ANALYSIS AND COUNTERMEASURE TO IMPROVE PRODUCTION SYSTEM PERFORMANCE BY USING OVERALL EQUIPMENT EFFECTIVENESS AT BI TECHNOLOGIES SDN. BHD.

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ANALYSIS AND COUNTERMEASURE TO IMPROVE PRODUCTION SYSTEM PERFORMANCE BY USING OVERALL EQUIPMENT EFFECTIVENESS AT BI TECHNOLOGIES SDN. BHD.

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
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FACULTY OF MANUFACTURING ENGINEERING

We certify that the project entitled "Analysis and Countermeasure to Improve Production System Performance by Using Overall Equipment Effectiveness at BI Technologies Sdn. Bhd." is written by Alicia Beh. We have examined the final copy of this report and in our opinion; it is fully adequate in terms of scope and quality for the reward of degree of Bachelor of Manufacturing Engineering. We herewith recommend that it be accepted in fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own expect for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature:

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ABSTRACT

To compete in global market, no organization will tolerate losses. Overall Equipment Effectiveness (OEE) is a novel technique to measure the effectiveness of a machine and it truly reduces complex production problems into simple and intuitive presentation of information. It considers all important measures of productivity. An attempt has been done to measure and analyze existing Overall Equipment Effectiveness (OEE) at BI Technologies Sdn. Bhd. in hope to reduce unplanned downtime losses on equipment failure and tooling damage to maximize the productivity. Before obtaining the data to calculate the existing OEE value, the product or process that have the most defects need to be identified which is component HM72A-10 series at Moulded Inductor area. The methods used to analyze these various causes were Ishikawa diagram, 5 Whys and 5W1H. After knowing the causes of various activities that leads to high rates of defects, then recommendations for improvements that could be used by BI Technologies were ready to be made.

ABSTRAK

Untuk bersaing dalam pasaran global, tiada organisasi akan bertolak ansur dengan kerugian. *Overall Equipment Effectiveness (OEE)* adalah teknik baru untuk mengukur keberkesanan mesin dan ia dapat mengurangkan masalah pengeluaran yang kompleks ke dalam persembahan yang mudah dan intuitif maklumat. Ia menganggap semua langkah-langkah penting dalam produktiviti. Satu percubaan telah dilakukan untuk mengukur dan menganalisis *Overall Equipment Effectiveness (OEE) yang* sedia ada di BI Technologies Sdn. Bhd dengan harapan untuk mengurangkan kerugian *downtime* yang tidak dirancang akibat kegagalan peralatan dan kerosakan alat untuk memaksimumkan produktiviti. Sebelum mendapatkan data untuk mengira nilai OEE yang sedia ada, produk atau proses yang mempunyai kerosakan yang perlu dikenal pasti iaitu merupakan komponen HM72A-10 siri di kawasan *Moulded Inductor*. Kaedah-kaedah yang digunakan untuk menganalisis sebab-sebab kerosakan adalah dengan menggunakan gambarajah *Ishikawa, 5 Whys* dan *5W1H*. Selepas mengetahui punca aktiviti-aktiviti yang membawa kepada kadar kerosakan yang tinggi, maka cadangan untuk penambahbaikan yang boleh digunakan oleh BI Technologies dikemukakan.

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LIST OF ABBREVIATIONS

CEMS	Contract Electronic Manufacturers
KPI	Key Performance Indicator
MCD	Magnetics Component Division
TQM	Total Quality Management
ODMs	Original Design Manufacturers
OEMs	Original Equipment Manufacturers
OEE	Overall Equipment Effectiveness

Specially dedicated this thesis to my beloved family and those
who have supported me each step of the way.

BORANG PENGESAHAN STATUS TESIS

JUDUL: **ANALYSIS AND COUNTERMEASURE TO IMPROVE PRODUCTION SYSTEM PERFORMANCE BY USING OVERALL EQUIPMENT EFFECTIVENESS AT BI TECHNOLOGIES SDN. BHD.**

SESI PENGAJIAN: 2012/2013

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CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

In a competitive market, the demand for quality is emerging as the single most critical factor for companies to survive in the ever-expanding global market place. Quality is vital in determining the economic success of manufacturing companies. Total Quality Management (TQM) is an approach for continuously improving the quality of goods and services delivered through the participation of individuals at all levels and functions of an organization. Quality Management practices also help to improve in reducing scrap, rework and stable the production process. These in turn minimize the production cost and increase productivity.

In this research, I have chosen to conduct my case study at BI Technologies. BI Technologies Corporation Sdn. Bhd was established in Jalan Tanjung Api, Kuantan, Pahang since 1976 by Allen Hilton. The worldwide manufacturing, engineering and sales support facilities include those in North America, Europe, the UK, Mexico, Barbados, Malaysia, Japan, Singapore, Hong Kong, India and China, with sales to major OEMs (original equipment manufacturers) or ODMs (original design manufacturers) and CEMs (contract electronic manufacturers) through manufacturers' representatives and the world's leading electronic distributors. Individual divisions of BI Technologies specialize in visible and infrared LED components; optoelectronic, potentiometric and magnetic sensors;

microcircuits and hybrids; fixed and variable resistors and resistor networks; resistive heaters and thermal management substrates; potentiometers and trimmers; and magnetic components which are low profile semiconductor magnetic devices (SMD) inductor, Toroidal SMD inductor, Isolation transformer, Common mode choke, Through-hole inductor, Bobbin base SMD transformer and Through-hole transformer. Figure 1.1 shows the examples of magnetic components that have been produced at BI Technologies Corporation Sdn. Bhd. These components have higher power density, faster switching, special packaging or miniaturization and also has precision control and measurement. Among the markets served by BI Technologies including Industrial for AC/DC power supplies, DC/DC converters and inverters, Military or Aero field for communications power supplies and engine controls, Medical industry for monitoring, diagnostic and surgical purposes, lastly in automotive industry which includes Hybrid vehicles for inverters or electric motor and battery management.

However, during and after the company visit I could not help but reflect upon what I observed at BI Technologies versus what I experience on typical factory visits to other plants in attempting a lean transformation. There are a few problems detected especially at the Moulded Inductor section area that might influence the quality level of products although they have implemented Lean Production System in this factory. There are four types of model that are produced at the Moulded Inductor area which are HM72A-06 Series, HM72B-06 Series, HM72A-10 Series and HM72A-12 Series. This study is conducted by choosing component HM72A-10 Series as a research. The production at this area is not fully-automated where they require humans to manually assemble the components from the beginning until the final production of the component which is why the probability for the product to assemble incorrectly and the tendency for defects to occur are high. The inadequate level of training given to the operator explains their lack of skills in handling the equipment. Therefore, leads to equipment failure and tooling damage. Too much material handling during creating or passing along products can affect the definition of product value or quality value.

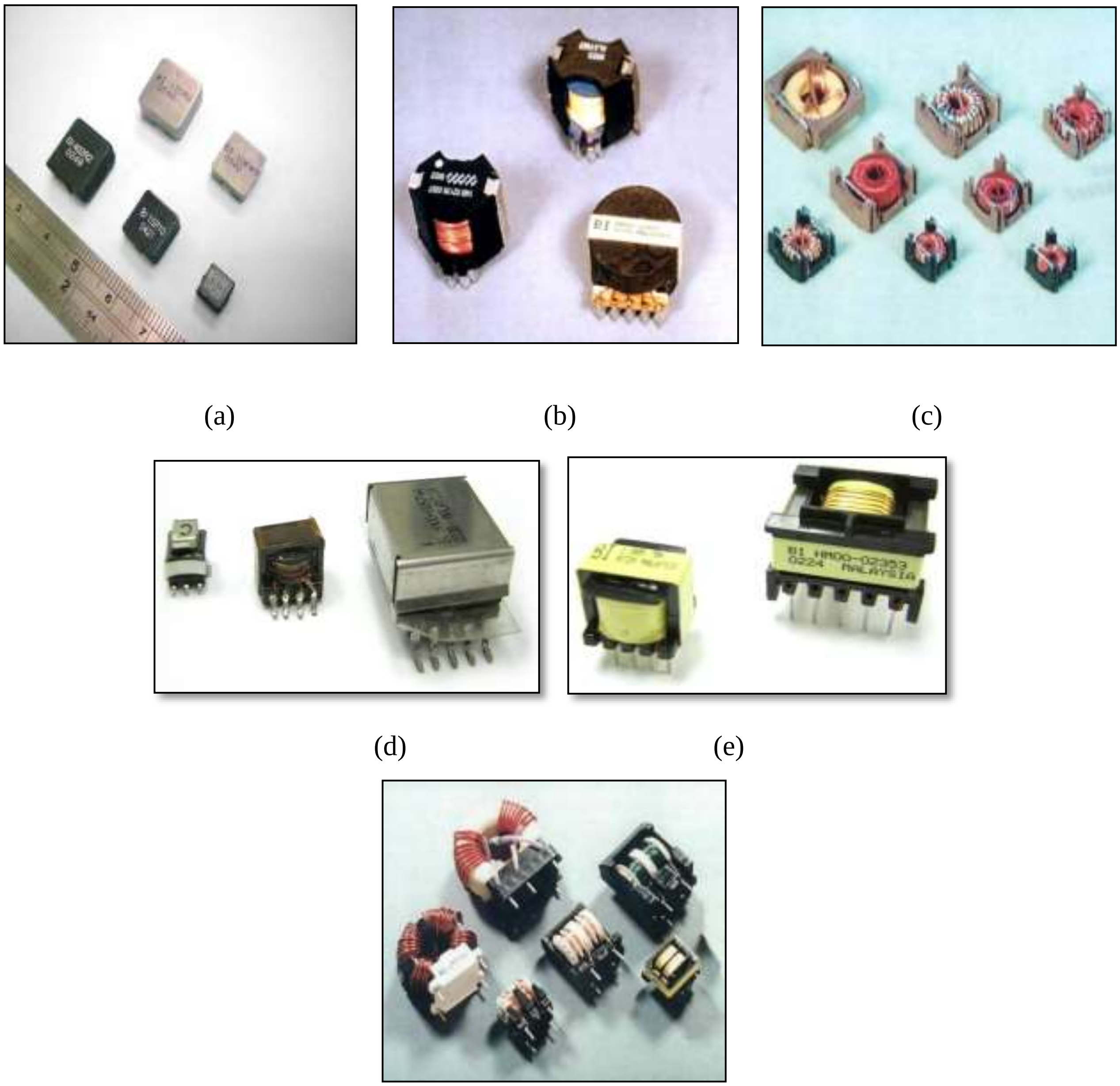

Figure 1.1: BI Technologies product; (a) Low profile SMD inductor (b) Toroidal SMD inductor (c) Isolation transformer (d) Bobbin Base SMD transformer (e) Through-hole transformer (f) Common mode choke

1.2 PROBLEM STATEMENT

Through numerous inspection and customer feedbacks, it is found out that there are a quite number of defects occur due to some factors at the Moulded Inductor production area which obviously need serious concern and improvement. BI Technologies require the aid of humans to manually assemble the product and high rate of equipment failure caused by tooling damage leads to high customer complaints and influence the effectiveness of the production.

There are four models of inductors which are produced; HM72A – 6 series, HM72B – 6 series, HM72A – 10 series, and HM72B – 12 series. To go further for this research some of research question need to take serious consideration. There are:

i. Which components or process have the highest rate of defects
ii. How to improve the quality of product and reduce the level of scrap and defects occur
iii. How to reduce equipment failures and tooling damage
iv. How to increase labor performance and effectiveness in man machine combination areas

1.3 OBJECTIVE

The objectives of this project are determined. These objectives have been defined to be focused on to simplify the project as stated:

i. To reduce unplanned downtime losses on equipment failure and tooling damage
ii. To evaluate and suggest recommendation to improve Overall Equipment Effectiveness (OEE) value in the factory

1.4 SCOPE OF PROJECT

The project objective is narrowed down by performing scopes of study. Firstly comprehensive literature review has been conducted to determine the best quality statistical method. Secondly a case study has been conducted at BI Technologies Industries Sdn. Bhd. on Moulded Inductor production area. It is selected due to the quality issues such as high number of defects detected.

CHAPTER 2

LITERATURE REVIEW

2.1 THE HISTORY OF QUALITY MANAGEMENT

From mere 'inspection' to Total Quality Management, and its modern 'branded interpretations such as 'Six Sigma', has led to the development of essential processes, ideas, theories and tools that are central to organizational development, change management, and the performance improvements that are generally desired for individuals, teams and organizations. (McAdam and Bannister, 2001)

A Quality Management System is typically defined as: "A set of co-ordinated activities to direct and control an organization in order to continually improve the effectiveness and efficiency of its performance." Customer expectations inevitably drive and define 'performance' criteria and standards. It is the way of managing for the future, and is far wider in its application than just assuring product or service quality – is a way of managing people and business processes to ensure complete customer satisfaction at every stage, internally and externally. Total Quality Management, combined with effective leadership, results in an organization doing the right things right, first time (Buzzel and Gale, 1987)

Everything we do is a process, which is the transformation of a set of inputs, which can include action, methods and operations, into the desired outputs, which satisfy the customers' needs and expectations. In each area or function within an organization there will be many processes taking place, and each can be analyzed by an examination of the input and outputs to determine the action necessary to improve quality.

2.1.1 What Is Quality?

A frequently used definition of quality is "delighting the customer by fully meeting their needs and expectations". These may include performance, appearance, availability, delivery, reliability, maintainability, cost effectiveness and price. It is, therefore, imperative that the organization knows what these needs and expectations are. In addition, having identified them, the organization must understand them, and measure its own ability to meet those (Krause et al., 2000).

Quality starts with market research – to establish the true requirements for the product or service and the true needs of customers. However, for an organization to be really effective quality must span all functions, all people, all departments and all activities and be a common language for improvement. The cooperation of everyone at every interface is necessary to achieve a total quality organization. Quality Management practices also help to improve in reducing scrap, rework and stable the production process. These in turn minimize the production cost and increase productivity (Ahmad and Schroeder, 2002). Through continuous improvement, not only errors and defects can be prevented but also product cycle's times can be reduced, thereby improving productivity and organizational performance (Huang and Lin, 2002).

According to Buzzel and Gale (1987), financial performance or profitability is an important measure of QM outcomes. This was support with Deming's (1986) argument that quality improvement leads to elimination of waste, reduction of cost and will increase profitability. Recent study by Hoang et al. (2006), noted that TQM has a positive impact on the firm's innovation performance. These findings have important implications at improving company's business performance.

