Developing efficient production lines within powder coating plant at Wispeco

By

TUMELO GIFT LESISA
27322816

Submitted in partial fulfilment of the requirements for the degree

Of

BACHELORS OF INDUSTRIAL ENGINEERING

In the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITY OF PRETORIA

October 2011

Acknowledgements

I acknowledge each and everyone who was involved in this project both from the university and from the company (Wispeco). I thank the following people for making this project possible and successful:

- Mrs Jozine Botha (University Mentor).
- Miss Lindie Pinaar (Wispeco Mentor).
- Mr France (Production Manager at Wispeco).
- My friends who contributed for their inputs.

Executive Summary

Wispeco aluminium (Powder Coating)coats the extruded metal from the extrusion profile for various customers. It has external customers and internal customers that request powder coated aluminium extrusions. The company has realised that there is a need for them to improve the efficiency of their production lines.

This project aims to identify the area(s) that needs to be improved in the lines to increase the capacity of the company, and to respond well on an increasing demand. This project includes detailed research on engineering techniques that will assist in developing a solution towards achieving efficient production lines. A detailed study on the production lines is done to identify the constraint that inhibits the organisation to achieve its goal.

A cost effective management system (Theory of constraints) is introduced to overcome the inconsistency caused by an unexpected increase in demand placed on the lines. The project will strive to provide the following benefits:

- An efficient production line.
- Increased capacity towards meeting production target.
- Controlled bottlenecks.
- Increased throughput by 6.8%.

.

Table of Contents

WISPECO Aluminium

List of Figures

List of Tables

WISPECO Aluminium

Glossary

Bottleneck – Is defined as any resource whose capacity is less than the demand placed on it.

Buffer – It refers to the storage area between the upstream and the bottleneck as means of communication.

Capacity – Is defined as the available time for production, this excludes maintenance and downtime.

Capacity constrained resource – Is a resource whose utilisation is close to capacity and could be a bottleneck if not scheduled carefully.

Cycle time–Is the elapsed time between starting and completing a job.

Jigging – A process of loading a material into a power free conveyor.

Pre-treatment – A chemical process to clean a material before it can be coated.

Pull system – Production need is created by actual demand for the product.

Starve – To wait for material to be processed by other activities before it can get to the next station.

Skip – Is the container used to put material inside to allow transportation of material from one point to another.

Throughput – Is defined as the money produced by the system.

Queuing Time – The time that a part waits for a resource while the resource is busy with something else.

Chapter 1- Introduction and Background

1.1 Company Background

Wispeco is one of the leading aluminium extrusion company in South Africa. Wispeco is situated in Johannesburg in Alberton Alrode. The company manufactures most products that are extruded from aluminium, such as curtain tracks, shower cubicles, window frames, door frames and blinds. Wispeco was involved in the Gautrain project; it supplied door and window extrusion to Gautrain coach units. The company supplies extrusions to various industries in the aluminium market. Wispeco also extrudes specialised engineering profiles and conveyor system sections. Wispeco has four main operating divisions; Aluminium Extrusion, Die manufacturing, Finishing (Powder Coating) and Aluminium systems.

The aluminium extrusion department is the internal customer for the powder coating. The extrusion profile is the major customer of the powder coating department. The Powder coating plant receives orders from the extrusion department for powder coating annually. Powder coating came to existence when there was a need for extrusions to be coated.

1.2 Problem Description

The company uses powder coating technique to finish the extruded aluminium products. The plant has a variety of colours available for the coating in the production line, such as; white, bronze, charcoal, black and wood look. Each colour is coated in a different production line to prevent contaminating one another.

There are five lines in the powder coating plant, and four of them are automated and the other one is manual. There is a difficulty in meeting the capacity allocated on the lines. The lines are sometimes idle due to starvation, this is seen by managers as an inefficient production lines. This project will attempt to identify constraints that are hidden within the production lines.

1.3 Project Aim

The aim of this project is to identify areas that are causing the organisation not to meet their production target on the lines, and to apply industrial engineering techniques in attempting to improve those areas.

The objectives towards the aim are:

1) To eliminate bottlenecks.
2) To provide better capacity utilisation of the plant.
3) To provide efficient production plant.

1.4Project Scope

The focus of this project will be on the Finishing department (powder coating). This entails studying and analysing the current situation in the production line. The main focus will be on identifying areas that needs to be improved in all powder coating lines. The project concentrates on processes or activities that are directly involved in the production. The study is conducted from the point when raw material is prepared until the final product is completed. The application of industrial engineering techniques may be useful to reduce bottlenecks as a result the production efficiency may be improved. A detailed literature review is developed to determine the methodologies that are suitable to manage constraints and to improve production efficiency.

.

Chapter 2- Literature Review

2.1 Overview

The study offered an opportunity to obtain information on the application of industrial engineering tools from published materials. The study assisted in finding techniques that are commonly used by industrial engineers to solve the current problem. A detail literature study helped to distinguish techniques that are used by other authors to improve production efficiency. hence the primary objective of the project is to minimise bottlenecks within the production lines which in return will maximise productivity. Table 1 list the possible techniques that were identified and their respective application guidelines.

Table 1: Techniques and their application guidelines

Techniques	Application Guidelines
Constraint Management	Identifying bottlenecks and eliminating them
Lean Manufacturing.	Removing Waste
Value Stream Map.	Non-value Adding activities are analysed and improved
Work Study and Work Design	Time study Standards and Methods.

