UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's Full Name : AINA NADIA AIDA BT MOHD LATIF
Identification Card No :
Title : IMPROVEMENT OF AVAILAILITY RATE OF OVERALL EQUIPMENT EFFECTIVENESS (OEE) FOR CNC WINDING MACHINE

Academic Session : 2014/2015

I declare that this thesis is classified as:

☐	**CONFIDENTIAL**	(Contains confidential information under the Official Secret Act 1972)
☐	**RESTRICTED**	(Contains restricted information as specified by the organization where research was done)*
☑	**OPEN ACCESS**	I agree that my thesis to be published as online open access (Full text)

I acknowledge that Universiti Malaysia Pahang reserve the right as follows:

1. The Thesis is the Property of University Malaysia Pahang.
2. The Library of University Malaysia Pahang has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

Aina Nadia Aida Bt Mohd Latif (Dr. Faiz Bin Mohd Turan)

Date: 02.JUL.2015 Date: 01.JUL.2015

IMPROVEMENT OF AVAILABILITY RATE OF OVERALL EQUIPMENT EFFECTIVENESS (OEE) FOR CNC WINDING MACHINE

AINA NADIA AIDA BT MOHD LATIF

Thesis submitted in fulfilment of the requirements
for the award of the degree of
B. Eng (hons) Manufacturing Engineering

Faculty of Manufacturing Engineering
UNIVERSITI MALAYSIA PAHANG

JUNE 2015

DEDICATION

"At the Almighty, for His praise offered and grace that he owns the Creator and the universe and knowledge in the world and in the hereafter."

For parents loved.
Mohd Latif B. Muda & Robiah Bt Mohd Nor.
A lot of support and help to prepare this report.

For a family member, a brother and sister.
Which gave little space and time.

For final year project supervisor, Dr Faiz Bin Mohd Turan
Thank you for your guidance and knowledge granted.

To colleagues.
Equally share the sad and happy

EXAMINER APPROVAL DOCUMENT

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MANUFACTURING ENGINEERING

We certify that the project entitled "Improvement of Availability Rate of Overall Equipment Effectiveness (OEE) For CNC Winding Machine" is written by Aina Nadia Aida Bt Mohd Latif. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of B. Eng (hons) Manufacturing Engineering.

(DR. AKM ASIF IQBAL)
Examiner

DR. AKM ASIF IQBAL
SENIOR LECTURER
FACULTY OF MANUFACTURING ENG...
UNIVERSITI MALAYSIA PAHANG
26600 PEKAN
PAHANG DARUL MAKMUR
TEL: +609-424 5835 FAX: +609-42...

Signature

PROF. MADYA DR. ISMED ISKANDAR
FAKULTI KEJURUTERAAN PEMBUATAN
UNIVERSITI MALAYSIA PAHANG
26600 PEKAN
PAHANG DARUL MAKMUR
TEL: 09-424 5834 FAKS: 09-424 5888

(PROF. ISMED ISKANDAR)
Examiner

Signature

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of B. Eng. (hons) Manufacturing Engineering

Signature
Name of Supervisor: DR FAIZ BIN MOHD TURAN
Position: LECTURER
Date: 01. JUL. 2015

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except 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

Name: AINA NADIA AIDA BT MOHD LATIF

ID Number: FA11003

Date: 02.JUL.2015

ACKNOWLEDGEMENT

I am grateful and would like to express my sincere gratitude to my supervisor Dr Faiz Bin Mohd Turan for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his outstanding professional conduct, his strong conviction for science, and his belief that a degree program is only a start of a life-long learning experience. I am truly grateful for his progressive vision about my training in engineering, his tolerance of my naïve mistakes, and his commitment to my future career.

My sincere thanks go to all my FYP mates and members of the staff of the Manufacturing Engineering Department, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable. Many special thanks go to member engine research group for their excellent co-operation, inspirations and supports during this study.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I am also grateful to my parents for their sacrifice, patience, and understanding that were inevitable to make this work possible. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Special thanks should be given to my committee members.

Last but not least, I want to take these favorable moments to express gratefulness to all of them again which are very much appreciated as friends and mentors. Without them, this project would not be perfect.

ABSTRACT

Most of manufacturers seek ways to reduce costs that associated with producing and distributing products. In order to reduce the cost, reduction of the losses is needed to improve the efficiency shop floor. High efficiency of machine needed to get higher profit in the global competition. A smooth production operation and lower downtime in production shows that the plant is in better management and maintenance. This research is proposed to eliminate waste in setting up CNC winding machine using lean techniques and subsequently improve the availability rate of OEE by reducing set up time. This research has conducted at BI Technologies Corporation production area which is at CNC winding area. By using overall equipment effectiveness as a tool, it is used to evaluate how effectively a manufacturing operation is utilized. The element of OEE which is availability, quality and performance. By propose a solution to company which is to improve current SOP and using control chart to investigate the OEE data. Ishikawa diagram also apply to show the root cause from investigation the chart from variation. At the end, the control chart used again to indicate the improvement at CNC winding area. The improvement of downtime will lower down the losses of company, and have higher availability with degree of utilization of the resources available. This paper reports the results of this research, including the results of an industrial implementation.

ABSTRAK

Kebanyakan pengeluar mencari jalan untuk mengurangkan kos yang berkaitan dengan menghasilkan dan mengedarkan produk. Bagi mengurangkan kos, mengurangkan kerugian diperlukan untuk meningkatkan kecekapan kawasan pengeluaran. Kecekapan mesin yang tinggi diperlukan untuk mendapatkan keuntungan yang lebih besar dalam persaingan global. Operasi pengeluaran yang lancar dan masa mesin terhenti yang singkat dalam pengeluaran menunjukkan bahawa kilang mempunyai pengurusan dan penyelenggaraan yang lebih baik. Projek ini bertujuan untuk menghapuskan pembaziran ketika menyelenggara mesin 'CNC winding' menggunakan teknik 'lean'dan seterusnya meningkatkan kadar 'availability' di 'OEE' dengan mengurangkan masa menyelenggara. Kajian ini telah dijalankan di kawasan pengeluaran BI Technologies Corporation tertumpu pada kawasan 'CNC winding'. Dengan menggunakan 'overall equipment effectiveness' sebagai alat, ia digunakan untuk menilai keberkesanan setiap proses pembuatan digunakan. Unsur 'OEE' iaitu 'availability', kualiti dan kemampuan. Situasi yang sempurna ialah untuk mempunyai kadar 'availability'yang tinggi dengan masa menyelenggara mesin 'CNC winding' yang rendah. Dengan menawarkan penyelesaian kepada syarikat dimana dengan memperbaiki 'SOP' sekarang dan menggunakan carta kawalan untuk menyiasat data 'OEE'. 'Ishikawa diagram' juga digunakan untuk menunjukkan punca utama dari siasatan carta dari perbezaan data. Akhir sekali, carta kawalan yang digunakan sekali lagi untuk menunjukkan peningkatan di kawasan CNC winding. Peningkatan masa mesin berhenti akan mengurangkan kerugian syarikat, dan mempunyai 'availability' yang lebih tinggi dengan tahap penggunaan sumber yang ada. Kertas kerja ini melaporkan hasil penyelidikan, termasuk hasil daripada pelaksanaan industri.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

CNC	Computer Numerical Control
FMEA	Failure Mode Effect Analysis
OEE	Overall Equipment Effectiveness
SMED	Single Minute Exchange Of Die
SOP	Standard Of Procedure
CUBES	Capacity Utilization Bottleneck Efficiency System

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Nowadays, manufacturers want to gain competitive advantage on tough global state where it must have a high efficiency, minimize waste and maximize productivity throughout their manufacturing processes. Most of manufacturers seek ways to reduce costs that associated with producing and distributing products. In order to reduce the cost, elimination of the losses is needed to improve the efficiency of shop floor. Furthermore, by improving time to market by producing product faster and bring the product to market faster.

A lean technique usually implements for a manufacturing company, which is to find efficiency and eliminate waste in the shop floor. Lean is a set of tool that used to remove waste within a manufacturing process. The waste eliminates through continuous improvement of processes of the entire value chain in the organization. Having trained a lean manufacturing mindset among the employees, it facilitates the achievement of continuous product flow through physical rearrangement and control mechanisms. So it will improve the production performance at shop floor.

As an engineering student, their main role is as a problem solver other than designing, building and testing. The research is conducted to give new experiences and to enhance the soft skill and implement hard skill in solving the problem in the industry. Research title is an improvement of the availability rate of OEE for CNC winding machine, introduce about one of lean tool that commonly used in industry.

Besides that, this title will contribute profit to the industry or company. Where OEE is one of a tool for lean manufacturing that used to evaluate how effectively a manufacturing operation is utilized. OEE is used to measure the equipment that will present a quality, performance and availability.

For this research, the proposed method solves the problem that occurs in the line where downtime for setup machine. In order to gain profit, student need to gain the production rate and output from the machining line and it can enable manufacturers to achieve world class manufacturing status. Specifically, it can reduce equipment downtime and maintenance costs, plus better management of the equipment life cycles.

This research is be conducted at BI Technology Corporation Sdn. Bhd. which is located at Kuantan, Pahang. BI Technology is a semiconductor company, manufacturer and marketer of passive, magnetics and microcircuit modules for 50 years. These component product lines encompass trimming potentiometers, precision potentiometers, turns-counting dials, chip resistors, power resistors, thick film and precision thin film resistor networks, magnetic components, hybrid microcircuits and custom integration of these technologies.

1.2 PROBLEM STATEMENT

In manufacturing plant, high efficiency of machine needed to get higher profit in the global competition of today. A smooth production operation and lower value of downtime in production shows that the plant is in better management and maintenance. The important condition is for having a high availability rate with lower set up time at CNC winding machine.

However, present condition shows that the CNC winding machine area has a higher set up time which is slow down the production of parts. It happens every time the coil is finished and need to change the new coil. It affects the number of outputs from the machine and also availability of the machine.

Management have the difficulty to apply most suitable measures of improvement the production in terms of productivity and also the efficiency of the production or to reduce the loss on it. Lean technique is used to identify eliminating waste and subsequently improve the set up time. OEE method is the way to measure the effectiveness of equipment. To get their data in production line, OEE is the main method when the line is still in running mode. The company will achieve their monthly/yearly target and can easily plan for their effective improvement in each system when OEE method is applied.

1.3 OBJECTIVE OF PROJECT

1. To eliminate waste in setting up CNC winding machine using lean techniques.
2. To improve the availability rate of OEE by reducing set up time.

1.4 SCOPE OF PROJECT

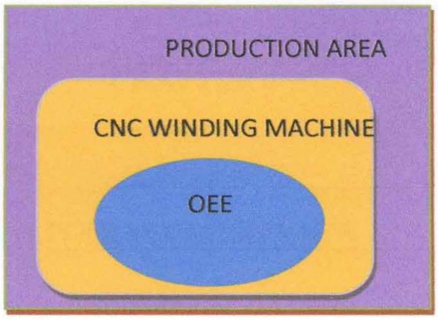


Figure 1.1: Productivity in a company using OEE method

The figure above shows that scope of the project. Our focus at production area where need to get the data and by using OEE as a tool at CNC winding machine.

CHAPTER 2

LITERATURE REVIEW

2.1 LEAN MANUFACTURING

Nowadays, most companies or factories have been experience a struggle and competitive situation to remain their profit for production, reduce waste and improve quality of production. By applying lean manufacturing management, it can help company or factory.

Applications of lean manufacturing have spanned many sectors, including the automotive industry, electronics, white goodsand consumer goods (Fawaz A. Abdulmalek, et. al., 2007; Taho Yang, et. al., 2015). The success of lean manufacturing can be attributed to its ability to attain and realize improved out-puts with less resource in comparison to traditional manufacturing systems (Anita Susilawati, et. a., 2015).

Lean manufacturing management is a tool that used in production to eliminate waste and reduce non-value added operations, improve value added processes and maximize performance (Gulcin Buyukozkan, et. al., 2015). The main purpose of lean manufacturing is to increase productivity, improve product quality and manufacturing cycle time, reduce inventory, reduce lead time and eliminate manufacturing waste (Farhana Ferdousi, et. al., 2009).

The benefit of lean production is having a lower inventory levels, higher quality and operational performance with less waste. (Hofer, et. al., 2012; Gulcin Buyukozkan, et. al., 2009). There are also others benefit that were mention in other journals such as decreased lead times for customers, reduced inventories for manufacturers and improved knowledge management. Figure 2.1 shows the typical benefit when applying lean at non process industry.

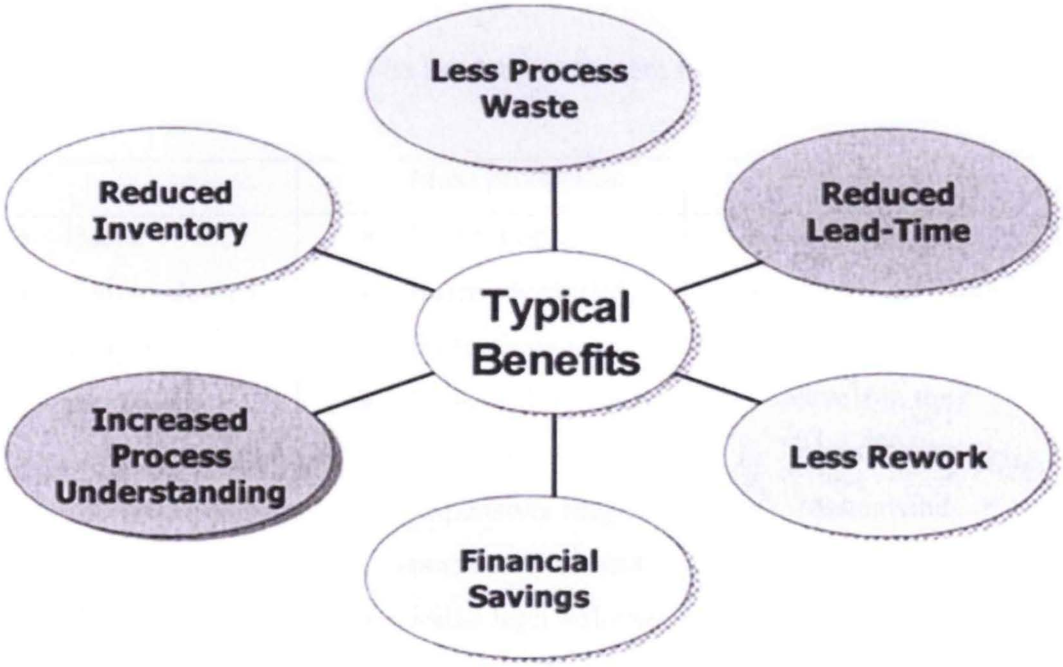


Figure 2.1: The Benefit of Applying Lean

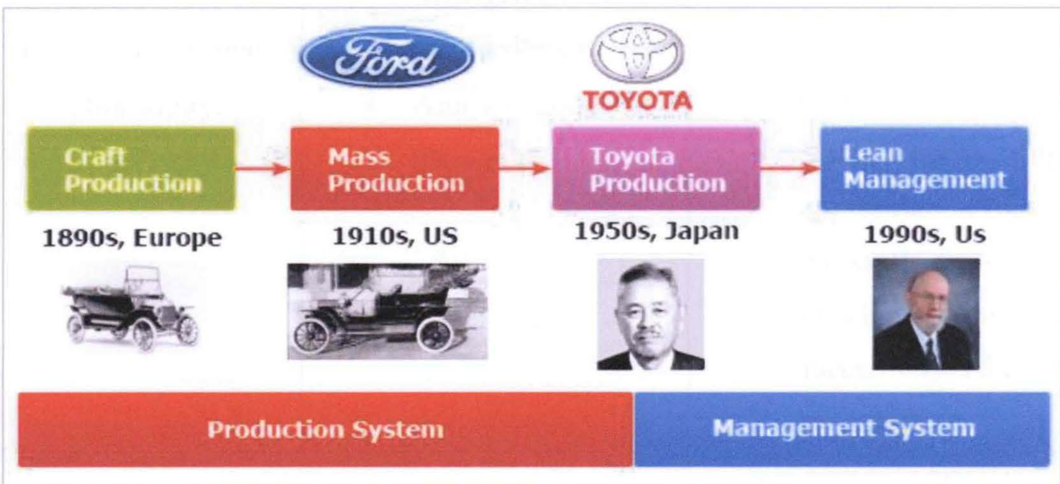


Figure 2.2: History of Lean Management

At the beginning, lean was birth at Japan within Toyota in the 1940s, after World War II (Fawaz A. Abdul Malek, et. al., 2005). It comes from the Henry Ford, Just in

Time Production or Toyota Production System, and other predecessors (Melton T, et. al., 2005). Figure 2.2 below shows that the flow birth of lean management. Table 2.1 shows the comparison of mass production and lean production.

