

IMPLEMENTING LEAN MANUFACTURING
TECHNIQUES AT ARCELORMITTAL, PRETORIA
WORKS.

By

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Executive Summary

The main aim for many companies is to maximise profit and optimise their costs in order to remain in business. The key drivers for manufacturing facilities to achieve the above goal is to consistently improve quality, flexibility and service while driving down costs, product variability and response time. ArcelorMittal South Africa (Special Profiles Mill) is no exception in the production of window and fencing products.

The aim of this project is to investigate and implement lean manufacturing techniques at ArcelorMittal Pretoria Works. A full investigation starting from when the customer places an order to when the final product is in the hands of the customer is required. The project focuses mainly on orders within the country (South Africa).

During SPM visits, several problems were discovered in the supply chain. These problems were analysed to see which lean technique will be most effective in trying to solve the problem. It was decided that value stream mapping (VSM) will be the main technique that will be used, supported with other lean tools and techniques such as the 5S system, facilities planning, kanban system and standard work. The application of these techniques will assist in highlighting and eliminating waste, which will eventually improve productivity and reduced production lead time and the amount of scrap generated.

Most of the sources of wastes will be eliminated from the operation processes and all the project objectives will be met after completion of this project. It is recommended that the implementation process is done using the VSM implementation procedure.

Acknowledgement

To my family and friends- for their support, advices and unconditional love.

To ArcelorMittal (Pretoria Works) Workers:

- Mr Muzi Malindi – Production Manager.
- Mr Moses Mwelase – superintended.
- All Floor Operators.

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List of Acronyms

Iscor – Iron and Steel industrial Corporation.

SPM – Special Profiles Mill.

VSM – Value Stream Mapping.

TPS – Toyota Production System.

SLP – Systematic Layout Planning.

Chapter 1

Introduction and background

1.1. Company Background

ArcelorMittal South Africa started as Iron and Steel industrial Corporation (Iskor) in 1928. Hendrik van der Bijl was the driving force behind the establishment of Iskor. Iskor was established as a state company in terms of the Iron and Steel industry Act, No. 11 of 1928, with its first works in Pretoria. The objectives of this company were to produce iron and to create employment opportunities.

During wartimes (1940's), the demand for steel increased rapidly and Iskor had to expand to a new area because Pretoria Works had reached the limit of growth. Then in 1941, Dr. van der Bijl and his fellow directors decided that the expansion should be at Vereeniging due to a nearby water supply. On 17 May 1969, the South African Government decided that a third fully integrated steelwork should be erected at Newcastle. The main factor leading to this selection was to decentralise industry away from the Witwatersrand complex and to promote industrial development in Natal.

During the steel industry's recession era (end of 1970's and early 1980's), some of Pretoria Works plants were shut down. The South African Government decided to start transferring certain state interest to the private sector and the company merged with other private companies. It was at this point that Iskor started to change its name. The last name change occurred on 25 June 2006 to ArcelorMittal South Africa.

ArcelorMittal South Africa, Pretoria Works mainly focuses on production of window Sections, fencing posts and grade A material. All of these products are produced at the Special Profiles Mill (SPM). The main concern that SPM has, is the problem with the high amount of scrap generated and high processing time which both affects the production rate.

1.2. Problem Statement

The SPM uses old equipment for production. Replacing this equipment with newer automated equipment will cost millions. The equipment used currently still works correctly. The problem is that the set-up is manual and instead of standardising the set-up, the trial and error method is used which requires lot of time and lot of raw material for testing. There are other key problems that contributes to high production lead time and amount of scrap generated.

The key problems that were encountered are as follows:

1. Information flow
2. Spare parts location.
3. Operations executed using trial and error method.
4. Unnecessary waiting time due to scarcity of tools.
5. Housekeeping.
6. Training procedure.
7. Transportation.

1.3. Project Aim

The aim of this project is to investigate and implement lean manufacturing techniques at ArcelorMittal Pretoria Works.

Objectives:

1. Improvement of productivity.
2. Reducing amount of scrap generated.
3. Reducing production lead time.

1.4. Project Scope

The project scope includes the whole process from when an order is made up until the order is received by the customer. The analysis of the following activities will also be considered:

1. Procurement of raw material
2. Receiving of orders
3. Production operations
4. Shipping of final product

The project will only focus on one product family (LF7: window Section). A product family is a group of products that pass through similar processing steps and over common equipment in downstream processes. (Rother & Shook, 1999).

1.5. Deliverables

The desired outcomes of this project are as follows:

1. Identification and elimination of the sources of wastes.
2. Documenting current-state value stream.
3. Developing the future-state value stream.
4. New plant layout that supports future state value stream and good housekeeping.
5. Implementation of the kanban system.
6. Standardised operations methods.

Chapter 2:

Literature Review

This Chapter of the report provides a brief background on the tools and techniques that can be used to find a solution for the problems stated in Chapter 1. Research was conducted on lean manufacturing tools and techniques. Other techniques discussed are techniques that complement lean manufacturing tools and techniques.

2.1. Lean Manufacturing

(i) Background

Lean manufacturing is one of the initiatives that many major businesses in the United States have been trying to adopt in order to remain competitive in an increasingly global market. Lean focuses mainly on the elimination and reduction of many types of non-value added activities, often referred to as wastes. The birth of lean was in Japan within Toyota, when it developed its Toyota Production System (TPS) after World War II. Toyota pursued the TPS primarily to eliminate waste and reduce costs in its production system. (Abdulmalek & Rajgopal, 2006; Burton & Boeder, 2003).

(ii) Application

Lean manufacturing aims to achieve the same output with less input such as; less time, less operating cost, less machinery, less human effort, and less material. In order to achieve these, one needs to understand the key principles of lean which are fundamental to the elimination of waste:

1. Value – Understanding the value of the work performed by defining it as something that the customer wants to pay for.
2. Value Chain – Mapping the process steps throughout the supply chain by identifying the steps that add value and striving to eliminate those that add waste.
3. Pull – Authorize production of products and service based on the pull by the customer.
4. Flow – Make the product and service flow without any interruption across the value stream.
5. Continuous Improvement – Strive for perfection by constantly removing layers of waste.

These principles need to be embraced across all the functions within the organisation and needs to be applied upstream and downstream in the value chain. (Chase et al., 2006; Burton & Boeder, 2003).

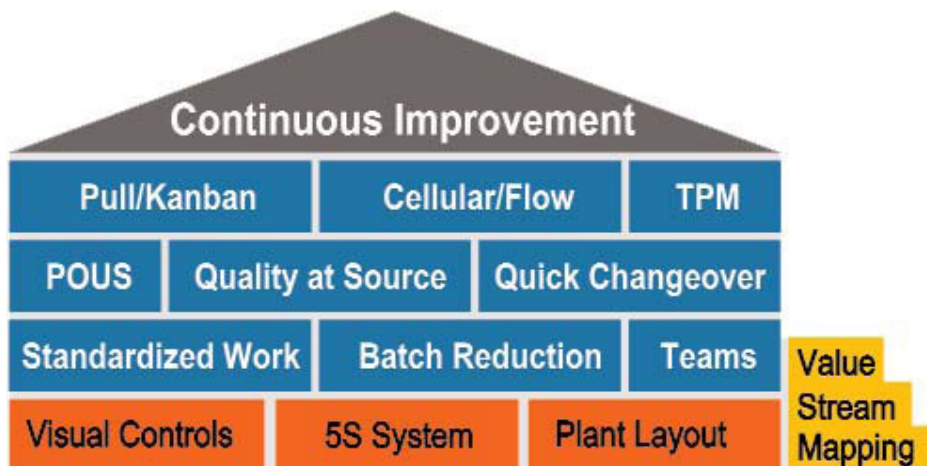
According to TPS there are eight types of wastes that need to be eliminated in order to create a lean environment. Table 1 below lists all the wastes identified by lean and their brief description.

Table 1: Lean wastes and their descriptions.

Wastes	Description
Overproduction	Producing more than what is demanded by the customer.
Waiting	Waiting for the next process step to occur.
Transportation	Unnecessary movement of material or information
Processing	Excessive processing because of poor product or process design.
Inventory	Storing more than the bare minimum.
Motion	Excess or unnecessary motion of anything: people, machine or material.
Defects	Creating scrap, rework, or paper work errors.
Human potential	Failure to utilize the skills of people.

Lean manufacturing uses many tools and techniques in eliminating the sources of wastes such as Value Stream Mapping (VSM), the Kanban System, 5S visual Management, facilities planning, etc. Figure 1 below illustrates all the tools and techniques found in lean manufacturing (House of Lean).

Figure 1: House of lean.



(iii) Conclusion

Lean production has proved its value to thousands of companies in the world. The idea behind lean is to achieve high volumes of production of a high-quality using minimal inventory of raw material, work-in-progress and finished goods. (Chase et al., 2006).

2.2. Value Stream Mapping

(i) Background

Toyota developed value stream mapping (VSM) in the 1950's. It gained widespread attention during the last several years. Value stream management and value stream mapping are key foundation principles for creating the lean enterprise. (Burton & Boeder, 2003).

(ii) Application

A value stream is a collection of all actions (value-added as well as non-value-added) that are required to bring a product (or a group of products that uses the same resources) through the main flows, starting with raw material and ending with the customer. (Rother & Shook, 1999). These actions consider two components of value stream map within the overall supply chain. The first component is the flow of material through transformation processes to produce finished goods or services.

The second component is the flow of information to support the transformation processes for the finished goods or services. Taking a value stream perspective means working on the bigger picture, not just individual processes, and improving the whole, not just optimising the parts. VSM is the tool that is utilised to graphically represent the current state of a value stream. Icons are used to show the sequence of materials, processes, and information for the specific value stream. (Rother & Shook, 1999; Burton & Boeder, 2003.).

There are five basic steps that must be followed when creating VSM:

1. Identify the product or product family.
2. Create a current state map.
3. Evaluate the current state map and identify wastes.
4. Create a future state map.
5. Implement the final plan.

The first step consists of choosing which product or product family the VSM will focus on. Then the second step deals with the creation of current state mapping which is basically the drawing of material and information flow of current production situation.

After completion of the current state mapping, all the processes are evaluated and all non-value adding processes are identified.

