MECHANICAL PROPERTIES OF THE ACRYLONITRILE- BUTADIENNE-STYRENE (ABS) – MIXED RECYCLED ABS

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ABSTRACT

Today, plastics are widely used in daily work, because the plastic easy to set up and easy and light to operate. Plastic is also considered a substitute for small items that had been using iron as a material substance. The problem happen when there produce a lot of product to be supplied to the industry. The problems occur when there is a defect in the product or the product does not meet the requirement of customers. The product were rejected and left behind as a waste. The product still can reuse and can be recycled. The objective for this project is to study the mechanical properties of the recycled ABS – mixed- recycled ABS. The ABS was crushed into pallet form to get the recycled material. The recycled material was combined with virgin material. Five samples were needed to make this project. This project was followed an ASTM D638 as a standard .Tests included the tensile stress to determine the strength of the product. After performing the tensile test, the results show that there is resistance on the product that content of 70% Abs and 30% recycled is considered as a percentage of the best in term of tensile strength.

ABSTRAK

Hari ini, plastik digunakan secara meluas dalam kerja seharian, kerana plastik yang mudah untuk menubuhkan dan mudah dan ringan untuk beroperasi. Plastik juga dianggap sebagai pengganti untuk barang-barang kecil yang telah menggunakan besi sebagai bahan penting. Masalah ini berlaku apabila terdapat menghasilkan banyak produk yang akan dibekalkan kepada industri. Masalah yang berlaku apabila terdapat kecacatan dalam produk atau produk tidak memenuhi keperluan pelanggan. Produk yang telah ditolak dan ditinggalkan sebagai sisa. Produk masih boleh menggunakan semula dan boleh dikitar semula. Objektif bagi projek ini adalah untuk mengkaji sifat-sifat mekanik dikitar semula ABS - ABS bercampur-dikitar semula. ABS telah dihancurkan ke dalam bentuk palet untuk mendapatkan bahan kitar semula. Bahan kitar semula telah digabungkan dengan bahan dara. Lima sampel yang diperlukan untuk membuat projek ini. Projek ini diikuti ASTM D638 sebagai standard. Ujian termasuk tegasan tegangan untuk menentukan kekuatan produk. Selepas melakukan ujian tegangan, keputusan menunjukkan bahawa terdapat tentangan mengenai produk yang kandungan ABS 70% dan 30% dikitar semula dianggap sebagai peratusan terbaik kekuatan tegangannya.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Nowadays, many parts in the world use plastic. This is because the plastic is light weight and easy to fabricate. Plastic is a type of polymer that has large molecules consist of long repeating chains of smaller molecular known as monomers.

One type of plastic that commonly used in industries is Acrylonitrile- Butadiene- Styrene (ABS).ABS is a common thermoplastic. Its melting point is approximately 105 ºc (221 ºF). The maximum temperature for ABS is 80 ºc and for the minimum temperature -20ºC [1].It is a copolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15 to 35% acrylonitrile, 5 to 30% butadiene and 40 to 60% styrene. The result is a long chain of polybutadiene criss-crossed with shorter chains of poly (styrene-co-acrylonitrile). The nitrile groups from neighboring chains, being polar, attract each other and bind the chains together, making ABS stronger than pure polystyrene. The styrene gives the plastic a shiny, impervious surface. The butadiene, a rubbery substance, provides resilience even at low temperatures. For the majority of applications, ABS can be used between −25 and 60 °C (-13 and 140 °F) as its mechanical properties vary with temperature. The properties are created by rubber toughening, where fine particles of elastomeric are distributed throughout the rigid matrix.

ABS's light weight and ability to be injection molded and extruded make it useful in manufacturing products such as drain-waste-vent (DWV)pipe systems, musical instruments (recorders and plastic clarinets), golf club heads (due to its good shock absorbance), automotive trim components, automotive bumper bars, enclosures for electrical and electronic assemblies, protective headgear, whitewater canoes, buffer edging for furniture and joinery panels, luggage and protective carrying cases, small kitchen appliances, and toys, including Lego bricks [2].