Table 2.1: The Production System Comparison.

	Mass production	Lean production
• Basis. • People–design. • People–production. • Teams of multi-skilled workers at all levels in the organization. • Equipment. • Production methods. • Organizational philosophy. • Philosophy.	• Henry Ford. • Narrowly skilled professionals. • Unskilled or semi-skilled workers. • Expensive, single-purpose machines. • Make high volumes of standardized products. • Hierarchical—management take responsibility. • Aim for 'good enough'.	• Toyota. • Teams of multi-skilled workers at all levels in the organization. • Manual and automated systems which can produce large. • Volumes with large product variety. • Make products which the customer has ordered. • Value streams using appropriate levels of empowerment—pushing responsibility further down the organization. • Aim for perfection.

Source: Melton T, 2005

2.2 OVERALL EQUIPMENT EFFECTIVENESS (OEE)

Overall equipment effectiveness, OEE is a method that usually used by factory floor. OEE is one of a tool from lean manufacturing that used for equipment and machineries used in industry where it is a percentage number. OEE is used to measure the equipment of lines that will present the potential like a quality, performance and availability. In order to prevent the bottleneck and the production run effectively. OEE is include three factor in it, which is availability, performance efficiency and quality rate (Puvanasvaran A.P, et, al., 2013).

Formula OEE = Availability X Performance X Quality (2.1)

Availability (down time loss) = $\frac{\text{Operating Time}}{\text{Planned Production Time}}$ (2.2)

Performance (Speed Loss) = $\frac{\text{T otal Pieces}}{\text{Operating Time}}$) x $\frac{1}{\text{Ideal Run Rate}}$ (2.3)

Quality (Quality Loss) = $\frac{\text{Good Pieces}}{\text{Total Pieces}}$ (2.4)

2.2.1 World class

In practice, the generally accepted World-Class goals for each factor are different from each other. Table 2.2 below shows the factor and percentage for the world class.

Table 2.2: World Class of OEE Factor

OEE Factor	World Class
Availability	90.0%
Performance	95.0%
Quality	99.9%
Overall OEE	85.0%

2.2.2 Time study technique

The aim of time study and motion is to eliminate unnecessary work and design most effective methods and procedures by providing methods of measuring work. To determine a performance index for an individual or group of workers, department or entire plant (Puvanasvaran A.P, et, al., 2013).

Table 2.3: Time Study Types

Time Study Technique	Description
Stopwatch	A conventional method to record and rate the work elements of a specified job done under specific condition and the data are further analyses to determine the standard time for particular job.
Work sampling	A large number of observations are made over a period of time for one or group of machines, processes or workers. This technique aims to measure the percentage of time during.
Predetermine motion time system (PMTS)	A work measurement technique which develop the time for a job using previously established time for the basic human motions in time measurement units (TMU)
MOST	A complete study of an operation or a sub – operation typically where appropriate parameter time values are assigned, resulting in total normal time for the operation or sub – operation.

2.3 ISHIKAWA DIAGRAM

The Ishikawa diagram is the tool that can be used to identify the causes of a problem. Ishikawa diagram also known as a Fish bone diagram which is the complete diagram resembles a fish skeleton. Fish bone diagram are usually used to assist in illustrating the relationships among the potential root causes to problem. It will reduce the risk to forget some causes and provide input for the study of solution. The history of Ishikawa diagram was introduced at Japan by Kaoru Ishikawa.

Typical Ishikawa diagram will show the problem or effect to be resolved, and the causes of the problem are laid out along the 'bone'. The general structure of an Ishikawa diagram is shown in example Figure 2.3.

It is classified into different types along the branches. The sub – causes can be laid out alongside further side branches. And there are other sub – sub cause also can be drawn to details, like Figure 2.3 below.

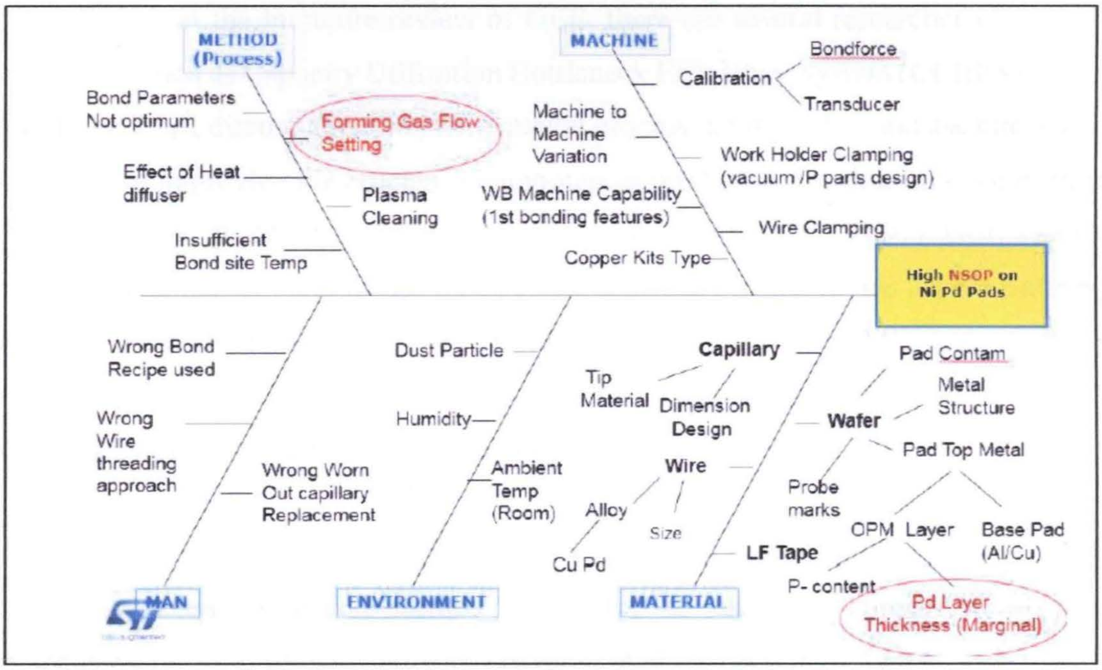


Figure 2.3: Example of Ishikawa Diagram for NiPd Pads

2.4 OTHER RESEARCHERS

According to the overall research from other thesis, it can conclude that lean technique can be implement in many industry, not just at shop floor also at the chemistry lab and small medium enterprises. Some of usually method for optimize the lean is 5S, single minutes exchange die, (SMED), First in first out (FIFO), poke yoke and many more is very effective to achieve short term improvements. Value stream mapping as a lean tool that also use at fishing net manufacturing (Taho Yang, et. al., 2015). There are others method of lean, such as kanban where it is used at small & medium enterprise (Nor Azian AR, et. al., 2013).

Equipment Effectiveness, OEE is a tool from lean manufacturing. OEE is used to measure the equipment of lines that will present the potential like a quality, performance and availability. In order to prevent the bottleneck and the production run effectively.

Based on the literature review of OEE, there are several researcher using OEE with system such as Capacity Utilization Bottleneck Efficiency System (CUBES). In this case study, it just discuss about implementation process, taking a data and use directly the OEE without improving the efficiency equipment at production monitoring system, either it in availability, quality and performance (Stuart Giegling, et. al., 1997). OEE also can apply with another tool like failure mode effect analysis, FMEA. In this paper an attempt has been made to establish a relationship between OEE and FMEA. Availability, performance rate and quality rate are evaluated with respective to FMEA such as severity, occurrence and detection (Chandrajit P Ahire, et. at., 2012).

On the other hand, OEE and Maynard's Operation Sequencing Technique, MOST is used to determine which method is suitable at autoclave process through the implementation of time studies (Puvanasvaran A.P, et, al., 2013). OEE also used to Measuring the machine efficiency and man power utilization. Relevant and valuable production data helps the management to efficiently monitor the workers. Information on human capital can optimize the true capacity of the machine efficiency.

Furthermore, the researcher using SMED to improve the setup time in OPE to analyze the efficiency of setup process at plastic industry. Other researcher also practice scheduling and OEE techniques but more detail at process improvement and production planning (planning and scheduling) at CNC machine. So, using SMED method to improve setup time at one of element OEE, in order to get production monitoring syst
(S. Vijaya Kumar, et, al., 2014)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter generally describes in detail the method of execution by the flow chart. It describes the initial stages of the project include the title until the conclusion of the project, which gives an overview of the entire research methodology. It started with a chart that describes the research methodology measures taken to carry out the study. For each of these steps, it is explained in detail in this chapter that is associated with the design of the framework and expected result that will get it.

3.2 FLOW CHART

The methodology used in this research in order to achieve the objective and solve the problem in production area. The flow chart for the task have been constructed to shown the detail of project.

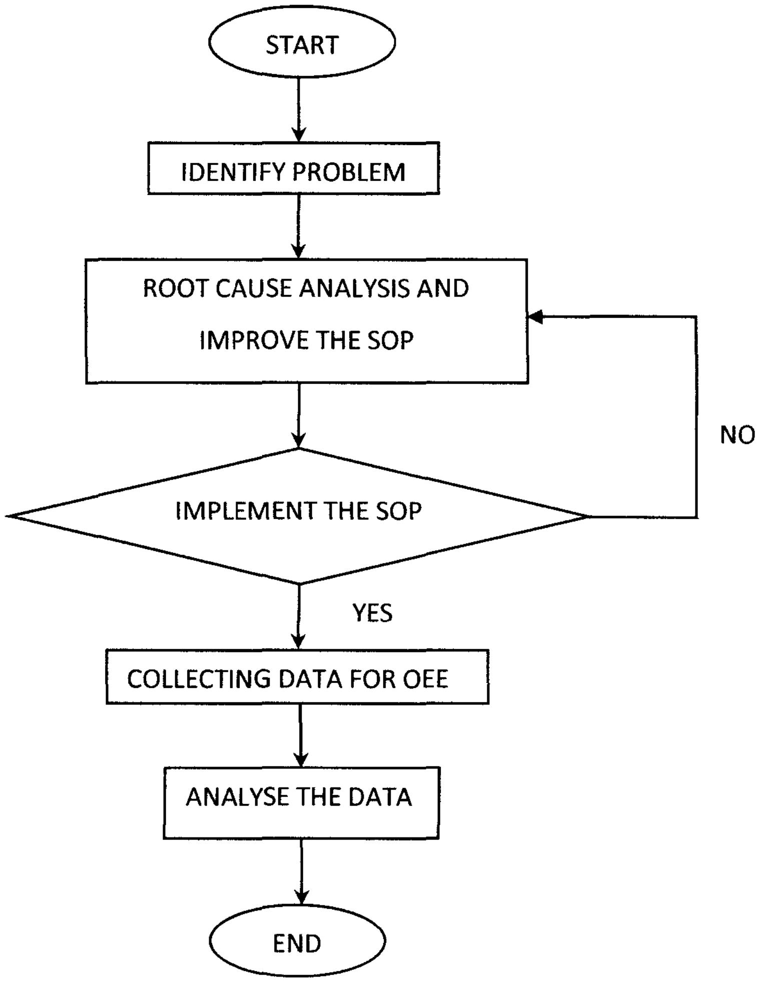


Figure 3.1: Flow Chart for Project Framework

Firstly the current data for production monitoring system was collected from the production site of a multinational company. Semiconductor Company that produces electronic components and have apply OEE at CNC Winding machine. The data have been taken from production, and the problem occurs at the data which is the percentage of overall equipment effectiveness is lower. It is lower because of percentage of availability, which is the value of machine breakdown is higher. According to Pareto chart the higher causes of machine breakdown is set up a model of machine.

Next, for the stage one is to identify the root causes from the effect that have it. Then analyze the current condition in this area using Ishikawa diagram. Observation also needed during the technician setting up to acknowledge some important information. On the other hand, next stage is to recognize the current practice that applies it in the machine and standardize the step for setup the machine. This stage need student to study and referring the old SOP of the machine.

After that, the technician will apply the SOP at the machine and record the set up time. If the time recorded do not have any improvement, the SOP will redo again. After the data of time is efficient, student will continue to collect OEE data and proceed with analyze the data. So the new data will come out and calculate the data to get a percentage of availability and OEE. Once done, both results are evaluated based on the percentage of improvement and control chart.

3.3 IMPLEMENTATION

The first formula [2.1], [2.2, [2.3], and [2.4] at chapter 2 (page 8) will use to find the efficiency of the machine in production line and to recalculate the data and recognize the problem at the machine.

Collect new data from production by using Microsoft office excel 2013 to make a simple table for record the data. This table will show the machine downtime, machine operating time, defect, and etc (table 3.1).

During observation also need to record and describe the type of causes make the machine break down. The control chart also will be construct in Microsoft office excel 2013 to investigate the OEE data.

Table 3.1: Sheet for record data

<table>
<tr><th rowspan="2">Week</th><th rowspan="2">Date</th><th colspan="4">Machine</th><th rowspan="2">Description (why break down)</th></tr>
<tr><th>Downtime</th><th>Operating time</th><th>Defect</th><th>output</th></tr>
<tr><td rowspan="5">1</td><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td rowspan="5">2</td><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
</table>

3.4 INFORMATION FROM THE CNC WINDING AREA

The data have been collected by the student at CNC Winding Machine where it is very important to calculate the overall equipment effectiveness. There are eleven machine at this area which is used for round and rectangle coil with different size.

There are many type size of coil will running where it will follow the schedule at whiteboard. This area working one shift where the total hours for one shift is 8 hour (480 minute). There are some data that very important in calculation of availability and OEE (table 3.2).

Table 3.2: Machine & Material Data

Specification	Value
Operation time	8 hour (480 minute)
Ideal run rate	8 unit/min
Machine number	CNC Winding machine 2
Model	HA00-08464LFTR
Size coil	0.8 X 2.3 X 3.5T
Type coil	Rectangle
No. of turn	3.5 turns
Height max	3.91 mm
Wire usage	1.557 gram

According to the scope, research have been done at model HA00-08464LFTR at CNC winding machine 2. Figure 3.2 shows the sample model that have been winding.

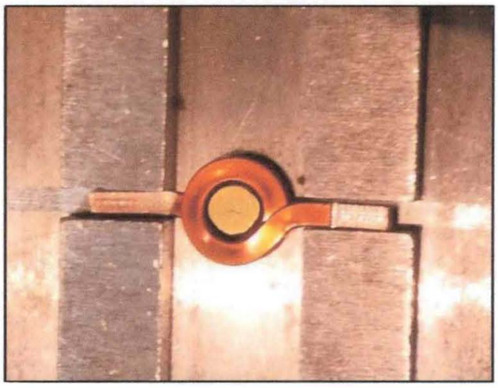


Figure 3.2 : Sample Model HA00-08464LFTR

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter will discuss the results of the study and present the findings at the industry which is related to real time production monitoring system. This chapter also will show the information and data that has analyze and discuss.

Based on the results and information obtained from observations and records from the factory, there are some table, diagram and graph that have constructed. There are some explanations for the detail of data and calculation was made to determine the availability and overall equipment of each past records.

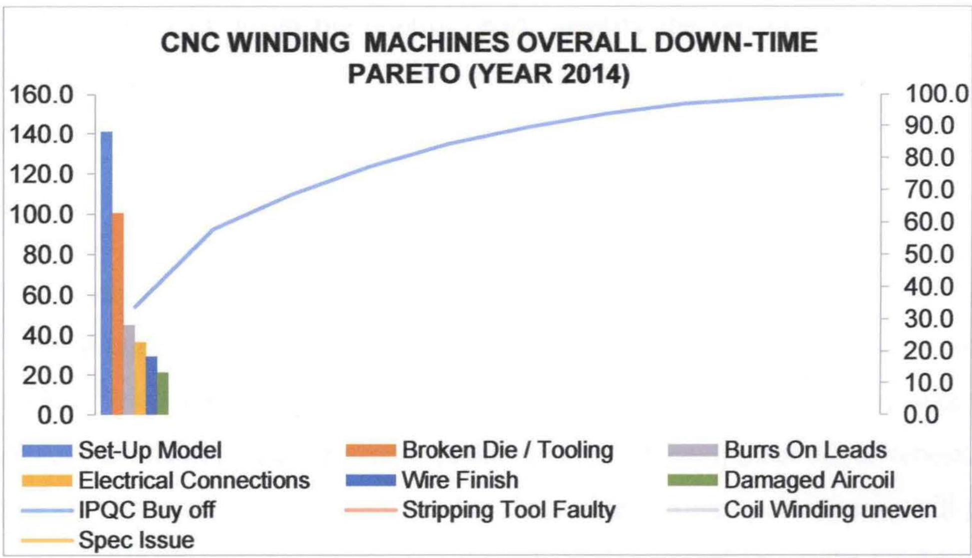


Figure 4.1: CNC Winding Machines Overall Down Time of Pareto

According to the Pareto from the November data, there are highest problem that has shown at CNC winding machines overall down-time Pareto (year 2014). This Pareto will show the major factors that make up the subject being analyzed.

