UNIVERSITI PUTRA MALAYSIA

FABRICATION OF COOLING JIG USING ELECTRO DISCHARGE MACHINING (EDM)

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For a high quantity production system such as PROTON, maintenance of equipments and related facilities at the production line is one of the critical factors to ensure the success of Just In Time system (JIT) and Synchronised System. A higher breakdown of equipments will affect the delivery to next processes and uncertain level of quality.

This project focused on body assembly process where this process is the second process in Proton cars manufacturing process. It features a mix of a variety type of welding assembly jig, welding equipments, material handling equipments and robots. A demand arises when the spare part of existing welding assembly jig - Cooling Jig is not available and extensive maintenance is required in maintaining the Cooling Jig.

This project focus on re-modelled and fabrication of Cooling Jig. The fabrication process needs information on surface data instead of detail drawing. But, the

information such as surface data is not available in Jig Making & Maintenance (JMM) section. The surface data is obtained thorough digitising process with coordinate measuring machine and produced the Cloud point data in a neutral data format (ASCII format). Then, Catia software was used to convert the file into DXF format. The Cooling Jig's surface was obtained first before NC data conversion can be generated. The fabrication of Cooling Jig is using EDM wire cut. Prior to machining, the Design of Experiment (DOE) was used as a method to obtain the optimum machining time and wire breakage without carrying numerous numbers of experiments at EDM Wire Cut machine – R290P, Agie Charmilles.

As a result, the In-House fabrication process reduced almost 60 % fabrication cost if outsourced and successfully forged a reverse engineering flows for JMM section.

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan ijazah Master Sains

PROSES FABRIKASI BAGI COOLING JIG MENGGUNAKAN ELECTRO DISCHARGE MACHINING(EDM)

Oleh

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Untuk sistem pengeluaran yang berkapasiti tinggi seperti PROTON, penyelenggaraan untuk peralatan-peralatan dan lain-lain kemudahan yang berkaitan merupakan salah satu faktor yang menentukan kejayaan sistem "Just In Time" dan system "Synchronised".

Projek ini memfokus kepada proses Pemasangan Badan dimana proses ini adalah proses kedua dalam pembuatan kereta PROTON. Ia terdiri daripada pelbagai jenis " Welding Assembly Jig", peralatan kimpalan, peralatan "Material Handling" dan robot. Keperluan timbul apabila tiada alat-alat ganti bagi "Cooling Jig" dan ianya juga memerlukan penyelenggaraan yang intensif.

Proses fabrikasi memerlukan maklumat bagi permukaan bersentuh diantara "Cooling Jig" dan panel "Body-In-White". Namun maklumat yang diperlukan adalah tiada di Seksyen "Jig Maintenance & Making". Data permukaan diperolehi melalui proses

"digitising" dengan "Coordinate Measuring Machine" dan menghasilkan data "Cloud Point" dalam format data neutral (format ASCII). Seterusnya, CATIA digunakan untuk menukarkan fail tersebut kepada fail dalam format DXF. Permukaan "Cooling Jig" dibentuk terlebih dahulu sebelum ditukarkan kepada data NC. "Design of Experiment" telah digunakan sebagai salah satu kaedah mendapatkan masa pemotongan yang minimum dan juga "Wire Breakage" tanpa perlu menjalankan banyak ekperimen di mesin "EDM Wire Cut" - R290P,Agie Charmilles.

Dalam bentuk kewangan, penjimatan hampir 60% telah dicapai sekiranya proses fabrikasi dijalankan diluar atau dibeli.Seterusnya, proses fabrikasi "Cooling Jig telah membentuk "System Operation Procedure"(S.O.P) untuk proses "Reverse Engineering" di Jig Making & Maintenance (JMM).

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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LIST OF ABBREVIATIONS

ASCII	American Standard Code for Information Interchange
CNC	Computer Numerical Control
DOE	Design of Experiment
DXF	Data Exchange Format
EDM	Electrical Discharge Machine
IGES	Initial Graphics Exchange Specification
JMM	Jig Making and Maintenance
MCU	Machine Control Unit
NC	Numerical Control
STEP	Standard for the Exchange of Product Model Data

CHAPTER 1

INTRODUCTION

1.1 Project Background

The classification of production activities are justified according to the quantity of product produce whereas the classification falls into 3 categories, namely Mass production, Batch production and Job shop production (Groover,2001).

