INTEGRATING QUALITY TOOL ON IMPROVING OVERALL EQUIPMENT EFFICIENCY IN AUTOCLAVE PROCESS: CASE STUDY

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management) (Hons.)

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I hereby, declared this report entitled "Integrating Quality Tools on Improving OEE in Autoclave Process: A Case Study" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management) (Hons.). The member of the supervisory committee is as follow:

………………………………

(IR. DR. PUVANASVARAN A/L A.PERUMAL)

ABSTRAK

Projek Sarjana Muda merupakan subjek yang wajib diambil oleh mahasiswa Tahun 4 Ijazah Sarjana Muda sebagai kerja kursus akademik dan pengijazahan. Tujuan projek sarjana muda tersebut adalah untuk mendedahkan mahasiswa terhadap etika kejuruteraan, tingkah laku profesionalisme kejuruteraan, kecekapan komunikasi, membina keyakinan dan menanam sikap positif dalam menjalani dan mengaplikasikan theori yang telah dipelajari sepanjang pembelajaran. Tajuk projek yang telah dipilih ialah “Integrating Quality Tools on Improving OEE in Autoclave Process” yang bermatlamat untuk meningkatkan pretasi kecekapan peralatan di industri pembuatan komposit dengan menggunakan pelbagai kualiti teknik. Intipati kajian ini adalah untuk menyampaikan satu kertas kerja yang mengesahkan aplikasi tertentu untuk meningkatkan kecekapan peralatan melalui pelaksanaan teknik quality di peringkat yang berbeza. Penggunaan melalui pengiraan kecekapan peralatan telah digunakan sebagai teknik quality yang utama dan teras untuk meningkatkan pretasi kecekapan peralatan. Cause and Effect Diagram, FMEA dan SMED akan digunakan sebagai alat sokongan. Penyelidikan terhadap teknik quality telah dijalankan melalui penemuan mengenai pelaksanaan taknik quality tersebut dalam kajian dahulu. Metodologi yang dibentangkan mengenai konsep integrasi teknik quality akan membantu dalam kawasan perindustrian yang menggunakan OEE sebagai ukuran kecekapan peralatan.

ABSTRACT

Final year project is the compulsory subject taken by the final year Bachelor students as to complete their own measure course and graduation. Purpose of the final year project is to expose students to engineering practice, professionalism engineering behavior, communication skills, build self confidence and instill the right work attitude to apply their technical knowledge in future. The project chosen entitled "Integrating Quality Tools on Improving OEE in Autoclave Process" aims to improve the overall equipment efficiency performance measure in the research company of composite manufacturing based using different types of quality tools. Essence of this study is to develop a manual instruction on OEE improvement methodology through the implementation of quality tools and techniques in different stage. OEE is the main or core quality tools that decide to use for the improvement where Cause and Effect Diagram, FMEA and SMED will use as the supportive tools. The research on the tools is carried out through findings on historical implementation of journal study. Methodology presented will help in the industrial area which performs OEE measurement by proposing them with the integrating quality tools concept.

DEDICATION

Give a precious dedicated to my beloved supervisor, parents, and my friends who fully support me along this project study.

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First and foremost, I would like to express my deepest gratitude to my supervisor IR.DR. Puvanasvaran A/L A.Perumal, of Manufacturing Engineering, University Technical Malaysia Malacca who guiding me with his valuable knowledge and spend his time to assist me on overcome any difficulties during the project study. Besides that, I would like to thank to my friends for giving me supports and helps especially in period of uncertainties and difficulties.

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LIST OF ABBREVIATION

FMEA	- Failure Mode Effect Analysis
FRACAS	- Failure Analysis and Corrective Action System
NST	- Non-Scheduled Time
NVA	- Non-Value Added
OEE	- Overall Equipment Efficiency
PM	- Performance Measurement
R&D	- Research and Development
RPN	- Risk Priority Number
SEMI	- Semiconductor Equipment and Material International
SMED	- Single Minute Exchange Die
SOW	- Statement of Work
SRD	- System Requirement Document
TPM	- Total Productive Maintenance
WIP	- Work In Process
VA	- Value Added
VSM	- Value Stream Mapping

CHAPTER 1
INTRODUCTION

1.0 INTRODUCTION

This chapter is the overall starting concept of the study conducted in the company which consists of the company background, problem statement that highlighted and emphasized the purpose to carry out the study which necessitates alternatives remedies, objectives that the research to be conducted and scope of study. The expected finding of this project will also be discussed in the end of this chapter.

1.1 BACKGROUND

ABC Company which situated in Malacca is selected to be studied in this project. A subsidiary of ABC Company is responsible in manufacturing the composites aero structures for its strategic partner and customers from around the world.

