DESIGN AND DEVELOPMENT OF SEMI AUTOMATIC CANTING TOOL (ELECTRICAL)

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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 Bachelor of Manufacturing Engineering.

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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 : ………………………………..
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Dedicated to my beloved family

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ABSTRACT

In traditional canting processes, the wax has to be melted on a stove, then the molten wax will be poured into canting tool, and the canting tool will be used to make sketches on a cloth. The traditional method is complicated and required skills just for preparation of canting processes. Semi automatic canting tool is a tool that is equipped with a heating element to melt the wax directly inside the canting tool and will make the canting process easier especially to beginner. This research is done by two researchers and divided by two main tasks. The first task is research on the mechanical design and mechanism of the semi automatic canting tool. The second task is about the heating element and analysis on the wax and this research is focus o the second task. Research on the heating element is about the type of heating element, type of power source and the material for the heating element. For analysis on the wax, the scope is on the physical properties, melting point, and the flow of molten wax.

ABSTRAK

Dalam proses canting batik tradisional, lilin akan dicairkan di atas dapur, kemudian lilin lebur akan dituang ke dalam alat canting, dan alat canting berisi lilin lebur akan digunakan untuk membuat lakaran di atas kain. Kaedah tradisional adalah rumit dan kemahiran diperlukan untuk penyediaan proses canting. Alat canting separa automatik adalah satu alat yang dilengkapi dengan elemen pemanas yang akan mencairkan lilin secara langsung di dalam alat canting dan akan membuat proses canting lebih mudah terutama kepada mereka yang baru. Kajian ini dilakukan oleh dua orang penyelidik dan dibahagikan dengan dua tugas utama. Tugas pertama adalah penyelidikan mengenai reka bentuk mekanikal dan mekanisme alat separa automatik canting. Tugas kedua adalah mengenai elemen pemanas dan analisis lilin dan kajian ini memfokuskan terhadap tugas kedua. Penyelidikan pada elemen pemanas adalah mengenai jenis elemen pemanas, jenis sumber kuasa dan bahan bagi elemen pemanas berkenaan. Bagi analisis lilin, skop kajian adalah mengenai sifat fizikal lilin, takat lebur lilin, dan aliran lilin lebur.

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LIST OF ABBREVIATION

PP	Polypropylene
AC	Alternating Current
ABS	Acrylonitrile Butadiene Styrene
NEMA	National Electrical Manufacturers Association
RMS	`Root Mean Square
TIG	Tungsten Inert Gas
ESR	Equivalent Series Resistance

LIST OF SYMBOLS

°C	Degree Celsius
$J\ g^{-1}\ K^{-1}$	Joule per Gram Kelvin
$J\ g^{-1}$	Joule per Gram
kg/m^3	Kilogram per meter cubic
ΔT	Temperature Different
%	Percent
W/mK	Watt per Meter Kelvin
Ti	Initial Temperature
Tf	Final Temperature
V	Volts
Hz	Hertz
kVA	Kilovolts Ampere
mm	Milimeter
°	Degree
m^2	Meter Square
F	Farad
ms	Milliseconds
Ω	Ohm
kW	Kilowatts
kJ	Kilo Joule
°K	Degree Kelvin

K/W	Kelvin per Watts
W	Watts

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Batik is one of the most famous handicrafts in Malaysia. Originated from Indonesia, since the 15th century, people have found the traditional method of batik making. In the past, Malays use potatoes as a tool for stamping but now batik fabrics were developed by using modern tools, which is steel. Batik was first introduced to our country, especially in Kelantan since 1910. Batik is derived from the Javanese word 'tick' which means dripping or writes the points. In Malaysia, the most abundant plant batik industry is in Kelantan and Terengganu.

Motif is the decorative patterns used in the process of batik painting. The forms of batik are produced in two main forms which are Motif Organic and Geometric Motif. Organic motifs characterized nature as clouds, plants, flowers, and animals. There are two types of batik which are block batik and canting batik.

The process of making block batik started with white cloth that will be applied with batik patterns using pattern blocks. Pattern blocks made of wood or metal. This process repeated with a certain order until complete, depend on the size of the cloth. In which the block was first dipped into the dye before stamped on the cloth. Block batik is suitable for mass production which the process is simpler and shorter. The products are also identical for each product although different operators make the batik.

Unlike block batik that use pattern block to make the design, canting batik use a tool called canting tools. The canting tool will be filled with melted wax and used to sketch on the cloth to form the design. After sketching work done, the cloth will be colored to suit the design using paint brushes, and the affected parts of the wax will act as the stronghold. The wax will be melted and leave white spot.

The canting tool consisting of the handle for the operator to hold the tool, the container to store the melt wax, and the tip that is the place for the molten wax to flow out to the cloth. The handle is made of wood so it will not be affected to the heat of the molten wax. There is a few shape of the container as the canting tool is called by the shape of the container such as ‘sampan’ or canoe shape and ‘sepatu’ or shoe shape. The tip has different size such as XS, S, and M.

1.2 PROBLEM STATEMENT

Traditional method of canting batik, for the canting process, the wax has to be heated on the stove until it melt before the wax can be feed into the canting tool, then it can be used to sketch on the cloth. If the melted wax has been stored for a long time inside the canting tool, it can froze and cause the canting tool to be stuck with the frozen wax.

Semi automatic canting tool is a canting tool that equipped with a heating element which can make the wax melt directly inside the canting tool and eliminate the need of stove. The wax will be heated inside the canting tool and directly the molten wax can be used to sketch on the cloth.

The heating element needs to be chosen correctly. It should be effective and not so heavy or else it will give difficulties to the operator to do the canting later on. The example of heating element is copper which is a very good insulating material. If external wire needed to supply the power, the connection has to be design properly so that it will not disturb the canting process and the contact of the wire with the melt wax that is just sketched on the cloth will make the drawing messy.

When the heating element is heated or powered for a long period, it will cause the temperature increased and it is undesirable. Thus, a thermostat is needed to maintain the temperature.

Available wax that sold in the market is in bulk material, big block. It has to be shaped in smaller size, cylindrical shape as it will be easier to be feed into the semi automatic canting tool. The wax is brittle thus it may need special coating to maintain the shape, but the coating material may affect the canting process later on

1.3 RESEARCH OBJECTIVES

The research objectives for this research are as follow;

1.3.1 To invent semi automatic canting tool that use direct heating
1.3.2 To study the processes of making canting batik
1.3.3 To develop a heating element that ensure continuous flow of wax at specified temperature
1.3.4 To form the wax in a small cylindrical shape

1.4 RESEARCH OUESTIONS

The research questions for this research are as follow;

1.4.1 What is the best design for the canting tools so that it can be integrate with the heating element?
1.4.2 What is the most efficient way to supply power to the canting? Battery or power source from plug?
1.4.3 How to maintain the temperature? What is the best thermostat?

1.4.4 What type of heating element is the best? What type of material?

1.4.5 How to form the wax?

1.4.6 What is the suitable size and shape of the wax?

1.4.7 Is special coating need for the wax? If yes, what is the material?

1.5 SCOPE OF RESEARCH

The scope of this research is about the development of the semiautomatic canting tool. Since this research will be done by two researcher, the scope has been divided by two task, first is about the design of the canting tool and the second is about the development of the heating element and analysis on the properties of the wax.

I have been assigned for the second task which is the development of the heating element and analysis on the properties of the wax.

The development of the heating element is more on electrical component, what is the best heating element, involving the selection the best type of material. Also the requirement of the adjustable thermostat to make the temperature controllable and can maintain the temperature. It is also need to be check on the aspect of the power source that will be supply to the heating element.

Analysis of the wax involving studying on the properties of the wax so that it can be form in smaller size.

1.6 SIGNIFICANT OF RESEARCH

This research will make the process of making canting batik become easier by eliminating one step. The elimination of the step will also lead to the decreasing the cost of making batik. Hopefully it can help to revive batik industry in Malaysia that is almost forgotten.

The semiautomatic canting tool that modernizes of the traditional method to make batik is also to make the new generation interested to involve in batik industry. Batik Malaysia has the potential to sell it worldwide because of its uniqueness.

1.7 DEFINITION OF TERM

Batik block

Batik that is make using block pattern. Has almost identical design. The block that is made of steel will be applied with wax before it is stamped on a cloth. The decoration will form as the shape of the block.

Batik canting

Batik that is make by drawing wax using canting tool on the cloth. The uniqueness is there are no batik that is identical or almost identical. The wax will be melt and put inside the canting tool. The canting tool then is used to make decoration on the cloth.

Canting tool

Tool that use to store molten wax and to draw on the cloth. The canting tool is used to make decoration on the cloth. There is different size of canting tool based on the size of the tip. There is also few type of canting tool based on the shape of the container and the number of the tip.

Wax

Combination of paraffin and resin that is used as a shield between colors on the cloth and form decorations. Act as glazing agent. In traditional canting method, the ratio between resin and paraffin is equal for both element.

Heating element

Heat insulator to melt the wax. will be equipped to the semi automatic canting tool to melt the wax directly inside the canting tool. Thermal resistivity is very important to get the best material for the heating element.

1.8 EXPECTED OUTCOMES

This research will give more understanding on the traditional process of making batik. The heating element can be integrated with the canting tool and the temperature can be maintain over a long period. The temperature is sufficient to melt the wax and the canting tool will not be affected by the heating element that may cause change in shape or malfunction.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews about literature review of some recent project or existing experiment that is related to the research and also will covers about the wax properties and design of heating element. Properties of wax involve thermal properties, mechanical properties, the flow of wax, surface tension, and surface roughness of the wax. The properties of wax will help to study on the properties of the wax and to analysis the wax. Reviews of heating element patents and applications will help to know about the best design to integrate with the semi automatic canting tools.

2.2 PROPERTIES OF WAX

Waxes are organic compounds that characteristically consist of long alkyl chains (Riemenschneider and Bolt, 2005). Characteristically, they melt above 45 °C to give a low viscosity liquid. Waxes are insoluble in water but soluble in organic, nonpolar solvents. All waxes are organic compounds, both synthetic and naturally occurring. Natural waxes are typically esters of fatty acids and long chain alcohols. Synthetic waxes are long-chain hydrocarbons lacking functional groups. Waxes are mainly consumed industrially as components of complex formulations, often for coatings.

The main use of polyethylene and polypropylene waxes is in the formulation of colourants for plastics (Schmidt *et al.*, 2001). Waxes confer matting effects and wear resistance to paints. Polyethyelene waxes are incorporated into inks in the form of dispersions to decrease friction. They are employed as release agents. They are also used as slip agents in furniture, and corrosion resistance.