2.2 Constraint Management

2.2.1 Introduction to Constraint Management

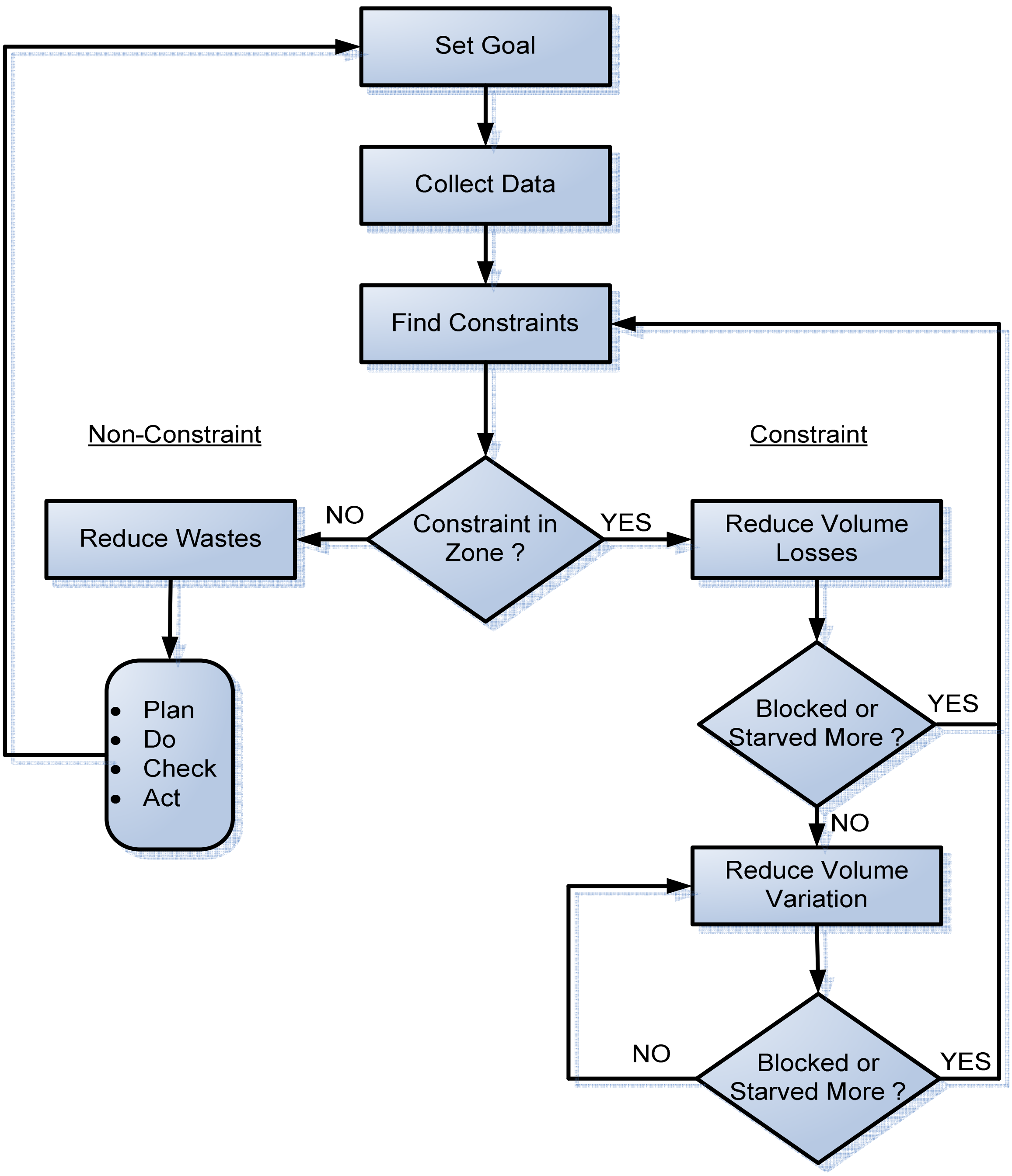
Constraint management is a process of continuous improvement at the system level. It improves overall productivity by focusing efforts on improving operations at the bottleneck resources [1]. Productivity traditionally is measured in terms of output per labour hour. A better definition would be; productivity is all the actions that bring a company closer to its goals [8]. The goal of constrain management is to increase productivity by eliminating bottlenecks. Bottlenecks cannot be eliminated completely, but can be managed [1]. According to(Goldratt & Cox, 1992)bottleneck reduces productivity and creates blockage and starvation in the production system. The blockage or excess inventory occurs at the resources prior to the bottleneck, and starvation occurs at operations after the bottleneck.

2.2.2 Importance of Constraint Management

The constraint management uses theory of constraint to identify bottlenecks. The theory of constraints (TOC) approach is more focused on its application. It concentrates its improvement efforts only on the operation that is constraining a critical process or on the weakest component that is limiting the performance of the system as a whole. If these elements are effectively managed, then it follows that better overall performance of the system relative to its goal is more likely to be achieved [8]. According to(Berro & Taj, 2006) constraints management views organisation as a chain of dependent activities/functions and includes items shown in Figure 1. The first step is to set the goal, setting a goal involves the six steps below:

(1) Define the system.
(2) Identify the system’s constraints.
(3) Decide how to exploit the system’s constraint.
(4) Subordinate everything else to the decisions made in Step 3.
(5) Elevate the system’s constraint.
(6) If a constraint is broken in Step 5, go back to Step 2.

Figure 1: Constraint management flow chart



2.2.3 Application of Constraint Management (TOC)

Constraint management is used in manufacturing industries as a tool to improve the performance of the organisations. The Theory of Constraint (TOC) since developed by Dr Eli Goldratt has been the tool used by manufacturing industries to deliver what is commonly known as constraint management [6]. The theory of constraint has gradually established itself as a major to the success of many organisations. According to (Rahman, 1998) many companies has implemented the theory of constraint and earned success with their application.

2.2.4 TOC and Performance Measurements

In any organisation there has to be performance measurements to understand whether they are meeting the company's goal or not. To adequately measure a firm's performance, two sets of measurements must be used: one from the financial point of view and the other from the operations point of view [8]. These two perspectives of performance measurements are discussed in depth.

<u>Financial Measurement</u>

According to Goldratt in his book *The Goal* he mentions that every organisation should have a goal. He has a very straightforward definition of the idea of the goal of an organisation. *The goal of an organisation is to make money.* There are three measures of the organisation's ability to make money:

(1) Net Profit – an absolute measurement in Rands.
(2) Return on Investment – a relative measure based on investment.
(3) Cash flow – a survival measurement.

All these three measurements must be used together. If they are used in separation then they are meaningless [8].

<u>Operational Measurement</u>

Financial measurement work very well at a higher level, but it cannot be used at the operational level. Another set of measurements developed by Goldratt are:

(1) Throughput – the rate at which money is generated by the system through sales.
(2) Inventory – all the money the system invested in purchasing things it intends to sell.
(3) Operating expenses – all the money spent to turn inventory into throughput.

2.3 Lean Manufacturing

2.3.1 Introduction to Lean

Lean manufacturing sometimes called lean thinking is a tool used mostly by the Toyota production system. Lean focuses on the removal of waste, which is defined as anything not necessary to produce the product or service [13]. Lean thinking also provides a way to make work more satisfying by providing immediate feedback on efforts to convert waste into value [9]. Lean thinking is lean because it provides a way to do more with less human effort, less equipment, less time, and less space while coming closer to providing customers with exactly what they want [9]. One common measure is touch time i.e. the amount of time the product is actually being worked on by the operator. Frequently lean focus is manifested in an emphasis on flow [13]. There are five essential steps in lean:

1) Identify which features create value.
2) Identify the sequence of activities called the value stream.
3) Make the activities flow.
4) Let the customer pull product or service through the process.
5) Perfect the process.

