FEASIBILITY STUDY ON PRODUCING FUNCTIONAL PARTS USING MOLDING TECHNOLOGY

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FEASIBILITY STUDY ON PRODUCING FUNCTIONAL PARTS USING MOLDING TECHNOLOGY

ADEL MUHSIN ELEWE

A thesis submitted in partial fulfillment of the requirement for the award of the Degree of Master of Mechanical Engineering

Faculty of Mechanical Engineering and manufacturing

University Tun Hussein Onn Malaysia

Dec 2014

Dedicate this work to my family…

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I am heartily thankful to my supervisor, Dr. Rd. Khairilhijra Bin Khirotdin, whose encouragement, supervision and support from the preliminary to the concluding level enabled me to develop an understanding until accomplished this project.

Special thanks for my great family for all the sacrifices they have made to ensure that I obtain the best.

ABSTRACT

The mechanical and electrical conductivity of a system based on ABS (acrylonitrile butadiene styrene) filled with metal powder have been studied. Copper powder having different percentage was used as fillers. Polymer composite investigated to produce high electrical conductivity from a low-cost thermoplastic with low conductive filler loading concern over the process ability. The composite preparation conditions allow the formation of a metal powder distribution in the polymer matrix volume to create a good network of electrically conductive fillers. The main objective of this study is to investigate the feasibility of producing functional composit material based on effective mixture. And also to formulate the metal-plastic which can produced by molding technology. ABS is compounded with a copper powder in the mixing machine at 190 to 230ºC for 15 minutes at 30 rpm, then charged to the plastic grinder machine in order to form the composite in suitable size to feed it in molding machine. The influence of viscosity on processing selection is being mapped by MFI test in order to perform the samples in a proper molding technology. The compositions were adjusted as the polymer volumes were equal to 10%, 20% for injection molding machine process and 30% to 70% were used in hot press molding machine process. In order to understand the variation in electrical and mechanical properties, several tests were performed such as density, porosity, tensile, hardness and IV test. Experimental data shows that the strength of the composite improved while the electrical resistivity decreases with the arising of percolation thresholds. The key parameter in this case is the packing factor F which equal to 0.46, represents the maximum point of percolation threshold that achieve conductive composite.

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LIST OF SYMBOLS AND ABBREVIATIONS

A	Area
ASTM	American Society for Testing and materials
E	Young's modulus
F	Packing Factor
L	Time piston stroke
I	Curve
J	Current density
P	Pressure
Rco	Resistance of the contact
Rcr	Resistance of the circuit
R m	Resistance of the sample
Rp	Resistance of the polymer
S	Average area
V	Voltage
Vf	Volume of Filler
Vp	Volume of Polymer
d	Material density
m	Mass
t	Time
v	Volume
μ	Viscosity
γ	Shear rate
τ	Shear stress

ρ	Density
x	Ristance
σ"c"	Critical conductivity
σf	Filler conductivity
σ"m"	Matrix conductivity
"Φ" c	Volume filler fraction
Ω	Ohms

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Plastics for replacement of metals and for new products began essentially in the late 1930s, and their development and use of products has proliferated ever since. Plastic materials display properties that are unique when compared to other materials and have contributed greatly to the quality of our everyday life. Plastics, properly applied, will perform functions at a cost that other materials cannot match. Plastics are changed into useful shapes by using many different processes. One of these processes is moulding process, which used to mould or shape thermoplastics basically softens the plastic material, it can be flow through a die, formed in or over a mould. A major advantage of this manufacturing technique is forming fairly complex shapes at a high production rate in view of the cyclic nature of the process. The process usually allows any scrap parts or material to be ground up and reused (Marino, 2005). Copper as a filler has a wide possible area in the industry because of their high conductivity, enhanced strength and stiffness, flexibility in design, good chemical corrosion and available. This study aims to investigate the feasibility of producing functional parts by mixing metallic particles into the polymer matrix material.

1.2 Background of Study

Composite materials are engineered materials made from two or more constituent materials that remain separate and distinct on a macroscopic level while forming a single component. The reason why composites are produced is to obtain a better property by combining the advantageous properties of constituents instead using them alone (Marino, 2005). Composite materials research in order to tailoring material properties for novel applications has resulted in important advancements in materials science and engineering. This importance arises from the fact that the electrical characteristics of such composites are close to the properties of metals, whereas the mechanical properties and processing methods are typical for plastics (Gul *et al*., 1984) (Bhattacharya, 1986). The achievement of metallic properties in such composites depends on many factors, and it is just the possibility of controlling the electrical and physical characteristics which determine the variety of ranges of their application (Mamunya *et al*., 2002). There are two separate phases in composite materials which are the matrix and the filler. The matrix material surrounds and supports the filler by maintaining their relative positions. The filler imparts their special mechanical and electrical properties to enhance the matrix properties. The importance of conductive composites appears widely from the fact that such materials can have exceptionally high conductive for a given weight of material so as a result of this, (Acrylonitrile-Butadiene-Styrene) ABS mixed with copper composites may take place in industrial applications. The ABS still represents by far the biggest and most important class of types of material. The combination of mechanical and thermal properties allows them to be employed for highly specified end users and often for metal replacement applications. ABS is also characterized moderately low cost and easily manipulated commercially by melt processing (Joseph, 1986).