2.2 PRODUCTION SYSTEM

Production can be explained as an act of either manufacturing or mining or growing of goods (commodities) generally in bulk for trade. Production is a method employed for making or providing essential goods and services for consumers. It is a process that puts intangible inputs like ideas, creativity, research, knowledge, wisdom, etc. in use or action. It is a way that transforms (convert) tangible inputs like raw-materials, semi-finished goods and unassembled goods into finished goods or commodities. System is an arrangement or assembly of inter-dependent processes (activities) that are based on some logic and function. It operates as a whole and is designed (build) with an intension to achieve (fulfill) some objective or do some work. Huge systems are often a collection (assembly) of smaller sub-systems. Production system may be defined as, "The methods, procedure or arrangement which includes all functions required to accumulate (gather) the inputs, process or reprocess the inputs, and deliver the marketable output (goods)." Production system utilizes materials, funds, infrastructure, and labour to produce the required output in form of goods. (Rodrigues M., 2006)

A production system (or production rule system) is a computer program typically used to provide some form of artificial intelligence, which consists primarily of a set of rules about behavior. These rules, termed productions, are a basic representation found useful in automated planning, expert systems and action selection. A production system provides the mechanism necessary to execute productions in order to achieve some goal for the system. A production system also contains a database, sometimes called working memory, which maintains data about current state or knowledge, and a rule interpreter. The rule interpreter must provide a mechanism for prioritizing productions when more than one is triggered. (L. Brownston, 1985)

According to AR Kusnadi in 1997, production system consists of three main components which are Inputs, Conversion Process and Output. Inputs include raw-materials, machines, man-hours, components or parts, drawing, instructions and other paper works. Conversion process includes operations (actual production process). Operations may be either manual or mechanical or chemical. Operations convert inputs into output. Conversion process also includes supporting activities, which help the process of conversion. The supporting activities include; production planning and control purchase of raw-materials, receipt, storage and issue of materials, inspection of parts and work-in-progress, testing of products, quality control, warehousing of finished products. Output includes finished products, finished goods (parts), and services

2.3 OVERALL EQUIPMENT EFFECTIVENESS

Efficiency and effectiveness are buzzwords in today's competitive market. The greater the efficiency and effectiveness, more productive is the organization. Overall Equipment Effectiveness is such a performance measure, which indicates current status of production with least calculation. It also helps to measure losses and corrective actions can be taken to reduce it. Effective utilization of Men, Machines, Material and Methods will result into higher productivity. (Anand S. Relkar and K. N. Nandurkar, 2012)

When manufacturing companies run up against capacity problems today, they immediately look to increase overtime, add shifts, or purchase new equipment. Instead the should look to optimize the performance of their existing machines to increase equipment reliability, minimize changeover times, improve operator performance and lower overall downtime. All these investments can be made to increase capacity and will pay greater dividends by allowing a manufacturing plant to spend its valuable time and money on their manufacturing process instead of new machine purchases. (P. Muchiri, 2006)

The OEE measure can be applied at several different levels within a manufacturing environment. Firstly, OEE can be used as a benchmark for measuring the initial performance of a manufacturing plant in it's entirely. In this manner the initial OEE measure can be compared with future OEE values, thus quantifying the level of improvement made. Secondly, an OEE value, calculated for one manufacturing line, can be used to compare line performance across the factory, thereby highlighting any poor line performance. Thirdly, if the machines process work individually, an OEE measure can identify which machine performance is worst and therefore indicate where to focus resources. (Ranteshwar Singh, 2013) Figure 2.1 shows the parameters that influence Overall Equipment Effectiveness value.

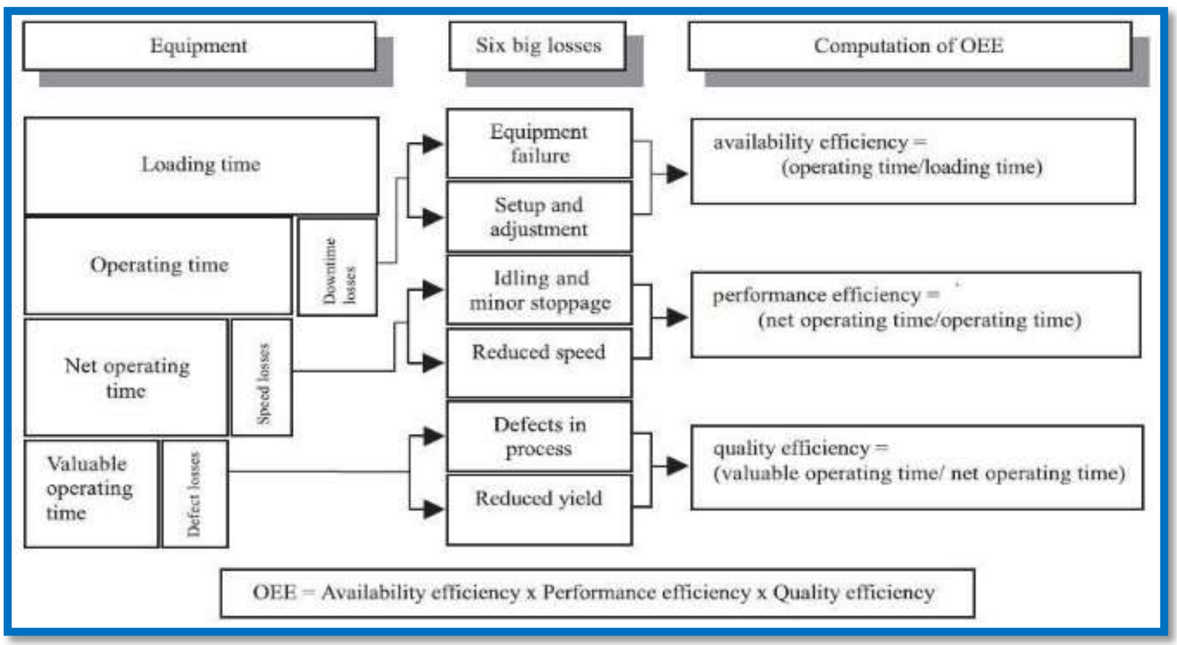

Figure 2.1: Overall Equipment Effectiveness

Source: Ranteshwar Singh, 2013

OEE is a simple tool that will help manager to measure the effectiveness of their equipment. (Sermin Elevli and Birol Elevli, 2010) It takes the most common and important sources of productivity loss, which are called six big losses and given in Table 2.1. These losses are quantified as availability, performance and quality in order to estimate OEE as given in equation below.

$$OEE = Availability \times Performance \times Quality \qquad (2.1)$$

Table 2.1: Six Big Losses

Six Big Loss Category	OEE Loss Category	OEE Factor
Equipment failure	Downtime Losses	Availability (A)
Setup and Adjustment		
Idling and Minor Stoppages	Speed Losses	Performance (P)
Reduced Speed		
Reduced Yield	Defect Losses	Quality (Q)
Quality Defects		

Overall equipment effectiveness (OEE) is a hierarchy of metrics developed by Seiichi Nakajima in 1960's (based on Harrington Emerson way of thinking regarding to labor efficiency) which evaluates and indicates how effectively a manufacturing operation is utilized. The results are stated in a generic form which allows comparison between manufacturing units in differing industries. It is not however an absolute measure and is best used to identify scope for process performance improvement, and how to get the improvement. If for example the cycle time is reduced, the OEE can also reduce, even though more products are produced for less resource. More changeovers (set-ups) will lower the OEE in comparison, but if the product is sold at a premium, there could be more margin with a lower OEE.

OEE measurement is also commonly used as a key performance indicator (KPI) in conjunction with lean manufacturing efforts to provide an indicator of success. OEE can be best illustrated by a brief discussion of the six metrics that comprise the system. The hierarchy consists of two top-level measures and four underlying measures.

2.3.1 The Elements of Overall Equipment Effectiveness

The three main categories of equipment-related losses —downtime, speed loss, and defect or quality loss— are also the main ingredients for determining the overall equipment effectiveness. Overall equipment effectiveness is calculated by combining three factors that reflect these losses: the availability rate, the performance rate, and the quality rate.

Availability takes into account "lost time" which includes any events that stop planned production for an appreciable length of time. This is usually because of equipment failures, waiting times, and etc. Then, availability is determined as follows.

$$Availability = \frac{Net\ Available\ Time - Downtime\ Losses}{Net\ Available\ Time} \times 100 \quad (2.2)$$

Performance takes into account "speed loss", which includes any factors that cause the equipment to operate at less than the maximum possible speed when running. Reasons for that can be substandard materials, operator inefficiency, and job conditions. Then performance is determined as follows:

$$Performance = \frac{Operating\ Time - Speed\ Losses}{Operating\ Time} \times 100 \quad (2.3)$$

Quality takes into account "product loss". It is the amount of good products versus the total amount of products produced. A low quality rate reflects defect losses:

- Scrap and rework

- Startup losses

$$Quality = \frac{Net\ Operating\ Time - Defect\ Losses}{Net\ Operating\ Time} \times 100 \qquad (2.4)$$

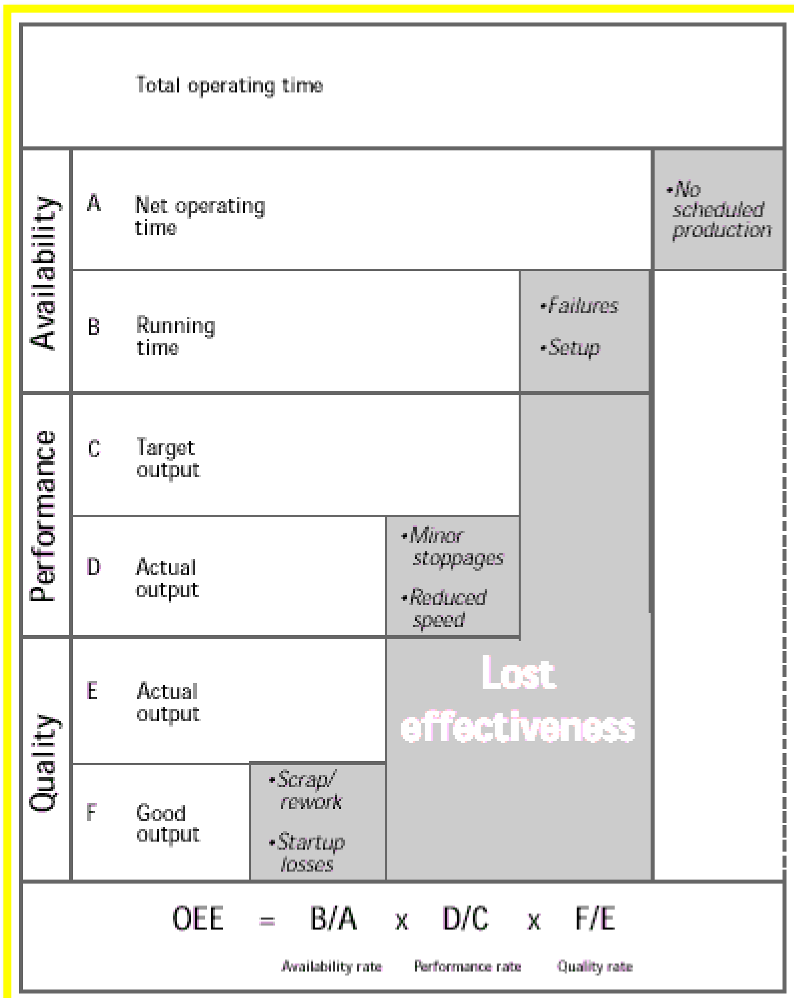

Figure 2.2: OEE Diagram

The inverted stair step diagram above shows graphically how the losses in availability, performance, and quality work together to reduce the overall effectiveness of a machine. The top bar, total operating time, shows the total time a machine is available to make a product.

Bars A and B show availability. Bar A represents the net operating time, which is the time available for production after subtracting planned downtime (no scheduled production) such as a holiday, no orders, or no personnel.

Bar B shows the actual running time after subtracting downtime losses such as equipment failures and setup and adjustments.

Bars C and D show performance. Bar C represents the Target Output of the machine during the running time, calculated at the designed speed of the machine. Below it, a shorter fourth bar, D, represents the actual output, reflecting speed losses such as minor stoppages and reduced operating speed.

Bars E and F show quality. As you can see, the actual output (E) is reduced by defect losses such as scrap and startup losses, shown as the shaded portion of bar F.

As this diagram shows, the bottom-line good output is only a fraction of what it could be if losses in availability, performance, and quality were reduced. The diagram also suggests that to maximize effectiveness —to grow the good output on the bottom line— you must reduce not only quality losses, but also availability and performance losses. The three factors work together, and the lowest percentage is usually the constraint that most needs addressing.

2.4 TOTAL QUALITY IMPROVEMENT TOOLS

A wide range of tools and techniques is used for identifying, measuring, prioritizing and improving processes which are critical to quality. Again these ideas and methods feature prominently in modern interpretations of Total Quality Management methodology, such as Six Sigma. These process improvement tools and techniques include: DRIVE (Define, Review, Identify, Verify, Execute), process mapping, flow-charting, force field analysis, cause and effect, brainstorming, Pareto analysis, Statistical Process Control (SPC), Control charts, bar charts, 'dot plot' and tally charts, check-sheets, scatter diagrams, matrix analysis and histograms. The effective use of these tools and techniques requires their application by the people who actually work on the processes, and their commitment to this will only be possible if they are assured that management cares about improving quality.

DRIVE is an approach to problem solving and analysis that can be used as a part of process improvement.

- Define – the scope of the problem the criteria by which success will be measure and agree the deliverables and success factors.
- Review – the current situation, understand the background, identify and collect information, including performance, identify problem areas, improvements and “quick wins”
- Identify – improvements or solutions to the problem, required changes to enable and sustain the improvements
- Verify – check that the improvements will bring the benefits that meet the defined success criteria, priorities and pilot the improvements
- Execute – plan the implementation of the solutions and improvements, agree and implement them, plan a review, gather feedback and review.

2.4.1 Ishikawa Diagram

Ishikawa diagrams (also called fishbone diagrams, herringbone diagrams, cause-and-effect diagrams, or Ishikawa) are causal diagrams created by Kaoru Ishikawa (1968) that show the causes of a specific event. Common uses of the Ishikawa diagram are product design and quality defect prevention, to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify these sources of variation. Causes in the diagram are often categorized, such as to the 6 M's, described below.