In mass production classification, it has specialised in manufacture of identical products. Mass production is characterised by a very high production rates, specialised equipment and tooling that are completely dedicated to the manufacture of a particular products. The investment in specialised tooling and equipments are proportionally high. The skill of workers are low where it was transferred from worker to the specialised tooling.

The batch production classification involves the manufacture of medium-sized lots of the same parts or products. The lots may be produced only once or produce at regular interval. The manufacturing equipment used is general-purpose but designed for higher production rate. It also involves specialised tooling to achieve high production rate. The plant is capable of high production rate that exceed the demand rate. Therefore, the plant produces to build up an inventory of the part. Then it changes to other orders and parts. When the stocks of the

previous parts become depleted, production is repeated to build up the inventory again.

Production system in PROTON can be stipulated into 4 processes; Stamping, Body Assembly, Painting and Trim & Final. Stamping meets the criteria of Batch production and it was the first process in the manufacturing of a car. While the Body Assembly, painting and Trim & Final can be categorised into mass production, where they are a continuous processes until a car is ready to deliver. Below outline will give a general background of the 4 processes that involved in the manufacturing of PROTON cars.

a) Stamping

Stamping consists of semi-automated equipment that have been synchronised to supply the line with parts on an almost just-in-time (JIT) basis. This affords the line to carry minimal buffer stock, thus saving space and inventory costs. With the eventual adoption of the just-in-time method of production, PROTON has incorporated a subsidiary company, PMM (PROTON Mitsubishi Metal) that handles and delivers blank parts to stamping. Stamping is the first process in car manufacturing work. The Stamping line consists of semi-automated equipment that have been synchronised to supply parts to the body assembly line on an almost just-in-time basis (PROTON Bhd, 1998).

b) Body Assembly

This process features a mix of manual and fully-automated activities incorporating the use of robot welders. This section of the production line has been equipped with an auxiliary line that manufactures components as and when they are required for a sub-assembly that is being built-up. Body Assembly is the second process; where cars parts are assembled into a complete unit of 'body-in-white'. The line mixes manual and fully-automated activities using robot welders as well as an auxiliary line that manufactures (PROTON Bhd, 1998).

c) Painting

In this process, a sophisticated painting system (the Micro-Micro Bell Electrostatic Auto Spray System) is used to affect a consistent layer of paint on a car's body, resulting in a near-mirror finish. The system also allows the use of materials to be precisely controlled, and incorporates a self-cleaning feature which ensures that the spraying equipment is always clean and in excellent condition. This new system as opposed to the previous one which was manually operated, has triggered savings on the consumption of paints and maintenance costs. More importantly, it has improved the quality of paintwork on PROTON cars (PROTON Bhd, 1998).

d) Trim & Final

Here, in the final process, the interior components of the car are installed and the finishing touches are added. Each PROTON car is put through an extensive battery of static and dynamic tests to verify its safety, roadworthiness, drivability, emissions level, and other characteristics. Each car is driven through a shower test to ensure that it is water-tight by exposing the car to three metric tons of falling water per minute for a period of five minutes. A car that graduates from the Trim and Final Assembly process receives the eventual seal of approval and its owner can be rest assured that the car has met PROTON's exacting standards for quality and performance.

Trim And Final is the last process in the car manufacturing activity, where trimmings, chassis and engine are installed to the painted car, and final testings, including leakage inspection using shower tester are done to 'completely built-up unit' (CBU) cars (PROTON Bhd, 1998).

1.2 Problem Definition

The assembly process – Body Assembly in car manufacturing system uses a various types of equipment such as Welding gun, Assembly jigs, Hemming dies, shuttle transfer, trolley and etc. In Jig Making & Maintenance (JMM), major responsibility is to maintain and manufacture assembly jig for welding process. The function of the assembly jig is to hold stamped part or semi-assembled parts

at a specified arrangement before welding process is carried out and meets assembly accuracy in mass quantity. There is various types of assembly jig in assembly process. However, this project will focus on one type of assembly jig – Cooling Jig. To understand in deep, the application of Cooling jig is illustrated in Figure 1.1.

