

# Mechanical Properties of Injection Molded Recycled High Density Polyethylene (rHDPE) Blends with pellets Low Density Polyethylene (pLDPE)

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## Abstract

*Recycling polymer has become a mandatory for sustainable development goals, life beyond water and land. Therefore, recycled polymer blends containing rHDPE/pLDPE (high density polyethylene and low density polyethylene) with composition 100/0, 80/20, 70/30, 50/50, 40/60, 30/70, and 0/100 have been prepared by melt compounding method using injection molding at 200 °C. Tensile testing shows that there is strong combination between rHDPE/rLDPE blends. Elongation at break differ from 122-230% and density test give results around 1.1 g/cm<sup>3</sup>. Injection molding process with the proper temperature setting and mixing of crushed plastic also affects the ductility, flexibility, brittleness and hardness of the specimen.*

**Keywords :** Injection molding, crusher machine, HDPE and LDPE plastic waste

## INTRODUCTION

In the era of globalization, the use of plastic is increasing and varies along with the needs of people's daily lives and if the plastic waste is left alone without any solution, its use will have a negative impact on the use of plastic continuously which will lead to new problems such as plastic waste which hard To be decomposed. Another reason why plastic waste has a bad impact on the environment is because of the nature of plastic which is difficult to be decomposed in the soil even though it has been buried for years.

The problem of plastic waste can be resolved by recycling process. One of the popular method is to crush then heat the plastic to become a new part with a proper use. Injection molding machine is the machine used for the manufacture of specimens in this study specimens using the ASTM638 type IV standard. While the crusher machine is a machine that is used to chop plastic waste bottle caps, bottles, and others

There are many ways to determine the strength or toughness, fracture structure of the material and the physical properties of a material, one of which is the tensile strength test method . polymer macro structure and material density testing. Plastic testing like this has been carried out and researched by many people before, including testing for high-density polyethylene (HDPE) and Low-density polyethylene (LDPE) plastics .

Luy Inggaweni (2015) conducted a study with the results of the characteristics of the best biodegradable plastic mixture of HDPE and cassava peel starch in a ratio of 7 : 3 with tensile strength, elongation, and Young's modulus values of 19.44 N/mm<sup>2</sup>, 18.14 %, 18.33 N/mm<sup>2</sup> respectively. The results showed that biodegradable plastic with a ratio of 7:3 has characteristics that are in accordance with commercial plastics and can be degraded by the environment, Ani Purwati (2010) with the results of chitosan plastic with a concentration of 1% (chitosan weight / mL acetic acid) with a drying temperature of 800 °C The plastic properties without the addition of sorbitol were stable during storage with a tensile strength value of 3.5 to 3.94 Mpa with an elongation value of 1.5 to 1.6%. Meanwhile, Sumaryono (2012) found that polypropylene material is more ductile than polystyrene and the average maximum stress for polypropylene is 19.53 (kg/mm<sup>2</sup>) while polystyrene is 1.59 (kg/mm<sup>2</sup>).

Zahrotul Marffu'ah (2015) conducted a study on the effect of variations in the composition of low density polyethylene (LDPE) and banana hump starch for the manufacture of biodegradable plastics. 99:1 ; 98:2 ; 97:3 ; and 96:4 (% v/v). The samples formed were characterized using FTIR, tensile, swelling and bacteria tests . FTIR test results indicate the presence of chemical interaction in the form of a shift in the wave with the functional groups CH 2 Another group formed is hydroxide (OH), carbonyl (CO) and ester (COO) resulted readily degradable plastic. In the tensile strength test, the addition of LDPE-g-MA, starch and glycerol generally decreased the tensile strength and elongation values of biodegradable plastics which were influenced by carbon chains. The tensile strength of the plastic produced meets the national standard for biodegradable plastic. The biggest swelling value in the 97:3 sample is 77.65%. The biodegradation test with EM4 showed that the variation in addition of starch and LDPE-g-MA increased the average number of colonies, this was due to the C=O and COC plastic constituent compounds were organic compounds.

Winarno (2018) conducted a research on the Tensile Strength Analysis of Recycled Plastic Samples of high-density polyethylene (HDPE) and Low-density polyethylene (LDPE) with a specimen printing process, namely the casting system (melting a mixture of HDPE and LDPE plastic by cooking and then pouring it over) on the mold and then pressed). The tensile test resulted in an average maximum stress for HDPE material of 3.68 (N/mm<sup>2</sup>), while for LDPE material of 4.34 (N/mm<sup>2</sup>), using the ASTM D638 type II standard. In this study, the researcher suggested that the pressing tool or process should be improved or updated again.