2.3.2 Principles of Lean

The critical starting point for lean thinking is value. Value can only be defined by the ultimate customer [9]. Value is only meaningful when is expressed in terms of how the product meets the customer's needs, at a specific price, at a specific time [13]. Once value is determined, activities that contribute value are identified. The entire sequence of activities is called the value stream [13]. This value stream is then analysed using the value stream maps. The next step is to improve flow, where flow is defined as an uninterrupted movement of product or services through the system to the customer. Then allow customer to pull product or services through the process [13]. After all four steps are performed, it dawns on those involved that there is no end to the process of reducing effort, time, space, cost. Suddenly perfection is the final principle of lean thinking. According to the book, Lean *thinking* they explained that lean manufacturing is much more than a technique; it is a way of thinking , and the whole system approach that creates a culture in which everyone in the organisation continuously improve operations[9].

2.3.3 Lean Approach and assumptions

While lean focuses on removing waste and improving flow, it too has some secondary effects. Quality is improved. The product spends less time in process, reducing chances of damage or obsolescence [13]. The lean methodology also makes some assumptions:

- People value the visual effect of flow.
- Waste is the main restriction to profitability.
- Small improvements are more beneficial than analytical study.
- Process interaction effects will be resolved through value stream refinement.

The lean approach is focused on systematically reducing waste in the value stream [1]. The waste concept includes all possible defective work or activities, not only defective products. Waste can be classified in eight categories as shown in Table 2.

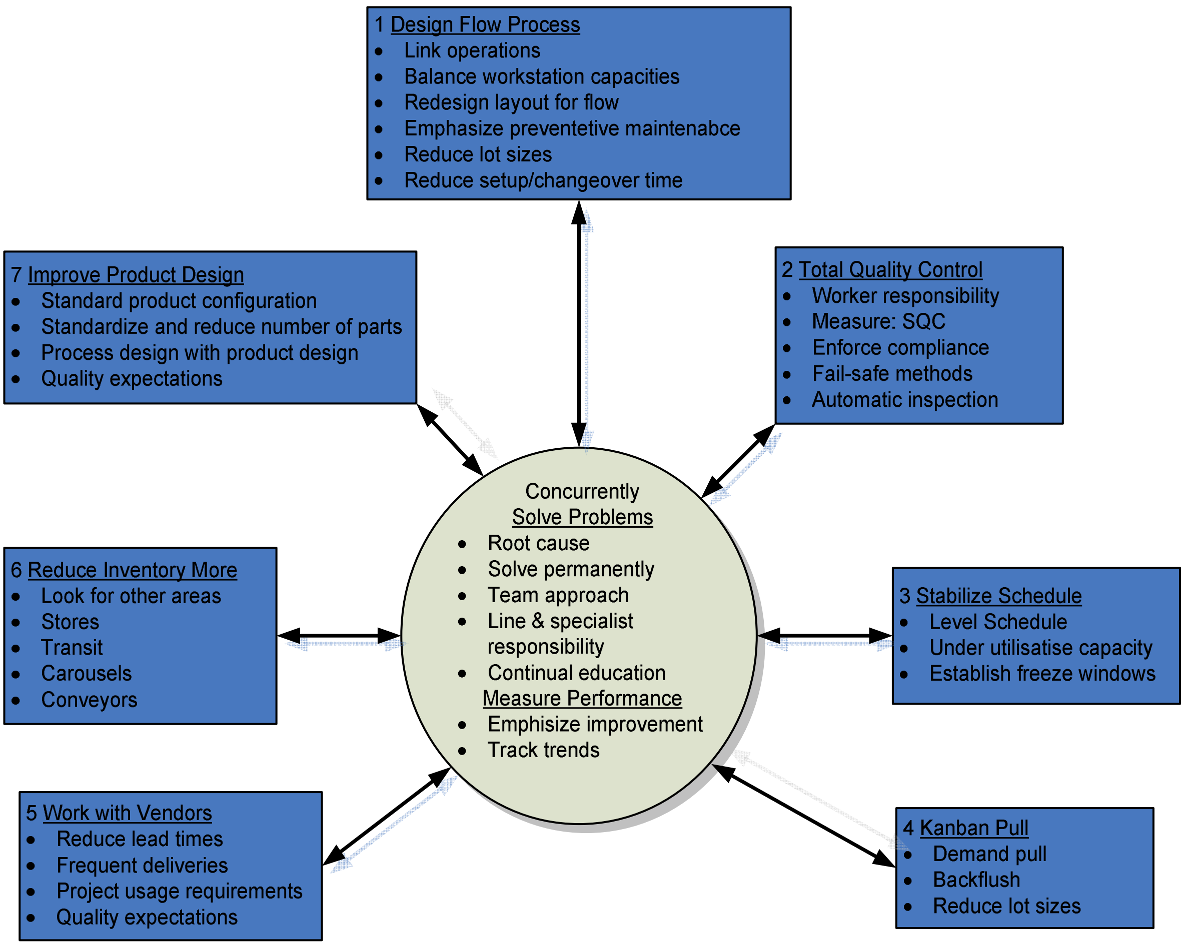
Table 2: Eight wastes that lean manufacturing identified

Types of Wastes	Waste Description
Motion:	Movement of people that does not add value.
Waiting:	Idle time created when material, information, people or equipment is not ready
Correction:	Work that contains defects, and reworks or lacks something necessary.
Over-production:	Producing more than the customer needs.
Over-processing:	Effort that adds no value from the customer's viewpoint.
Transportation:	Movement of product that does not add value.
Inventory:	More materials, parts or products on hand than the customer needs.
Knowledge:	People doing the work are not confident about the best way to perform tasks.

2.3.4 Lean Application

Most companies waste 70 to 90 percent of their available resources [1]. It is interesting that every company has to find its own way of implementing lean method: there is no universal way that will apply to all [1]. Lean manufacturing can be accomplished by applying the steps shown in Figure 2 [8]. These suggestions are geared to repetitive production systems. Lean manufacturing requires the plant layout to be designed to ensure balanced work flow with a minimum work-in-progress inventory [8]. The model shown in Figure 2 is used as a cycle to assist in applying lean production.