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Other uses of wax are sealing wax was used to close important documents in the Middle Ages (Butler, 1954). Wax tablets were used as writing surfaces. There were different types of wax in the Middle Ages, namely four kinds of wax Ragusan, Montenegro, Byzantine and Bulgarian, "ordinary" waxes from Spain, Poland and Riga, unrefined waxes and colored waxes red, white and green. Waxes are used to make wax paper, impregnating and coating paper and card to waterproof it or make it resistant to staining, or to modify its surface properties. Waxes are also used in shoe polishes, wood polishes, and automotive polishes, as mold release agents in mold making, as a coating for many cheeses, and to waterproof leather and fabric. Wax has been used since antiquity as a temporary, removable model in lost-wax casting of gold, silver and other materials.

Wax with colorful pigments added has been used as a medium in encaustic painting, and is used today in the manufacture of crayons and colored pencils. Carbon paper, used for making duplicate typewritten documents was coated with carbon black suspended in wax, typically contain wax, but has largely been superseded by photocopiers and computer printers. In another context, lipstick and mascara are blends of various fats and waxes colored with pigments, and both beeswax and lanolin are used in other cosmetics. Ski wax is used in skiing and snowboarding. Also, the sports of surfing and skateboarding often use wax to enhance the performance. Beeswax or colored synthetic wax is used to decorate Easter eggs in Ukraine and the Czech Republic. Paraffin wax is used in making chocolate covered bon-bons (Baker, 1982). Wax is also used in wax bullets, which are used as simulation aids.

2.2.1 PROPERTIES OF PARAFFIN

Pure paraffin is an excellent electrical insulator, with an electrical resistivity of between 1013 and 1017 ohm meter (Kaye, 1995). Paraffin is an excellent material to store heat, having a specific heat capacity of 2.14–2.9 J g−1 K−1 and a heat of fusion of 200–220 J g−1. This property is exploited in modified drywall for home building material: it is infused in the drywall during manufacture so that, when installed, it melts during the day, absorbing heat, and solidifies again at night, releasing the heat (Seager *et al.*, 2008).

Paraffin wax phase change cooling coupled with retractable radiators was used to cool the electronics of the Lunar Rover. Wax expands considerably when it melts and this allows its use in thermostats for industrial, domestic and, particularly, automobile purposes (Dean, 1993).

Paraffin used for candle-making, coatings for waxed paper or cloth, food-grade paraffin wax, shiny coating used in candy-making; although edible, it is non digestible, passing right through the body without being broken down, coating for many kinds of hard cheese, like Edam cheese, sealant for jars, cans, and bottles, chewing gum additive, investment casting, anti-caking agent, moisture repellent, and dust binding coatings for fertilizers, agent for preparation of specimens for histology, bullet lubricant with other ingredients, such as olive oil and beeswax, phlegmatizing agent, commonly used to stabilize or desensitize high explosives such as crayons (Freund *et al*,. 1982).

2.2.2 PROPERTIES OF DAMMAR GUM (RESIN)

Dammar gum is obtained from the Dipterocarpaceae family of trees in India and East Asia, principally those of the genera Shorea, Balanocarpus or Hope (Aarssen *et al*,. 1990). Most is produced by tapping trees; however, some is collected in fossilized form from the ground. The gum varies in colour from clear to pale yellow, while the fossilized form is grey-brown (Rene 1988). Dammar gum is a triterpenoid resin, containing a large number of triterpenes and their oxidation products. Many of them are low molecular weight compounds. Melting point approximately at 120 °C and the density is 1.04-1.12 kg/m³ (Brannt, 1893).

The crude product occurs as irregular white to yellow or brownish tears, fragments or powder, sometimes admixed with fragments of bark; refined grades are white to yellowish and are free of fragments of ligneous matter; practically odorless, although refined grades may carry an odors of the essential oils used in the refining process (Brannt, 1893).

Resin or dammar gum is used as a clouding agent, glazing agent, or stabilizer. In batik process, dammar gum functions as the glazing agent. A glazing agent is a natural or synthetic substance that provides a waxy, homogeneous, coating to prevent water loss and provide other surface protection for the substance

2.3 HEATING SYSTEM

This canting tool will be integrated with heating system to melt the wax. Unlike traditional ways that need to melt the wax in stove, this canting tool will use direct heating. A heating element converts electricity into heat through the process of Joule heating. Electric current through the element encounters resistance, resulting in heating of the element. The heating system will be placed inside the canting tool body and will be powered by alternating current from housing plug. The heating system will be made by copper because it is an excellent electrical and heat conductor. The design of the heating element is based on capacitor which are two parallel conducting plates with insulator in between.

The figure below shows the cross sectional view of the canting tool. It shows the location of the heating element and how it will integrate with the mechanism in canting tool. The cylindrical shape wax will enter the canting tool from the back of the tool, then when the wax enter the heating element, it will melt and stored before the molten wax come out from the tip. The heating element will be powered from housing plug so that the user can use the canting tool anywhere as long the place has power electrical supply.

Figure 2. 1 : Cross Sectional View of Canting Tool

2.3.1 CAPACITOR CONCEPTS

A capacitor is a passive two-terminal electrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric for example, one common construction consists of metal foils separated by a thin layer of insulating film (Scherz, 2006). Capacitors are widely used as parts of electrical circuits in many common electrical devices.

When there is a potential difference or voltage across the conductors, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate (Dyer, 2001). Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them.

The capacitance is greatest when there is a narrow separation between large areas of conductor; hence capacitor conductors are often called "plates," referring to an early means of construction (Bird, 2007). In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, resulting in a breakdown voltage, while the conductors and leads introduce an undesired inductance and resistance.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass, in filter networks, for smoothing the output of power supplies, in the resonant circuits that tune radios to particular frequencies, in electric power transmission systems for stabilizing voltage and power flow, and for many other purposes.

2.3.2 HEAT MANAGEMENT FOR ELECTRICAL COMPONENTS

Every electric circuit and electric component will produce heat because of the current that flows through it. In some cases, the heat generated is important and for same cases is not desirable. The objective of the thermal management is to ensure the generated heat in electrical components is dissipated into the ambient air while a safety operating temperature is maintained. Power dissipation in the electrical components is equal to heat generation in that particular component.

Since the only circuit property that can produce power dissipation or power loss is a resistance, a pure capacitance does not dissipate any power, so all of the power taken from a purely capacitive circuit during the charge cycle is returned during the discharge cycle (Bird, 2007). If we drive an ideal perfect capacitor with a sine wave, the capacitor gives back all the power put into it on each cycle. Thus, an ideal capacitor would produce no loss when current passes through it. However, in practice, every capacitor has some resistance in its leads, solder, metal end-spray, electrode and dielectric.

2.3.3 HEAT GENERATED IN CAPACITOR

When a certain amount of total power is applied to the real capacitor, the current needs to pass through the components (leads, solder, metal end-spray, electrode and dielectric) from entering one side of the lead to exiting the other lead, so, a small amount of power is dissipated (Kent and Shaffer, 1984). The difference between the amounts in and out is lost or used in capacitors, and is referred to as the power loss or power dissipation in the capacitor. The power loss is the wasted consumption of power by the capacitor itself, since such power is unable to do otherwise useful work, rather most of the consumed power will be converted into heat, which increases the capacitor's temperature. Because of resistance by the element to the current flowing through the capacitor, the resistances and the current consume power as heat and losses occur, that is the power dissipation equal to i^2, then, the capacitor generates heat and the capacitor temperature rises.

In other words, as the current passes through the element, it generates heat, which is the power that the capacitor will dissipate. When currents are flowing, causes the capacitor to produce loss, in the form of heat, which cause the capacitor's temperature to rise. The temperature rise will continues until the capacitor reaches thermal equilibrium that is the amount of heat generation resulting from power dissipation becoming equal to the amount of the heat dissipated from a capacitor surface. However, thermal-runaway occurs when a current exceeding the permissible range flows into capacitor results in the heat generation value exceeds the heat dissipated value continuously. This cause to possibly leading to smoke or fire. Therefore, the Th and ΔT of a capacitor must be limited so that the thermal-runaway does not occur by limiting the current within permissible current. Temperature rise increases the likelihood of catastrophic failure.

The total heat generated by power dissipation is from two distinctly different sources of dielectric heating and resistance heating.

Dielectric heating is the result of the energy required to first polarize the dielectric in one direction and then re polarize the dielectric in the other direction for each succeeding half-cycle of the AC voltage applied. This is a natural phenomenon and produce frictional heat. So, part of electric power is lost in heat. The amount of heat generated varies with inherent polarization orientation of the dielectric material (polypropylene is the best), the magnitude and frequency of the applied voltage, and the geometrical character of the voltage wave-shape.

2.3.4 HEAT TRANSFER

The alternating current that is supplied to the copper will increase the temperature of the copper. The flow of the current over certain time will produce heat. Copper that has low electrical resistivity has enable more current to flow, thus it is an excellent heat conductor and electric conductor.

The body of the canting tool will be made using acrylonitrile butadiene styrene (ABS) (Ozcelik, 2010). ABS is a material that has high strength, rigidity and toughness. The most important mechanical properties of ABS are impact resistance and toughness. ABS also has high heat resistance and has melting point for about 105°c (Rutkowski and Levin, 1986). For the canting tool, the body will also act as the insulator so that the heating element will not expose to the room condition. Only the tip of the canting tool will exposed to the room condition. According to Deborah, the heat transfer coefficient in a normal room condition is estimated at 10 W/m.k and the temperature is 27°c.

The heat will transferred in conduction heat transfer. In heat transfer, conduction or heat conduction is a mode of transfer of energy within and between bodies of matter, due to a temperature gradient. Conduction means collisional and diffusive transfer of kinetic energy through particles of ponderable matter as distinct from photons (Dehghani, 2007). Conduction takes place in all forms of ponderable matter, such as solids, liquids, gases and plasmas. Heat spontaneously tends to flow from a body at a higher temperature to a body at a lower temperature. In the absence of external driving fluxes, temperature differences, over time, approach thermal equilibrium.

In conduction, the heat flows through the body itself, as opposed to its transfer by the bulk motion of the matter as in convection, and by thermal radiation (Bailyn, 1994). In solids, it is due to the combination of vibrations of the molecules in a lattice or phonons with the energy transported by free electrons. In gases and liquids, conduction is due to the collisions and diffusion of the molecules during their random motion. Photons in general do not collide with one another and thermal transport by electromagnetic radiation is not regarded as conduction of heat. In solids, it is not simple to separate transfer by photons from transfer by ponder able matter, but the distinction can be more easily made in liquids, and is routinely made in gases.

2.3.5 PROPERTIES OF COPPER

The heating element is made of copper. It is a ductile metal with very high thermal and electrical conductivity. Low hardness of copper partly explains its high electrical (59.6×106 S/m) and thus also high thermal conductivity, which are the second highest among pure metals at room temperature (Hammond, 2004). This is because the resistivity to electron transport in metals at room temperature mostly originates from scattering of electrons on thermal vibrations of the lattice, which are relatively weak for a soft metal .The maximum permissible current density of copper in open air is approximately 3.1×106 A/m2 of cross-sectional area, above which it begins to heat excessively (George 1994).