In fulfilling the requirements and quality standard put forward by its customers, it is committed to adopt the Lean Enterprise Systems as its business strategy and work culture. The main objectives of adopting the Lean Enterprise Systems are to achieve the profitable and sustainable growth, improving the work force empowerment, to develop and utilise all company resources, implementing structured and goal orientated change management programme and to align the company's strategies for global challenges through KPI and Industrial benchmarking.

This project is conducted by implementing the quality tools to improve the Overall Equipment Efficiency (OEE) in the autoclave study. Overall Equipment Effectiveness (OEE) is a key measurement of efficiency in manufacturing processes (at machine, manufacturing cell or assembly line levels). This research is focusing on the improvement of autoclave utilization through implementation of several quality tools and OEE as the core measurement of the improvement. Few quality tools to be implemented as the supportive tools here include Failure Mode Effect Analysis (FMEA), Cause and Effect Diagram and Single Minutes Exchange of Die (SMED).

1.2 PROBLEM STATEMENT

Overall equipment effectiveness (OEE) is seen to be the fundamental way of measuring performance efficiency. It is the essential measure of total productive maintenance (TPM) and lean maintenance. The concept of OEE is being used increasingly in industry because it monitors the actual performance of a machine relative to its performance capabilities under optimal manufacturing conditions. OEE at its simplest form is the cumulative impact of three factors availability, performance and quality. In the measurement of the three factors, the key reasons that most operations do not achieved high OEE percentages are generally caused by the six big losses which are breakdowns, setup and adjustments, small stops, reduced speed, start-up rejects and the production rejects. These losses created during the operation would somehow reduce the efficiency of the machine and material usage, quality of products and the time utilization for the overall process. The performance of OEE would be affected due to the changing of parameter during the autoclave process. In this project, the Autoclave is chosen as the subject of study among the processes of the production because it is the bottleneck that contributes to delay of the production and shipment. The problems exist in the Autoclave include the excessive long setup time, unexpected breakdown or delay and sometimes the cancelation of curing process just before the scheduled time for the particular curing. Some of these problems happen in relatively short time and are usually neglected. This is somehow contributing to big loss when they are accumulated and there is a necessity to quantify the total loss in effectiveness of utilization for the autoclave.

1.3 OBJECTIVES

The objectives of this study are:

(a) To identify the area of improvement in autoclave curing process.
(b) To quantify the loss accumulated and improvement of the autoclave section, before and after quality tools implementation.
(c) To develop a macro framework as a Standard Operating Procedure in any field that involved in OEE calculation.

1.4 SCOPE OF STUDY

This project is mainly implementing the quality tools as well as lean tools along with OEE approach for the improvement of curing process in an aerospace company. Throughout the study, time utilization can be reduced in term of the six big losses. OEE will be calculated via real time data which is acquired from the computerized recording system. Performance measurement via OEE is one of the scopes in this project before and after the implementation of quality tools. Implementation of quality tools as stated above, on the other hand, is responsible in reducing and eliminating six losses identified in the OEE measurement. In short, problem solving technique using quality and lean tools is introduced to optimize the root causes as well as the six big losses that will affect the performance of OEE. However, the improvement of the process from the term of finance is not covered in this project.

CHAPTER 2
LITERATURE REVIEW

2.0 INTRODUCTION

This chapter consists of the general information and the historical data which obtained through several resources from the research of journals, articles, books or any internet server. General knowledge of the quality tools that developed in this study is included to serve as a guideline in designing and planning the project. Furthermore, the information that highlighted in this chapter is used to support the result and discussion which is developed in the following chapter. The content of this chapter includes the information of OEE as the core quality tool in this project, and other related supportive tools to facilitate the implementation of OEE measurement.

2.1 OVERALL EQUIPMENT EFFICIENCY (OEE)

Overall equipment effectiveness (OEE) is the key measure of both total productive maintenance (TPM) and lean maintenance. The concept of OEE, introduced by Nakajima (1988), is being used increasingly in industry. It looks at the wider manufacturing aspects, not only the equipment availability and performance, but also the efficiency losses that result from rework and yield losses.

According to Tajiri and Gotoh (1992) the relationship between OEE and losses depends on equipment availability, their performance rates and the quality of the product. OEE monitors the actual performance of a machine relative to its performance capabilities under optimal manufacturing conditions. While OEE reveals equipment's hidden losses after loading time, a new method in the steel industry based on market factors can monitor all losses within duration of satisfying the needs of internal and external market.

Tajiri and Gotoh (1992) classified major losses into six groups. Breakdown losses, setup and adjustment losses are downtime losses used to determine a true value for the availability of a machine. The third and fourth losses including minor stoppage and reduced speed losses are known as speed losses. They are used as a measure of performance rate of a given machine. Rework and yield losses are defined as quality losses that determine the quality rate for the equipment.

According to Ericsson (1997), OEE attempts to identify production losses and other indirect and "hidden" costs, which are those that contribute with a large proportion of the total cost of production. These losses are formulated as a function of a number of mutually exclusive components (Huang et al., 2003), namely: availability (A), performance (P) and quality (Q). In essence, OEE is the result achieved by multiplying these three factors altogether.