The 6 Ms (used in manufacturing industry)

- Machine (technology)
- Method (process)
- Material (Includes Raw Material, Consumables and Information.)
- Man Power (physical work)/Mind Power (brain work): Kaizens, Suggestions
- Measurement (Inspection)
- Milieu/Mother Nature (Environment)

Cause-and-effect diagrams can reveal key relationships among various variables, and the possible causes provide additional insight into process behavior. These groups can then be labeled as categories of the fishbone. They will typically be one of the traditional categories mentioned above but may be something unique to the application in a specific case. Causes can be traced back to root causes with the 5 Whys technique.

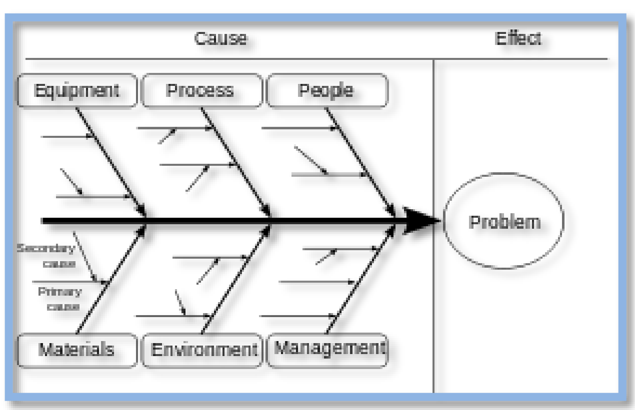

Figure 2.3: Example of Ishikawa diagram

2.4.2 Pareto Chart

A Pareto chart is a bar and line chart that displays data in a hierarchical order identifying where any given problem occurs most frequently. A Pareto Chart (also called a Pareto Diagram) is a unique type of bar chart with the values ordered from largest to smallest and a superimposed line graph showing the cumulative total. The line graph uses the secondary axis (the axis on the right side) with values between 0% and 100%.

The Pareto Principle, or 80-20 Rule, is a general rule-of-thumb or guideline that says that 80% of the effects stem from 20% of the causes. Vilfredo Pareto originally observed that in Italy, 80% of the land was owned by 20% of the people. Dr. Joseph M. Juran, a 20th century evangelist for quality management, applied this principal to quality control and preferred the use of the phrase "the vital few and the useful many" to describe the 80-20 rule.

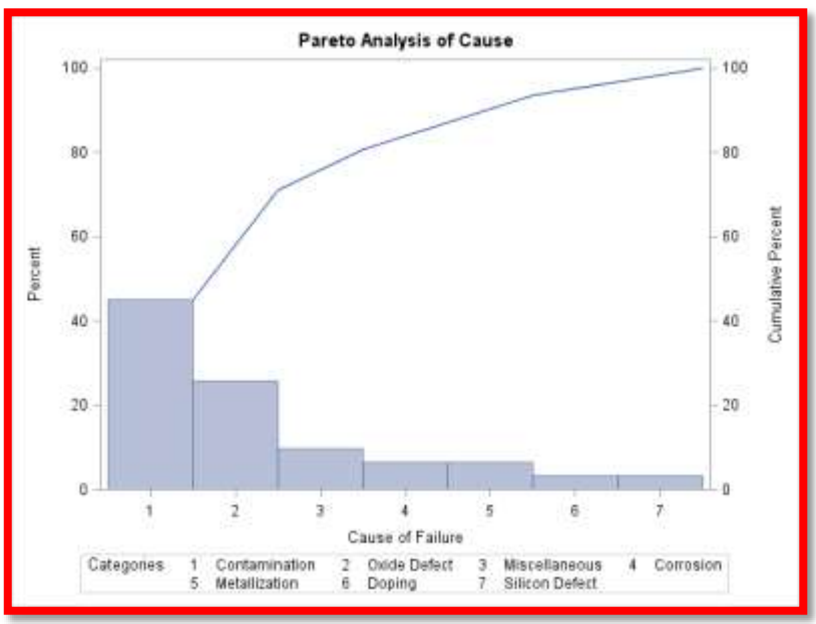

Figure 2.4: Example of Pareto Chart

2.4.3 Control Chart

Control charts, also known as Shewhart charts (after Walter A. Shewhart) or process-behavior charts, in statistical process control are tools used to determine if a manufacturing or business process is in a state of statistical control. If analysis of the control chart indicates that the process is currently under, then no corrections or changes to process control parameters are needed or desired. In addition, data from the process can be used to predict the future performance of the process. If the chart indicates that the monitored process is not in control, analysis of the chart can help determine the sources of variation, as this will result in degraded process performance. A process that is stable but operating outside of desired limits, for example, scrap rates may be in statistical control but above desired limits needs to be improved through a deliberate effort to understand the causes of current performance and fundamentally improve the process. (William McNeese, 2006).

A control chart is a statistical tool used to distinguish between variations in a process resulting from common causes and variation resulting from special causes. It preset a graphic display of process stability or instability overt time. Every process has variation. Some variation may be the result of causes which are not normally present in the process. This could be special cause variation. Some variation is simply the result of numerous, ever-present differences in the process. This is common cause variation. Control Charts differentiate between these two types of variation. One goal of using a Control Chart is to achieve and maintain process stability. Process stability is defined as a state in which process has displayed a certain degree of consistency in the past and is expected to continue to do so in the future. There are two types of control charts which are attribute data and variables data. Control chart are used to identify process variation over time which in the other words is the process for identifying processes that are out of control. The degree of variance and the causes of the variance can be determined using control charting techniques. (Philip L Ross, 1998)

2.4.3.1 Control Chart Techniques

In order to establish a pair of control charts for the average ($\bar{X}$) and the range (*R)*, it is desirable to follow a set procedure. The steps in this procedure are as follows:

1. Select the quality characteristics

   The variable that is chosen for an ($\bar{X}$) and R chart must be a quality characteristics that is measurable and can be expressed in numbers. Those quality characteristics affecting the performance of the product or service will normally be given first attention. These maybe a function of the raw materials, component parts, subassemblies or finished parts. In other words, give high priority to the selection of those characteristics that are giving difficulty in terms of production problems and/or cost.

2. Choose the rational subgroup

   The data that are plotted on the control chart consist of groups of items that are called rational subgroups. It is important to understand that data collected in a random manner do not qualify as rational. A rational subgroup is one in which the variation within the group is due only to chances causes. This within-subgroup variation is used to determine the control limits. Variation between subgroup is used to evaluate long-term stability.

3. Collect the data

   This step can be accomplished using the type of form shown in Table 2.2, where in the data are recorded in a vertical fashion. By recording the measurements one below the other, the summing operation for each subgroup will become easier. The last row in the table shows the difference between successive measures. The difference is called the “range”.

Table 2.2: Examples of a set of sample data

MONTH	**MODULE**	***RANGE***
JAN	106	n. a.
FEB	72	34
MARCH	44	28
APRIL	90	46
MAY	51	39
JUNE	83	32

4. Determine the trial central line and control limits

   The central lines called $\bar{X}$ since the measurement values are plotted on the X-axis of a graph, is:

$$\bar{X} = \frac{\sum_{i=1}^{g} X}{g} \qquad (2.5)$$

Where $\bar{X}$ = average of the subgroup averages

X = value of the ith subgroup

g = number of subgroups

The average of the moving range, called $m\bar{R}$ is:

$$m\bar{R} = \frac{\sum_{i=1}^{g} R}{g} \qquad (2.6)$$

Where $m\bar{R}$ = average of the moving range

R = value of the ith subgroup

g = number of subgroup

To put this data onto a control chart, we need to generate the upper and lower control limits (UCL and LCL, respectively). One technique to calculation the control limits is to use an equation that approximates standard deviation:

$$UCL = \bar{X} + (2.66 \times m\bar{R}) \tag{2.7}$$

$$LCL = \bar{X} - (2.66 \times m\bar{R}) \tag{2.8}$$

5. Establish the revised central line and control limits
   The first step is to post the preliminary data to the chart along with the control limits and central lines. This has been accomplished and is shown in Figure 2.5. The next step is to adopt standard values with the available data. Good control can be briefly described as that which has no out-of-control point, no long runs on either side of the central line, and no unusual patterns of variation.

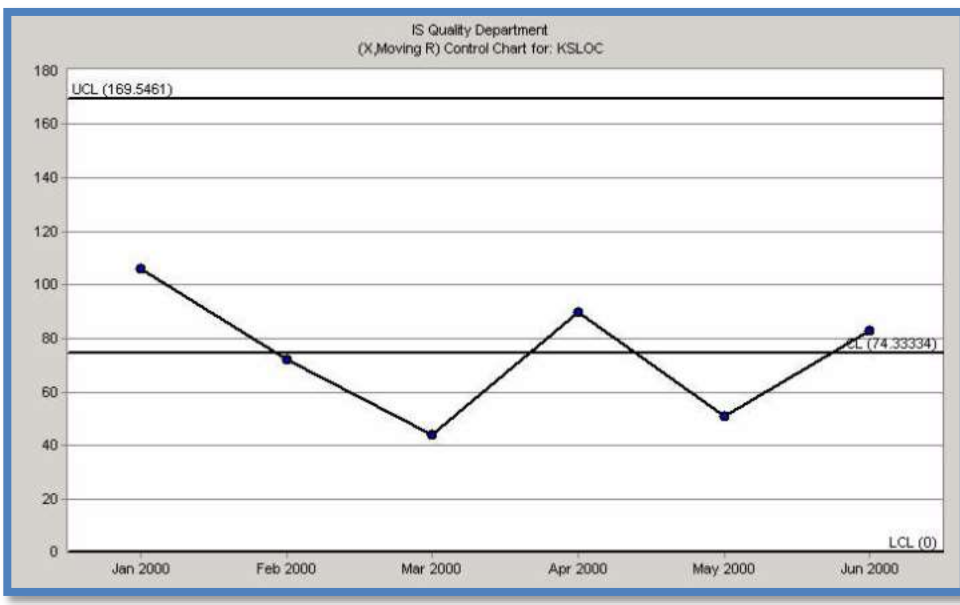

Figure 2.5: Example of X chart

6. Achieve the objectives

   When control charts are first introduced at a work center, an improvement in the process performance usually occurs. This initial improvement is especially noticeable when the process is dependent on the skill of the operator. Posting a quality control chart appears to be a psychological signal to the operator to improve performance. Most workers want to produce a quality product; therefore, when management shows an interest in the quality, the operator responds. The generation of ideas by many different personnel is the most essential ingredient for continuous quality improvement. When the objectives for initiating the charts has been achieved, its use should be discontinued or the frequency of inspection be substantially reduced to a monitoring action by the operators. Efforts should then be directed toward the improvement of some other quality characteristics. If a project team was involved, it should be congratulated for its performance and disbanded. (Dale H. Besterfield, Quality Control Eighth Edition, page 202)

2.5 5 WHYS

The application of the 5-whys analysis in a manufacturing industry provides a fact-based and structured approach to problem identification and correction that not only reduces, but also totally eliminates defects. Corrective action has permanently eliminated the top defect, which is the “last piece material scratch” and this results in zero scrap thereafter. It was also proven that with sound understanding of manufacturing coupled with possible solutions using the 5-whys analysis were not only able to eliminate waste, but also to do it with zero-cost. (Saravanan Muthaiyah, 2010)

5-why analysis, used throughout the kaizen concept and in quality control, is a tool to discover the root causes of a problem. More often than not, people fix a problem by dealing with issues that are immediately apparent. While it may provide a quick fix, the problem tends to rear its ugly head in the same form, or with a different face later on. Fixing the problem by nipping it in the bud is what all leaders and associates should aim to do. (Karn G. Bulsuk, 2009)

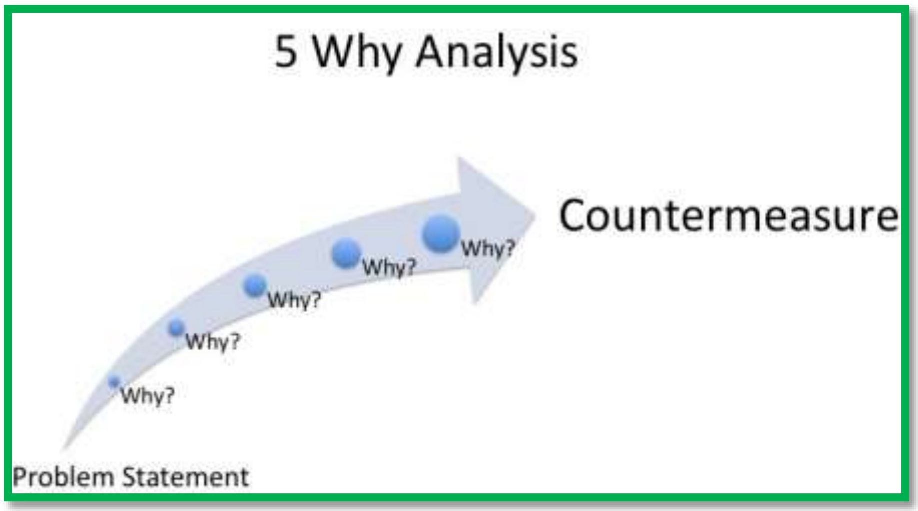

Figure 2.6: Example of 5 Whys Analysis

2.6 5 W 1 H

5W1H (who, what, where, when, why, how) is a method of asking questions about a process or a problem taken up for improvement. Four of the W's (who, what, where, when) and the one H is used to comprehend for details, analyze inferences and judgment to get to the fundamental facts and guide statements to get to the abstraction. The last W (why) is often asked five times so that one can drill down to get to the core of a problem. (Pradeep Mahalek, 2010)