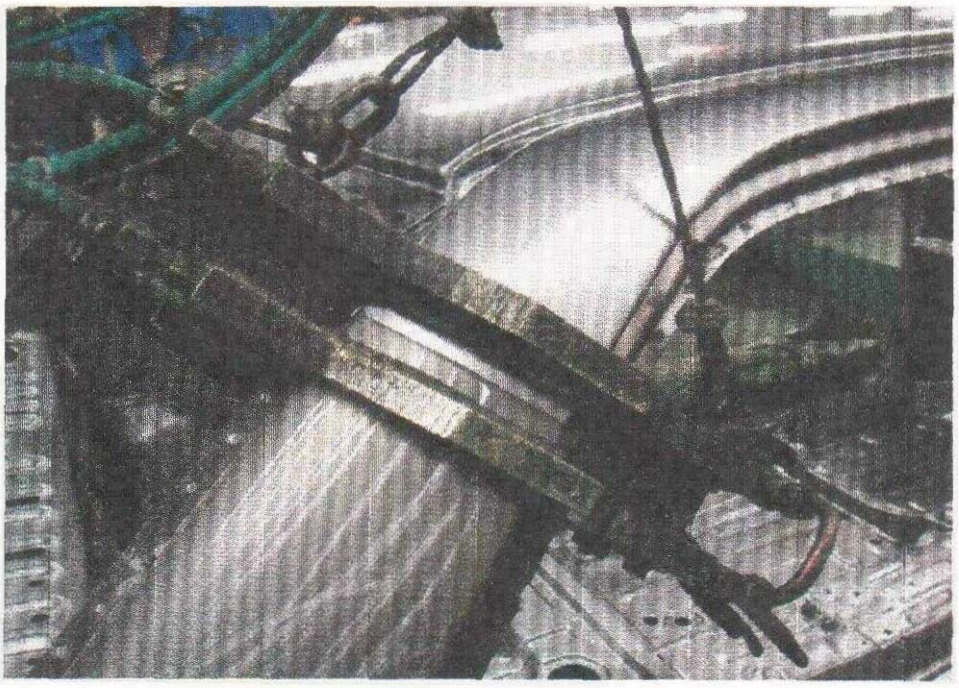

Figure 1.1: Application of Cooling Jig where it is clamped to Body-In-White panel.

The curvature portion is the contacted surface between Cooling Jig and Body-In-White panel where this portion or profile should match with Body-In-White panel. The picture of the structure of cooling jig is shown in Figure 1.2 while Figure 1.3 shows the detail drawing of cooling jig.

