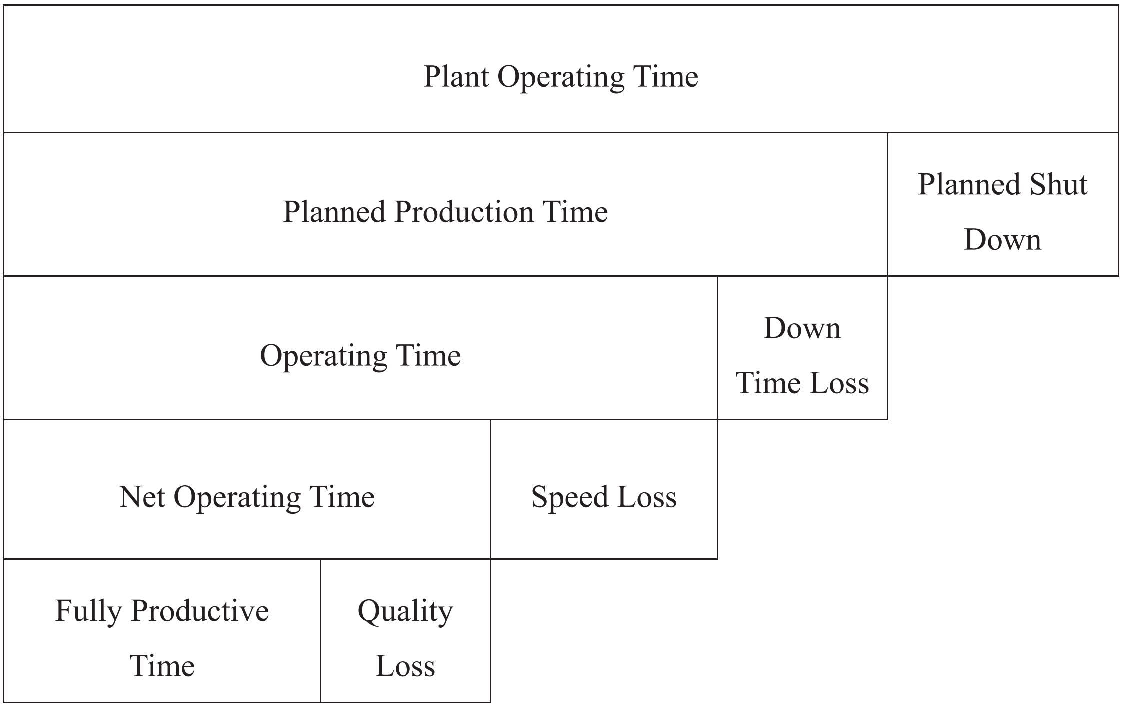

Fig. 1 . Fully productive time in relation to the different losses.

3.5.2 Plan operating time

It starts with Plant Operating Time which is the amount of time the facility is open and available for equipment operation. From Plant Operating Time, Planned Shut Down is subtracted which represents all events like breaks, lunch, scheduled maintenance, or periods where there is nothing to produce like when the company had reduced work time in 2009 due to financial crisis. The resulting time is planned production time. OEE begins with Planned Production Time and considers the three general categories of loss, Down Time Loss, Speed loss and Quality loss. (Vorne Industries Inc., undated)

3.5.3 Availability

Availability takes into account Down Time loss, which includes any trackable events that stop planned production for a certain time. Examples include machine failures, material shortages and changeover. The remaining available time is called Operating Time. (Vorne Industries Inc., undated)

3.5.4 Performance

Performance takes into account Speed loss, which includes any factors that cause the process to operate at less than the maximum possible speed. Examples include machine wear, substandard materials, and operator inefficiency. The remaining available time is called Net Operating Time. (Vorne Industries Inc., undated)

3.5.5 Quality

Quality takes into account Quality Loss, which accounts for produced pieces that do not meet quality standards, including pieces that require rework. The remaining time is called Fully Productive Time. The Goal is to maximize Fully Productive Time. (Vorne Industries Inc., undated)

3.5.6 Small differences in literature

According to Vorne Industries Inc. (Undated), breaks, lunch, scheduled maintenance or periods where there is nothing to produce, come under Planned Shut down Time

Koch (2008) describes breaks and lunch as a part of Waiting Time in Availability Losses.

Vorne Industries Inc. (undated) takes into consideration operator inefficiency as Performance Loss while Koch (2008) says that the approach of OEE is focusing only on machines and not on operators.

In accordance with Vorne Industries Inc. (Undated), the goal is to maximize Fully Productive Time while Koch's (2008) approach is to maximize the number of units of products satisfying the quality requirements.

3.5.7 Three different OEE factors

Equations 1 to 4 are the calculation for the different factors according to Vorne Industries Inc (Undated)

Degree of Availability = Operating Time / Planned Production Time (1)

Degree of Performance = (Ideal Cycle Time x Parts produced) / Operation Time (2)

Ideal Cycle Time is the minimum cycle time that the process can be expected to achieve in optimal circumstances. Ideal Cycle Time is also called Design Cycle Time or Theoretical Cycle Time or Nameplate Capacity.

Degree of Quality = Good Pieces / Total Pieces (3)

OEE = Availability x Performance x Quality (4)

3.5.8 World class OEE

According to Vorne Industries Inc. (Undated), the World Class OEE table looks like shown below.

Table 1 World class OEE values

OEE Factor	World Class
Availability	90 %
Performance	95 %
Quality	99.9 %
OEE	85 %

Worldwide studies indicate that the average OEE rate in manufacturing plants is 60%. As you can see from the above table, a World Class OEE is considered to be 85% or better.

According to Koch's (2008) experience, he studied in 2000 over 1000 machines worldwide from very different processes and in relation with the OEE Industry Standard from Fullfact bv (Undated), most of these machines had a OEE between 35 and 45%. These results came from many observations. There are big differences between companies, for example OEE is sometimes only about 20% in chemical firms whereas OEE is about 80% in the automotive industry.

3.6 Measurements and reports

3.6.1 Manual measurements and data collecting

How to measure OEE? What data is it necessary to collect? What should be the frequency?

This is an important aspect that addresses the measurement scale, data source and measurement frequency. The validity and usefulness of OEE measure is highly dependent on the data collection and on its accuracy. Data collection is an important phase of performance measurement and continuous improvement since what has not been measured cannot be improved. It has been claimed that many manufacturing companies measure efficiency of their lines in such a way as to “mask” many of the causes of lost efficiency (Parsec, Undated).

According to Koch (2008), the measurements, which could for example be done per shift, do not have to exceed a sheet of paper A4 using both sides. On these sheets there will be the measurement of time, quantity and quality. An example of measurement sheets that could be applied in Timac Agro Austria is described in the chapter 5 and a layout is provided in appendix 1 and 2.

Generally, the layout of the first sheet takes into consideration availability. It contains: the name of the shift or team; the date; the reference of the production line which was running; the shut down reasons (start up, set up, break, training/meeting, waiting for support, self maintenance, preventive maintenance, cleaning); the line restrictions (no supply, no delivery); and failure (failure by filling, set up).

The layout of the second sheet is about performance and quality. It contains: the name of the products; the quantity of units produced satisfying the quality requirements; the number of units which broke; the number of under filled units; the number of quality tests made; the number of units to rework; the current output; the operating time; the standard defined per product in units/minute; the estimated output; and the speed set. At the bottom of the sheet, there are the availability rate, performance rate, the quality rate and the final measurement of OEE.

The data collecting is being undertaken most of the time by an operator. The document to fill out has to be as simple as possible and structured so that they are motivated to do it. This document should have the necessary data types the operator needs to improve the machine. That means before improving they have to make some assumptions then collect the data, then compare the results with the assumptions in order to be able to start thinking about possible improvement of the machine. In recording daily data about the machine, after a certain period of time, there should appear patterns which also give information about the category of losses and provide direction on how to proceed to eliminate major losses.

3.6.2 Manual versus automated data collection

Jonsson and Lesshammar (1999) propose that data collection should be at such a detailed level that fulfils its objective without being unnecessarily demanding of resources. The difficulty of data collection is dependent on the complexity of the manufacturing system and whether the data collection is manual or automated.

For manual data collection, accuracy is very low since recording of some minor stoppages or downtime can often be forgotten. Though the cost of manual data collection is minimal, detailed manual data collection may demotivate the personnel and lead to reaction against the measurements. With the use of MES (manufacturing execution system) and ERP (enterprise resource planning), collection of OEE related data is automated in some manufacturing enterprises. Though the cost associated to these installations is considerable, the data accuracy is high and the data collection process is simplified. Introduction of these modern software tools is being leveraged to produce sophisticated real time reports that allow manufacturers to fully understand all their sources of lost productivity (Parsec, Undated).

Koch (2008) says that complex, lengthy technical system implementations are indeed exciting for many managers and supervisors, but such games are often very expensive. These costs would on the other side be a good reason not to start with the improvements. If it is not possible to prove that the investment will pay for this type of system within a few months, then you should have big doubts.

At the same time Koch (2008) believes manual data collecting produces lots of paper documents to store in the company. This is generating a history of the machine which is good to keep in order to look at the trend over the time. On the other hand he says: if it is possible to install an automated data collection in only one day, then there is no lost time and improvements can start fast. With a manual data collection, there is no direct feedback, but with the help of software, the operator is able to react instantaneously in order to get better results without delay.

If the team is convinced about the effectiveness of OEE and when a culture of continuous improvement has been developed then the team will adopt the automated data collection.

3.6.3 Psychological barriers

Koch (2008) asks some questions about barriers some operators could feel with automated data collection. Would the operator who is in charge of collecting data be able to identify themselves with OEE? Do they feel responsible for the system? Do they know the importance of collecting such data? Would they give some ideas about possible improvement to management (bottom-up) or would they wait about initiatives from management (top-down)? Would they adapt their way of working because of data collecting on the machine? Do they feel that data collecting would help them or in contrary see it as a possible threat?

3.6.4 Technical barriers

According to Koch (2008) there are some technical barriers because as soon as a precise view about the losses is wanted, and automated data collection is wanted, then the system should do this in an intelligent way.

On a time point of view when the sensor indicates a problem, the operator has the responsibility to attach a reason even if it is unknown. Is it certain that the operator would attach the right information to the problem? Is it difficult to find out? Unless the operator needs this information to be correct and is motivated to get an idea about the losses structure, then the data collection would be incorrect.

On a quality point of view, how is it possible to measure quality? Is it possible to install a sensor for each quality parameter? And how is it possible to know that the sensors are working in the sense we expect it?

Also on a performance point of view, minor stops are able to occur every time and everywhere. Even if some video control and sensors are installed, how is it possible to know when these minor stops occurred? What is the added value? What do you do with this information? Is the problem solved when you set the guiding device of a conveyor? Does it make sense to invest time and technology to measure a problem if you could have solved the problem at the same time?

Off course it is necessary to know about the amount and category of loss concerned because it helps you to look for the cause of the problem.

It is good to take one hour of time with an operator, an engineer and a process engineer to watch and to hear the process running in order to know what is going on. Find out objectives and collect data for one week and undertake a PDCA cycle to find out the cause of the losses. According to Wikipedia (31 October 2010), PDCA (plan–do–check–act) is an iterative four-step problem-solving process typically used in business process improvement. It is also known as the Deming circle, Shewhart cycle, Deming cycle, Deming wheel, control circle or cycle, or plan–do–study–act (PDSA).

PLAN: Establish the objectives and processes necessary to deliver results in accordance with the expected output. By making the expected output the focus, it differs from other techniques in that the completeness and accuracy of the specification is also part of the improvement.

DO: Implement the new processes. Often on a small scale if possible.

CHECK: Measure the new processes and compare the results against the expected results to ascertain any differences.

ACT: Analyze the differences to determine their cause. Each will be part of either one or more of the P-D-C-A steps. Determine where to apply changes that will include improvement. When a pass through these four steps does not result in the need to improve, refine the scope to which PDCA is applied until there is a plan that involves improvement.

3.6.5 Frequency of data collection

Aberdeen Group (2006) indicates that best in class companies are not only more vigilant and persistent in their measurement efforts but also monitor and measure their performance more frequently. The survey indicates that operational measures such as OEE, for such companies are monitored daily, at minimum, in order to trigger effective corrective or preventive action.

Koch (2008) tells that OEE data collection should be done periodically with the same intervals, for example per shift, over a long period of time so that it is possible to determine some patterns which enables effective improvements.

3.6.6 Data management

Koch (2008) indicates data management should stay within the department. The analysis of data can be done by an operator but most of the time this person does not have an overview about the entire process, so it should be the person responsible for the shift or at least the person responsible for the department. They would manage OEE data and therefore would get an overview about the losses. With this overview they are able to ask questions in order to find solutions to improve the process. They are in charge of converting data into diagrams. This is a necessary step to be able to eliminate losses. The team and all the people working in relation with the machine, have to know the diagrams. The highly visible communication through reading and understanding the diagrams is a key success factor for real improvement. These diagrams should help to reply to these following questions: is the effectiveness increasing over a longer period? What are the major time losses? How much is the MTBF? What is the average time needed for set up or cleaning? How long does it take to repair the breakdown (MTTR)? What is the availability rate? How often and how long does the machine have to wait for supply of material or delivery of goods?

According to May and Schimek (2009), the MTBF is calculated by the operating time divided by the number of failures and the MTTR is calculated by the time required to repair a device divided by the number of failures.

OEE measures the impact of improvements activities done on the machine.

3.7 OEE implementation steps

Implementing such a tool will be done like the following sequence:

- Select a pilot machine
- Definition of OEE
- Develop a form to collect data
- Production team training
- Collect OEE data
- Data management (diagrams)
- Feedback about the results to the team
- Feedback to management

4 PROBLEM DESCRIPTION

4.1 Process

Timac Agro Austria is composed of several buildings that are spread on a large area. Among these buildings, you can find a main building for production, two buildings for milling, six buildings for raw material storage, two buildings for finished goods (storage in bulk), one building for filled big-bags storage, an outside area for 50 kg bags pallets storage and an administrative building.

The entire process is composed of several machine categories e.g. pre-granulator, granulator, dryer, cooler, coating drum, conveyor belt, silo, bucket elevator, motor, pump, screening machine, mill, ventilator, tank, 50 kg bag palletizer, crane, big-bag filling station, forklift, loader and hopper.