The ABS plastic also can be recycled. It is because the recovered polymers are compatible with virgin materials and can be used for such products as computers, office equipment, auto parts, telephones, and home appliances. The technology has proven successful in recovering the selected plastic from obsolete appliances, auto shredder residue, disassembled car parts, industrial scrap plastics, and consumer electronics.

1.2 PROBLEM STATEMENT

Many people know that a lot of parts nowadays use plastic because the plastic is easy to fabricate and light weight. We have plastic in household equipment, vehicle and more.

But the problem was happened when the produced part not following the specification requirement and being left as a waste. However, a concern arises when the produced parts were rejected and left behind as a waste.

Therefore, this project was initiated with the main purpose to reduce the waste by recycling it. Consequently, reduce waste and also increase profit.

In this project, the recycle ABS was blended with the virgin ABS. Tensile testing was used in order to determine the mechanical properties of the recycled – mixed virgin ABS.

1.3 OBJECTIVE OF THE PROJECT

1. The main objectives of the project are to study the mechanical properties of the Acrylonitrile- Butadienne- Styrene (ABS) – mixed with recycled ABS
2. To determine the optimum percentage of recycled ABS to be blended with the virgin ABS for part production.

1.4 SCOPE OF THE PROJECT

The projects were used virgin ABS plastic material mixed with recycled ABS. This is because the ABS has a good balance of properties, toughness, strength and high quality surface. The recycled materials were produced by rejected part. The rejected part was taken from company. The material was injected into injection moulding and will be tested using tensile test. The result will be studied is tensile strength. The tested will follow the ASTM D638 standards.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The large amounts of plastics produced with the recent economic growth are producing high quantities of waste. This rapid development has coincided with the equal dramatic rise of many environmental problems and in consequence, industry has to be concerned with waste disposal strategies. For example, study on waste from electrical and electronic equipment has shown that it reached 6 million tons, and it is expected to double over the next decade [3]. Recycling of polymeric materials is of special interest due to the high chemical resistance of these materials, which leads to a long degradation time before their disappearance [4]. Nowadays there are four main approaches to polymer recycling [5], primary recycling, secondary recycling [6], tertiary or chemical recycling [7] and quaternary recycling or energy recovery.

Several studies have describes the importance of applying environmental strategies in product manufacturing [8] , in which one of the major approaches used to minimize the global environmental impact is the knowledge of the product post-consumption phases and what it represents for the economy of natural resources. With regard to that aspect, we can point out that knowledge of the real mechanical properties of recycled materials can be used to reduce uncertainty in the use of these materials to develop new products. In this sense, it could also encourage their greater applicability and reduce use of virgin materials during the production process.

Therefore, the development of a design cycle involving the reduction, reuse and recycling of materials (3R's) becomes essential. In this study, recycling is to seize the disposed materials in the primary production process. This will be the base of this research. Efficiency in the recycling processes is regarded as a priority in many industrialized countries, because of the increased quantity of discarded materials [9]. In addition to the environmental aspect, the economics of recycling has become strategically important, not only for polymeric materials, but also for other classes of materials [10].

According to the Domingo (2008) [11] defined three main points to evaluate the quality of recycled materials are the composition, the state of degradation and the level of contaminants, e.g., additives, fillers and others. He also reported that some factors hinder the separation and reuse of materials during the recycling process, including difficult of materials identification, few researches in the area of recycling processes to assess the composition, structure and properties of recycled materials presence of aggressive components in their composition poor development of the characterization techniques aim at evaluating their recyclability lack of standardized recycling methods, etc.

According to Carvalho (2009) [12], he said that the companies consider recycling as an opportunity to maximize profits and cooperate with society. However, there is also a strong constraint about the use of recycled material for the manufacture of technical parts of higher added value. This is due to the lack of technical data and simulations of the conditions on how the product is being used. Therefore, this 3R's design practice should be a landmark for the development of new products, in order to reduce the environmental impact during all phases of production and disposal. The development of tools and techniques is essential for recycling as they can provide a better control of the recycled material properties and thus encourage their use by the manufacturing industries.

According to Callister (2004) [13], he said that any material used in some final product, which has not been discarded, will pass throughout its life by various stages of use called life cycle of materials. Figure 2.1 shows the structure of this cycle and the relations of extraction, processing, use and disposal. Figure 2.1 shows that the recycling stage comes after the product application and not in previous phases, for example, in the design and manufacture of the product. It reveals that it is impossible to foresee the chance for recycling and the effect it could have on the final physical properties of the materials, independently from the product to be designed.

