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THE EFFECT OF PRESS MEDIA FROM CERAMIC AND METAL MATERIALS ON THE TENSILE STRENGTH OF RECYCLED POLYPROPYLENE FOR THE DEVELOPMENT OF COMPOSITE MATRIX MATERIALS

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Abstract

Composites generally consist of fiber (filler) and resin (matrix). Resin from recycled polypropylene (plastic) polymer was chosen because it has superior properties compared to other types. The manufacturing process with a hot air melting temperature (heat gun) of 300oC was chosen with two variations of press media, namely metal and ceramic, to compare the mechanical properties of tensile strength. Specimens were shaped according to the ASTM D638 standard. The results showed that the recycled polypropylene with ceramic press media had an average tensile stress of 15.05 MPa, which was higher than that of compressed metal media of 13.06 MPa.

Keywords: *Composites, Recycled Polypropylene, Tensile Stress*

Introduction

Polypropylene (PP) waste is a type of polymer or plastic that is easily obtained, has a resin identification code: 5 (five), and includes a type of thermoplastic polymer that softens when heated and hardens when cooled – a process that is reversible and repeatable.

Suyadi (2010) revealed that the decrease in the tensile strength of recycled PP was the lowest compared to other polymer types. The tensile test for recycled plastic resulted in a decrease in tensile stress of 63% for PET, a decrease in HDPE of 35%, and a decrease in PP of 12% against a tensile stress for non-recycled plastic with a melting process with injection pressure of 5-7 bar with a temperature of 130-200^{o}C.

Another study showed the comparison of the decrease in tensile strength of pure PP material with commercial recycled PP was 22.1% through the Injection Molding Machine (IMM) process (Jun, B.J.H. and Juwono, A.L., 2010).

Resin with thermoplastic material for the development of composite materials is also applied to aircraft components. The Airbus A380 and Airbus A350WBX use glass fiber reinforced plastic, quartz fiber reinforced plastic and are dominated by carbon fiber reinforced plastic (Mrazova, M. 2013).

Carbon fiber reinforced plastic/polymer is a type of composite with carbon fiber as reinforcement and plastic or polymer as the matrix. In this context, the researcher intends to develop the use of recycled polymer types of polypropylene to decompose plastic waste and engineer the manufacturing process in order to obtain resin characteristics with good tensile mechanical properties and are close to the application of aircraft components.

The formulation of the problem raised in this study is how the influence of the use of press media from ceramic and metal materials in the melting process of polypropylene waste recycling on its tensile strength.

Researchers hope to make theoretical and practical contributions in terms of enriching knowledge of mechanical properties of recycled polypropylene engineering materials and their use as composite matrices. As well as being a trigger for making process improvements in the manufacturing process.

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Literature Review and Hypothesis Development

Naturally occurring polymers, generally of plant and animal origin, these materials include wood, rubber, cotton, wool, leather and silk. Other natural polymers including proteins, enzymes, starch, and cellulose are important parts of biological and physiological processes in plants and animals. The development of modern scientific research is capable of engineering the determination of the molecular structure of natural polymers and developing various polymers, which are synthesized from small organic molecules. Most plastics, rubbers, and fibers are synthetic polymers. Synthetic polymers can be produced cheaply, and their properties can be treated to a level superior to those of natural polymers. In many applications, metal and wood can be replaced by plastics, because they have better properties and can be produced at a lower cost.

The response of polymers to mechanical forces at high temperatures is related to their dominant molecular structure. In fact, one classification scheme for these materials corresponds to their characteristics due to temperature rise. Thermoplast (or thermoplastic polymers) and thermoset (or thermoset polymers) are two subdivisions of polymers. Thermoplastics soften when heated (and eventually melt) and harden when cooled – a reversible and repeatable process.