Within these categories, there can be hundreds of units, especially by belt conveyors for example as the plant is spread over a large area the products are conveyed over large distances.

Some of these machines have a different history in terms of maintenance. Some of them require more repairs than others. That is why the unreliable machines come easily to mind in people. These machines get more attention because the effectiveness of the plant is dependent on these 20% of machines which cause 80% of the breakdowns. According to Wikipedia (21 September 2010, Pareto_principle), the Pareto principle (also known as the 80-20 rule, the law of the vital few, and the principle of factor sparsity) states that, for many events, roughly 80% of the effects come from 20% of the causes.

Within Timac Agro Austria, it is easy to find out which machine caused the problem because operators often complain about it. The quantity produced the day before is then below the quantity expected. This discrepancy gets the attention of the people involved who check for the machine which caused the problem.

4.2 Big-bag filling station

One particular machine is of interest; this machine is the big-bag filling station in the Logistic Department.

Fig. 2 . The big-bag filling station

This machine is important because it is located between the production and the customers. Improving the productivity of this machine through the implementation of technical solutions would motivate the operators because they would achieve their performance in better conditions. It would also help to free the storage space quicker so that production has more possibilities to store the finished goods. There are four different kinds of packaging sold to customers: small bags (5, 10 and 15 kg), standard bags (50 kg), big-bags (600 kg) and product in bulk.

A big-bag is called a Flexible Intermediate Bulk Container (FIBC). According to Wikipedia (17 March 2010, Flexible_intermediate_bulk_container) a FIBC is a big-bag, bulk bag, or super sack which is a standardized container in large dimensions for storing and transporting and storing for example sand, fertilizers, granules of plastics or other dry products. It is most often made of thick woven polyethylene or polypropylene and normally measures around 110 × 110 cm and varies in height from 100 cm up to 200 cm. Its capacity is normally around 1000 kg but the larger units can store even more. Transporting and loading is done on either pallets or by lifting it in loops. Bags are made with either one loop or four lifting loops. The single loop bag is suitable for one man operation as there is no need for a second man to put the loops on the loader hook. Emptying is made easy by a special opening in the bottom or by simply cutting it open.

4.3 Market

In the last years the demand from the market changed, so that more customers are ordering fertilizers in big-bags. This means that the big-bag filling station has more pressure to perform. Also it acts as a bottleneck in the entire process. According to Sayer et al (2007 b), the bottleneck process is the process with the longest cycle time. Further Sayer et al (2007 e) explain a bottleneck as a process that constricts or limits the flow of overall process.

The big-bag filling station is generally not able to run fast enough, however this is dependent on the quantity of orders, the location of the product, and the scheduling of the product. When the big-bag filling station was purchased the requirements were different to the ones today. Therefore all the effort should be focused on finding ways to improve the performance of this machine.

5 PRACTICAL APPROACH ON IMPLEMENTING OEE

5.1 Select a pilot machine

The reasons the big-bag filling station has been selected are already described in the chapter 4.

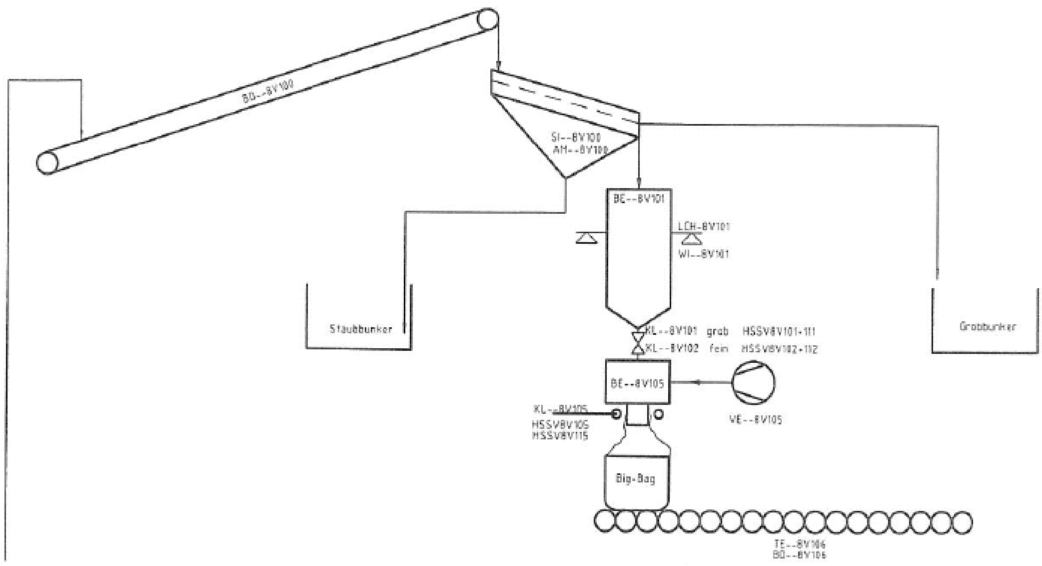

Fig. 3 . The big-bags filling station process

5.1.1 How does the machine works

The process begins with the loader which fills up a 6 ton hopper with finished goods. The loader is either taking stored finished goods from the same building (referenced as C22) where the big-bag filling station is located or it has to cross a street to look for stored product in another building (referenced as B29). The loader has not only to feed the big-bag filling station but also to load trucks with finished goods. Therefore its time is shared between different activities.

The finished goods are taken from the hopper on demand by use of a vibrating chute under the hopper. The finished goods fall on a conveyor belt and are carried to a transfer chute to land on another conveyor belt. This has to be done because it is only possible to convey finished goods in a straight line with a belt conveyor. The final conveyor belt feeds a screening machine via a final chute.

The purpose of the resonance screening machine is to screen fines (fertilizer granules < 2mm), the product to be sold (2 mm < fertilizer granules < 5 mm) and coarse material (fertilizer granules > 5 mm). According to Binder+Co AG, Resonance screens (Undated), the screening machine efficiency is provided by a horizontally arranged screen. Due to low dynamic forces generated during screening, only lightweight support structures of low height are required, giving operating benefits in simpler associated conveyor systems. The Resonance Vibratory Screen operates according to the ejecting principle, describing a linear motion, guided by suspension arms. Both rocker arms are excited by an eccentric drive. According to Wikipedia, (18 August 2010,Eccentric_(mechanism)), in mechanical engineering, an eccentric is a circular disk (eccentric sheave) solidly fixed to a rotating axle with its centre offset from that of the axle (hence the word "eccentric", out of the centre). It is most often employed in steam engines and used to convert rotary into linear reciprocating motion in order to drive a sliding valve or a pump ram. In order to do so an eccentric usually has a groove at its circumference around which is closely fitted a circular collar (eccentric strap) attached to which an eccentric rod is suspended in such a way that its other end can impart the required reciprocating motion. A return crank fulfils the same function except that it can only work at the end of an axle or on the outside of a wheel whereas an eccentric can also be fitted to the body of the axle between the wheels. Unlike a cam, which also converts rotary into linear motion at almost any rate of acceleration and deceleration, an eccentric or return crank can only impart simple harmonic motion.

The screening machine is located above the filling station so that the product falls via gravity force. The benefit is that there is no need of any machine to transfer the product to the next step. The screening machine has three outputs. The first output of the screening is the fines. These fines fall through a pipe onto the floor where the loader takes them back to production as a raw material. The second output is the saleable product. The last output is the coarse material, being collected into a scrap bin hopper. Coarse material in mainly formed by gluing of some fertilizer granules together.

Under the screening machine, there is a tank which is filled with saleable product. The tank is mounted on a weighing system and is loaded until the weight reaches about 600 kg. When the tank is full, then the screening machine, the two belt conveyors and the vibrating chute under the hopper stop.

While the tank is being filled with product, one operator is preparing the big-bag. The big-bag is unfolded, and the bag and the inliner inside of it opened. This inliner prevents that the big-bag gets dirty. There is no need to clean it before reuse. It protects also the fertilizer against air and water. The big-bags are not immediately used by the customers and are sometimes stored for a certain time. If humidity can penetrate the inliner, the fertilizer granules can glue together and form one big rock of fertilizer. The pump blows air into the inliner in order to take the appropriate form and to be ready for the loading step.

As soon as the filling of the tank is finished the operator manually opens the valve to enable the filling of the big-bag. As soon as the 600 kg have been unloaded, the screening machine, the two belt conveyors and vibrating chute start to run again.

While the tank is being filled and unloaded into the big-bag by the first operator, the second operator seals and closes the inliner and the big-bag and puts a label on it. After that the big-bag is released on the conveyor which places the big-bag in a row. The maximum capacity of this conveyor is three big-bags.

While two operators are working on the filling station, one forklift driver takes the big-bags per two units away. These big-bags are either loaded on a truck or stored at the corresponding place in building C22.

5.1.2 Operation time of the big-bag filling station and organization

There are two operators, one loader driver and one forklift driver needed to run the machine. Two teams are working in shifts from 5:00 to 13:00 and 13:00 to 21:00, from Monday to Thursday and Friday from 5:00 to 11:00 and 11:00 to 17:00. There are some additional shifts sometimes on Friday and/or Saturday depending on the volume of product to be delivered to the customers.

There is one shift leader per team working the same hours as the corresponding team and there is one employee responsible for the department of Logistic.

Beside this organization, there are two teams of three mechanics working the same hours as the team for the big-bag filling station on weekdays. There is always one electrician available twenty four hours a day and seven days a week.

In addition, it is possible to contact the workshop from an external company located in the same area to do some mechanical and electrical maintenance. They have one electrician and one mechanic working the afternoon and night shifts during the week and working three shifts during the week-end.

This last section summarized the main ideas about how the machine is running, how the teams are working on the machine, how the organization is structured and what kind of support the operators have in case of problems.

In order to implement OEE on the big-bag filling station, material from “A Guide to the Project Management Body of Knowledge” (2008), Fourth Edition, PMBOK Guide was referred to.

5.2 Project scope planning

5.2.1 Objective

Implementation of OEE to improve productivity of big-bag filling station

5.2.2 Initiation

The project concentrates on four departments:

- Logistics because the teams where the machine is located are involved.
- Maintenance, because electricians and mechanics support the Logistics teams on two factors of OEE, availability and performance. Availability issues can be solved by maintenance teams in terms of breakdowns but they can also help to modify the big-bag filling station so that the performance of the machine increases.
- Production, because this department delivers product to the Logistic department. Depending on what kind of fertilizer is produced and depending on the quality of the granules, the big-bag filling station sees the performance reduced.

- Upper management, because feedback and support of such an implementation are needed.

5.2.3 *Project justification*

- Due to increase of the market demand on big-bags, there is a real need to know about the current OEE. Indeed the big-bag filling station has been purchased at a time where the demands were lower.

- Based on the current OEE, it will be important to estimate a realistic level of OEE which can be reached through the realisation of some improvements.

- Funds are available and the will to make the project succeed is real.

- Satisfying customer in terms of delivery time.

5.2.4 *Brief description*

The market demand for fertilizer packaged into big-bags has grown. The productivity of the big-bag filling station has to increase. The project will focus on implementing OEE and also focus on possible improvements.

5.2.5 *Summary of all deliverables*

- OEE daily measurements

- History of data and issues

- Diagrams helping to follow and analyze OEE progress

- Analysis of current OEE

- Analysis of the current losses

- OEE will indicate where it is necessary to focus on, in using problem solving in relation with the six big losses

- Operators get involved in effectiveness of the machine

- Continuous improvement measures
- Possible investments for improvement
- Satisfied operators due to better work conditions
- Satisfied customers
- Better results in quality and safety

5.2.6 *Statement of what determines project success*

- Choice of the machine. The big-bag filling station should not be technologically too complex to get a good experience by implementing OEE.
- Choice of persons responsible for the different tasks (collecting data, managing to transform data into diagrams, and so on)
- Availability of the different persons responsible
- Motivation of all the persons involved in the project
- Knowledge and experience of the persons about the machine
- The data collected have to be consistent and nothing should be forgotten
- Acceptance of the approach by the operators
- Credibility of the OEE analysis
- Increase of the OEE through this approach and improvement realizations
- Support of upper management

5.3 Project scope definition

5.3.1 *Project objectives*

- Implement OEE on big-bag filling station

- Use data collection and diagrams to find out the areas of possible improvement

- Determine current OEE

- Find improvements using diverse methods for example RCA to solve breakdowns

- Implement improvements

- Control change of OEE

- Implement continuous improvement

- Offer better work conditions to operators

- Improve quality and safety

5.3.2 Project requirements (deliverables)

- Team composed of Project Manager, Plant Manager, Logistics Manager, four persons: shift leaders and/or operators (still to be decided depending on motivation), two mechanics and two electricians

- Consistency of the data collected at the machine

- Task/function assignment for each person involved in the project implementation

- Data collected on paper format

- Diagrams on IT format

- Sheets with diagrams to see evolution of OEE, displayed on a specific location (still to decide where)

- Meetings

- Feedback to upper management

5.3.3 *Project boundaries*

- Loader and driver
- Hopper and input belt conveyors
- Screening machine
- Tank with weighing system
- Output conveyor
- Forklift and driver

5.3.4 *Project constraints*

- Manual data collection: if there is a high frequency of minor stops (less than 5 minutes), operators will have a tendency to filter out these events because of the manual work to track these frequent occurrences. If the operators are busy because of troubleshooting then they may not have time to write down the events accurately. Therefore OEE will be higher than it is in reality.
- Availability of people involved because they are busy most of the time
- Keeping the motivation by people involved in collecting data

5.3.5 *Project assumptions*

- Consistency of collected data
- Possibility to find improvements
- Possibility to improve effectiveness of big-bag filling station
- Possibility to motivate people to do their tasks

5.3.6 *Initial defined risks*

- Change in market demand
- Change of operators and employees involved in the project
- Data collection consistency and work load
- No possibilities to improve performance of machine
- Availability of people involved in project
- Management over optimism, unrealistic goals
- Management incompetency
- Operator collecting data and influencing performance

5.3.7 *Scheduled milestones*

- Project charter (acceptance of the project)
- Trainings of people involved completed
- Start collecting data
- OEE after 3 weeks
- Meeting with Logistic department, subject: possible progress of OEE and possible improvements
- OEE after implementation of improvements (3 months later)
- Meeting with upper management, subject: evaluation of improvements realized
- Review of the future of the project (4 months later)
- Meeting with upper management, subject: evaluation of improvements realized

5.3.8 Fund limitations

The fund is limited to the use of the Mechanical and Electrical Departments for improvements and the purchase of material to a maximum of € 50,000 for the first six months.