1.3 Problem Statement

Polymers are used in a wide range of applications because of their properties. Composite materials are inherently heterogeneous and represent a defined combination of chemical and structural different constituent materials, ensuring the required properties such as mechanical strength, stiffness, low density, or other specific characteristics depending on their purpose. One area of interest is maximizing the efficiency of the fuel cell by controlling the electrical conductivity of the bipolar plate which is represented conductive plates in a fuel cell stack that act as an anode for one cell and a cathode for the next cell. Bipolar plates can be made from various materials with the most common being graphite, metal, carbon/carbon, and polymer composites. Each type of material has its strengths and weaknesses. Materials for polymer composites are relatively inexpensive and channels can be formed by means of compression or injection molding. The rapidly growing of the industries has stimulated the need for new material specification that can be formed into housings that possess mechanical and electrical characteristics. Considerable interest has developed in the use of polymeric materials filled with metal to obtain a composite features with mechanical and electrical (Leigh et al., 2012). One of the major challenges in the production of economical polymer (bipolar plates) for fuel cells in the automotive applications is the development of materials with a balance between sufficient electrical conductivity and mechanical properties while allowing for rapid continuous rnanufacturing. The bipolar plates contain the important mechanical and electrical features by means of collecting the current produced by the electrochemical reactions and carry the clamping force to hold the fuel cell stack together (Cunningharn and Baird, 2006). The evolution of an interpenetrating polymer depends on the type of mixing and this composite with electrical features could be realized theoretically by molding processes. The challenge is whether the available molding technology could be realistically employed in producing functional parts with unique properties, essentially high electrical conductivity and good mechanical strength (Planes, 2012). Systematical evaluation on the process of mold technology is essential due to conventionally the available rnolding technology is vastly used on pure plastics while this research study utilizes a thermoplastic polymer as the matrix to incorporate with the various conductive metal fillers and these multi matrix materials will be molded to produce a composite of conductive features using the available mold technology (in a ceramic polymer laboratory at UTHM).

1.4 Objective of Study

The objective of this study is to investigate the feasibility of producing functional parts by mixing metallic particles into the polymer matrix materials using the available plastic molding technology. In order to achieve the objective, some of the tasks are planned which are:

i. To investigate the effective mixture of the materials used on producing the functional parts using the packing factor method.

ii. To assess the strength of the composite to prove its strength characteristic and the resistivity of the parts to determine its electrical conductivity.

iii. By validating the formulation of the metal-plastic from mold technology proposed.

1.5 Research Scopes

The scopes of the study are:-

i. The main technology used to produce samples is molding technology.

ii. The resistance of the functional parts will be measured IV test which is measure the current flow into the specimen.

iii. The strength of the functional parts will be measured using a tensile test and the hardness test in order to determine the strength chracteristice.

iv. The polymer material compositions used are (Acrylonitrile-Butadiene-Styrene) ABS

v. The metallic particles used are copper powder material.

1.6 Significant of Study

Thermoplastics are non corrosive, are lighter, and are often more cost effective than metals . It can be tailored for specific applications and properties depending on the matrix of the material. This work has been conducted by varying the amount of a filler in a composite material to fill the gap between metal and polymer in order to enable to produce more functional composite material combine the advantageous properties of metals and plastics including high electrical conductivity at low filler loading levels, and also controlling the electrical and physical characteristics which determines the variety of ranges of their application by offering a wide fabrication range of design flexibility.

1.7 Organization of Thesis

The MP (Master's Project) study is organized to include six chapters. Chapter 1 is an introduction to this study, which includes a statement of the problem, background study, objective of study and research scope. Chapter 2 is discussing about the literature review. Chapter 3 is discussing on methods and procedures used. The research flow chart and planning are shown in an Appendix A. Chapter 4 contains the results and analysis of the obtained results. Chapter 5 contains discussion. And finally Chapter 6 contains the conclusion and recommendations.

CHAPTER 2

LITERATURES REVIEW

2.1 Introduction

The purpose of this literature review is to provide background information on the issues to be considered in this thesis and to emphasize the relevance of the present study. This treatise embraces some related aspects of polymer composites with special reference to their electrical conductivity and stress characteristics.

2.2 Composites

Composites can be defined as materials that consist of two or more chemically and physically different phases separated by a distinct interface. The different systems are combined judiciously to achieve a system with more useful structural or functional properties non attainable by any of the constituent alone (Sabu *et al.*, 2012), they are playing an increasing role as construction materials in a wide variety of applications. In particular, thermoplastic polymer composites are falling under increasing scrutiny due to their potential to be easily repaired and/or reshaped.