Thermoplastics are high molecular weight polymers that are linear and branched stable. Its ease of processing and its mechanical and thermomechanical properties depend on its molecular weight, molecular flexibility, crystallinity and polarity. Its stability, solubility and permeability depend on its chemical composition and crystallinity. Examples are polyethylene, polypropylene, polystyrene, polyvinyl chloride, polytetrafluoroethylene, polymethyl methacrylate, polyoxymethylene, cellu lost acetate, polysulphone and so on. Typical properties of thermoplastic resins made from polypropylene have a modulus of elasticity of 1.4 GPa, tensile strength of 34 MPa, density of 0.9 g/cm^3 (Rana, S. and Fangueiro, R., 2016).

Table 1. Properties of polypropylene

Properties	Value/Description
Density	0.905 g/cm^3
Modulus of elasticity	1.14–1.55 GPa
Poisson's Ratio	0.40
Yield strength	31.0–37.2 MPa
Tensile strength	31.0–41.4 MPa
Elongation at break	100-600 %
Glass transition temperature	-18 ºC
Melting temperature	175 ºC
Major application characteristic	Resistant to heat distortion; excellent electrical properties and fatigue strength; chemically inert; relatively inexpensive; poor resistance to UV light

Sumber : Callister, Jr. W.D. (2001)

The use of a matrix of polypropylene type polymer material requires a melting process, with variations in melting temperature and press media is expected to be able to produce variations in mechanical properties that can be analyzed and compared with other studies.

The initial hypothesis that the researcher wants to put forward is that there is an effect of using press media from ceramic and metal materials in the melting process of polypropylene waste recycling on its tensile strength.

Factors That Influence the Mechanical Properties of Semicrystalline Polymers

1. The mechanical behavior of a polymer will be influenced by both in-service and

structural/processing factors.

2. Increasing the temperature and/or diminishing the strain rate leads to reductions in tensile modulus and tensile strength and an enhancement of ductility.
3. Other factors affect the mechanical properties:
    - Molecular weight—Tensile modulus is relatively insensitive to molecular weight. However, tensile strength increases with increasing.
    - Degree of crystallinity—Both tensile modulus and strength increase with increasing percent crystallinity.
    - Predeformation by drawing—Stiffness and strength are enhanced by permanently deforming the polymer in tension.
    - Heat-treating—Heat-treating undrawn and semicrystalline polymers leads to increases in stiffness and strength and a decrease in ductility.

Forming Techniques for Plastics

Fabrication of plastic polymers is usually accomplished by shaping the material in molten form at an elevated temperature, using at least one of several different molding techniques—compression, transfer, injection, and blow. Extrusion and casting are also possible.

Research Methods

Research Tools and Materials

PP plastic waste, Heat Gun, Press Media: Ceramic (A1) and Metal Aluminum Alloy Series 2 (A2), Hand Saws, Benchvise (Ragum), Sandpaper and caliper are used to form physical and mechanical test specimens according to ASTM D638 standard , Tensile Testing Machine.

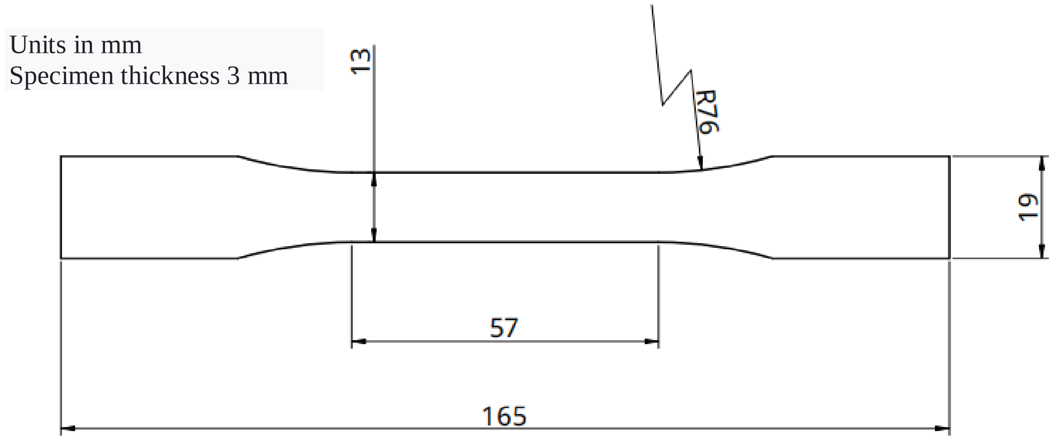

Figure 1. Dimensions of the tensile test specimen ASTM D638

Testing Mechanism

Polypropylene specimens, prepared by heating and melting using a heat gun (heat gun) PP polymer waste at a temperature of 300^{o}C then pressed with two types of ceramic and metal media variations, after that they were cut according to ASTM standards and then a tensile test was carried out.