5.3.9 Approval requirements

- Upper management approval for implementation of OEE on the big-bag filling station
- Mechanical department manager for allocating resources for improvements of the machine
- Electrical department manager for allocating resources for improvements of the machine

5.3.10 Monitoring and controlling

- Time monitoring through weekly progress meeting attended by the two operators, the two shift leaders, the Logistics manager, one mechanic, one electrician and the project manager
- Cost controlling through monthly invoice about hours and cost spent

5.4 Work breakdown structure

5.4.1 Project initiation

- Identify project team members
- Define roles and responsibilities
- Create project charter
- Acquire upper management approval and signatures
- Acquire team member approvals and signatures

5.4.2 *Definition of OEE*

- Collection of ideas about possible improvements (enables definition of the measurements needed to check for improvements if OEE progressed after implementation)
- Definition of time categories
- Decide if measurement will take place for each product or for a product group
- Decide if start up loss or rework will be identified
- Definition of the maximum speed depending on the machine and product properties

5.4.3 *Develop a form to collect data*

- Use the KISS method: Keep It Short and Simple
- Put only necessary information
- Closely follow the sequence of information to fill out
- It should only take 5 minutes to fill out the form and calculate OEE

5.4.4 *Production team training*

- Kick-off meeting to explain the objectives of OEE
- Get the understanding of the project team on how OEE works, how OEE will be defined for the big-bag filling station and communicate that OEE is machine oriented

5.4.5 *Collect OEE data*

- Start immediately after Kick-off meeting
- Project Manager available for support during the first steps of the team
- Listen to comments and adapt data collection form

- Immediate feedback on OEE is recommended

5.4.6 Data management (diagrams)

The shift leader and/or Logistics manager should be responsible for this task.

5.4.7 Feedback about the results to the team

- Diagrams
- OEE discussion and objectives
- Five Ws Analysis
- Support of production team

5.4.8 Feedback to management

Facts, Figures and Data

5.5 Communication management

Communication management plan is provided in Appendix 5.

5.6 Definition of OEE

The following collection of ideas for improvement and solutions comes from the operators, managers and me.

5.6.1 Loader: loss of product on the road

Issues:

- Safety issue: crossing of the street from loader where the trucks are driving (medium and high traffic depending on days)
- Cost of cleaning the road
- Availability loss, line restrictions due to several tasks from driver to be realized, especially when a loader is missing because of maintenance

Solutions:

- Take less product in the bucket: it is time consuming and more back and forth drives are required

- Use of trailer to transport product from one building to the other: it is time consuming and an additional worker is requested

- Mount a belt conveyor between buildings: it is an eco-friendly solution (no further product on the road, less cleaning of the road) and the loader does not need to spend time by the big-bag filling station anymore. An investment is required

- Enclose the bucket with a plastic film: it is time consuming and an additional worker is requested

- Pave the road between buildings with asphalt to avoid shaking the bucket: it does not solve the street crossing issue

- Move the big-bag filling station in building B29 (it was the case in the past) where loader is looking for product: there is a loss of storage space in building B29, it does not solve the street crossing issue, no further product on the floor, less cleaning of the road, the vehicle still needs to drive back and forth

- Change location of storage: it can be done for a few products but the capacity of storage is limited

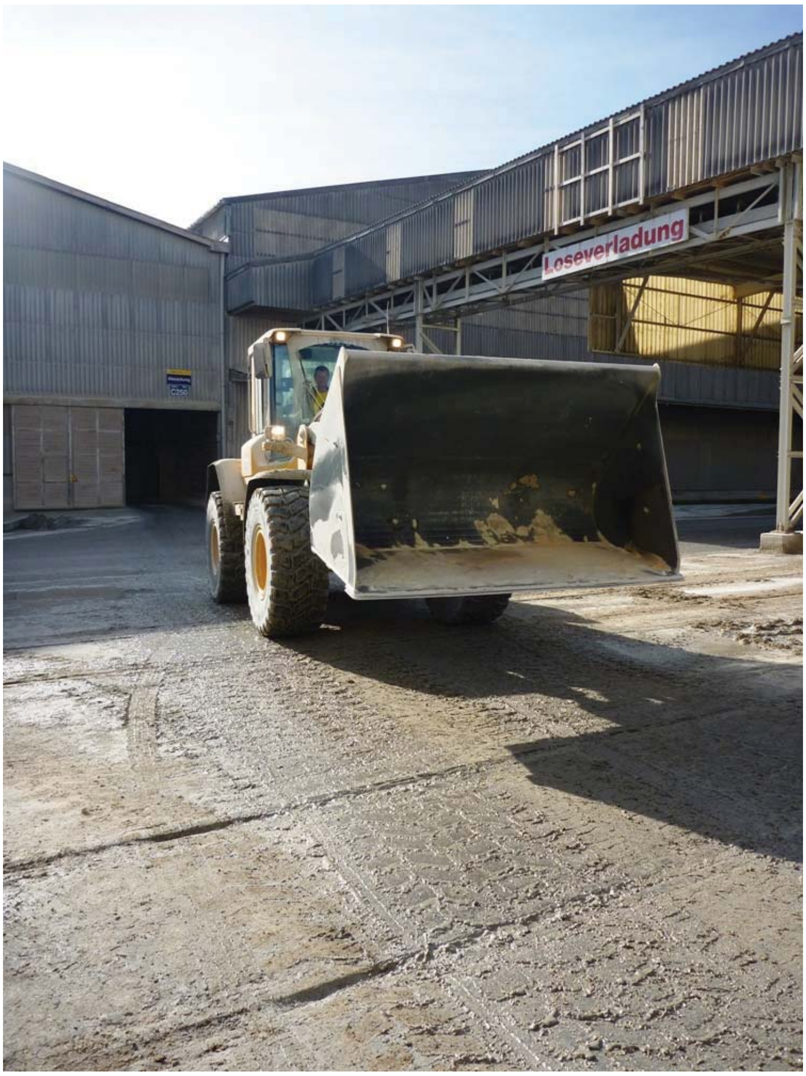

Fig. 4 . The loader crossing the road and the railway

5.6.2 Forklift: loss of time to drive back and forth

The forklift has to drive from big-bag filling station to the truck or the storage of big-bags and back again.

Issues:

- Availability loss, line restrictions
- Safety issue: the forklift is driving either in loader operating area or in forklift 50 kg packaging area

Solutions:

- Reverse output and input of big-bag filling station: the forklift would avoid the loader area but would be in conflict with the forklift operating for the 50 kg bags palletizer. The distance to drive would be smaller. The location of the palletizer would have to be changed.

- Change location of the big-bag filling station: there is an issue about supply of product or delivery of big-bags.

- Change the location of loading trucks area: it is not possible to change entrance and exit of trucks because the remaining and third gate would be too small.

- Increase the size of the output conveyor to be able to reduce waiting time (minor stops) of big-bag filling station because the output conveyor capacity would be greater.

- Repair the floor which has cracks in some areas (mainly by building gates). Currently, forklift drivers have to drive slowly through these areas so that they do not damage the forklift. Driving normally through these cracks generates lots of strong vibration which is also not comfortable for the driver.

- Verify the carrying capacity of the forklift. Currently, the forklift is able to take 2 big-bags to the loading area. If the forklift would be able to take 3 big-bags by each trip, the big-bag filling station could work with less waiting time (minor stops). This is not so easy to implement because the output conveyor would have to be modified. Checking the loading capacity of the current pole is required. It would be helpful for the storage of the big-bags as well as for the loading of the trucks because truck width is large enough to place three big-bags in a row across the width of the truck.

  According to Wikipedia (30 October 2010, Forklift truck): Pole Attachments - In some locations, such as carpet warehouses, a long metal pole is used instead of forks to lift carpet rolls. Similar devices, though much larger, are used to pick up metal coils.

5.6.3 *Screening machine: Loss of time for replacing screen*

Issue:

- Availability loss, breakdown

Solutions:

- Change the system of screen mounting: the current mounting is made with a lot of screw to maintain the screen flat. The new mounting is made with a new screen to hook on one side (standard screen used also for other installed screening machine) and stretched on the other side with screws. The screen is also fixed on each side with wood pieces attached through screws from above. See Fig. 7 page 49.

  Before: the time to replace a screen was eight hours due to a large number of screws to unscrew. This is a really difficult task because most of the times the screws need to be cut because there is no other alternative to remove them due to fertilizer dust. It is important to remove the frame mounted on both sides of the screen before being able to remove the screen.

  After: the current time to replace the screen is four to five hours due to the use of a standard screen which is hooked and stretched.

- Replace the current screening machine with an old one with direct excitation of screen cloths (the screen is inclined about 45 degrees): one additional worker to scrape the screen is required.

- Change the design of screening machine to Pharma vibrating screening machine where the replacement of the screen is faster. An investment is required.

- Mount a second screening machine to be able to switch in case of any disturbance: an investment is required but there is no space above the tank to mount a second machine. See Fig. 6 page 46.

- Change the input of the product in the screening machine: the screen is used to get a hole most of the time at the first stage of the screening. This screening stage is made for fines and if there is a hole, saleable product will be mixed to the fines. This mix has to be reloaded in the hopper or has to be reworked into the production. There could be a possibility to mount a deflector shield to prevent the screen from getting a large pressure of weight concentrated at this point. It is simple and cheap to mount.

- Change the position of the screen: incline the screen a few degrees. Basically it is a good reasoning but the design and the technical data of the screening machine do not allow using the machine in this way.

Fig. 5 . The screening machine

5.6.4 Big-bag filling station (bottleneck): discrete running

The operating of the machine is discrete. The belt conveyor feeds the screening machine and the tank. The tank fills the big-bag with 600 kg of finished product. The bottom valve of the tank gets closed once the big-bag is filled. Then the tank is being refilled. Operators have to wait during the time the tank is being refilled. Due to this situation, the workforce is not used efficiently. The conclusion is the machine acts as a bottleneck in the process. The definition of a bottleneck is given in section 4.3.

The machine has been first installed in a different building. In the past, there was no screening machine installed at the top of the big-bag filling station. The performance of the filling machine is unfortunately not described in the technical documentation. The screening machine has been bought afterwards. The performance of the screening machine is also not available in the technical documentation. The unique possible reference would be the use of the maximum reached level of productivity.

Issue:

- Performance loss, minor stops

Solutions:

- Add another tank next to the existing one which will be feed by the same screening machine. This machine could run constantly with a reduced speed. The operators would need two conveyors to evacuate the big-bags and they could work without any minor stops. An investment for this solution is required. Some additional features would be needed to implement this solution, e.g. a switch between the screening machine and the tanks, an additional tank and an additional conveyor. There is currently no space to install such equipment.

- Increase the valve diameter to be able to unload the tank faster. An investment of the valve and the modification of the tank would be required.

- Weighing system mounted under the big-bag instead of under the tank. This would enable feeding the screening machine and the tank constantly. It would add pressure on operators. Some investments would be required due to the modification of the conveyor system. This conveyor would get more complex and the feasibility should be analyzed. The disadvantage would be the accuracy of the total weight of the big-bag.

A precise Cycle Time Analysis should be realized.

Fig. 6 . The screening machine and the tank

5.6.5 Screening machine: loss of quality at maximum speed

The way the screening machine is designed brings automatically some disadvantages about quality.

There are 3 stages of screening: fines, saleable product and coarse material.

The size of the granules of the saleable product has to be between 2 mm and 5 mm. For technical reasons, the size of the granules has to be less than 5 mm otherwise the machine mounted on the tractor and used to spread the granules on the field would not be able to operate adequately. Bigger granules could obstruct the machine. If the granules are too small the granules would not have the desired impact because they would disintegrate too fast in the soil.

Feeding the screening machine is done through the belt conveyor. The conveyor speed can be adjusted from 0 to 10.

If the belt conveyor is running slowly (speed adjustment from 1 to 4) then the fines are screened efficiently because the layer of finished product on the screen is not too high. The upper layer has the chance to be screened due to vibration of the screen. If the layer of product is too small then the vibration of the machine ejects easily the granules outside the screening machine. The main issue in this case would be the productivity of the machine.

If the speed of the belt conveyor is adjusted from 4 to 8 then the layer of product is large enough to avoid some granules to be ejected but there is still a disadvantage: the upper level of product moves forward due to vibration and it has no chance to reach the screen where fines are screened. As a result, fines are mixed with the saleable product in the big-bags. Coarse material is not screened and runs along the screen in order to be collected in a bin hopper.

If the speed of the belt conveyor is bigger than 8 then the screening machine is overloaded. Some granules are ejected outside the machine and most of the fines are not screened and are mixed with the saleable product. Because of the flow of finished product coming in the screening machine, even fines and saleable product are filled in the bin hopper, normally used for coarse material.

A test based on this three speed levels has never been made to determine which percentage of fines are mixed with the saleable product in the big-bag. This quality test could be done by taking arbitrary some samples of big-bags. The product contained in the big-bags should get through a screening machine to measure the quantity of fines mixed with the saleable product. Finding a way to screen these samples is probably the most difficult issue. The screening machines installed in the different processes are not accessible. If quality has to be improved, an investment has to be made to be able to measure it.

<u>Issue</u>:

- Quality loss: rework

Solutions:

- Mount a sheet of metal piece to slow down the product and to guide it to the bottom layer separate the fines screening stage and the saleable product screening stage. The product would have to get through an open space between the sheet of metal piece and the screen so that fines would be screened in a better way.

  The screen should not be horizontally but should be inclined a few degrees so that the product runs via gravity force to the saleable product stage. There is an issue regarding static and dynamic forces that could cause problem. There are also some concerns about reducing the productivity of the machine.

- Change the position of the product entrance. Instead of having the product falling vertically on the screen, the product could run on the screen almost horizontally at the front of the screening machine. There would be fewer fines mixed with the saleable product filled in the big-bag.