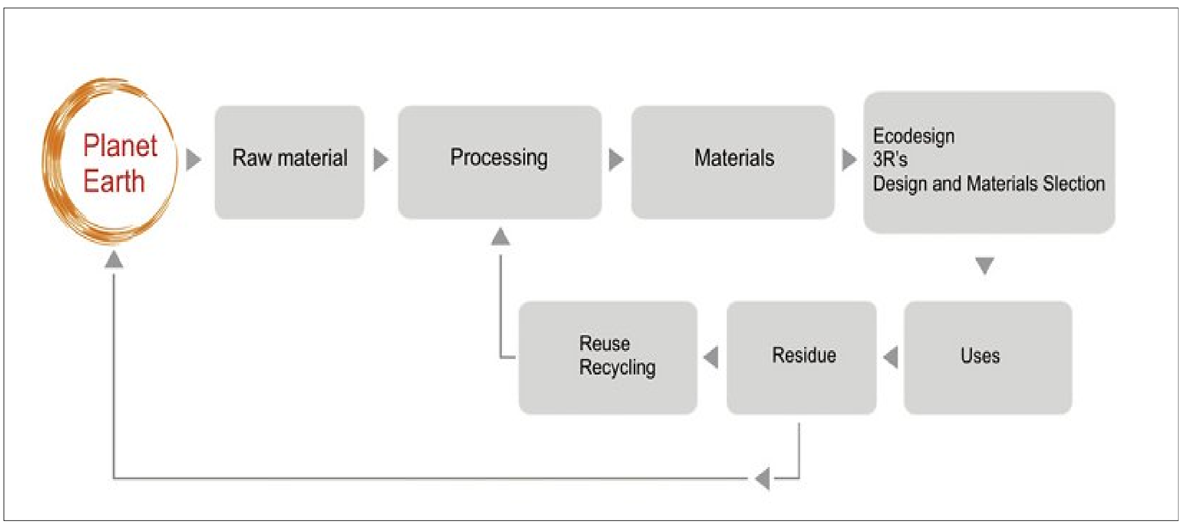

Figure 2.1: The life of material [13].

2.2 ABS THERMOPLASTIC

According to Mark HF [14], he describe that one type of plastic that can commonly use in plastic industries is Acrylonitrile-Butadiene-Styrene (ABS). ABS is an engineering thermoplastic polymer which consists of an amorphous-continuous phase and a rubbery-dispersed phase. Poly (styrene-coacrylonitrile) (SAN) copolymer forms the continuous phase. The second phase consists of dispersed butadiene, or butadiene copolymer; these particles have a layer of SAN grafted onto their surface which makes the two phases compatible. The properties of ABS are given by the composition, thermoplastic and rubbery phase characteristics, and interactions between them. The content, molecular weight and distribution of SAN control properties such as process ability, heat resistance, surface hardness and chemical resistance. Meanwhile, butadiene content contributes mainly to toughness. The main applications of ABS are the automotive industry, the white line application and electric and electronic casing.

The ABS was recycled by dissolution up to four cycles and then injection moulded. The mechanical properties were measured after each cycle. The characteristic that has been testing is tensile test. The method were used for testing part is followed the ASTM D638 standard. ABS was dried first at 80 ^{0}c for 3 hour in an oven before processing in order to avoid moisture degradation reactions. Figure 2.2 show the stage of dissolution based recycling ABS.