The bar was arranged in descending order beginning from left to the right. Figure 4.1 shows that the overall down time is to set up model for machine where it has higher downtime from other problem. The higher downtime will be the first subject to improve.

4.2 CURRENT CONDITION

In the first place, data were recorded to identify any problem during machine has been set up. The higher down time was occurring during set up the machine where it will show the problem. Then the data will identify and calculate to get the OEE, availability, quality and performance. It intends to investigate the problem that influence the value of OEE. In order to get a better product with lower defect, the company wants to reduce their losses. The best product means it follows the specification that has been given.

Attribute data is special for data size or sample size in the range 50 – 10 per sample, it will indicate the qualitative and good or bad sample. By using p chart type which is will calculate percent defective in the sample. The p chart will be constructed using Microsoft excel. From the control chart, identify the processes that are out of control. The processes need to be stabilized before it can improve using the problem solving process.

Special causes require an immediate cause and effect analysis to eliminate variation. Once the out of control sample is eliminated (revise), the attention will go to the in control sample which is sampled in control limit. Then eliminating will be done to the sample at below the control limit (target). So the last chart will indicate the maximum value of each availability, performance, quality and overall equipment effectiveness. The investigation using Ishikawa diagram need to determine if some special cause will made changes. So from the common cause, it will use to solve the problem at the machine.

Table 4.1 below show the formula for the control chart. This is formula have been used to calculate the lower centre limit, centre limit and upper centre limit. This formula has been used in excel where the table is shown in appendix A and B.

Table 4.1: Calculation for Control Chart

$LCL = \bar{q} - 3\left(\frac{\bar{q}(1-\bar{q})}{n}\right)^{\frac{1}{2}}$
CL = Average value of q
$UCL = \bar{q} + 3\left(\frac{\bar{q}(1-\bar{q})}{n}\right)^{\frac{1}{2}}$

Where $\bar{q}$ is an average value for each type data, e.g. average for availability, average for quality, average for performance and average for OEE. For the availability, the n value is a total production, for nq is operation time and q is a division of operation time with total production.

For the quality calculation, n is using the output to produce by machine, nq is good pieces and the q is a division of good pieces with an output of the machine. For the performance, n is an ideal run rate, nq is a division of total pieces with operation time and q is a division of ideal run rate with the value of total pieces divide by operation time. OEE calculation using n with value 100, nq is a product of and for the q is a product of n and nq which is value of availability, quality and performance multiple of 100.

4.2.1 Downtime and OEE for present condition

Table 4.2: Downtime for Detail Setup

Details	Setup Programming	Setup coil to machine	Setup mechanism (cam, spring & key slot))	Setup Bending Tool	total time/cycle	Average
1	5	11	19	33	68	80.25
2	7	14	17	48	86	
3	12	17	26	51	106	
4	10	16	16	39	81	
5	5	15	18	31	69	
6	6	15	23	31	75	
7	7	13	15	43	78	
8	15	18	30	49	112	
9	10	16	24	30	80	
10	5	14	17	42	78	
11	6	9	21	31	67	
12	10	16	21	34	81	
13	6	12	20	31	69	
14	12	15	16	35	78	
15	5	14	15	33	67	
16	7	10	13	38	68	
17	10	16	22	38	86	
18	14	17	28	47	106	

Table 4.3: Current condition at CNC winding machine

CNC WINDING (HA00-08464LFTR) (IDEAL RUN RATE ;8UNIT)								
NO.	DOWNTIME	OPERATE TIME	AVAILABILITY	OUTPUT	PERFORMANCE	REJECT	QUALITY	OEE
1	68	412	0.86	2880	0.85	68	0.98	71.50
2	86	394	0.82	2880	0.88	98	0.97	69.98
3	106	374	0.78	2200	0.70	104	0.95	52.00
4	81	399	0.83	2880	0.88	83	0.97	70.74
5	69	411	0.86	2880	0.85	70	0.98	71.40
6	75	405	0.84	3270	1.03	71	0.98	81.50
7	78	402	0.84	2000	0.60	72	0.96	48.40
8	112	368	0.77	2880	0.94	113	0.96	69.23
9	80	400	0.83	3270	1.12	83	0.98	80.89
10	78	402	0.84	2880	0.87	75	0.97	71.14
11	67	413	0.86	2880	0.85	58	0.98	72.01
12	81	399	0.83	2880	0.88	83	0.97	70.74
13	69	411	0.86	2880	0.85	70	0.98	71.40
14	78	402	0.84	3300	1.00	75	0.98	82.08
15	67	413	0.86	2880	0.85	58	0.98	72.01
16	68	412	0.86	2880	0.85	68	0.98	71.50
17	86	394	0.82	2880	0.88	98	0.97	69.98
18	106	374	0.78	2200	0.70	104	0.95	52.00
19	78	402	0.84	2000	0.60	72	0.96	48.40
20	72	408	0.85	2880	0.86	69	0.98	71.45
TOT	80	400	0.83	56200	0.85	1592	0.97	68.98

Table 4.3 shows the acceptance rank of OEE is three sample, and unacceptance OEE is four sample. The others sample is just in fair ranking.

Figure 4.2, 4.3, 4.5 show the control chat for availability, quality and OEE rate where there are some data out of control from LCL and UCL, so this chart can be evaluated as an unstable condition chart. In the figure 4.4 shows the control chart for performance, where it has a stable control chart.

4.2.2 Control Chart For Attribute (Current Condition)

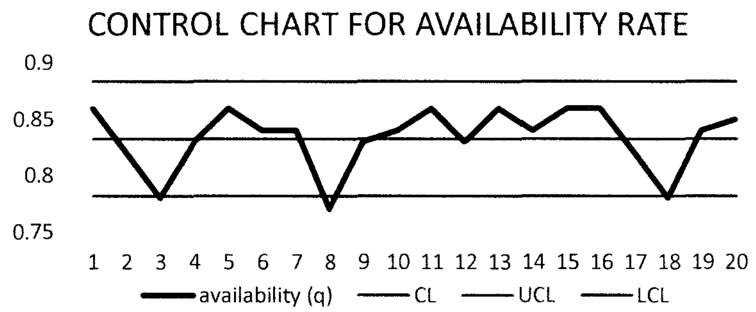


Figure 4.2: Control Chart for Availability Rate (Current Condition)

The data that out of control is sample number 3, 8, and 18, where the data is lower than the value of LCL. Sample number 3 has a higher time when setup the bending tool because of technician try and error when enter the programming to get the precision angle of winding coil. Also the bending tool is wear and out of adjustment sometime. Sample number 8 has a long time taken at setup the mechanism, this is because the new spring has used and the extension of a spring is different than before. Other than that, this sample has the higher total downtime than other sample. Sample number 18 is repeated setup programming and setup bending because of the product output is not precise. They try and error to get the good output. Because of downtime for this 3 sample is higher (106 min, 112 min, and 106 min) it affects the value of availability where availability will have a lower value. Refer the table calculation for current conditions, appendices A & C.

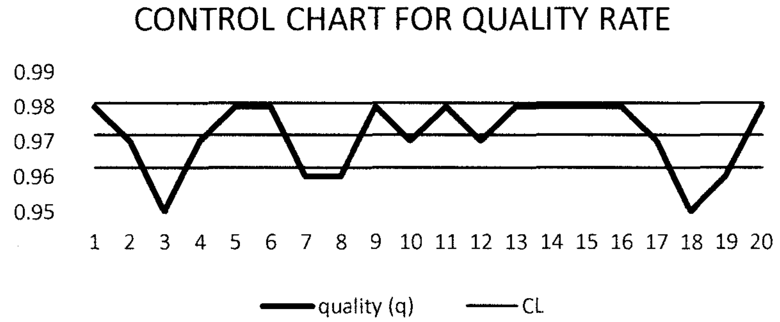


Figure 4.3: Control Chart for Quality Rate (Current Condition)

According to the figure 4.3, the data that out of control is sample number 3, 7, 8 and 18. Sample number 3, 7, 8, 18 and 19 is has the same causes with for the quality rate. Where the value of rejects product is higher than other sample. The technician takes long time to set up the bearing tool, where its function to draw angles of the coil. It is because, during setting up a technician try and error method, the effect is many defects is where having a wrong angle is produced.

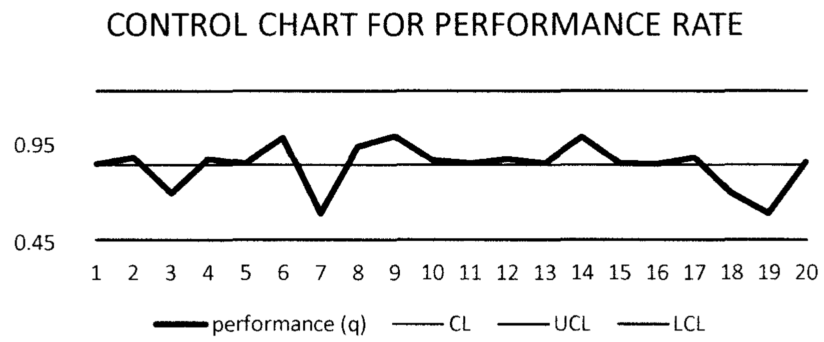


Figure 4.4: Control Chart for Performance Rate (Current Condition)

From the figure 4.4, the sample is in control and chart is in stable condition.

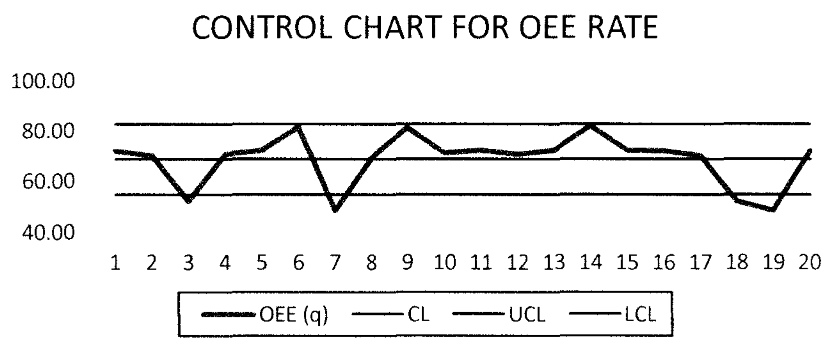


Figure 4.5: Control Chart for OEE Rate (Current Condition)

According to the figure above, there are many samples that out of control, which are at the lower is sample number 3, 7, 18, and 19. The upper sample is 6 and 9 where the value is higher than others. Sample 6 and 9 has a higher performance and quality, this two element contributes to the higher value of OEE. It is because the value of defect is lower and value of output is higher than other sample. For the sample 3, 7, 18, and 19, as stated in the figure 4.2 and 4.3, this sample has a lower availability and quality rate. Where their downtime is higher and also has lower good pieces.

After revising and eliminate the sample at control chart as shown as figure 4.6, 4.8, and 4.9, where the only sample at upper section will remain. The sample that has value under centre limit or below average will eliminate.

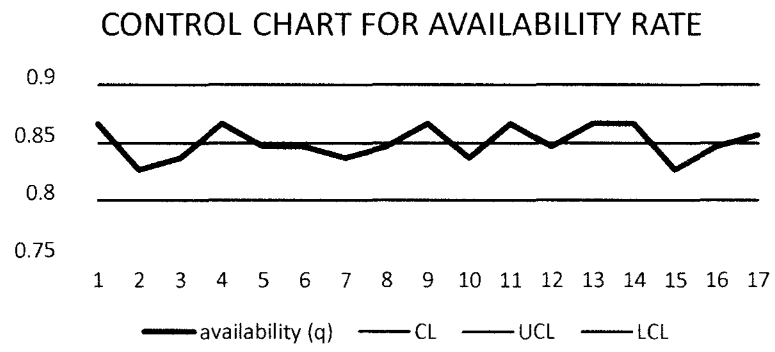


Figure 4.6: Control Chart for Availability Rate (Revise)

Sample number 2, 3, 7, 10, and 15 has a lower value and a point at below average, so it will eliminate from the chart. Figure 4.7 shows the control chart, only the maximum availability rate will remain in the chart. The maximum value is 0.86.

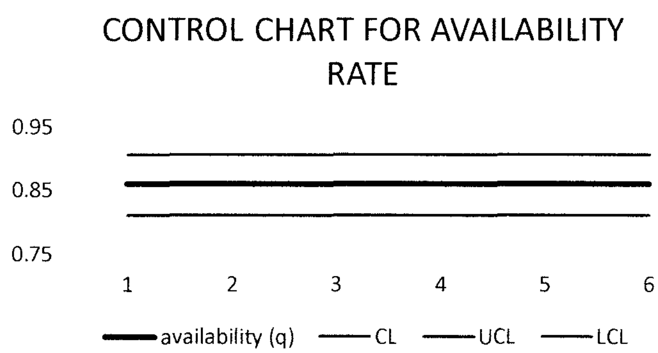


Figure 4.7: Control Chart for Availability Rate (Target)

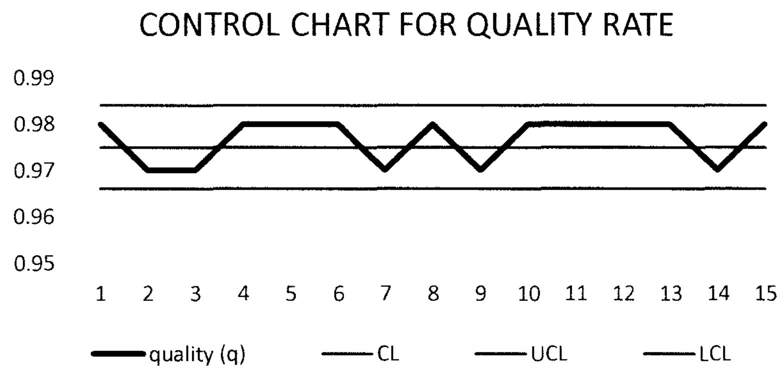


Figure 4.8: Control Chart for Quality Rate (Revise)

By referring to the control chart for quality rate, there are 5 sample need to eliminate, which is sample number 2, 3, 7, 9, and 14. This sample has a lower value of quality which is 0.97 of quality rate the machine.

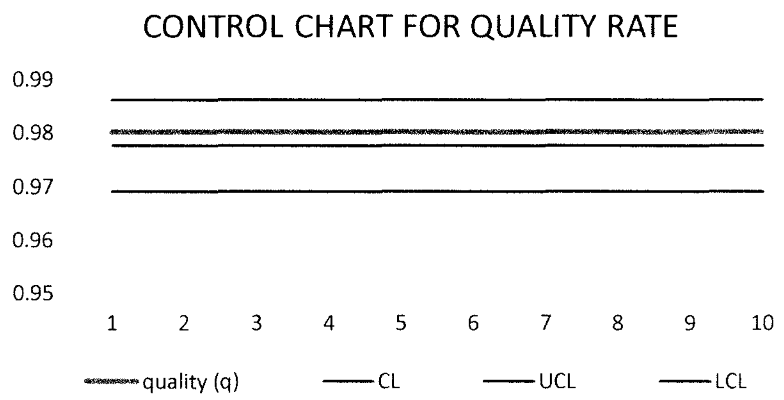


Figure 4.9: Control Chart for Quality Rate (Target)

Figure 4.9 shows the maximum value of quality rate for the machine, the value is 0.98 of quality rate.