Various kinds of polymers and polymer matrix composites reinforced with metal particles have a wide range of industrial applications such as heaters, electrodes, composites with thermal durability at high temperature etc. (Kumlutas, 2006). In the past, composites, such as coconut fiber/natural rubber latex was extensively used in 40 years of applications such as boat hulls, corrugated sheet, pipe, automotive panels, and sporting goods (Rodney, 1988).

Today, many thermoplastic-based materials have also been developed to address a wide range of applications. Many researchers improved the composite material properties such as low mechanical properties (Impact, Tensile, Flexural Strength, and hardness) (Bell *et al*., 2008) (Robert, 2014) (Wilkinson, 2013) (Carlos *et al.,* 2003). Essentially, the advantage of a composite material is the ability to combine the desired properties of its building blocks. To date, the driving force in the development of composites has been enhanced strength-to-weight ratios in the aircraft industry (Rodney, 1988), but now cost advantages are also becoming a major factor, particularly in automotive applications. There is even a burgeoning industry to incorporate sustainable materials into composite structures (Wilkinson, 2013).

2.3 Electrical Conductivity

Electrically conductive polymer composites are obtained by combining an insulating polymer with electrically conductive filler(s). Typically, polymers exhibit electrical conductivities in the range of 10-14 to 10-17 Siemens per centimeter (S. cm-1) (Rodwick, 2008). The resulting electrical conductivity of the composite will be heavily dependent on the filler concentration (Gabriel, 2011). As the concentration of filler increases to a critical volume fraction (percolation threshold), a conductive network form due to inter-particle contacts providing a continuous pathway for electron travel and resulting in a dramatic increase in electrical conductivity.

2.4 Percolation Theory

Pike and Seager denoted the percolation theory was a measure of connectivity between regularly or randomly positioned sites within a space (Pike, 1974) (Eliodoro, 2010). To embellish on the definition of Pike and Seager, Stauffer explained percolation theory with the assistance of a square lattice as shown below in Figure 2.1A (Stauffer, 1985).

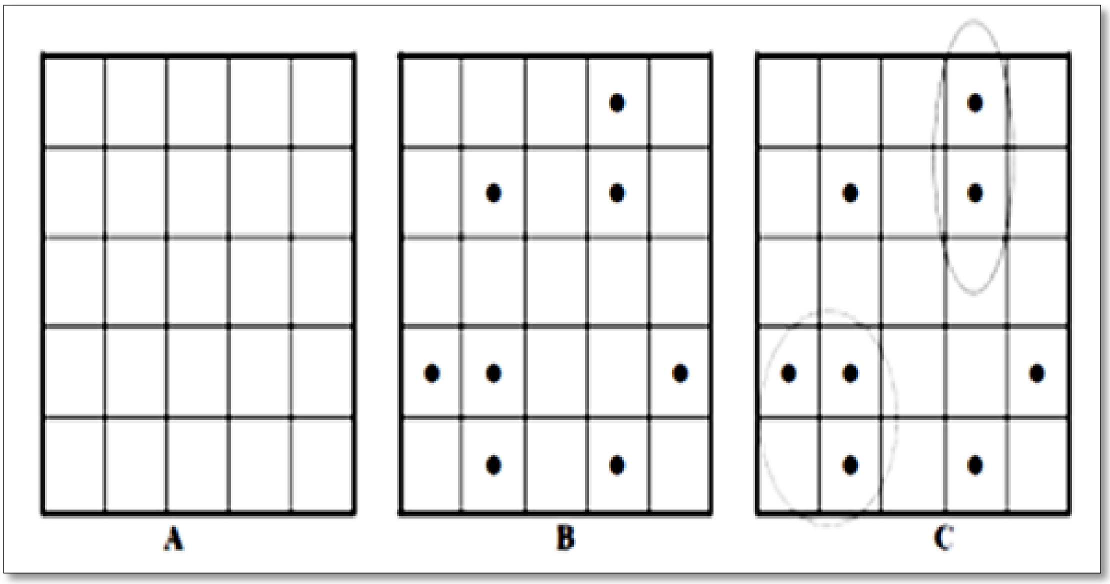

Figure 2.1: Square lattice diagram with clusters circled (Mamunya *et al.*, 2002)

Randomly placed dots are placed in the squares with some squares left empty as shown in Figure 2.1B with a probability, p, that a site will be occupied with a dot. These randomly placed dots form clusters, highlighted in the circles and shown in Figure 2.1C. A cluster is a group of adjacent squares occupied by dots with a common side. The percolation theory deals with the clusters thus formed, in other words the groups of neighbouring occupied sites. In the case of the lattice, percolation occurs at a certain probability where a cluster extends from top to bottom or right to left in the case of these square lattices (Stauffer, 1985). In conductive resins, the percolation threshold is the measure of the volume fraction of conductive fillers that results in a percolating system.

