UNIVERSITI TEKNIKAL MALAYSIA MELAKA

An Analysis of Jig Designs to Assembly Time in Plug Assembly Line Using Design of Experiment

Report submitted in accordance with the requirements of the
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Bachelor's Degree of Manufacturing Engineering (Manufacturing Management)

By

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BORANG PENGESAHAN STATUS REPORT*

JUDUL: **AN ANALYSIS OF JIG DESIGNS TO ASSEMBLY TIME IN PLUG ASSEMBLY LINE USING DESIGN OF EXPERIMENT**

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This report submitted to the senate of UTeM and has been accepted as fulfillment of the requirement for the Degree of Bachelor of Manufacturing Engineering (Honors) (Management). The member of supervisory committee is as follows:

……..

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DECLARATION

I hereby, declare this report entitled "An Analysis of Jig Designs to Assembly Time in Plug Assembly Line Using Design of Experiment" is the result of my own research except as cited in the references.

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ABSTRACT

This research has developed some jig designs for plug assembly line. The design is based on number plugs per jig (3 or 4), orientation of jig design (vertical or horizontal) and screwing process (no flip or flip). To find the most efficient design of jig, an experiment has been conducted based on Design of Experiment. Design of experiment 2^4 with two levels of each factor is used. Two subjects were employed to conduct the plug assembly experiment. 36 experiments for each level of factors were conducted and each subject conducted total 288 for 8 different sets of combination factor. With using Analysis of Variance (ANOVA) the most efficient design were identified. The results shows that number plug per jig in this research have most significant effect to the assembly time. Orientations of jig design and screwing process also show have significant effect to assembly time. Interaction combinations of two and three factors do not show any significant effect to assembly time. The most productive with lowest assembly time achieved at factors: number plugs per jig are 4, orientation of jig design is vertical and screwing process is flip.

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ABSTRAK

Kajian ini telah membina rekaan jig untuk membantu dalam pemasangan soket BS 1363. Rekaan jig adalah berdasar kepada nombor bilangan soket bagi setiap jig (3 atau 4), susunan soket di jig (tegak atau mendatar) dan proses pemasang skru (terbalikkan jig atau tidak terbalikkan jig). Untuk mencari rekaan jig yang paling berkesan, satu eksperimen berdasarkan konsep rekaan eksperimen dijalankan. Rekaan eksperimen 2^4 dengan dua tingkatan bagi setiap faktor telah digunakan. Dua subjek diarahkan untuk menjalankan eksperimen pemasangan soket. Secara keseluruhan, 36 eksperimen bagi setiap gabungan faktor telah dijalankan dan setiap subjek menjalankan 288 eksperiment bagi setiap gabungan faktor. Dengan menggunkan Analisa untuk Variasi, rekaan jig yang paling berkesan dapat ditentukan. Megikut keputusan yang dapat, nombor bilangan soket bagi setiap jig adalah factor paling memberi kesan kepada masa pemasangan soket. Susunan soket di jig dan proses pemasang skru juga adalah faktor yang penting bagi memberi kesan kepada masa pemasangan soket. Bagi gabungan 2 dan 3 faktor, mereka tidak menunjukan sebarang kesan kepada masa pemasangan soket. Untuk gabugan faktor rekaan jig yang paling baik dengan masa pemasangan soket yang terpendek adalah dengan nombor bilangan soket bagi setiap jig adalah 4, susunan soket di jig adalah tegak dan proses pemasang skru adalah terbalikkan jig.

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DEDICATION

For my beloved mother and father

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

ANOVA	-	Analysis of Variance
BS	-	British Standard
df	-	Degree of Freedom
DOE	-	Design of Experiment
MS	-	Mean Square
PSM	-	Projek Sarjana Muda
p-value	-	Probability Value
sec	-	Second
SS	-	Sum of Square
UTeM	-	Universiti Teknikal Malaysia Melaka

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CHAPTER 1
INTRODUCTION

1.1 Background

Today, engineers have become highly interested in the application of anthropometric and biomechanical information, especially to the design of equipment and the arrangement of workstations.

Productivity in assembly line determined by many variables, which included skill of the workers, design of equipment or tools, design of workstation and design of assembly process. Improve one variable among them can brought to the whole productivity improvement.

Workstation design is one of the major areas in which human factor professional can help improve the fit between human, machine and environment. Nowadays, in the industry, assembly job environment workplace design playing a important role that able influencing worker performance, such as use of jig and fixture, position of standing or sitting and working table height. This all aim to design a system or workstation that can reduce human error, increase productivity, and enhance safety and comfort.

