

## Analysis of Dart Impact Test Results and Tensile Tests on Plastics

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**Abstrak--** *Plastics are polymers of long, slightly attached affixes. These chains make up many sub-atomic units or "monomers". Plastics are framed from organic build-up or polymer development and can also be shaped using different materials to produce efficient plastics. Plastics are formed from the condensation of organics or the addition of polymers and can also be formed by using other substances to produce economical plastics. Along with the growing use of plastics in the form of daily human activities, this is certainly a competitive advantage between the quality of the materials used and the safety of the plastics used. There are three types of plastic materials used in general, namely Low-Density Polyethylene (LDPE), Polypropylene (PP), and High-Density Polyethylene (HDPE). In this study, the Tensile Test and Dart Impact were tested to determine the characteristics of the results of the experimental analysis using the Dart Impact and Tensile Test plastic sampling techniques directly. The method used in this research is to use qualitative research methods using methods with direct sampling techniques for plastic Dart Impact and Tensile Tests. Data collection techniques used in this study were direct observation, interviews, and direct testing. The dart impact test on this plastic is to find out how strong the plastic is in holding the load when dropped or given a bag the tensile test in this study includes tensile strength, elongation, and Young's modulus. The test results can tell that from the nature of the plastic being tested there are differences between types of plastic in both the tensile test and the impact dart test.*

**Keywords:** *Dart Impact , Plastik PE, PP, HD, Tensile Test*

### 1. INTRODUCTION

Human daily activities cannot be separated from the existence of goods intended to assist in daily activities. One of them is plastic, the use of plastic in everyday life is the most important factor, because plastic is a light and elastic item. Many household items can also be found from plastic materials, such as buckets, tables, drinking bottles, pipes to items that are often used when shopping, namely plastic bags. There are many types of plastics with various shapes that are adapted to their useful functions and the selling brands that are marketed.

Plastics are polymers of long, slightly attached affixes. These chains make up many sub-atomic units or "monomers". Plastics are framed from organic build-up or polymer development and can also be shaped using different materials to produce efficient plastics. [1] Plastic is one of the compound polymer materials that are widely used in human life, this is because plastic has advantages over other polymer materials including materials that are light but strong, waterproof and relatively cheaper. Plastic is one of the compound polymer materials that is widely used in human life, this is because plastic has advantages over other polymer materials

including materials that are light but strong, waterproof and relatively cheaper. [2]

Along with the growing use of plastic with the existence of forms of daily human activities, this is certainly a competitive advantage between the quality of the materials used and the safety of the plastics used. There are several types of plastics commonly used, including: Polyethylene Terephthalate (PET/PETE), High Density Pouluethylene (HDPE), Polyniny Chloride (PVC), Low Density Pouluethylene (LDPE), Polypropylene (PP), Polystyrene (PS) and Other (O). Plastic production continues to grow and goes hand in hand with market selling power and daily needs, of course from all these aspects it can be seen that the use of plastics is appropriate, such as plastics for food, drinks, wrappers, crackle bags and so on. There are three types of plastic materials used for packaging in general, namely Low Density Pouluethylene (LDPE), Polypropylene (PP), and High Density Pouluethylene (HDPE).

Polyethylene is a thermoplastic material that has strong properties and is suitable for making soft and rigid products. Polyethylene is divided into two types, namely low-density polyethylene (LDPE) and high-density polyethylene (HD).

become material for cardboard products, electrical insulators, cable coatings, etc. [3] Then Polypropylene (PP) is a type of thermoplastic made from propylene monomer which is rigid, odorless, and resistant to chemical solvents, acids, and bases. Polypropylene is often used for automotive component products, loudspeakers, laboratory equipment, and containers or containers that are repeatedly used. [3] While HDPE (High Thickness Polyethylene) is a straight thermoplastic polymer produced using ethylene monomer through reactant interactions HDPE with fewer branches creates a denser construction with only a higher thickness and has a higher synthetic opposition than LDPE. HDPE (High Thickness Polyethylene) is a straight thermoplastic polymer produced using ethylene monomer through a reactant cycle. HDPE with fewer branches results in a denser construction with a higher thickness and has a higher compound opposition than LDPE. While HDPE (High Thickness Polyethylene) is a straight thermoplastic polymer that is produced using ethylene monomer through the interaction of reactants. HDPE with fewer branches creates a denser construction with a higher thickness and has a higher synthetic opposition than LDPE. HDPE (High Thickness Polyethylene) is a straight thermoplastic polymer produced using ethylene monomer through a reactant cycle. HDPE with fewer branches results in a denser construction with a higher thickness and has a higher compound opposition than LDPE. [4]