The major applications of copper are in electrical wires (60%), roofing and plumbing (20%) and industrial machinery (15%). Copper is mostly used as a metal, but when a higher hardness is required it is combined with other elements to make an alloy (5% of total use) such as brass and bronze. A small part of copper supply is used in production of compounds for nutritional supplements and fungicides in agriculture (Emsley, 2003). Machining of copper is possible, although it is usually necessary to use an alloy for intricate parts to get good machinability characteristics.

The electrical properties of copper are exploited in copper wires and devices such as electromagnets. Integrated circuits and printed circuit boards increasingly feature copper in place of aluminum because of its superior electrical conductivity, heat sinks and heat exchangers use copper as a result of its superior heat dissipation capacity to aluminum. Vacuum tubes, cathode ray tubes, and the magnetrons in microwave ovens use copper, as do wave guides for microwave radiation.

Copper's greater conductivity versus other metallic materials enhances the electrical energy efficiency of motors. This is important because motors and motor-driven systems account for 43%-46% of all global electricity consumption and 69% of all electricity used by industry. Increasing the mass and cross section of copper in a coil increases the electrical energy efficiency of the motor. Copper motor rotors, a new technology designed for motor applications where energy savings are prime design objectives, are enabling general-purpose induction motors to meet and exceed National Electrical Manufacturers Association (NEMA) premium efficiency standards

2.3.6 PROPERTIES OF ALUMINUM

Aluminum is the third most abundant element after oxygen and silicon, and the most abundant metal, in the Earth's crust. It makes up about 8% by weight of the Earth's solid surface. Aluminum metal is too reactive chemically to occur natively (Shakhashiri, 2008). Instead, it is found combined in over 270 different minerals. The chief ore of aluminum is bauxite.

Aluminum is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation (Greenwood and Earnshaw, 1997). Structural components made from aluminum and its alloys are vital to the aerospace industry and are important in other areas of transportation and structural materials (Barthelmy, 2008). The most useful compounds of aluminum, at least on a weight basis, are the oxides and sulfates.

Despite its prevalence in the environment, aluminum salts are not known to be used by any form of life. In keeping with its pervasiveness, aluminum is well tolerated by plants and animals (Barthelmy, 2008). Due to their prevalence, potential beneficial or otherwise biological roles of aluminum compounds are of continuing interest.

Aluminum is a relatively soft, durable, lightweight, ductile and malleable metal with appearance ranging from silvery to dull gray, depending on the surface roughness. It is nonmagnetic and does not easily ignite (Greenwood and Earnshaw, 1997).

Aluminum is a good thermal and electrical conductor, having 59% the conductivity of copper, both thermal and electrical. Aluminum is capable of being a superconductor, with a superconducting critical temperature of 1.2 Kelvin and a critical magnetic field of about 100 gauss (10 milliteslas) (Greenwood and Earnshaw, 1997).

2.3.7 PLASTIC COATING

The heating element which is two copper sheet and the insulator will be coated with a plastic coating. The plastic coating will be functioned as an electrical insulator. The material used is thermally conductive polypropylene which is an electrical insulator and thermal conductor. Based on Cool Polymer, a company that produce and supply various kind of polymers, the thermal conductivity for this material is 5 W/mK and the melting temperature is high which is 170°c.

The coating is important to ensure that there will be no electricity on the aluminum heating. It is because people tends to touch the tip of the aluminum heating and it will be dangerous if current flows through it.

Polypropylene, also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes

(Clive *et al.,* 1998). An addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids.

2.3.8 HEAT DISTRIBUTION

Figure 2. 2 : Heating Element

Figure 2.2 above is the picture of the heating element. The heating element do not has constant cross sectional area, only at certain part. According to Deborah(2010), the formula to calculate heat transfer coefficient is,

$$Q = \frac{kA(Ti - Tf)}{L}$$

Where Q is the heat transfer rate coefficient, k is the thermal conductivity, Ti is the temperature at the first point, Tf is the temperature at the second point, A is the cross sectional area, and L is the length. This formula only can be used for part that has constant cross section. For the heating element that has no constant cross sectional area, we will use the average cross sectional area.

Hypothesis for the heat distribution, all area of the heating element will achieved the required temperature only difference in time. For the tip that located far from the power supply connection, it will take longer time compare to the middle part.

CHAPTER 3

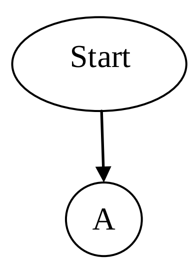
METHODOLOGY

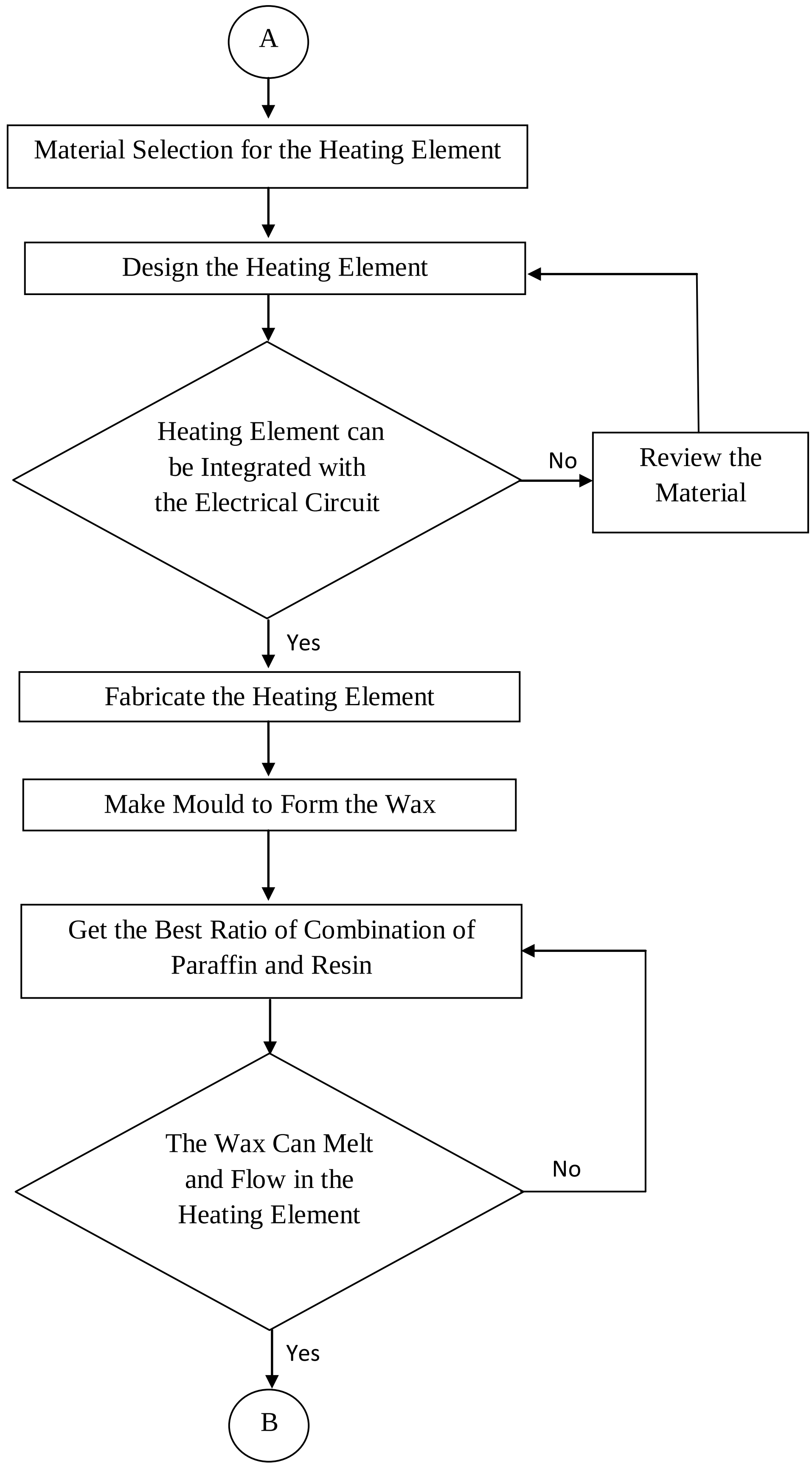
3.1 INTRODUCTION

This chapter is discussed the ideas about the method how to implement this research. In this study, there are a few process stages will be conducted in this methodology process. The process started from searching the material, then fabricate the canting tool, then analyze and testing the canting tool before finishing with the final report.

3.2 FLOW CHART

The flow chart for this research is as follow;




A
Material Selection for the Heating Element
Design the Heating Element
Heating Element can be Integrated with the Electrical Circuit
No
Review the Material
Yes
Fabricate the Heating Element
Make Mould to Form the Wax
Get the Best Ratio of Combination of Paraffin and Resin
The Wax Can Melt and Flow in the Heating Element
No
Yes
B

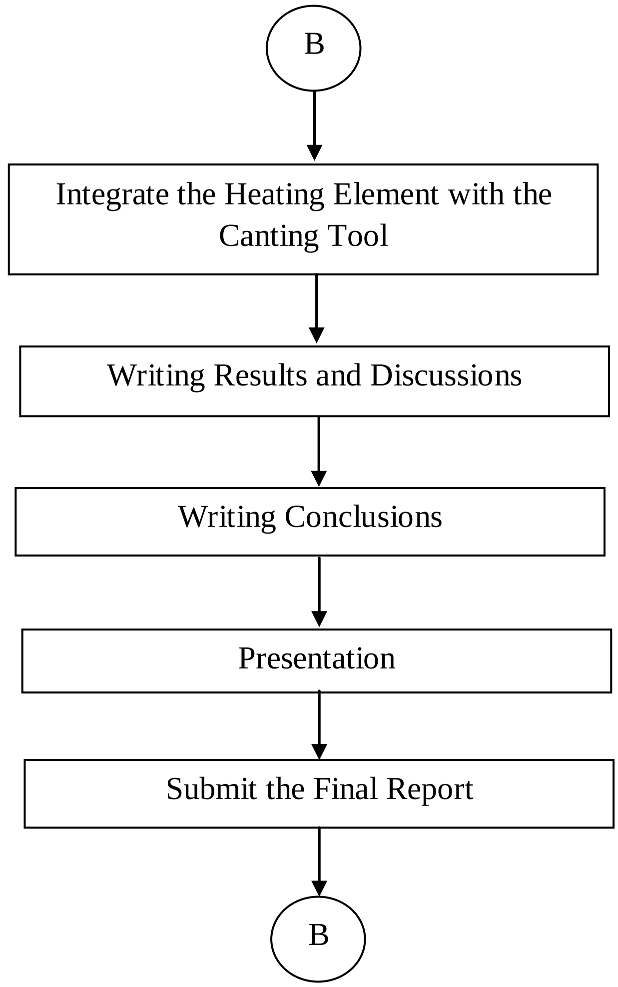


Figure 3.1 : Flow Chart

3.3 DESIGNING HEATING ELEMENT

Designing the heating element started with selecting type of material to be used. Criteria of the material that has to be considered are the electrical conductivity, and thermal conductivity as the heating element should have high electrical conductivity and also high thermal conductivity.