- Buy a new kind of screening machine. There are some other kinds of technologies used nowadays to screen such products. These new technologies are designed to maintain the machine in an effective way. A new machine could take into consideration for example: the volume of product coming from the belt conveyor; the screening performance; the replacement of the screen and the problem of dust. This option would be expensive and would solve the problem only partially. If the screening machine would not be a bottleneck anymore, then the filling and unloading system of the tank would become an important issue.

Fig. 7 . The layer of product in the screening machine

5.6.6 Big-bag filling station and environment: dust generation

Dust is coming out from the top of the screening machine and also from the fines collection place because it is not closed. Dust is arising when simultaneously the loader is filling the hopper for the big-bag filling station and the granules of fertilizer are not coated. There is dust in the air and also on the floor. This has an impact on the workers because it is not healthy and the dust lying on the floor gets slippery when the weather becomes rainy and humid.

Issues:

- Safety issue
- Availability loss: line restrictions
- Health of workers

Solutions:

- Enclose the screening machine. On one hand the solution could be relatively cheap; on another hand it could be technologically difficult to develop a dustproof solution that could be removed in case of maintenance. It is not possible to install something rigid due to strong vibrations during operation of the screening machine. If nothing could be mounted on the top of the screening machine then it would be difficult to avoid the dust falling down over the operators, the big-bags and the conveyor. A system should therefore be built under the screening machine to collect the dust. It is technically feasible but complex because the system should not get in touch with the tank, otherwise the weighing system would not operate properly.

- Enclose the place where the fines are collected. One cheap solution would be to mount a curtain that has to be long enough to make this area dustproof. This would make the loader driver getting off from the vehicle to remove or put in place again the curtain each time the fines have to be removed. An analysis should be realized to determine how many times the driver would have to do it per product.

- Collect fines in a bin hopper. This is a good solution to be dustproof but it would require a forklift to pick up the bin hopper once it is full. As the fines need to be reworked in production the forklift should drive on a partially defective road to the corresponding building. On one hand the forklift is not adapted to drive in such a case. On another hand, the forklift would not be available for a while in the packaging area. An Analysis should be made to determine how many times in a day the bin hopper would have to be emptied.

- Move and turn the big-bag filling station in building C22 and enclose the wall between both buildings. This solution enables having one dusty building (C25) and another one that would be almost dust free (C22). Moving the entire big-bag filling station is expensive. A calculation has to be made to determine if it makes sense to realize this solution or not.

- Find a system to enclose the hopper where the loader is unloading the product. The loader needs to bring the bucket above the hopper. Unfortunately there is no solution available guarantying a dustproof area.

- Find a solution for the dust generated by the product falling from the belt conveyor under the roof in the storage box in building C25. There is no solution available to avoid dust generation. The only possibility would be to restrict this building C25 only to a loader traffic. Then the gate between buildings C25 and C22 should be enclosed. This would reduce the number of people exposed to the dust. Only one may remain in the area, the loader driver.

Fig. 8 . Dusty situation

5.6.7 Bib-bags: cutting of big-bags already filled

It happens that product is being filled in the big-bags that are stored and then cut. There are three reasons why this happens:

- The customer made an order and canceled it before the big-bags were delivered. If this case happens, the big-bags are stored for a certain amount of time in case the product would be requested by another customer before it is cut and reworked in the production. Sometimes after a long period of storage, the granules might stick together. Cutting the big-bag and reprocessing the product through the screening machine again, helps separating granules. New big-bags are delivered to the customer.

- Some big-bags have been stored in advance to respond to peak demands but not all of them have been sold. The big-bags are stored for a certain amount of time and then cut so that the product gets reworked in the production.

- The customer needs a product to be delivered in bulk and unfortunately this product is only available in a packaging of big-bags. The big-bags need to be cut and delivered to the customer in bulk.

<u>Issues</u>:

- Storage issue, not useful big-bags take the storage place where some other big-bags with another product could be stored

- Quality loss: rework

- Availability loss: line restriction because the operators have to cut the big-bags instead of packaging the big-bags by the filling station

- Motivation of operators. Cutting the big-bags is not an easy task, lots of handling is needed and waste is produced. The operators get pressure to reach a good level of performance and if they have to cut the big-bags they have filled before, it is simply not motivating them to maintain good performance at the big-bag filling station.

<u>Solutions</u>:

- Write a clause in the customer´s contract that says that no cancelation is possible after the order has been produced. This solution would minimize the big-bags cutting.

- There is no solution to get more storage place or the solution would be very expensive.

- Add an additional shift or an additional team to cut the big-bags so that the standard team is able to fill the big-bags. They would stay motivated to reach a good level of performance.

- Better scheduling and forecasting of the production

5.6.8 *Weighted Scoring Table for: loader losing product on the road*

Table 1a Solutions for loader losing product on the road

Sol.1	Taking less product in the bucket
Sol.2	Use of trailer to transport more product
Sol.3	Mount a belt conveyor between the two buildings
Sol.4	Cover the bucket during transportation of product
Sol.5	Pave the road between the two buildings with asphalt
Sol.6	Move big-bag filling station in building B29
Sol.7	Change location of storage

Table 1b Weighted scoring table for loader losing product on the road

Criteria	Weight	Sol.1	Sol.2	Sol.3	Sol.4	Sol.5	Sol.6	Sol.7
implementation within a week	10	90	70	10	90	90	30	10
no need of investment	10	100	80	20	60	20	10	30
some costs can be saved after implementation	10	40	40	80	40	20	20	20
the implementation makes sense	5	10	10	80	20	10	50	60
the solution adds value	10	10	20	70	20	20	50	50
the solution has a positive impact on another issue	5	10	10	50	10	10	10	50
need of additional workforce or loss of time	5	60	90	10	20	10	10	10
eco-friendly solution (or health of operators)	10	60	60	90	60	20	60	80
safety improvement	15	20	20	80	20	10	40	60
benefits the OEE value (expectation)	20	5	5	70	5	5	60	60
Total	100	38	36,5	60	33,5	21	38,5	46

Table guideline

Table entries are in the range between 0 to 100 where 100 is the highest value and 0 the lowest value. The sum of the different weights must equal to 100. The best score is the highest score.

Concerning the weighted scoring table, there are two solutions to consider in terms of possibility to add value to OEE: solution 3 and solution 7.

Solution 7

The different products currently stored in bulk in building B29, could be stored in building C24 instead. This is located next to building C25 where the big-bag filling station is operating. There is already an automated scraper, an elevator and a conveyor available to transport the product in building C24. The transportation needs to be extended with new conveyors. The product could either be conveyed next to the hopper where the product is currently loaded or directly to the existing belt conveyor via a chute.

An analysis should be made to determine the best solution of storage of the different products. If this analysis proves the first solution to be most effective then the first solution should be implemented. If this analysis proves otherwise then solution 3 should be verified.

Solution 3

An analysis about the different possibilities should be made to select the best way of transportation from building B29 to building C22. For this solution a new elevator and some new belt conveyors are required. There is already a bridge existing between both buildings that could be used.

A buffer storage should be installed in building C22 for solutions 3 and 7 due to the discrete operating of the big-bag filling station.

Solution 1

This solution will not be implemented due to the difficulty to get the right volume of product in the loader bucket. The driver would lose time and this solution would not add any value.

Solution 2

This solution does not make sense because an additional workforce is required to handle the situation with a trailer. It would be time consuming and would finally not bring any benefit. This solution would not be implemented.

Solution 4

As the driver is spending most of his time working alone, the driver would have to get off the loader many times to cover the bucket and to remove it. This is time consuming and makes no sense. Additional workforce would be required to cover the loader bucket. This solution should not be implemented.

Solution 5

The loader has to cross the street and the railway as it is shown on Fig. 4 page 41. There are many bumps that shake the bucket so that product is being lost during the drive. Pave the road between both buildings with asphalt would help the loader but disturb the traffic of trucks and wagons. This solution would be very expensive in comparison with the benefit it would bring. This solution should not be implemented.

Solution 6

This solution is describing a situation of the past because the big-bag filling station was operating in building B29 before it is moved to building C22. It would make no sense to return it to the original location. The reason for moving the big-bag filling station was to gain more space for storage of products in building B29. Storage capacity is critical nowadays because the number of different products has increased by 50% since the last 5 years. This requires a better management of the storage boxes. This solution also does not solve the street crossing issue with loss of product. It should not be implemented.

Measurements

- Measurement of the time lost when the big-bag filling station has to stop because no product has been loaded into the hopper (Availability loss)
- Cost of cleaning review on waterway and road

5.6.9 WST for: Loss of time to drive back and forth

Table 2a Solutions for loss of time to drive back and forth from filling station to truck or storage of big-bags

Sol.1	Reverse output and input of the big-bag filling station
Sol.2	Change location of the big-bag filling station
Sol.3	Change of the location of loading trucks
Sol.4	Increase the size of the output conveyor
Sol.5	Repair the cracks in the floor, mainly by gates
Sol.6	Verify the carrying capacity of the forklift

Table 2b Weighted scoring table for loss of time to drive back and forth from filling station to truck or storage of big-bags

Criteria	Weight	Sol.1	Sol.2	Sol.3	Sol.4	Sol.5	Sol.6
implementation within a week	10	30	30	80	70	70	80
no need of investment	10	40	10	10	50	50	60
some costs can be saved after implementation	10	60	20	10	30	50	50
the implementation makes sense	5	60	50	10	60	70	60
the solution adds value	10	50	50	20	50	70	70
the solution has a positive impact on another issue	5	50	10	10	50	40	40
need of additional workforce or loss of time	5	10	10	10	10	10	10
eco-friendly solution (or health of operators)	10	50	60	30	30	10	30
safety improvement	15	60	40	20	60	50	30
benefits the OEE value (expectation)	20	60	60	20	60	50	60
Total	100	50	38,5	23,5	50	48,5	51

Concerning the weighted scoring table, there are several solutions to consider: solution 1, solution 4, solution 5 and solution 6. These solutions would add value.

Solutions 4 and 6

These two solutions have to be implemented together because increasing the size of the output conveyor will help the forklift to take more big-bags at once. Increasing the capacity of the forklift means verifying that the pole is sufficient for the requested load. If it is not the case then the pole has to be changed to scale up the load capacity chart.

Increasing the length of the conveyor is technically not really difficult. The body of the conveyor and the conveyor itself need to be extended. Some adjustments need to be done on sensors as well. After implementation of these two solutions, improving the performance of the big-bag filling system would be required.

Solution 5

Each crack in the floor impacts the driver with strong vibrations because the forklift has no damper due to its duty. Repairing the cracks on the floor enhance the driver´s experience while driving. For safety reasons, the forklift driver would be more secure and would minimize the risk for the load to swing or to overbalance. But it increases the danger of collision between two different types of vehicles because this solution enables the driver to be faster by driving back and forth. This should be minimized through implementing solution 1.

Solution 1

This solution would assign a new area to the forklift so that loader and forklift would not risk a collision anymore. However, reversing output and input of the machine would maximize the risk of collision between two forklifts. This solution would also enable the forklift to travel less distance per day and to save operating costs.

Reengineer the configuration of building C22 with a new position for the big-bag filling station and for the palletizer would help to solve different problems.

Place the palletizer so that its output would be on the opposite side of the output of the big-bag filling station, would help for example both forklifts to avoid any collision; would assign one forklift indoors and the other one outdoors; and would enable both forklifts to drive less distance per day.

The palletizer has been built in 1984. Since then the technology has evolved and it is difficult to find spare parts in order to repair it. It would make sense to determine the specifications of a new palletizer and to plan a budget for a new machine. The current palletizer handles 50 kg bags and the new one would be able to handle 25 kg, 15 kg, 10 kg and even 5 kg bags. It would be interesting to palletize also 25 kg bags because this bag size could meet a new market demand in the future in Austria. In the past the weight of cement bags changed from 50 kg to 25 kg in 1999 in Austria. This could be required in the future with all kind of goods. Investing in a new palletizer would help to get a reliable machine in comparison with the current one. A next step could be a new bagging machine investment to adapt the process to 25 kg and 50 kg bags.

Solution 2

If the big-bag filling station would be placed closer from the truck loading area then the forklift would have less distance to drive but it would occupy some space from the storage area. This was also the case with the previous issue. As the storage space is a critical issue, this solution should not be implemented.

Solution 3

This solution has to deal with the traffic of trucks. The traffic has changed last year to guide all the trucks through one way and to queue them on one location outdoors. Depending on their order form, the drivers turn left for pallets of 50 kg bags (outdoor storage place) or they turn right for big-bags (indoor storage place). Due to the size of the two gates by building C22 there are only two ways of traffic possible. The upper management has taken the decision to guide the trucks through the west entrance of building C22 so that they have to turn right and to wait for loading. This area is located in the middle of the big-bags storage area. The trucks drive through the south gate once loaded. Unfortunately there is no other possibility for loading trucks. This solution would not be implemented.

Measurement

- Measuring the time lost when the operators have to stop the filling of big-bags because the output conveyor is full.

- Safety is difficult to measure and especially in that case. No accident has occurred yet. Safety should be improved whenever it is possible. One measure could be the experience of the drivers.

5.6.10 WST for: loss of time for replacing screen

Table 3a Solutions for Loss of time for replacing screen by screening machine

Sol.1	Change the system of screen mounting
Sol.2	Replace the current screening machine with an old one (inclined by 45°)
Sol.3	Change the design of screening machine to Pharma vibrating screening machine type
Sol.4	Mount a second machine to be able to switch
Sol.5	Change input of product into the screening machine, because screen is having a hole most of the time on the first stage of screening
Sol.6	Change the position of screen from flat to a inclination of some degrees

Table 3b Weighted scoring table for loss of time for replacing screen by screening machine

Criteria	Weight	Sol.1	Sol.2	Sol.3	Sol.4	Sol.5	Sol.6
implementation within a week	10	80	60	70	60	90	60
no need of investment	10	80	70	40	30	90	70
some costs can be saved after implementation	10	70	50	70	70	70	50
the implementation makes sense	5	70	50	70	60	80	60
the solution adds value	10	80	80	80	80	50	50
the solution has a positive impact on another issue	5	10	10	10	10	10	10
need of additional workforce or loss of time	5	10	10	10	10	10	10
eco-friendly solution (or health of operators)	10	10	10	10	10	10	10
safety improvement	15	10	10	10	10	10	10
benefits the OEE value (expectation)	20	60	70	70	80	60	60
Total	100	50	46	47	46,5	49,5	41,5

The weighted scoring table shows a distribution of solution which is uniform. Each solution should be analyzed.

