NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

Polymer Blends – PP/HDPE

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Engineering (Honors) Manufacturing (Process)

By

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November 2005

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JUDUL: POLYMER BLENDS – PP/HDPE

SESI PENGAJIAN : NOVEMBER 2001 - NOVEMBER 2005

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APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Engineering (Honors) Manufacturing (Process). The members of the supervisory committee are as follows:

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ABSTRAK

Fokus utama dalam projek ini ialah untuk mengadunkan polipropilena dengan polietelina berketumpatan tinggi mengikut peratusan berat komposisi adunan dan berlainan suhu pemprosesan yang berlainan. Adunan material ini dilakukan dengan menggunakan acuan suntikan pada suhu 250, 260 dan 270°C. Kemudian adunan ini dilakukan ujian tegangan dan kekerasan bagi menentukan sifat dan ciri-cirinya. Adunan ini diuji untuk sifat-sifat kekakuan, keliatan, kemuluran dan kekerasan. Alat penguji yang digunakan ialah mesin ujian tegangani universal dan mesin kekerasan Brinell. Dengan menganalisa, graf tegasan-keterikan dan nombor Brinell di diperolehi dan sifat-sifat adunan kemudiannya dapat diketahui. Kekuatan tegangan, modulus elastik dan nombor kekerasan Brinell menunjukkan bahawa setiap penurunan kandungan atau peratusan polietilina berketumpatan tinggi yang diadun dengan polipropilena akan menyebabkan kekuatan tegangan dan nombor kekerasan Brinell semakin meningkat dan sifat kemulurannya semakin menurun. Ini mungkin disebabkan oleh penambahan polietilena berketumpatan tinggi ke dalam polipropilena yang akan menyebabkan perubahan sifat mekanikal dan fizikalpada adunan tersebut.

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ABSTRACT

The main focus of this project is to mixing the polypropylene with high density polyethylene according to the blend composition weight percentage in various processing temperatures. The blends were processed by an injection molding at 250, 260 and 270°C processing temperature. Then the blends were tested with tensile test and hardness in which to carry out the properties and characteristic determination. These blends were tested for stiffness, toughness, ductility and hardness. A universal testing machine and Brinell hardness testing machine were used to determine tensile and hardness properties. Stress-strain curves and Brinell number were obtained and tensile properties were determined. The tensile strength, modulus of elasticity and Brinell hardness number increased significantly with reducing the content of high density polyethylene into polypropylene, besides the ductility is increases. This is due to the addition of the high density into polypropylene which the characteristic of the blends.

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DEDICATION

My Parents

Who has always been there for me and always prays of me,

My older brother and younger sister,

My friends

Who has support me.

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ACKNOWLEDGEMENT

Several people should be mentioned for their contributions and assistant to me for complete of Final Year Project title The Experimental Investigation of polymer blends PP/HDPE. I am grateful to Mr. Jeeffrie Bin Abd. Razak as my supervisor who gave a lot of guidance and encourages on project. I am also grateful to other lecturers and my beloved friends who gave a wonderful encouragement. To my parent that gives a lot of support I while doing this project. Lastly, thanks to everybody's that helping whether direct or indirect. Thanks a lot.

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CHAPTER 1
INTRODUCTION

Generally, polymer blend or alloy is a mixture of two or more polymer. The purpose of the blending is to improve the mechanical and physical properties also to reduce the cost of creating a new polymer. Beside that, polymers can be recycled easily by converting it into the form of polymer blends.

Today's, plastic waste has become one of the main issues of environmental concerns. Major of polymeric components of plastic waste are polypropylene and polyethylene. Most of the plastic products are made by polypropylene and polyethylene because of their outstanding properties and characteristic. It almost used in foods packaging because of their behavior in which its resistance to chemical. Beside that, addition of polyethylene into polypropylene can improves the specific properties and characteristic of the virgin polymer. Thus these blends are technologically are important.

1.1 Overview of Project

PP/HDPE blend was tested experimentally and tensile properties evaluation was done in order to obtain the characteristic of each blend compositions. Blending process was done by using injection molding (ARBURG, ALLROUNDER 270/420 C). The parameters of the processing are totally depend on the type of the material used in blending stage.