Each process in the VSM consist of certain parameters such as cycle time, TAKT time, work in progress (WIP), set up time, down time, number of workers, and scrap rate. A VSM identifies where value is added in the manufacturing process and also all other processes where there is non-added value. After analysing and evaluating the current state map, all non-value adding processes can be eliminated and a future state map can be developed. The last step of the value stream mapping process is to implement the final plan. (Wolfgang et al., 2007)

(iii) Conclusion

Value stream is a good place to start because in order to be competitive, the value stream needs to flow in a way that serves the customer with the overall shortest lead time, lower cost, highest quality, and most dependable delivery. It should not be sub-optimised to serve the desires of individual processes, departments, functions, or people. (Rother & Shook, 1999). VSM has a lot of benefits in many forms: it exposes sources of wastes, allows identification of non-value-added steps, reduces lead time, distances travelled and amount of inventory for a process and shows linkages and connections between information and material flow. (Burton & Boeder, 2003)

2.3. The 5S Management System

(i) Background

The techniques for 5S visual management were originally applied to production operations and have recently been extended to safety and office activities. The 5S visual management is defined as the improvement process originated by Japanese to create a workplace that support the company-wide integration of workplace organisation, visual control, visual display and visual metrics. (Burton & Boeder, 2003)

(ii) Application

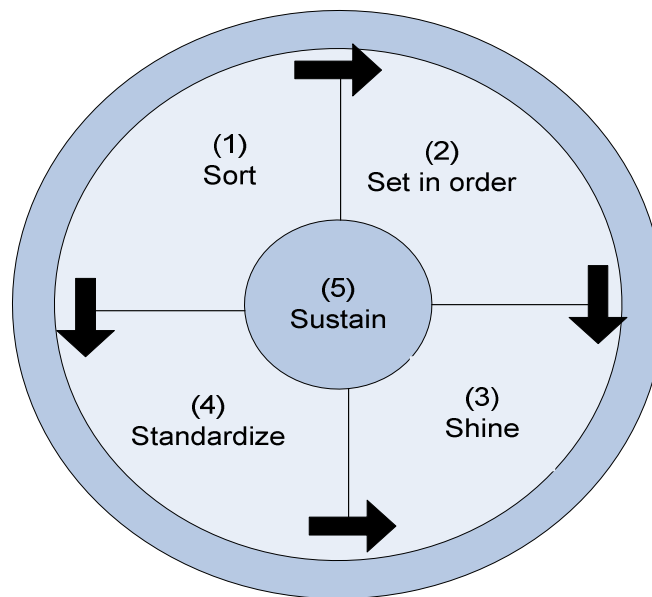
The techniques used for 5S activities are useful during implementation of various lean techniques. For example, many of the techniques for sort, set-in-order, shine and standardise are also applicable to the lean tools of quick changeover, one piece flow, kanban system and mistake-proofing.

The 5S visual management uses five activities or principles to create a workplace suited for visual control and lean practices:

1. Seiri (Sort) - keep only what is required and eliminate everything else.
2. Seiton (Set in order) - neatly arrange and identify any equipment for ease of use.
3. Seiso (Shine) - clean and inspect the workplace by eliminating contaminations.
4. Seiketsu (Standardize) – maintain compliances with the established standards.
5. Shitsuke (Sustain) – maintain the first four S's.

Figure 2 below shows the sequential procedure of 5S visual management principles.

Figure 2: Sequential Procedure of 5S visual management principles.



The 5S visual management can be used at the start of a lean induction to break down barriers and get a team to own their workspace. (Burton and Boeder, 2003)

(iii) Conclusion

This technique mainly focuses on tidiness of the workplace which is often an issue which cause wastes (unable to find the right equipment, use what is there, lose key paperwork and so on). (Melton, 2005)

2.4. Kanban System

(i) Background

Kanban is a Japanese word that means “instruction card” or “signal”. At the core of pull production, a kanban signals upstream operations to deliver what is needed, in the quality needed, and when needed. (Burton & Boeder, 2003).

(ii) Application

Kanban system uses many different approaches depending on the nature of the company. A brief discussion of some kanban approaches are given below:

1) Kanban squares

1. Using marked spaces on the floor or on a table to identify where material should be stored. When the square is empty, the supplying operations are authorized to produce; when the square is full no parts are needed.

2) Container system

1. Container is used as signal device. An empty container on the factory floor visually signals the need to fill it. The amount of inventory is adjusted by simply adding or removing container.

The kanban system consists of many types such as transportation kanban, withdrawal kanban, supplier kanban, emergency kanban, etc. It can be used not only within a manufacturing facility but also between manufacturing facilities and between manufacturers and external suppliers. (Chase et al., 2006).

(iii) Conclusion

Success of a kanban system is best achieved when the company is committed to implementing lean tools. The kanban system integrates all processes to one another and connects the value stream to customer demand.

2.5. Facilities Planning

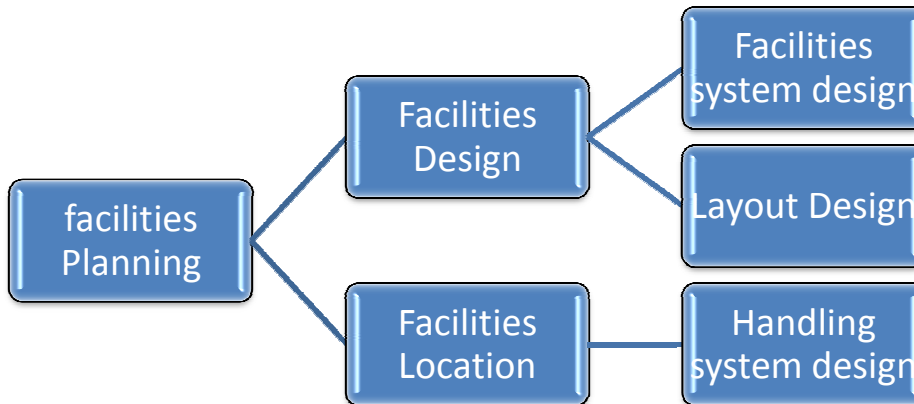
(i) Background

Over the past 10 years, facilities planning has taken a whole new meaning. In the past, facility planning was primarily considered to be a science but today it is a strategy for a competitive global marketplace. (Tompkins et al., 2010).

(ii) Application

Facilities planning is divided into two components such as facilities location and facilities design. Figure 3 below illustrates how the components of facilities are divided.

Figure 3: Components of facilities planning



The generation and evaluation of a number of layout alternatives is a critical step in the facilities planning process, since the selected layout will serve to establish the material flow and physical relationship between activities. (Tompkins et al., 2010)

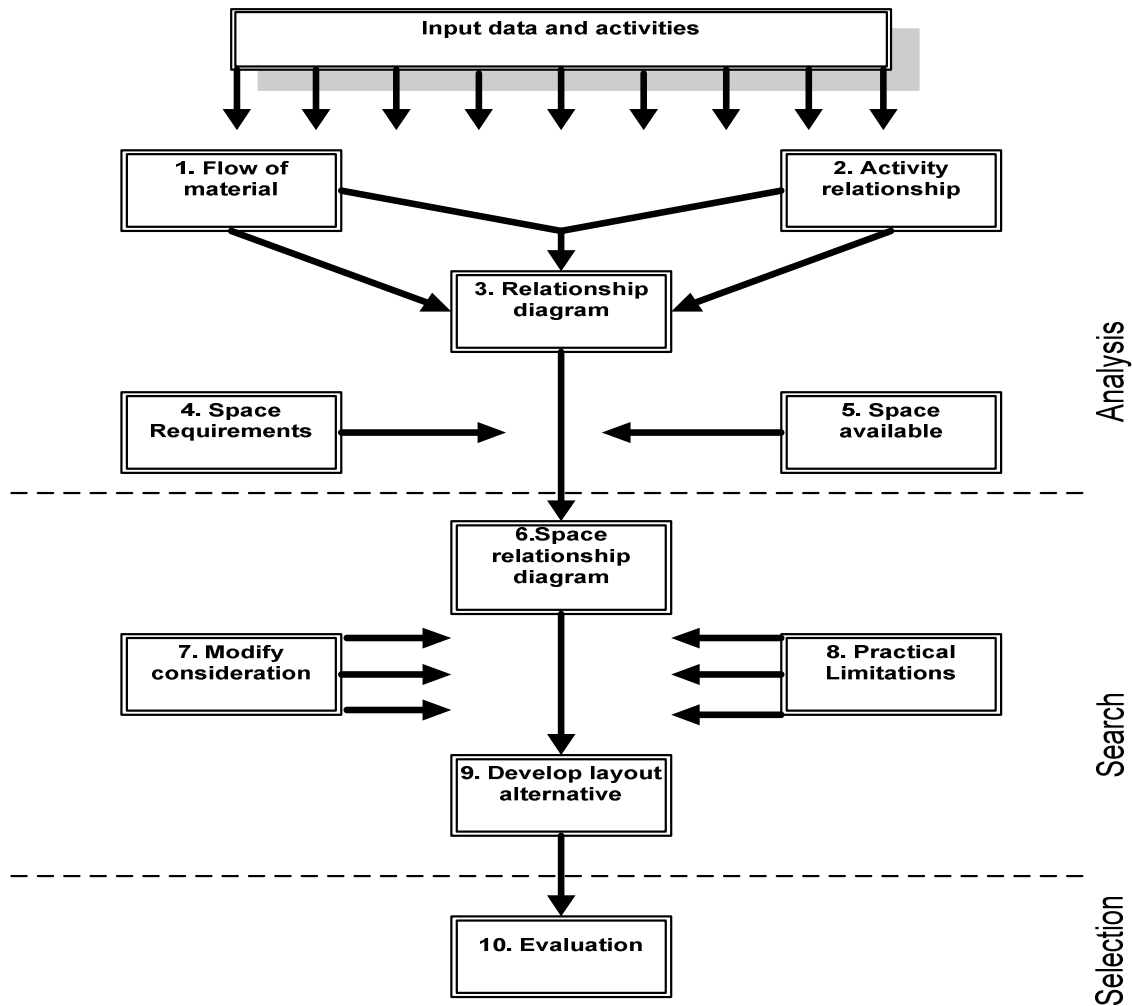
2.5.1. Muther’s Systematic Layout Planning

Muther developed a layout procedure he named Systematic Layout Planning (SLP). A framework of SLP is given in Figure 4 on the next page.

The SLP procedure uses different charts and diagrams for different functions. The relevant charts and diagrams with their functions are listed below.

1. From-To Chart: used for material flow analysis.
2. Activity Relationship Chart: used for determining the relationship between the departments and the importance of that relationship.
3. Relationship Diagram: positions activities spatially.
4. Space Relationship Diagram: similar to relationship diagram but it includes space of each department.

Figure 4: Systematic Layout Planning (SPL) procedure.



(Tompkins et al., 2010).

2.5.3. Weighted Factor Comparison

The weighted factor comparison method provides an explicit method for integrating the ranking. Numerical weights are assigned proportionally to each factor based on its degree of importance. A numerical score is then assigned to each alternative based on its performance against a particular factor. The scores are multiplied by the weights and the products are summed over all factors to obtain a total weighted score. Both ranking approach and the weighted factor comparison approach include a comparison of facilities planning alternatives for each factor. (Tompkins et al., 2010).

2.5.4. Layout Design or Planning

The key step that is most essential in developing layout is identification of right number and types of departments that are going to be used to populate the layout. For the facilities layout to be complete and effective, a thorough evaluation and development of both detailed and block layout must be done carefully. (Tompkins et al., 2010).

(iii) Conclusion

Facilities layout decisions entail determining the placement of department, work group within the department, workstations, and machines and stock-holding points within a production facility. The objective is to arrange these elements in a way that ensures a smooth workflow in a factory. (Chase et al., 2009).

2.6. Simulation

(i) Background

Since early 1970's, simulation has been increasingly employed for the solution of problems of human endeavour in business, engineering, science and social science. Simulation is a set of numerical and programming techniques (analysis methodology) for representing stochastic models and conducting experiments on those models using a computer. (Seila et al., 2003).

(ii) Application

The simulation modelling is used in different sectors as mentioned above. In manufacturing companies, more often simulation is used as a complementary tool for VSM to quantify the gains during early planning and assessment stages. (Abdulmalek et al., 2006). Several steps are required in developing a valid working simulation model:

1. Determining decision problem and objectives.
2. System analysis.
3. Analysis of input distribution and parameters.
4. Model building.
5. Design and coding of the simulation program.
6. Verification of the simulation program.
7. Analysis of output data to estimate parameters.
8. Validation of the model.
9. Experimental design
10. Statistical analysis and interpretation of data.

Simulation can also be used to handle uncertainty and create dynamic views of inventory levels, lead-times, and machine utilization for different future state maps. (Abdulmalek et al., 2006; Seila, 2003).