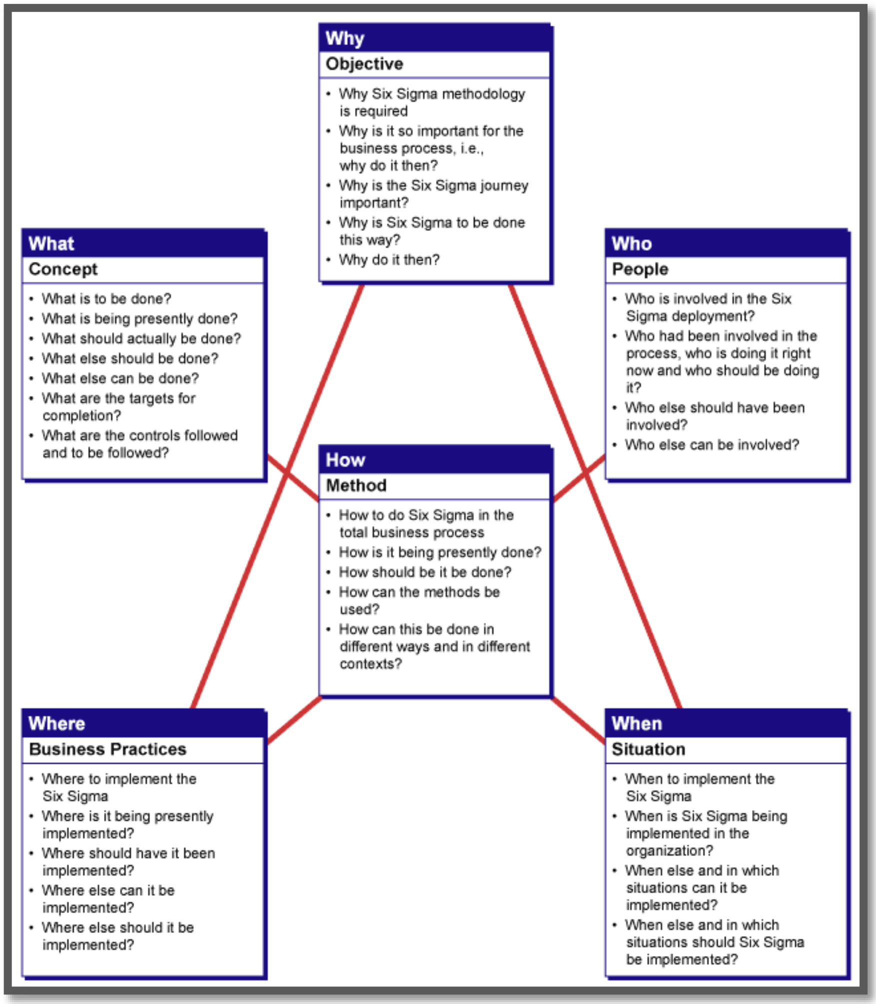

Figure 2.7: Example of 5W 1H

2.7 EQUIPMENT FAILURE

An "Equipment Failure" occurs when a piece of our electrical equipment, such as a transformer or a cable, stops working. Troubleshooters will identify the equipment that stopped working and, when possible, repair immediately. If additional equipment or support is needed, a crew will be called to bring in the additional equipment and restore power as quickly and as safely possible. (Gary Fore, 2009)

CHAPTER 3

METHODOLOGY

This chapter describes the research methods that will be used to conduct this study. A methodology can be considered to include multiple methods, each as applied to various facets of the whole scope of the methodology. It can be defined also as the study or the description of method. The observation is the direct observation of events that happen at Moulded Inductor area for HM72A-10 Series model. The flow chart in Figure 3.1 shows the steps that have been taken in doing this research while the Gantt chart (Appendix A1) shows the time frame schedule to conduct this research.

3.1 EXPLANATION OF FLOWCHART

3.1.1 Field Research

Field research deals with creation and collection of actual and authentic information by field of operation in any organization. It is also can be defined as the collection of information outside of the laboratory and workplace setting. The process involves determining what precise data is necessary and from where this information needs to be obtained, methods: informal interviews, direct observation, participation in the life of the group, collective discussions, analyzes of personal documents produced within the group, self-analysis, and life-histories.

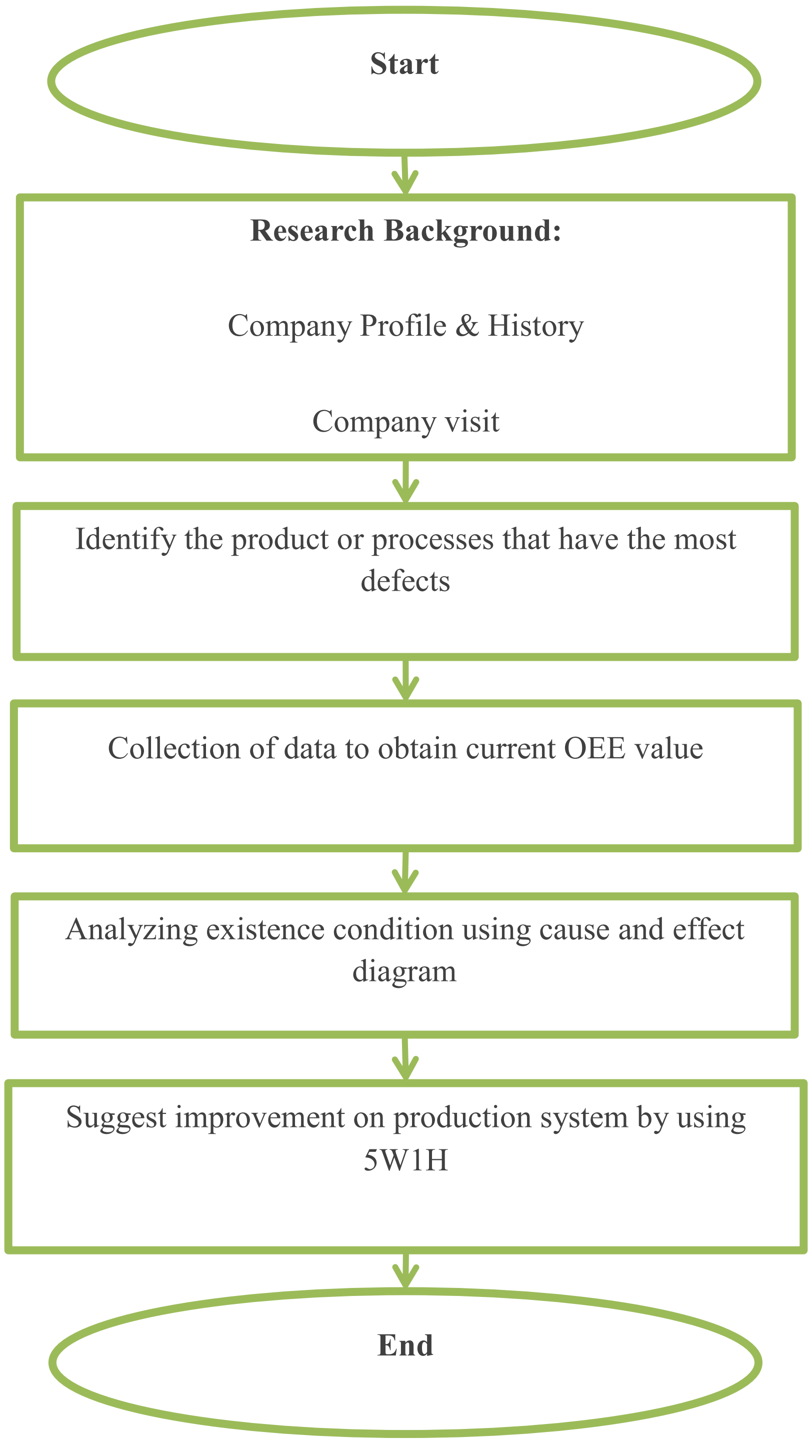

Figure 3.1: Flow Chart of the Project

At this stage, the method used is focus on the direct observation in order to collect the information in general view of the problem at the selected company.

First of all, a company must be selected to make the observation and case study. An application letter was drafted and sent to BI Technologies at Tanjung Api Kuantan. The appointment of the company visit is done each time before visiting. During the visit, the Quality Department engineer briefly explained the background of the company; types of the products produce in BI Technologies, BI Technologies main customers and how the product is produced. After the briefing, a visit to the production line and Quality Control Department were organized by the engineer to get the whole picture of how the parts are produced. A few problems in producing are highlighted by the engineer and all the problems are jotted down for analysis purpose.

3.1.2 Problem Identification

Problem identification is actually seeing the problem before trying to solve it. In other word, it is a first strategy in solving a problem. First, it has to realize and accept there is a problem. Once the problem have identified, then do the observation and reflect what is going on, gather the information that is related and begin working on the solution. For this step, there are a few problems detected especially at the Moulded Inductor section area where component HM72A-10 Series is produced that might influence the quality level of products although they have implemented Lean Production System in this factory. BI Technologies is not fully-automated where they require humans to manually assemble the components from the beginning until the final product which is why the probability for the product to assemble incorrectly and the tendency for defects are high. The level of training given to the operator is also not enough which explains their lack of skills in handling the equipment. Therefore, leads to equipment failure and tooling damage.

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3.1.3 Data Collection for OEE calculation

Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables to answer stated research questions, test hypotheses, and evaluate outcomes.

The method of data collection is by using Overall Equipment Effectiveness (OEE). There are mainly two ways for retrieving OEE input data; manually or automatically. The manual data collection method consisted of a paper template, where the cause and state changes in equipment and performance are identify. Next, duration of a breakdown, total time of production and comments could be made about minor stoppages and speed losses are taken for calculation.

3.1.4 Analyze Existing Condition

Analysis is the process of breaking a complex topic or substance into smaller parts to gain a better understanding of it. In this research, the relevant data is collected and then move to the next process which is analysis the data. For analyze the data, the existing OEE value are then compared to World-class OEE value in order to look for the causes and set a target in the future for an improvement. Next, there are some tools that has been use such as Control Chart, Ishikawa diagram, Pareto chart, 5 Whys and 5W 1H. One of the main purposes of analysis the data is to find the root causes of the problem, highlighting useful information, suggesting conclusions, and supporting decision making.

3.1.5 Conclusion and Recommendation

A conclusion is to tie together, or integrate the various issues, research, covered in the body of the paper, and to make comments upon the meaning of all of it. This includes noting any implications resulting from the discussion, as well as recommendations and the need for further research. For the recommendation it is about to recommend the best solution to improve the quality of product by reducing the number of defects occur.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents the analysis of the QC data obtained from BI Technologies Sdn Bhd. The data were been presented manually and with aid of Overall Equipment Effectiveness calculation. The output of the data is observed and compared for further analysis.

4.1 DATA COLLECTION

4.1.1 Company Background

Incorporated in 1976, BI Technologies Corporation Sdn. Bhd. covered up by 101,300 sq ft per area is a part of TT Electronics group of companies. With the six Group Core Values which are customer driven, integrity, passion for excellence, people focused, innovative problem solving and teamwork, BI Technologies has become a leading manufacturer of precision magnetic component for the Malaysian electronic industry. This company delivers performance critical solutions, turning research and technology into innovative products. Working closely with world leading manufacturers, this company target markets with strong fundamental growth dynamics where the pace of deployment of electronics is being driven by increasing demands in terms of performance and reliability. BI Technologies also are accredited from SIRIM QAS International and DQS Medizinprodukte GmbH for a good design and manufacture of magnetic device, a good manufacture of resistive devices and connectors and a good manufacture of printed circuit board assemblies, electronic assemblies, and sub-assemblies for electronic industry. ISO 9002 and MS ISO 9001 for a good Quality of Manufacturing Management System and flexible production line. Figure 4.1 shows the certificates of the company succeed from 1993 until 2010.

Certificate type	Version	Certification Body	Certified Since
ISO 9001	2008	SIRIM QAS International	1993
TS 16949	2009	SIRIM QAS International	2006
ISO 14001	2004	SIRIM QAS International	2009
ISO 13485	2009	DQS Medizinprodukte GmbH	2010
ISO 9001	2008	DQS GmbH	2010

Figure 4.1: Company Certificates based on ISO

There are four global businesses serving for multiple industries in this corporation company which are IMS, Sensors, Components and Secure Power. Figure 4.2 show the customer of the product based on the percentage of global business serving. The percentage of Components has the highest serve which is 41% where there are 11 companies in the world have involved to serve the product including BI Technologies Corporation Sdn. Bhd, IRC AFD, IRC WAFT, BI Technologies ECD, Optek Technology, Semelab, AB Microelectronic, Welwyn Components, AB Connectors, AB Interconnect and New Chapel Electronics. Meanwhile, the percentage of product serving for IMS and Sensors are 17% and 28% respectively. For IMS, there are three companies that produce this product which are TTe IMS (Suzhou), TTe IMS (Perry OH) and TTe IMS (Malaysia). This is also the same with the product serving for Sensors which are produce by AB Electronics, AB Electronic Sachsen and Padmini (JV). The percentage of product serving for Secure Power has the lowest serve which is only 14% and is consist of two companies which are Ottomotores and Dale Power. It has the lowest serve because the customer need for the product is not as much as Components, IMS and Sensors.

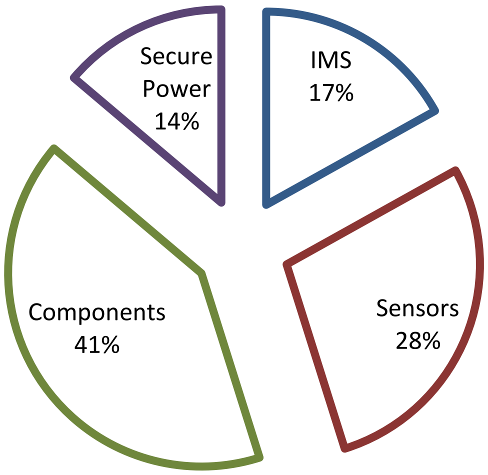

Figure 4.2: Percentage of each product produce at TT Electronics

4.1.2 Organizational Structure

There are about 447 personnel in Bi Technologies which is divided into 7 divisions. The divisions at Bi Technologies consist of Finance, Human Resource, Customer Service and Planning/Shipping, Production Engineering, Operation, Quality and Purchasing. Bi Technologies is led by Mr. Allen Hilton as the Managing Director of the company and he is assisted by his executive secretary, Mrs. Angie Kong. Bi Technologies have 431 direct labor, 9 Process Engineer and 7 Product Design Engineer. Mr Podzi as the Operation Manager while Mr Rashidi Jamaluddin as the Quality Assurance Manager.

The group of Production Engineering is being led by Mr. Cs Teor as Production Engineer Manager and for Process Engineer, it is being led by Mr Akhyani Badri as Process Engineer Manager and the last one is a group of Finance which is being led by

Jeya Jeyapaalan as Finance Director. The structure of the organization is as in Figure 4.3.