<u>Solution 1</u>

One step of improvement has been done to reduce the initial time of replacing the screen from 8 hours to 5 hours. The Mean Time To Repair (MTTR) has been reduced. According to May C. and Schimek P. (2009), MTTR is the average time needed in case of an unplanned shutdown to repair the machine which is ready to be actuated again. There are still possibilities to improve this system of dismounting the old screen and mounting a new screen by the screening machine. A way to improve the MTTR would be to use the method of mind map with the operators and mechanics. According to Wikipedia (24 October 2010, Mind map), mind maps are used to generate, visualize, structure, and classify ideas, and as an aid to studying and organizing information, solving problems, making decisions, and writing.

There are still some improvements possible to reduce the time for replacing the screen.

Solution 5

Changing the input of the product by the screening machine means changing it from the current position where the product falls straight on the screen (see Fig. 7 page 49). The weight of the product on this particular spot weakens the screen which causes a hole to appear frequently in this area. A way of solving this problem would be to mount a chute from the conveyor to the screening machine and with a slope of 45 degrees. Another possibility would be to add some technical feature like a deflecting shield to avoid that the product falls straight on the screen. It is easy and cheap to implement.

Hypothetically it should improve the life time of the screen. This solution should be implemented.

Solution 3

A good way of gaining performance and quality would be to invest in a new technology of screening machine called Pharma: name given to this kind of screening machine because this type is often used in Pharma industry. This machine is cylindrical and able to contain several screens. The advantages of this technology are: the screens are replaced quickly and the machine can be cleaned very easily. Historically, the big-bag filling station did not have a screening machine at the beginning. This second hand filling station has been bought in Italy with the corresponding technical documentation written in Italian. There is no information available in the technical documentation about the quantity of big-bags that is possible to produce in one hour. This screening machine is not adapted to the big-bag filling station in terms of performance and technology. At the time this screening machine has been bought, the demand of the market was not so high. It is possible that the project manager in the past did not really think about the combination of the big-bag filling station and the screening machine in terms of efficient system.

This solution should be implemented and an investment is required.

Solution 4

The possibility to switch from one screening machine to another is the best situation for maintenance. It is often made this way by critical path in the process to ensure reliability on this path. As the big-bag filling station is critical it would be interesting to mount a second screening machine. The question is would it make sense to adapt another screening machine or simply replace the current installed one by a new one with a new technology?

A second question would be to find the space at this particular location to mount a second screening machine. There is currently no place at the top of the big-bag filling station. This solution seems not to add value and will not be implemented.

Solution 2

There is a possibility to replace the current screening system by another one. One screening machine has been dismounted in production in the past. This type of screening machine is inclined about 45 degrees and is for sure a better technology to use. A better screening performance is achieved because a thin layer of granules is running on the screen. As the granules can be trapped on the screen, an operator should scrap the screen periodically to maintain the screening efficiency. One disadvantage would be the location of the screening machine because the operator would have to climb to the top of the big-bag filling station. A second disadvantage would be that this screening machine does not have the possibility to separate fines, saleable product and coarse material. This solution should not be implemented.

Solution 6

Changing the slope of the screen would not be enough to solve the problem: the flow of product coming from the belt conveyor is too large. The surface of the screen should be larger instead. This solution should not be implemented.

Measurement

- Measuring the time lost when the big-bag filling station cannot produce due to a breakdown (availability loss: breakdowns). With this measure it will be possible to calculate the MTTR and the MTBF.

5.6.11 WST for: discrete running of the big-bag filling station

Table 4a Solutions for discrete running of the big-bag filling station

Sol.1	Add another tank next to the existing one
Sol.2	Increase the valve diameter to be able to unload the tank faster
Sol.3	Weighing system mounted under the big-bag instead of under the tank

Table 4b Weighted scoring table for discrete running of the big-bag filling station

Criteria	Weight	Sol.1	Sol.2	Sol.3
implementation within a week	10	40	70	30
no need of investment	10	40	70	40
some costs can be saved after implementation	10	10	10	10
the implementation makes sense	5	60	70	30
the solution adds value	10	80	60	60
the solution has a positive impact on another issue	5	10	10	10
need of additional workforce or loss of time	5	10	10	10
eco-friendly solution (or health of operators)	10	10	10	10
safety improvement	15	10	10	10
benefits the OEE value (expectation)	20	80	70	60
Total	100	39,5	42	31

This weighted scoring table indicates two possibilities of solving this issue.

Solution 2

This solution would increase the diameter of the valve which is opening when the tank is full to fill the big-bag faster. This solution would be easy to implement because there would be no need to make large modifications. Cutting the tank on a higher position, buying and adapting a new valve are required. The current valve is composed of two rectangular slices that are sliding back and forth to open and close the valve. A new and more reliable technology is available nowadays. This new type of valve should have a system of two shell slides to stop the product from falling in the big-bag. One advantage of this new system would be to avoid getting stucked as it happens on the current valve. This solution should be implemented as it would increase the availability of the big-bag filling station.

Solution 1

This solution suggests adding another tank that would be filled while the other one would fill the big-bag. This would require moving up the screening machine to be able to insert two stages of switches. One switch would trigger filling one tank with product and the second one would trigger emptying the other tank. A weighing system should be mounted as well on the second tank. Moving up the screening machine would be risky without checking the structure first. It should probably be strengthened because of the static and dynamic forces due to vibration of the screening machine. This solution should be implemented after the investment in a new screening machine.

Solution 3

This solution would recommend changing position of the weighing system. Technically it is feasible but it would not bring any value because it makes difficult to regulate the quantity of product flowing in the tank.

If it would be regulated on a time basis the tank would be loaded until the time is passed, then the tank would be emptied but not completely due to the density difference of each product. Each cycle would add more quantity of product in the tank which would make the tank overflow sometime. This way to regulate the flow of product is not adapted to the big-bag filling system. This solution should not be implemented.

Measurement

- Measuring the minor stops (Performance Loss) occurring because of the system. The stops represents the time operators have to wait until the tank is filled. This has an impact on the productivity of the big-bag filling station. These measurements are difficult to realize because the loss is about 10 to 20 seconds per big-bag. Supposing that 480 big-bags are filled in a shift and 10 seconds are lost per big-bag then the loss is 80 minutes for this shift. It would be interesting to transform this loss into a potential. The operators will not be able to measure these minor stops, however they should note an average time for each product packaged in the shift.

5.6.12 WST for: loss of quality at maximum speed

Table 5a Solutions for Loss of quality at maximum speed

Sol.1	Mount a sheet of metal piece to guide the product
Sol.2	Change position of entry product
Sol.3	Buy a new kind of screening machine

Table 5b Weighted scoring table for Loss of quality at maximum speed

Criteria	Weight	Sol.1	Sol.2	Sol.3
implementation within a week	10	70	60	70
no need of investment	10	70	70	40
some costs can be saved after implementation	10	10	10	70
the implementation makes sense	5	50	60	70
the solution adds value	10	20	30	80
the solution has a positive impact on another issue	5	10	10	10
need of additional workforce or loss of time	5	10	10	10
eco-friendly solution (or health of operators)	10	10	10	10
safety improvement	15	10	10	10
benefits the OEE value (expectation)	20	40	50	70
Total	100	31	33,5	47

The weighted scoring table shows solution 3 as a prevailing solution to the problem.

Solution 3

Solving the problem of quality by buying a new kind of screening machine would not be enough if it is taken into consideration that the big-bag filling station is running in a discrete way. As long as this discrete running of the machine is not solved it would just solve the problem of quality but would not have an impact on the productivity of the big-bag filling station. This solution should anyway be implemented because it would solve two different issues: reduce the time to replace the screen and improve quality even at maximum speed.

Solution 1

This solution suggests mounting a sheet of metal piece to separate the different stages of screening of the screening machine. This would slow down the flow of product so that fines have more chance to be screened at the first stage. Due to the current configuration the upper layer of product is often not screened at the first stage. As a result fines are not screened and mixed to the saleable product. The disadvantage of using this technique of sheet of metal piece would be the loss of performance of the big-bag filling station because it would take more time to fill the tank. This solution should not be implemented.

Solution 2

The solution of changing the position of the product entry would help to screen efficiently the product at the beginning when the product arrives in an empty screening machine. Once the screening machine would be full, the layer of product would be too large to be able to screen efficiently the product. This solution would not be implemented.

Measurement

- Measuring the quality loss due to rework is difficult to realize because it cannot be measured when the big-bag filling station is running. Two options: either one big-bag is checked after some hours and analyzed immediately to adapt the speed of the conveying system or the big-bag is analyzed at the end of the shift and outside the normal working hours to avoid any performance loss. The difficulty is in controlling how many fines are mixed with the saleable product. There is no other possibility than lifting the big-bag to the top of the big-bag filling station, starting the screening machine and emptying slowly the big-bag to fill a new big-bag. The result would be displayed on the weighing system. At this time there is no quality control and there are only a few complaints in comparison with the entire quantity sold (less than 1%).

5.6.13 *WST for: dust generation*

Table 6a Solutions for dust generation

Sol.1	Enclose the screening machine
Sol.2	Enclose the place where the fines are collected
Sol.3	Collect fines into a bin hopper
Sol.4	Turn and move big-bag filling station in building C22 and enclose the wall between both buildings
Sol.5	Find a system to enclose the hopper where the loader is unloading the product
Sol.6	Find a solution for the product being conveyed under the roof of building C25 and then falling down in the box

Table 6b Weighted scoring table for dust generation

Criteria	Weight	Sol.1	Sol.2	Sol.3	Sol.4	Sol.5	Sol.6
implementation within a week	10	70	70	60	10	60	20
no need of investment	10	80	80	60	20	60	20
some costs can be saved after implementation	10	10	10	10	10	10	10
the implementation makes sense	5	60	50	30	70	30	10
the solution adds value	10	60	60	60	80	30	20
the solution has a positive impact on another issue	5	10	10	10	50	10	10
need of additional workforce or loss of time	5	10	10	10	10	10	10
eco-friendly solution (or health of operators)	10	60	60	60	80	40	30
safety improvement	15	50	50	50	70	30	10
benefits the OEE value (expectation)	20	10	30	30	40	10	10
Total	100	41,5	45	41	45	29	15

The weighted scoring table shows four solutions which have the almost the same score: solution 2, solution 4, solution 1 and solution 3.

Solution 2

This solution suggests enclosing the place where the fines are collected. There are many ways to do it but it should be done so that the loader driver has the lowest inconvenience to load the fines in the bucket. When the screening machine is running, the fines fall down via gravity force from the screen via a chute to a small place with one roof and three walls. This solution could be simply implemented with a curtain so that by collection of fines the dust would stay in this closed place. Fines piles up and the size of the place should be reworked otherwise the pile would open the curtain and dust would come out. One feature should be done for the driver to open and close the curtain without getting off from the loader. This solution should be implemented.

Note: if the quantity of fines is larger than usual, it implies that the granules have not been coated in production. For example a breakdown on the coating drum in production can occur but the production of fertilizer cannot be stopped otherwise the product in each machine would become hard as concrete.

Solution 4

This solution reinforces solution 1 regarding the problem of loss of time to drive back and forth from filling station to the loading area. The idea is to separate totally buildings C25 and C22 in order to have one dusty building (C25) where the loader is driving and one cleaner environment (C22) where the operators from the big-bag filling station and the forklift driver could work in an healthier place. The big-bag filling station should be moved about some meters in building C22 in order to be able to enclose the current gate and the hole in the wall. The gate between both buildings has a door that is worn out. The door would need to be fixed or probably changed in an automatic rolling door. This last option would be more comfortable for the forklift drivers to actuate.

Solution 1

This solution addresses the issue of the dust coming from the screening machine. This dust is due to the screening machine vibrations. A system in two parts should be mounted in order to collect the dust. The first part would be located under the screening machine and would collect the dust falling down in order to evacuate it via the existing chute. The dust collection system should be rigid and adapted right under the screening machine. However it would be difficult to build an inclined system to a certain slope so that the dust falls down because there are some inconveniences to take into consideration: a tank; a chute for the fines; and the structure which support the screening machine. The second part would be at the top of the screening machine in order to retain the dust from being spread in buildings C22 and C25. It would be easier to solve this issue because there is enough space to build whatever the solution has to be. One requirement would be to cover the screening machine with one light material otherwise it will change the vibration specification which would prevent for the screen from moving the product forward.

Considering these two different parts, only the covering from the upper part of the screening machine makes sense to be implemented.

Solution 3

This solution would probably be the most effective way to guarantee collecting the dust coming from the screened fines. However, this solution has some disadvantages. The bin hopper would require a forklift to empty it when it is full. The forklift drivers are most of the time busy with loading trucks and storing the big-bags. The forklift would not drive anyway to the production to unload the fines due to the fact that the road is not in good condition. It would be time consuming because the driver would have to drive slowly. Once the forklift would arrive to the production area, the fines would have to be unloaded in a hopper to rework them. This is not possible by using a forklift. While the bin hopper would be on the way to production, the screening machine would have to continue and the fines would be collected on the floor, which would be a problem when the bin hopper would have to be placed at its location again. The solution of using the loader makes more sense. This solution should not be implemented.

Solution 5

This solution is facing the problem of dust generation when the loader is loading product in the hopper. The solution does not make sense because there are some disadvantages. Due to the handling of the bucket, it would not be possible to build a system on the hopper. It would always be a gap between the hopper and the dust system because the bucket has to go to the middle and over the hopper to be able to unload the product. The bucket could also damage easily the system built if the driver does not care. This solution should not be implemented.

Solution 6

This solution suggests finding a way to avoid dust generation in building C25 through running the product down a belt conveyor located under the roof in the corresponding box. There is no feasible way to prevent dust generation in that case. One solution that has already been mentioned would be to move the big-bag filling station in building C22 and to separate the two buildings. This would restrict building C25 only to the loader and occasionally to a forklift. The operators, forklift drivers and other people would not be exposed to the dust as it is currently the case.