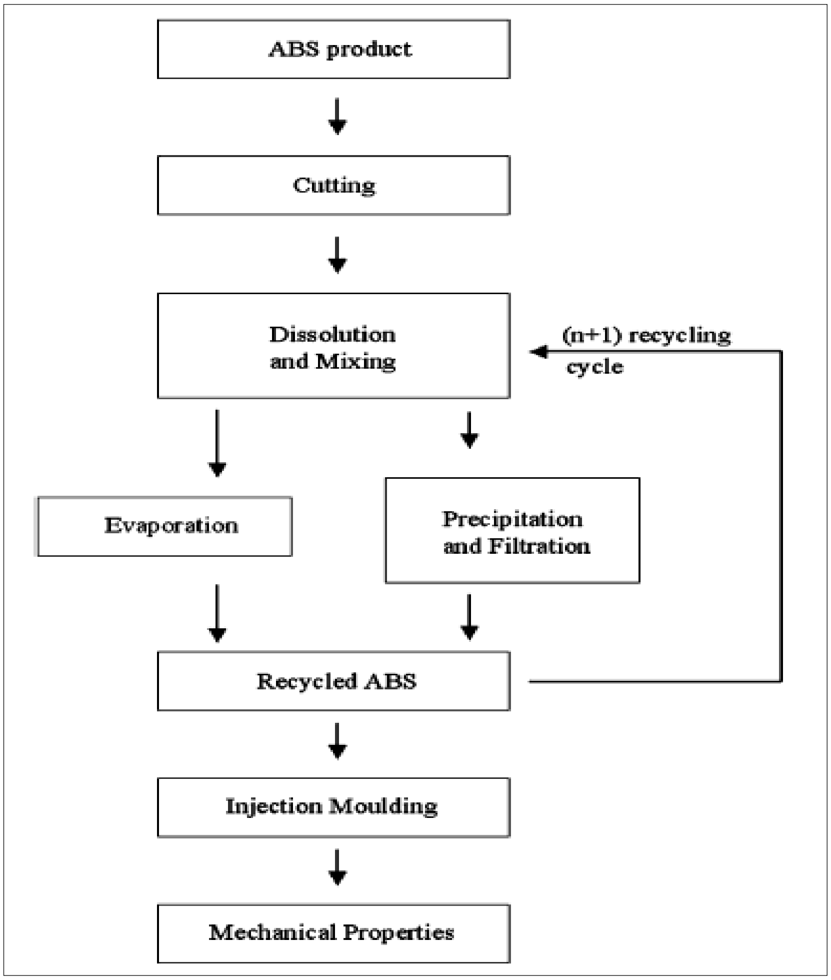

Figure 2.2: Dissolution based recycling ABS [14].

Figure 2.3 shows the Young's modulus of recycled ABS against the number of recycling cycles. The figure showed that the modulus remained unchanged at a mean value of 2.3 GPa, indicating that the degradation of ABS did not have effect on this low-strain mechanical property.