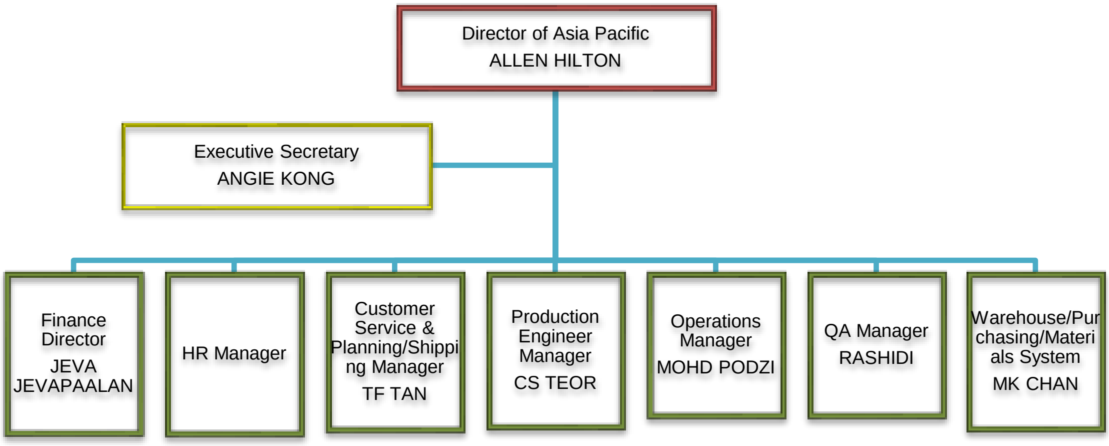

Figure 4.3: BI Technologies Corporation Sdn. Bhd. Organizational Chart

4.1.3 Service Integration

To further empower BI Technologies industrial advantage, BI Technologies are always committing resources to a new and dynamic R&D initiatives with advanced design, drawing and CAD technologies for design and Development of Custom Magnetic Component**.**

Testing expertise is a key element to assure that BI Technologies meet their customer's quality and specifications. To maximize their competitive edge and to ensure complete support to their customers, they made large capital-intensive investment in high-end testing equipment. A significant amount of capital is often invested to design, build and implement a system so that product can be made uniformly at a high rate with minimal waste. Figure 4.4 shows the BI Technologies Magnetics Component Division quality assurance process gate.

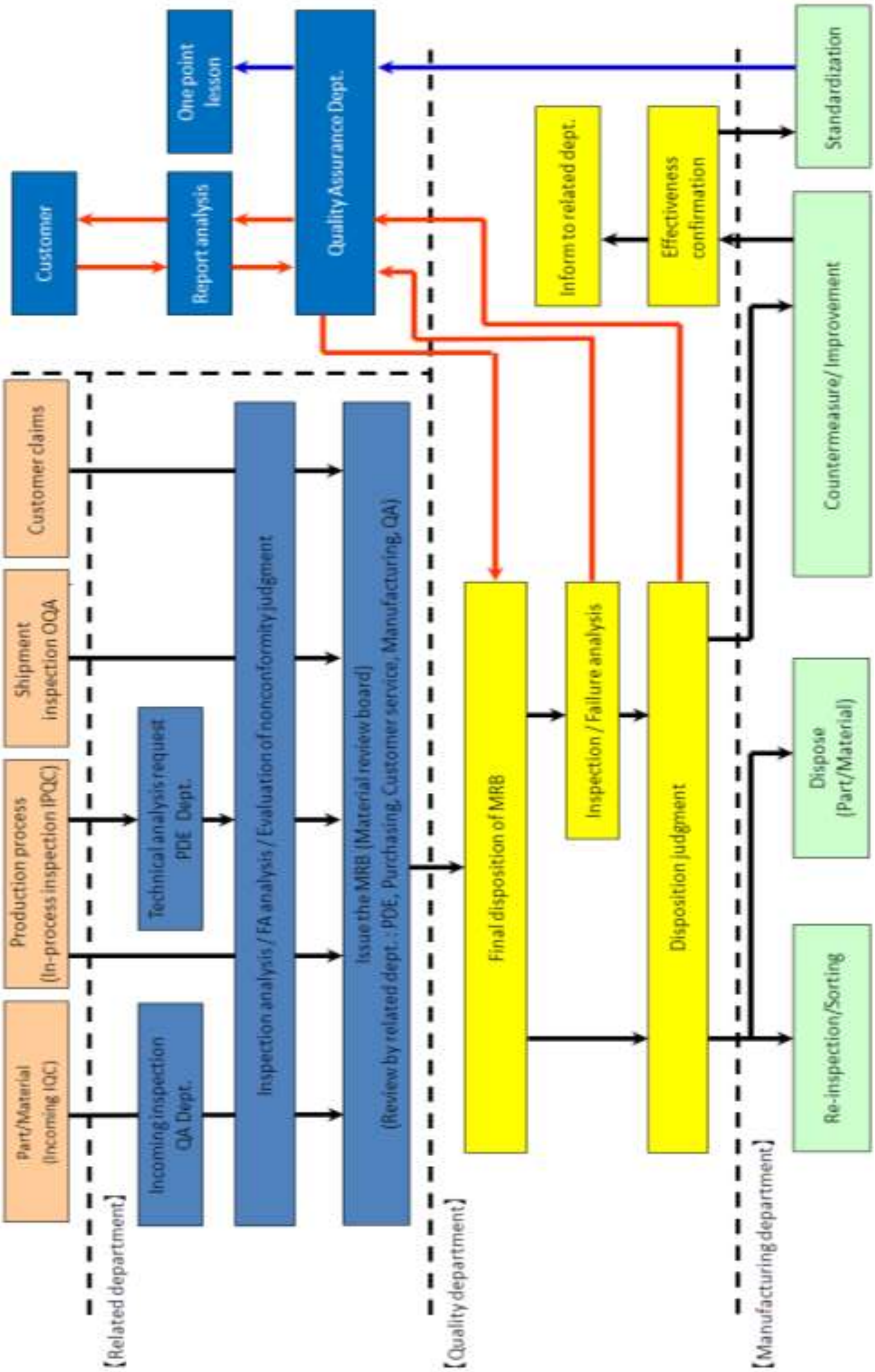

Figure 4.4: BI Technologies MCD Quality Assurance Process Gate

4.1.4 Types of model at Moulded Inductor section

BI Technologies mainly focus more on production of magnetics components such as power and signal, inductors SMD and through hole, Molded Inductor and Lamination Transformer. Other components are also M44 Trimming potentiometers, Thin Film Test and Pack, and also Military connectors. There are four production line which are magnetic line where the standardization and customize design of Transformers and Inductors product are done, M44 Potentiometers trimming and assembly line, CNC area which capable to wind or form flat/rectangular wire and round wire air coil, production of high power, high performance SMD Inductor with air coil molded into Iron Powder press.

Moulded Inductor is “High power low cost molded SMD Inductor” which are used in electronic technologies such as computer, optoelectronics and as a connector in electronic product. There are four types of moulded inductor produce in BI Technologies, Kuantan and the chosen component is HM72A-10 Series.

Table 4.1: High power low cost molded SMD Inductor produce in BI Technologies

 **HM72A-06 SERIES** (Size: 7.23mm x 6.6mm)	 **HM72B-06 SERIES** (Size: 7.23mm x 6.6mm)
 **HM72A-10 SERIES** (Size: 11.5mm x 10.5mm)	 **HM72A-12 SERIES** (Size: 13.5mm x 13.0mm)

4.1.5 Manufacturing Process

All four series of the moulded inductor are fabricated at BI Technologies. The process flow for each series from the beginning until the end of the product are observed and studied in order to have a better understanding.

4.1.5.1 Production Process of HM72A-10 Series (Flat Wire) model

The winding and stripping process of HM72A-10 Series (Flat Wire) are done manually by the operator.

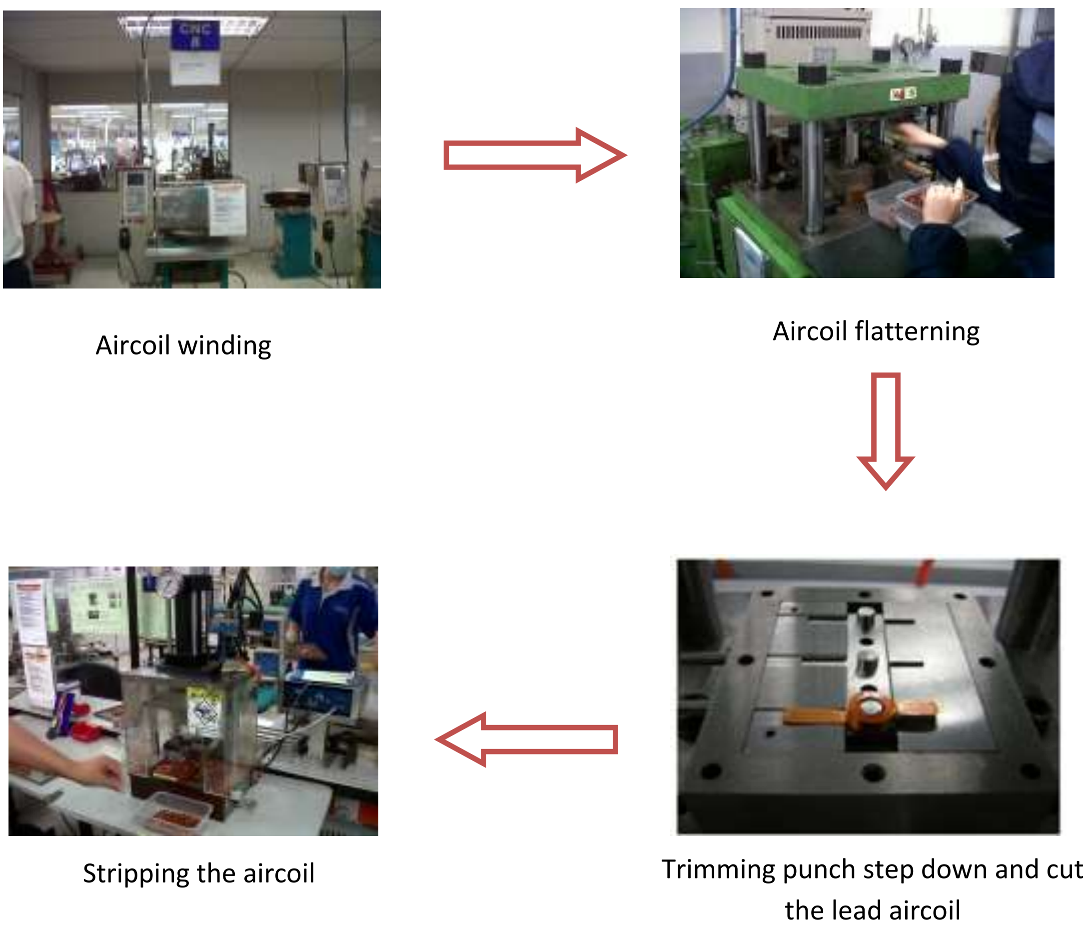

Figure 4.5: The steps in making the HM72A-10 Series model

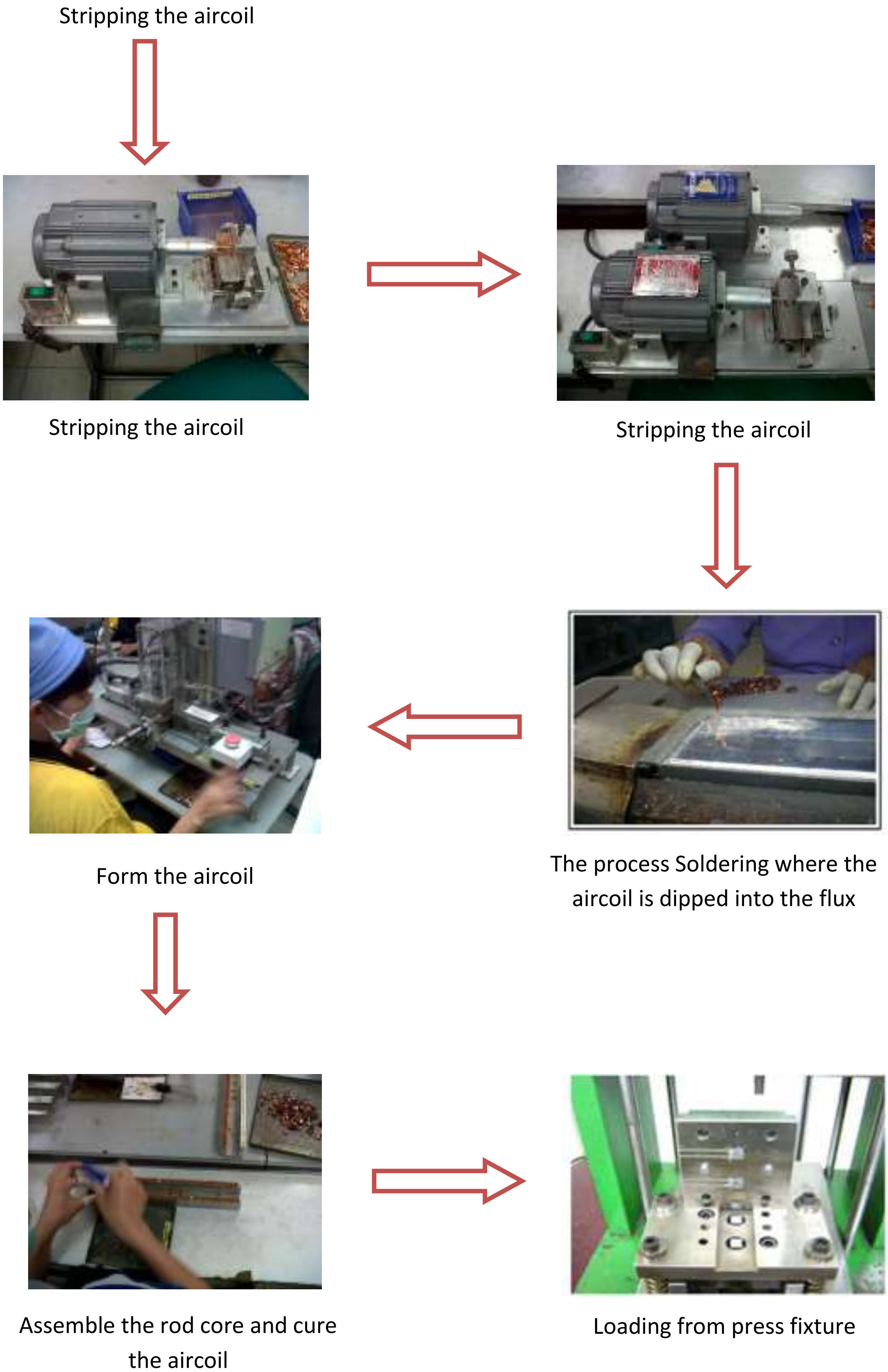

Figure 4.5: The steps in making the HM72A-10 Series model (continue)