Jig is a special tool used for locating and firmly holding work piece in the proper position during the manufacturing or assembly operation. Besides that, it also guides the tool or work piece during the operation. Jig is designed to increase the productivity of operation by assist worker to do job easier, faster and more comfortable. If the jig designed is not suitable for operation or operator, bad design

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jig may hinder the process of worker doing their jobs, which the jig is not productive. Design of jig is help worker in performing their job more productive but not hinders the performance.

In this experiment, practical experience is exposed in recording assembly response time data for design of an electrical plug assembly workplace. 2 students are required to assemble 36 plugs for each jig design setting with each assembly time being recorded. This research is investigating the different design of plug assembly jig by design of experiment (DOE). Some different number plug per jig, orientation design and screwing process is analyzed whether contribute to different productivity.

The task given in this research experiment is to analyze the productivity between the different designs of plug jig. The data collected is analyzed using basic statistical method such as t-test, analysis of variance (ANOVA), descriptive statistics, bar chart, stock diagram, interaction plot and main effect plot in order to determine the most contribute factor to assembly time and most productive jig design which is suitable the electrical plug assembly line.

This research project is conducted in Manufacturing Engineering Laboratory of University Teknikal Malaysia Melaka (UTeM).

1.2 Problem Statement

Productivity in assembly line is depending on many variables, design of equipment or tools (jig) is one of them. Productivity can improve by upgrading this controlled variable by test and verify which design of jig is the most contribute the productivity by reducing the assembly response time. Other variable that can contribute to the productivity, such as skill of the worker, and design of workstation are kept remain constant along the experiment task.

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The effect of the number plug per jig are investigated, how many is the optimum plugs that give the optimum assembly response time. On this research, design of jig was made to able handle 3 or 4 plugs at the same time. Besides that, the performance given by different orientation of the jig (horizontal or vertical) and design of screwing process (flip the jig and tighten the screw of plug, or took out plug one by one and screw the plug without flip) also analyzed.

A proper jig design used in assembly line is designed to help workers in performing their job easily in plug assembly job and contributes to reduce the assembly response time, but improper or bad design of jig may hinder their performance.

1.3 Objective of Study

The objective of this research is to investigate the different design of plug assembly jig by design of experiment (DOE) to see their contribution to the productivity.

The objectives of this study are:

a) To design different type of plug assembly jig according different number of plug per jig, orientation and screwing process.
b) To investigate the effect of different factor (number plug per jig, orientation of jig, and screwing process) to the response time.
c) To test and verify which plug assembly jig is the most productive.

1.4 Scope of Study

In order to understand the design of the jig, definition, basic requirement, purpose, advantage and application of jig in manufacturing field had been briefly explain. The method that been used to investigate the performance of different jig by statistic tool, such as t-test, ANOVA, descriptive statistics, bar chart, main effect plot, interaction plot and stock diagram.

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This research project is conducted in Manufacturing Engineering Laboratory of University Teknikal Malaysia Melaka (UTeM). Different design of jig are designed and made by researcher. Data gathered - assembly response time is based on the electrical appliance, which is a BS 1363 plug, which assists by different design of jig. The subjects in this research are UTeM students. Subjects are trained to assemble plug for total 2 hours until they are comfortable and familiar in doing the plug assembly job. So the data collected are consider that the assembly response time are constant, which the subject has doing assembly job in a constant performance. Height of table is set to 91 cm for light work and precision work. The position of sitting selected while performing the plug assembly task.

The jig is only used on assembly BS 1363 plug, which the result of this research may not apply to other products. For factor number plugs per jig are only limited to 3 and 4 plugs per jig.

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CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Many manufacture tasks require precise alignment during assembly or during other operations such as plain holding, bending, cutting, drilling, or gluing. Normally, when doing an assembly task, a reliable assembly tooling needed to able to hold components in an accurate and repeatable position, prevent undesired motion of components, and avoid posing interference problems.

Especially for repeated assembly line processes, one or more flexible or specific work holding devices can use for great aids and time savers. Some commercial ones are available and many can be made from ply wood, metal or plastic material. Often many tool accessories can be adapted for use, but normally all facilitate their associated own processes.

There are many standard work holding devices such as jaw chucks, machine vises, and drill chucks, which are widely used in workshops and are usually kept in stock for general applications.

Work holder is the general term for either a jig or a fixture. The economical production of engineering components is greatly facilitated by the provision of jig and fixture. The origin of jig and fixture can be traced back to the Swiss watch and clock industry form which, after proving their usefulness, they spread through out the entire metalworking industry.