Continuous production of plastic, of course, is closely related to the quality of the plastic. There is a test that can provide a measurement of the strength, elasticity of a plastic so that later it can renew the goods. Based on the results of practical research by taking several specimens as samples in the test, namely the tensile strength between the types of PE, PE and HD plastics, each having different and different tensile strengths between the types of plastics, as well as based on the results of plastic trials with the types of PE, PP. and HD. In this trial, the practitioner will test the tensile and elasticity of plastic samples according to the standards set by testing using the ATM-D882 standard tool, the plastic sample material is obtained by taking samples from the extruder machine through the WIF roll, taking samples of each type of plastic along the length of the sample 2 meters.

Given the importance of knowing the tensile strength and tensile strain of plastic products as well as resistance to a load from different materials by identifying the type of material to be

tested such as PE, PP and HD, it is necessary to observe several plastic products in PT by looking at of the production through the Extruder machine. Seeing from the different compositions and materials used, it is necessary to have a trial to find out whether , there are defects with uneven, too thick and thin films/plastics, etc.

The objectives of this research are:

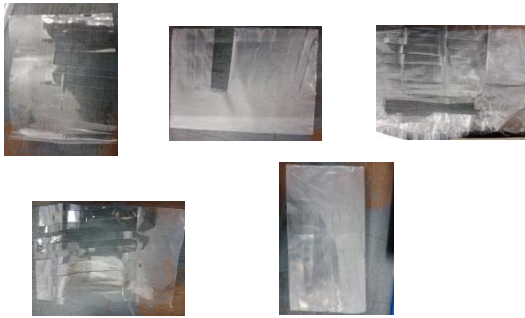
1. to identify the tensile strength and strain of plastic product materials and the strength to the presence of a load of PE, PP and HD plastic types so that research from the trials can be useful for the plastic molding industry on a strength characteristic of the three types. the plastic.
2. Identify the factors that affect the tensile strength of plastics and plastics against a given shock load [5].

Plastics have a flexible area limit as different materials. The size of the flexible area limit on the polymer material is highly dependent on changes in temperature, the length of the stack, and the level of strength applied to the declaration. [6] The existence of a ductile test (elastic test) is the most basic material test. Playing a ductility test on a material, it will find out how the material responds to stress and the extent to which the material expands over time. The state of the test sample conforms to the American standard ASTM D882. [1] Then there is a dart impact test or shock strength test to find out that it is expressed by the amount of energy needed to break the specimen broken. [6]

## 2. METODHS

The study was conducted at PT. Dolpin Putra Sejati is located on Jalan Leuwilimus, Kec. Cikande, Serang Regency, Banten 42186. The time of the study was carried out in July 2022. The research subjects were in the tensile test and dart impact trials on plastic types. In this study, 5 samples of 3 types of plastic were tested using a cutting tool. The results of the sample pieces were tested on a dart impact and tensile test machine.

There are several plastics used, namely PE, PP and HD. The three types of plastic differ in thickness for PE uk 12 x 0.025 (5 samples), PP uk 14 x 0.04 (5 samples) and HD uk 37/24 x 0.013 (5 samples). sample). All this plastic we cut into vertical and horizontal.



**Figure 1.** Samples of PE, PP and HD plastics

In this study, the method using the Dart Impact and Tensile Test plastic sampling techniques was used directly. The strategy used in this test is to use subjective exploration techniques. This study uses an enlightening subjective methodology, especially exploration that tries to describe side effects, events, events that are currently happening. [7] So that this study aims to describe the activities of using the experimental method [8]

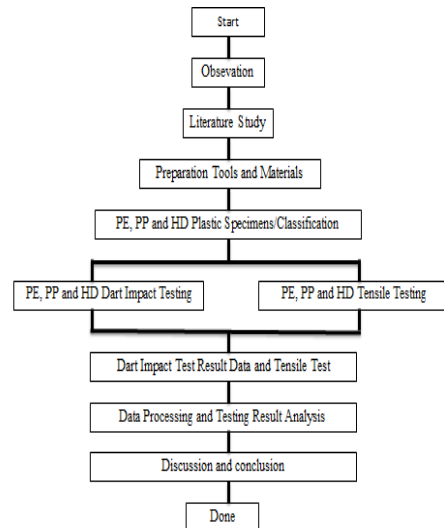
The data collection techniques used in this study were direct observation and interviews and direct trials. Observations are carried out when the research will be carried out to obtain data as a basis for carrying out research and development. Interviews were conducted with supervisors and Quality Control staff. The trials were carried out 5 times for TD and 5 times for MD on each type of plastic and 10 times on each plastic in the dart impact test, this was done to take samples from the results of the analysis of trials that have been carried out to be used as materials for discussion in this study.