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After the sample produce, it will test go through to the testing stage by using the universal testing machine (Shimadzu, AG-10KN) to evaluate the tensile strength, yield strength and elongation properties of the samples. Analysis of tensile properties for PP/HDPE blends will be carried out in order to investigate and obtain the optimum values of mechanical properties. Besides that, samples were tested with Brinell hardness tester testing machine (Mitutoyo, Wizhard) to determine the Brinell hardness number.

The blending recipes of the PP/HDPE blends is determine by percent of weight, 90%, 75%, 50%, 25% and 10% HDPE content added into PP. The blending is categorized as PP90, PP75, PP50, PP25 and PP10 in which based on the percent of the weight which added by HDPE. The processing of the PP/HDPE blending will be done at different processing temperature which 250°C, 260°C and 270°C. The processing temperature is depending at the nozzle injection molding temperature.

The sample preparations are determined by blending formulation as shown at **Chapter 3**. The blending formulation is depending to the blends composition by weight and processing temperature. That means it include the parameters that involve in this experiment.

The results of the PP/HDPE blends are shown in stress-strain behaviors graph at **Chapter 4**. From the stress-strain behavior, the samples behavior of the blends can be determined. As a result, the composition and processing temperature were affecting the properties and characteristic of the PP/HDPE blends.

1.2 Objective

The objectives of the project are:

i. To know the properties of PP/HDPE polymer blend.
ii. To study the characteristics of PP/HDPE polymer blend that effect in the processing of the materials.

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1.3 Scope of Study

The scope of this project is to prepare the polymer to be blends and evaluate the properties and characteristic based on tensile properties.

1.4 Problem Statement

Since the miscibility of the polymer to be blend is very hard to determine, PP/HDPE blend should be conducted. Previous research is focuses more on Chemistry and physic of the blend rather than mechanical properties of the blend itself. From this study the correlation between the miscibility and mechanical properties will be further investigate.

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CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

In this project, the material that will be used is polypropylene and high density polyethylene. These materials will be blending by using injection molding method with varying compositions of each material and melting operation temperature. Polyethylene and polypropylene is a major types of polymers which given a special name as polyolefin's because of their similarity in chemical properties. Polyolefin's consist of only carbons and hydrogen without any other atoms in the polymer chain [A. Bent Strong, 2000].

2.2 Introduction of Plastics

Plastics are polymers. The simplest definition of a polymer is something made of many units. Think of a polymer as a chain. Each link of the chain is the "-mer" or basic unit that is usually made of carbon, hydrogen, oxygen and/or silicon. To make the chain, many links or "-mers" are hooked or polymerized together. Polymerization can be demonstrated by linking countless strips of construction paper together to make paper garlands or hooking together hundreds of paper clips to form chains, or by a string of beads [R. J. Crawford. 1998].

Polymers are divided into two distinct groups, thermoplastics and thermosets. The majority of polymers are thermoplastic, meaning that once the polymer is formed it can be heated and reformed over and over again. This property allows for easy processing and facilitates recycling. The other group is thermosets

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which its can not be remelted. Once these polymers are formed, reheating will cause the material to scorch.

Thermoplastic tends to consist of long polymer chains with little breadth and essentially two-dimensional structures. Thermosetting have a structure that is characterized by a three dimensional network of molecules.

2.2.1 Thermoplastics

When the temperature is raised above the glass-transition temperature T_g or melting point T_m, the polymer become easily to formed or molded into desired shapes. The increased temperatures weaken the secondary bonds in which through thermal vibration of the long molecules and the adjacent chains can thus move more easily under the shaping forces. Then cool the polymer, it returns to originals hardness and strength. Therefore these exhibit behaviors are known as thermoplastics [Serope Kalpakjian et.al, 2001].

Thermoplastics are plastics that soften when heated and harden when cooling into products. Its can be repeatedly softened by reheating. Their morphology, molecular structure is crystalline or amorphous. However thermoplastics has a practical limit to the number of heating and cooling cycles before appearance or mechanical properties are drastically affected [Dominick V Rosato et. al.,2003].

Two main types of thermoplastics that perform on injection molding are crystalline and amorphous. Crystalline plastics form crystals when they cool but do not totally crystallize. They form islands of crystals surrounded by amorphous material. The crystalline areas are true solids; thus they tend to be more rigid than amorphous plastics. Amorphous plastics, on the other hand, never form crystals and really never solidify. Amorphous materials are more subject to creep.

