SAVING PURE POLYPROPYLENE THROUGH MECHANICAL RECYCLING FOR MATERIAL VALUE CONSERVATION

[1]WAKHID LAYMINA IKHSAN, [2]DJOKO SIHONO GABRIEL

Farizal, University of Indonesia (Lecturer), University of Indonesia (Lecturer)
E-mail: [1]ikhsan.wakhid@gmail.com, [2]dsihono@gmail.com

Abstract- Polypropylene has been used in various needs such as packaging, rope, automotive components and so forth. In this case, the polypropylene used as packaging can be recycled. Until now, there is still no evidence of a decrease in recycling strength. This research wanted to know how much the plastic recycling didn't change significantly through the paradigm of material value conservation. By doing tensile strength and density test also physical changes (color) of polypropylene.
In this research, polypropylene recycling was processed once, twice, four times and eight times. There is no different significant value for tensile test and modulus but for elongation value has increased after recycling eight times. For density, value remains the same from one times to eight times recycling. The big changes of this experiment in color changes, more recycled the color become darker.
Based on Material Value Conservation paradigm, the functional of plastic packaging from polypropylene still usable in eight times recycling.

Keywords- Material value conservation, Plastic packaging, Pellets, Polypropylene

I. INTRODUCTION

Plastics are polymers that relate in everyday human life. Many things in life are related to plastics. Starting from the packaging, electronic components, automotive components, building materials such as pipes and so forth. Plastic production always improves as human needs increase.

Indonesia's plastic consumption from 2015 to 2017 has increased above 5%. In 2015 Indonesia's plastic consumption is around 4.5 million tons and has increased in 2016 to 4.8 million tons (5.4%). In 2017, plastic consumption in Indonesia is growing rapidly due to the growth of domestic industries that require large quantities of plastic consumption, bringing total production to 5.6 million tons. [14]

More specifically, for domestic consumption of polypropylene (Indonesia) of 1.6 million tons in 2017, which is increasing from previous years where in 2015 the amount of 1.4 million tons and in 2016 amounted to 1.5 million tons. While the average domestic production of polypropylene in Indonesia only about 800 thousand tons per year. To fulfill domestic demand, imported polypropylene [1]. That information related with the research about China and Indonesia are the top country of plastic waste reaching the ocean with approximately 8.8 million and 3.2 million tons per year in 2010 [9].

Based on these problems, this study aims to determine the decrease in material strength and physical properties of polypropylene plastic so it can increase the life cycle of polypropylene.

II. LITERATURE REVIEW

Some of the studies that have been done and become references in the writing of this paper, the first one is research about plastic PP / PBAT degradation with recycling cycle as much as 1, 3, 5, 7 times [11]. Observation of the PP / PBAT structure using FTIR did not show any significant difference. The tests using Elasticity Modulus, Yield Stress and Impact Strength. The result, Morphology changed. Blending is more rigid. Yield Stress has little effect on when the 7^{th} recycle and Impact Strength have decreased.
Research about recycle plastics for Polypropylene and HDPE types [7] to know the impact on the quantity and quality of production. In the study was recycled once. From these studies only recycling and judging from the material strength (quality value).

And the phenomenon of material value conservation (MVC) [6]. MVC is a new phenomenon that is the implementation of various approaches, design principles, processes or material treatment and other efforts to minimize degradation of its value and maximize residual value, thereby increasing the life cycle and overall value. Prevention of material degradation values with designs for recycling makes faster recycling processes with better quality and improved financial feasibility. The phenomenon of conservation of material value in Indonesia is not actually intended for conservation purposes, but as a result of the minimization of the cost of producing cheap products. There are two main things that focus on this research, not only on the quality value but also on the price value. Recycling follow the paradigm of material value conservation and predict the benefits to

profit, source and environment are the novelty in this research.