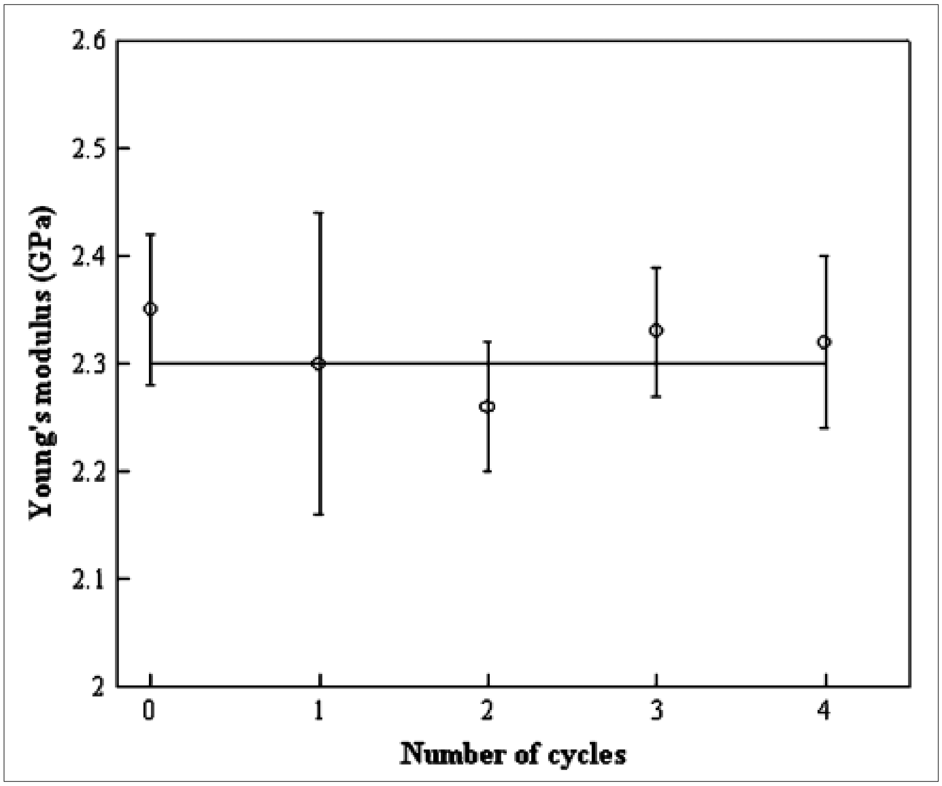

Figure 2.3: Young's modulus of recycled ABS as a function of number of cycles [14].

The yield stress values of recycled ABS against the number of recycling cycles are shown in figure 2.4. The yield stress slightly decreased with only one cycle from approximately 38 MPa to 34MPa, and then it was kept unchanged up to the fourth cycle. The slight decrease in the yield stress with only one cycle probably was due to the degradation of both phases of ABS, as it was seen by FTIR, TGA and MFI measurements. This decrease in yield stress could be related to the molecular weight reduction, and consequently, to the entanglement density reduction.

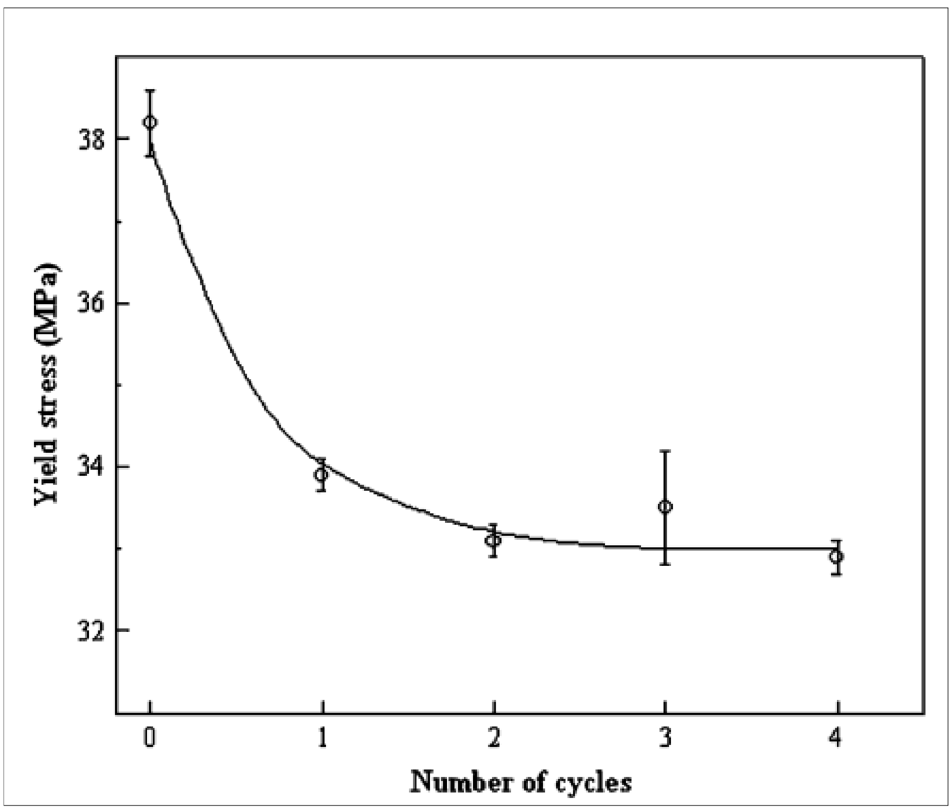

Figure 2.4: Yield stress of recycled ABS as a function number of cycles [14].

Figure 2.5 shows the Charpy impact strength evolution with the number of recycling cycles. There was relatively a large reduction with the first cycle from approximately 14 kJ/m^2 up to10 kJ/m^2, and for the following recycling cycles the impact strength values decreased slowly up to approximately 8 kJ/m^2. This impact property degradation was associated to the lower molecular weight and entanglement density of the SAN matrix, and to the degraded butadiene particles.