This research was conducted using the experimental method :

1. Observation: the researcher makes direct observations regarding the matter to be studied
2. Literature study: researchers conduct research studies based on trusted and published sources regarding the matter being studied.
3. Tools and materials: prepare everything needed in the research, both the tools and materials used.
4. Classification of PE, PP and HD specimens: selection of materials to be used in the study. Researchers used materials PE uk 12 x 0.025 (5 samples), PP uk 14 x 0.04 (5 samples) and HD uk 37/24 x 0.013 (5 samples).

5. There are dart impact and tensile tests on plastic types.
6. Performing experimental data collection
7. Adaph
8. Conclude related after conducting experiments on research
9. And done

**2.1 Tools and Materials**



**Figure 2.** Research Structure of PE, PP and HD Plastic Tests

Tools and materials used in testing PE, PP and HD types of plastic Dart Impact and Tensile teststests include:

**Tools :**

1. Dart impact test equipment
2. Tensile test equipment
3. Thickness gauges
4. Scissors
5. Ruler
6. Pendulum
7. Star
8. Plastic cutting tools
9. Loads 5, 15 and 30

**Materials :**

1. PE uk 12 x 0,025 (5 sampel)
2. PP uk 14 x 0,04 (5 sampel)
3. HD uk 37/24 x 0,013 (5 sampel)

**Dart Impact**

Plastic dart impact test conducted from the three types of plastic cut into 5 each for TD and MD. Transverse Direction or TD is a great strength to withstand the load of the contents (the direction of the plastic piece is done transversely). Meanwhile Machine Direction or MD must have good seal strength to withstand the load when stacked (the direction of the plastic pieces is carried out parallel to the machine).

**Tensile Test**

The plastic tensile test was carried out by all types of PE, PP and HD plastics by taking 5 samples each. Tensile strength is the maximum force that plastic can withstand until it breaks. This test aims to determine the resistance of a material to loading at the bending point and also to determine the elasticity of a material [9] Stiffness is the most extreme stress that a material can withstand before breaking. [10] Machines for flexural testing are used to carry out straightenable tests (formable tests), this test determines the level of flexibility of a material and sees the quality of the material, the machine used. [11]

**3. RESULTS AND DISCUSSION**

**3.1 Tensile Test Tensile Test Results**



**Figure 3. Tensile test**

The machine for elasticity testing is used to carry out straightening tests (flexibility tests), this test determines the level of flexibility of a material and looks at the quality of the material, the machine used [12] Analysis Tensile test aims to determine the tensile strength associated with the cross-links present in the HDPE filler film samples. The greater the tensile strength, the sample can be said to have a high tensile strength (high crosslinking). The results of tensile tests carried out by TD and MD. The difference in characteristics between the three plastics produces different characteristics. This tensile test was carried out to determine the tensile and stress properties of the three plastics.

**Table 1. Results of MD Plastic PE uk 12 x 0.025**

PE uk 12 x 0.025							
MD							
F @ yld	F @ Brk	Ext.	Thick.	T @ Yld	T @ Brk	Elong.	Remark
(N)	(N)	(mm)	(mm)	(N/mm <sup>2</sup> )	(N/mm <sup>2</sup> )	(%)	
2,0	5,0	178,0	0,026	10,8	19,2	356,0	
3,0	5,0	187,0	0,024	12,5	20,8	374,0	
3,0	9,0	167,0	0,031	9,7	29,0	334,0	
3,0	7,0	170,0	0,032	9,4	21,9	340,0	
2,0	6,0	217,0	0,026	7,7	23,1	434,0	
<b>Average :</b>			<b>0,028</b>	<b>10,01</b>	<b>22,81</b>	<b>367,6</b>	
<b>Standard Dev. :</b>			<b>0,003</b>	<b>1,78</b>	<b>3,75</b>	<b>40,23</b>	
<b>Range :</b>			<b>0,008</b>	<b>4,808</b>	<b>9,801</b>	<b>100,00</b>	

From the table after doing the experiment 5 times. It was found that the difference in the final results. The standard deviation is 40.23 on elongation properties.