Figure 2: How to accomplish lean production



2.4 Value Stream Mapping

2.4.1 Introduction to Value stream mapping

The value stream maps (VSM), originally called "material and information flow maps" are one page diagrams depicting the process used to make a product [2]. According to (Chase et al, 2009) the value stream mapping is an approach that has been adopted to analyse a process to identify steps that can be improved. The idea is to develop a detailed diagram of the process that clearly shows those activities that add value, activities that do not add value, and steps that involve just waiting [8]. The value stream maps helps management to improve productivity and competitiveness, and help people implement system rather than isolated process improvements [2]. The value stream maps are created by teams of people who are directly or indirectly involved in the process under consideration. There are two types of value stream maps: the current state and future state [2]. The VSM has emerged as the preferred way to implement lean [11].

2.4.2 Importance and Uses of the Value stream mapping

This technique is used to understand the flow of material and information in office activities such as order entry, new product development, and financial reporting. Indeed the value stream maps can be used to map any service business process [2]. The value stream maps help people see waste that exists in business process, where waste is defined as an activity or behaviour that add cost but do not add value. Eliminating waste focuses people's effort on the value adding activities that customers desire and are willing to pay for, and result in improved business processes. The value stream maps results in shorter lead times, fewer defects and errors, and lower costs [2]. The information contained in value stream maps can be used to calculate current and future state process costs and create value stream profit and loss statements [2]. The technique reflects accurate costs associated with production and non-production activities. According to (Emiliani & Stec, 2004) the use of this technique extends to the field of leadership and organisational improvement. It uses value stream maps to determine the beliefs, behaviours, and competencies of senior managers that support the current state, and compares them to senior managers that implement the future state. This technique is versatile in a sense that it can be used in different organisations.

2.5 Work Study and Work design

2.5.1 Introduction to Work study and Work design

The fundamental tools that result in increased productivity are: methods, time study standards (frequently referred to as work study), and work design [14]. As part of developing or maintaining new method, the principles of work design must be used to fit the task and workstation ergonomically to the human operator [14]. Work study then aims at examining the way an activity is being carried out, simplifying or modifying of operation to reduce unnecessary or excess work, or a wasteful use of resources, and setting up a standard for performing that activity [10].

2.5.2 Importance of Work study and Work design

The principal objectives of work study and work design are: (a) to increase productivity and product reliability; and (b) to lower unit cost, thus allowing more quality goods and services to be produced for more people [14]. According to (Niebel & Freivalds, 2004) Work study and work design has the following seven corollaries to the principal objectives:

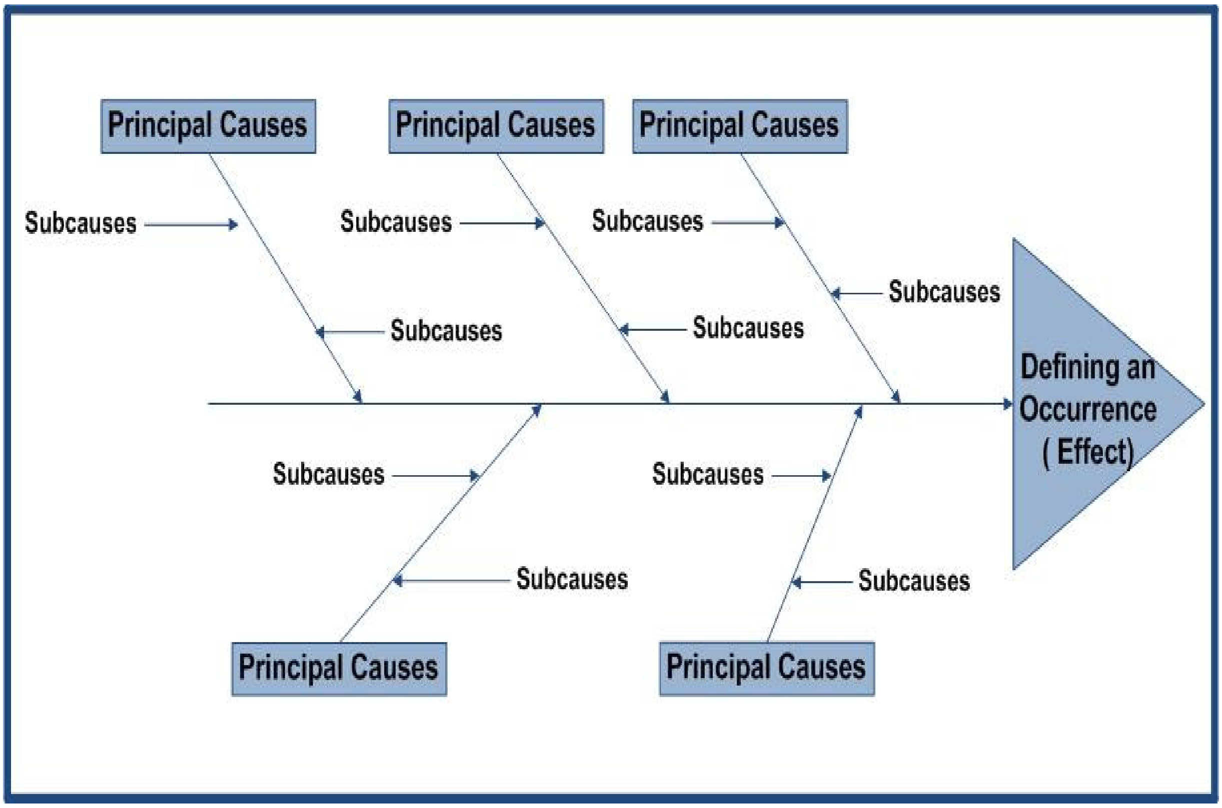
(1) To minimise time required to perform tasks.
(2) To continually improve quality and reliability of products and services.
(3) To conserve resources and minimise cost by specifying the most appropriate direct and indirect materials for the production of goods.
(4) To take the availability of power into careful consideration.
(5) To maximise safety, health, and well-being of all employees.
(6) To produce with an increasing concern for protecting the environment.
(7) To follow a humane program of management that results in job interest and satisfaction for each employee.

Work measurement is concerned with investigating, reducing and subsequently eliminating ineffective time, that is the time during which no effective work is being performed [10].