(iii) Conclusion

The simulation model allows the analyst to draw inferences from a new system without building them, or make changes to an existing system without disturbing them. (Abdulmalek et al., 2006).

2.7. Standard Work

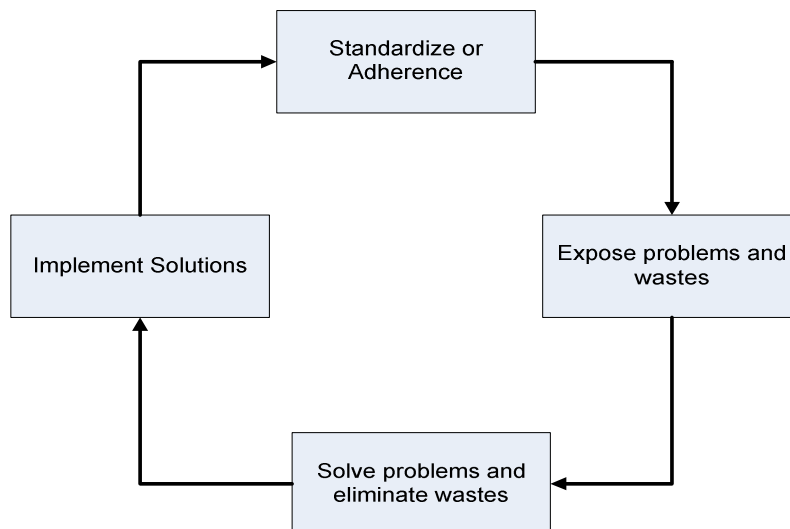
(i). Background

Standard work is defined as a set of work procedure that effectively combine people, materials, processes, technology and machines to maintain quality, efficiency, safety, and predictability. According to the lean perspective, standardized work means to focus on reducing waste within the system. (Burton & Boeder, 2003)

(ii). Application

Standard work establishes the best methods and sequence steps to optimize performance and minimize waste. It also includes the use of visual controls and uniform work instructions. The application of standard work focuses on work sequence as figure 5 below shows the sequential steps.

Figure 5: Process cycle of standard work.



The process of applying standardized work is as follows:

1. Study the process and document the specific steps to expose the problems and process wastes that have an impact on productivity.
2. Analyse the problems and identify action items to solve the problem and reduce or eliminate waste.
3. Implement identified solutions.
4. New standards can be established after implementation of solutions.

Standard work should be applied throughout the enterprise to gain consistency in administrative and manufacturing processes. (Burton & Boeder, 2003).

(iii). Conclusion

The results from standardized work are simple instructions that enforce uniform methods and a standard for operator training. Other benefits from standardized work are as follows:

1. Identifies wastes
2. Increase productivity.
3. Reduce cost associated with scrap and rework.
4. Higher process and product quality.
5. Established documentation for each process.

2.8. Implementing VSM

The VSM can be used to specify value-adding and non-value-adding activities in the value chain which is required by the second principles of lean (value chain).

Many tools of lean manufacturing complement each other. For instance, VSM sometimes requires one or two of the following techniques to be more effective:

1). Kanban System

1. Helps in authorizing production and halt if necessary to the upstream processes based on the pull by the customer.

2). Facilities Layout

1. Assist in optimising material flow which helps in reducing processing time.

There are many other tools and techniques that can be used in collaboration with VSM but these two techniques are more often used.

2.9. Selection of Appropriate Techniques or Tools

This Section deals with the selection of tools and techniques that has the ability to solve the encountered problems discussed in Chapter 3.

In Chapter 3, it is discussed how the information flow affects material flow which results in high amount of scrap generated and also other causes that increase processing and production lead time. The most suitable technique discussed in the literature review that has the ability to solve such problems is VSM. The VSM is able to create a link between information and material flow, making sure that they are both aligned correctly. Other tools that will be used to assist VSM are as follows:

1. Facilities Layout
2. 5S visual Management
3. Kanban System
4. Standard work

The VSM will be used to design current- and future- State Maps which will show production lead time and processing time. All the non-value adding activities will be identified and eliminated before the future state map is designed.

The facilities layout technique will be used for designing current and future layout that will support VSM and 5S visual management. Facilities layout assist in determining which department or workstation should be next to each other in order to minimise travelling distance and to get optimal material flow. Problem 4 in Chapter 3 resembles characteristics that facilities layout is mostly effective in solving.

The kanban system is mostly for signalling purposes which help with the information flow crisis and it used mostly in future-state mapping design. For all of these techniques to be effective, operations should be standardised. Therefore the standard work technique will be used to standardise the operations that are currently done using a trial and error method.

2.10. Conclusion

The right combination of techniques is the most essential first step in trying to solve the problem. Each tool or technique has the ability to solve certain types of problems and also has its own drawbacks, but through collaboration with other techniques an optimal solution can be achieved.

Chapter 3:

Current State Analysis

This Chapter focuses on the analysis of current operations using some of the selected techniques from Chapter 2.

3.1. Background

The Special Profiles Mill produces two main profiles namely window section and fencing posts. Window section includes the exterior window frame called LF7 and the interior part called F4B. The LF7 product is produced every month while other products are produced after one or two months. The production of all the profiles requires only billets as raw material and it supplied by Newcastle or Vereeniging Works. The billets come in different dimensions, namely 80 mm x 80mm with the length of 7 meters and 120 mm x120 mm with the length of 9 meters. All the billets are stored at the billet yard next to the reheating furnace.

There are three sub-mills that follows after the reheating furnace namely the Roughing, Centre and Finishing mill. All the sub-mills consist of hot rolling machines and few shears. All reheated billets passes through all these sub-mills. Then its goes to the cooling bed for few minutes. Afterwards the product goes to the cutting section and then to the scaling section for mass measurement and recording. At the Scaling Section 1, the products are taken by overhead crane either to the straightening machines 1 or 2 or the temporal storage section, depending on the availability of a straightening machine. The cutting and packaging process follows after the straightening process. Lastly all the packed products are scaled and transported to the shipping section.

3.2. Current Operation

All the billets are stored at the billet yard which takes a maximum of 10 000 billets. Rollers are used to transport the billets from the billet yard to the reheating furnace. The furnace has capacity for 18 billets and the discharging temperature of 1100°C with the rate of 40 tons per hour. The billets are heated during the changeover procedure which implies that the time it takes to heat billets does not affects production time because whenever production starts the billets are always ready (no delays). There are two control offices close to the furnace, the first office is for pushing billets into the furnace and the second one is for pushing them to roughing mill (out of the furnace). The operator from the first office (operator 1) has all the camera screens that shows every operation that is performed while on the other hand the operator from the second office (operator 2) does not have anything.

Hot rolling process takes place at all three sub-mills. The roughing mill has seven rolling machines called Stands (A, B and 1 to 5), two vertical and five horizontal while centre mill only consist of five horizontal stands (6 to 10). The Finishing mill consists of five stands (11 to 15), four horizontal and one vertical. Each sub-mill has its own control room called Cabins:

Cabin 1

1. Controls all the stands or machines at the Roughing Mill and all the daily stoppage reports are generated from this control room.

Cabin 2

1. All the stands in the Centre Mill are controlled by Cabin 2 and all the downtimes occurred at the Centre Mill are reported to Cabin 1.

Cabin 3

1. Controls all the stands from Finishing Mill and reports all stoppages to Cabin 1.

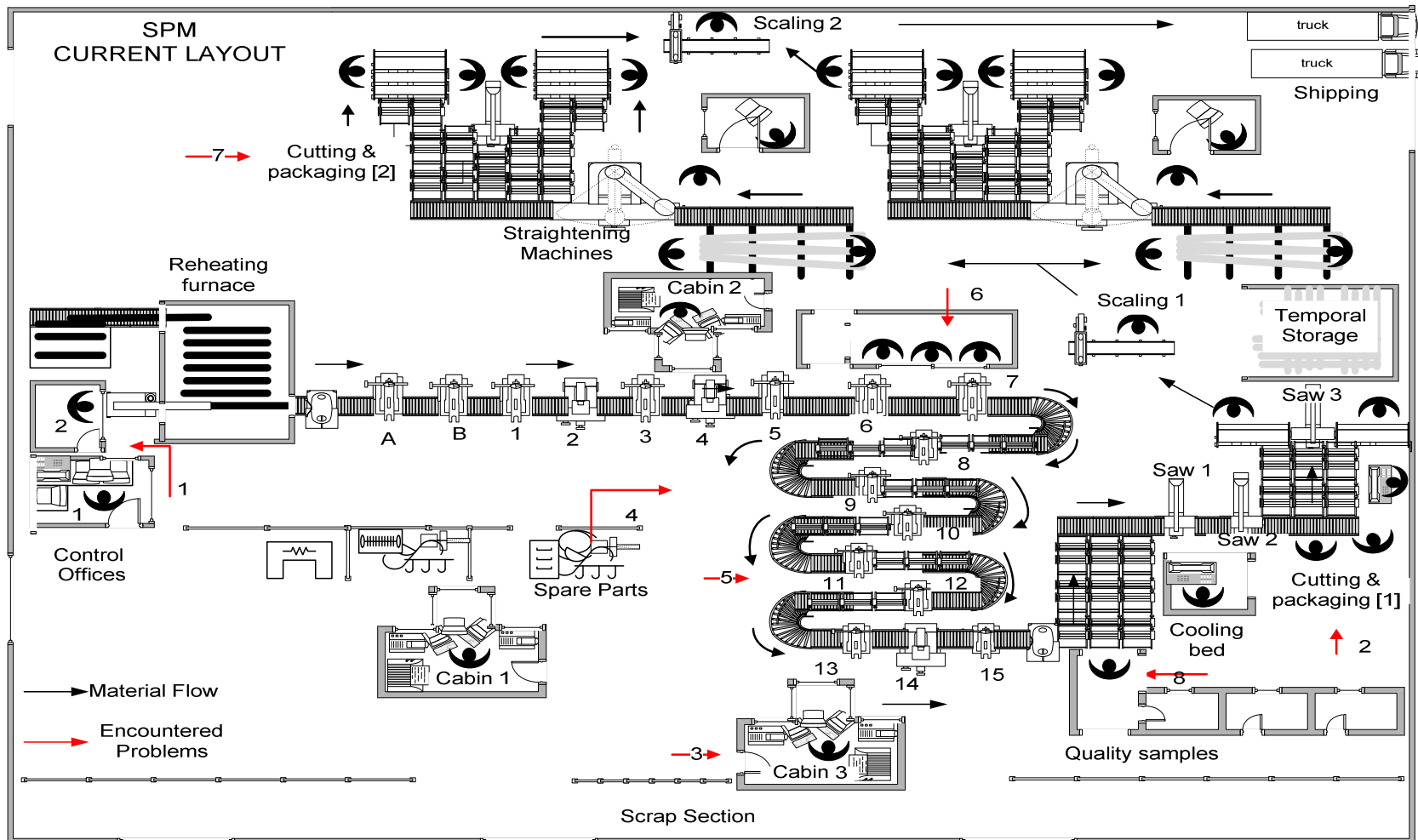
The stands from the roughing mill are arranged in series format and the one from the centre and finishing mill are arranged in loops format. Refer to Figure 6 on page 18 for the arrangement of stands and locations of the Cabins.