III. METHODOLOGY

The raw materials used are polypropylene. Product manufacture and testing is done at Sentra Teknologi Polimer, PUSPITEK, South Tangerang, Indonesia.
There are three stages in the method used in this research:

1. **Product Making**
   The parameters used are temperature for injection 225^{0}C, Temperature for molding 50^{0}C, and cooling time for 10 seconds. The tool used is Battenfeld BA 400 CDC.
   Method for making product in this research by using mechanical recycling process. Mechanical recycling has a sequence of processes in the following order [10]:
   1. Identification, separation and classification of various types of plastics
   2. Cutting or enumeration
   3. Washing with or without additional cleaning materials
   4. Drying
   5. Inclusion of materials from silos
   6. Agglutination
   7. Extrusion, and
   8. Granulation or pelletization.

   The process of making these products as follows:

   - Products formed from pure plastic seeds are called initial products.
   - From the initial product is then recycled back to produce the first recycled product.
   - The results of the first recycled product are then recycled back into second recycled products.
   - The results from the third recycled product are then recycled back into the fourth recycled product
   - The results from the seventh recycled product are recycled back into eighth recycled product

2. **Product Testing**
   In this step, the products are made then tested in Laboratory Sentra Teknologi Polimer in Tangerang Selatan Indonesia.
   Methods and Parameter can be seen on Table 1.

   Method for tensile test and density test is different. Tensile test using ASTM D638 and density test using ASTM D792. Conditioning for tensile and density test is same due to the laboratory standard for the test is same.

Table 1. Product Testing

	Tensile Test (Modulus, Elongation and Tensile Strength)	Density Test
Method	ASTM D638 [3]	ASTM D792 [2]
Conditioning	Duration > 40 Jam Temp. 23 C, Humidity 50%	Duration> 40 Jam Temp 23 C, Humidity 50%
Parameter	speed 50mm/min	Ethanol Solution
	Gap 65mm	
Tools	Shimadzu AGS 10 KN	Sartorius Balance

3. Calculation of benefit (Estimation)
   To collect data / information in the field on price list of pure Polypropylene and recycled Polypropylene. Then compare the price of pure polypropylene with recycled polypropylene in indonesia.

IV. RESULTS

A. Making and Testing Product

This research begins with the manufacture of products that will be the object of research, in getting the product with color change. More recycling causes darker discoloration. This can be seen in Figure 1, the product made of pure polypropylene seed has a bright color while the eighth recycled product (right part) becomes darker.
Manufacture of the product in this study only on: the initial product (from pure polypropylene seeds), the first recycled product, the second recycled product, the fourth recycled product and the eighth recycled product.

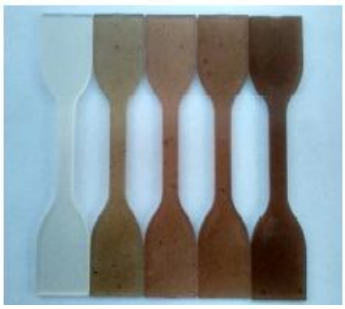


Fig.1 Product Result

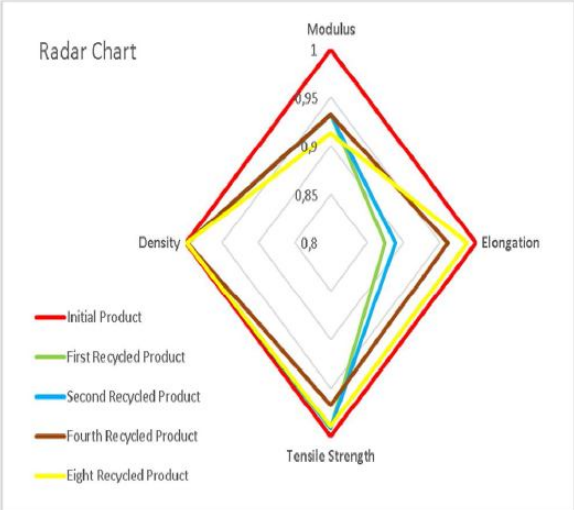
after making the product and then testing the product. The tests performed are tensile test and density test. Test result can be seen in table 2.