**Table 2. Results of PE Plastic BP uk 12 x 0.025**

TD							
F @ yld	F @ Brk	Ext.	Thick.	T @ Yld	T @ Brk	Elong.	Remark
(N)	(N)	(mm)	(mm)	(N/mm <sup>2</sup> )	(N/mm <sup>2</sup> )	(%)	
2,0	4,0	268,0	0,027	7,4	14,8	536	
3,0	3,0	266,0	0,025	12,0	12,0	532	
3,0	4,0	307,0	0,025	12,0	16,0	614	
4,0	5,0	279,0	0,024	16,7	20,8	558	
4,0	5,0	256,0	0,024	16,7	20,8	512	
<b>Average :</b>			<b>0,025</b>	<b>12,95</b>	<b>16,90</b>	<b>550,4</b>	
<b>Standard Dev. :</b>			<b>0,001</b>	<b>3,88</b>	<b>3,88</b>	<b>39,13</b>	
<b>Range :</b>			<b>0,003</b>	<b>9,259</b>	<b>8,833</b>	<b>102,00</b>	

From the table after doing the experiment 5 times. It was found that the difference in the final results. The standard deviation is 39.13 in elongation properties. Of course it is different from the first table, because each plastic tested, both MD and TD, will have a different value. This indicates that the nature of the PE material is flexible.

LDPE (low thickness polyethylene) is a plastic obtained from gasoline with a thickness of 0.92 which is commonly used for food containers, plastic bundling, and smooth containers. The mechanical properties of LDPE plastic are solid, especially clear, adaptable, and the surface is slightly slippery. Used under temperatures below 600C, highly resistant to chemical compounds, excellent protection against water fumes, very good for products that require adaptability and strength.

**Table 3. Results of MD Plastic PP uk 14 x 0.04**

PP uk 14 x 0.04							
MD							
F @ yld	F @ Brk	Ext.	Thick.	T @ Yld	T @ Brk	Elong.	Remark
(N)	(N)	(mm)	(mm)	(N/mm <sup>2</sup> )	(N/mm <sup>2</sup> )	(%)	
10,0	18,0	395,0	0,056	10,8	32,1	790,0	
9,0	20,0	449,0	0,060	15,0	33,3	898,0	
9,0	19,0	402,0	0,054	16,7	35,2	804,0	
9,0	20,0	445,0	0,058	15,5	34,5	890,0	
9,0	19,0	432,0	0,057	15,8	33,3	864,0	
<b>Average :</b>			<b>0,057</b>	<b>14,75</b>	<b>33,70</b>	<b>849,2</b>	
<b>Standard Dev. :</b>			<b>0,002</b>	<b>2,29</b>	<b>1,17</b>	<b>49,53</b>	
<b>Range :</b>			<b>0,006</b>	<b>5,867</b>	<b>3,042</b>	<b>108,00</b>	

From the table after doing the experiment 5 times. It was found that the difference in the final results. The standard deviation is 49.53 on elongation properties.

**Table 4. Results of BP Plastic PP uk 14 x 0.04**

TD							
F @ yld	F @ Brk	Ext.	Thick.	T @ Yld	T @ Brk	Elong.	Remark
(N)	(N)	(mm)	(mm)	(N/mm <sup>2</sup> )	(N/mm <sup>2</sup> )	(%)	
9,0	15,0	357,0	0,058	15,5	25,9	714	
9,0	17,0	411,0	0,057	15,8	29,8	822	
8,0	12,0	328,0	0,053	15,1	22,6	656	
8,0	14,0	438,0	0,053	15,1	26,4	876	
9,0	18,0	427,0	0,057	15,8	31,6	854	
Average :			0,056	15,46	27,26	784,4	
Standard Dev. :			0,002	0,35	3,51	94,99	
Range :			0,005	0,695	8,937	220,00	

From the table after doing the experiment 5 times. It was found that the difference in the final results. The standard deviation is 94.99 on elongation properties. Of course it is different from the first table, because each plastic tested, both MD and TD, will have a different value. This indicates that the nature of the PP material is related to its ductility.