Any misunderstanding between operators from Cabin 2 and 3 based on speed control causes a lot of scrap (interruption in material flow). Sometimes the misunderstanding occurs between maintenance operators and cabin's operators. All the set-ups in these three sub-mills are done based on trial and error method and it takes a lot of time to get it right especially when there is no experienced operator on duty. Most of the operations in these sub-mills are not standardised which makes the training procedure for new operators ineffective. The exit speed of the product from hot rolling process is about 1.2 m/s and the product has a length of 75 meters.

The hot rolling process ends at the Finishing Mill, and then the product goes to the cooling bed for cooling and also for quality checking of the product. Then the product is transported to the cutting section using roller tables. The first saw (saw 1) cuts the head and the tail of the product and saw 2 together with saw 1 are used to cut 75 meters of product into three pieces of 24 meters long. The third saw divides the product further into two halves (12 meters each) and it is packed in batches which consist of 315 pieces. Then the overhead crane transports those two batches to the scaling section where their weights are measured, recorded and attached to each relevant batch.

The overhead crane takes those batches to either the straightening machine's Table 1 or 2 or to the temporary storage depending on whether the straightening machines tables are full or not. Each straightening machine table has a capacity of occupying two batches at a time. The batches need to be unwrapped before it can be used because the straightening machines only take one pieces at a time. Saw 4 cuts all the pieces coming out from the straightening machine into 6 meters long. Then 300 pieces are required to make a new final product batch. The overhead crane takes two finished batches at a time for scaling, and then it transports the batches to the shipping section. Figure 6 from the next page shows the current plant layout, material flow and the problems encountered.

Figure 6: SPM current plant layout.



3.2.1. Problems Encountered.

The detailed descriptions of problems discovered during plant visits are discussed below.

Problem 1:

The task for an operator from control office 2 is to push the billets out of the furnace but there is no camera screen that shows whether the billet is aligned correctly. The screen is located in control office 1 therefore an operator from office 1 has to go out and inform operator 2 if something went wrong which causes unnecessary operations and waste of time.

Problem 2

At the cutting Section it is too noisy; therefore the operators cannot communicate well which can cause one of the operators to cut wrong dimensions which results in scrap. Hand signals are not effective.

Problem 3

Between cabin 2 and 3, the problem arises concerning speed control of the machines. Sometimes the problem does not lie on machines set-ups, it is the speed that needs to be adjusted and because it trial and error situation (set-up not standardised), the cabin's operator mostly do not agree on same decision based on speed adjustment which results in high levels of scrap generated.

Problem 4

The spare parts location is far from where the parts are mostly needed which contributes to time wasting.

Problem 5

The Machine's set-up at the centre and the finishing mill are not standardized. The trial and error method is used which is mostly quicker for the experienced operator than for new operators to get it right especially when there are no experienced operators around. This causes high amounts of scrap and time delays.

Also there is no dedicated place for the tools used during machine set-up. After fixing or machine set-up the tools are just left lying around.

Problem 6

New operators are supposed to master all the operation methods by watching and working with experienced operators. It seems as a good strategy but the challenge lies in whether the experienced operator is willing to share all the information or not. This is proven when the new operator that has been trained for months fails to execute certain tasks when the expert is not around.

Problem 7

At the cutting and packaging Section [2], the operators share the cutting and clamping tool which is used for wrapping and unwrapping of the batches. The operators from this Section have to wait for the operators at the straightening table to finish which contributes to time wasting.

Problem 8

The quality operator takes the sample to one of the experienced operator at the centre mill so that the stands can be adjusted if it is not of good quality. This is done after each and every set-up. The problem in this process is that while the quality operator is taking the sample to the centre mill, the production carries on which implies that everything produced within that period will be scrapped if the test results are negative.

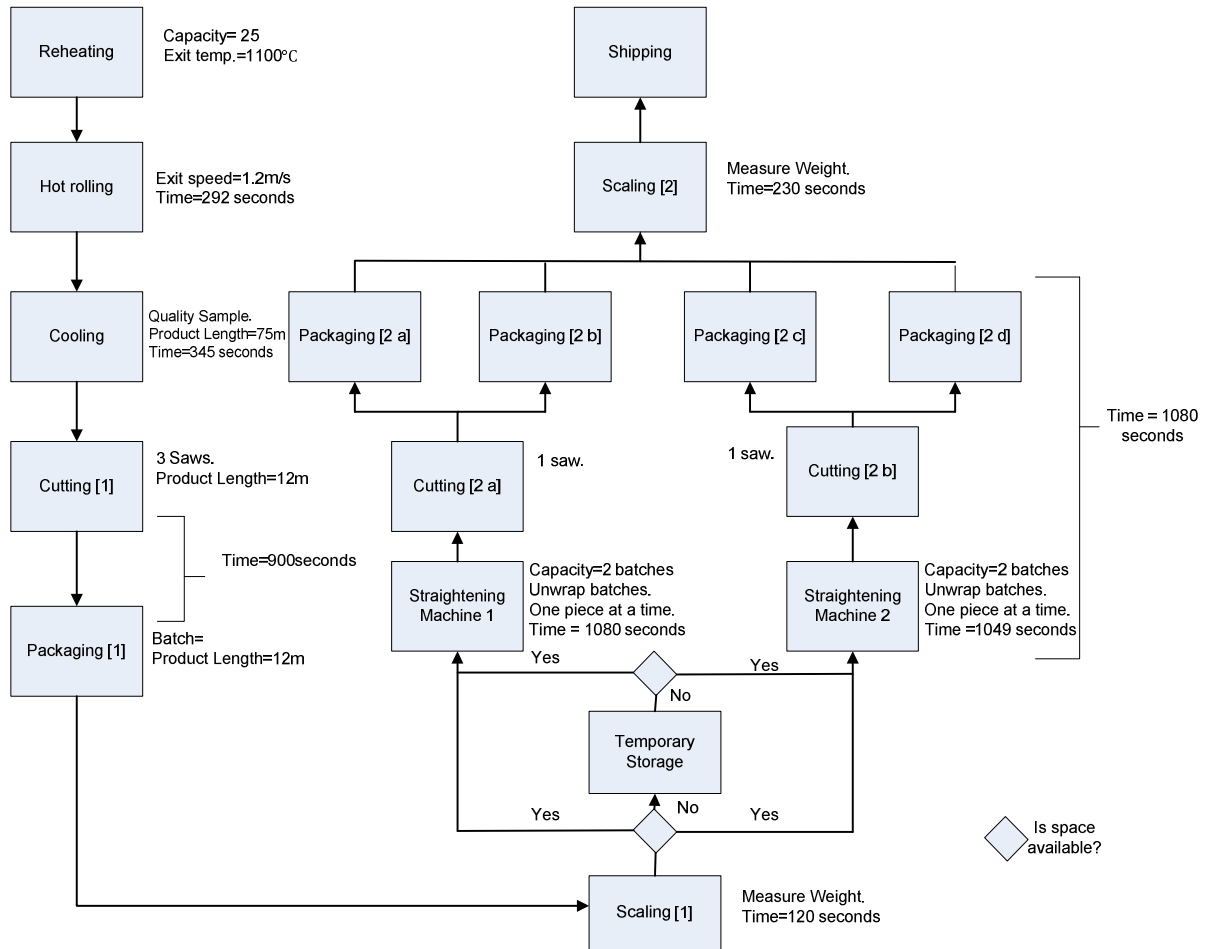
3.3. Current –State Value Stream

The VSM uses five basic steps as discussed in the literature view:

2. Identify the product or product family.
3. Create a current state map.
4. Evaluate the current state map and identify wastes.
5. Create a future state map.
6. Implement the final plan.

The product family have already been mentioned in the project scope which is LF7 (exterior part of window Section). This Section of the project deals with the creation or design of the current production situation. Figure 7 below shows the process flow chart and it includes the time each process takes. The process flow chart also shows the main activities that occur in each process.

Figure 7: Process flow chart.



The information from the process flow chart and from the production control office at SPM was used to design the current state map.

3.4. Analysis

3.4.1. Current-State Map Analysis

The SPM does not produce based on customer order. They have a monthly target of 3000 tons of LF7 per month. If the orders from the customers exceed this target, all the orders are reduced by equal percentage and the remaining amount of tonnages is scheduled for the next month. The customer must place an order a month before. Once the orders are received, the production control office makes orders for raw material which is supplied by either Vereeniging or Newcastle Works. The raw material (billets) is delivered every day (Monday to Sunday). The amount of 4264 billets of raw material is required to produce 3000 tons which takes 5 days to finish.

Each process in the current state map includes cycle time (time that elapses between one part coming off from the process to the next part coming off), machine uptime, number of operators, available working time per shift and lastly the number of shifts. EPEX stands for ‘every part every _’ for example if change over to produce another part occurs after four days then it means every part every four days.

From the hot rolling process to scaling [1], it is only ArcelorMittal workers who works in those sections and three shifts are used with no lunch. Then from the straightening to the shipping process it contractors’ workers and they only work for two shifts per day and each shift has the lunch of 30 minutes. Table 2 below shows the calculations of effective working time per shift.

Table 2 : Effective Working Time per Shift

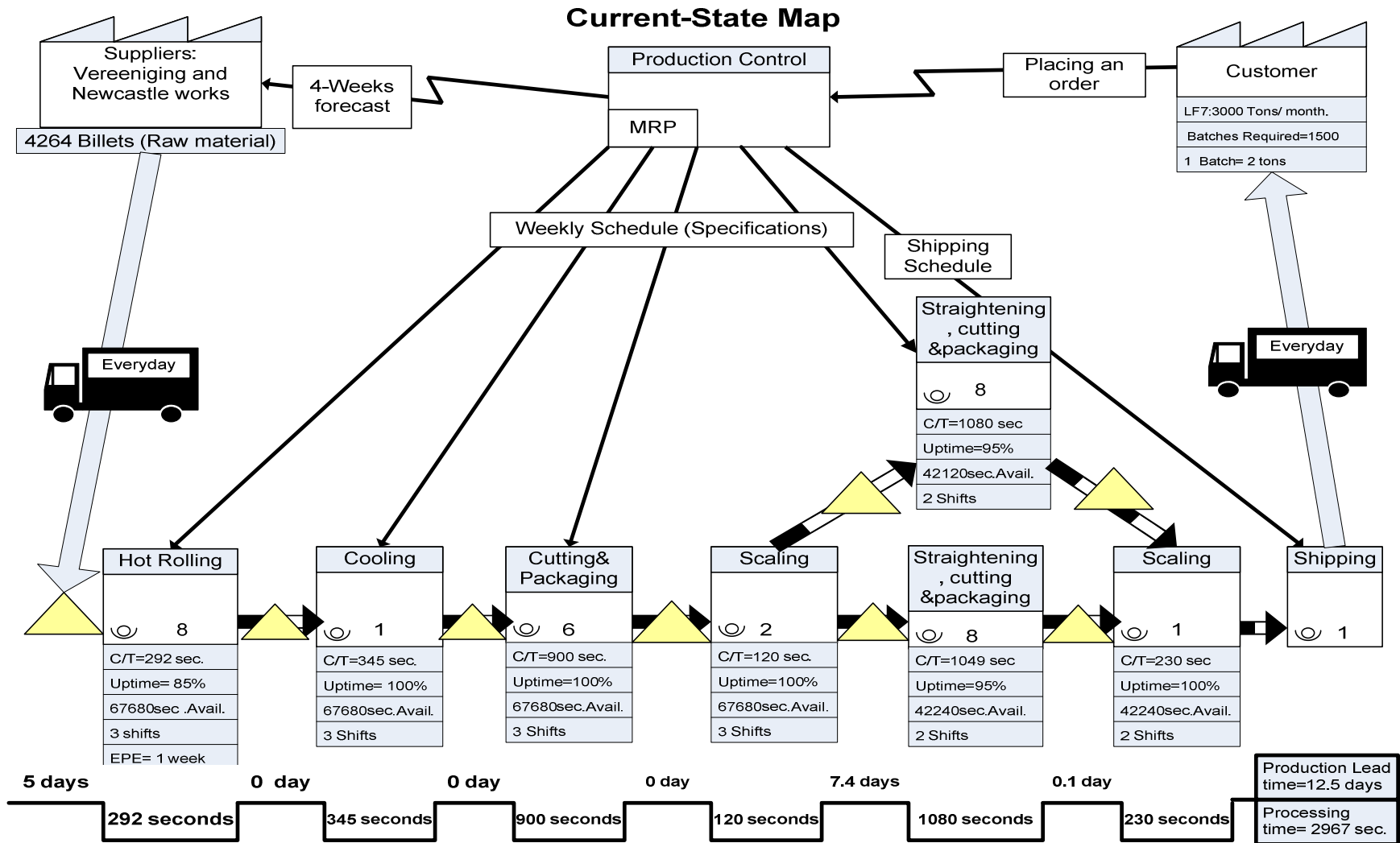
	Mittal workers	Contractors
60 min/ hr X 8 hrs	480 minutes	480 minutes
Less: Allowance [Personal fatigue]	(10 minutes)	(10 minutes)
Lunch	0	(30 minutes)
Available time per shift	470 minutes	440 minutes
Expected efficiency	X 80%	X 80%
Effective working time per shift	376 minutes	352 minutes
	=22560 seconds	= 21120 seconds