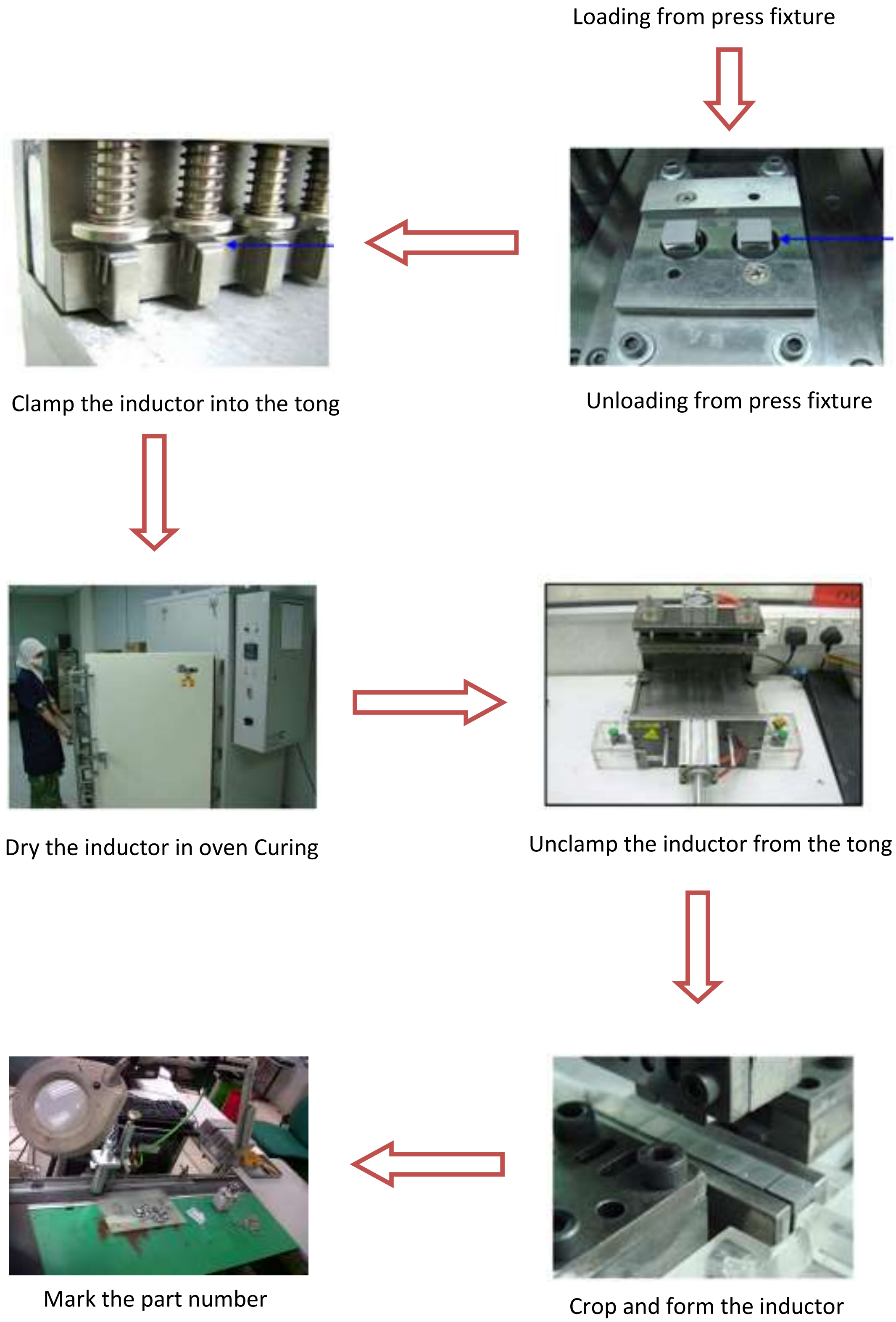

Figure 4.5: The steps in making the HM72A-10 Series model (continue)

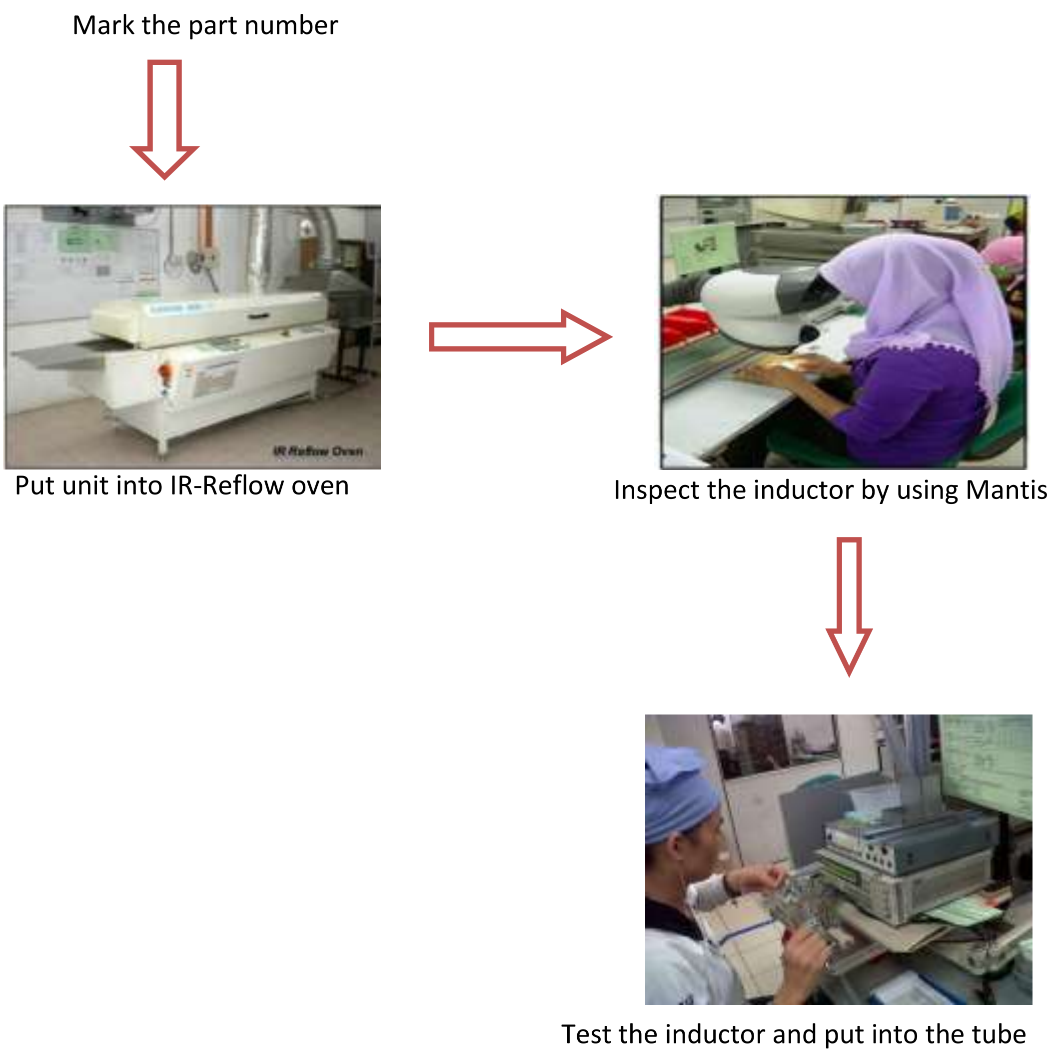

Figure 4.5: The steps in making the HM72A-10 Series model

4.1.6 Company Manufacturing Philosophy

Every factory attempts to be an effective, low cost producer. This effort is required in today's challenging environment when customers demand quality product at the best value. Few factories attain and maintain high level productivity and low costs. Many of these use a disciplined approach to identify the best improvements to make. They use teams to eliminate the root problems that otherwise keep the factory from driving toward continuously higher levels of effectiveness.

4.2 EXISTING CONDITION IN BI TECHNOLOGIES SDN. BHD.

4.2.1 TQM Evaluation

At any given factory, a vast number of events occur simultaneously every workday. The tasks of producing goods and maintaining equipment usually hold the central focus. Approval and rejection of products can affect overall operations for years to come that otherwise keep the factory from driving toward continuously higher level of effectiveness. In short, to achieve the desire target value of Overall Equipment Effectiveness.

Therefore, problems are identified by using Bar Chart analysis to show comparisons among categories. Figure 4.6 shows the Bar Chart analysis represents the number of defects for each component in month January, February and March. It shows that component HM72A-10 Series has the highest defects among the other components. Therefore, this study will focus more on component HM72A-10 series to identify the root and causes of such defects to occur.

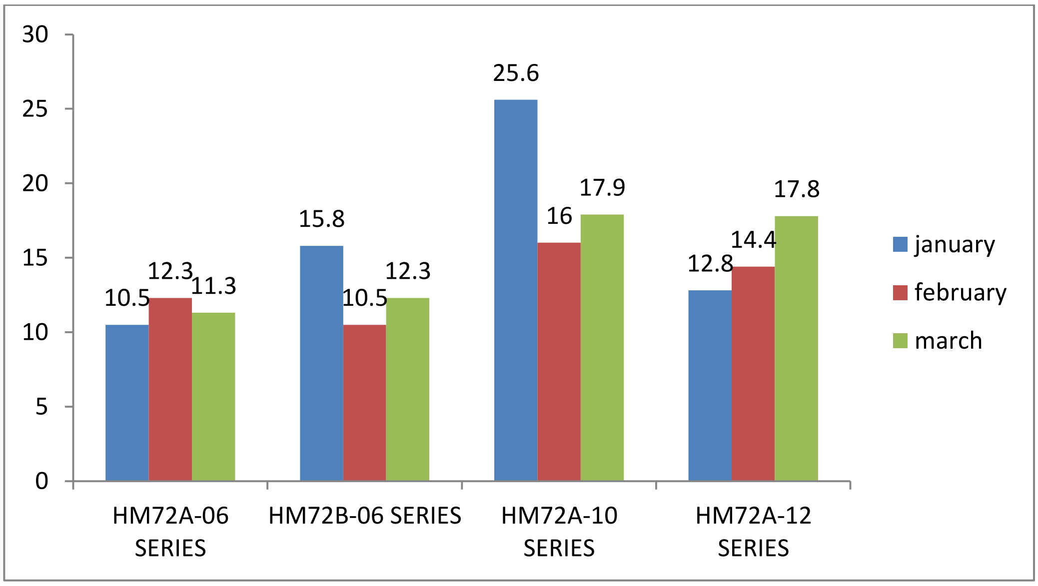

Figure 4.6 : Number of defects occur in January, February and March

4.2.2 Calculation of Existing Overall Equipment Effectiveness

True OEE multiplies factors that represent availability, performance and quality. The result can be expressed as a percentage of effectiveness that directly correlates with actual factory floor output, and can be reconciled 100 percent. OEE should be first applied to the bottlenecks that affect throughput or any other critical and costly areas of a manufacturing line. Here, component HM72A-10 series has been taken into considerations. In developing the OEE formulas, the answers to the following questions must be identified:

1) How many units that meet specifications were made and transferred to the next step?
2) How much time was scheduled for production of that product?
3) What is the ideal or best theoretical cycle time or throughput for units of that product?

With this information, an accurate OEE data collection for the component HM72A-10 series can be generated as shown in Table 1.2. Data are taken every day excluding off day which are Saturday and Sunday for the month January, February and March.

Table 4.2: Machine Production Data

Machine Data	Values
Shift length (8 hours)	480 minutes
Run time	375 minutes
Breaks	60 minutes
Setup time	15 minutes
Downtime	30 minutes
Total time	420 minutes
Ideal Cycle time	1 part every 63 secs

Total count	360
Good count	355
Target counter	400

Table 4.3: Processing data

Process Data	Formula	Result
Run Time	Total Production Time of the machine	375
Total Time	Down Time + Run Time + Setup Time	420
Good Count	Total Good Parts Produced on the Machine	355

Table 4.4: Calculation of OEE

OEE Variables	Formula	Result
Availability	Runtime / Total Time	375 ÷ 420 = 89.29%
Performance	Total Count / Target Counter	360 ÷ 400 = 90.00%
Quality	Good Count / Total Count	355 ÷ 360 = 98.61%
OEE	Availability × Performance × Quality	79.24%

4.2.3 Calculation of Control Chart

In order to indicate when observed variations in quality are greater than could be left to chance, the control chart method of analysis and presentation of date is used. The control chart method for variables is a means of visualizing the variations that occur in the central tendency and dispersion of a set of observations. Table 1.5 shows the data for control chart in January, February and March. 64 samples of data were taken during these months excluding the weekends. With this information, a control chart for the component HM72A-10 series can be generated as shown in Figure 4.7. Data are taken every day excluding off day which are Saturday and Sunday for the month January, February and March.