2.6 Cause and Effect Diagrams

The cause and effect diagram is the popular tool developed by Ishikawa in early 1950s while working on a quality control project for Kawasaki Steel Company [14]. The Ishikawa diagram is a graphical tool used to identify , explore, and depict problems and the causes and effects of those problems. The method consist of defining an occurrence of a typically undesirable event or problem, that is the effect, as the “fish head” and then identifying contributing factors, that is the causes, as “fish bones” attached to a backbone and fish head. The causes are then divided into sub-causes to identify the actual cause of the problem. An example in Figure 3 is the graphical representation of the cause and effect diagram.

Figure 3: An example of the cause and effect diagram



This technique follows a linear cause and effect approach, and it is simple to apply in the real world. There are no assumptions that needs to be made when applying the cause and effect diagram.

2.7 Layout and Flow Analysis

The way in which machinery, equipment and material are arranged in a working area determines the layout in that area [10]. Even if the initial layout was well thought out, a re-examination of the utilisation of space is often called for because of various factors.

According to (George Kanawaty,1992) in the book *Introduction to work study* he state that factors that influence the redesign of layout and determining the new flow of material involve the following:

- New products are added or product design changes introduced. Both types of action may necessitate a different sequence of operations.
- New equipment or machinery or a different shape and size of materials are introduced.
- Material handling equipment that has different space requirements from the original equipment is acquired.
- Modifications are made to the building to increase space.
- Temporary arrangements may have been made to cope with an upsurge of demand for a certain product, but these then remain semi – permanent.
- Moves are made by management towards advanced technologies such as the use of robotics, automation, computer networking or flexible manufacturing systems.

When situation like these arise it is said that the plant has outgrown its present layout [10]. Operations become cumbersome with either congestion or lengthy and unnecessary movements of product - in - progress or production resulting in loss of time and energy. The current plant layout and material flow for the powder coating plant is shown in Appendix A. According to (George Kanawaty, 1992) there are four types of layout: (1) layout by fixed position; (2) layout by process or function; (3) layout by product or line layout; (4) group layout.

(1) Layout by Fixed position

This type of arrangement is used when the material to be processed does not travel around the plant but stays in one place. All necessary equipment and machinery are brought to it instead. This is a case when the product is bulky and heavy and when only a few units are made at a time.

(2) Layout by process or function

Here all operations of the same nature are grouped together. This layout is usually being chosen where a great many products which share the same machinery are being made and where any one product has only a relatively a low volume of out put.

(3) Layout by product or line layout

This type of layout is sometimes referred to as "mass production". In this layout all the necessary machinery and equipment needed to make a given product are set out in the same area and in the sequence of the manufacturing process. This layout is used mainly where there is a high demand for one or several products that are more or less standardised.

(4) Group Layout

This layout is arranged in a way, with a group of workers working together on a given product or on a part of a product and having at hand all machinery and equipment needed to complete their work.

2.8 Conclusion on Techniques

2.8.1 Constraint Management

Theory of constraints on its own was intentionally developed to assist management to understand their organisation's goal. Eliyahu Goldratt and Jeff Cox defined the goal of any organisation as being "to make money" [5].

In order for the manufacturing organisation to make money the production system has to be analysed to identify bottlenecks and constraints resources. It is believed that theory of constraint is the accurate tool in controlling throughput, inventory and operating expenses to bring the organisation close to its goal [8]. The Theory of constraints deals with constraints reduction. Theory of constraints is an appropriate technique to identify bottlenecks, and to understand the type of bottlenecks within the organisation.

2.8.2 Lean Manufacturing

Lean production is based on the logic that nothing will be produced unless is needed. Lean focuses its effort on eliminating wastes. It requires the plant layout to be designed to ensure balanced workflow within a minimum of work-in-process inventory [8]. The technique can be applied for line flow as well as for work centre shops [8]. There is no universal way of applying this technique [1].

2.8.3 Value Stream Mapping

The value stream map within manufacturing organisation reveals the non-value adding activities. These non- value adding activities are then reduced or completely removed. However the maps alone are not sufficient when applied in isolation. It needs other techniques such as lean thinking or theory of constraints to support its application [1].

2.8.4 Work Study and Work Design

The work study establishes a time standard allowed to perform a given task or activity, based on the measurement of the work content of the prescribed method. Time studies are developed using work study. Work measurement as name suggest, provides management with a means of measuring the time taken in the performance of an operation or series of operations [10].

2.8.5 Cause and Effect Analysis

The Ishikawa diagram is a graphical tool used to identify , explore, and depict problems and the causes and effects of those problems. This method is appropriate to analyse the problem within the system.

2.8.6 Layout and Flow Analysis

These types of layouts explain how the plant or the organisation operates. An organisation can combine two types of layout to perform its operation. The layout in Appendix A reveals the **layout by product or line layout**. A layout of an organisation has an effect on the productivity. Arrangement of activities has an impact on the material flow, hence productivity may improve.