Measurement

- The dusty environment makes measuring the time lost difficult. There is no way to evaluate the availability loss (line restrictions) even if the dust has an impact on the entire system. The floor gets slippery when the weather gets humid or rainy. Due to these conditions, the traffic becomes slower around the big-bag filling station. The poor visibility is sometime due to uncoated product that is conveyed in building C25 so that drivers may just see the lights from other vehicles. Dust may have an impact on the performance of the operators as well. However, the working conditions should appear on the data collection form. The deterioration of performance would be an argument to discuss the problem with the upper management. Some investments could be done to improve the situation.

- Measuring safety is also difficult because it is subjective. When should the traffic of vehicles be suspended? If the drivers only see the lights of other vehicles like I described it? Would it be reasonable to stop the traffic before an accident occurs? Operators and drivers are pressured to pack and load the product for the customer. Fortunately no accident has happened since the beginning of the packaging. A way to make progress would be to record the working conditions and to ask for investment to improve the situation.

5.6.14 *WST for: Cutting of big-bags already filled*

Table 7a Solutions for cutting of big-bags already filled

Sol.1	Write a clause in the customer´s contract
Sol.2	No solution possible to get more storage place
Sol.3	Add an additional shift or an additional team to cut the big-bags
Sol.4	Better scheduling and forecasting of the production

Table 7b Weighted scoring table for cutting of big-bags already filled

Criteria	Weight	Sol.1	Sol.2	Sol.3	Sol.4
implementation within a week	10	90	0	60	20
no need of investment	10	80	0	60	60
some costs can be saved after implementation	10	80	0	60	80
the implementation makes sense	5	90	0	80	80
the solution adds value	10	80	0	30	50
the solution has a positive impact on another issue	5	80	0	30	60
need of additional workforce or loss of time	5	10	0	70	10
eco-friendly solution (or health of operators)	10	80	0	50	80
safety improvement	15	30	0	10	30
benefits the OEE value (expectation)	20	50	0	50	50
Total	100	64,5	0	46,5	51

The weighted scoring table shows different solutions to prevent cutting a large quantity of big-bags. It is important to understand the process between the production plant and the customers to be able to estimate the feasibility of the solutions.

There are three types of models used by Timac Agro Austria: one model for the Austrian market for selling standard fertilizer, then one model for the Austrian market for selling specific fertilizer and finally one model for the market abroad.

Austrian market and standard fertilizer

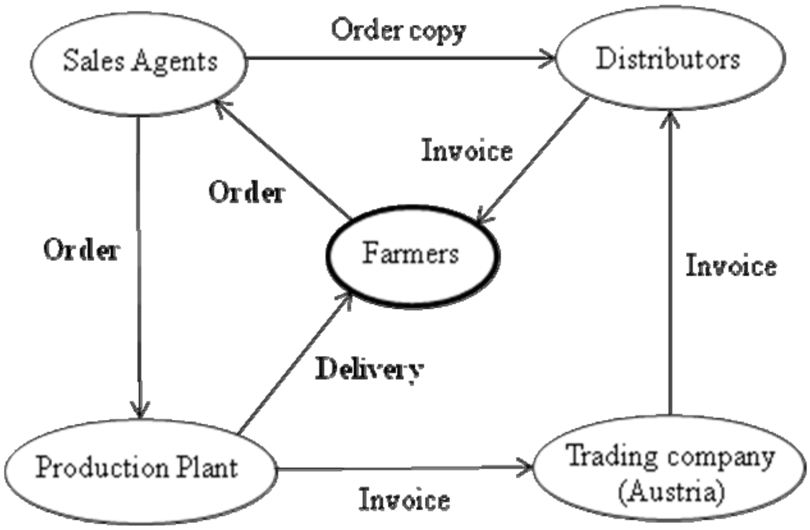

Fig. 9 . Process for Austrian market and standard fertilizer

The process starts with an order from the farmer collected by the sales agent. The order goes to the production plant in order to be scheduled for production and a copy goes to the distributor. This copy enables to send an invoice for the farmer´s order. The unique trading company in Austria gets the invoice from the production plant that sends also an invoice to the distributor that sends an invoice to the farmer. The distributor checks the consistency of the order copy and the invoice delivered by the trading company in Austria. As manufacturer it is required to go through the trading company in Austria to get access to the farmers. Once the order is produced, it is delivered directly to the farmer. There are weekly meetings organized with sales agents so that a scheduling of the different orders can be done. The farmers do not have a large storage capacity dedicated to fertilizer therefore the quantity bought by the farmer is small. The sales agent has to manage to sell a total quantity equal to the capacity of a truck to be able to deliver the different farmers with a fair price.

The situation gets more difficult because theoretically the farmer has until two weeks after signature of the order to cancel it. But in reality everything looks different and cancelations are solved through an agreement between the farmer and the sales agent in order to keep the farmer as a customer. As a result, some product is manufactured and packaged but not delivered. The sales agent is responsible for finding another customer that could use this product. In case the new customer needs fertilizer in bulk, the big-bags are cut and sold. In case no customer is found, the big-bags are cut and reworked as a raw material in the production. The cancelation of an order can also happen when the product is not yet produced. The products manufacturing sequence is important because the different products are composed of different raw materials. This makes the scheduling very tricky.

The quality complaints are no easy to prove and most of the time the management of claims is being solved with an agreement between the farmer and the sales agent. Theoretically the farmer has six months to issue a quality complaint. Currently this year the rate of claims is about 1 percent of the total quantity delivered.

Due to smaller quantity ordered by the farmer, the lost of money in production is smaller than in the next model.

<u>Austrian market and specific fertilizer</u>

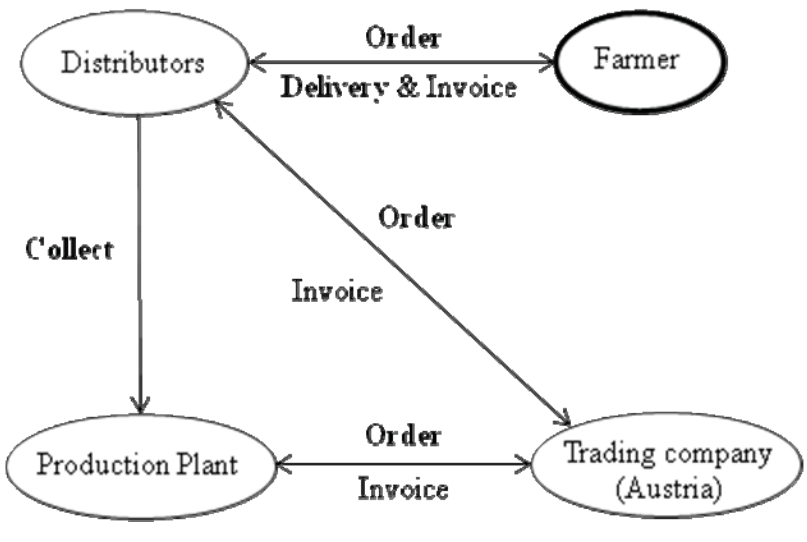

Fig. 10 . Process for Austrian market and specific fertilizer

The farmer sends an order to the distributor that sends an order to the trading company in Austria that sends an order to the production plant. A soon as the order is produced the distributor gets the product from the production plant to be able to deliver it to the farmer. The production plant sends an invoice to the trading company in Austria that sends also an invoice to the distributor that sends an invoice to the farmer.

This model is the most common applied in Austria. As the farmers do not have a large storage capacity the distributors store fertilizer for them and when they need it they collect it from there.

First case, the farmer cancels the order issued to the distributor and the distributor does not cancel the order issued to the production plant in order to increase its storage for other customers. The situation is simple and no problem occurs on the production plant side. The situation gets more difficult when the distributor cancels the order to the production plant. The product being produced and stored in bulk have to wait until a new customer will be found or it will be reworked in the production when the product expires. The way of reworking the product is binding because only 2 to 6 percents of the total quantity of product produced in an hour on the production line can be reworked at a time. The problem of non delivered order is solved with an agreement between the distributor and the production plant. This situation can have a negative impact on the production plant storage capacity and its management.

Second case, the distributor cancels an order, which was dedicated for storage to the purpose of selling the fertilizer to several farmers. This can happen when the distributor finds afterwards a fertilizer from a competitor for a better price. If the order is not yet produced it has an impact on the sequencing of the fertilizers being produced in the production plant. The scheduling can change totally because some fertilizers cannot be produced one following the other due to different raw materials composition. If the order has been produced then an agreement solves the issue between the distributors and the production plant. The fertilizer is either stored for a longer time waiting about a new customer or reworked in the production.

The farmer claims go to the distributors that send them further to the production plant as each claim from the distributors goes also to the production plant.

Market abroad

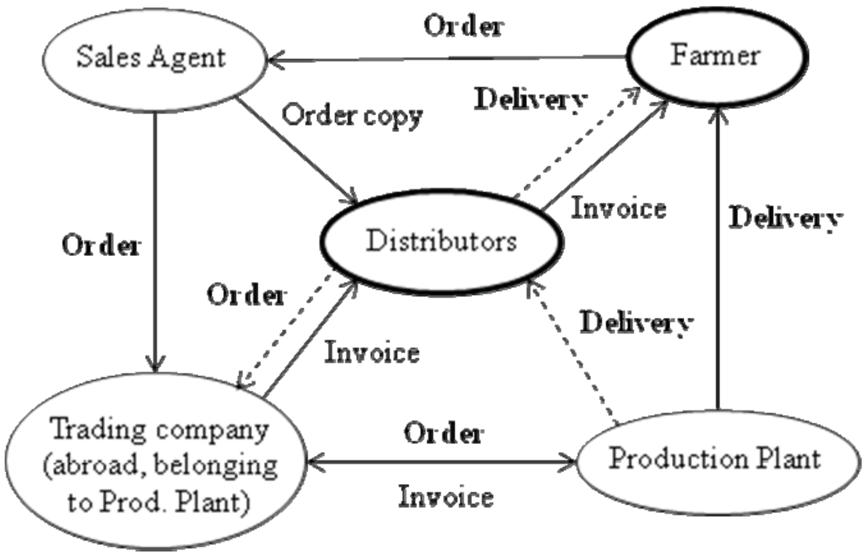

Fig. 11 . Process for market abroad

There are two situations for this model concerning each country where the production plant is represented by its trading companies abroad.

First case, the sales agent gets an order from the farmer. The trading company gets the order and sends it to the production plant. As soon as the order is produced the product will be delivered directly to the farmer. The production plant sends an invoice to its trading company that sends an invoice to the distributor that sends an invoice to the farmer.

In case of cancelation, the farmer cancels by the sales agent and when the order is not yet produced, it has an impact on the sequencing of the fertilizers being produced. The scheduling has to be modified. If the order has been produced the sales agent has to find some other customers to sell the product that is stored in the production plant. In case of big-bags, they may be cut to satisfy other customers. The sales agent has to find an agreement with the farmer due to the cancelation.

In case of quality complaint, it is solved through an agreement between the farmer and the sales agent.

Second case, the distributor sends an order to the trading company, which sends an order to the production plant. As soon as the order is produced the product is sent by the production plant directly to the distributor. The production plant sends an invoice to the trading company that sends an invoice to the distributor. The distributor then delivers the product to the farmer.

In case of cancelation, the distributor cancels by the trading company and when the order is not yet produced, it has an impact on the sequencing of the fertilizers being produced. The scheduling has to be modified. If the order has been produced then an agreement solves the issue between the distributors and the trading company. The fertilizer is either stored for a longer time waiting for a new customer or reworked in the production.

In case of quality claim, it is solved through an agreement between the distributor and the trading company.

Factors of cancelation

On the farmers side there are many factors that can influence buying or not fertilizer for the fields. If one year the farmer had a good harvest, there is a chance that the farmer will buy some fertilizer the next year. If the weather gets worse during the time where the farmer should fertilize the fields, the farmer would be influenced not to buy or to cancel an order of purchasing fertilizer. If the soil is wet the fertilizer will not have the expected impact. If the farmer needs the fertilizer quickly and if the production plant cannot deliver it in time then it happens that the farmer cancels the order. If the price of cereals decreases then the farmer will get less profit. The use of fertilizer will then be canceled. If the raw material prices increase, the fertilizer price increases as well and the farmer will not buy fertilizer. During the financial crisis at the end of year 2008, lots of factors have played a major role and farmers did not buy any fertilizers so that on a European scale level the different production plants of the group did sell much less quantity of fertilizers. The situation was disastrous. The farmers realized that they are able to harvest the crops without any fertilizer or using fewer amounts. The farmers are influenced by many factors and production plants are dependent on the farmers. That makes the entire business and process difficult.

Conclusion to the issue

There are some ideas on how to solve this problem of cutting the big-bags that are already filled. In the case of the three different models of making business, there are the same factors influencing the process of the production plant, in our case the big-bag filling station. These factors are composed by the entire organization and disturbances that are not possible to control. The sales agents play the most important part in this process because they directly interact with the farmers, the distributors and the production plant or its trading company via a weekly teleconference. The sales agents are also responsible for the orders that are cancelled and for finding new customers for the produced good. This issue is solved in most of the cases. Unfortunately it happens sometimes that already filled big-bags have to be cut. The distributors can also cause some strains on the system, since that they try to adapt their storage capacity to the market and the needs of the farmers. The distributors are treated like a customer and some agreements have to be made to keep good relationship with them for the good of the business. The farmers have many factors influencing them like the harvest, the weather, the delivery time and the prices of fertilizers, the good prices and the world economical situation. These factors make the scheduling very tricky as it is impossible to satisfy each customer. The customer is protected by some rules so that the right to cancel until a specific time after signature of the corresponding form can be used. It would make sense wanting to change the situation by writing a new clause in the contract but it would have more negative consequences than good ones resulting from organizing the procedure of cutting the big-bags. As it is not possible to prevent this issue, the only solution that would make sense, is to organize temporary an additional shift so that the big-bag filling station would not be impacted and would keep its availability.

5.7 Definition of time categories

The time categories are defined in six major categories (based on FullFact bv, 2010).

5.7.1 Production time

Production time is equal to running time or operating time and corresponds to the time where the big-bag filling station is filling fertilizer into the big-bags regardless of the quantity and the quality. The production time begins when the valve from the tank is unloading the fertilizer into the big-bag. The production time stops when the screening machine is not running and the tank cannot be unloaded because the product stored is insufficient. Operators stop filling big-bags.