The availability factor measures the total time that the system is not operating because of breakdowns, set-up, adjustment, and other stoppages (Jonsson and Lesshammar, 1999). It is traditionally calculated using the Nakajima's (1988) formula presented below. In this formula, loading time refers to the equipment's total length of operation after any deduction of planned activities that may have disrupted production, for example: schedule and planned maintenance, official production breaks, process improvement initiatives or equipment tests, maintenance performed by the machine operator (e.g. equipment cleaning), operator training, etc.:

A = (Loading time – downtime)/ Loading time

The second OEE element, performance rate, measures the ratio of the actual operating speed of the equipment (e.g. the ideal speed minus speed losses, minor stoppages and idling) to its ideal speed (Jonsson and Lesshammar, 1999). It can be calculated in a number of different ways. However, Nakajima (1988) measures a fixed amount of output, and in his definition of "performance", it indicates the actual deviation in production in time from ideal cycle time. Performance (P) is calculated using the following Nakajima's (1988) equation:

P = (Ideal cycle time – output)/ Operating time

The third element of OEE is quality (Q). It indicates the proportion of defective production to the total production volume. An important characteristic that should be noted is that the quality concept, as defined by Nakajima (1988), only involves defects that occur in that designated stage of production, usually on a specific machine or production line and not elsewhere. Quality (Q) is calculated using the Nakajima's (1988) equation presented below:

Q = (Input - volume of quality defects)/ Input

Table 2.0: Defining Six Big Losses (Vorne, 2008).

OEE Loss Category	**Six Big Loss Category**	**Event Examples**	**Comment**
Down Time Loss	Breakdowns	• Tooling Failures • Unplanned Maintenance • General Breakdowns • Equipment Failure	There is flexibility on where to set the threshold between a Breakdown (Down Time Loss) and a Small Stop (Speed Loss).
	Setup and adjustments	• Setup/Changeover • Material Shortages • Operator Shortages • Major Adjustments • Warm-Up Time	This loss is often addressed through setup time reduction programs.
Speed Loss	Small Stops	• Obstructed Product Flow • Component Jams	Typically only includes stops that are under five minutes and that

		• Misfeeds • Sensor Blocked • Delivery Blocked • Cleaning/Checking	do not require maintenance personnel.
	Reduced Speed	• Rough Running • Under Nameplate Capacity • Under Design Capacity • Equipment Wear • Operator Inefficiency	Anything that keeps the process from running at its theoretical maximum speed (Ideal Run Rate or Nameplate Capacity)
Quality Loss	Start-up Rejects	• Scrap • Rework • In-Process Damage • In-Process Expiration • Incorrect Assembly	Rejects during warm-up, startup or either early production. May be due to improper setup, warm-up period, etc.
	Production Rejects	• Scrap • Rework • In-Process Damage • In-Process Expiration • Incorrect Assembly	Rejects during steady-state production

2.1.1 General Causes of Low OEE Value

Historical data of Overall Equipment Effectiveness (OEE) value was very low compared to the general manufacturing scenario will due to which the machines were not utilized effectively and hence production rate and volume was affected (Harsha, et al, 2009).

Low OEE might be contributed by:

(a) Operator Awareness: For any machine to run effectively the operator should be well experienced and capable enough to handle the machine. The operators were not well trained to operate the machine and any minor abnormalities found could not be rectified. Though the machine was capable of producing quality goods, due to manual error the quality was lost.

(b) Lack of standardized procedure: Operating procedure was not given. No shadow board near machines about the operating procedure of machines and lack of visual management made it difficult for any operator to produce the parts consistently. SOP (Standard Operating Procedure) was not in place. In addition, Process Flow chart was not provided.

(c) Maintenance Frequency: Periodic maintenance was not in place and only when the machine stopped, the maintenance was carried out. Preventive maintenance was not planned for any of the machines in the cell

(d) Checklist Points: The critical points of the machine, which required frequent attention was not identified. This led to frequent breakdown of the machine. Lack of checkpoint identification may be one of the reasons for low OEE.

2.1.2 Application of OEE

Dal et al. (2000) point out the OEE measure can provide topical information for daily decision making by utilizing largely existing performance data, such as preventive maintenance, material utilization, absenteeism, accidents, labor recovery, conformance to schedule, set-up and changeover data. Hansen (2001) describes OEE as a powerful production and maintenance tool for increasing profit. Bamber et al. (2003) discuss OEE as a total measure of performance and concluded that cross-functional team working is essential for its success.

Although OEE was originally designed to monitor and control performance, Dal (1999) suggests that the role of OEE goes far beyond the task of just monitoring and controlling. This is because OEE takes into account process improvement initiatives, prevents the sub-optimization of individual machines or production lines, provides a