Data Analysis

The tensile test data were then observed, calculated, analyzed and compared between the two defined variables and compared with the results of other studies. It is hoped that the results of the analysis support the hypothesis and answer the research objectives. However, if it does not support the hypothesis, then the acquisition of this data is then used as a recommendation for further research in terms of materials and manufacturing processes or other mechanical tests are carried out so as to obtain even better mechanical characteristics.

Results and Discussion

Table 2 shows the tensile test results in the form of tensile stress, tensile strain and Young's modulus of recycled polypropylene with ceramic (A1) and metal (A2) press media at a melting temperature of 300ºC. The highest tensile stress was obtained from specimens with ceramic press media of 15.05 MPa, so it can be stated that the tensile strength of the material was better than specimens with metal press media of 13.06 MPa.

Table 2. Comparative Data on Average Stress and Tensile Strain of Recycled Polypropylene with Different Press Media and Comparison with Other Research

Spesimen	Average Tensile Stress (MPa)	Average Tensile Strain (%)	Modulus Young (MPa)
A1	15,05	17,25	0,87
A2	13,06	14	0,93
B	12,23	16,46	0,74
C	25	10	2,5

Description : A1 (press media using ceramic); A2 (press media using metal); B (research by Suyadi (2010)) and C (research by Jun, B.J.H. and Juwono, A.L. (2010))

Comparison of tensile strain shows the same thing, where the use of ceramic compression media produces 17.25% greater strain than specimens with 14% metal compression media. Tensile strain expresses the ability of a material to undergo long deformation due to tensile stress. The higher the tensile strain value, the more ductile the material will be. So it can be stated that recycled polypropylene pressed using ceramics is more ductile than using metal.

Young's modulus is a measure of the stiffness of a material, so the greater the Young's modulus of a material, the more inelastic the object is, so that the object is difficult to change. Young's modulus of A1 specimen is lower than A2, it can be stated that recycled polypropylene specimens with ceramic press media are more elastic than metal press media and their ability to undergo changes is better.

Based on table 2, if the research that has been carried out for specimens A1 and A2 is also compared with other studies, specimen B polypropylene melted with temperature parameters 130-200ºC with injection pressure of 5-7 bar and specimen C molded using the Injection Molding Machine (IMM), shows that specimen C has the highest tensile strength of the material, with a tensile stress of 25 MPa. While the lowest tensile strength is specimen B with a tensile stress of 12.23 MPa. While specimens A1 and A2 the tensile stress value is in the middle.

In the results of the tensile strain comparison, specimen A1 was much larger than the other specimens at 17.25% and the lowest was specimen C, which was only 10%. This shows that the A1 specimen has a better or more ductile deformation ability than the other specimens.

However, if you look at the results of the comparison of Young's modulus, specimen B has the lowest modulus value of 0.74 MPa and the highest modulus value is in specimen C. This indicates that specimen B has good elastic properties and deformation capability than the other specimens. Meanwhile, specimens A1 and A2 have modulus values in the middle.

Conclusion

Based on the research that has been done, it can be concluded that the recycled poplypropylene specimen with a melting temperature parameter of 300oC using ceramic press and printing media has superior tensile mechanical properties than metal. When compared with other studies, the tensile mechanical properties are in the middle. For further research, it is still possible to develop manufacturing processes with various temperature parameters and printing processes, so as to obtain other characteristics that may be better than existing research. It is also possible to test other mechanical properties so as to get a complete picture of the engineering characteristics of the material.

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