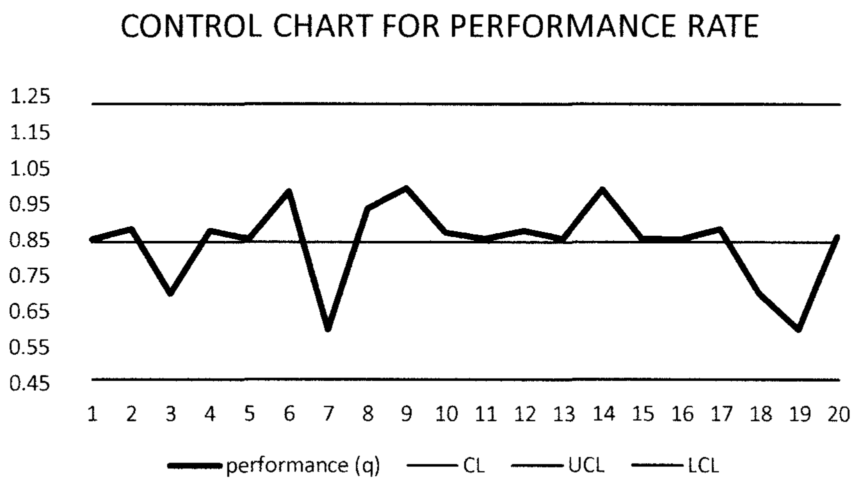


Figure 4.10: Control Chart for Performance Rate (Revise)

The lower value of the performance is sample 3, 7, 18 and 19. This sample have a lower value of good pieces so the value of performance also affected.

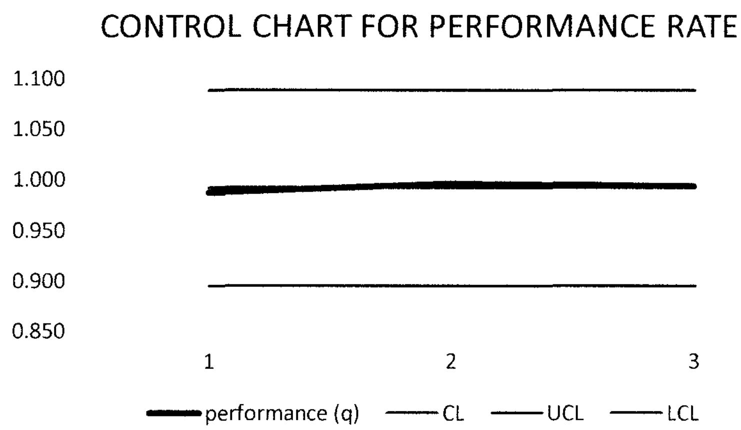


Figure 4.11: Control Chart for Performance Rate (Target)

The maximum value of this performance rate is sample 2, the value is higher because the output is able to achieve with lower downtime. The maximum value is 0.996.

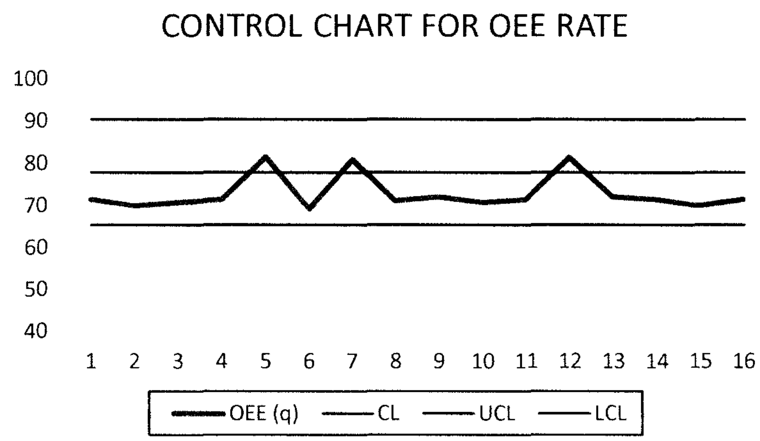


Figure 4.12: Control Chart for OEE Rate (Revise)

There are many sample that point below average, the sample will be eliminate is 1, 2, 3, 4, 6, 8, 9, 10, 11, 13, 14, 15, and 16. This sample eliminates because has a lower output and has higher defect.

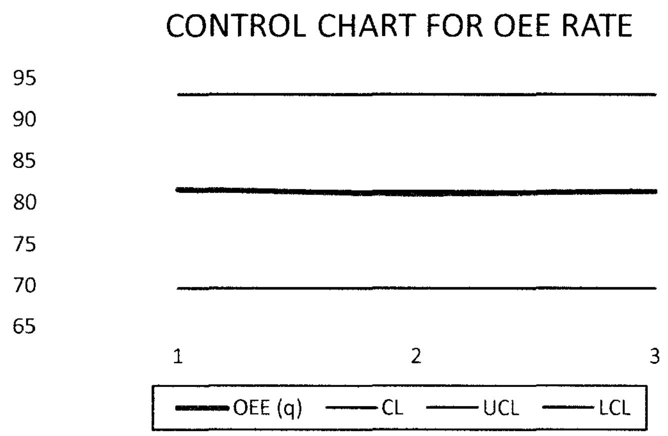


Figure 4.13: Control Chart for OEE Rate (Target)

The maximum value for OEE id sample 1, which is 81.5%. The others 2 samples is lower than sample 1. This sample higher because has a high performance rate and quality rate.

4.3 ROOT CAUSE ANALYSIS

There is a tool that have used to find the root cause of the higher set up the model of the machine. The Ishikawa Diagram helps work backward to diagnose root causes. To make the diagram, the problem of interest is entered on the right side of the diagram at the end of the main bone.

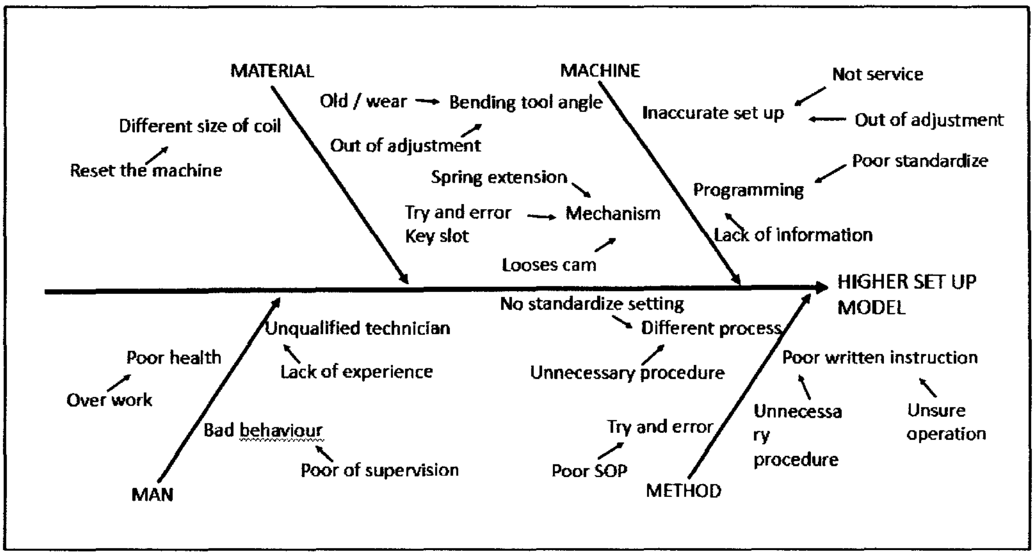


Figure 4.14: Root Cause Analysis Ishikawa Diagram

There are five main categories of possible causes that influences the problem. Each of the main categories has a specific cause to the sub – bones on the main bones. The categories are 4M's which are machined, method, material and man where it is suitable to use in a manufacturing shop floor.

1. Machine

   At this categorize, there are many major causes that need to concentrate to reduce the setup model time. First, the bending tool, where it is wear and out of adjustment every time it has been used. So the technician needs to repair the tool bit to make it suitable to the coil. Second, the technician has a problem with inaccurate data where every time they set up the same model, the angle of bending cam will change in the gap of 1 degree or 2 degree. Thirdly, programming for the model will be same and just little bit different at an angle. Furthermore, the technician does not have standardize for the programming and procedure. Lastly, the mechanism at machine also has a problem with spring, key slot and also a cam. It is shown on the machine where the technician used hard span to fix the position of bending cam and the key slot also needs to try and error the shape that suitable to the movement. The reference angle of round desk of the machine also blurred and dusty.

2. Method

The possible cause that lead to the high set up model down time is no standardized setting and some of the procedure is unnecessary while doing different process at changeover process. The technician also uses method try and error because lack of recording information and poor standardize the procedure. The main cause that may affect higher downtime is the poorly written instruction. The written instruction may have unsure operation and unnecessary procedure that will apply by technician and will take long time.

3. Material

In one machine, there are many type of coil (raw material) that will produce so to change the model the technician need to reset the coil many time. Then it will take higher down time.

4. Man

There are three main causes in this categorize where it is refer to the technician in charge in CNC winding machine area. Firstly, the unqualified technician where the technician does have any experience or maybe a fresh graduate student. Second causes is the worker have a poor health and always have emergency leave because of over work. The last causes is bad behavior of technician where they always leave from their station and it happen because of poor supervision from supervisor.

4.4 STANDARD OF PROCEDURE TO SET UP A NEW MODEL/COIL

Suggestion to improve the old standard of procedure by observation during the set up process is conducted. This method is propose in order to reduce downtime during set up process and this SOP will be apply by technician at CNC Winding machine area.

1. Recognize the type of coil, usually the operation instruction card (OIC) will show the specification of coil for winding.

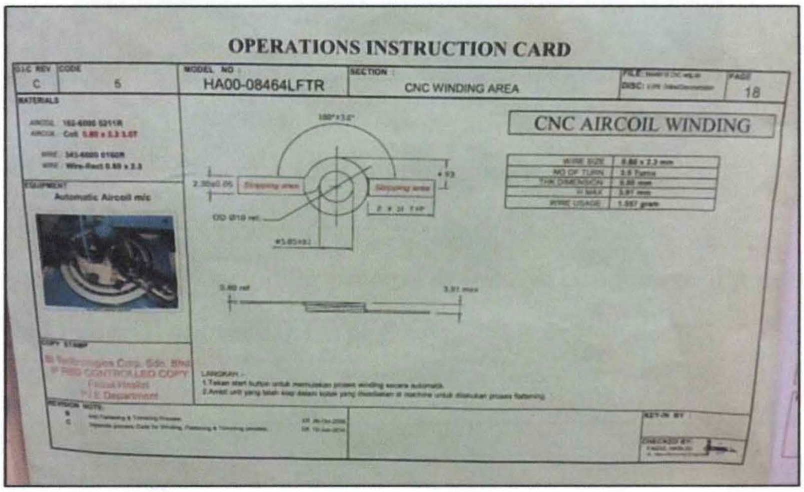


Figure 4.15: Example of OIC

2. Mounting source coil at the spool holder.

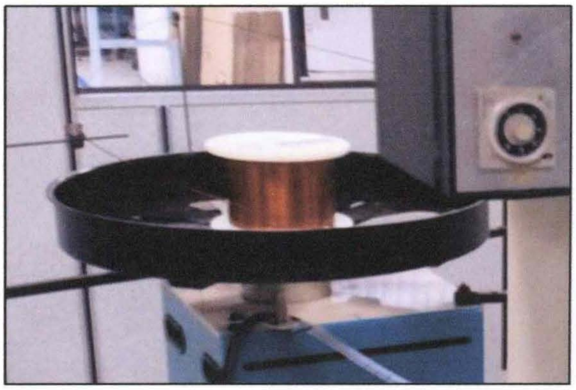


Figure 4.16: Coil at Spool Holder

3. The coil will guided by feeders and insert into roller. Roller function to straighten the wire.

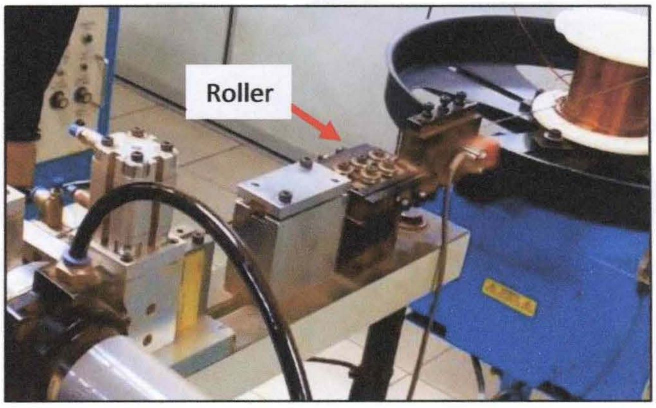


Figure 4.17: Coil through the Roller

4. The wire will through stripping process to remove conductive filament as the insulation material at every 0.1m coil.

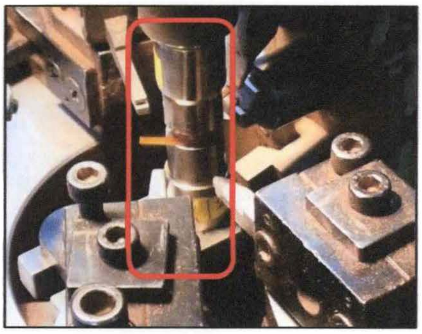
Figure 4.18: Stripping Process

5. The wire will continue through to the wire guider to the front machine.

Figure 4.19: Wire Guider

6. The bottom and upper chalk will install at machine and the wire will tested. The chalk function as a wire guider, and holder.

(a)



(b)

Figure 4.20 (a & b): Chalk

7. Positioning the cam for bending tool holder, key slot and the spring was attach to the cam to control the movement of bending tool according to specification of part.

Figure 4.21: Cam, Key Slot and Spring

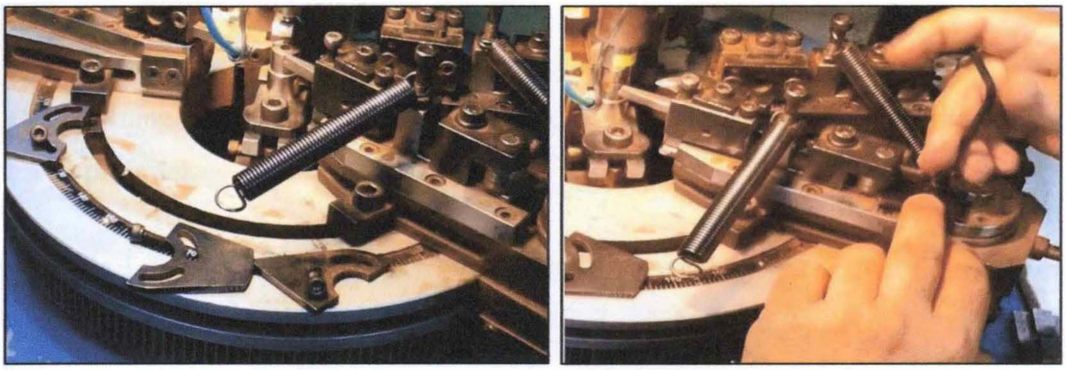
i. Prepared the bending tool that have used to set up model HA00-08464LFTR

Figure 4.22: Bending Tool

ii. Then the bending tool are installed to the cam and key slot also attach to the cam. The key slot type is same and then the spring is attach to cam.

Table 4.4: Position of Cam

CNC WINDING					
NO.	MODEL	ANGLE TOOL 1	ANGLE TOOL 2	ANGLE TOOL 3	ANGLE AT PROGRAM
CNC 2	HA00-08464LFTR	94	136	103	970
CNC 4	HA00-08464LFTR	98	135	104	1170



(a) (b)

Figure 4.23 (a & b): Key Slot and Spring

iii. Make sure the position of cam is follow the information in the table 4.4 below.