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2.2.2 Thermosets

When the long chain molecules in polymer are cross-linked in a three-dimensional arrangement, the structure in effect becomes one giant molecule with strong covalent bonds. [Serope Kalpakjian et.al., 2001]. These polymers are called thermosets. Thermosets are not recyclable because they do not melt when reheated, although they can be granulated and used as filler in other thermosets.

Thermosetting polymers do not have a sharply defined glass transition temperature because the bonds, strength and hardness also are not affected by temperature or rate of deformation. Thermosetting possesses better in mechanical, thermal and chemical properties, electrical resistance and dimensional stability.

Thermosets applications is include kitchen appliances, heat shield for an electric iron, collectors and a wide variety of circuit breaker housing in electrical devices, automotive parts. There are two methods used to produce molded product from thermosets which is compression and transfer molding.

2.2.3 Characteristics of Plastic

Most of the plastics materials may be fabricated in the melt and at the quite low temperatures the energy requirements for processing are low. Since the plastics generally have low densities, cost of transportation and general handling are also relatively low.

The development of such as techniques as an injection molding make it is possible to make highly complex parts in one operation without the need for the assembly work or the generation of more than a notional amount of scrap material.

Coloring is not usually restricted to the surfaces but is throughout the mass so that damage due to scratching and abrasion is less obvious than with coated material.

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An extremely wide range of surfaces finishes is possible which may not only simulate non-plastic materials but in addition procedure novel effects.

Many plastic is superb electrical insulators including in many instances, good insulation characteristic at high frequencies. Besides that, plastics have excellent thermal insulators, being particularly useful in expanded form.

2.2.4 Plastics Processing

2.2.4.1 Plastic processing by Injection Molding

One of the most common methods of converting plastics from the raw material form to an article of use is the process of injection molding. This process is most typically used for thermoplastic materials which may be successively melted, reshaped and cooled. Injection molded components are a feature of almost every functional manufactured article in the modern world, from automotive products through to the food packaging. This versatile process allows us to produce high quality, simple or complex components on a fully automated basis at high speed with materials that have changed the face of manufacturing technology over the last 50 years or so. Thermosets and thermoplastics are the general types of plastics materials that commonly used in injection molding [Charles A. Harder, 1999].

A thermosets plastic is one in which cross-linking is stopped early in the reaction. The reaction either will not continue, or will continue at a very slow rate, under normal conditions. At temperatures above about 93°C (200°F), the material is a viscous fluid that can be forced into a mold. At temperatures of 150°–175°C (300° to 350°F), the cross-linking reaction proceeds at a rapid rate until the reaction is complete and essentially all possible cross-links are established. For thin parts, the reaction is complete in a matter of a few seconds. Thicker wall parts can require several minutes or more. Once the reaction is complete, the material will not again soften to allow molding. This is a one-time process and is irreversible. Thermosets materials include many types of rubber, alkyds, phenolic panhandles and many

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electrical products, diallyl phthalate and mostly electrical parts and melamine commonly used in dinnerware.

A thermoplastic material also softens to a viscous fluid when heated; however, few, if any, cross-links are established during processing. A thermoplastic hardens to a useful condition when cooled. While soft, the material can be forced into a mold to assume the shape of the mold. This cycle can be repeated many times because the finished part can be ground up and reprocessed. There is no significant chemical reaction during the processing of thermoplastics other than some degradation of the physical properties. When properly processed there is little degradation, but if the material requires drying and is not properly dried before processing, or if excessive heat is used during processing, significant degradation will occur. The processing temperatures required for thermoplastics differ according to their melt temperature. Some plastics can be processed at 205°C (400°F) or less. Other high performance thermoplastics can require processing temperatures of 315°C (600°F) or more. Common thermoplastics are seen in everyday life.

According Charles A. Harder, the injection molding of thermoplastics is a form of processing in which highly complex physical processes take place. Each molding compound reacts differently as it is heated to a temperature suitable for molding and as it cools within the mold. The molding compound first has to be melted and then injected at high pressure into a "cold" mold. Since the mold is cooler than the compound, the shaped plastic part solidifies rapidly and can then be removed from the mold. Each step of the injecting and cooling process affects the quality of the subsequent molded part.

The temperature control system of the mold plays a central role in the quality and cost-efficiency of injection-molded parts. It decisively influences quality features such as surface appearance and warpage. Efficient mold-temperature control also helps to save costs, since the cooling time, and hence the cycle time, can be optimized. Cooling that is too aggressive can cause post-molding problems such as excessive size change; these can occur days, weeks, or even months later.

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