Because of the heating element is design based on the concept of resistor, copper will be used as the electrical conductor plate and ceramic as the insulator. These material is chose because it met all the required criteria and also the availability. The required shape is simple which is a cubic, only cutting process is needed.

The heating element also consist the aluminum heating, the container to melt the wax. The aluminum has to be formed to the required shape. The shape is complex and has to be melt using TIG (Tungsten Inert Gas) welding. TIG welding is the best method to weld aluminum.

The heating element consist of the capacitor heating, plastic coating that will be the coating of the capacitor heating, and the aluminum heating.

3.4 ELECTRICAL CIRCUIT

Electrical circuit for the semi automatic canting tool is simple, the heating element will be directly connected to the residential power supply. The power will be connected through electrical wire and a 2-plug pin. The power supply is 240 volts and the frequency is 50Hz, 12kVA.

3.4.1 HEAT GENERATED

AC current through the capacitor dissipates power in ESR (equivalent series resistance), in the form of heat, which causes the capacitor's temperature to rise. Under the sine wave form, the basic formulas for calculating the heat generated by power dissipation in a capacitor are;

Pd (power dissipation) = $Irms^2$ x ESR, where $ESR = \tan\delta \times \frac{1}{2\pi fC}$

$Pd = \frac{Irms^2}{2\pi fC} \times \tan\delta$, where $Irms = \omega C\, Urms = 2\pi fC Urms$

$Pd = Urms^2 \times 2\pi fC \times \tan\delta$

$Pd = Urms \times Irms \times \tan\delta = Urms \times Irms \times \frac{ESR}{Xc}$

Irms = current at a given frequency in ampere

ESR = equivalent series resistance at a given frequency in Ω

Urms = operating rms voltage in V

C = capacitance in F

f = Hz

tanδ = at the frequency under the sine wave from at the frequency of the steepest pulse part under the non-sinusoidal wave pulse frequency $\frac{1}{pulse\ width}$

3.4.2 CAPACITANCE VALUE

The parallel conductive plate, the area of each plate is denoted as A. The rectangular plate, the width is W, length is L, and area = A = W x L. The plates are parallel, and the distance between them is denoted as d.

If the distance d between the plates is much smaller than both of the width and the length of the plates, the capacitance is approximately given by;

$$C = \frac{\epsilon A}{d}$$

In which Є is the dielectric constant of the material between the plates, or the dielectric of the insulator.

3.4.3 TIME REQUIRED TO ACHIEVED FINAL TEMPERATURE

Time for the heating element to reach the required temperature from room temperature is a very important consideration. The required temperature enable the wax to completely melt when is pushed toward the heating element. The time needed can be calculated using lumped system analysis for transient conduction.

The Biot number is,

$$Bi = \frac{hm}{kA\rho} \quad .$$

Then we apply conservation of energy to the closed system defined in the schematic and assume negligible potential and kinetic energy effects, giving us;

$$\frac{dU}{dt} = m\frac{du}{dt} = Q - W$$

Assuming the iron is an ideal solid with a constant specific heat and describing the heat transfer in terms of the rate equation for convective heat transfer, we obtain;

$$mc\frac{dT}{dt} = -hA(T - Tf) - W$$

Rearranging this equation to separate the variables,

$$\frac{dT}{dt} = -\frac{hA}{mc}(T - Tf + \frac{W}{mc}$$

Separating the variables;

$$\int_{Ti}^{T} \frac{dT}{T - Tf + \frac{W}{mc}} = -\int_{0}^{t} \frac{hA}{mc} dt$$

And integrating;

$$ln\left[\frac{T - Tf + \frac{W}{mc}}{Ti - Tf + \frac{W}{mc}}\right] = -\frac{hA}{mc}t$$

Exponentiating both sides;

$$\frac{T - Tf + W/mc}{Ti - Tf + W/mc} = \exp(-\frac{hA}{mc}t)$$

Letting the T rearranging once again;

$$T - Tf = -\frac{W}{hA}[1 - \exp{(-\frac{hA}{mc}t)}$$

This can be solved for the required input power, to give;

$$W = \frac{-hA(T - Tf)}{1 - \exp{(-\frac{hA}{mc}t)}}$$

Because of all the parameter known, except the time, then the time needed can be calculated. The time needed from calculation may be different to the original because of the outer effects such as room condition.

3.5 MACHINING THE MOULD

The mould has to machine from raw material. The material for the mould is aluminum. Aluminum has the ability to resist corrosion, which is the most important characteristic. Anti-corrosion is very important because it can help to make the life span of the mould longer. Aluminum also is a low-density material which means it can be easily machined to form the mould. Another important characteristic of aluminum is it is lighter compare to other metals. Lighter means the process can be more easy and faster.

Machining of the mould begin with facing and squaring the raw material. The material should be exact 90° on all edges or else, the alignment of the mould will be misplaced. The surface of the mould should also flat to make sure the mould can completely closed and all area is touched with the other side. If the mould is not flat, there is a possibility of leaking when the solidification process of the molten wax. The next process is to machine the semi-circular slot on the face of the mould. The length of the slot should be sufficient to make sure the cylindrical wax has enough length. 4 hole is drilled as it will be the hole to put the bolt. The last process of the mould is to make thread at the hole of the first side of the mould. The thread is made using thread maker for m6. The thread should be straight and long enough to clamp the bolt.

The mould has to be machined to the required dimension according to the drawing. Once the machining done, the mould can be tested. The problems during the testing should be eliminated by applying countermeasure. If the mould cannot functional well, then the wax cannot be formed to cylindrical shape.

3.6 FORMING THE WAX TO CYLINDRICAL SHAPE

The wax has to be formed into long cylinder. The wax is combination of paraffin and resin. Paraffin and resin bought is in a bulk material, big block. Paraffin and resin has to be combined together and formed into cylindrical shape as then it can be pushed towards the heating element.

Paraffin and resin has to be melt on a stove. The ratio between both material should be study. The properties such as ductility, and melting point should be considered. Ductility is important because if the wax is brittle, then it may be broke when is pushed toward the heating element. Melting point also has to be considered because if the melting point is high, then there is a possibility that the wax will not completely melt inside the heating element. Resin is more ductile than paraffin but has higher melting point. Thus if the ratio of resin is higher, then the wax will be more ductile which is a desirable criteria, but the melting point will become high which is an undesirable criteria.

In traditional canting process, the ratio between paraffin and resin is 50% - 50%. But for the semi automatic canting tool, the ratio may be different.

Figure 3.2 : Raw material of (1) Paraffin (2) Resin (Dammar Gum)

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTORDUCTION

This chapter will discuss about result and discussion of the research. The data and findings collected throughout the project will be discussed. The area to be focused is about the mold analysis, wax formation, wax analysis, and analysis of the heating element.

4.2 MOLD ANALYSIS

The mould is used to form the wax to cylindrical shape. The mixture of resin and paraffin is melted, and then poured into the cavity of the mould. The solidified wax will formed as the shape of the cavity which is cylindrical.

The mould consists of two parts. Each part has semi-circular cavity slot on the face which it will form cylindrical shape when both part being assembled. The purpose of the design is to make sure the wax can be removed from the mould after it solidified, such as industrial plastic injection moulding that has core plate and cavity plate.

The mould is clamped together using 4 bolts, which to ensure the mould did not slide off during the solidification process. The clamping also to ensure the mould will not be miss alignment during the pouring of melt wax process.

Analysis on the mould is about the process plan to machine the mould from raw materials, analysis on the formation of wax inside the mould, and problems and countermeasure when pouring the molten wax inside the mould and when the wax solidified. Also analysis of the moulds' surface and the effect to the wax's surface.

Figure 4. 1: Mould

Both side of mould is identical. This is to ensure both slot will met and form cylindrical cavity when the mould is combined. The only difference is the hole. The first side's hole has thread to hold the bolt. The second side's hole is a hole with diameter larger than bolt size and has counter bore for the bolt's head. The depth of the counter bore should higher than the high of the bolts' head. This to ensure the bolts' head can sink completely. The bolt used is M6 with length 40mm. All 4 bolt will clamp the mould together. The bolt is hexagonal cap screw because it can match with Allen key to open and closed the mould. It is better to use Allen key than use screw driver. Allen key has better strength and the bolt will not easily wear like the normal screws.

4.2.1 WAX FORMATION

The wax is formed in cylindrical shape with the combination of 50% paraffin and 50% resin. The first mixture is based on the traditional method. The most important element which should be considered is the melting temperature of resin, paraffin, and the combination of both. Based on the study, the melting temperature of the wax is low which 46°c is, and the melting temperature of the resin is higher which is 120°c. Melting point of the wax which is the combination of resin and paraffin is in between which is 60-70°c.

Resin will help to add more ductility to the wax as paraffin is very ductile. Resin also will give more toughness and hardness. But because of resin has high melting point, if more resin added, it will make the melting point of the wax higher.

The mixing process of the resin and paraffin is done on a pot, on a stove. The mixing process is done while heating the material in a low temperature for a long period. This is because resin will take more time to melt as the melting temperature is higher. It is essential to maintain continuous stir during the heating process to make sure the mixture is well and balance. Overcook is also not desirable because the mixture can be burned.

Figure 4.2 : Mixture on a pot

When the mixture is completely melted, it is poured in a mold to form the cylindrical shape. The mixture is leaved for few minutes for it to cool down and solidified to form the cylindrical shape. Then the mould can be opened and remove the solidified wax as the next mixture will be poured.

Before the mould can be open, the wax has to be ensure has completely solidified. If the wax is still not fully solidified, it could break when the mould opened. Another thing that need to be consider when opened the mould is to open the mould carefully or the mould surface could scratches.

4.2.2 ALUMINUM ADVANTAGES

Material used for the mould is aluminum. It is because aluminum posses a lot of good characteristics compare to other possible material. Thus, aluminum is selected as the material to form the mould.

Aluminum has the ability to resist corrosion, which is the most important characteristic. Anti-corrosion is very important because it can help to make the life span of the mould longer. If the mould has already corroded, then it cannot be used anymore because the surface is not smooth. The dimension will also be different from the original if the corroded part is removed. The mould will be exposed to wax and heat which it can trigger the corrosion element. Thus, selecting an anti-corrosion material is very important.