Seeing from previous research which is still not good in the process of making specimens and testing, for this reason, this study will conduct research on the effect of variations in the percentage of plastic waste material blends High-density polyethylene (HDPE) and low-density polyethylene (LDPE) with injection pressure on strength.

tensile, polymer fracture and density test by making specimens using injection molding machines. In this study, a tensile test with the ASTM D638 type IV standard will be carried out with the addition of the effect of macro-polymer photos and the density test of the tensile test results will be compared in previous studies, namely the previous tensile test resulted in an average maximum stress for HDPE material of 3.68 (N/mm<sup>2</sup>), while for LDPE material it is 4.34 (N/mm<sup>2</sup>), using the ASTM D638 type II standard.

The purpose of this study is to gain knowledge about the mixture of rHDPE and rLDPE plastic waste materials on their mechanical properties from injection process.

## MATERIALS AND METHODS

This research was conducted at the Materials Laboratory of Wahid Hasyim University, Semarang. The investigated materials are recycled of bottle caps HDPE and recycled of infusion bottles LDPE, shown in Fig.1, which were crushed using crusher machine and printed using injection molding at temperature of 200 °C and the pressure rate was 0.87 MPa.



**Figure 1:** The raw materials: (a) HDPE (bottle cap) and (b) LDPE (infusion bottle)



**Figure 2:** (a) Chopped/recycled HDPE (bottle cap) and (b) Pellets of LDPE (infusion bottle)

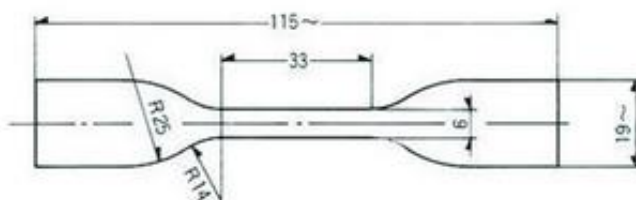
The different compositional ratios were, 100/0, 80/20, 70/30, 50/50, 40/60, 30/70, and 0/100 by weight of recycled high density rHDPE and virgin pellet of LDPE plastics.

Detail of sample preparation were presented in Table 1, while the tensile standard and research flow chart presented in Figure 3 and Figure 4 respectively.

**Table 1.** Composition of plastic blend

No.	Mixture of plastic types (% by weight)		Number of specimens
	HDPE (%)	LDPE (%)	
1	8 gram (100%)	0%	3
2	6,35 gram (80%)	1,58 gram (20%)	3
3	5,55 gram (70%)	2,38 gram (30%)	3
4	3,96 gram (50%)	3,96 gram (50%)	3
5	3,17 gram (40%)	4,76 gram (60%)	3
6	2,38 gram (30%)	5,55 gram (70%)	3
7	0%	8 gram (100%)	3

Tensile testing was carried out according to the ASTM 638 type IV standard, by using the Gotech instruments material testing machine connected to a remote computer for data acquisition and analysis. The load was measured by a load cell 100 kN capacity, while the displacement was measured using and internal extensometer. The time of testing was 3 minute. Tensile specimens of a dog-bone shape were produced with a gauge length of 25 mm, width of 6 mm and thickness of 5 mm. Three samples were tested under the same condition for each blend.