This type of PP plastic (polypropylene) has 0.91 with a temperature of ± 1000 - 2800 C. The type of PP plastic produced is intended for food packaging. Polypropylene is more grounded, lighter, and very shiny. In view of the elastic test results for PP plastics shown in the table and that these plastics have the third best stiffness after PET and HDPE, but the straightenable strain is the second best after LDPE. So this plastic has medium elasticity but the strain is large, so for this type of plastic PP material is widely used as a material for making family items.

**Table 5. Results of HD Plastic MD uk 37/24 x 0.013**

HD uk 37/24 x 0.013							
MD							
F @ yld	F @ Brk	Ext.	Thick	T @ Yld	T @ Brk	Elong	Remark
(N)	(N)	(mm)	(mm)	(N/mm <sup>2</sup> )	(N/mm <sup>2</sup> )	(%)	
4,0	4,0	237,0	0,013	10,8	30,8	474,0	
3,0	4,0	238,0	0,013	23,1	30,8	476,0	
3,0	4,0	227,0	0,014	21,4	28,6	454,0	
3,0	3,0	260,0	0,014	21,4	21,4	520,0	
3,0	4,0	270,0	0,014	21,4	28,6	540,0	
Average :			0,014	19,63	28,02	492,8	
Standard Dev. :			0,001	4,99	3,85	35,74	
Range :			0,001	12,277	9,341	86,00	

From the table after doing the experiment 5 times. It was found that the difference in the final results. The standard deviation is 35.74 on elongation properties.

**Table 6. Results of HD Plastic TD uk 37/24 x 0.013**

TD							
F @ yld	F @ Brk	Ext.	Thick.	T @ Yld	T @ Brk	Elong.	Remark
(N)	(N)	(mm)	(mm)	(N/mm <sup>2</sup> )	(N/mm <sup>2</sup> )	(%)	
5,0	8,0	143,0	0,016	31,3	50,0	286	
3,0	4,0	269,0	0,014	21,4	28,6	538	
3,0	3,0	153,0	0,016	18,8	18,8	306	
4,0	8,0	142,0	0,014	28,6	57,1	284	
4,0	5,0	256,0	0,014	28,6	35,7	512	
Average :			0,015	25,71	38,04	385,2	
Standard Dev. :			0,001	5,33	15,61	128,24	
Range :			0,002	12,500	38,393	254,00	

From the table after doing the experiment 5 times. It was found that the difference in the final results. The standard deviation is 128.24 on elongation properties. Of course it is different from the first table, because each plastic tested, both MD and TD, will have a different value. This indicates that the properties of the HD material are stronger. It can be distinguished from PP and HD. If HD is made with ethylene monomer while PP is made from propylene monomer. So that its flexible and resistant properties are stronger.

The results of the tensile test for HDPE (high density polyethylene) plastic have a density of 0.95 which is intended for plastic wrap, plastic bags, fruit etc. The tensile results of HDPE plastic have hard properties, the material has the second order of tensile strength after the tensile strength of PET plastic, compared to PP and LDPE materials, HDPE plastic is stronger but in terms of the measurement results HDPE plastic is very small, this shows the elasticity of HDPE is very low or tend to be brittle.

**TEST RESULTS**



**Figure 4. PE dart impact test uk 12 x 0.025**





	44)	
Large	(40/28 x 48 s/d 47/32 x 54)	Test load 5 kg
Jumbo	(51/35 x 55 s/d 51/35 x 60)	Test load 8 kg
Super jumbo	(60/40 x 63 s/d 71/50 x 75)	Test load 12 kg

From the table above is a standard T-shirt seal in holding the load. It will be tested when the HD plastic is finished.

**2. Tensile Test**



**Figure 6.** Tensile Test Equipment

Mechanical properties of plastics are the main thing and take an important part. The mechanical properties tested in this study include stiffness, extension, and Youthful modulus. Elasticity is the main sign of the strength of a material. Estimates of elasticity are generally followed by estimates of elongation at break. The elongation at break determines the flexibility of the plastic. The higher the elongation at break, the more flexible the plastic, so the material can be extended more. [7] in addition to the strain and stress tests, tested the elongation which is the change in the maximum length of the film before breaking. [13] The elongation test is carried out by comparing the increase in length that occurs with the length of the material before the tensile test is carried out. [9]

Each density of each plastic is different, namely:

- PE = 0.92
- PP = 0.91
- HD = 0.95
- PX = 0.93
- PEX = 0.92

The tests were carried out using tools according to the ASTM-d882 standard with the dart impact test, tensile test and COF.