Aluminum also is a low-density material which means it can be easily machined to form the mould. It has high machine ability and can give smooth surface finish which is very important for the wax. The wax has to have smooth surface as then it can easily flow into the canting.

Another important characteristic of aluminum is it is lighter compare to other metals. Lighter means the process can be more easy and faster. Also help when moving the material.

4.2.3 PROCESS PLAN

Machining of the mould started with facing and squaring the raw material. The material should be exact 90° on all edges or else, the alignment of the mould will be misplaced and to ensure both side of the mould is equal.

The surface of the mould should also flat to make sure the mould can completely closed and all area is touched with the other side. If the mould is not flat, there is a possibility of leaking when the solidification process of the molten wax. The machining is done using conventional milling machine and the tool is flying cutter for both squaring and facing.

The next process is to machine the semi-circular slot on the face of the mould. The machining is also done using conventional milling machine with cutting tool ball end mill. The required diameter of the cylindrical wax needed is 8mm, thus the ball end mill used is ball end mill r4. The length of the slot should be sufficient to make sure the cylindrical wax has enough length.

4 holes is drilled as it will be the hole to put the bolt. The diameter of the hole is different for both side. The bolt to be used is bolt m6. The first side of the mould, the diameter of the hole drilled is 5mm. This is because the hole will need thread to clamp the bolt. 0.5mm is required for both side of the thread. The second hole will be drilled with diameter 7mm. This is to ensure the bolt did not stuck at the hole. The hole also need counter bore to hold the head of the bolt. The length of the counter bore should be as the length of the bolts' head.

The last process of the mould is to make thread at the hole of the first side of the mould. The thread is made using thread maker for m6. The thread should be straight and long enough to clamp the bolt.

Figure 4. 3 : Machining the Mould

Figure above show the process of facing and squaring using conventional milling machine. A milling machine is a machine tool used to machine solid materials. Milling machines are often classed in two basic forms, horizontal and vertical, which refers to the orientation of the main spindle. Both types range in size from small, bench-mounted devices to room-sized machines. Unlike a drill press, which holds the workpiece stationary as the drill moves axially to penetrate the material, milling machines also move the workpiece radially against the rotating milling cutter, which cuts on its sides as well as its tip.

4.2.4 PROBLEMS AND COUNTERMEASURE

The mould has a few problems at the beginning and countermeasure has be done to overcome the problems. Countermeasure is very important to ensure the wax can be form to the required cylindrical shape.

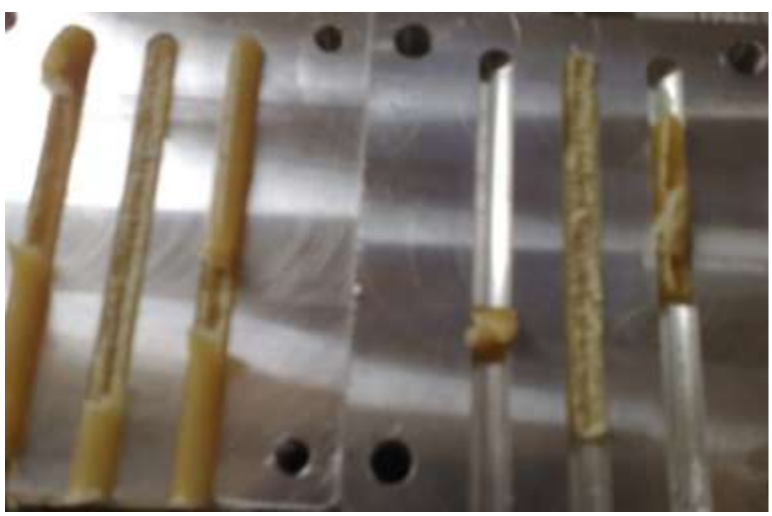


Figure 4. 4 : Mould problems. Air traps and wax stuck

4.2.4.1 AIR TRAPS

In the first trial, there is air traps inside the cavity of the mould. The air is the air that already inside the cavity before the molten wax poured, when the molten wax poured, the air traps inside the cavity. The air traps has make the wax cannot fully fill the cavity and there is hollow on the center of the cylindrical wax. although the hole can make the wax stronger, but it is undesirable. It is because the hollow will make the wax lost strength and ductility. The hollow will also reduce the volume of wax per cylinder, thus it is very undesirable.

To eliminate the air traps, air vents should be made at the end of the slot. The air vents will allow the air inside cavity to escape when the molten wax poured into the cavity of the mould. Thus, there will be no air traps inside the cavity and the wax can fully fill the cavity without leave hollow at the centre of the wax. The diameter of the air vents should be sufficient for the air to escape and should not be too big. If the diameter of the air vents is too big, then there is a possibility that the wax will flow into the air vents and can cause flashing. The best diameter is 1 mm.

To make the air vents, use filling, file the end of the slot. The air vents must be straight and equal for all slots. It is better to use milling machine to make the air vents, but since the air vents is just short, thus it is not very critical.

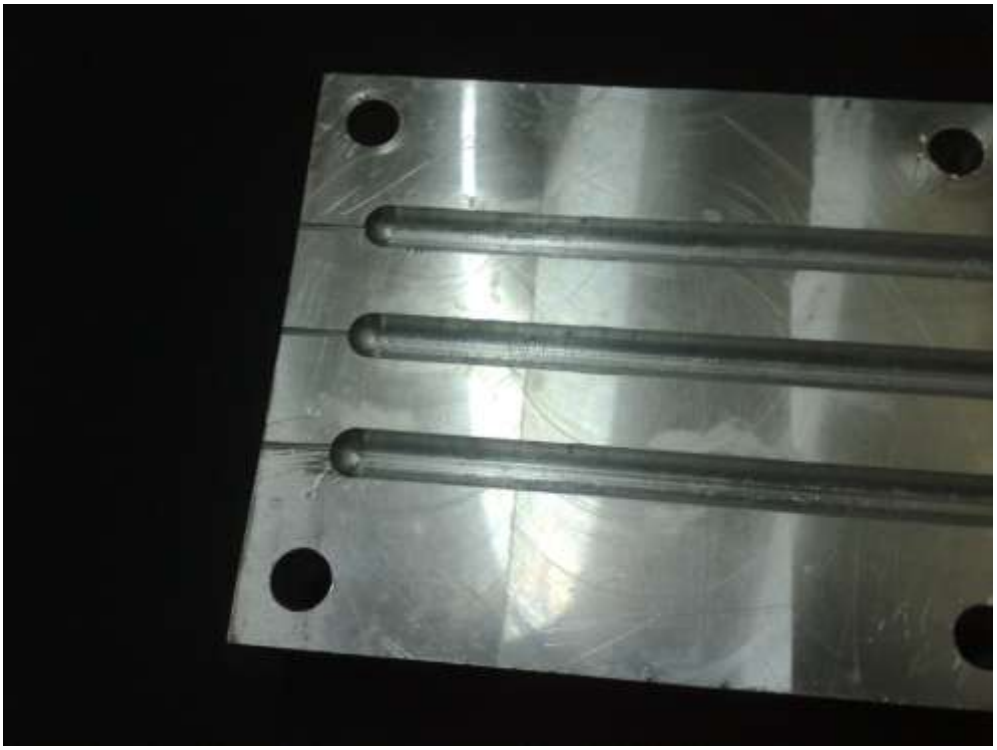


Figure 4. 5 : Air Vents at the end of the cavity slot

4.2.4.2 WAX STUCK

Another problem of the mould is the wax is stuck at the slot after the wax solidified. The wax has stuck at the cavity of the mould and it will broke if try to be remove by force. The wax should not broke or else the required length cannot be met.

The countermeasure for this problem is simply by applying oil on the surface of the cavity before pouring the molten wax. The slippery action of the oil will ensure the wax will not stuck at the slot upon solidified. Applying the oil will also make the surface of the cylindrical wax smoother.

Oil will also give good action to the mould. The mould can be more easily opened after the wax solidified because of the slippery action of oil. In the first trial which is without the oil, the mould become stuck and cannot be open easily, only can be done by force. This could damage the mould if the action be done for a few times. Also the oil helps to increase the life span of the mould.

4.3 WAX ANALYSIS

The analysis of the wax is the analysis on the best mixture of resin and paraffin, which is the percentage of each substance, also the study on the melting temperature of each substance, and the study of wax flow from the heating element.

The wax will determine the success of this research. The research can be said as success if the wax can be melt in the heating element, the mixture can be used for batik process, and also the flow of the wax from the heating element is smooth and continuous. If the criteria cannot be met, recommendations have to be made for better improvement.

The wax has been successfully formed into the cylindrical shape as to be feed into the heating element. There is few problems in the first trial to form the wax, but countermeasure has be done.

Figure 4. 6: Wax in cylindrical shape

4.3.1 MELT ABILITY AND MELTING POINT

One of the things that have to be considered is the melt ability of the wax after it is formed into cylindrical shape. When the paraffin and resin has already melt and combined, it may be cannot melt again. It is because the behavior of resin which is has high melting point. The uses of resin is as the glazing agent, which is a natural or synthetic substance that provides a waxy, homogeneous, coating to prevent water loss and provide other surface protection for the substance.

Melting temperature also has to be considered. Because of paraffin has low melting temperature while resin has higher melting temperature. Thus it is important to know the melting temperature of the combination of the substance.

The research shows that the wax can be melt after it is formed into cylindrical shape. The melting point of the wax is between 60°c to 70°c.

4.3.2 BEST MIXTURE

For traditional canting process, the wax used 50% of paraffin and 50% of resin. In traditional canting process, the wax will be heat on a stove, in a low temperature for a long period. Time is not being considered to melt the wax because the canting process only done when the wax is completely melt and the paraffin and resin is mixed completely.

For the semi automatic canting, the wax will be melt inside the heating element. After the wax has completely melt, then it will flow through the tip of the heating element and the canting process can be done. Thus, time needed for the wax to melt is very important to be considered. If the wax is not completely melt, it could stuck inside the heating element and it can interfere with the wax flow.

If the ratio of paraffin in the wax is higher, then the melting temperature of the wax will be lower. Then the wax can easily be melted inside the heating element. But, paraffin is very brittle and it tends to broke if it is over pushed. If the ratio of the resin is higher, then the wax will be more ductile. But, the melting temperature will be higher because of the melting point of resin is high. Then, there will be a possibility that the wax will not be completely melt inside the heating element.

The first mixture is between 65% of paraffin and 45% of wax. The result shows that the wax is quite brittle. The melting point is low which is about 55°c. The wax can be completely melt inside the heating element and the flow of the melting wax through the tip is smooth. But, when the wax is over pushed, the wax broke. Thus, it is undesirable.