5.7.2 Failure time

Failure time is equal to breakdown time or downtime and means that the big-bag filling station has no output due to a machine related technical problem.

5.7.3 Idle time

Idle time is equal to waiting time and corresponds to the time spent on waiting for a mechanic or an electrician.

5.7.4 Line restriction

Line restriction time is equal to waiting time and means the big-bag filling station is not able to run because the operators are waiting for some product to be loaded in the hopper or there are too many big-bags on the output conveyor of the machine due to the slow pace of the forklift and/or driver.

5.7.5 Unscheduled

Unscheduled means that the big-bag filling station is not running due to some reasons beyond the control of the team. A good example was the part time job organization for several months due to the financial crisis. No need to run the machine because the market demand decreased dramatically.

5.7.6 Not scheduled

Not scheduled corresponds to the time where no activities are occuring at all. The big-bag filling station can be stopped during the yearly technical stop.

5.8 Definition if measurement of each product or if product group

There are different groups of products and therefore different densities. However based on each product, there will be more or less product in the tank. That means that the speed of unloading the tank to fill the big-bags is varying. The different products should be split into groups and OEE should be measured according to these groups.

5.9 Definition if startup loss or rework will be identified

In the case of the big-bag filling station there is no loss due to startup. But rework should be identified when the operators are not producing big-bags at the machine and are cutting the big-bags instead. The availability of the big-bag filling station has to appear on the measurement of OEE. If an additional shift is being organized to cut the big-bags then rework should not be identified.

5.10 Definition of maximum speed of the big-bag filling station

Defining the maximum speed is difficult because the big-bag filling station has been built in two steps. First, the filling station has been delivered by a supplier without the screening machine. Then, the screening machine has been mounted by the former owner of the company without taking into consideration the specification of the filling station. This screening machine was a second hand machine exported from Italy. The technical documentation of the big-bag filling station is thin and does not include much information about the machine. The technical documentation of the screening machine is large and in Italian but does not provide information about any screening performance. There is no documentation that provides information about the maximum speed of the big-bag filling station.

For a few months now, the quantity of big-bags produced is displayed next to the big-bag filling station to inform the operators and forklift drivers about the results of the past days. Informing the operators about the performance makes them feel more involved in the success of the company. However the indicators displayed by the machine are not related to any product and that makes it difficult to compare the performance of each shift. As I wrote in the section 5.8 determining whether the measurement should be done per product or product group, the quantity of product filled into the tank varies due to the density of the product. As a result the big-bag is filled faster or slower. There is also no information about any loss of time due to breakdown or waiting time, that would help to understand why one shift filled less big-bags than the other shift. This is a critical issue that needs to be addressed in order to be able to evaluate performance.

A detailed analysis should be made to determine the performance per shift and per products.

As soon as the performance would be related to a certain product and to any loss of time, it would be possible to define a maximum speed of filling the big-bags per group of products.

5.11 Develop a form for data collection

The data collection form should keep track of these following features.

5.11.1 First Sheet

See Appendix 1.

Production

- Name of product 1
- Name of product 2

These names are important to be filled out in order to show the product change time and which products have been filled in the big-bags. This allows tracking the performance of filling each product type.

Products

- Waiting time for supply of product
- Waiting time for delivery of filled big-bags
- Waiting time for supply of empty big-bags
- Other (energy)

These features enable measuring whether some improvements have been done on forklifts traffic or loader traffic.

Staff

- Waiting for electrical support
- Waiting for mechanical support
- Training / meeting
- Break
- No staff
- Other

These features deal with the human factor and allow to see where some improvements can still be made and then measured.

Big-bag filling station

- Breakdown (mechanical)
- Breakdown (electrical)
- Autonomous maintenance
- Preventive maintenance *
- Cleaning *
- Check of the screen from the screening machine
- Other

These features refer to the machine aspects and enable analyzing where some improvements should be implemented. The measurements after implementation will allow verifying the value of the improvement.

- Other
- Cost of cleaning review (each 10th of the month)

- Dust pollution, if more than usual: medium – high (no visibility for the drivers)
- Traffic issue: low – medium - high
- One shot analysis of waiting time by tank filling
- One shot analysis of waiting time due the pace of the forklift by looking for the big-bags unpicked at the output conveyor
- One shot analysis of quality (proportion of fines in a big-bag)

These features are difficult to measure. Most of them are based on a one shot analysis to get an idea or to be able to explain some results of OEE. Some other features are subjective but allow analyzing the situation and report it to the upper management.

5.11.2 Second sheet

See Appendix 2.

Column of the table:

- Name of the product
- The number of big-bags produced
- The number of defective big-bags
- The number of big-bags used to run a quality test
- The number of big-bags to rework
- The current number of big-bags produced
- The operating time in minutes
- The standard performance rate by corresponding product in pieces per minute
- The estimated performance in number of big-bags

These data enable calculating the availability, the performance and the quality in order to calculate OEE.

5.12 Production team training

Kick off meeting Agenda would take place in three parts. See Appendix 5.

5.12.1 First part (theory and strategy)

Participants: Upper Management, Project Manager, Logistic Manager and Plant Manager would attend the first part of the kick-off meeting.

Agenda:

- Basics of OEE
- Mission for OEE implementation on big-bag filling station
- Feedback on the results
- Feedback requested by management

5.12.2 Second Part (theory)

Participants: Project Manager, Logistic Manager, Plant Manager, four persons from Logistic team (shift leaders and/or operators), two mechanics and two electricians would attend the second part of the kick-off meeting.

Agenda:

- Introduction to OEE (done by Upper Management)
- Basics of OEE
- How is OEE defined for the Big-bag filling station?
- OEE is machine-oriented
- Basics of the strategy

- OEE data collection
- Communication of Results

5.12.3 Third part (practice)

Participants: Project Manager, Logistic Manager, four persons from Logistic team (shift leaders and/or operators) would attend the third part of the kick-off meeting.

Agenda:

- OEE data collection
- OEE data management (diagrams)

5.12.4 Implementation support

The Project Manager would use 100 percent of his time to assist the team by implementing OEE during the two first weeks which would improve the process.

5.13 OEE data collection

As two operators are working on the big-bag filling station per shift, it is possible that one of them collects data and fills out the form. The operator that undertakes filling the big-bags is the one who is able to observe the operation the most and would be assigned to collect data. See attached the layout of the data collection form in appendix 1 and 2. These two operators should be able to know how to fill out the form and should also sometimes change position on the workstation.

5.14 Data management (diagrams)

Due to the workload of the Logistic team, it would be reasonable to assign the data management task to the Logistic Manager. However the Logistic Manager has currently no connection to the network. This should be solved before the implementation project. The Logistic Manager would be in charge based on each daily data collection form to feed a file describing the history of issues occurred by the big-bag filling station. The Logistic Manager would be able to develop some diagrams that have to be presented once a week. One method to present the results would be to visualize the percentage of the different causes related to a loss of time, listed on the collection data form. A Pareto diagram would be the appropriate way to visualize the results. It would be difficult to react fast on any OEE variation due to the complexity of the process and the number of persons involved. As long as the data collection would be mainly made by the operators, the Logistic Manager would have to support and correct them to be able to get the most precise data collection as possible. If the data collection would be automated then it would be possible to get an accurate measure and also a faster process to manage the data.

5.15 Feedback on the results to the team

The Logistic Manager would be responsible to post up the results from the past week with a Pareto diagram or a Pie chart on the location where the team is taking a break so that when there is shift change, the different operators would be able to discuss together about the results. Shift change would be also a good occasion to remind the team of the objectives of OEE.

Following the feedback on the results to the team, the Logistic Manager would be in charge with the help of his team to suggest some ideas to improve the major causes of time loss. This could be done during a meeting where all the participants think about each problem and ask themselves five times why questions which corresponds to the five Ws Analysis.

5.16 Feedback to management

The Logistic Manager would have to present figures and facts to the Upper Management, Plant Manager and Project Manager by using the different diagrams and presenting the ideas that the team would have found based on the different issues.

5.17 Communication management

The communication management layout is provided in Appendix 5.

6 RESULT OF THESIS

The ultimate goal of my thesis was to look for technical solutions to improve the productivity of the big-bag filling station as stated in section 4.2. The outcome is an improvement plan suggesting a sequence of short term improvements to be implemented. The cost and the time needed to implement the solutions have been taken into account in my approach.

6.1 Environment of the big-bag filling station

Improving productivity means focusing not only on the machine but also on its environment. This environment is mainly composed of traffic and safety issues associated with loading the finished product and delivering the packaged product to the storage area or to the trucks waiting for loading. As one of the current goals of Timac Agro Austria is increasing safety in the plant, this improvement plan focuses firstly on the traffic of vehicles. Implementing these following technical solutions would have an impact on safety and availability of the big-bag filling station.

The sequence for improving the environment of the big-bag filling station is:

- Increase the capacity of the output conveyor of big-bag filling station

  It is important to increase the capacity of the output conveyor before increasing the performance of the big-bag filling station. It will help to reduce the minor stops due to line restrictions.

- Verify the carrying capacity of the forklift

  Increasing the output conveyor of the big-bag filling station would help to load more than 2 big-bags on the pole of the forklift. If it would be possible to load 3 big-bags then the forklift would need to travel shorter distance to load a truck. The 3 big-bags on the pole of the forklift could also be loaded directly from the side onto the truck without having to handle them. Nowadays the forklift takes 2 big-bags per each trip. Assuming there are already 2 big-bags placed in a row across the width of the truck. On the next trip, the driver has to unload one big-bag on the floor next to the truck, then take the other one and load it onto the truck. The remaining big-bag has then to be loaded on the truck in a new row. Checking the loading capacity chart for the pole and the forklift would help to know if the current pole is authorized to carry a load of 3 big-bags. If not, investment in a new pole should be made. It would help to reduce time spent handling the big-bags.

- Repair the cracks on the floor

  Due to the need for loading 3 big-bags on the forklift it would be important to repair the cracks on the floor so that the load is not at risk of swinging or overbalance. The forklifts driving indoors and outdoors would be able to drive faster.

- Analysis of storage reorganization to transport product from building C24 to building C25

  This analysis should focus on reducing or stopping the loader from driving with finished product from building B29 to building C25. If it is possible to achieve this goal by storing requested finished products in building C24 and transport these products to building C25 then there would be no need to transport the finished products from building B29 to C25.

6.2 Big-bag filling station

After optimization of the big-bag filling station environment, the next step would concentrate on the machine. These following technical solutions show how to increase the performance of the big-bag filling station and how to solve the bottleneck. Solving the issues stated in section 4.3, would enable to: increasing availability and performance of the big-bag filling station; increasing the quality of the products; and allowing the operators to work in better conditions.

The sequence for improving the big-bag filling station is:

- Change the diameter of the valve under the tank

  Increasing the valve diameter would enable better performance and better availability of the machine through investing in a more modern, reliable valve.

- Enclose the place where the fines are collected

  Most of the dust is coming from this place because some granules of fertilizer are not coated due to breakdown of the coating drum, or of the pipe between the coating tank and the coating drum, or because there is a delay in the delivery of coating product. Implementation of this solution would enable that dust is not spread in the building as it is shown on Fig. 8 page 51. The operators would work in a less dusty environment.

- Enclose the upper part of the screening machine

  This solution would protect electrical devices e.g. sensors, and the operators from getting dust falling from above.

- Change the system of screen mounting

  The mounting of the screen has already been modified to reduce the MTTR. There are still some possible modifications to increase the availability of the screening machine, thus the productivity of the big-bag filling station.

- Change the input of product into the screening machine

  Changing the input by mounting a deflector would allow extending the lifetime of the screen. The availability of the screening machine would therefore be increased as well.

- Invest in a new screening machine

  This solution would be the most important one because it would solve several issues: increase the quality of the product packaged; reduce the time for replacing the screen; increase generally the availability of the big-bag filling station; and reduce dust because the new machine would be enclosed. This solution would need a larger investment than the previous ones to modify the top of the big-bag filling station.

- Add another tank next to it which would be feed by the same screening machine

This solution would enable the big-bag filling station to operate in a continuous mode rather than in a discrete mode and would also increase its performance. This solution would also need a larger investment because large modifications are required.

Two solutions do not need to be included in the above sequences because they can be implemented as soon as possible:

- Add an additional shift or an additional team to cut the big-bags

  An additional shift should be organized each time some big-bags have to be cut. This team should be preferably composed of external workforce so that our own workforce stays motivated to fill big-bags. It would also allow operating the big-bag filling station while handling the cutting of the big-bags.

- Find a way to check per product the quantity of fines included in a big-bag

  This solution would enable to check the quality of the product packaged in the big-bags and then to interact with the process to get a better quality. It is important to implement this solution as soon as possible to deliver quality products to the customers until an investment in a new screening machine can be made.

In conclusion, these solutions need to be analyzed in detail to define specifications and to assign costs in order to develop a business plan for the next 2 years.

7 SUMMARY OF FURTHER WORKS

These works need more investments than the improvements described in the chapter 6 because it would change the entire packaging system. These improvements would: increase safety in buildings C22 and C25; increase the availability of the big-bag filling station and the palletizer; offer to the operators a healthier environment; and increase efficiency in the entire packaging system.

The sequence of works is:

- Invest in an new palletizer and change current location

  This investment would help to increase the availability because a new palettizer would be more reliable. Due to the age of the current palettizer it is becoming more and more difficult to find spare parts for it in case of breakdowns. This would also enable the position to be changed so that the forklift could take the pallets directly from outside instead of driving in the building as shown in appendix 4. A new palettizer would allow ~~to~~ packaging of 25 kg and 50 kg bags and this new technology would also set up the change automatically. By making this change of palettizer and location there would be the possibility to change the location of the big-bag filling station.

- Move the big-bag filling station in building C22

  Once the new palettizer is bought and placed in a new location, it would be possible to move the big-bag filling station in building C22 and rotate it so that the output conveyor would be on the other side as it is currently. This change of location would help to separate the two buildings C25 and C22 with a wall and an automatic rolling door. The loader would be assigned to the building C25 and the forklift to the building C22 as shown in appendix 4. This would solve the traffic issue with no risk of collision of vehicles anymore. The place where the fines are collected would stay in place in the building C25 so that most of the dust stays in this building where only one driver is operating. The operators in the building C22 would have much less dust than in the present situation.