In the test results, there are anomalies in the tensile test (modulus, elongation and tensile strength), there are three important factors in tensile test are sample preparation, tension level, and temperature [12]. This may cause the anomaly.
The test results are converted it will be seen on the chart 1. It aims to know the reduction of recycled polypropylene strength.

Table 2. Result of Testing

Sample	Modulus (GPa)	Tensile Strength (MPa)	Elongation (%)	Density (g/cm)
Intial Product	1,04 ± 0,07	30,66 ± 0,80	414,90 ± 26,34	0,8994 ± 0,0045
First Recycled Product	0,97 ± 0,05	30,37 ± 0,64	363,70 ± 27,27	0,8970 ± 0,0004
Second Recycled Product	0,97 ± 0,05	30,38 ± 0,68	369,80 ± 25,71	0,8976 ± 0,0005
Fourth Recycled Product	0,95 ± 0,11	29,64 ± 1,17	399,50 ± 21,64	0,8978 ± 0,0013
Eight Recycled Product	0,91 ± 0,04	30,32 ± 1,37	410,30 ± 18,10	0,8983 ± 0,0002

Chart 1. Radar Chart of Tensile and Density Test



From the chart it can be seen that the decrease in strength of polypropylene is about 20%. This shows that the product of recycled polypropylene product eight times still feasible to be used as packaging (nonfood grade).

The tensile test is a measurement of the ability of the material to withstand the forces that tend to attract and to determine the extent to which the material can stretch before it finally breaks out. In the tensile test can be seen also the value of elongation and modulus and tensile strength. The value of elongation and modulus is an important indication in looking at the strength of the material and at most to determine the properties of the plastic material. Tensile modulus is also an indication of the stiffness of a material. Density tests are used as a means to ensure product uniformity [12].

B. Benefit Estimation

The current price of polypropylene is very important to determine the estimated benefit. The price applicable in Indonesia is not only the price of pure polypropylene but the price of some recycled polypropylene products in Indonesia such as the price of polypropylene with the quality of the nodes, super, and black. Prices applicable in Indonesia can be seen in table 3.

Table 3. Price of Polypropylene in Indonesia

No	Type of Polypropylene	Price
1	Pure Polypropylene	Rp 22.000 – 25.000
2	Polypropylene Clear Quality	Rp 13.000 – 16.000
3	Polypropylene Super Quality	Rp 11.000 – 13.000
4	Polypropylene Black Quality	Rp 7.000 – 9.000

After knowing the price of polypropylene in Indonesia, an assumption is made for the recycled product:

1. The first and second recycled product are the same with polypropylene with clear quality
2. The fourth recycled product is the same with polypropylene super quality
3. The eight recycled product is the same with polypropylene black quality

This assumption is made due to the quality of tensile test and density test no significant changes, it is seen through the changes in the resulting color.
If a company converts a pure product with a first and second recycled product it will be profitable by 36%. Estimated benefits to the source will be obtained at 88% with a ratio of 1 times polypropylene can be used eight times the recycling process. And the decrease value if not using the paradigm of conservation value and material as much as 72%.

CONCLUSION

Color changes from initial specimen (pure polypropylene) to eighth recycle. polypropylene still feasible to be used as plastic packaging after eight times recycling. Estimated savings on the use of pure plastic as much as 88%, Profit estimation obtained as much as 36%. Decrease in value if not using the paradigm of conservation value and material as much as 72%.
In terms of science can know the decrease of material strength and physical properties of polypropylene plastic so as to increase the life cycle of the polypropylene material. This study limited to tensile testing (modulus, elongation and tensile strength), and density. Further research can be done by comparing the results of pure polypropylene with the addition of addictive to polypropylene. As well as testing visibility and bond testing using FTIR.

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