The second mixture is between 45% of paraffin and 65% of resin. The result shows that the wax is more ductile. The melting temperature is higher which is about 80°c. When the wax is pushed towards the heating element, it took longer time to be melt and is not completely melt. The flow of the molten wax from the tip is also not very smooth.

The mixture is as the traditional canting process, which is 50% of paraffin and 50% of resin. The result shows that the wax has enough ductility, which the wax is not broke when it is pushed into the heating element. This is the desired characteristic.

The melting point for this mixture is about 65°c and it can completely melt inside the heating element. Then, the ratio of paraffin and resin used for this research is as the traditional canting process which is 50% of paraffin and 50% of resin. The wax has enough ductility and a moderate melting point which can be completely melt inside the heating element.

Figure 4. 7 : (1) 65% of paraffin and 45% of resin (2) 50% of paraffin and 50% of resin (3) 45% of paraffin and 65% of resin

4.3.3 WAX FLOW

When the wax is pushed towards the heating element, the heat form the heating element will melt the wax and the molten wax will flow through the tip of the heating element. Traditional canting tool has different size of tip. Based on the diameter of the tip. S for small diameter of the tip, M for medium size, and L for large size. For the semi automatic canting tool, in the preliminary design, there is only one size of the diameter of the tip, considered as free size. This is because this research only focused on the design of the heating element, and the mechanism to push the wax. If the research can achieved its objective, then more improvement can be done, such as making a changeable tip.

Analysis on the wax flow is to study the smoothness of the wax flow. The best flow is the smooth flow, because it can assure a good canting process.

The research shows that the flow of the wax is not smooth. Sometime the flow is too slow, caused the batik drawing become inconsistent or dotted line. There is also a time when the flow of the wax become too swift, then the batik drawing becomes too large or big line.

The flow of the molten wax become inconsistent is because the length form the heating element to the tip is too short. The molten wax is not stored, when the wax is melted, it quickly falls out through the tip. The better design is to have a storage area for the molten wax before it falls through the tip. If the molten wax can be stored for some time, then the flow of the molten wax can be smoother.

When the trigger of the canting tool is pushed, it will push the wax and the wax will be pushed into the heating element. The trigger is pulled once, the wax also will be pushed once, no continuous movement of the wax. This also leads to the discontinuous flow of the molten wax because the trigger has to be pull continuously. It is difficult to maintain a continuous pulling of the trigger. An idea of a better design is put a stopper at the end of the tip. And mechanism for the trigger, when the trigger is pulled, it is not to push the wax towards the heating element, but to open the stopper at the end of the tip. Then when the canting process want to be done, only need to pull the trigger once and the molten wax can continuously flow.

The result shows that the research is less successful than expected. This is because the discontinuous flow of the wax. A better improvement can be done to ensure of more continuous flow of the wax.

4.4 HEATING ELEMENT ANALYSIS

Heating Element is the most important part of the semi-automatic canting tool because this is the major difference with the traditional canting tool. The canting tool use power supply from alternating current residential power supply which is 240v, 50Hz. The power of the canting tool is 60W.

The heating element consists of a heating capacitor, plastic coating, and aluminum heating. The design of the heating element is based on the concept of capacitor which is two parallel conducting plate separated by an insulator. Plastic coating will act as electrical insulator and thermal conductor while aluminum heating will melt the wax. Aluminum heating is the heating area that will melt the wax.

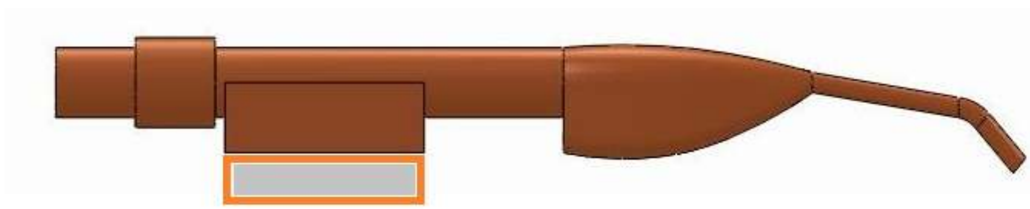


Figure 4. 8 : Heating Element

The figure above is the drawing of the heating element. The grey is the capacitor heating which will be powered by electrical power. The orange is the plastic coating and the brown is the aluminum heating. The actual heating element is slightly different with the drawing.

4.4.1 CAPACITANCE

The capacitor heating is designed based on a capacitor and the capacitance value need to be calculated. The capacitance value can be calculated using a formula.

The area of the copper conductive plate is;

$$\text{Area, } A = 13mm \times 6mm$$

$$= 0.013m \times 0.006m$$

$$= 7.8 \times 10^{-5}\ m^2$$

The capacitance value of the heating element is;

$$C = \frac{\epsilon A}{d}$$

Where Є, the relative dielectric constant for mica is 7.0. and d which is the distance between two parallel conductive plate is 2mm. Thus, the capacitance value is;

$$C = \frac{(7.0)(7.8 \text{ x } 10^{-}5 \text{ m}^2)}{0.002m}$$

$$= 0.273\text{F}$$

After both resistivity and capacitance value of the capacitor plate has calculated, the value will be used to calculate the heat generated in the heating element. Thus, it is very important to get the exact value or else the final result will be different from the supposed result.

4.4.2 HEAT GENERATED IN HEATING ELEMENT

The heat generated in the heating capacitor can be calculated using the formula of power dissipation. The total power loss in the capacitor is equal to the amount of heat generated in the capacitor.

$$\text{Power dissipation} = \frac{\text{Irms}^2}{2\pi\text{fC}} \text{ x} \tan\delta$$

The values required are;

Volt, Vm = 240v

Frequency, f = 50Hz

Period, T = 1/f

= 1/50Hz = 0.02

$= 20ms$

$$Vrms = \frac{Vm}{\sqrt{2}}$$

$$= \frac{240v}{\sqrt{2}}$$

$= 169.7056$

$$\text{Resistivity of the copper, R} = \frac{(\text{resistivity})(\text{length})}{(\text{cross sectional area})} = \frac{(17.2\ n\Omega m)(0.002m)}{(7.8 \times 10^{-5}\ m^2)}$$

$= 4.4102 \times 10^{-7}\ \Omega$

$$Irms = \sqrt{\frac{V^2 rms}{R^2}}$$

$$= \sqrt{\frac{(169.7056)^2}{4.4102 \times 10^{-7}\ \Omega^{\ 2}}}$$

$= 384.\ 802\ MA$

Tan δ = at the frequency under the sine wave from at the frequency of the steepest pulse part under the non-sinusoidal wave pulse frequency $\frac{1}{pulse\ width}$

= -240v

Thus, the power dissipation can be calculated and the value is;

$$\text{Power dissipation} = \frac{(384.802MA)^2}{2\pi(50Hz)(\ 0.273F)}\ x - 240v$$

= -414.355 kW

Assume the canting tool is powered for one minute. Then, the total power generated for one minute is;

Heat generated in 1 minutes, H = Pt = 414.355 kW(60s)

= 24.816 kJ

Total work done, U = 24.816 kJ = mc(T1-T2)

$$T1 - T2 = \frac{24.816\ kJ}{\left(\frac{0.002kg}{9.81ms^{-2}}\right)(385kJ.kg^{-1}.K)}$$

= 316.735 °K

= 43.5855°c

The initial temperature is room temperature which is 27°c. Thus, the final temperature of the heating element after one minute;

T2 = 43.5855 + 27

= 70.5855°c.

From the calculation, we know the temperature at the capacitor heating after one minute which is 70.5855°c. The result on actual component show the temperature is 70°c and it show the calculation is correct.

4.4.3 HEAT TRANSFER

The heat generated in the capacitor heating transferred through the plastic coating, then to the aluminum heating. The heat transferred is as the figure below.

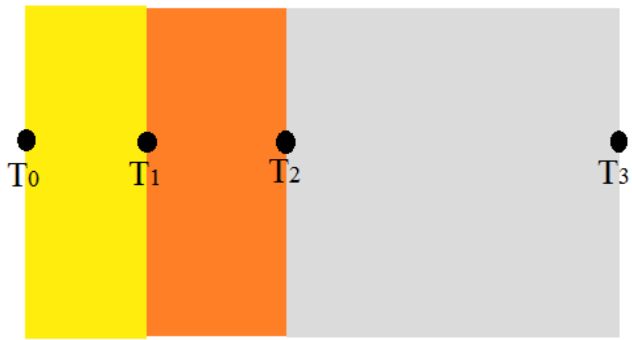


Figure 4. 9 : Heat transferred between the element

The gold is capacitor heating element. Electrical power will be supplied to the capacitor heating and it will generate power. The orange is the plastic coating and the grey is aluminum heating.

Thermal resistance of copper;

$$R(C) = \frac{L}{k(c)A}$$

$$R(C) = \frac{0.0002\text{m}}{\left(401\,\frac{W}{mK}\right)(7.8\text{x}10^{-}5\ \text{m}^2)}$$

$$= 6.394 \text{ x } 10^{-}5 \text{ K/W}$$

Thermal resistance of polypropylene

$$R(P) = \frac{L}{k(p)A}$$

$$R(P) = \frac{0.0005\text{m}}{\left(5\,\frac{W}{mK}\right)(8.775\text{x}10^{-}5\ \text{m}^2)}$$

$$= 1.1396 \text{ K/W}$$

Thermal resistance of aluminum

$$R(A) = \frac{L}{k(a)A}$$

$$R(A) = \frac{0.001\text{m}}{\left(237\,\frac{W}{mK}\right)(8.755\text{x}10^{-}5\ \text{m}^2)}$$

$$= 0.04808 \text{ K/W}$$

Assuming the initial temperature of the plastic coating and aluminum heating is at room temperature which is 27°c. As we know, the temperature of capacitor heating after one minute is 70.5855°c. Then the temperature at the aluminum heating after one minute also can be calculated.

$$Q = \frac{T0 - T1}{R(C)} = \frac{T1 - T2}{R(P)} = \frac{T2 - T3}{R(L)}$$

$$\frac{70.5855°c - T1}{6.394x10^{-3}\ K/W} = \frac{T1 - 27°c}{1.1396\ K/W}$$

T1 = 70.3425°c

$$\frac{70.3425°c - T2}{1.1396\ K/W} = \frac{T2 - 27°c}{K/W}$$

T2 = 28.7546°c

Then, the rate of heat transferred in the heating element is;

$$Q = \frac{T0 - T3}{R(total)}$$

$$Q = \frac{70.5855°c - 28.7546°c}{(6.394x10^{-3} + 1.1396 + 0.04808)K/W}$$

= 35.0321 W

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This research has achieved most of the objectives. The semi automatic canting tool has been successfully developed. The canting tool has direct heating that used to melt the wax and the capacitor concepts has ensure the final temperature can be maintain at specified temperature.