Chapter 3- Data Analysis

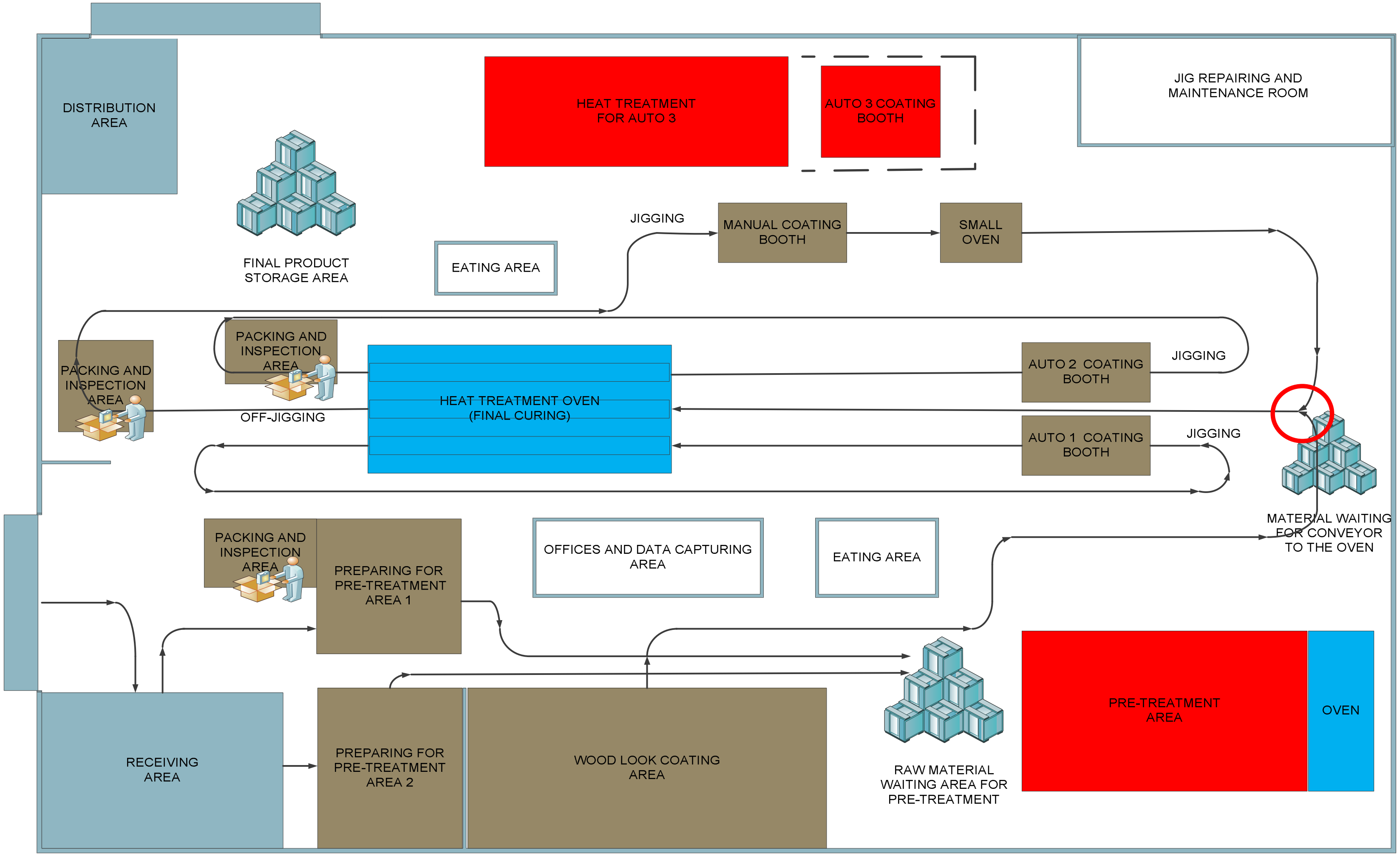
3.1Operation Analysis

3.1.1 Production lines

This analysis is a necessary part of developing a solution to the problems experienced in the production lines. Analysis of the current production system is done to identify areas that need to be improved. The powder coating division has a variety of colours available for the coating in the production line. The colours used are: white, bronze, charcoal, black and wood look. There are three lines that are operating regularly, and the other line operates only when there is demand for black colour. Among the three lines that are always operating there are two automated lines that are used to paint white and bronze and one manual line that is used to coat various colours. The first line is the automated line one (auto1) and the second line is automated line two (auto 2) and the third line is manual line. The fourth line used for black or charcoal is also automated and is called automated line three (auto 3). The powder coating lines uses a power-free conveyor to transport a jigged material for coating and for final curing. Each line has its own rail of power free conveyor that transport material from the paint booth to the oven for final curing. A detailed layout of the plant is depicted in Figure 4. The plant has two overhead cranes to lift raw material from the truck to the receiving area, and the other crane is used for pre-treatment.

The layout shows the automatic line three (auto 3) without the flow of lines, since it is not considered. Automatic line three is not operating regularly hence there is not much of work flow. It is also visible in the layout that there is an inventory piling up in front of the pre-treatment machine. Another inventory piling up is shown on the layout next to the red circle, to illustrate that sharing an oven between manual and wood look creates inventory in front of a resource.