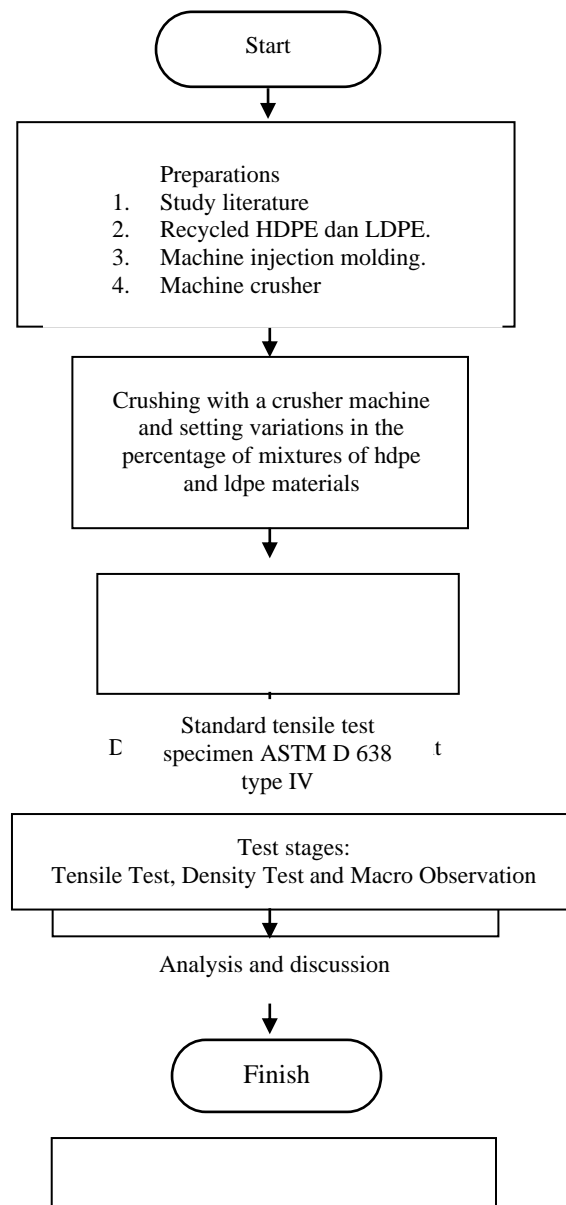


**Figure 3:** Dimensions of ASTM 638 type IV tensile standard.

The tensile specimen that mould using injection machine presented in Figure 5.



**Figure 4:** The results of the ASTM 638 type IV specimen injection molding machine



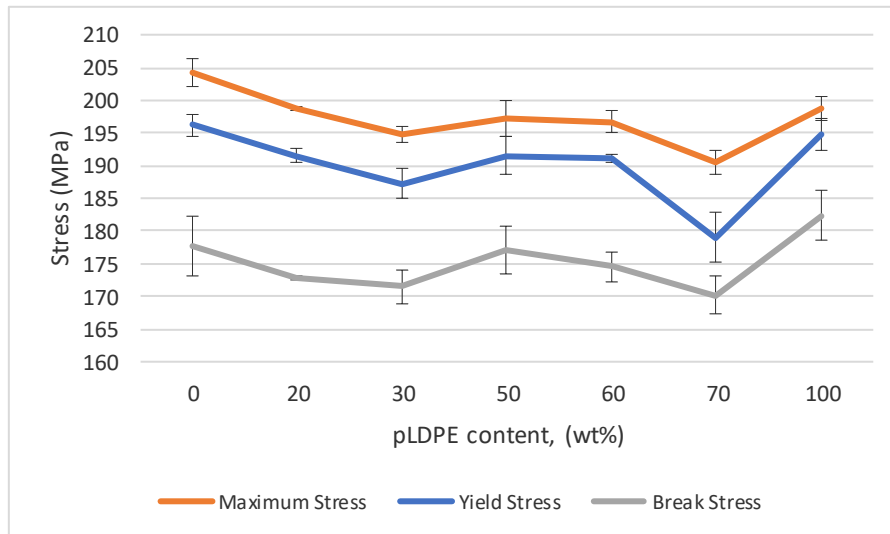
**Figure 5:** Research flow chart

## RESULTS AND DISCUSSION

The results of the injection molding process for combination polymer of HDPE and LDPE analyzed using tensile test, density test, and macrography.

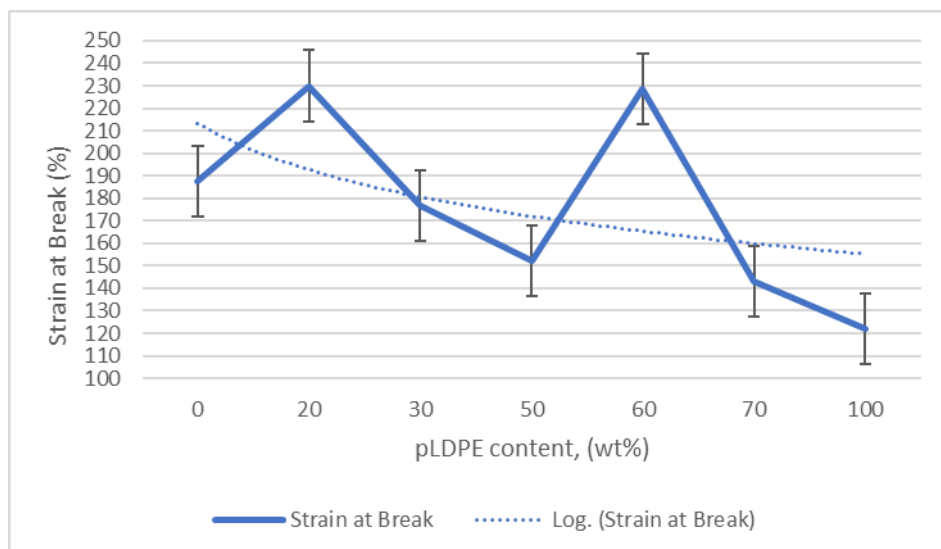
### 1. Tensile Test

The results of tensile test from combination of HDPE and LDPE in this research conducted in Figure 6 and 7 below.