The percolation theory provides an explanation of the composite's electrical conductivity near the critical volume or percolation threshold value. In Figure 2.2, Clingerman graphically described the dependence of conductivity on the filler volume fraction (Clingerman, 2003).

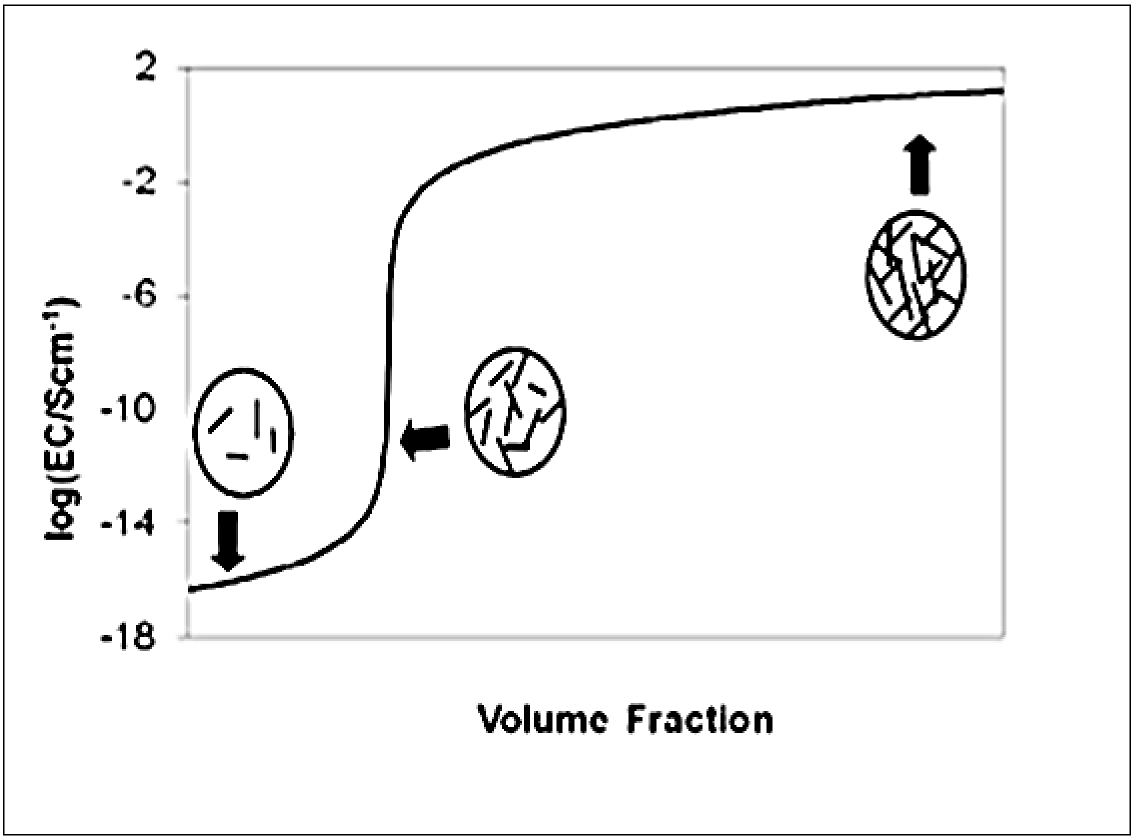

Figure 2.2: Dependency of electrical conductivity on filler volume fraction (Clingerman, 2003)

Many studies have been conducted with the intent of reducing the percolation threshold value so that mechanical integrity and high electrical conductivity can be achieved within the composite. The percolation thresholdvalue allows to evaluate how effective a conductive filler is on increasing the electrical conductivity of the composite system (Park and Bandaru, 2010) (Carlos, 2003) (Mamunya *et al.*, 2002). The factors that affect this critical volume fraction and the ultimate electrical conductivity of the conductive resin are relevant to this research.

2.5 Factors Affecting Electrical Conductivity

Filler properties play a significant role in determining the electrical conductivity of the composite (Rodney, 1988) (Mamunya *et al.*, 2002). Studying these variables affecting the electrical conductivity will result in the mechanical stability of the composite and may influence the choice of conductive filler utilized. In the forefront.

2.5.1 Filler Conductivity

The conductivity of the filler is the major factor in the electrical conductivity of the composite (Bell and Goh, 2008) (Marino, 2005) (Mamunya *et al.*, 2002).