Figure 4: Current plant layout and material flow



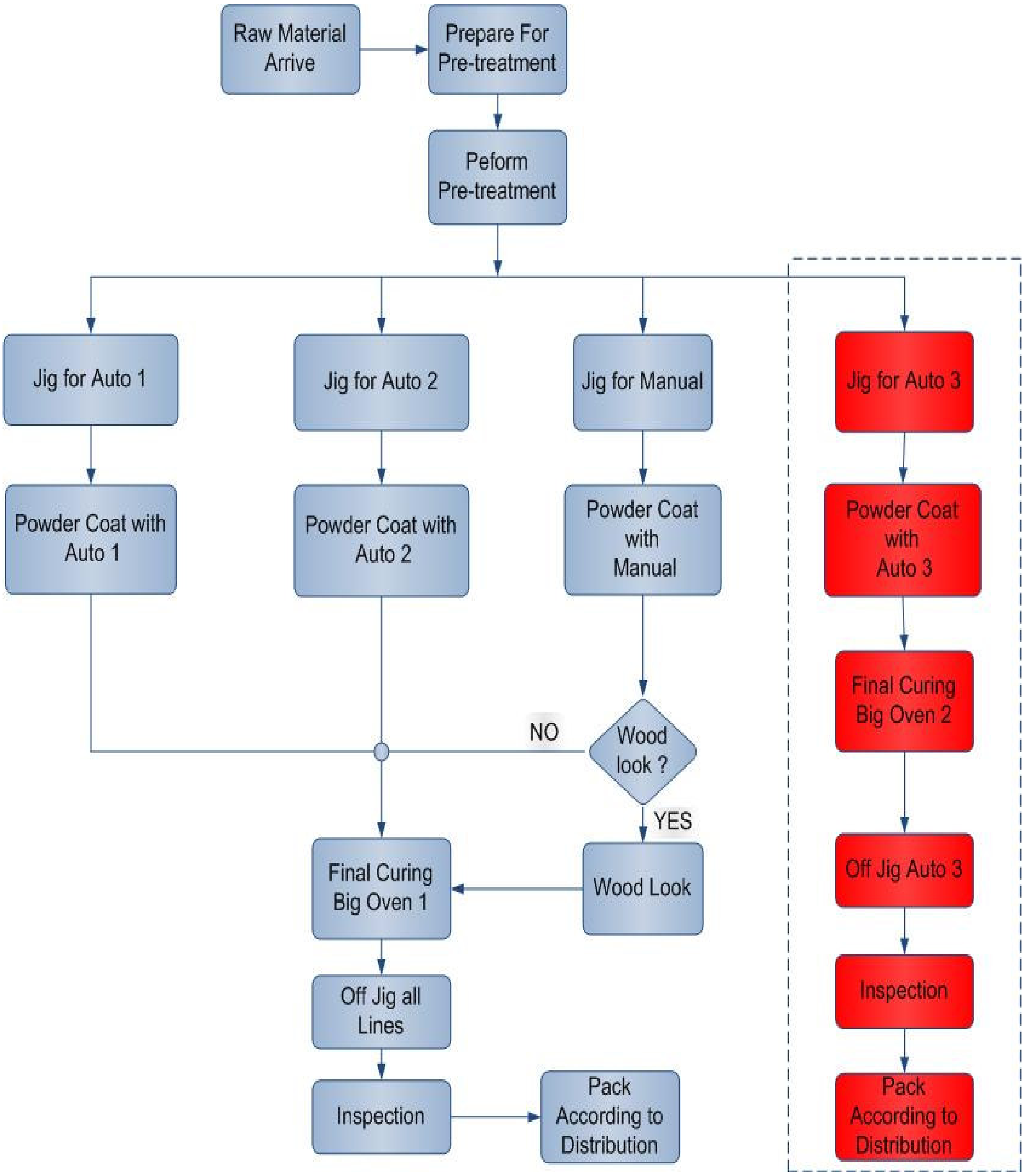
3.1.2 Current operation

The operation of the plant is studied and analysed to understand how material flows from preparing raw material to finished product. A series of activities involved in transforming raw material into final product are as follows:

- When material comes from the extrusion department as extruded aluminium they are packed in a skip.
- The skip is then prepared into a cart and material is then transported to pre-treatment area.
- The pre-treatment is then performed and this process takes about 37 minutes to process, only one operator is working on this station.
- Then the lines are jigged into three different painting booths.
- Each automatic line has three operators working in it, two operators jig material and one operator operates machine.
- Manual line has four operators working on the line the two jiggers and two painters.
- If there is demand for wood look then the manual line paints the material with brown and sends it to wood look coating line as shown in Figure 5.
- Then material from wood look will be sent to the oven for final curing. Manual line and wood look shares the oven.

Then all the lines are sent to the oven for final curing. Then material is off-jigged, inspected and packed ready to be delivered to a customer. As seen from Figure 5 that auto 3 is operating in isolation, the reason being it can contaminate other lines with black or charcoal.

Figure 5: Material flow diagram at powder coating plant



3.1.3 Production Analysis

The plant operate from 6:00am till 18:00pm daily (shift) 12 hours per shift, it has a production target for each line. The production target for each line is set as shown in Table 3. It is clear from the table that automatic lines are expected to produce more than manual line. The targets are different on the automatic lines and manual lines for the reason that man cannot paint as much as machine can do.

Table 3: Table of production target in different lines

Production Lines	Target in square metre (m^2) per shift
Automatic line 1	2000
Automatic line 2	2000
Manual & Wood look lines	500

Production for June is depicted on the following charts to illustrate the variation that is generated between the actual production and the target. The charts behave as control charts, since there is variation within the process. These charts illustrates that there is a hitch within the production line that causes the plant not to be stable. It can be seen from the diagrams that there is uncertainty, sometimes caused by defects produced per day.

The chart shown in Figure 6 illustrates the actual production of automatic line 1 against the expected production target. The red line shows the target and the blue line shows the actual production. There is a necessity that attention is given to the causes of these variation.

Similar with Figure 7 it shows that there is a variation, and production target is not met during the month. This variation is for automatic line 2. The targets set for automatic line 1 and automatic line 2 are high. The chart in Figure 8 shows that the actual production exceeds the target and drops again, so this type of inconsistency creates uncertainties whether demand placed on the line will be met.

According to (Gitlow et al 2005) he states that reduction of variation must be done by following **5W1H** process of questions:

(1) Why didn't we meet production target during this month?
(2) Why does the actual production vary every day?
(3) Why manual line exceeds the target and drops?
(4) Why automatic lines don't meet their target?
(5) Why is the target for manual line low that it is exceeded?
(6) How can we resolve this problem so it doesn't happen again?

These questions will be answered by resolving the current problem by applying the techniques that will provide efficient production lines.