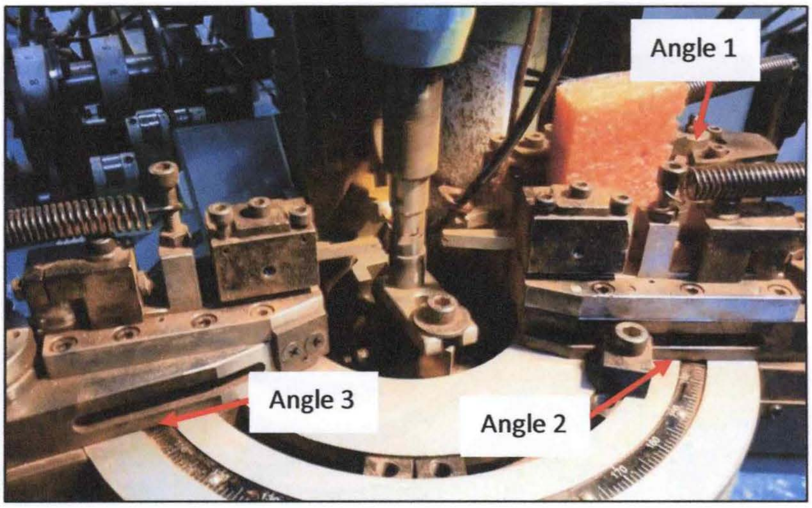


Figure 4.24: The Positon of Cam

8. Set up the programming according to OIC that provided, where the value of coil turning, speed, the angle, pressure of compressor at bending tool are key in program.

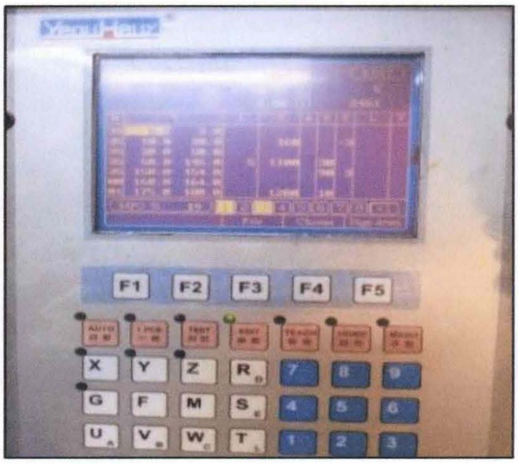


Figure 4.25: Programming At Panel

9. The position of cam will follow the standard setting from previous record as a guide for technician to setting model or coil.

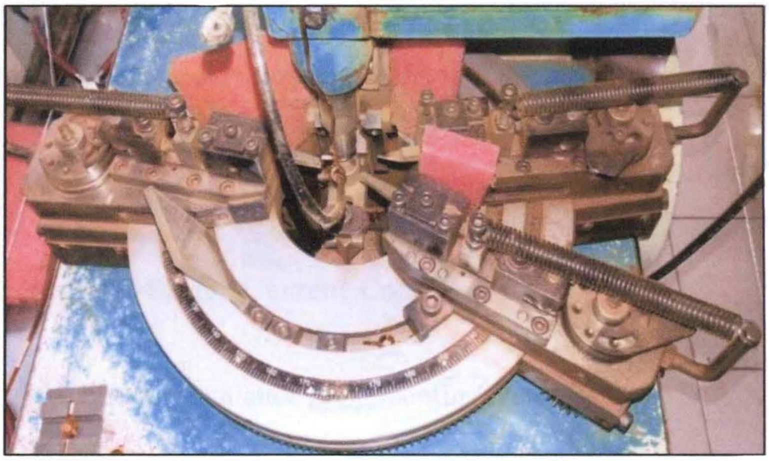


Figure 4.26: Standard Position of Cam

10. Check the part that come out using special tool to make sure the part follow the specification that have provided at OIC. If the product come out with different angle of coil then it is a defect.

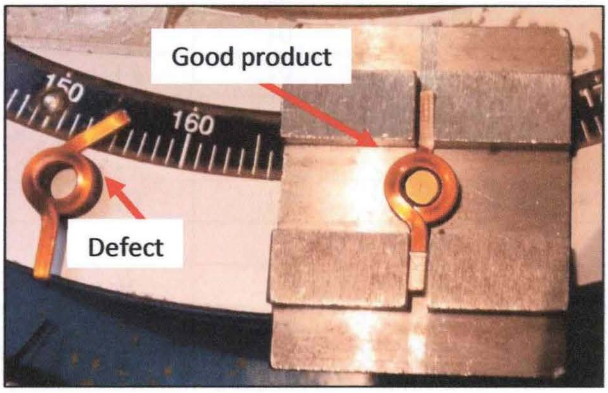


Figure 4.27: Two Product with Different Angle and Special Tool to Measure the Quality of Specification

4.5 IMPLEMENTATION OF LEAN TECHNIQUE

After improving SOP has been applied, the improve downtime was recorded for the next data. The data was recorded from February until April where it has information about operation time, output, performance, reject part and how many unit per minute the machine produce.

4.5.1 Downtime and OEE for Current Condition

Table 4.5: New Data after Implementing New Proposed Solution

Details	Setup Programming	Setup coil to machine	Setup mechanism (cam, spring & key slot))	Setup Bending Tool	total time/cycle	Average
1	2	7	12	19	41	63.95
2	4	12	17	30	65	
3	4	9	11	24	51	
4	4	14	15	32	69	
5	0	5	10	15	35	
6	8	13	19	32	78	
7	8	10	16	34	75	
8	7	11	19	28	73	
9	3	10	12	24	58	
10	5	9	10	30	64	
11	0	9	11	17	48	
12	4	8	13	26	63	
13	5	13	17	24	72	
14	7	12	21	32	86	
15	3	13	18	34	83	
16	8	8	18	31	81	
17	0	5	13	22	57	
18	3	6	10	21	58	
19	2	8	14	24	67	
20	1	4	10	20	55	

By using data that student get from the industry (table 4.1 and table 4.4) and there are two of data that has been collected and calculate for availability, quality, performance and OEE, which the data is before implement SOP (table 4.2) and the data after implement SOP (table 4.5)

Table 4.6: Result after Implementing New Proposed Solution

CNC WINDING (HA00-08464LFTR) (IDEAL RUN RATE ;8UNIT)								
NO.	DOWNT IME	OPERATE TIME	AVAILA BILITY	OUTPU T	PERFOR MANCE	REJE CT	QUALITY	OEE
1	40	440	0.92	2880	0.82	8	1.00	74.58
2	63	417	0.87	3330	0.99	27	0.99	85.32
3	48	432	0.90	2880	0.83	18	0.99	74.07
4	65	415	0.86	2880	0.86	32	0.99	73.34
5	30	450	0.94	3600	0.99	28	0.99	92.30
6	72	408	0.85	3200	0.97	38	0.99	81.37
7	68	412	0.86	2880	0.86	30	0.99	73.45
8	65	415	0.86	2880	0.86	25	0.99	73.70
9	49	431	0.90	2880	0.83	23	0.99	73.81
10	54	426	0.89	2000	0.58	37	0.98	50.17
11	37	443	0.92	2880	0.81	6	1.00	74.69
12	51	429	0.89	2880	0.83	33	0.99	73.29
13	59	421	0.88	3360	0.99	28	0.99	86.05
14	72	408	0.85	3300	1.03	38	0.99	86.57
15	68	412	0.86	2880	0.86	30	0.99	73.45
16	65	415	0.86	2880	0.86	25	0.99	73.70
17	40	440	0.92	3200	0.91	8	1.00	82.92
18	42	438	0.91	3300	0.93	27	0.99	84.54
19	48	432	0.90	3170	0.91	18	0.99	81.62
20	36	444	0.93	2880	0.81	6	1.00	74.69
TOT	54	426	0.89	35170	0.88	305	0.99	77.22

After technician implement the new solution, the value of OEE is increase with six number of good rank and just one number of unacceptance rank (table 4.6).

4.5.2 Control chart for attribute for New Condition

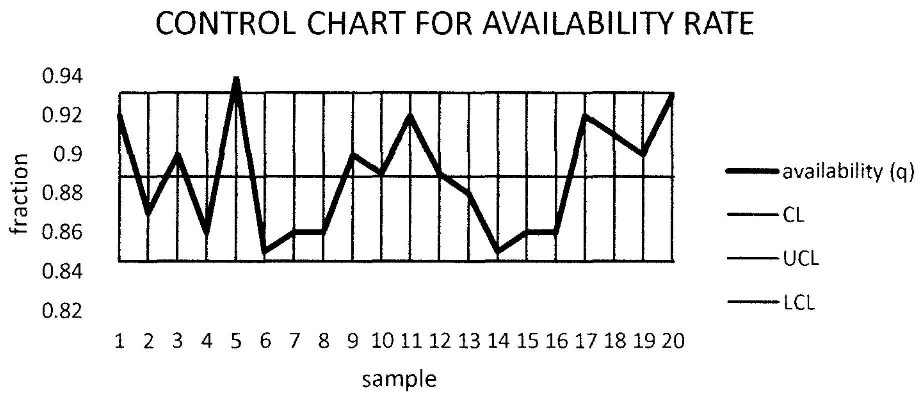


Figure 4.28: Control Chart For Availability Rate (new data)

The control chart show that has some sample is out of control, where it indicate that the chart is unstable condition. So some sample need to eliminate to made the chart more stable. The sample that out of control is sample number 5. Sample number 5 shown that the down time is very short. On the other hand, during technician set up the machine, the SOP is really help them to know what the standard of procedure for setting this model. So it shown the faster time technician can set up is 30 minute without any disturbant from people and environment. The program also do not have to change anything, and other part just follow the SOP. Refer the table calculation for new condition, appendices B & C.

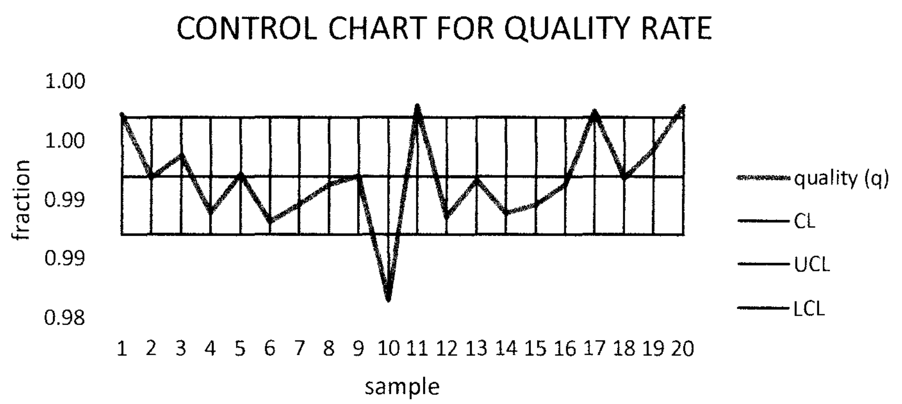


Figure 4.29: Control Chart For Quality Rate (new data)

According to the figure 4.28, there are 5 sample need to eliminate, it is sample number 1, 10, 11, 17, and 20. For sample number 10, it has a lower quality rate where it is because this sample has many defect than others sample. On the other hand, the downtime during set up the bending tool also higher, where the technician taking long time to try and error using the coil to get the angle of model. For other sample that have higher quality rate, show that the defect is in small number and downtime for programming and mechanism is lower, it is because the technician just used the value in SOP to key in program. The angle for position of mechanism aslo state in SOP. So the technician just follow the SOP without estimate the position.

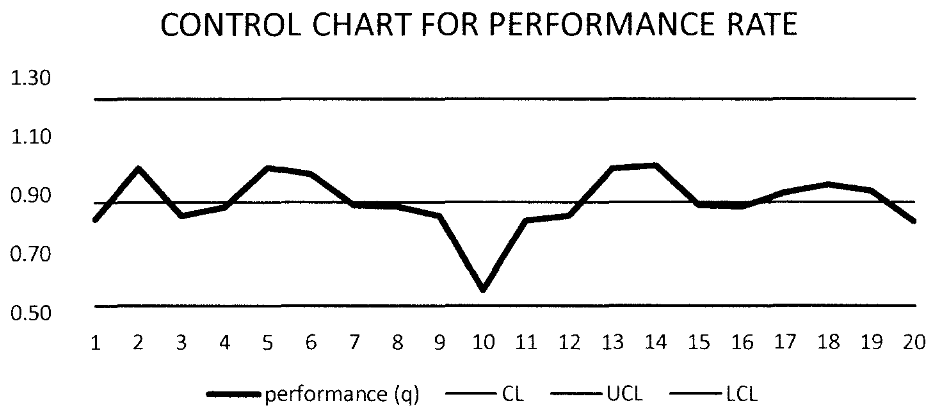


Figure 4.30: Control Chart For Performance Rate (new data)

From the figure above show that the control chart for performance which is the chart is in stable condition. No elimination is need to stabilize it.

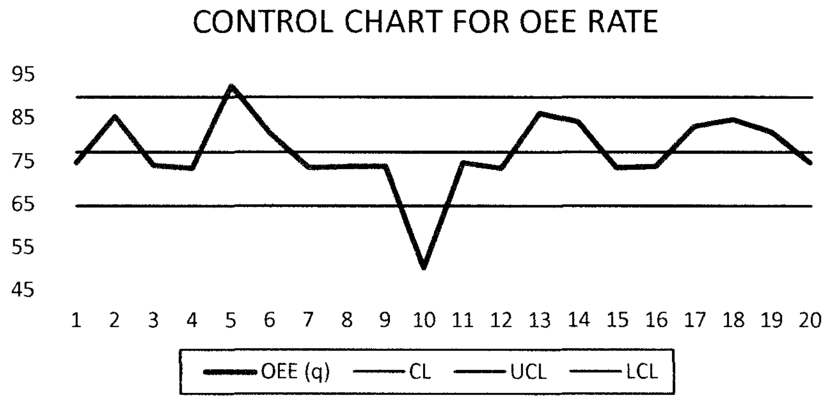


Figure 4.31: Control Chart For OEE Rate (new data)

According to the control chart for OEE, there are 2 sample need to eliminate for stablize it condition. The sample number 5 and sample number 10, where it out from upper limit and out from lower limit. Sample number 5 have higher OEE, it is because the value of availability and performance is the highest from other sample. It is because the lower downtime if sample number 5 has affect the value for the other calculation.

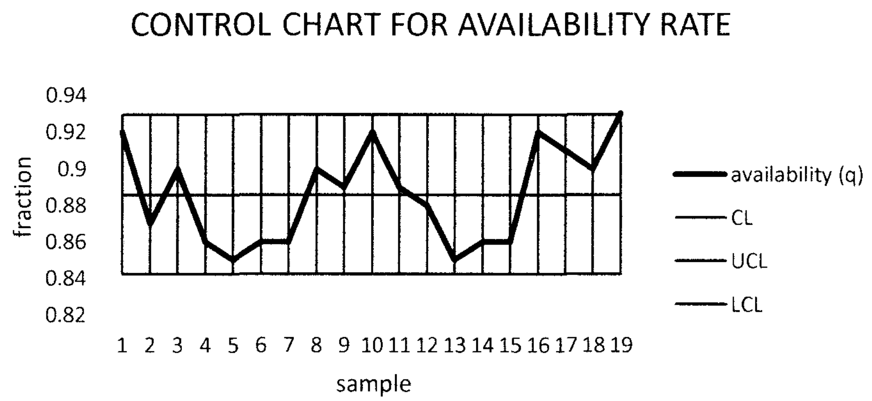


Figure 4.32: Control Chart For Availability Rate (Revise)

By referring the control chart above, stable condition has achieve. The next step is to revise and eliminate the sample that has value below than centre limit or below average. The sample number 1, 11, 17, and 20 is eliminate to revise it. Figure 4.33 show the chart that already eliminate the sample. The maximum value of availability rate is 0.93 and other 2 sample that it point at upper centre limit.

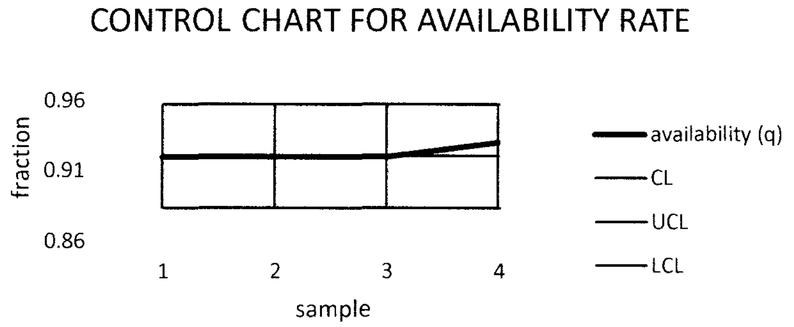


Figure 4.33: Control Chart For Availability Rate (Target)

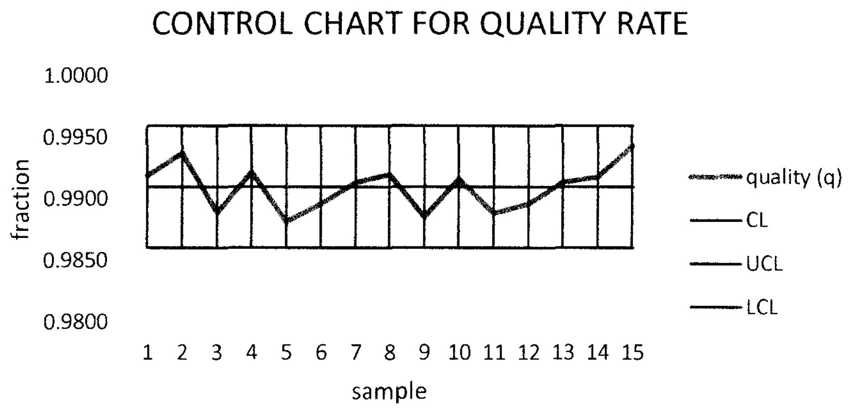


Figure 4.34: Control Chart For Quality Rate (Revise)

According to the figure 4.34, there are many sample need to eliminate to get the maximum point. The sample is 1,3,4, 5,6 ,7 , 8, 9, 10, 11, 12, 13, and 14 will eliminate to get target of quality rate.