- Transport product from B29 to C22 with a conveyor system

  If the analysis of storage reorganization to transport the product from building C24 to building C25 did not give any relevant results then it would be possible to analyze the way the product would be conveyed from building B29 to building C22. This solution requires the investment of belt conveyors to transport horizontally the products, elevators with chains and buckets to transport the product vertically and also one buffer tank to store the products in building C22. This improvement is not easy to implement but would solve the main issue of the loader crossing the railway and the street that is used by a large number of trucks for loading products in bulk.

- Invest in a new bagging machine (25 kg and 50 kg bags)

  Once the investment in a new palletizer has been made and the big-bag filling station moved in building C22, then it would be possible to invest in a new bagging machine that has been adapted to the specification of the palletizer in terms of different possible bags to process. It would be only in Timac Agro Austria´s interest to fill 25 kg and 50 kg bags. This would be the last step to finalize the improvement of the packaging system by Timac Agro Austria.

One solution does not need to be included in the above sequence because it can be implemented as soon as possible:

- Implementation of an automated data collection system

  The objective of such a system would be to track in real-time and in an automated manner some key performance indicators on the big-bag filling station. There would be no longer a loss of time in performing the different functions such as collecting the data, making calculations and discussing the validity of the data and calculations. There would be one snapshot of the filling station effectiveness available in real-time that would lead to the ability to act almost in real-time instead of after the fact with the manual data collection. Some improvements could be achieved with this automated data collection system

In conclusion, these solutions need to be analyzed in detail to define specifications and to assign costs in order to develop a business plan for the next 5 years.

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10 LIST OF ABBREVIATIONS

BB	Big-Bag
EM MSc Program	Master of Science Program in Engineering Management
ERP	Enterprise Resource Planning
FIBC	Flexible Intermediate Bulk Container
IT	Information Technology
OEE	Overall Equipment Effectiveness
MES	Manufacturing Execution System
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
PDCA cycle	Plan Do Check Act cycle
RCA	Root Cause Analysis
SMED	Single Minute Exchange of Dies
TPM	Total Productive Maintenance
WST	Weighted Scoring Table

11 APPENDIX

Appendix 1: First sheet of data collection form

Workstation: BIG BAG FILLING STATION

Date:

		Early shift	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00		
		Afternoon shift	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00		
		Night shift	21:00 00:30	22:00 00:30	23:00 00:30	00:00 00:30	01:00 00:30	02:00 00:30	03:00 00:30	04:00	05:00	Minutes	Frequence
PROD.	Name of Product 1												
	Name of Product 2												+ A
GOODS	Waiting time for supply of finished product												
	Waiting time for delivery of filled BB												
	Waiting time for supply of empty BB												
	Other (Energy)												
STAFF	Waiting for electrical support												
	Waiting for mechanical support												
	Training / Meeting												
	Break												
	No staff												
	Other												

Appendix 1: First sheet of data collection form (continuation)

MACHINE	Breakdown (mechanical)			
	Breakdown (electrical)			
	Autonomous maintenance			
	Preventive Maintenance *			
	Cleaning *			
	Check the screen from the screening machine			
	Other			
OTHER	Cost of cleaning review (each 10th of the month)			
	Dust pollution, if more than usual: medium – high			
	Traffic issue: low – medium - high			
	One shot analysis of waiting time by tank filling			
	One shot analysis of waiting time due to forklift by looking for the big-bags by output conveyor			
	One shot analysis of quality (proportion of fines in a big-bag)			+ B
				C = A + E

* not to be included in operating time to measure effectiveness of activity

Appendix 2: Second sheet of data collection form

Name of the product	Number of BB produced	Number of defective BB	The number of big-bags used to run a quality test	Number of BB to rework	Current number of BB produced	The operating time in minutes	The standard performance rate (BB per minute)	The estimated performance in number of BB
	+	+	+	=		x	=	
	+	+	+	=		x	=	
	+	+	+	=		x	=	
	+	+	+	=		x	=	
	+	+	+	=		x	=	
+				+			+	
	D: qualitative product				E: Actual output			F: Possible output

Standard	
Product	BB / Minute

Availability (A) / (C) [ ]

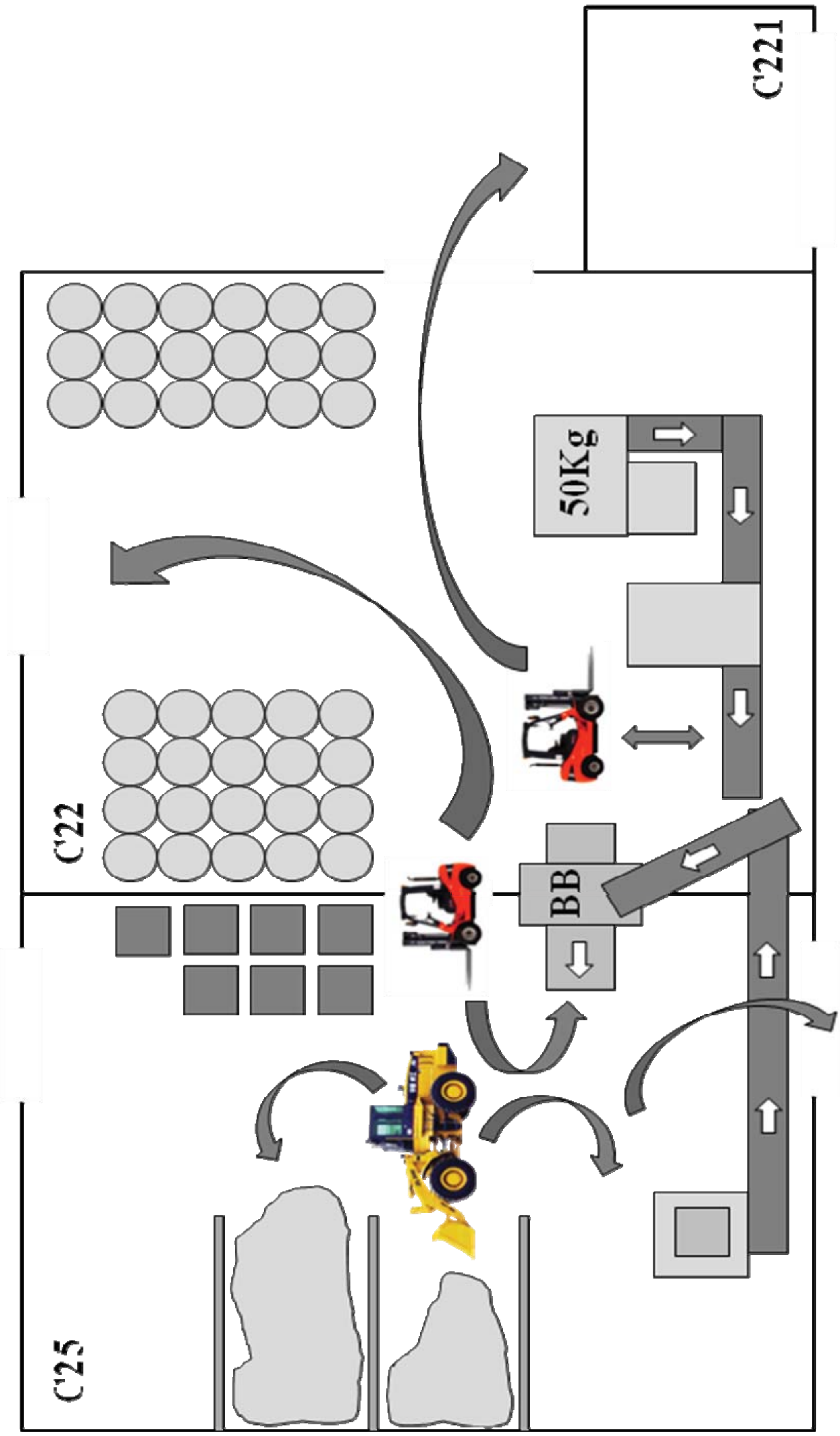
X

Performance (E) / (F) [ ] = [ ] OEE

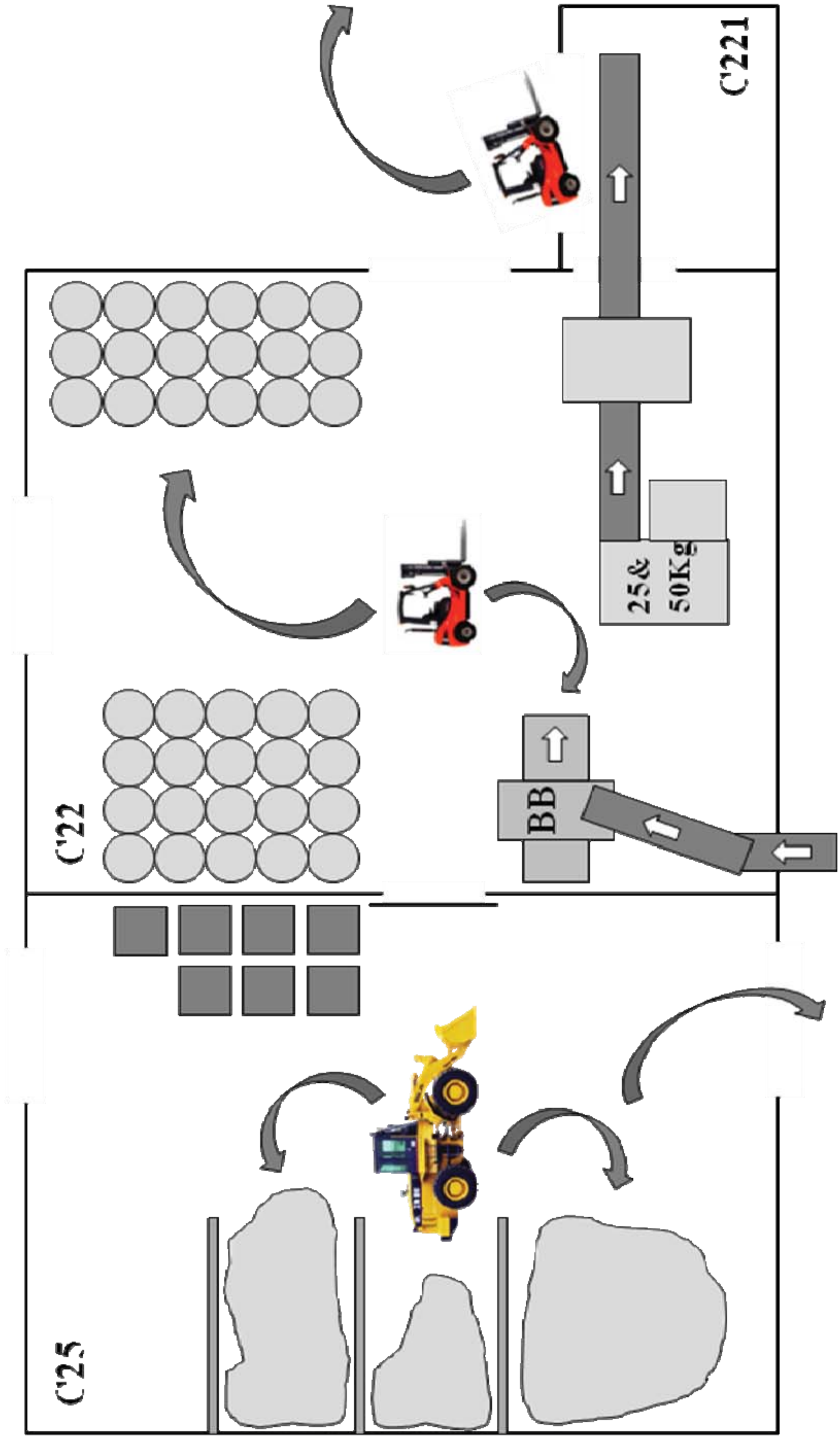
X

Quality (D) / (E) [ ]

Appendix 3: Current situation in Logistic department



Appendix 4: Situation in Logistic department after improvements



Appendix 5: Communication management plan

Communication Type	Objective of Communication	Medium	Frequency	Audience	Owner	Deliverable
KickoffMeeting (Theory and Objectives)	Introduce the project team and the project to the managers. Review project objectives.	Face to Face	Once	• Upper Management • Project Manager • Logistic Manager • Production Manager	Project Manager	• Agenda • Meeting Minutes
KickoffMeeting (Theory)	Introduce the project team and the project. Review project objectives.	Face to Face	Once	• Upper Management (only for Introduction) • Project Manager • Logistic Manager • Production Manager • Logistic Team (4) • Mechanics (2) • Electricians (2)	Project Manager	• Agenda • Meeting Minutes
KickoffMeeting (Practice)	Learning phase at the big-bag filling station	Face to Face	Once	• Project Manager • Logistic Manager • Logistic team (4)	Project Manager	• Agenda • Meeting Minutes
Weekly Project Status Meetings	Review status of the project	Face to Face	Weekly	• Project Manager • Logistic Manager • Production Manager	Project Manager	• Agenda • Meeting Minutes
Project Status Meeting after 3 weeks (milestone)	Possible progress of OEE and possible Improvements	Face to Face	Once	• Project Manager • Logistic Manager • Logistic Team (4)	Project Manager	• Agenda • Meeting Minutes
Project Status Report after 3 weeks (milestone)	Possible progress of OEE and possible Improvements	Email	Once	• Top Management • Logistic Manager • Production Manager	Project Manager	• Project Status Report

Appendix 5: Communication management plan (continuation)

Communication Type	Objective of Communication	Medium	Frequency	Audience	Owner	Deliverable
Project Status Meeting after 3 Months (milestone)	Evaluation of improvements realized	Face to Face	Once	• Upper Management • Project Manager • Logistic Manager • Logistic Team (4)	Project Manager	• Agenda • Meeting Minutes
Project Status Report after 3 Months (milestone)	Evaluation of improvements realized	Email	Once	• Upper Management • Logistic Manager • Production Manager	Project Manager	• Project Status Report
Project Status Meeting after 4 Months (milestone)	Review about the future of the project	Face to Face	Once	• Upper Management • Project Manager • Logistic Manager • Production Manager	Project Manager	• Agenda