The contractors' work only for two shifts per day which is more cost effective for ArcelorMittal but it prohibits continuous flow which causes an increase in work-in-progress inventory and production lead time. The contractors' follows a pull system meaning they only start with the production based on customer orders and specifications while ArcelorMittal follows a monthly plan.

These two approaches work well together because when ArcelorMittal has finished with the production and has started with change over it takes a minimum of 12 hours depending on the next product that needs to be produced. The contractors on the other hand carry on for seven and half days more.

The production lead time to reach the target is 12.5 days and the processing is 2967 seconds. Many factors contribute to this results as mentioned in Chapter 1. Refer to Figure 8 for current state map on the next page and Appendix A for interpretation of icons used to constructs current state map.

Figure 8: Current -State Map



3.4.2. Current Layout Analysis

The current plant layout does not support good housekeeping and quick response during unplanned incidents. There is no delegated place for the tools and the spare parts are far away from where they are needed. Therefore someone has to take a wheelbarrow to fetch the required parts which takes a lot of time and also before trying to do anything, they also have to search for the tools first which wastes time.

3.5. Current State Conclusion

The two analyses above has proven the effect of wastes or problems on the processing time, production lead time and the amount of scrap generated as mentioned in Chapter 1.

Chapter 4:

Future State Analysis

This Chapter includes the development of a solution for the current problems that were discovered from the previous Chapters.

4.1. Standard Work

This section gives only the procedure that should be followed in order to standardise the operations and floor operators should be involved in developing standard operations because they know which operation procedure is faster, safe and easier to follow than anyone.

The four processing steps of standard work will be followed to standardise the hot rolling operations.

1]. Expose problems and wastes.

The problem with high amount of scrap generated is due to the trial and error method that is used for machine set-up and twister guides alignment. The misunderstanding between floor operators and Cabin 2 and 3 operators also cause interruption in material flow.

2]. Solve problems and eliminates wastes.

Most of the problems encountered at the hot rolling section, occurs because the operations are not standardised. Through standardisation, the problems that contribute to high amount of scrap generated will be eliminated. The problem with misunderstanding between the Cabins can be solved by combining the Cabins and keeping the speed of the Stands constant.

3]. Implementing solution.

The discharging temperature from the Furnace must always be 1100°C with a slight fluctuation. At the Roughing Mill the base roller speed must be 350 rotations per minute and for the top roller speed it must be 940 rotations per minute. After the production of LF7, the alignment of twister guides must be measured (measuring the angles and the distance between each twister guide.) and the measurements must be documented. Video clips must be taken for training purposes. The base speed for each stand must be 480 rotations per minute and top speed of 1200 rotations per minute. The alignment of both the rollers inside all the stands should be measured.

4] Standardise

All the measurements, safety policies, video clips and changeover manuals must be used to compile a standard work manual.

After the manual is completed, the new operators must be trained using the procedure that the manual stipulates. Other benefits that will be gained from standardised operations are as follows:

1. Reduce scrap or rework.
2. Ease of tracking the problems.
3. Effective training procedure.
4. Higher process and product quality.

Figure 9 and 10 below shows the images of Stands rollers and hot rolling process.

Figure 9: Rollers inside the Stand.



Figure 10: Movement of billet in the Hot Rolling Section.



4.2. Designing new layout alternatives

The Muther's Systematic Layout Planning (SLP) Procedure will be used to develop layout alternatives and to improve the current layout.

4.2.1. Material flow analysis

The flow of material at SPM it in series format meaning that there is one straight line flow with no other activities coming from the sides.

The From –To chart was used for determining the quantity of material flow from one department to another. The quantity of material flow at SPM is not constant. It depends on the downtime that occurs. Therefore the From-To chart is constructed for one billet flow from the Billet Yard to the Shipping Section. After the Hot Rolling Section, the billet is elongated and divided into 3.5 pieces and transported to the Cutting & Packaging Section 1 in batches of 15 pieces and is packed as a batch of 315 pieces afterwards. Those batches are transported to the Scaling Section 1, then either to the temporal storage or Straightening Section. Lastly the batches from the Cutting & Packaging Section 2 are scaled and transported to the Shipping Section. There is no material flow at the spare part and floor operator's safety zone section. Table 3 below represent the From-To Chart and Table 4 on the next page shows the sections or departments used for constructing the From-To chart.

Table 3: From - To Chart

		To												
		1	2	3	4	5	6	7	8	9	10	11	12	13
From	1		1	0	0	0	0	0	0	0	0	0	0	0
	2	0		1	0	0	0	0	0	0	0	0	0	0
	3	0	0		0	0	3.5	0	0	0	0	0	0	0
	4	0	0	0		0	0	0	0	0	0	0	0	0
	5	0	0	0	0		0	0	0	0	0	0	0	0
	6	0	0	0	0	0		15	0	0	0	0	0	0
	7	0	0	0	0	0	0		2	0	0	0	0	0
	8	0	0	0	0	0	0	0		2	2	0	0	0
	9	0	0	0	0	0	0	0	0		2	0	0	0
	10	0	0	0	0	0	0	0	0	0		315	0	0
	11	0	0	0	0	0	0	0	0	0	0		2	0
	12	0	0	0	0	0	0	0	0	0	0	0		2
	13	0	0	0	0	0	0	0	0	0	0	0	0	

Table 4: Sections for the From -To chart

Number	Section Presented
1	Billet Yard
2	Reheat Furnace
3	Hot rolling
4	Spare parts
5	Floor operators safety zone
6	Cooling bed
7	Cutting & Packaging 1
8	Scaling 1
9	Temporal Storage
10	Straightening
11	Cutting & Packaging 2
12	Scaling 2
13	Shipping

4.2.2. Activity Relationship.

The activity relationship chart was used for determining the closeness of each department or section due to material or information flow and dependence between those departments. Table 5 below illustrate the closeness rating index and Table 6 shows the reasoning behind every rating.

Table 5: Closeness Rating Index

Value	Closeness
A	Absolutely necessary
E	Especially important
I	Important
O	Ordinary Closeness okay
U	Unimportant
X	Not desired

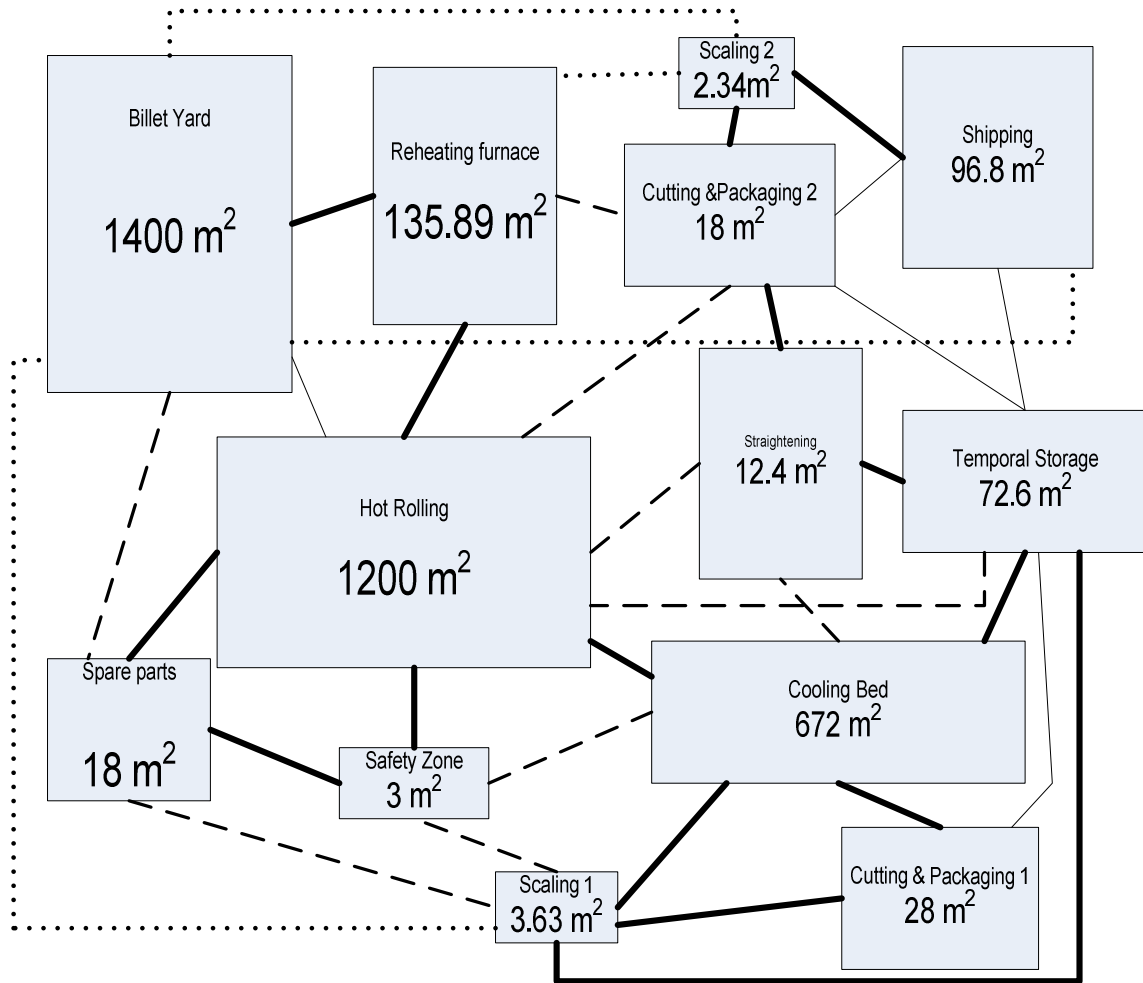
Table 6: Reason behind closeness rating

Code	Reason
1	High frequency of use
2	Medium frequency of use
3	Low frequency of use.
4	High information flow
5	Medium information flow
6	Low information flow
7	No use or flow

4.2.3. Space Requirement

The space requirement diagram was constructed to show space required by each department and workstation at SPM. The thickness of each connector line indicates the traffic volume. Figure 12 below shows the space requirement for each department.