2.5.2 Particle Size and Morphology

Other filler properties can have a significant impact on the electrical conductivity, such as particle size and morphology for partical size(Mamunya *et al.*, 2002) reported that For systems having size of polymer and metal particles D and d

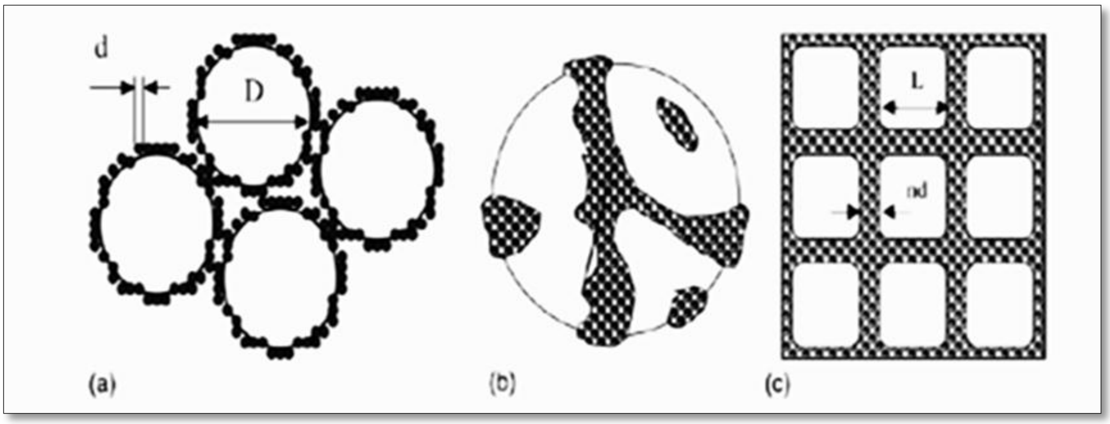

Figure 2.3: (a) Schematic representation of the assumed distribution of polymer and metal particles (having D and d sizes, respectively) for mechanical mixtures of PVC/Ni; (b) The minimal polymer particle covering with metallic particles needed

for conductivity arising in the system ; (c) Schematic representation of the shell structure model.(Mamunya *et el*., 2002)

It is important to mention that for the appearance of conductivity it is not required that each polymer particle is completely covered with a monolayer of metallic particles in contact with each other. As is shown in Fig. 2-3b taken from (Mamunya *et al.*, 2002) certain effective filler portion on the polymer particle surface provides conductive cluster. Further increase of filler content results in the increase of the number of layers n of metallic particles on the kernel surface and in the decrease of the size L of the unfilled region, L ¼ D. The schematic picture of the composite structure having shell thickness equal as is shown in Fig. 2-3c (Mamunya *et al.*, 2002).

2.5.3 Polymer Wets

The factors mentioned in the previous paragraphs are excellent at forecasting the electrical conductivity of the composite system (Rodwick and Julia, 2008) but there are some subtle factors which when coupled can lead to erroneous electrical conductivity predictions. One factor is how well the polymer wets the surface of the filler (Rodwick and Julia, 2008) (RIOS, 2007). This adhesion of the filler of the polymer can be quantified by the difference between the two surface energies of the materials. Poor wetting of the filler by the polymer will result in segregated filler distributions within the composite (Ruschau, 1992). Mamunya (Mamunya *et al.*, 2002) showed the smaller the difference between the surface energies of the materials leads to better wetting and an increase in the ultimate electrical conductivity (Mamunya *et al.*, 1997).

2.5.4 Filler Orientation

Another factor is the orientation of the fillers within the composite (Rodney and Nichols, 1988). The orientation factor is usually a condition of the fabrication process of the composite and the filler angle measurement gives some indication of the filler's orientation in the composites and its measured from the direction of conduction (Rodwick and Julia, 2008) (Beth *et al.*, 2009).

2.5.5 Packing Factor

One of the most important characteristics of the filler polymer composite is the filler packing factor F (Mamunya *et al.*, 2002).Packing factor is a dimensionless ratio that describes the amount of volume that a substance takes up in a particular volume. The value of F depends on the particle shape and on the possibility of the skeleton or chained structure formation (Marino, 2005). The parameter F is a limit of system filling and equal to the highest possible filler volume fraction at a given type of packing:

$$F = Vf/(Vf + Vp) \qquad \text{………………. 2.1}$$

Where Vf is the volume occupied by the filler particles at the highest possible filler fraction and Vp the volume occupied by the polymer (space between filler particles). For statistically packed monodispersed spherical particles of any size, F is equal to 0.64 (Mamunya and Mater, 1998) (Mamunya *et al.*, 2002).

2.5.6 Density and Porosity

Density of a composite is the mass unit related to the volume, which is important in applications to specify the characteristic of product and production process needed.

The determination of filler volume contents and composite densities, void volumes of each composite prepared were then determined (Yeetsorn 2010).

One of the correlate factors to the density is the porosity.Porosity is a voids and air bubbles in composite (Mehmet 2006). It represents one of the affecting Parameters on the performance of polymer composites containing functional fillers which related to processing, structure, property relationships (Marino 2005) and also solidification shrinkage(Aran 2007).