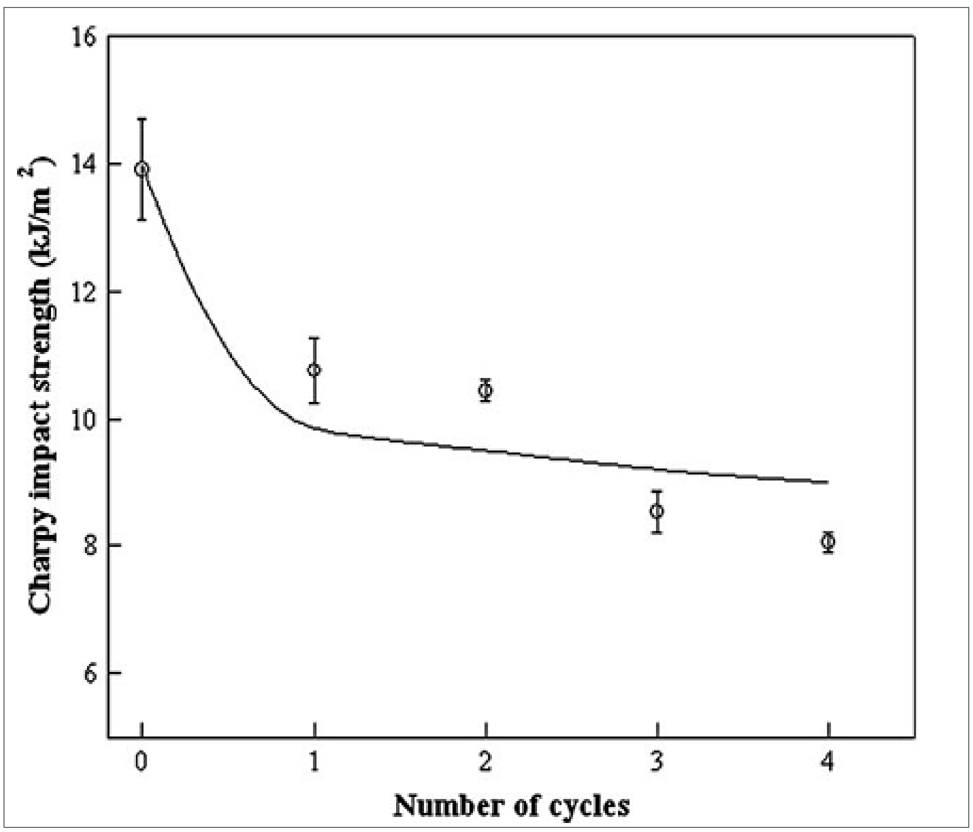

Figure 2.5: Charpy impact test data of recycled ABS as a function of number of cycles [14].

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

For the methodology process, they are three stages have been involved in this project. They are material preparation, injection moulding process and part testing.

In respect to the material selection, the ABS had been chosen in this study because of its good mechanical properties such as good balance of properties, toughness and strength. Furthermore it is easy to moulded. Figure 3.1 shows an overview on the overall steps involved in the research.

Below is the list of ABS properties:

- Maximum temperature : 176 ºF (80ºC)
- Minimum temperature : -4 ºF (-20ºC)
- Melting point : 221 ºF (105ºC)
- Tensile strength : 4300 psi