Figure 12: Space Requirement Diagram



The alternative block layout can now be constructed because the space requirement and traffic volume of each department has been identified.

4.2.4. Alternative Block Layout

To develop the optimum layout, different alternative block layouts were constructed each with certain advantages over the other. The Activity Relation Diagram and the Space Requirement Diagram results were used to construct the alternative block layouts. Figure 13 to 15 below shows three alternative block layouts that were constructed.

Figure 13: First alternative block layout

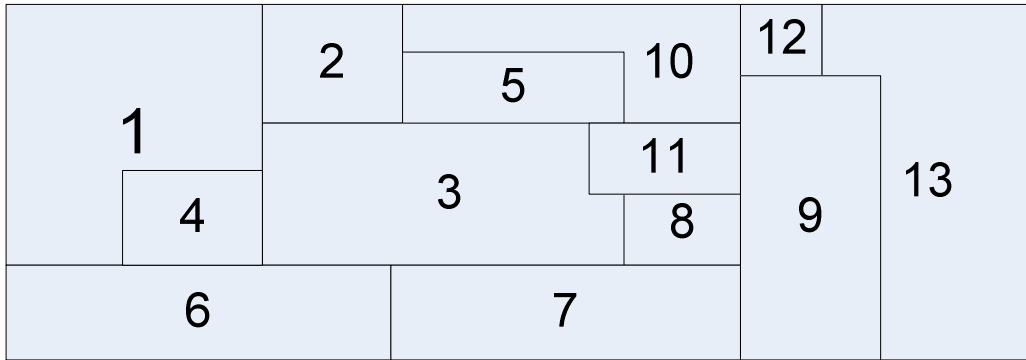


Figure 14: Second alternative block layout.

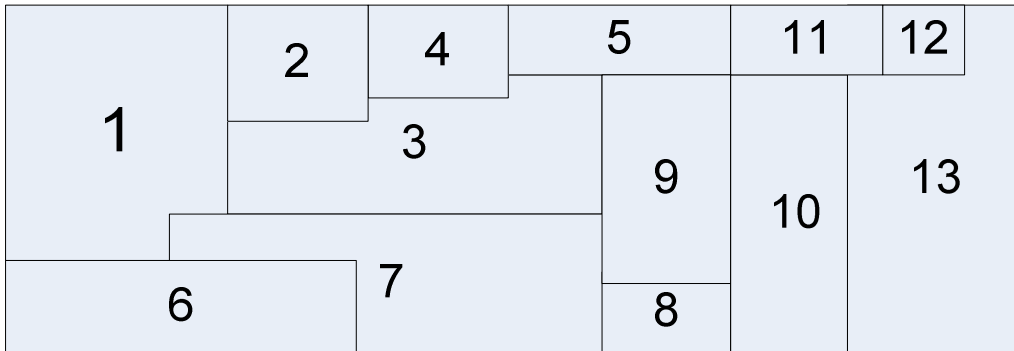
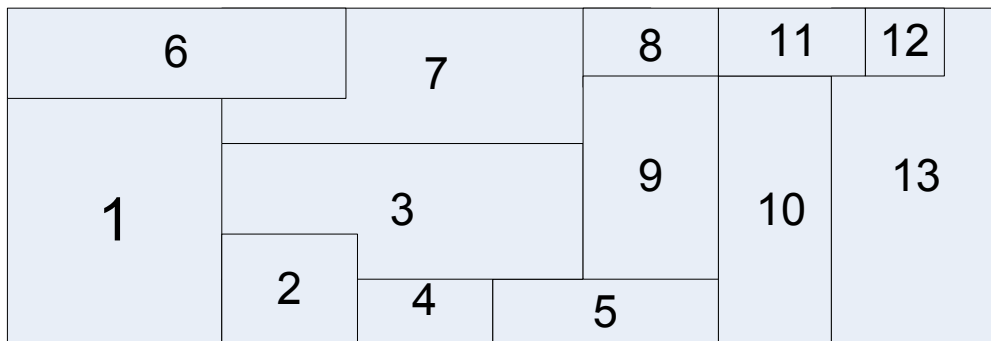


Figure 15: Third alternative block layout.



4.2.5. Evaluation of Alternative Block Layout

The weighted factor comparison was used to evaluate the alternative block layouts that were constructed from the previous page. Table 7 below lists all the factors that were used to evaluate the alternative block layouts.

Table 7: Evaluation factors

Evaluation Factors
1. Material & information flow
2. Space utilisation
3. Implementation cost
4. Layout flexibility
5. Material handling.

The factors are listed according to the importance of each factor. Material and information flow is the first important factor that needs to be addressed by the new layout. Table 8 below shows the evaluation procedure of alternative block layouts.

Table 8: Weighted factor comparison form.

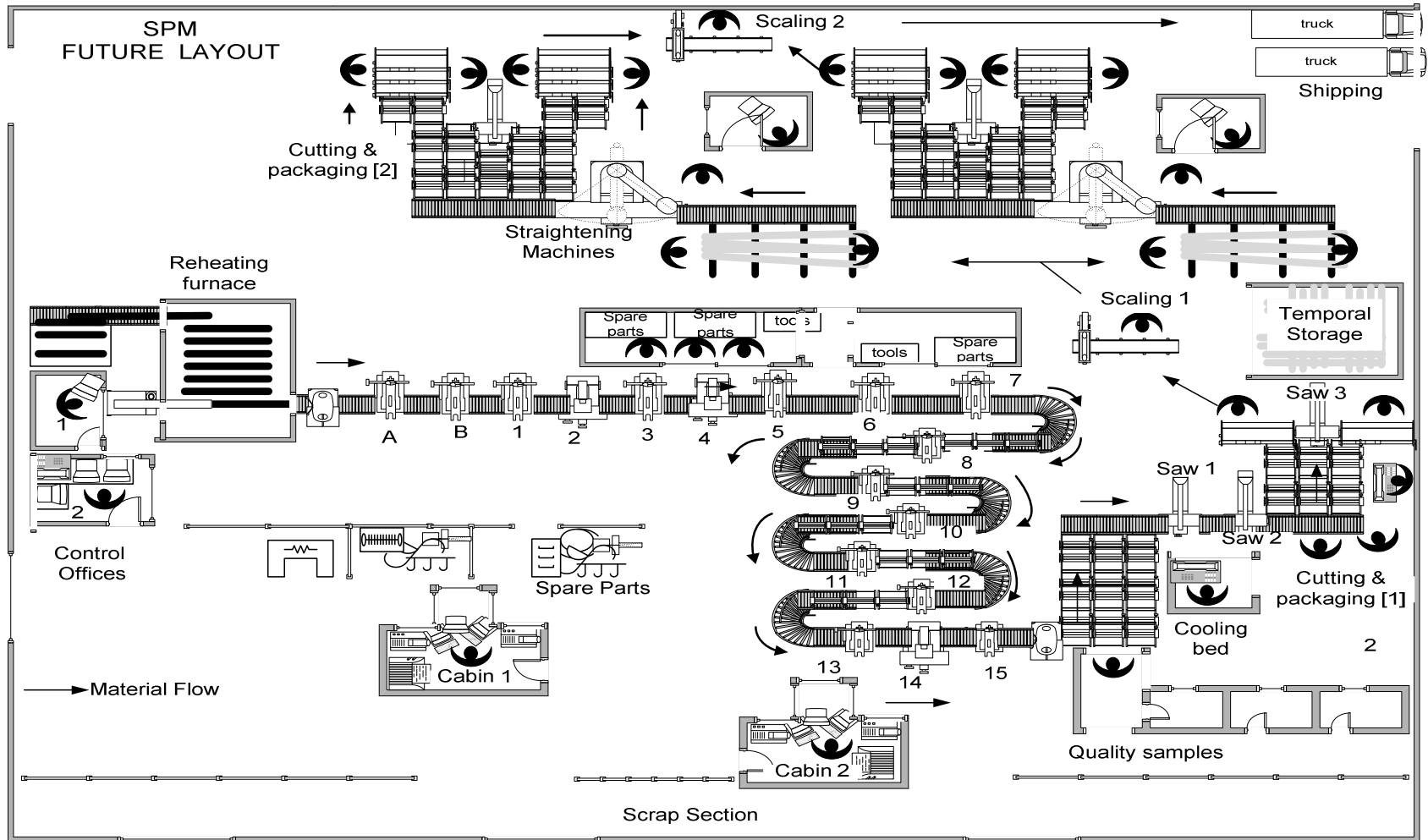
WEIGHTED FACTOR COMPARISON FORM							
Company	ArcelorMittal Pretoria Works						
Description of investment	Improve SPM layout						
Factors	Weight	first Alternative		Second Alternative		Third Alternative	
		Rate	Score	Rate	Score	Rate	Score
1. Material & information flow	30	18	540	22	660	20	600
2. Space utilisation	25	12	300	18	450	15	375
3. Implementation cost	15	8	120	13	195	2	30
4. Layout flexibility	10	5	50	5	50	6	60
5. Material handling.	20	9	180	18	360	18	360
Total	100	52	1190	76	1715	61	1425

The second alternative has the highest score which implies that it is the best alternative block layout that can be used to develop a new plant layout.

4.2.6. Proposed Final Layout

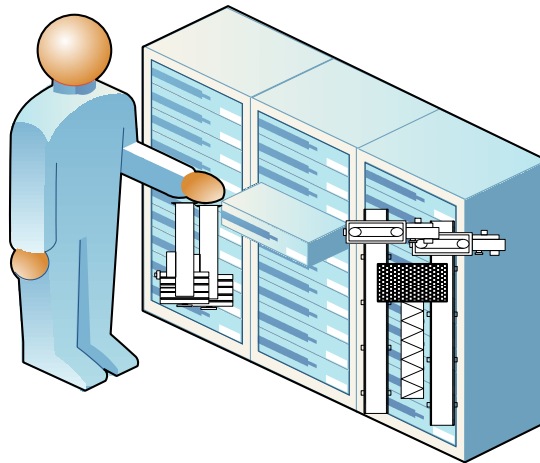
New SPM layout was designed using the second alternative block layout. Figure 16 on the next page shows the new SPM layout that assist in reducing processing time, production lead time and in good housekeeping.

Figure 16: Proposed Future Layout



From the layout on the previous page, the spare part Section has been separated into two separate sections, one remained in its current location and the other one moved to floor operator zone. The tools shelf will be used to put tools and other small spare parts like bolts. The 5S visual management principles were followed to design the tools shelf. Figure 17 shows the tools shelf.

Figure 17: Tools and spare parts shelf



Now the tools have the delegated location and spare parts are located next to the centre mill where they are mostly required. Then the problem concerning housekeeping is eliminated.

4.3. Developing Future State Value Stream

In order to develop Future State Map the Current State Map need to be analysed using the following guidelines developed by Rother and Shook:

Guideline # 1: Produce to your takt time.

“Takt time” is how you should produce one part or product, based on the rate of sales, to meet customers’ requirements. Takt time is calculated by dividing the customer demand rate per day (in units), into your available working time per day (in seconds). (Rother & Shook, 1999).

The contractor’s available time per day will be used to calculate takt time because they are the last people that add value to the product and with less working time per day.