The functional material should have improved properties such as low porosity, low water adsorption, higher flexural strength and higher electrical conductivity(Marino 2005) Increased electrical conductivity, along with reduced porosity, have been attributed to a homogeneous distribution of conductive particulates, creating a conductive network throughout the composite (Chan 2011). These problems are usually overcome by hot pressing i.e. by sintering under pressure between punches in a die. The pressure provides the major part of driving force to eliminate porosity(Beura 2012).

2.5.7 Viscosity and MFI

Viscosity is the parameter that relates deformation rate to stresses in the fluid and hence the pressure in any flow, layers move at different velocities and the fluid's viscosity arises from the shear stress between the layers that ultimately oppose any applied force.

Thermoplastic polymers are viscoelastic materials and as such exhibit a pronounced time or frequency dependence. For convenience, thermoplastic melts are characterized with a representative material relaxation time. In a similar way, individual steps in a manufacturing or transformation process can be described by a characteristic process time.

Viscoelasticity describes the internal resistance to flow which represent Dynamic viscosity, or absolute viscosity, (typical units Pa•s).It is an optimal tool to utilize viscoelastic formula to solve the problem of fluidity.

Viscosity depends on both shear rate and temperature. When temperature increases melt viscosity decreases, which creates lower force acting on the polymer matrix at the interface. During molding process, molten material is forced into the mold, where excessive shear occurs.

A complicating factor is that shear stress τ, is the product of viscosity and shear rate (Cansever 2007)

$$\tau = \mu\gamma \qquad \text{………………. 2.2}$$

Where μ is viscosity, and γ is shear rate, to specify the viscosity, the Melt flow index can be used as a method for finding viscosity, that's because MFI is inversely related to viscosity (Hamilton 2010).

2.6 Material Selection:

The performance of an engineering component is limited by the properties of the material of which it is made, and by the shapes to which this material can be formed (Ashby and Cebon, 1993). Materials selection is a task normally carried out by design and materials engineers. The aim of materials selection as the identification of materials, which after appropriate manufacturing operations, will have the dimensions, shape and properties necessary for the product or component to demonstrate its required function at the lowest cost. Free-form fabrication is a very promising technology due to the efficient and simple process for creating microstructures (Khairu, 2013).For the purpose of material selection, thousands of data would be needed to characterize all the grades of materials. Many selection systems are available to help design engineers to choose the most suitable materials. At the most basic level, design engineers could use tables of material properties in data books. However, data sheets are incomplete and once published, they are difficult to update. How information about engineering materials, can be divided into two main categories. Data is defined as the results of measurements, whereas knowledge represents the connections between items of data, the source of this knowledge, which contributes to an understanding of the results.

2.6.1 ABS (Acrylonitrile-Butadiene-Styrene)

Because of a unique balance of properties, modern ABS (-(CH2-CH=CHCH2) n-[(CH2-CHh-CNi) n-(CH2-CH) (Yoshitake *et al.*, 2010) co- polymers have been used in an ever increasing scale for the manufacture of many industrial and domestic products.

ABS is a thermoplastic that has an acrylonitrile-styrene matrix with butadiene rubber uniformly distributed in it. This quality makes it unique (John, 1990) and the physical properties of ABS show in Table 2.1 below.

Table 2.1: Physical Properties of ABS

PROPERTY	VALUE	UNITS	REFERENCES
Thermal conductivity	0.177	W/mk	Rodreguez-Matas 1999
Specific heat	2080	J/Kg.K	Rodreguez-Matas 1999
Density	1.050	Kg/m3	Rodreguez-Matas 1999
Melting Point	180	°C	
Viscosity	5100	Pa s	Sun 2005

The material is very tough and resilient, has high impact strength, good chemical resistance and is non-toxic and taint free, also it’s capable of being recycled or reused. These advantageous properties have attracted engineers in many industries. Additional factors make ABS materials are an excellent choice, such as (John, 1990):

1-Lowcost

2-Low coefficient of thermal expansion

3-Ease of moulding

4-Good metal adhesion to the substrate

5-Good appearance after plate

Since ABS copolymer has been developed to have a higher performance value which is often called a polymer alloy (Yoshitake *et al.,* 2010) the high specifications percolate it for models, prototypes, patterns, tools and end-use parts (Fred, 2011).

2.6.2 Copper Powder

Copper and its alloys are so adaptable that they can be used in a multitude of applications in almost every industry. Malleability, machinability and conductivity have made it a long-time favourite metal of manufacturers and engineers (Madison, 2010).

High conductivity coupled with intrinsic strength, formability and corrosion resistance make copper alloys unique as conductors of electricity as show in Table 2.2, making them ideal for connectors and other electrical/ electronic products (Madison, 2010) (Yoshitake *et al.*, 2010).