The only objective that on this research fails to achieve is to maintain a continuous flow of the wax. The flow of the molten wax is not smooth thus effecting the canting process.

This chapter will discuss about the conclusion of the research and few recommendations that can be made on the canting tool.

5.2 CONCLUSION

The semi automatic canting tool has achieved the first objective which is to invent a semi automatic canting tool that has direct heating. Direct heating is a heating system that will melt the wax directly inside the canting tool, without the need of stove like traditional canting process. The heating element is design based on the concept of a capacitor. The design has two parallel conductive plate separated by a insulator. Copper is used as the conductive plate and mica is the insulator. Heat generated in the heating element because of the dissipation of energy. When the current pass through the dielectric plates, entering one side of the plate the other plate, a small amount of power is dissipated. The difference between the amounts in and out is lost or used in capacitors, and is referred to as the power loss or power dissipation in the capacitor. The power loss is the wasted consumption of power by the capacitor itself, since such power is unable to do otherwise useful work, rather most of the consumed power will be converted into heat, which increases the capacitor's temperature.

The second objective is to study the processes of making canting batik. The study is done by make a visit to a batik factory, which is RM Batik that is located at Kuantan. The process is started with heating the wax on a stove, then, the molten wax is poured into a traditional canting tool. The canting tool is used to make decorations on a cloth. After the sketching finished, the cloth will be colored. The purpose of the wax drawing is as the glazing agents, prevents the area from the color, and provides surface protection. The wax also act barrier between the colors, forms colorful design. When the wax removed after the coloring process done, the area will still have the original color of the cloth. The artistic value of batik is the design is done manually using hand, though the semi automatic canting tool only adds a heater. Which means it will never be two or more batik that has 100% same design.

The third objective is to develop a heating element that ensures continuous flow of wax at specified temperature. The heating element can maintain the same temperature even it is heated for a long period, but it cannot ensure a continuous flow of the molten wax. The flow of the molten wax has been disrupted, forming dotted line instead of the required straight line.

The flow of the wax based on the action of the pulling the trigger. When the trigger is pulled once, the wax will be pushed towards the heating element once. Thus the flow of the wax will be discontinuous because it is difficult to maintain the action of pulling the trigger repeatedly. People will tends to pull the trigger some time slow and some time quite fast because of need to focused on the canting process in the same time. Discontinuous flow of the molten wax is very undesirable because it will make the sketching process harder.

5.3 RECOMMENDATIONS

As the third objective is fails which the flow of wax is discontinuous, recommendations can be made to improve the design. The design of the heating element has to be improved as to maintain a continuous flow of the molten wax. Few recommendations can be made.

One of the methods is by designing the heating element with a storage, to store the molten wax for a few seconds before it fall through the tip of the heating element. Design of heating element in this research has short distance between the heating element and the tip for the molten wax to fall through. When the wax has melt, it will quickly fall through tip and the melting process is inconsistent as the action of pulling trigger is also inconsistent as mention earlier. If the heating element has a storage area for the molten wax, some of the molten wax can be store while waiting the next melting process. From the initial design that only has two processes which is melting and pouring, the storage area has adds one more process which is waiting. The molten wax waits for other wax to be melt and it can be poured or sketched slowly. Thus, the flow of the molten wax will become more stable and continuous.

Another method that can be recommended is by redesign the mechanism of the trigger. In the design in this research, when the trigger is pulled, the mechanism will push the wax into the heating element. The drawback is when the trigger is pulled once, the wax will also be pushed once. Another type of design is to put a stopper at the tip of the heating element, the place where the molten wax flowed out. When the trigger is pulled, instead of the trigger push the wax, the trigger will change its function by open the stopper. Which means the trigger only need to be pulled once and hold, then the stopper will be opened and the wax can flow out. As long as the trigger is being pulled and hold, the stopper will remain opened. Then the molten wax can continuously flow form the tip smoothly.

Whenever want to stop the canting process, just need to released the trigger and the stopper will automatically closed.

Another recommendation that can be made is to make a changeable tip. For traditional canting tool, the tip has different size of diameter which S is small, M for medium and L for large. There is also has a canting tool that has three tip, then a new type of batik design can be done. If the tip can be change, then the canting tool will be more flexible.

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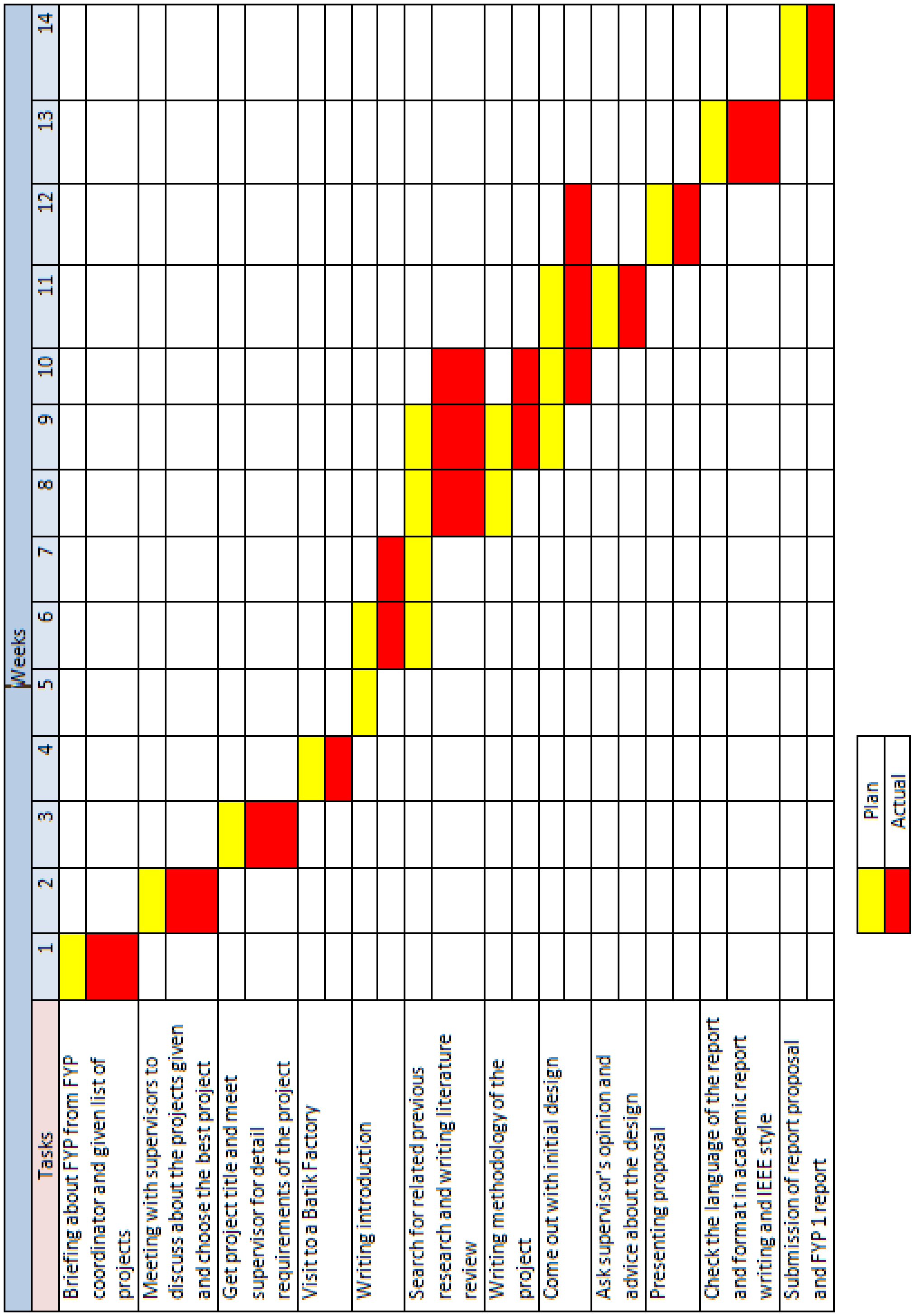
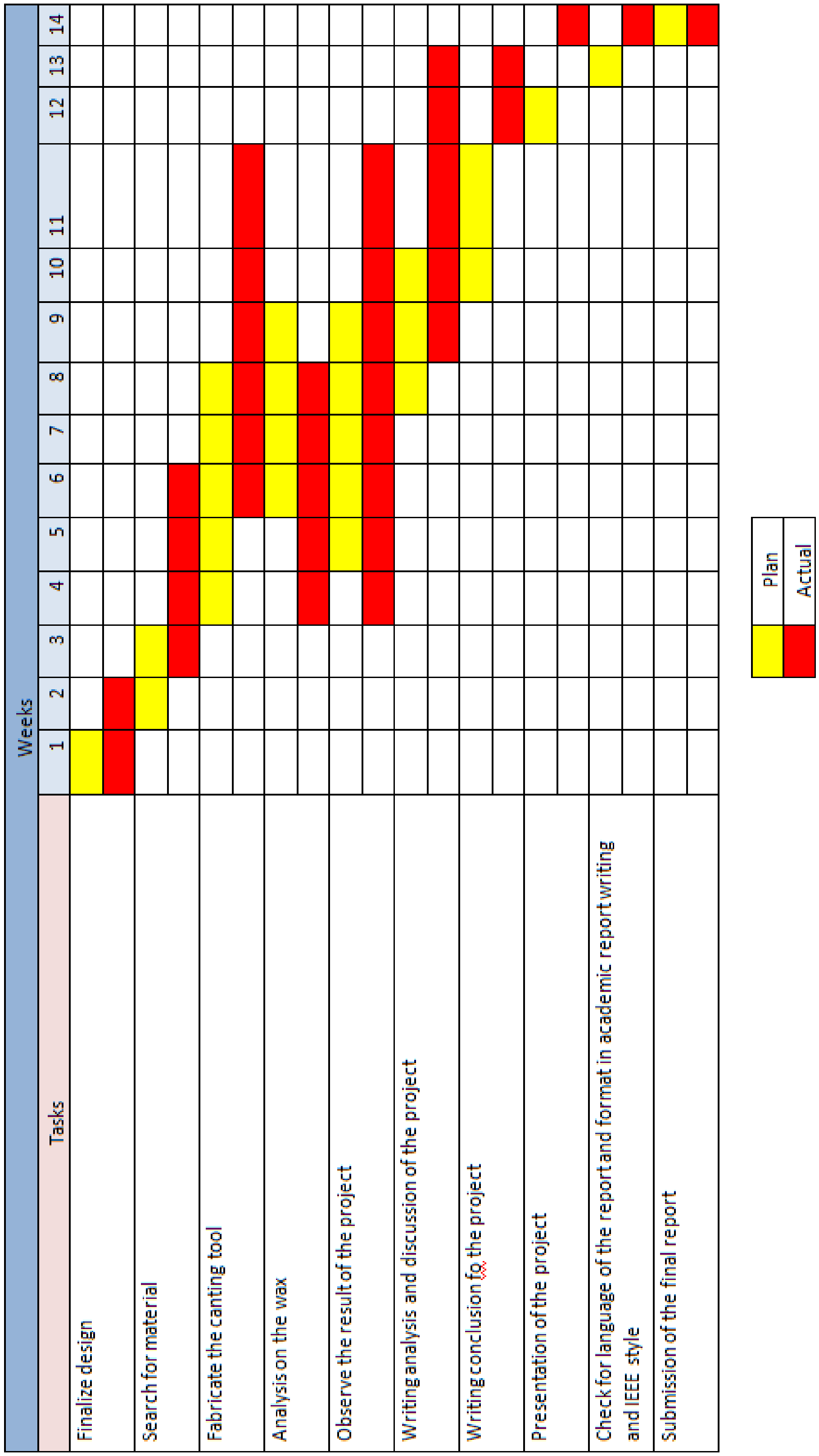
APPENDIX A1: Gant-Chart for Final Year Project 1