Table 4.5: Calculation for control chart for January, February and March

Month	sample	DAYS (N)	OEE	UCL	Average	LCL	RANGE
January	1	1	76.27	90.9	78.4	66.0	0
	2	2	80.3	90.9	78.4	66.0	4.03
	3	3	80.49	90.9	78.4	66.0	0.19
	4	4	73.98	90.9	78.4	66.0	6.51
	5	7	77.8	90.9	78.4	66.0	3.82
	6	8	83.89	90.9	78.4	66.0	6.09
	7	9	80.2	90.9	78.4	66.0	3.69
	8	10	81.81	90.9	78.4	66.0	1.61
	9	11	80.39	90.9	78.4	66.0	1.42
	10	14	88.4	90.9	78.4	66.0	8.01
	11	15	72.3	90.9	78.4	66.0	16.1
	12	16	74.8	90.9	78.4	66.0	2.5
	13	17	81.9	90.9	78.4	66.0	7.1
	14	18	89	90.9	78.4	66.0	7.1
	15	21	77.9	90.9	78.4	66.0	11.1
	16	22	77.4	90.9	78.4	66.0	0.5
	17	23	80.67	90.9	78.4	66.0	3.27
	18	24	87.5	90.9	78.4	66.0	6.83
	19	25	79.55	90.9	78.4	66.0	7.95
	20	28	84.44	90.9	78.4	66.0	4.89
	21	29	75.66	90.9	78.4	66.0	8.78
	22	30	83.2	90.9	78.4	66.0	7.54
	23	31	77.9	90.9	78.4	66.0	5.3
FEBRUARY	24	1	79.64	90.9	78.4	66.0	1.74
	25	4	83	90.9	78.4	66.0	3.36
	26	5	76.3	90.9	78.4	66.0	6.7
	27	6	78.55	90.9	78.4	66.0	2.25
	28	7	73.7	90.9	78.4	66.0	4.85
	29	8	78.99	90.9	78.4	66.0	5.29
	30	11	80.1	90.9	78.4	66.0	1.11
	31	12	79.46	90.9	78.4	66.0	0.64
	32	13	76.3	90.9	78.4	66.0	3.16
	33	14	78.6	90.9	78.4	66.0	2.3
	34	15	76.55	90.9	78.4	66.0	2.05
	35	18	80.49	90.9	78.4	66.0	3.94
	36	19	80.14	90.9	78.4	66.0	0.35
	37	20	79.38	90.9	78.4	66.0	0.76
	38	21	86.1	90.9	78.4	66.0	6.72
	39	22	76.83	90.9	78.4	66.0	9.27
	40	25	74.99	90.9	78.4	66.0	1.84
	41	26	74.59	90.9	78.4	66.0	0.4
	42	27	61.99	90.9	78.4	66.0	12.6
	43	28	76.25	90.9	78.4	66.0	14.26
MARCH	44	1	76.43	90.9	78.4	66.0	0.18
	45	4	78.9	90.9	78.4	66.0	2.47
	46	5	79.66	90.9	78.4	66.0	0.76
	47	6	79.1	90.9	78.4	66.0	0.56
	48	7	78.25	90.9	78.4	66.0	0.85
	49	8	79.09	90.9	78.4	66.0	0.84
	50	11	74.09	90.9	78.4	66.0	5
	51	12	73.21	90.9	78.4	66.0	0.88
	52	13	79.54	90.9	78.4	66.0	6.33
	53	14	72.85	90.9	78.4	66.0	6.69
	54	15	75	90.9	78.4	66.0	2.15
	55	18	76.8	90.9	78.4	66.0	1.8
	56	19	80	90.9	78.4	66.0	3.2
	57	20	79.55	90.9	78.4	66.0	0.45
	58	21	63	90.9	78.4	66.0	16.55
	59	22	81	90.9	78.4	66.0	18
	60	25	78.73	90.9	78.4	66.0	2.27
	61	26	76.27	90.9	78.4	66.0	2.46
	62	27	79.07	90.9	78.4	66.0	2.8
	63	28	84	90.9	78.4	66.0	4.93
	64	29	76.06	90.9	78.4	66.0	7.94
TOTAL			5018.3				295.03

Based on Figure 4.7, with the value of 78.4 as the central line, 90.9 and 66.0 as the upper control limit and lower control limit respectively, it is noted that the OEE values in the month January mostly falls near to the upper control limit which are 88.4, 89 and 87.5 meanwhile there are two OEE values in the month February and March which are 61.99 and 63 falls below the lower control limit; therefore indicates the process is out of control based on BI Technologies organization policies.

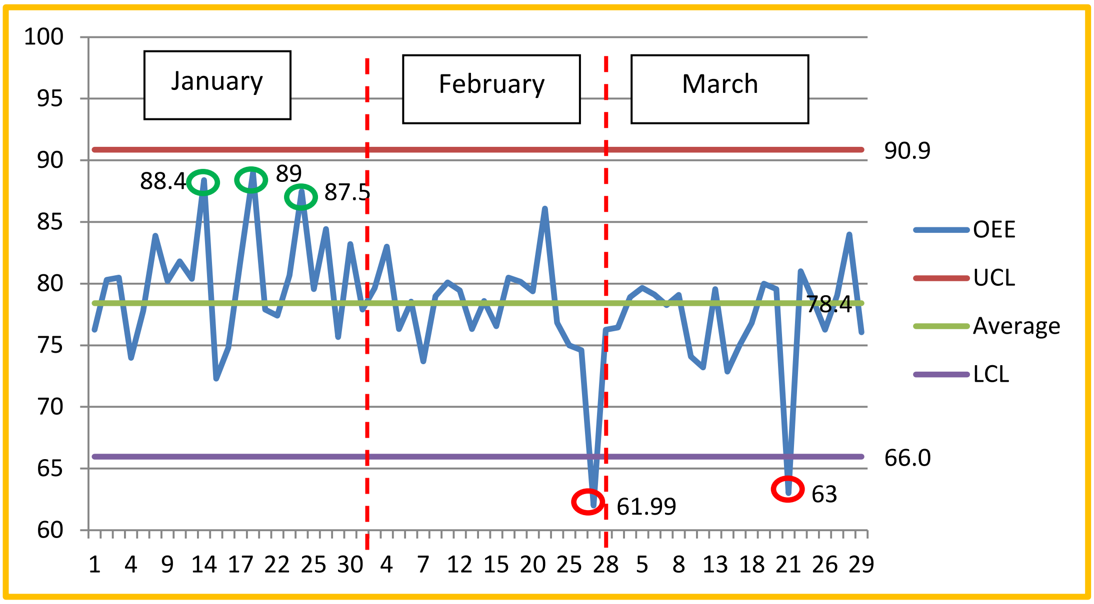

Figure 4.7 : Control Chart of OEE percentage for the month January, February and March

4.2.3.1 Comparison to World-Class OEE

To compare to the world class OEE level, any values that falls below 65% are unacceptable. The company should seek for help since hidden money is slipping away. 65% to 75% are passable only if quarterly trends are improving. 75% to 85% is pretty good. However, if this is continuous, it will drive to a world class level. More than 90% is considered excellent. Using OEE metrics and establishing a disciplined equipment performance reporting system will help any manufacturing area to focus on the parameters critical to its success. Analyzing OEE categories can reveal the greatest limits to success.

4.2.3.2 Target OEE

It is obvious that BI Technologies have achieved above the average range of OEE value. Figure 4.8 shows the target OEE Control Chart for HM72A-10 series where only the OEE values above the average are taken. Generally, to obtain the only good OEE values are by minimizing six big losses such as equipment failure, lost time for setup and adjustment, idle equipment and minor stoppages, reduced equipment speed, process defects and reduced equipment yield.

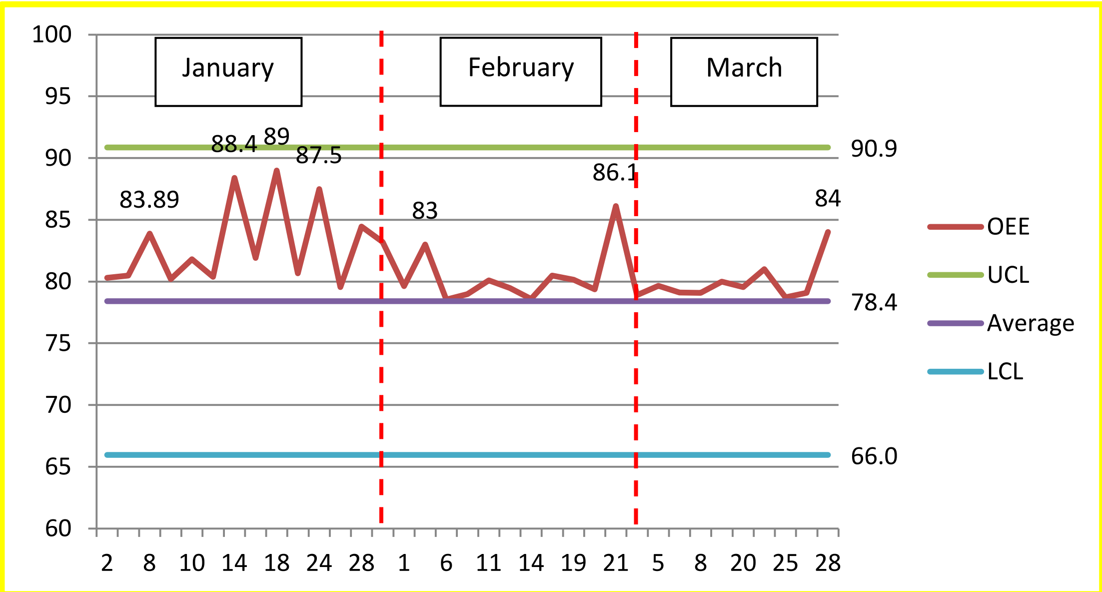

Figure 4.8: Target OEE Control Chart for HM72A-10series

4.3 DATA ANALYSIS

Analysis of data is a process of inspecting, cleaning, transforming, and modeling data with the goal of highlighting useful information and supporting decision making. Some of the tools that will be used are Pareto Chart, Ishikawa Diagram and 5W 1H in order to find the solutions to these problems. Improvement and recommendations are then proposed.

4.3.1 Explanation of OEE Control Chart

Based on Figure 4.7, it is noted that on date February 27th and March 21st with OEE value of 61.99% and 63% respectively falls below the lower control limit of 66%. This is considered undesirable under the organization policies. Meanwhile there are 3 points that are dated on January 14th, 18th and 24th, which are 88.4%, 89% and 87.5% falls above the target range of OEE. They have achieved the world class goals of OEE.

Table 4.6 shows the machine production data on January 14th, 18th and 24th, February 27th and March 21st.

Table 4.6: Data production on critical dates

	Values				
Machine Data	**14-Jan**	**18-Jan**	**24-Jan**	**27-Feb**	**21-Mar**
Shift length (8 hours)	480	480	480	480	480
Run Time	380	380	375	365	370
Breaks	60	60	60	60	60
Setup Time	10	10	15	25	20
Down Time	30	30	30	30	30
Total Time	420	420	420	420	420
Ideal Cycle Time	1 part every 63 secs	1 part every 63 secs	1 part every 63 secs	1 part every 63 secs	1 part every 63 secs
Total Count	377	380	375	378	377
Good Count	362	371	356	335	338
Target Counter	400	400	400	400	400
Process Data					
Run Time	380	380	375	365	370
Total Time	420	420	420	420	420
Good Count	362	371	356	335	338
OEE VARIABLES					
Availability	90.48%	90.48%	89.29%	86.90%	88.10%
Performance	94.25%	95.00%	93.75%	94.50%	94.25%
Quality	96.02%	97.63%	94.93%	88.62%	89.66%
OEE	88.40%	89%	87.50%	61.99%	63%

To improve the situation that happens on February 27th and March 21st are reducing the downtime losses. The amount of time needed to start and end production must be minimized. To minimize setup time, the company must first improve operator performance in handling equipment and machines. Downtime is the most critical factor to improving OEE because when the process is not running, the other metrics cannot be address. Table 1.7 shows the list of problems happen to the Moulded Inductor machine on January 14th, 18th and 24th, February 27th and March 21st.

February 27th and March 21st has the highest rate of problems happen compare to the other dates. Based on the Pareto analysis on Figure 4.8, it is noted that Powder adjustment are the major causes of the machine breakdown followed by crack, planned tooling P/M and hydraulic failure. These in turn lowers the performance rate during that day. After conducting a Q&A session with the production engineer, is it found that there are no hydraulic failure during January 14th, 18th and 24th due to machine maintenance event. 5S activity and inspection were also carried out on those specific dates by the management. Employees were also given multiple trainings on equipment handling a week before those dates.

4.3.2 Possible causes of High Rates of Defects by using Ishikawa Diagram

To identify the root cause of this problem, one of the 7QC tools have been used which is Ishikawa diagram. Figure 4.9 shows the Ishikawa diagram to analyze why defects rate are higher on February 27th and March 21st. There are four major possibilities that cause to this problem. There are machine, man, method and environment.

i. Man

There are two main causes that involve operators at Moulded Inductor section. First, replacement and unskilled operator causes the misassemble of HM72A-10 Series product. To prove this statement, Figure 4.10 shows the education status of employees at BI Technologies according to their level of school and skills. Most of the replacement operators have lack of knowledge on the process therefore this will create a lot of problems. They should be given adequate training before being appointed to their task.