**Figure 6:** Tensile strength of rHDPE/pLDPE blends versus pLDPE weight percent.

The results of the tensile test analysis show that the effect of variations in the percentage of the highest HDPE and LDPE plastic waste material blend is HDPE 100%: LDPE 0%, this is evidenced by the tensile strength value of 205 MPa, which is influenced by a mixture of all HDPE and mixed type materials. 100% HDPE and 0% LDPE are ductile, flexible and stronger than other blend percentage variations and the lowest is 40% HDPE; LDPE 60% is 190 MPa. High density polyethylene has higher tensile strength than Low density polyethylene. But, the composite of this two material can not be surpass the pure of the HDPE and LDPE.



**Figure 7:** Strain at break for rHDPE/pLDPE blends versus pLDPE weight percent.

One of the interesting features of rHDPE/pLDPE blends is their tensile properties. The tensile properties of the blend samples are shown as a function of pLDPE composition as shown in Figs. 6 and 7. Each data point represents the mean of at least three measurements, with related standard deviation shown as error bars. The changes of the maximum stress were close to what is predicted by the rule of mixtures (Fig. 6); the stress decreased monotonically as the percentage of pLDPE is increased from 20 to 70 wt%. But the strain at break was differ by blending, and the trend line was going down for the sake of mix LDPE (Fig. 7). These results support the observations by Madi NK (2013).

### 3. Density test

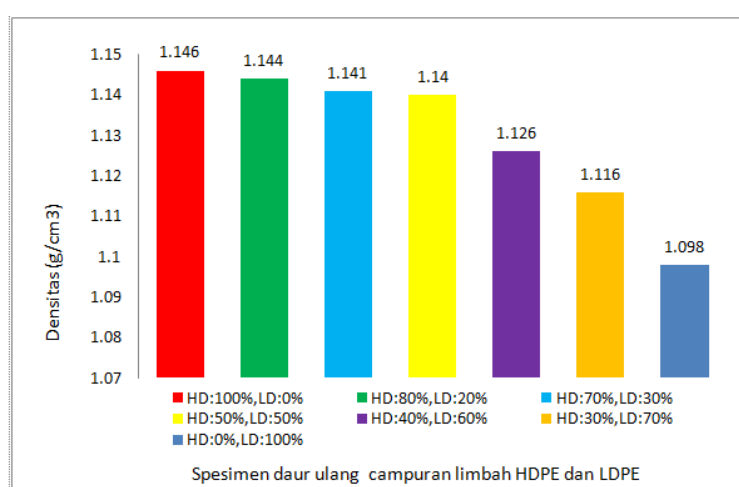


Figure 7 Average density test

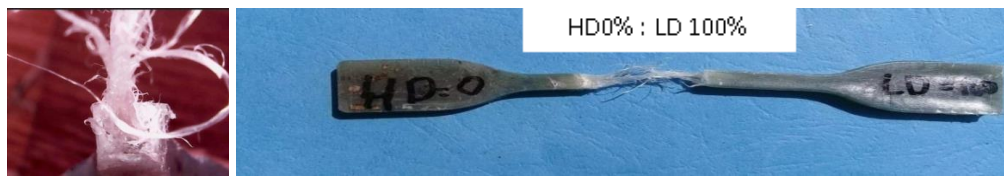
The results of the analysis of the density test showed the effect of variations in the percentage of the highest HDPE and LDPE plastic waste material, namely HDPE 100%: LDPE 0%, this was evidenced by the density value of 1.146 grams/cm<sup>3</sup>, which was influenced by the blend, all of which were 100% intact HDPE. and the lowest blend are HDPE 0% and LDPE 100%. 1,098 grams/cm<sup>3</sup>. In testing the density is graphed decreased drastically from blend HDPE 100%: LDPE 0% to the blend HDPE 0%: LDPE 100%.

### 4. Effect of fracture photo macro



(a)





(b)

Figure 8 Macro photo of strain break rHDPE/pLDPE  
 (a). Top view and side view of 80/20 break specimen,  
 (b). Top view and side view of full pLDPE break specimen.

Of the seven variations in the percentage of plastic waste blends, macro photos show the effect of variations in the percentage of HDPE and LDPE plastic waste material blends with the most pieces of fiber. The results of macro photos that show in the percentage of the 80% HDPE and 20% LDPE blend, strain break is the longest. Top view give explanation how polymer blends break from each fiber.

## CONCLUSION

Experimental investigation for inject molding of polymer blend containing recycled HDPE and pellet LDPE has been conducted and compared by mechanical properties and physical appearance.

The tensile strength was influenced by the composition of rHDPE:pLDPE. Pure rHDPE give the best result, and the blends of pLDPE gradually decrease strength. The density was also influenced by the composition of rHDPE and pLDPE. Greater pLDPE percentage will decrease the density of the product.

The macro photo of the rHDPE and pLDPE polymer blends is clearly observed with an average elongation 2 times the initial length and the strain break is in the form of fibers.

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