Thickness tolerance calculation:

$$T \times 20\% : 100$$

Calculation of scales:

$$\frac{P \times L \times T \times D \times 2}{10}$$

Calculation of weight/meter:

$$15 \times 100 \times D \times 2 \times H$$

Calculation of tensile test at yield (T@yield):

$$F@yld (N) / Thick (mm) = T@Yild (N/mm2)$$

Calculation of tensile test at break:

$$F@Brk(N) / Thick(mm) = T@Brk(N/mm2)$$

Elongation calculation:

$$Ext (mm) / 50 (mm) \times 100\% = Elongation$$

⇒ 50 mm = Grip (two doors gripping plastic door distance)

Calculation of dart impact:

$$WF = WL - [\Delta W(S/100-0.5)]$$

Where:

- ⇒ WF = value of impact load
- ⇒ WL = smallest load value when all test specimens fail (151 gr)
- ⇒ W = difference in load increase (15 gr)
- ⇒ S = number of failures (190)

The dispensing cycle is a non-stop interaction that results in several items such as plastic films, raffia rope, pipes, pellets, plastic sheets, fibers, fibers, connecting sheaths and some items can also be framed.. [14] The plastic extruder machine works in several stages, namely:

1. The most common way to stack seeds into containers. This stage is carried out with the aim that the plastic seeds are pushed by screws into the treatment zone, which is a place to heat and dissolve the plastic.
2. The most common way to warm plastic pellets. At this stage, the most common way to heat the plastic seeds in a vat which takes place as a treatment zone is carried out. After going through the maintenance zone, the plastic seeds will be sent through the substantive.
3. Printing Interaction. At this stage the molten plastic will be removed and shaped with the desired shape ideal.

Plastic production is initially produced using an extruder machine. Then there is only the form of WIF or semi-finished goods, elongated plastic rolls which will then be followed by cutting with a cutting machine according to size. The process of making films from plastic raw material seeds using a heater, namely a heater to melt plastic seed flakes with parameters having a temperature of ±1000 - 1950, its use in

temperature settings will differ according to the type of plastic, namely: PE, PP and HD. This of course will be related to the final result of the product/plastic. With different temperature settings, so that it can have an impact on the unequal results in the film produced. It can be seen that, in the impact test / shock load. X explained that there was a break in the plastic when the load was dropped and it was carried out 10 times until the plastic broke. This is because in order to be able to know to what extent the plastic used in the absence is added a burden. Then in a tensile test on a different type of plastic, starting from the initial zero start. PE plastic on MD has a standard deviation obtained with the results of 40.23 for elongation and 3.75 for strain and 1.78 in the middle with different thicknesses, on TD PE the standard deviation for elongation is 39, 13 and stress strain is 3.88 and 3.88. PP MD plastic, obtained standard deviation of 49.53 and stress strain of 1.17 and 2.29. Then for TD, the standard deviation is 94.99 and the stress strain is 3.51 and 0.35.

Based on this, HD plastic has a large standard deviation value among other plastic types for its elongation properties. And the lowest in PE. From the results of the tensile test and dart impact testing, it can be seen that the type of plastic has different properties and characteristics with different values as well as the capacity in resistance to received loads and plastic elongation when there is a pull.

#### 4. CONCLUSION

Plastics are polymers of long bonds of particles attached to each other. These chains make up many sub-atomic units or "monomers". Plastics are framed from organic build-up or polymer development and can also be shaped using different materials to make discreet plastics.

The results of tensile tests on PE, PP and HD plastics have different levels of assessment. In PE, the average value is the elongation value of MD = 367.6 and TD is 550.4. In PP the value of MD = 849.2 and the value of TD = 784.4. In HD with MD = 492.8 and TD = 385.2. Meanwhile, from the trial results on dart impact on PE and PP Face = 153 and HD Face = 97.5. Showing the results of the tensile test on the MD and TD of each type of plastic can determine the tensile value. This of course can affect the film-making process and is related to the results of the dart impact test, when the plastic is dropped by a load to determine the strength of the plastic when it receives a load to what extent and can tell from the thickness and thinness of the film in the plastic circumference.

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