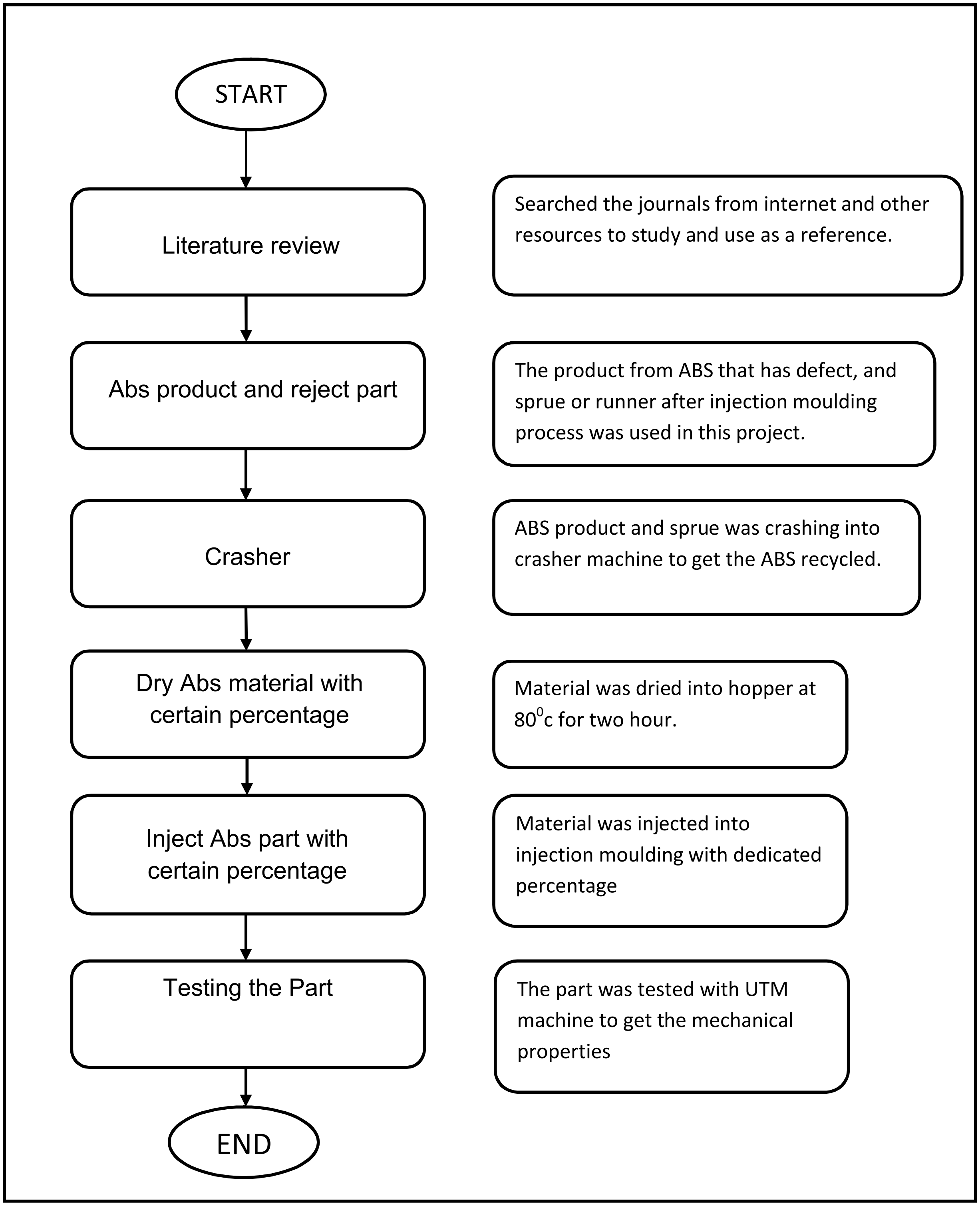

Figure 3.1: Flowcharts for methodology

3.2 EXPERIMENTAL DESIGN

There are many types of method in planning, conducting experiment and analyzing data from the experiment. Some of methods require the experiment to be run repetitively in order to determine the average results from the repetitive experiments. The average value will represent the overall result of the experiment. Therefore, these methods use five samples for one experiment to get the average for the result outcome. The method for testing part is followed the ASTM D638 standard. The past was tested at UTM (Universal Testing Machine). Below are the list of five experiments that were tested.

- **i.** Experiment 1 : Content 0% ABS
- **ii.** Experiment 2: Content 10% Recycled / 90% ABS
- **iii.** Experiment 3: Content 30% Recycled / 70% ABS
- **iv.** Experiment 4: Content 50% Recycled / 50% ABS
- **v.** Experiment 5: Content 70% Recycled / 30% ABS

3.3 MATERIAL PREPARATION

The first step for this experiment is material preparation. To get the recycled material, the ABS product has been chosen for this experiment. The product that have defect and reject were used again to get the recycled material for ABS. Runner and sprue that produced after injection moulding process also were used in this experiment. Figure 3.2 shows the ABS product and sprue.

Figure 3.2: Abs products with runner and sprue