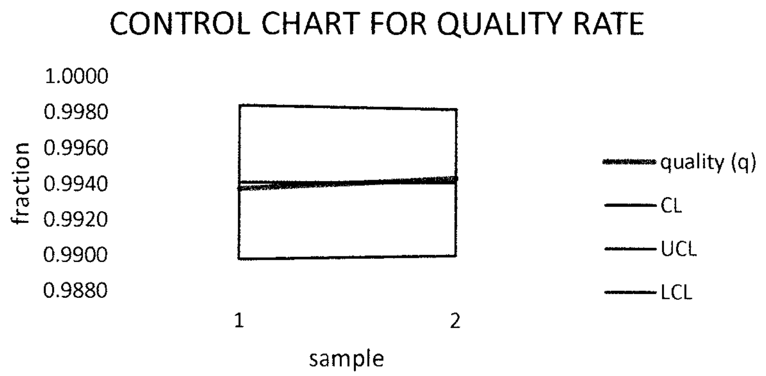


Figure 4.35: Control Chart For Quality Rate (Target)

The maximum point for quality rate is 0.9943.

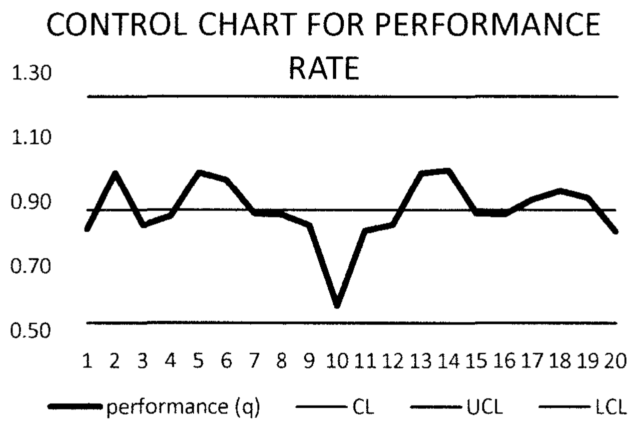


Figure 4.36: Control Chart For Performance Rate (Revise)

The sample all in control, but need to eliminate the value under centre limit to find the maximum point of performance rate. So the sample that need to eliminate is 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 15, 16, 17, 18, 19, and 20 to get the upper point.

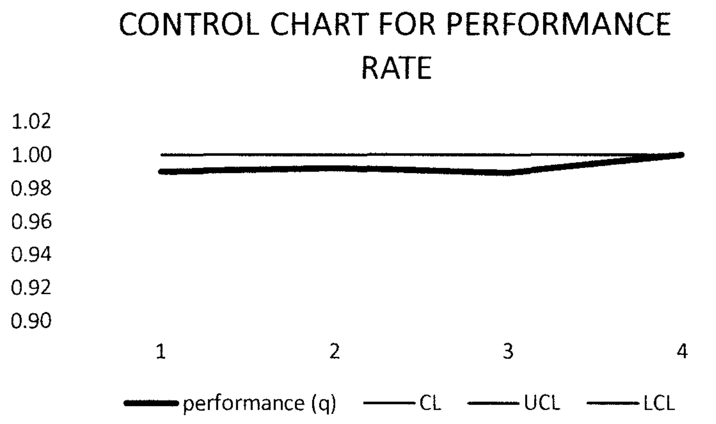


Figure 4.37: Control Chart For Performance Rate (Target)

The maximum point is 1.00 where according to the figure 4.37 it is a sample number 4.

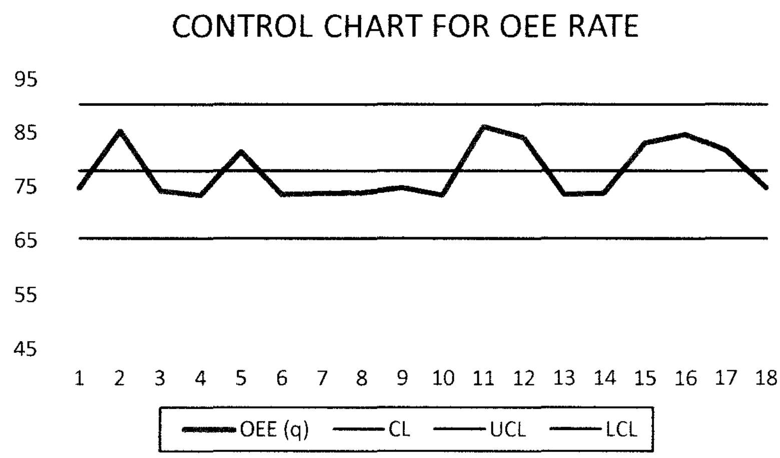


Figure 4.38: Control Chart For OEE Rate (Revise)

Figure 4.38 shown the control chart for OEE rate where in stable condition. The below average sample need to eliminate to get the maximum point of OEE in percentage.

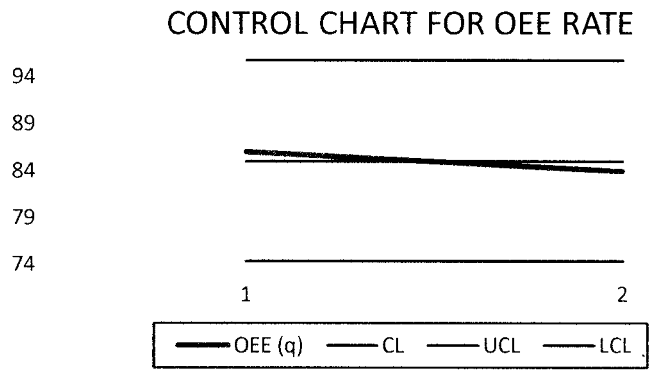


Figure 4.39: Control Chart For OEE Rate (Target)

Control chart above shown that the value of maximum is 86.05% where it is a sample number one.

4.6 DISCUSSION

Table 4.7: OEE for Current Condition

ELEMENT	MAX
availability rate	**0.86**
quality rate	**0.98**
performance rate	**0.996**
Overall equipment effectiveness	**0.839**

Table 4.8: OEE for New Condition

ELEMENT	MAX
availability rate	0.93
quality rate	0.99
performance rate	1.00
Overall equipment effectiveness	0.92

The table 4.5 and table 4.6 shows the maximum value of OEE by using the maximum point of the control chart. The present condition value of OEE is 0.839 or 83.9%, which is this value is not achieved world class of OEE. So CNC winding machine area has applied some lean tool to improve the value of OEE.

After applying it, as shown in table 4.6 the value of OEE has improved to 0.92 or 92%. This value has over 85% where it is a world class value. The waste has been eliminated and this area successful achieves the higher OEE by improving availability and reduce setup time. This project has indirectly contributed to the profit of the company by increasing the production performance and reduce downtime and also defect of the product.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, a conclusion from this study is made based on the chapter before this. A recommendation is provided to OEE, by implementing the given tools OEE make production and also technical site work under one roof to produce a good production level in the company.

5.2 CONCLUSION

According to the research, the objectives are to eliminate waste in setting up CNC winding machine using lean techniques and also to improve the availability rate of OEE by reducing set up time. For both of the objective, lean technique has applying at CNC winding machine in order to eliminate waste and also as shown as in chapter 4, the value of availability rate is improve by reducing set up time and also for the OEE.

First of all, the data have collected from the company where it is for CNC winding machine 2 where this machine produce model HA00-08464LFTR only. Then the data were constructed and analyzed it using OEE calculation.

By using the data which are from February month until the April month (new data) and analysis have been done to see the different data record of the company. According to the control chart, the value of maximum OEE is calculate and recorded and also for the improvement of OEE after the company has apply the propose solution given.

The challenging part when doing this project is needed to request some data from the company. Some of data are confidential and need some time to approve it to give. And this person also has their own job and task, so in order to obtain the data, independent needed to get it in time.

5.3 RECOMMENDATION

In this study, an example of solution has been given which is by applying OEE method to get an accurate raw data and also make a relationship between technical and also production site to produce good production efficiency. So that, company management need to take this matter a bit serious because while using this OEE method, it can change the whole production style and ensure that the production will get 100% better result in terms of productivity. There are some recommendation to the next final year's project that may improve this project. Firstly, the student can use SMED (single method exchange dies) to reduce the changeover time at CNC winding machine by referring the SOP at chapter 4.

REFERENCES

Gulcin Buyukozkan,Gulgun Kayakutlu, Ibrahim S. Karakadılar. 2015. Assessment of lean manufacturing effect on business performance using Bayesian Belief Networks.

Nor Azian Abdul Rahmana, Sariwati Mohd Sharifb, Mashitah Mohamed Esac. 2013. Lean Manufacturing Case Study with Kanban System Implementation.

Fawaz A. Abdulmaleka, Jayant Rajgopalb. 2007. Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study.

T. Melton. 2005. The Benefits of Lean Manufacturing What Lean Thinking Has To Offer the Process Industries.

Farhana Ferdousi Amir Ahmed. 2009. An Investigation of Manufacturing Performance Improvement through Lean Production: A Study on Bangladeshi Garment Firms.

Torbjørn H. Netlanda, Jason D. Schloetzerc, Kasra Ferdowsc 2015. Implementing corporate lean programs: The effect of management control practices.

P. Schnellbacha, G. Reinharta. 2015. Evaluating the Effects of Energy Productivity Measures on Lean Production Key Performance Indicators.

Taho Yang, Yiyo Kuo, Chao-Ton Su, Chia-Lin Houa. 2015. Lean production system design for fishing net manufacturing using lean principles and simulation optimization.

Anita Susilawati, John Tan, David Bell, Mohammed Sarwar 2015. Fuzzy logic based method to measure degree of lean activity in manufacturing industry.

U. Dombrowski, T. Mielke. 2014. Lean Leadership – 15 Rules for a sustainable Lean Implementation.

Juan M. Jauregui Becker, Jesper Borst a, Abele van der Veen. 2015. Improving the overall equipment effectiveness in high-mix-low-volume manufacturing environments.

C. Anderssona, M. Bellgranb. 2015. On the complexity of using performance measures: Enhancing sustained production improvement capability by combining OEE and productivity.

Tai-Yue Wang, Hsiao-Chun Pan. 2011. Improving the OEE and UPH data quality by Automated Data Collection for the semiconductor assembly industry.

A.P. Puvanasvaran, C.Z. Mei, V.A. Alagendran. 2013. Overall Equipment Efficiency Improvement Using Time Study in an Aerospace Industry.

S. Vijaya Kumar, V.G.S Mani, N. Devraj. 2014. Production Planning and Process Improvement in an Impeller Manufacturing Using Scheduling and OEE Techniques.

Ranteshwar Singh, Dhaval B Shah, Ashish M Gohil, Milesh H Shah. 2013. Overall Equipment Effectiveness (OEE) Calculation – Automation through Hardware & Software Development.

S.E.Gouv & ada Costa, E.Pinheiro de Lima. 2002. Uses and Misuses of the 'Overall Equipment Effectiveness' for Production Management.

Stuart Giegling, Dr. William A. Verdini, Tim Haymon & Dr. John Konopka. 1997. Implementation of Overall Equipment Effectiveness (OEE) System at a Semiconductor Manufacturer

Chandrajit P Ahire, Anand S Relkar. 2012. Correlating failure mode effect analysis (FMEA) & Overall equipment effectiveness (OEE

APPENDIX A1
TABLE FOR CONTROL CHART CALCULATION

Table 6.1: Present Condition

Availability = operation time/total production							
NO.	No. sample	total production (n)	operation time (nq)	availability (q)	CL	UCL	LCL
1	1	480	412	0.86	0.83	0.88	0.78
2	2	480	394	0.82	0.83	0.88	0.78
3	3	480	374	0.78	0.83	0.88	0.78
4	4	480	399	0.83	0.83	0.88	0.78
5	5	480	411	0.86	0.83	0.88	0.78
6	6	480	405	0.84	0.83	0.88	0.78
7	7	480	402	0.84	0.83	0.88	0.78
8	8	480	368	0.77	0.83	0.88	0.78
9	9	480	400	0.83	0.83	0.88	0.78
10	10	480	402	0.84	0.83	0.88	0.78
11	11	480	413	0.86	0.83	0.88	0.78
12	12	480	399	0.83	0.83	0.88	0.78
13	13	480	411	0.86	0.83	0.88	0.78
14	14	480	402	0.84	0.83	0.88	0.78
15	15	480	413	0.86	0.83	0.88	0.78
16	16	480	412	0.86	0.83	0.88	0.78
17	17	480	394	0.82	0.83	0.88	0.78
18	18	480	374	0.78	0.83	0.88	0.78
19	19	480	402	0.84	0.83	0.88	0.78
20	20	480	408	0.85	0.83	0.88	0.78
total		**9600**	**7995**	**0.83**			

APPENDIX A2

TABLE FOR CONTROL CHART CALCULATION

Table 6.2: present condition

Quality = good piece /output							
NO.	No. sample	output (n)	good pieces(nq)	quality (q)	CL	UCL	LCL
1	1	2880	2812	0.98	0.97	0.98	0.96
2	2	2880	2782	0.97	0.97	0.98	0.96
3	3	2200	2096	0.95	0.97	0.98	0.96
4	4	2880	2797	0.97	0.97	0.98	0.96
5	5	2880	2810	0.98	0.97	0.98	0.96
6	6	3400	3329	0.98	0.97	0.98	0.96
7	7	2000	1928	0.96	0.97	0.98	0.96
8	8	2880	2767	0.96	0.97	0.98	0.96
9	9	3660	3577	0.98	0.97	0.98	0.96
10	10	2880	2805	0.97	0.97	0.98	0.96
11	11	2880	2822	0.98	0.97	0.98	0.96
12	12	2880	2797	0.97	0.97	0.98	0.96
13	13	2880	2810	0.98	0.97	0.98	0.96
14	14	3300	3225	0.98	0.97	0.98	0.96
15	15	2880	2822	0.98	0.97	0.98	0.96
16	16	2880	2812	0.98	0.97	0.98	0.96
17	17	2880	2782	0.97	0.97	0.98	0.96
18	18	2200	2096	0.95	0.97	0.98	0.96
19	19	2000	1928	0.96	0.97	0.98	0.96
20	20	2880	2811	0.98	0.97	0.98	0.96
total		56200	54608	0.97			

APPENDIX A3
TABLE FOR CONTROL CHART CALCULATION

Table 6.3: Present Condition

Performance = Total Pieces/Operation Time /Ideal Run Rate								
No.	No. Sample	ideal run rate (n)	total pieces	tot pieces/operation time (nq)	performance (q)	CL	UCL	LCL
1	1	8	2812	6.83	0.85	0.85	1.23	0.46
2	2	8	2782	7.06	0.88	0.85	1.23	0.46
3	3	8	2096	5.60	0.70	0.85	1.23	0.46
4	4	8	2797	7.01	0.88	0.85	1.23	0.46
5	5	8	2810	6.84	0.85	0.85	1.23	0.46
6	6	8	3199	7.90	0.99	0.85	1.23	0.46
7	7	8	1928	4.80	0.60	0.85	1.23	0.46
8	8	8	2767	7.52	0.94	0.85	1.23	0.46
9	9	8	3187	7.97	1.00	0.85	1.23	0.46
10	10	8	2805	6.98	0.87	0.85	1.23	0.46
11	11	8	2822	6.83	0.85	0.85	1.23	0.46
12	12	8	2797	7.01	0.88	0.85	1.23	0.46
13	13	8	2810	6.84	0.85	0.85	1.23	0.46
14	14	8	3195	7.95	0.99	0.85	1.23	0.46
15	15	8	2822	6.83	0.85	0.85	1.23	0.46
16	16	8	2812	6.83	0.85	0.85	1.23	0.46
17	17	8	2782	7.06	0.88	0.85	1.23	0.46
18	18	8	2096	5.60	0.70	0.85	1.23	0.46
19	19	8	1928	4.80	0.60	0.85	1.23	0.46
20	20	8	2811	6.89	0.86	0.85	1.23	0.46