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The use of a jig or fixture makes a fairly simple operation out of one which would otherwise require a lot of skill and time. Both jig and fixture position components accurately and hold components rigid, prevent movement during working in order to impart greater productivity and part accuracy to perform on the work piece a manufacturing operation. (Andrew, Y. C. N., *et al*., 2004)

A jig is a type of fixture with means for positively guiding and supporting tools for assembly and related operations. (Henriksen, E. K., 1973)

Jig and fixture are production tools used to accurately manufacture duplicate and interchangeable parts. Jig and fixture are specially designed so that large numbers of components can be machined or assembled identically, and to ensure interchangeability of components.

Jig and fixture may be large (as in air plane fuselages are built on picture frame fixtures) or very small (as in watch making). Their use is limited only by job requirements and the imagination of the designer.

Jig and fixture must be clean, undamaged and free from grit, which components must not be forced into a jig or fixture. Jig and fixture are precision tools and some of them are expensive to produce because they are made to fine limits from materials with good resistance to wear. They must be properly stored or isolated to prevent accidental damage, and they must be numbered for identification for future use.

2.2 Different Between Jig and Fixture

Both jig and fixture are tools with holding work pieces for machining operations, but there are some differences between them. Table 2.1 shows the different between jig and fixture. Jig is rarely clamped on the machine table because it is necessary to move that jig on the table to align the work piece and machine tools. Jig is devices

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that hold and move a work piece in relation to a tool. Often they are designed as carriages that slide.

Fixture is often clamped on the machine table. A fixture is static devices that hold the work piece or tools in stationary and correct position in relation to machine tools during the operation. There is something a provision for setting that tool with respect to work piece or fixture but the tool is not guided as in jig. The features are employed for holding work in milling, grinding, planning or turning operation. Some of the more typical examples of fixtures are fences, such as a ripping fence on the table saw. Jig is generally used for more temporary holding and positioning, while fixture considered more permanent and complex.

From the construction point of view jig are lighter in weight if compare to fixture. They are quicker handling and clamping with that the table. They are used for particularly drilling, taping operations. Fixture is generally heavier in construction and is bolted rigidly on the machine table.

Table 2.1: Differentiate between jig and fixture

JIG	FIXTURE
Rarely clamped on machine table	Often clamped on machine table
Guide tools relative to work piece	Not guided as in Jig, hold the work piece
Slide device	Static device
Temporary holding and positioning	More permanent and complex
Lighter in weight	Heavier in weight
Example – holding work in drilling and tapping operations	Example - a ripping fence on the table saw, holding work in milling, grinding, planning or turning operations

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2.3 Purpose and Advantage of Jig

The main purpose of jig is to locate work quickly and accurately, support it properly, and hold it securely, thereby ensuring that all parts produced in the same jig will come out alike within specified limits. In this way accuracy and interchangeability of the parts are provided.

It also reduces working time in the various phases of the operation, in the setup and clamping the required dimensions, and during the cutting operation itself by allowing heavier feeds due to more efficient work support hence improving production rate.

The use of jig eliminates individual marking positioning and frequent checking before machining operation starts, thereby resulting in considerable saving in set-up time. In addition, the usage of work holding devices saves operator labor through simplifying locating and clamping tasks and makes possible the replacement of skilled workforce with semi-skilled labor, hence effecting substantial saving in labor cost which also translates into enhanced production rate.

Jig expand the capacity of standard machine tools to perform special operations, which they make it possible to use plain or simplified, and therefore less expensive, machinery instead of costly standard machines. In the other words, they turn plain and simple machine tools into high production equipment and convert standard machines into the equivalent of specialized equipment.

By maintaining or improving the interchangeability of the parts, a jig contributes to a considerable reduction in the cost of assembly. In effect, jig reduces costs and improves the potential of standard machines and the quality of the part produced.

Jig represents an embodiment of the principle of the transformation of skill. The skills of the experienced designers and engineers are permanently built into the jig and there made cautiously available to the unskilled operator. One important goal is

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to design jig in such way as to make it foolproof and thereby contribute to added safety for the operator as well as for the work.

2.4 Basic Requirement and Features of Jig

A good jig must satisfy the following conditions:

a) Reduction of response time

The design of jig should be such that the process of loading and unloading the components takes the minimum possible time and enables on easy loading and clamping should be such that ideal time is reduced to minimum.

b) Convenience to use

The locating and supporting surfaces should be replaceable that is not permanently fastened so that of worn out they may be replaced by new ones. Moreover they should be standardized so that their interchangeable manufacture is possible.

c) Not cause damage to work piece

Designed jig should not damaged component of the work pieces. Due to this situation, sometime natural material needed for jig. For this study, ply wood selected as plug assembly jig, because harden material will damaged pin of the plug.

d) Economic soundness

The equipment to be used should be economic sound that is the cost of designing and manufacturing it should be in production to the quantity and price of product. Ply wood used as material and simple procedure to construct the plug jig, which it is an economic low cost.

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