Figure 1.2: Cooling Jig structure

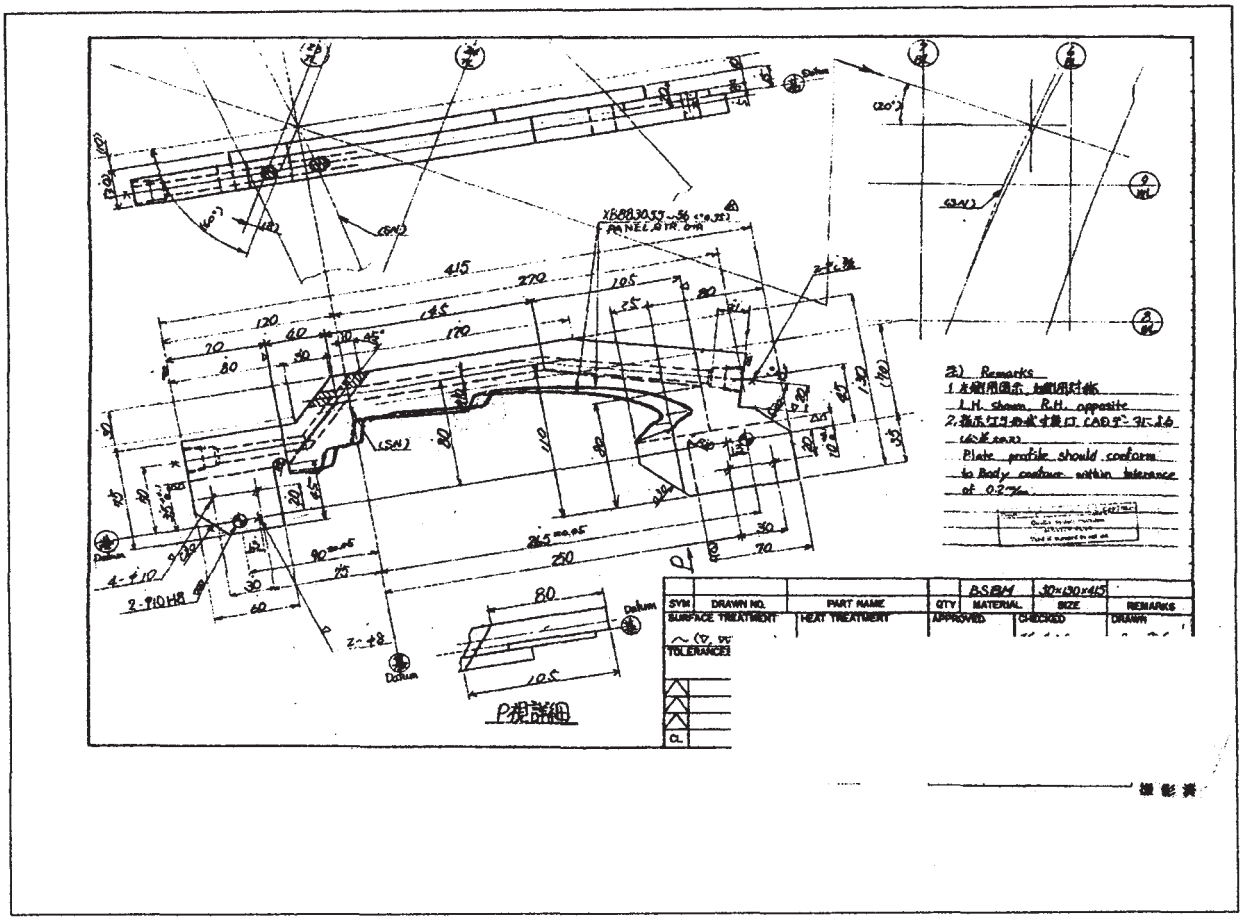

Figure 1.3 : Detail drawing of cooling jig.

This Cooling Jig will be mounted on Body-in-White panel part before brazing process. There is a through hole (refer Figure 1.3) inside the Cooling jig where chilled water is flowing continuously and absorbs heat during soldering process. If the heat is not absorbed, it will produce distortion and waviness on Body-in-White panel surface. Thus, sanding and finishing time more longer than cycle time and it will affect the production quantity.

Since the cooling jig was used intensively at production line, a few portions of cooling jig need major repairs and rectifications. One of the major problem is the flow of chilling water is not smooth enough where there is leaking at joining portion. The chilled water drops through the leaks and create a pool of water on the parts. After 6 hours, the parts that pool the water turn rusty. The repair process takes 2 days to complete from dismantling and re-install the cooling jig at production line. And at the same time, the production line has to stop in order to facilitate the repair process of cooling jig. Therefore, the production will loss about 1200 units of car if the production stop for 2 days. This figure is so big and another alternative is fabricating a new sets of cooling jig where the cost is only RM 1832.00 if produced at Jig Making & Maintenance (JMM).

Since PROTON has a few advantages to fabricate the cooling jig due the availability of related equipment such as Coordinate Measuring Machine (CMM), 3D Magic Software, CATIA software, POWERSHAPE software and EDM wire cut machine. The study showed that the in-house fabrication process reduced 60% of fabrication process if the cooling jig was purchased from vendor as illustrated in Appendix B.

For example, the EDM wire cut machine is used to cut the curvature portion inside cooling jig. The process leaves no burrs on the edges. It is also produce a good surface finish with a single cut where it is between 20 microns to 30 microns. With the flexibility of wire movements, the machine is also capable to cut the taper portion or conic section up to 30^{o} in angle at 40 mm thickness (Charmilles Technologies(Nc Manual), 1999).

1.3 Objective

The objectives of this project are:

i. To develop a new System Operation procedure (S.O.P) for Coordinate Measuring Work, Data conversion process And Machining work to produce Cooling Jig.

ii. To generate a surface data for curvature surface of Cooling Jig.

iii. To establish flowchart for the related machining process For fabrication process for Cooling Jig.

1.4 Organisation of Thesis

There are five chapters in the thesis. The first chapter is an introduction to manufacturing process of PROTON cars. Definition of problems and objectives of this project are described in this chapter. Chapter two outlined the basic and advancement in Machine Tool technology that enable the fabrication process of complex parts. Chapter two also outlined a brief description on neutral data format and file exchange in CAD/CAM environment. A brief explanation on Design of Experiment was also given. In chapter three, each process in fabrication process of Cooling Jig was explained briefly. All the processes were summarised and simplified in flow chart manner. Chapter four outlined the experiments where the assumptions, experiment set up and experiment results were described and shown. The last chapter - chapter five has the conclusions and observations on each process in fabrication process of Cooling Jig.