Figure 6: A current measurement of actual production versus target on auto 1

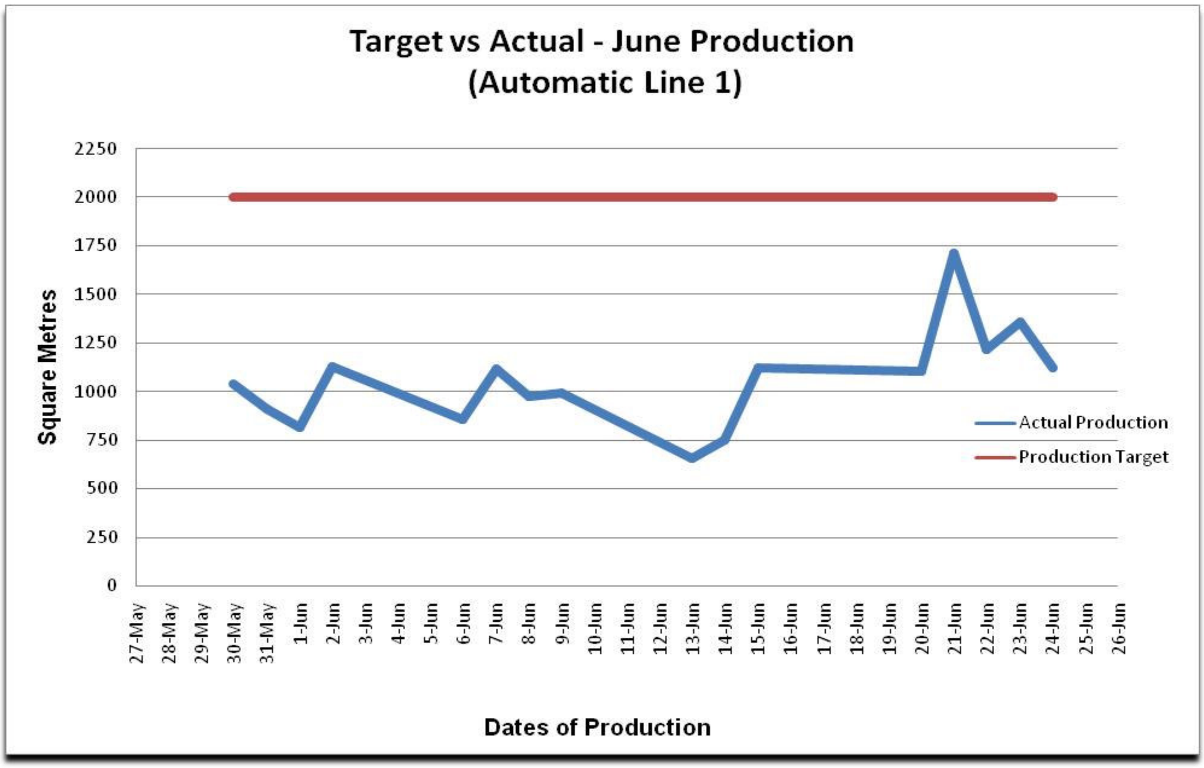


Figure 7: A current measurement of actual production versus target on auto 2

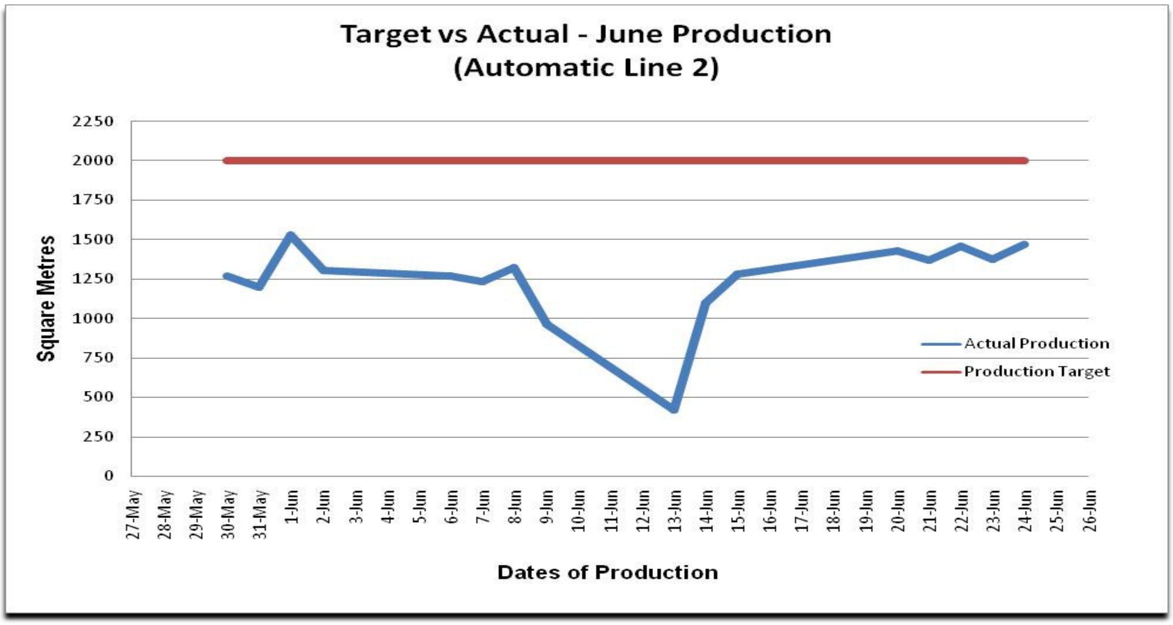
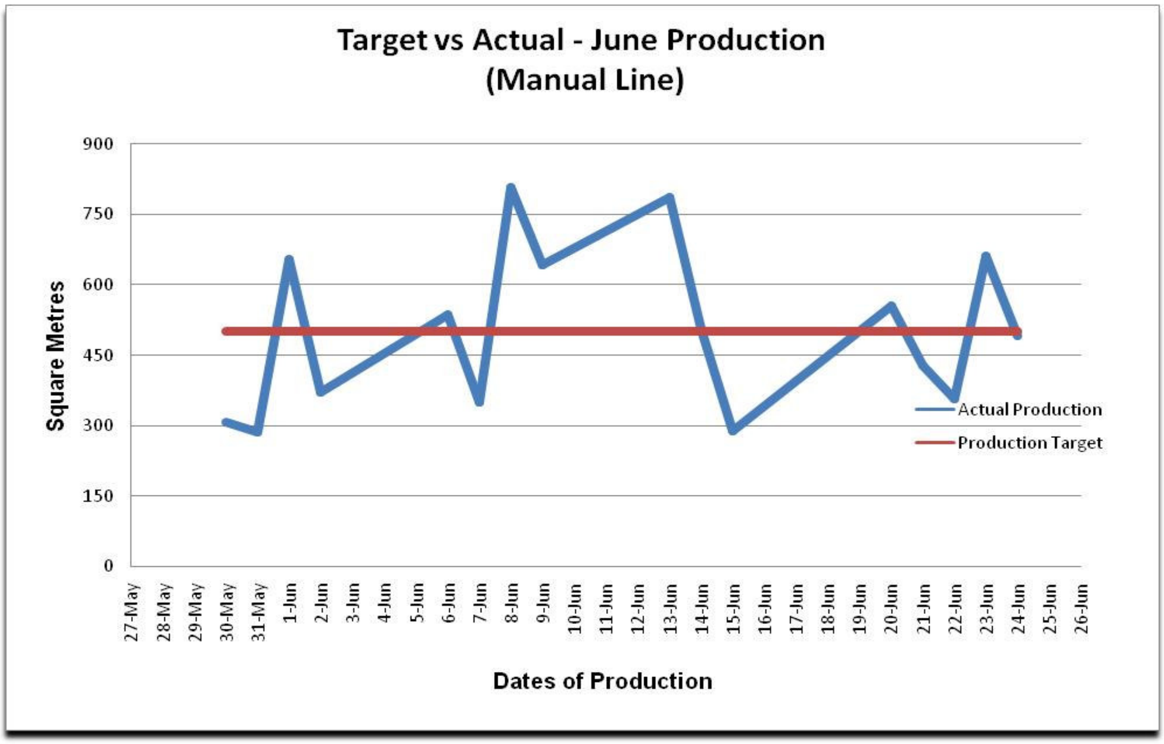


Figure 8: A current measurement of actual production and target on manual line



3.2 Cause and Effect Analysis

The cause and effect diagram is the popular tool that is used to identify problems within the organisation. The cause and effect diagram as discussed in the literature review (section 2.6) has worked quite successfully in Japanese quality circles, where input is expected from all levels of workers. While trying to understand the problems of the organisation the cause and effect was appropriate in the study.

The principal causes are divided into five major categories – poor operating processes, poor distribution of work, poor layout, machine processing, and human factors [14]. Each of the causes are then subdivided into sub – causes. An interview with production manager and workers was conducted and some of the causes were identified through the interview. The method assists in identifying the causes of the problems within the plant. These causes contributed in the identification of the main causes of the inefficient production plant.

Figure 9: The Cause and Effect Diagram illustrating problems