The contractors are the bottleneck in the production operations. Therefore the straightening process can be considered as the pacemaker process because it the one that determines the production pace.

The takt time using the information from the current state map is calculated as follows:

$$\begin{aligned} \text{Takt time} &= \frac{\text{available working time per day}}{\text{customer demand rate per day}} \\ &= \frac{21120 \text{ seconds}}{75 \text{ batches}} \\ &= 281.6 \text{ seconds.} \end{aligned}$$

What this takt time means is that to meet customer demand within its available work time, the SPM need to produce LF7 every 281.6 seconds in its straightening process (pacemaker process). The takt time excludes equipment downtime, changeover or time for producing scrap. Therefore SPM can cycle straightening process faster than takt time, if it cannot eliminates downtime problems. The scarcity of the tools at straightening Section can be considered as downtime at this Section and it can be eliminated by providing sufficient tools to the operators.

Guideline # 2: Develop continuous flow wherever possible.

Continuous flow refers to producing one piece at a time, with each item passed immediately from one process step without stagnation. (Rother & Shook, 1999).

The SPM production is divided into two parts, one controlled by ArcelorMittal workers and the other one by contractors. These two teams have different working time and benefits as mentioned before and those differences prohibit continuous flow.

Guideline # 3: Use supermarkets to control production where continuous flow is not possible upstream.

The supermarket is a controlled inventory of a part that is used to schedule production at an upstream process. The supermarket is placed next to the process that operates at a very fast or slow cycle time. (Rother & Shook, 1999).

Starting from the straightening section to shipping section, the pull system is used meaning that the productions starts and stop based on customer pull or orders. The straightening

process has a very slow cycle time which causes accumulation of inventory between the Scaling Section 1 and the Straightening Section. To reduce this inventory, the supermarket can be introduced between the Scaling Section 2 and the Shipping Section. The kanban system is used together with the supermarket to signal the supplier of the supermarket of products required or to trigger production. The contractors will produce to fill up the supermarket and once the shipping section takes something from the supermarket, the signal will be sent to the straightening section to start with production to fill up the supermarket again. Instead of waiting for customer orders while the inventory accumulates at a temporal storage, the contractors after fill up the supermarket, changeover can be initiated and start to fill up the supermarket of the next product that ArcelorMittal is producing at that time. Once the supermarket of the next product is full, the contractors can change back to the first product and refill that product supermarket. This will help in stabilising inventory level at the temporal storage and satisfying different customers.

Guideline # 4: Try to send the customer schedule to only one production process.

By using supermarket pull system, the customer schedule should be placed at pacemaker process. (Rother & Shook, 1999).

At SPM, the straightening process is the pacemaker. Then the customer schedule will be placed there. The customer schedule includes the specifications and the amount of product required.

Guideline # 5: Distributes the production of different products evenly over time at the pacemaker process.

Most production departments probably find it easier to schedule long runs of one product type and avoid changeovers, but this creates serious problems for the rest of the value chain. Grouping the same products and producing them at once makes it difficult to serve a customer who wants something different from the batch being produced now. This requires more finished goods inventory with the hope that there will be something on-hand that customer wants or more lead time to fulfil an order. (Rother & Shook, 1999).

As mentioned in Guideline number 3, the product mix will be done at straightening Section in order to distribute the production of different products evenly over a time period. The more the levelling of product mix, the more the SPM will be able to respond to different customer requirements with short lead time while holding little finished-goods inventory.

Guideline # 6: Create an initial pull by releasing and withdrawing small, consistent increments of work at the pacemaker process.

Establishing a consistent production pace creates predictable production flow. A good place to start is to regularly release only a small, consistent amount of production instruction at the pacemaker and simultaneously withdraw an equal amount of finished goods. This consistent increment is called the pitch. (Rother & Shook, 1999).

Currently the SPM uses the same procedure but it does not include the kanban system and it not used to predict production flow. The SPM pitch is calculated as follows:

$$\begin{aligned}\text{Pitch} &= \text{takt time} \times \text{Pack Size} \\ &= 281.6 \text{ seconds} \times 2 \text{ batches.} \\ &= 9.4 \text{ minutes.}\end{aligned}$$

This implies that every 9.4 minutes, the material handler brings the next production kanban card to the Straightening Section and takes the batches to the Shipping Section. If the batches are not finished by that time, the SPM will know that there is production problem.

Guideline # 7: Develop the ability to make every part every day in the processes upstream of the pacemaker.

The SPM produces many products and most of the changeovers occur after one week. The main point of this guideline is to improve all the upstream processes of the pacemaker process before designing the future-state map.

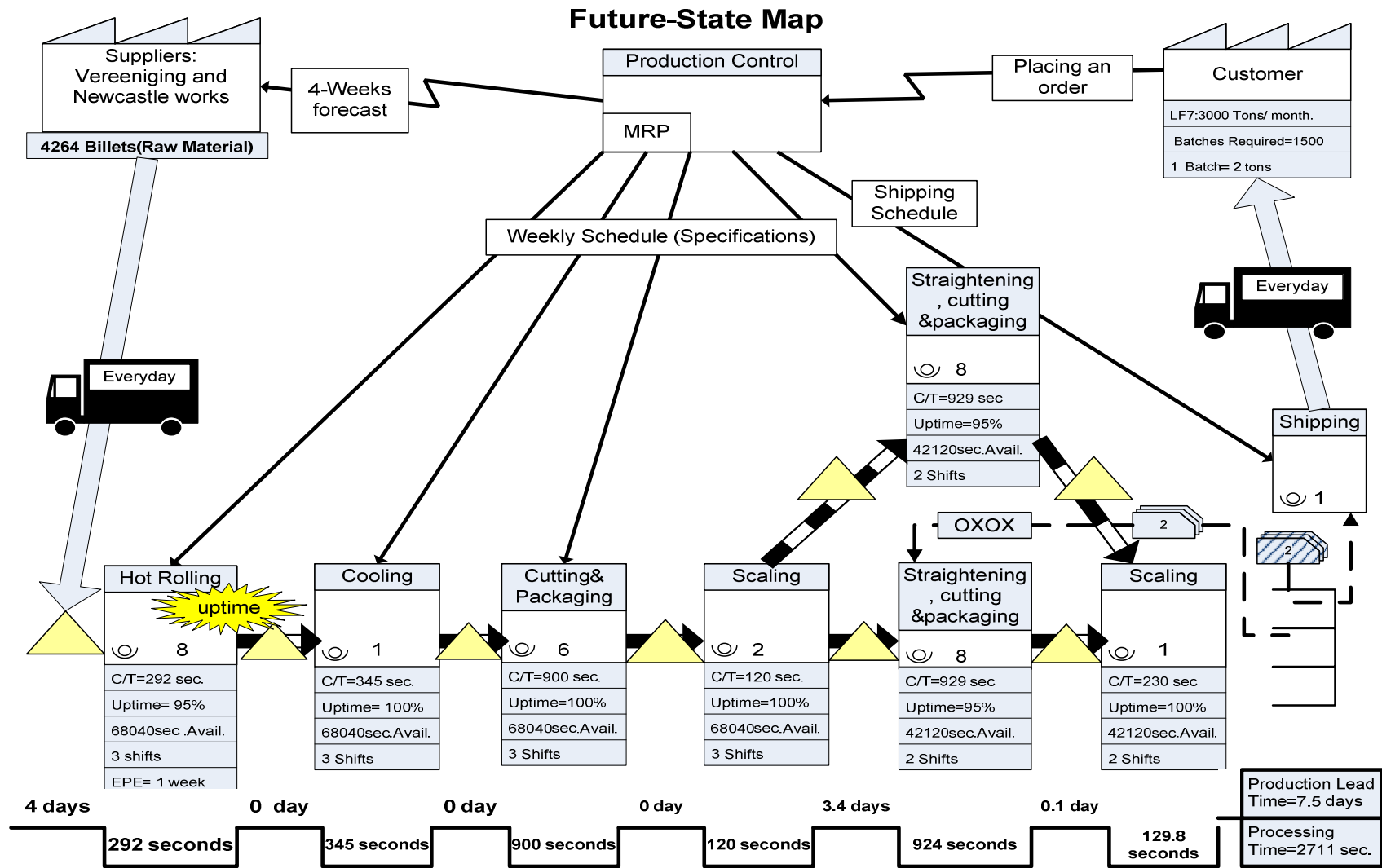
Starting with the hot rolling process, problem 1 can be solved by putting a camera screen at control office 1 that will show operations done by this office. The second problem can be solved by putting road robot but with red and green lights only at saw 1 control room. The operator from saw 3 control room will be responsible for controlling this robot for signalling the operator from control room 1 either to push material or not. For the third problem, Cabin 2 and 3 will be combined into one Cabin in order avoid misunderstanding between the two and to reduce scrap generated due that misunderstanding. The fourth problem was solved using facilities layout technique. While on the other hand, standard work technique was used to solve problem 5 and 6. The second last problem 7 can be solved by providing sufficient number of tools required at that Section. For the last problem, the quality operator should be someone that knows which machine to be adjusted if the sample has defects. Then instead of walking to the centre mill, the microphone can be used to instruct the Centre operators to adjust the machines.

Because all the wastes or problems that were identified are eliminated, a future-state map can be designed using all the information from the guidelines and the current-state map.

4.3.1. Analysis

Figure 18 on the next page shows the Future-State Map. The production lead time has decrease from 12.5 days to 7.5 days due to levelling product mix, 2 shifts (24 hours) and standardising of hot rolling operations. The processing time has been reduced from 49.45 to 45.18 minutes. Provision of sufficient tools at straightening section reduces the cycle time by 2.6 minutes. The remaining minutes (1.67) are from scaling section 2 which all add up to 4.27 minutes saved. All the expenses and savings that will be incurred from this proposal are summarised in the following Chapter.

Figure 18 : Future-State Map



Chapter 5

Proposed Solution

This Chapter summarises the proposed solution and its benefits. The cost analysis is discussed at the end of this Chapter and it includes the implementation cost, labour cost, savings or losses and comparison of different options based on production lead time and cost.

5.1. Tools and Techniques Required

The sources of wastes throughout the production process have been identified using different lean manufacturing techniques and tools. The techniques that were used in solving the problem are discussed below:

5.1.1. Standardization

It was used for standardizing machine set-up and for training purposes.

Benefits

1. Reduces the amount of scrap generated.
2. An ease in tracking down the problems.
3. Helps in developing the effective training procedure.

5.1.2. Plant Layout

It was used to determine the required closeness of different sections for effective material flow and good housekeeping purposes.

Benefits

1. Faster material flow within the mill.
2. Shorter travelling distances of material or operators.
3. Increase in production rate.

5.1.3. 5S Visual Management

It was used for good housekeeping and elimination of wastes.

Benefits

1. Easy to see if there are tools missing.
2. Good housekeeping.
3. Reduce time wasted looking for tools.

5.1.4. Levelling the Product Mix.

The supermarket (defined in Chapter 4, Guideline # 3) was used to make the product levelling mix more effective. The production of LF7 product is mixed with other product production that requires less changeover time. The changeover will be done once the supermarket is full. The capacity of the supermarket should be 50% of the monthly target (1500 batches) in order to avoid long production runs of one product type.

Benefits

1. Different customer satisfaction.
2. Less production lead time.
3. Holding less finished – goods inventory.

5.1.5. Kanban system

The signalling system at the Cutting and Packaging Section 1 is required for communication or information flow to avoid any misunderstanding between the operators. The supermarket and the production pacemaker process (Straightening process) also require the kanban system for controlling production.