APPENDIX A4

TABLE FOR CONTROL CHART CALCULATION

Table 6.4: Present Condition

performance X quality X availability							
NO.	NO. SAMPLE	100 (n)	av x qua x perform(nq)	OEE (q)	CL	UCL	LCL
1	1	100	0.72	71.90	68.51	82.44	54.58
2	2	100	0.70	70.20	68.51	82.44	54.58
3	3	100	0.52	51.91	68.51	82.44	54.58
4	4	100	0.71	70.55	68.51	82.44	54.58
5	5	100	0.72	72.03	68.51	82.44	54.58
6	6	100	0.81	81.28	68.51	82.44	54.58
7	7	100	0.48	48.34	68.51	82.44	54.58
8	8	100	0.69	69.48	68.51	82.44	54.58
9	9	100	0.81	81.01	68.51	82.44	54.58
10	10	100	0.71	71.07	68.51	82.44	54.58
11	11	100	0.72	71.98	68.51	82.44	54.58
12	12	100	0.71	70.55	68.51	82.44	54.58
13	13	100	0.72	72.03	68.51	82.44	54.58
14	14	100	0.82	81.78	68.51	82.44	54.58
15	15	100	0.72	71.98	68.51	82.44	54.58
16	16	100	0.72	71.90	68.51	82.44	54.58
17	17	100	0.70	70.20	68.51	82.44	54.58
18	18	100	0.52	51.91	68.51	82.44	54.58
19	19	100	0.48	48.34	68.51	82.44	54.58
20	20	100	0.72	71.74	68.51	82.44	54.58
total		100	0.69	68.51			

APPENDIX A5

TABLE FOR CONTROL CHART CALCULATION

Table 6.5: Present condition for revise.

availability = operation time/total production							
NO.	no sample	total production (n)	operation time (nq)	availability (q)	CL	UCL	LCL
1	1	480	412	0.86	0.84	0.89	0.79
2	2	480	394	0.82	0.84	0.89	0.79
3	4	480	399	0.83	0.84	0.89	0.79
4	5	480	411	0.86	0.84	0.89	0.79
5	6	480	405	0.84	0.84	0.89	0.79
6	7	480	402	0.84	0.84	0.89	0.79
7	9	480	400	0.83	0.84	0.89	0.79
8	10	480	402	0.84	0.84	0.89	0.79
9	11	480	413	0.86	0.84	0.89	0.79
10	12	480	399	0.83	0.84	0.89	0.79
11	13	480	411	0.86	0.84	0.89	0.79
12	14	480	402	0.84	0.84	0.89	0.79
13	15	480	413	0.86	0.84	0.89	0.79
14	16	480	412	0.86	0.84	0.89	0.79
15	17	480	394	0.82	0.84	0.89	0.79
16	19	480	402	0.84	0.84	0.89	0.79
17	20	480	408	0.85	0.84	0.89	0.79
total		8160	6879	0.84			

APPENDIX A6
TABLE FOR CONTROL CHART CALCULATION

Table 6.6: Present condition for revise.

quality = good piece /output							
NO.	no sample	output (n)	good pieces(nq)	quality (q)	CL	UCL	LCL
1	1	2880	2812	0.98	0.975	0.984	0.966
2	2	2880	2782	0.97	0.975	0.984	0.966
3	4	2880	2797	0.97	0.975	0.984	0.966
4	5	2880	2810	0.98	0.975	0.984	0.966
5	6	3400	3329	0.98	0.975	0.984	0.966
6	9	3660	3577	0.98	0.975	0.984	0.966
7	10	2880	2805	0.97	0.975	0.984	0.966
8	11	2880	2822	0.98	0.975	0.984	0.966
9	12	2880	2797	0.97	0.975	0.984	0.966
10	13	2880	2810	0.98	0.975	0.984	0.966
11	14	3300	3225	0.98	0.975	0.984	0.966
12	15	2880	2822	0.98	0.975	0.984	0.966
13	16	2880	2812	0.98	0.975	0.984	0.966
14	17	2880	2782	0.97	0.975	0.984	0.966
15	20	2880	2811	0.98	0.975	0.984	0.966
total		44920	43793	0.97			

APPENDIX A7

TABLE FOR CONTROL CHART CALCULATION

Table 6.7: Present condition for revise.

Performance = Total Pieces/Operation Time /Ideal Run Rate								
No.	No. Sample	Ideal Run Rate (N)	Total Pieces	Tot Pieces/Operation Time (Nq)	Performance (Q)	CL	UCL	LCL
1	1	8	2812	6.83	0.85	0.85	1.23	0.46
2	2	8	2782	7.06	0.88	0.85	1.23	0.46
3	3	8	2096	5.60	0.70	0.85	1.23	0.46
4	4	8	2797	7.01	0.88	0.85	1.23	0.46
5	5	8	2810	6.84	0.85	0.85	1.23	0.46
6	6	8	3199	7.90	0.99	0.85	1.23	0.46
7	7	8	1928	4.80	0.60	0.85	1.23	0.46
8	8	8	2767	7.52	0.94	0.85	1.23	0.46
9	9	8	3187	7.97	1.00	0.85	1.23	0.46
10	10	8	2805	6.98	0.87	0.85	1.23	0.46
11	11	8	2822	6.83	0.85	0.85	1.23	0.46
12	12	8	2797	7.01	0.88	0.85	1.23	0.46
13	13	8	2810	6.84	0.85	0.85	1.23	0.46
14	14	8	3195	7.95	0.99	0.85	1.23	0.46
15	15	8	2822	6.83	0.85	0.85	1.23	0.46
16	16	8	2812	6.83	0.85	0.85	1.23	0.46
17	17	8	2782	7.06	0.88	0.85	1.23	0.46
18	18	8	2096	5.60	0.70	0.85	1.23	0.46
19	19	8	1928	4.80	0.60	0.85	1.23	0.46
20	20	8	2811	6.89	0.86	0.85	1.23	0.46
Total		160	54058	6.76	0.85			

APPENDIX A8

TABLE FOR CONTROL CHART CALCULATION

Table 6.8: Present condition for revise.

OEE							
NO.	NO.	100 (n)	av x qua x perform(nq)	OEE (q)	CL	UCL	LCL
1	1	100	0.72	71.5	77.76	90.23	65.28
2	2	100	0.70	69.98	77.76	90.23	65.28
3	4	100	0.71	70.74	77.76	90.23	65.28
4	5	100	0.71	71.4	77.76	90.23	65.28
5	6	100	0.81	81.5	77.76	90.23	65.28
6	8	100	0.69	69.23	77.76	90.23	65.28
9	9	100	0.81	80.89	77.76	90.23	65.28
7	10	100	0.71	71.14	77.76	90.23	65.28
8	11	100	0.72	72.01	77.76	90.23	65.28
9	12	100	0.71	70.74	77.76	90.23	65.28
10	13	100	0.71	71.4	77.76	90.23	65.28
11	14	100	0.81	81.29	77.76	90.23	65.28
12	15	100	0.72	72.01	77.76	90.23	65.28
13	16	100	0.72	71.5	77.76	90.23	65.28
14	17	100	0.70	69.98	77.76	90.23	65.28
15	20	100	0.71	71.45	77.76	90.23	65.28
total		100	0.78	77.76			

APPENDIX A9

TABLE FOR CONTROL CHART CALCULATION

Table 6.9: Present condition for target.

availability = operation time/total production							
NO.	no sample	total production (n)	operation time (nq)	availability (q)	CL	UCL	LCL
1	1	480	412	0.86	0.86	0.91	0.81
2	5	480	411	0.86	0.86	0.91	0.81
3	11	480	413	0.86	0.86	0.91	0.81
4	13	480	411	0.86	0.86	0.91	0.81
5	15	480	413	0.86	0.86	0.91	0.81
6	16	480	412	0.86	0.86	0.91	0.81
total		2880	2472	0.86			

Table 6.10: Present condition for target.

quality = good piece /output							
NO.	no sample	output (n)	good pieces(nq)	quality (q)	CL	UCL	LCL
1	1	2880	2812	0.98	0.977	0.986	0.969
2	5	2880	2810	0.98	0.977	0.986	0.969
3	6	3400	3329	0.98	0.977	0.986	0.969
4	9	3660	3577	0.98	0.977	0.986	0.969
5	11	2880	2822	0.98	0.977	0.986	0.969
6	13	2880	2810	0.98	0.977	0.986	0.969
7	14	3300	3225	0.98	0.977	0.986	0.969
8	15	2880	2822	0.98	0.977	0.986	0.969
9	16	2880	2812	0.98	0.977	0.986	0.969
10	20	2880	2811	0.98	0.977	0.986	0.969
total		30520	29830	0.98			

APPENDIX A10
TABLE FOR CONTROL CHART CALCULATION

Table 6.11: Present condition for target.

Performance = Total Pieces/Operation Time /Ideal Run Rate								
No.	No. Sample	Ideal Run Rate (N)	Total Pieces	Tot Pieces/Operation Time (Nq)	Performance (Q)	CL	UCL	LCL
1	6	8	3199	7.90	0.987	0.99	1.09	0.89
2	9	8	3187	7.97	0.996	0.99	1.09	0.89
3	14	8	3195	7.95	0.993	0.99	1.09	0.89
Total		16	6386	7.93	0.99			

Table 6.12: Present condition for target.

performance Xquality X availability							
NO.	NO. SAMPLE	100 (n)	av x qua x perform(nq)	OEE (q)	CL	UCL	LCL
3	13	100	0.86	86.05	85.01	95.72	74.30
4	14	100	0.84	83.97	85.01	95.72	74.30
total		100	0.85	85.01			

APPENDIX B1
TABLE FOR CONTROL CHART CALCULATION

Table 6.13: new condition

availability = operation time/total production							
No.	No. Sample	Total Production (N)	Operation Time (Nq)	Availability (Q)	CL	UCL	LCL
1	1	480	440	0.92	0.89	0.93	0.85
2	2	480	417	0.87	0.89	0.93	0.85
3	3	480	432	0.9	0.89	0.93	0.85
4	4	480	415	0.86	0.89	0.93	0.85
5	5	480	450	0.94	0.89	0.93	0.85
6	6	480	408	0.85	0.89	0.93	0.85
7	7	480	412	0.86	0.89	0.93	0.85
8	8	480	415	0.86	0.89	0.93	0.85
9	9	480	431	0.9	0.89	0.93	0.85
10	10	480	426	0.89	0.89	0.93	0.85
11	11	480	443	0.92	0.89	0.93	0.85
12	12	480	429	0.89	0.89	0.93	0.85
13	13	480	421	0.88	0.89	0.93	0.85
14	14	480	408	0.85	0.89	0.93	0.85
15	15	480	412	0.86	0.89	0.93	0.85
16	16	480	415	0.86	0.89	0.93	0.85
17	17	480	440	0.92	0.89	0.93	0.85
18	18	480	438	0.91	0.89	0.93	0.85
19	19	480	432	0.9	0.89	0.93	0.85
20	20	480	444	0.93	0.89	0.93	0.85
total		9600	8528	0.89			

APPENDIX B2
TABLE FOR CONTROL CHART CALCULATION

Table 6.14: new condition

quality = good piece /output							
NO.	NO. SAMPLE	output (n)	good pieces(nq)	quality (q)	CL	UCL	LCL
1	1	2880	2872	1.00	0.9919	0.9969	0.9870
2	2	3330	3303	0.99	0.9919	0.9969	0.9870
3	3	2880	2862	0.99	0.9919	0.9969	0.9870
4	4	2880	2848	0.99	0.9919	0.9969	0.9870
5	5	3600	3572	0.99	0.9919	0.9969	0.9870
6	6	3200	3162	0.99	0.9919	0.9969	0.9870
7	7	2880	2850	0.99	0.9919	0.9969	0.9870
8	8	2880	2855	0.99	0.9919	0.9969	0.9870
9	9	2880	2857	0.99	0.9919	0.9969	0.9870
10	10	2000	1963	0.98	0.9919	0.9969	0.9870
11	11	2880	2874	1.00	0.9919	0.9969	0.9870
12	12	2880	2847	0.99	0.9919	0.9969	0.9870
13	13	3360	3332	0.99	0.9919	0.9969	0.9870
14	14	3400	3362	0.99	0.9919	0.9969	0.9870
15	15	2880	2850	0.99	0.9919	0.9969	0.9870
16	16	2880	2855	0.99	0.9919	0.9969	0.9870
17	17	3200	3192	1.00	0.9919	0.9969	0.9870
18	18	3300	3273	0.99	0.9919	0.9969	0.9870
19	19	3170	3152	0.99	0.9919	0.9969	0.9870
20	20	2880	2874	1.00	0.9919	0.9969	0.9870
total		60240	59755	0.99			

APPENDIX B3
TABLE FOR CONTROL CHART CALCULATION

Table 6.15: new condition

Performance = Total Pieces/Operation Time /Ideal Run Rate								
No.	No. Sample	Ideal Run Rate (N)	Total Pieces	Tot Pieces/Operation Time (Nq)	Performance (Q)	CL	UCL	LCL
1	1	8	2872	6.53	0.82	0.87	1.23	0.52
2	2	8	3303	7.92	0.99	0.87	1.23	0.52
3	3	8	2862	6.63	0.83	0.87	1.23	0.52
4	4	8	2848	6.86	0.86	0.87	1.23	0.52
5	5	8	3572	7.94	0.99	0.87	1.23	0.52
6	6	8	3162	7.75	0.97	0.87	1.23	0.52
7	7	8	2850	6.92	0.86	0.87	1.23	0.52
8	8	8	2855	6.88	0.86	0.87	1.23	0.52
9	9	8	2857	6.63	0.83	0.87	1.23	0.52
10	10	8	1963	4.61	0.58	0.87	1.23	0.52
11	11	8	2874	6.49	0.81	0.87	1.23	0.52
12	12	8	2847	6.64	0.83	0.87	1.23	0.52
13	13	8	3332	7.91	0.99	0.87	1.23	0.52
14	14	8	3262	8.00	1.00	0.87	1.23	0.52
15	15	8	2850	6.92	0.86	0.87	1.23	0.52
16	16	8	2855	6.88	0.86	0.87	1.23	0.52
17	17	8	3192	7.25	0.91	0.87	1.23	0.52
18	18	8	3273	7.47	0.93	0.87	1.23	0.52
19	19	8	3152	7.30	0.91	0.87	1.23	0.52
20	20	8	2874	6.47	0.81	0.87	1.23	0.52
Total		160	59655	7.00	0.87			

APPENDIX B4
TABLE FOR CONTROL CHART CALCULATION

Table 6.16: new condition

performance X quality X availability							
NO.	NO. SAMPLE	100 (n)	av x qua x perform(nq)	OEE (q)	CL	UCL	LCL
1	1	100	0.75	74.58	77.05	89.67	64.44
2	2	100	0.85	85.32	77.05	89.67	64.44
3	3	100	0.74	74.07	77.05	89.67	64.44
4	4	100	0.73	73.34	77.05	89.67	64.44
5	5	100	0.92	92.3	77.05	89.67	64.44
6	6	100	0.81	81.37	77.05	89.67	64.44
7	7	100	0.73	73.45	77.05	89.67	64.44
8	8	100	0.74	73.7	77.05	89.67	64.44
9	9	100	0.74	73.81	77.05	89.67	64.44
10	10	100	0.50	50.17	77.05	89.67	64.44
11	11	100	0.75	74.69	77.05	89.67	64.44
12	12	100	0.73	73.29	77.05	89.67	64.44
13	13	100	0.86	86.05	77.05	89.67	64.44
14	14	100	0.84	83.97	77.05	89.67	64.44
15	15	100	0.73	73.45	77.05	89.67	64.44
16	16	100	0.74	73.7	77.05	89.67	64.44
17	17	100	0.83	82.92	77.05	89.67	64.44
18	18	100	0.85	84.54	77.05	89.67	64.44
19	19	100	0.82	81.62	77.05	89.67	64.44
20	20	100	0.75	74.69	77.05	89.67	64.44
total		100	0.77	77.05			