Table 2.2: Physical Properties of Copper powder (Madison, 2010)

Property	Value	Units
Atomic Number	29	
Atomic Weight	63.54	
Density	8.92	g/cm3
Melting Point	1083	°C
Latent Heat of Fusion	205	J/g
Electrical Conductivity	58.0 - 58.9	MS/m(mΩmm2)
Electrical Resistivity	1.7241 - 1.70	μΩ·cm
Modulus of Elasticity	118,000	MPa

2.7 Injection Moulding

Injection moulding machine shown in Figure 2.4 is singularly the most popular of all the plastics processes. Unlike extrusion or blow moulding, it allows producing a plastic part with three-dimensional characteristics. This permits very intricate designs and high production rates (Muccio, 1994). The injection moulding machine consists of an injection unit and a clamp unit. The injection unit is the part where the plastic pellets are melted and the plastic melt is forced into the mould. The injection unit is very similar to an extruder in design and construction, particularly in that it has an alloy barrel and a flighted screw (Marino, 2005).

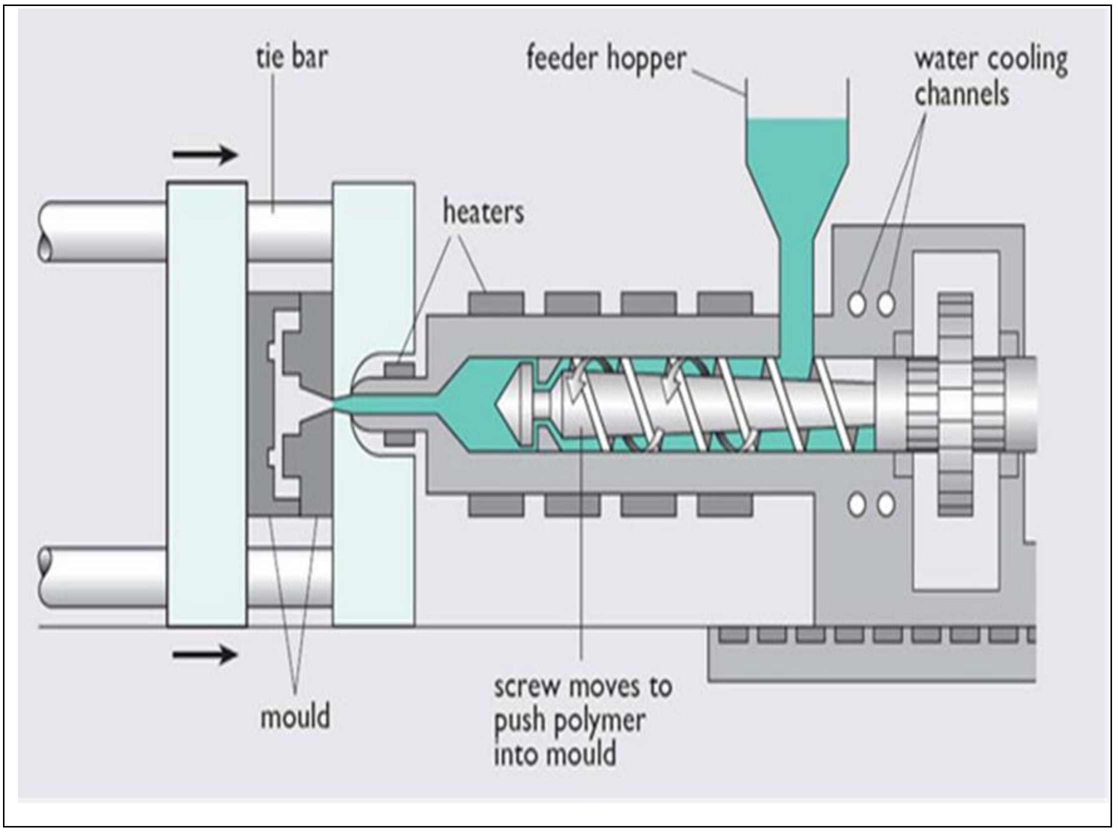

Figure 2.4: Injection moulding machine (Marino, 2005)

2.8 The effective Injection Moulding Process

2.8.1 Barrel Temperature

Barrel temperature influences the orientation, degradation and viscosity of the melt (CAHIT and Yılmazer, 2007).

Depending on the size and design of the injection unit, there may be three to five distinct zones to control. If there are five zones, the middle zone may have a temperature setting 100C higher than that of the feed zone and the temperature of the front zone will be set approximately equal to the desired melt temperature of the plastic being processed. The nozzle's temperature is higher because of keeping the plastic melted (Muccio, 1994).

2.8.2 Injection Pressure

Injection pressure influences the surface quality, orientation and mechanical stressing of the melt (CAHIT and Yılmazer, 2007) and also increases the percolation (Mamunya *et al.,* 2002).