Benefits

1. Good information flow.
2. Controlling production to avoid overproduction.

5.2. Cost Analysis

The LF7 product is produced every month and all the calculations are based on production of this product only.

5.2.1. Implementation Cost

Table 9 below shows the cost of the things that will be required to implement the proposed solution.

Table 9: Implementation Cost

Requirements	Cost (Rands)
Material	R 23 140
Labour for construction of tools shelves.	R 18 000
Labour for construction of spare part shelter.	R 87 456
Developing operations standards.	R 1500
Development of Kanban system.	R 5200
Total Implementation Cost	R 135 296

5.2.2. Labour Cost

The Labour Cost includes labour rate, number of employees and the Working Time. The following equations show how the Labour Cost and Working Time are calculated.

Working Time = Working Hours per day X Production lead time (days)

Labour Cost = Labour Rate X Working Time X number of employees.

The production lead time is used to check how much money the company will save if it only produces LF7 products.

5.2.3. Current and Future State Comparison.

The production at SPM is divided into two sections as mentioned before. ArcelorMittal workers production section starts from the Furnace to the scaling section 1, with 3 shifts per day. The contractor's production portion starts from the Straightening to the Shipping Section with 2 shifts per day. The difference between the shifts causes a lot of idle time at the contractor's production portion. There are two straightening machines and when the batches come from the scaling section 1, it has to go to one of them while the other straightening machine idles for 20 minutes up until the next batches arrives. This occurs only for the first day of production.

Day 1's processing time differs from the processing time of the second day onwards because on the first day the contractors have to wait for the batches from the ArcelorMittal production portion. On the second day, the batches are stored at the temporary storage which was produced during the third shift. Table 10 below and Table 11 on the next page shows the effect on production lead time and labour cost by changing the working hours for the contractor's production portion

5.2.3.1. Current State

The labour rate for contractor per hour is equals to R 18.6/hr and there are 16 employees. Other relevant information required for labour cost calculation is listed in Table 10 below.

Table 10: Shifts Comparison for Current State

Current State		
Critical Factors	2 Shifts(16 hrs)	2 Shifts(24 hrs)
Processing Time (minutes)	22	22
Effective Working Time (hrs).	11.7	11.7
Batches : First Day	76	114
Second Day onwards	120	188
Production Lead Time (days)	12.5	8.2
Labour Cost (Rands)	29 760	29 283.84

The labour cost for current state is calculated as follows:

Working Time (16 Hrs Shifts) = Working Hours per day X Production Lead Time (days)

$$= 8 \times 12.5$$

$$= 100 \text{ hours}$$

Labour Cost (16 Hrs shifts) = Labour Rate X Working Time X number of employees.

$$= R 18.6 \times 100 \times 16$$

$$= R 29 760$$

Working Time (24 Hrs Shifts) = Working Hours per day X Production Lead Time (days)

$$= 12 \times 8.2$$

$$= 98.4 \text{ hours}$$

Labour Cost (24 Hrs shifts) = Labour Rate X Working Time X number of employees.

$$= 18.6 \times 98.4 \times 16$$

$$= \text{R } 29\,283.84$$

Savings per annum = (R29 760- R29 283.84) X12

$$= \text{R } 6000$$

This implies that the company can increase the number of hours per day to be 12 hours per shift and still save something. That saved amount is the amount saved from the production of LF7 product only.

5.2.3.2. Future State

Table 11 below shows comparison of shifts for the future state and other relevant information for labour cost calculations.

Table 11: Shifts Comparison for Future State

Future State		
Critical Factors	2 Shifts(16 hrs)	2 Shifts(24 hrs)
Processing Time (minutes)	19.5	19.5
Effective Working Time (hrs).	17.6	17.6
Batches : First Day	80	120
Second Day onwards	140	211
Production Lead Time (days)	11.1	7.5
Labour Cost (Rands)	26 426.88	26 784

Working Time (16 Hrs Shifts) = Working Hours per day X Production Lead Time (days)

$$= 8 \times 11.1$$

$$= 88.8 \text{ hours}$$

Labour Cost (16 Hrs shifts) = Labour Rate X Working Time X number of employees.

$$= R 18.6 X 88.8 X 16$$

$$= R 26 426.88$$

Working Time (24 Hrs Shifts) = Working Hours per day X Production Lead Time (days)

$$= 12 X 7.5$$

$$= 90 \text{ hours}$$

Labour Cost (24 Hrs shifts) = Labour Rate X Working Time X number of employees.

$$= 18.6 X 90 X 16$$

$$= R 26 784$$

Savings per annum = (R26 784- R26 426.88) X12

$$= R 4285.44$$

5.2.4. Nett Savings

Savings per annum = Current State Labour Cost (16 Hrs Shifts) – Future State Labour Cost (24 Hrs Shifts).

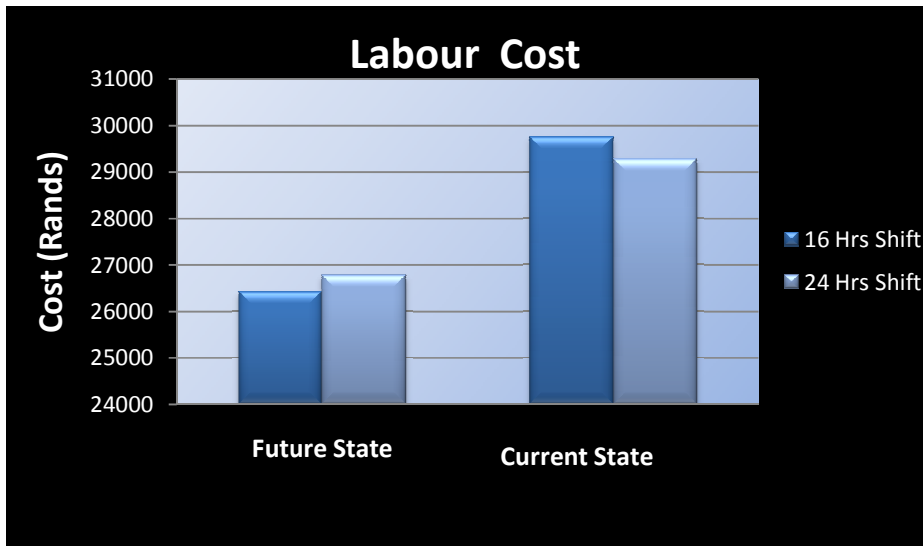
$$= (R 29 760 – R 26 784) X 12$$

$$= R 35 712$$

This implies that ArcelorMittal can save money and time. The excess time can be used either to increase the monthly target to get more customers or producing more other products.

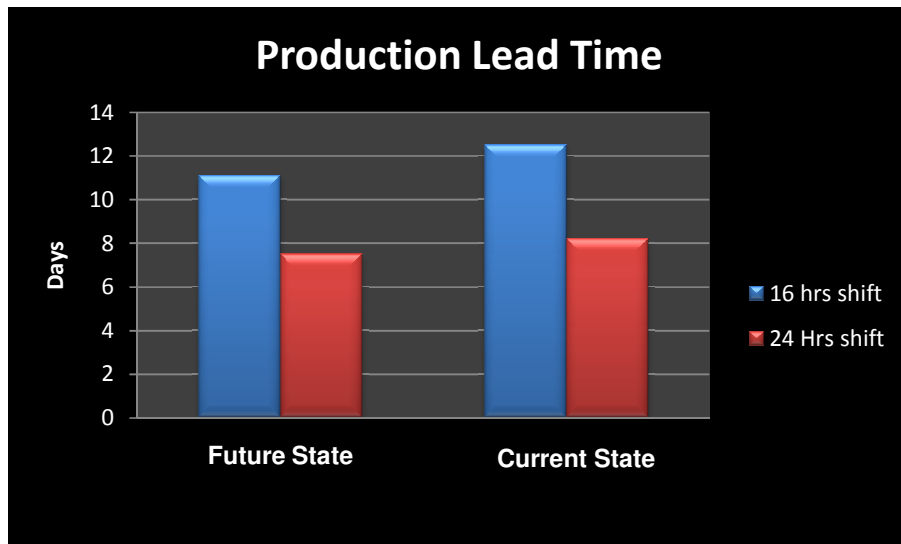
Figure 19 below shows the comparison between Future and Current State Labour Costs.

Figure 19: Labour Cost Comparison.



The processing and the production lead time decreases slightly when 2 shifts of 16 hours are used compared to 2 shifts of 24 hours (12 hours for each shift). The proposed solution is to use 2 shifts of 12 hours per shift. Refer to Figure 20 below for the comparison of both the Current and the Future States production lead time.

Figure 20: Production Lead Time Comparison for both States.



Chapter 6

6.1. Conclusion

The aim of this project was to investigate and implement lean manufacturing techniques at ArcelorMittal with the objectives of reducing the amount of scrap generated, production lead time and to improve productivity.

The sources of wastes that causes an increase in the amount of scrap generated and production lead time were identified and eliminated using different lean tools and techniques.

The results that were obtained through application of lean manufacturing tools and techniques are summarised as follows:

1. Standardized production operations.
2. Production operations standards for training purposes.
3. New plant layout that supports good housekeeping and effective material flow.
4. Future state map that shows how the information and material flow should be linked.
5. Less production lead time.
6. Levelling of product mix.

The reduction in the amount of scrap generated and production lead time cause an increase in productivity. This concludes that through application of lean manufacturing techniques, ArcelorMittal will achieve same output with less input such as less production lead time, less operating cost and less human effort.

6.2. Recommendations

It is recommended that all the improvements proposed in the previous Chapters must be done in the sequential order as stated below:

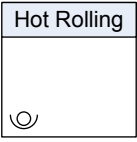
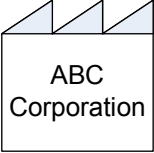
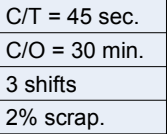



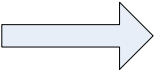
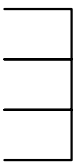
- 1] Standardize Operations
- 2] Train all employees using new standard manual
- 3] Improve plant layout
- 4] Construct tools shelves
- 5] Building supermarkets
- 6] Implementing Kanban System
- 7] Implementing product levelling mix
- 8] Increasing working hours for the contractors.



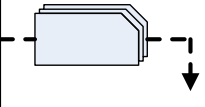


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Appendices

Appendix A: Value Stream Mapping Icons

Material Icons	Represents	Notes
	Manufacturing Process	<ul style="list-style-type: none"> Process box indicates one area of material flow, ideally a continuous flow. The process box stops wherever processes are disconnected and material flow stops
	Outside Sources	Used to show customers, suppliers and outside manufacturing processes.
	Data Box	Used to record information concerning a manufacturing process, department, customer, etc.
	Inventory	Capture the location and the amount of inventory that accumulates between two processes.
	Truck Shipment	Note frequency of shipment.
	Movement of production material by PUSH	Material that is produced and moved forward before the next process needs it.
	Movement of finished goods to the customer	
	Supermarket	A controlled inventory of parts that is used to schedule production at an upstream process.

Information Icons	Represents	Notes
	Manual Information flow	For example: production schedule and shipping schedule.
	Electronic information flow	Electronic data interchange.
	Production Kanban arriving in batches. (dotted lines indicates Kanban path)	Card or device that tells a process how many of what can be produced and gives permission to do so.
	Withdrawal Kanban	Card or Device that instructs the material handler to get and transfer parts.
	Load leveling	Tool to intercept batches of Kanban and level the volume and mix of them over a period of time.