APPENDIX B5

TABLE FOR CONTROL CHART CALCULATION

Table 6.17: new condition for revise

availability = operation time/total production							
NO.	NO. SAMPLE	total production (n)	operation time (nq)	availability (q)	CL	UCL	LCL
1	1	480	440	0.92	0.89	0.93	0.84
2	2	480	417	0.87	0.89	0.93	0.84
3	3	480	432	0.9	0.89	0.93	0.84
4	4	480	415	0.86	0.89	0.93	0.84
5	6	480	408	0.85	0.89	0.93	0.84
6	7	480	412	0.86	0.89	0.93	0.84
7	8	480	415	0.86	0.89	0.93	0.84
8	9	480	431	0.9	0.89	0.93	0.84
9	10	480	426	0.89	0.89	0.93	0.84
10	11	480	443	0.92	0.89	0.93	0.84
11	12	480	429	0.89	0.89	0.93	0.84
12	13	480	421	0.88	0.89	0.93	0.84
13	14	480	408	0.85	0.89	0.93	0.84
14	15	480	412	0.86	0.89	0.93	0.84
15	16	480	415	0.86	0.89	0.93	0.84
16	17	480	440	0.92	0.89	0.93	0.84
17	18	480	438	0.91	0.89	0.93	0.84
18	19	480	432	0.9	0.89	0.93	0.84
19	20	480	444	0.93	0.89	0.93	0.84
total		9120	8078	0.89			

APPENDIX B6

TABLE FOR CONTROL CHART CALCULATION

Table 6.18: new condition for revise

quality = good piece /output							
NO.	NO. SAMPLE	output (n)	good pieces(nq)	quality (q)	CL	UCL	LCL
1	2	3330	3303	0.9919	0.9909	0.9959	0.9860
2	3	2880	2862	0.9938	0.9909	0.9959	0.9860
3	4	2880	2848	0.9889	0.9909	0.9959	0.9860
4	5	3600	3572	0.9922	0.9909	0.9959	0.9860
5	6	3200	3162	0.9881	0.9909	0.9959	0.9860
6	7	2880	2850	0.9896	0.9909	0.9959	0.9860
7	8	2880	2855	0.9913	0.9909	0.9959	0.9860
8	9	2880	2857	0.9920	0.9909	0.9959	0.9860
9	12	2880	2847	0.9885	0.9909	0.9959	0.9860
10	13	3360	3332	0.9917	0.9909	0.9959	0.9860
11	14	3400	3362	0.9888	0.9909	0.9959	0.9860
12	15	2880	2850	0.9896	0.9909	0.9959	0.9860
13	16	2880	2855	0.9913	0.9909	0.9959	0.9860
14	18	3300	3273	0.9918	0.9909	0.9959	0.9860
15	19	3170	3152	0.9943	0.9909	0.9959	0.9860
total		46400	45980	0.9909			

APPENDIX B7

TABLE FOR CONTROL CHART CALCULATION

Table 6.19: new condition for revise

Performance = Total Pieces/Operation Time /Ideal Run Rate								
No.	No. Sample	Ideal Run Rate (N)	Total Pieces	Tot Pieces/Operation Time (Nq)	Performance (Q)	CL	UCL	LCL
1	1	8	2872	6.53	0.82	0.87	1.23	0.52
2	2	8	3303	7.92	0.99	0.87	1.23	0.52
3	3	8	2862	6.63	0.83	0.87	1.23	0.52
4	4	8	2848	6.86	0.86	0.87	1.23	0.52
5	5	8	3572	7.94	0.99	0.87	1.23	0.52
6	6	8	3162	7.75	0.97	0.87	1.23	0.52
7	7	8	2850	6.92	0.86	0.87	1.23	0.52
8	8	8	2855	6.88	0.86	0.87	1.23	0.52
9	9	8	2857	6.63	0.83	0.87	1.23	0.52
10	10	8	1963	4.61	0.58	0.87	1.23	0.52
11	11	8	2874	6.49	0.81	0.87	1.23	0.52
12	12	8	2847	6.64	0.83	0.87	1.23	0.52
13	13	8	3332	7.91	0.99	0.87	1.23	0.52
14	14	8	3262	8.00	1.00	0.87	1.23	0.52
15	15	8	2850	6.92	0.86	0.87	1.23	0.52
16	16	8	2855	6.88	0.86	0.87	1.23	0.52
17	17	8	3192	7.25	0.91	0.87	1.23	0.52
18	18	8	3273	7.47	0.93	0.87	1.23	0.52
19	19	8	3152	7.30	0.91	0.87	1.23	0.52
20	20	8	2874	6.47	0.81	0.87	1.23	0.52
Total		160	59655	7.00	0.87			

APPENDIX B8

TABLE FOR CONTROL CHART CALCULATION

Table 6.20: new condition for revise

performance X quality X availability							
NO.	NO. SAMPLE	100 (n)	av x qua x perform(nq)	OEE (q)	CL	UCL	LCL
1	1	100	0.75	74.58	77.70	90.19	65.21
2	2	100	0.85	85.32	77.70	90.19	65.21
3	3	100	0.74	74.07	77.70	90.19	65.21
4	4	100	0.73	73.34	77.70	90.19	65.21
5	6	100	0.81	81.37	77.70	90.19	65.21
6	7	100	0.73	73.45	77.70	90.19	65.21
7	8	100	0.74	73.7	77.70	90.19	65.21
8	9	100	0.74	73.81	77.70	90.19	65.21
9	11	100	0.75	74.69	77.70	90.19	65.21
10	12	100	0.73	73.29	77.70	90.19	65.21
11	13	100	0.86	86.05	77.70	90.19	65.21
12	14	100	0.84	83.97	77.70	90.19	65.21
13	15	100	0.73	73.45	77.70	90.19	65.21
14	16	100	0.74	73.7	77.70	90.19	65.21
15	17	100	0.83	82.92	77.70	90.19	65.21
16	18	100	0.85	84.54	77.70	90.19	65.21
17	19	100	0.82	81.62	77.70	90.19	65.21
18	20	100	0.75	74.69	77.70	90.19	65.21
total		100	0.78	77.70			

APPENDIX B9

TABLE FOR CONTROL CHART CALCULATION

Table 6.21: new condition for target

availability = operation time/total production							
NO.	NO. SAMPLE	total production (n)	operation time (nq)	availability (q)	CL	UCL	LCL
1	1	480	440	0.92	0.92	0.96	0.88
2	11	480	443	0.92	0.92	0.96	0.88
3	17	480	440	0.92	0.92	0.96	0.88
4	20	480	444	0.93	0.92	0.96	0.88
total		1920	1767	0.92			

Table 6.22: new condition for target

quality = good piece /output							
NO.	NO. SAMPLE	output (n)	good pieces(nq)	quality (q)	CL	UCL	LCL
1	3	2880	2862	0.9938	0.9940	0.9983	0.9898
2	19	3170	3152	0.9943	0.9940	0.9981	0.9900
total		6050	6014	0.9940			

APPENDIX B10
CONTROL CHART CALCULATION

Table 6.23: new condition for target

Performance = Total Pieces/Operation Time /Ideal Run Rate								
No.	No. Sample	Ideal Run Rate (N)	Total Pieces	Tot Pieces/Operation Time (Nq)	Performance (Q)	CL	UCL	LCL
1	2	8	3303	7.92	0.99	1.00	1.00	1.00
2	5	8	3572	7.94	0.99	1.00	1.00	1.00
5	13	8	3332	7.91	0.99	1.00	1.00	1.00
6	14	8	3362	8.24	1.00	1.00	1.00	1.00
Total		32	13569	8.00	1.00			

Table 6.24: new condition for target

performance X quality X availability							
NO.	NO. SAMPLE	100 (n)	av x qua x perform(nq)	OEE (q)	CL	UCL	LCL
3	13	100	0.86	86.05	85.01	95.72	74.30
4	14	100	0.84	83.97	85.01	95.72	74.30
total		100	0.85	85.01			

APPENDIX C

CNC WINDING MACHINE

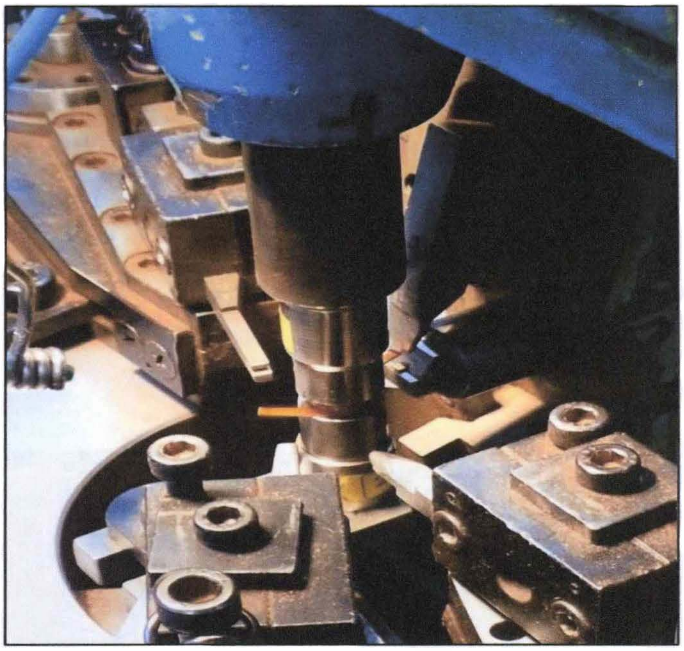


Figure 6.1: Bending Tool Move to Form the Coil

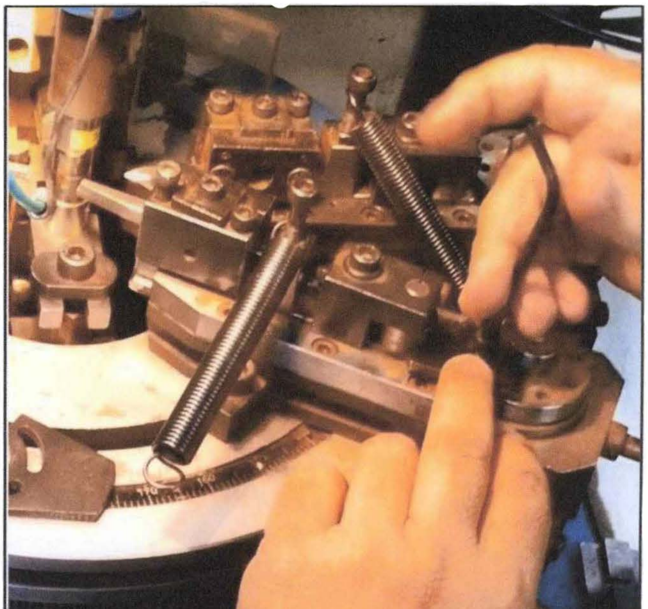


Figure 6.2: Technician Attach The Mechanism.

Figure 6.3: Wire Guider

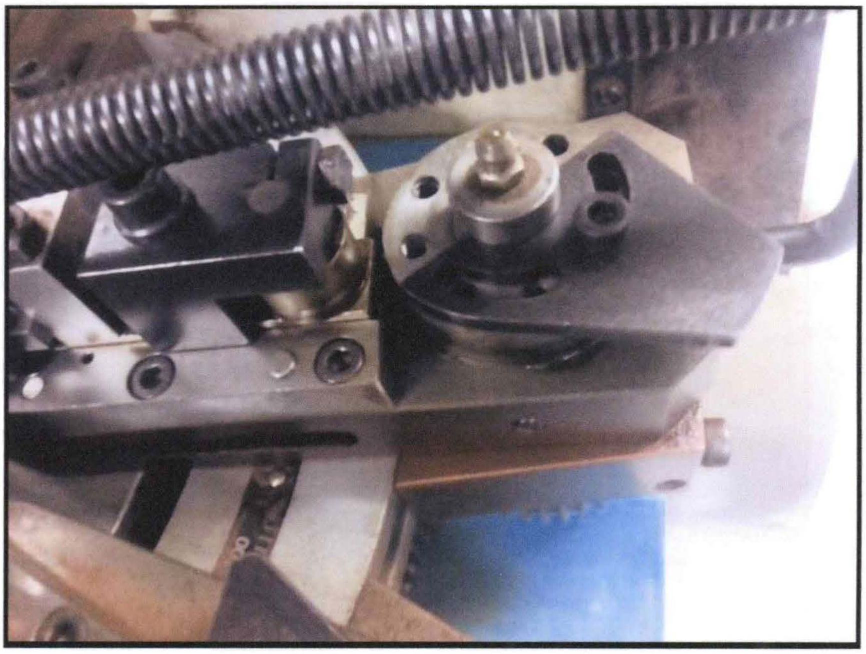


Figure 6.4: Mechanism

Figure 6.5: At The Back of Machine

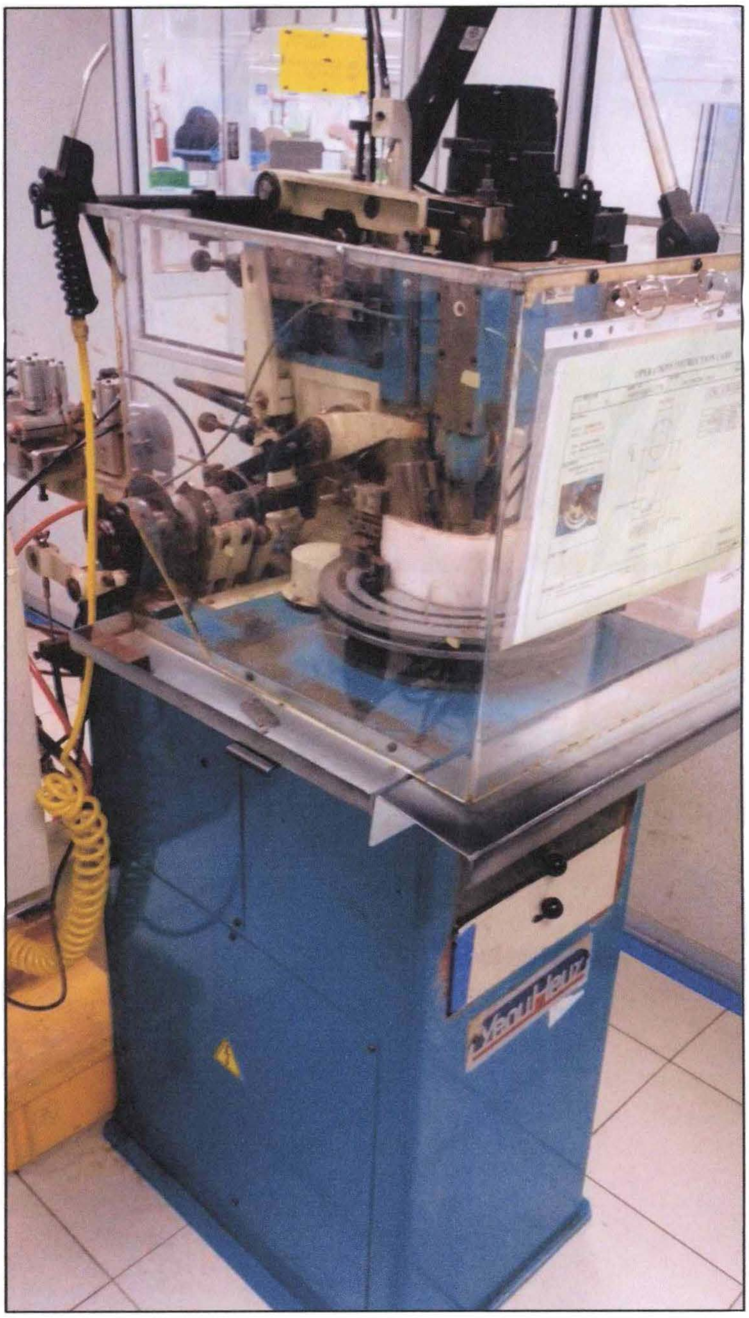


Figure 6.6: CNC Winding machine

Figure 6.7: CNC Winding Machine with Controller

APPENDIX D
GANTT CHART