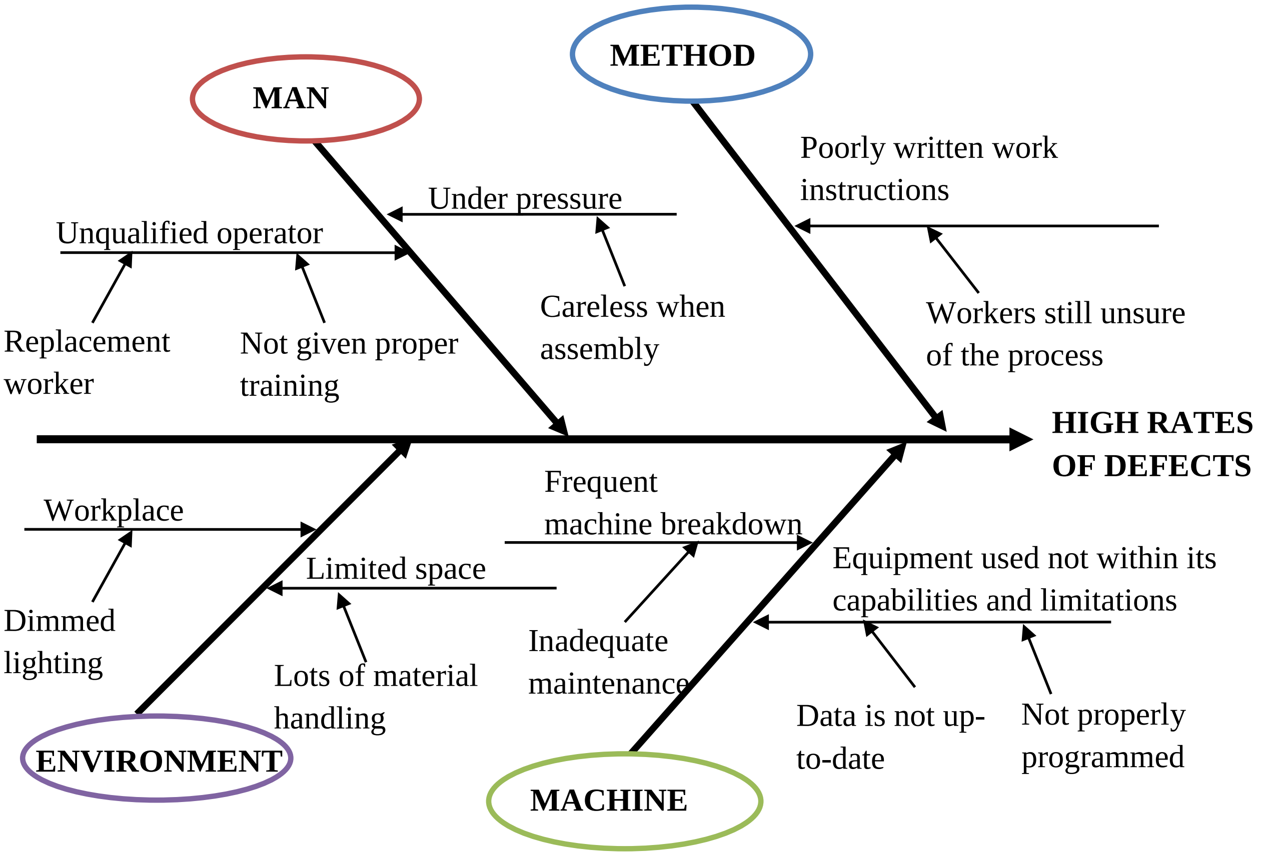

Figure 4.9: Root cause analysis by using Ishikawa Diagram

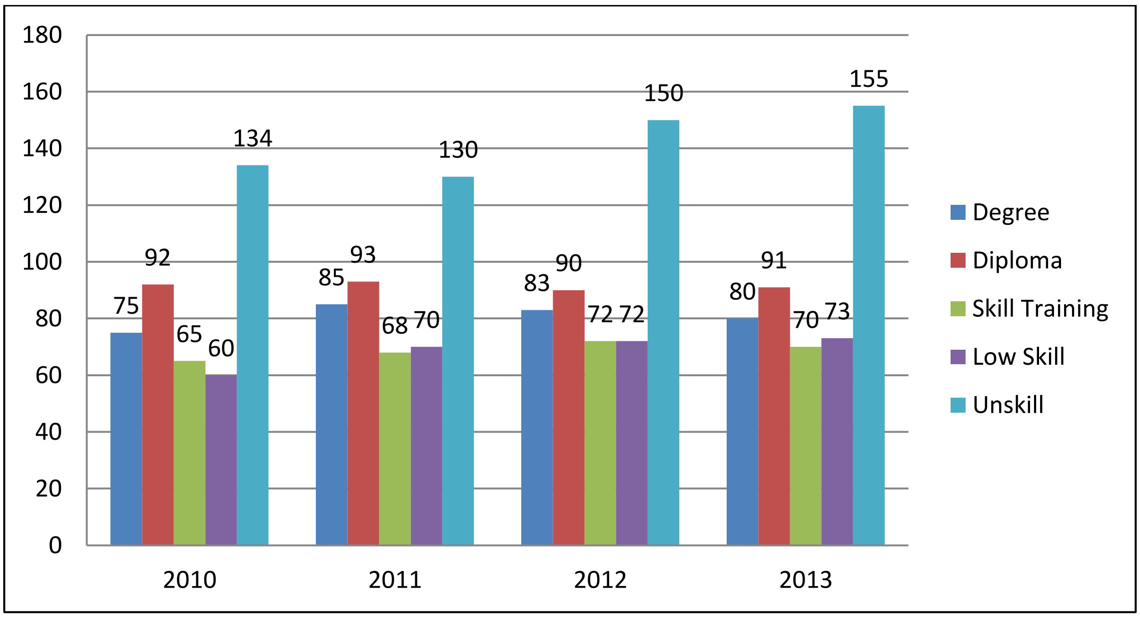

Figure 4.10: Education Status for employees at BI Technologies Sdn. Bhd.

ii. Method

The possible cause that leads to high defects under method section is poorly written Work Instruction that made the operators still unsure of the process. Figure 4.11 shows a picture of the Work Instruction that is being display clearly at the work cell in order for the operators to have a better look and understanding of the process. The only possibility of the operators to misunderstand it is the difficulties to understand the Work Instruction which is only written or translated in English despite the fact that most of the operators are from Myanmar.

Figure 4.11: Work Instruction displayed clearly at the work cell

iii. Environment

For environment, the minor possibility that causes the defects to occur is the insufficient lighting near by the operator's work cells.

iv. Machine

This is the major causes that need to be concentrated because it gives a big reason on how the frequent machine breakdown causes by the delay of maintenance could leads to unplanned downtime losses to the company. Figure 4.12 shows the pareto analysis of machine breakdown for component HM72A-10 series. System failure is the major cause that leads to machine breakdown, followed by broken tool, powder adjustment, hydraulic failure, converting of model and waiting units. To add to this problem, the equipment used is also not within its capabilities and limitations. Data and tools calibrations are not up to date and are not replaced when worn out.

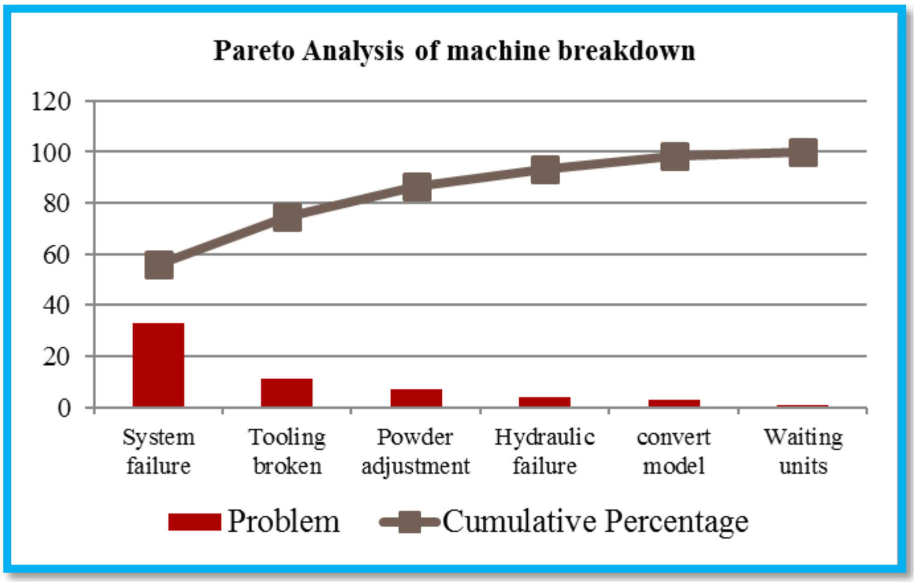

Figure 4.12: Pareto Analysis of Machine Breakdown

4.3.3 Root-Cause Analysis of Factors of Defects

RCA practice tries to solve problems by attempting to identify and correct the root causes of events, as opposed to simply addressing their symptoms. By focusing correction on root causes, problem recurrence can be prevented. RCFA (Root Cause Failure Analysis) recognizes that complete prevention of recurrence by one corrective action is not always possible.

Table 4.7 shows the root analysis breakdown of the possible causes that leads to defects. Skill matrix are provided in the factory to avoid operators been given tasks that are not within their expertise, therefore this is not a major factor that leads to defects. Inspections on the operators work and with the Standard Operation Procedure are conducted to identify if it is one of the major reason for high rates of defects to occur. Here, Work Instruction are clearly displayed at the workplace, it not a factor to the defects. Based on the data collection from BI Technologies daily production report and with the aid of Question and Answer session held with the Production Engineer, En. Rashidi, it shows that machine is the major factor that leads to defect.

Table 4.7: Root cause analysis of problem

	Causes	How to check?	Result
MAN	Unqualified operator	Skill matrix	Not a factor for the defects
ENVIRONMENT	Workplace	Site visit	Not a factor for the defects
MACHINE	Frequent machine breakdown	Data collection from daily production report Q&A session with PE	A factor to the defects
METHOD	Poorly written work instruction	Check SOP and compare to the work done by operator	Not a factor foo the defects

4.3.4 5 Whys on Frequent Machine Breakdown

The method known as 5-Why or 5-Whys is an analysis method used to dig below the outward symptoms, which is frequent machine breakdown in order to find its real root cause. This methodology is closely related to the Cause & Effect (Fishbone) diagram, and can be used to complement the analysis necessary to complete a Cause & Effect diagram.

Why: Frequent machine breakdown?
Answer: System machine failure

Why: System machine failure?
Answer: Tightener misalignment

Why: Tightener misalignment?
Answer: Not replacing worn part when needed

Why: Not replacing worn part when needed?

Answer: Maintenance team ignore warning signals

Why: Maintenance teams ignore warning signals?

Answer: BI Technologies has not implement Total Preventive Maintenance and this leads to maintenance delay

4.3.5 Improving by using 5W 1H method

From the Table 4.7 above, the problems are identified. Next, 5W1H method will be used to improve problems happen at the Moulded Inductor production area. The information are gathered through What, Why, Who, Where and How question. It will be shown in Table 4.8.

Table 4.8: Improve problem by using 5W1H method

What are the ways to reduce system machine failure?	• Adjusting the mix of reactive, preventive, predictive and proactive maintenance strategies so workers can focus on doing the right things at the right time • Better preventive maintenance (PM) can reduce early failures while better maintenance can reduce failures during the wear-out period
When to apply?	• Reactive maintenance – "fix it when it breaks", most basic maintenance strategy. The cost to repair (or replace) equipment that's run to failure is typically much higher than if the problem were detected and fixed earlier – not to mention the cost of lost production during extended downtime • Preventive maintenance – equipment is serviced on a calendar- or run-time basis,

Table 4.8: Improve problem by using 5W1H method

	whether it needs it or not, this "fix it just in case" approach is about 30% less expensive than reactive maintenance • Predictive maintenance – constantly monitoring actual equipment condition and using the information to predict when a problem is likely to occur. With this insight, you can schedule maintenance for the equipment that needs it – and only what needs it – before the problem affects process or equipment performance. A great way to improve maintenance productivity, as well as reduce costs for repairs and unexpected downtime
Where to apply?	• Both machines and manpower
Who should take part?	• The whole organization
Why?	• Avoid premature failure plus lubrication, cleaning, adjusting, calibration and the replacement of minor components to extend equipment life, all applied throughout the life cycle of the equipment.
How can this help?	• These actions tend to reduce the variability of equipment life-spans because equipment problems are being more carefully identified by operators and corrected more quickly • Conduct training to improve skills. Specialized maintenance skills training is provided to maintainers to ensure they are competent in the latest, best diagnostic and repair techniques.

4.4 DISCUSSION

The vast majority of these improvements usually come from non-capital projects. Changes to basic procedures often reduce bottlenecks. Changing supply or distribution policies can help manage bottlenecks. Significant equipment reliability improvement may result by changing maintenance methods or substituting different materials. Focused projects, such as Reliability-centered Maintenance, can provide major increases in uptime.

4.4.1 Non-production activities

When the focus is only on production, and non-production activities are ignored or undervalued, poor work practices develop in off-line work that eventually impacts OEE. Improvement on non-production tasks:

1. Reduce planned maintenance downtime
2. Use pre-assembled equipment modules to "swap out", reducing replacement time
3. Staff work areas appropriately to cover lunches, breaks, weekends and holiday
4. Train and educate workers off-line
5. Hold multiple meetings to communicate with employees before or after shifts. This avoids work stoppage for full community meetings
6. Improve reliability of delivery
7. Improve transitions to new equipment modifications

4.4.2 Why factories fail?

A bigger problem was the resistance to change; new methods and good practices presented for the managers to implement were met with numerous excuses and delays.

Next, directing and redirecting people, events, and actions leave no time for gathering data, documenting processes or validating information.

It is also when motivated workers become frustrated when managers never have time to address or implement their suggestions and recommendations. Scheduling and planning must undergo change on a daily, not hourly basis.

Certain specialized workers were needed on multiple jobs; therefore some jobs had delayed starts. Some contractors were not able to locate their proper work area and lost time seeking directions. Not unexpectedly, the work was not accomplished in the day that had been set by production. Startup had to be delayed. Most of the borrowed employees from within the plant had to report back to their original working areas; thus, resources dwindled. The final result, not all tasks were accomplished and the startup was not smooth. Overtime was high, effectiveness was poor, and operating schedules were delayed. All of these results acted negatively on the bottom line.

Active leadership from knowledgeable managers is needed routinely and consistently on the plant floor. The workforce should be educated and engaged with the principles and methods that can make a great improvement. Top-down leadership that drives aggressive OEE strategy will accelerate the win-win outcome for everyone.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

In this chapter, a conclusion will be made based on the research done on previous chapter. A few recommendations are also given to enhance and improve the production system performance at BI Technologies, Kuantan.

5.1 CONCLUSION

As a conclusion, analyzing the existing Overall Equipment Effectiveness to improve the production system performance at BI Technologies resulted in positive activity of Total Quality Management (TQM). Constantly monitoring actual equipment condition and using the information to predict when a problem is likely to occur can significantly reduce unplanned downtime in the factory. From the calculation and possible solution that has been figured out, one can schedule maintenance for the equipment that needs it, and only what needs it before the problem affects process or equipment performance. By avoiding premature failure plus lubrication, cleaning, adjusting, calibration and the replacement of minor components to extend equipment life, all applied throughout the life cycle of the equipment. From the analysis of the OEE tool, its evolution and application in the industries, it is concluded that OEE is a valuable measure that provides information on the sources of lost time and lost production. It is a great way to improve maintenance productivity, as well as reduce costs for repairs and unexpected downtime.

The challenging part while completing this project is requesting some data from the company. Most of the data are confidential and require time to be approved by the head of department before giving out to the writer. Nevertheless, objectives has been achieved.

Many manufacturing companies have capacity constraints and consider adding overtime, hiring new workers or buying new equipment. The bottom line is a modest investment to optimize the performance of their existing machines may outweigh the major investment to purchase new equipment. By reducing downtime, minimizing setup time and improving operator performance, a manufacturing company can unleash hidden capacity and benefit from monitoring OEE data.

5.2 RECOMMENDATION

Every studies or researches that have been done, there are always have a space for further improvements. Here are some suggestions and method that can be used for better improvements in this study in the future:

- Initiating automous (operator) maintenance
- Applying a competent schedule maintenance program
- Increasing the skills of operators and maintenance personnel
- Applying these factors to specific types of equipment

One of the countermeasures is by emphasizing more on preventive maintenance to improve equipment effectiveness and tries to involve all employees in the effort. Targets zero breakdowns and zero defects when possible. As defects are reduced, the availability of equipment will increase while costs are reduced, product inventory is minimized, and productivity is increased. These actions tend to reduce the variability of equipment life-spans because equipment problems are being more carefully identified by operators and corrected more quickly

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APPENDICE

APPENDIX B

PROCESS FLOW HM72A-10/12 SERIES (FLAT WIRE-FLATENNING REQUIRED)

APPENDIX C

HM72A-10 SERIES PRODUCT YIELD

APPENDIX D

MACHINE DOWNTIME DATA FOR JANUARY, FEBRUARY AND MARCH