It is also called pack pressure, high pressure, boost pressure and first stage pressure. Basically stated, it is the pressure generated by the screw tip on the plastic melt (the pressure used to pack the mould cavity once it has been filled. There is a hydraulic pressure continuum from the screw through the plastic into the mould. Until this pressure is generated, the only pressure on the plastic melt is associated with its resistance as it fills the mould (Muccio , 1994).

2.8.3 Mould Temperature

Accurate temperature control of the mould cavity walls is important and has a direction influence on the production of quality moulded part (CAHIT and Yılmazer, 2007).

Cavity surface temperatures are the temperatures, which often would be essentially the same as the temperature of the circulating water or other fluid used to control the mould temperature. Higher mould temperatures delay freezing to facilitate filling long, thin sections. They also encourage greater crystallization of the semi crystalline resins, which affects both mechanical properties and shrinkage or dimensions.

2.9 Hot-press Compression Molding

Compression molding is a method of molding in which the molding material, generally preheated, is first placed in an open, heated mold cavity. The mold is closed with a top force or plug member, pressure is applied to force the material into contact with all mold areas, while heat and pressure are maintained until the molding material has cured as shown in Figure 2.5.

Figure: 2.5: Hot press Compression molding machine

(Wabash, ceramic polymer lab in UTHM)

2.10 The Effective Compression Molding Process

The process employs thermosetting resins in a partially cured stage. it's The oldest and simplest method of processing thermoset molding materials(Plenco 2008).

Hot-press temperature, time, pressure, density level, is effective parameters on the mechanical properties of matrix (Gu 2010) and also the electrical conductivity.

2.10.1 Hot-Press Pressure

The press closing and the initial energy transfer from the hot platens to the mat characterization, as seen in Figure 2-6 it shows the temperature rise which can be detected in the core, which indicates the energy has been transferred from the platens (Bolton et al. 1989a and Torrey 2001)(Hood 2004)

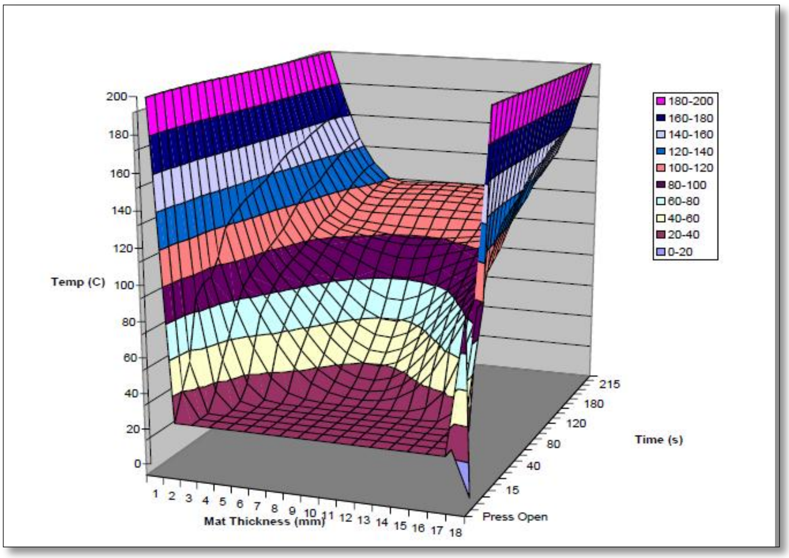

Figure 2.6: the temperature gradient at different times during the press cycle (Hood 2004)

2.10.2 Hot-Press Temperature

Thermal energy is transfer from one body to another of different temperature by way of direct contact. This can occur between solids, fluids at rest or both, from the high thermal energy body to the low thermal energy body from the platens of the hot-press to the surface particles of the mat (Bolton 1989).that plays a more important role in heat transfer as the mat is consolidated further and the void fraction in the mat decreases with increasing density

2.10.3 Hot-Press Time

Conductive heat transfer plays an important role in hot-pressing initially because of the direct contact between the hot plates and the oriented strandboard mats that's give the time sensitive nature of hot-pressing a total reliance on conduction would not be practical due to the slow rate of heat transfer (Hood 2004).

This time requirement to increase the mat temperature is the main restraining factor in the production rate.

2.11 Summery of Literature Review

There are a number of works reported in literature on the different methods of enhancing the mechanical and electrical properties of composite materials. To produce functional material using composites, many technologies presented including mixing a conductive material as filler with the polymer in different percentages to enhance the polymer specification. One of the best fillers can be used is copper. Copper is unique as conductors in addition to the other properties like high strength and low cost. The best way to mix it with the polymer is in powder form. To achieve a conductive composite, we must create a long chain of copper particles to enable the current to flow into the material also some of mechanical properties became more effective dramatically. This can be achieved by achieving percolation threshold based on the filler content and pressure. One of the important questions is how to choose the suitable molding technology fabrication process in which in this case the mold technology is potential to be incorporated.