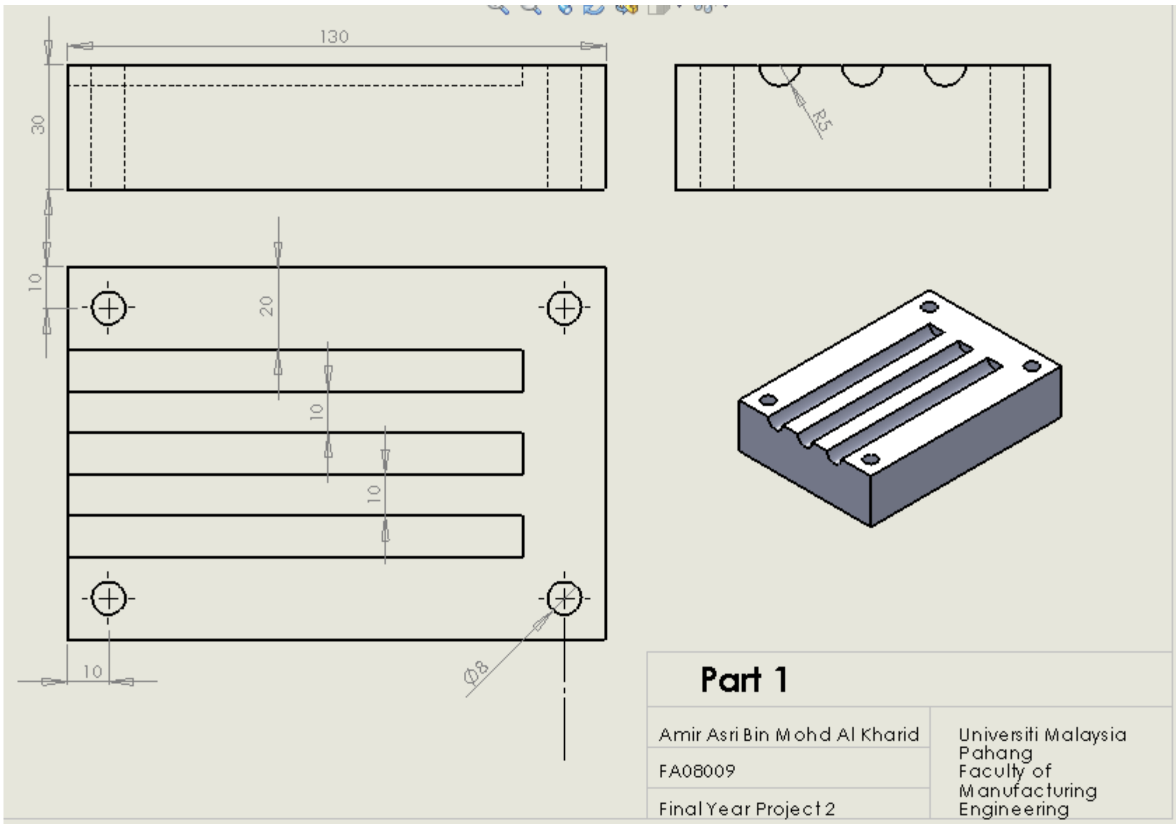


APPENDIX A2: Gant-Chart for Final Year Project 2



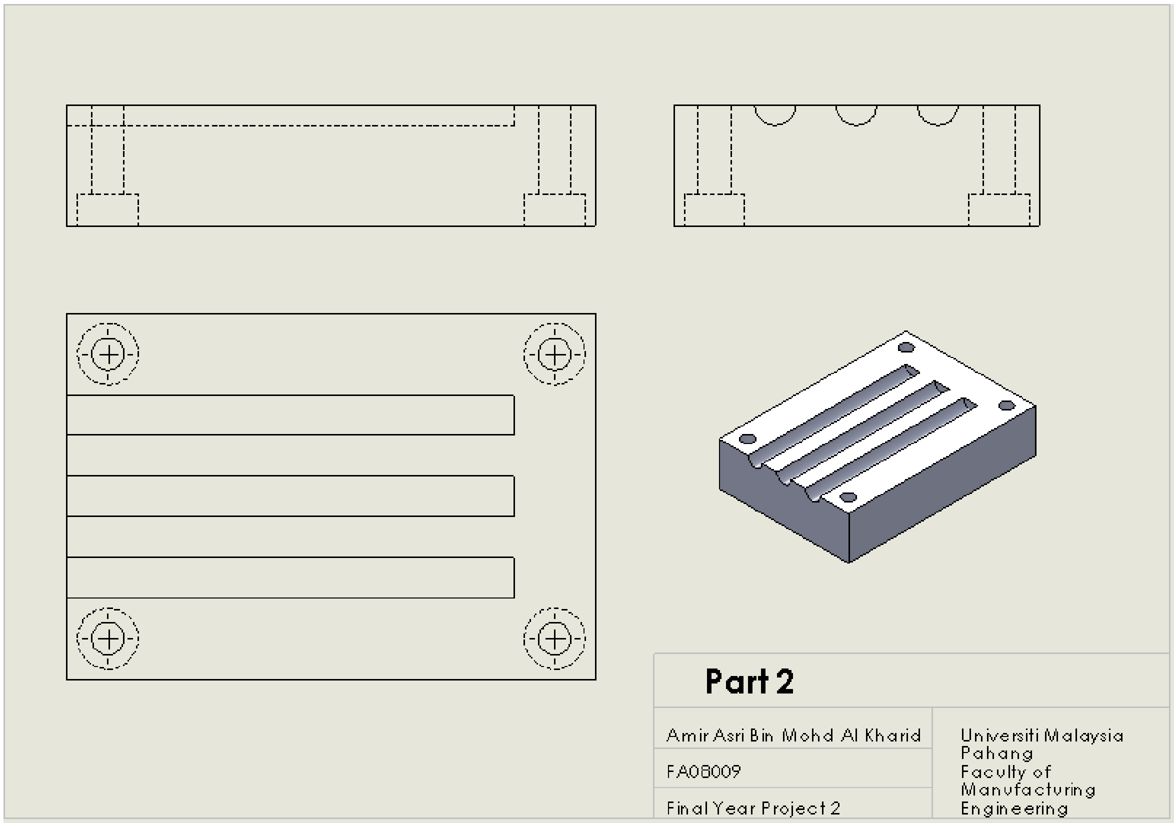
APPENDIX B1: Mould Drawing

Part 1 Drawing



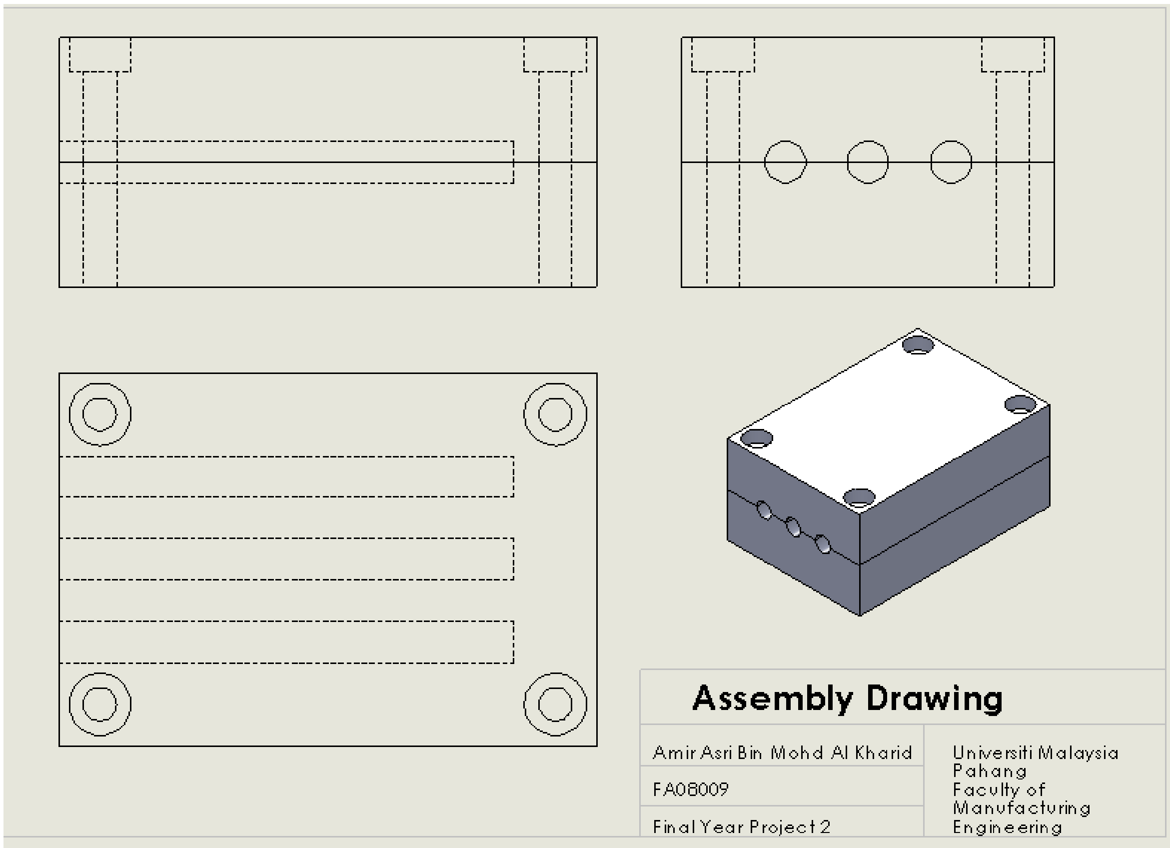
APPENDIX B2: Mould Drawing

Part 2 Drawing



APPENDIX B3: Mould Drawing

Assembly Drawing



APPENDIX C

Heating Element Diagram