

Study on the strength of a fishing boat made from plastic recycles

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Abstract. Ship's strength is a very significant factor in ship design. In this research, a study of the strength of ships made of recycled plastic material has been carried out. The ship has been designed according to the needs of the load weight, passengers, propulsion system, fishing equipment and the weight of the material itself. Then the load is distributed into the design, where the profile shape and plate thickness used are assumed to be temporary. The strength of the boat analysed, and the minimum plate thickness required in the design is 10 mm with maximum strain The recycle plastic used is type 2 (HDPE).

Keywords: Boat's Plastic Recycle, Boat's Strength, HDPE Plastic Recycle

1 Introduction

According to data from the Ministry of Environment and Forestry in 2016, Indonesia annually produces around 9.85 billion pieces of plastic bags. Approximately 90 thousand modern outlets generate waste. That is, the plastic waste it produces takes about 20 to 500 years to completely decompose. And if left unchecked, it will disrupt the balance of nature. One way that can be done to reduce plastic waste is to recycle it so that it can be used as an item with other functions. With the development of technology, more and more innovations are found, such as the use of plastic waste as a mixture of various handicrafts and household appliances that use plastic-based materials [1][2][8].

The shipping industry has experienced many technological developments and many innovations in the selection of materials used for the manufacture of ship hulls. As one of the innovations used is the use of type 2 plastic material (HDPE), which, Turkey first used type 2 plastic material (HDPE) as a boat-building material. Where, type 2 plastic material (HDPE) aims to replace shipbuilding materials using fiberglass reinforced plastic (FRP), fiberglass reinforced plastic (FRP) material is considered more environmentally unfriendly than the use of type 2 plastic (HDPE) which is better and safer for humans. environment.

Because with the advancement of technology in the shipping world, the author tries to make a new breakthrough by making materials from plastic waste, using type 2 plastic waste (HDPE) which if left unchecked will damage the environment, it is hoped that this material has the advantage of being durable, resistant to corrosion for approximately 50 years to

decompose, has small cracking power so that it can reduce damage, and has high flexibility so it is very suitable in case of bad weather at sea, and can be recycled again .

2 Literature Review

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2.1 Plastic

Plastics are polymers consisting of molecules called monomers which are commonly known as comonomer, if they meet different types of monomers, they are called copolymers. There are types of natural polymers that we are familiar with such as: cellulose, protein, natural rubber etc. However, natural polymers only survived in the 19th century and beyond, polymers experienced a fairly rapid development until for the first times polymers from nitrocellulose were distributed to the public until now used in household appliances etc [2][6]. The types of plastics can be seen. in below figure.



Fig. 1 Type of Plastic

Type 2 plastic (HDPE) is a type of plastic that has the ability to prevent chemical reactions between the plastic packaging and the packaged food or beverage. HDPE also has the characteristics of being stronger, harder, opaque, and resistant to high temperatures. Because HDPE is made from petroleum, to make 1 kg of HDPE requires around 1.75 kg of petroleum as the raw material for its manufacture. We can find many types of HDPE plastic in our daily lives, such as: shampoo packaging, plastic bags, milk packaging, plastic rolls and others, the HDPE manufacturing process is made with a catalyst process. Because, type 2 plastic (HDPE) is a type of plastic that can be recycled, therefore, the processing process is by first sorting it from other types of plastic. After that, the process of crushing type 2 plastic (HDPE) in the recycling plant. Then, the smelting process is the last process of a product can be seen in below figure [2][4].



Fig. 2 HDPE

2.2 HDPE Boat

Some countries have applied HDPE as material for small boat, like Turkey, Germany and other. The application has success by use virgin HDPE variant like sheet HDPE, powder or granule. And this method also has conducted in Indonesia for 5-6 six years ago. There are some advantage use HDPE as main material for small boat; not corrosive, good in impact, small resistance (low roughness resistance), easy to make and assembly, low maintenance and 100% recycle [9][5][3].

3 Methodology Research

Noverdo et all [9] has tried to applicate recycle HDPE into non class boat. The methodology will apply in this research as follow chart

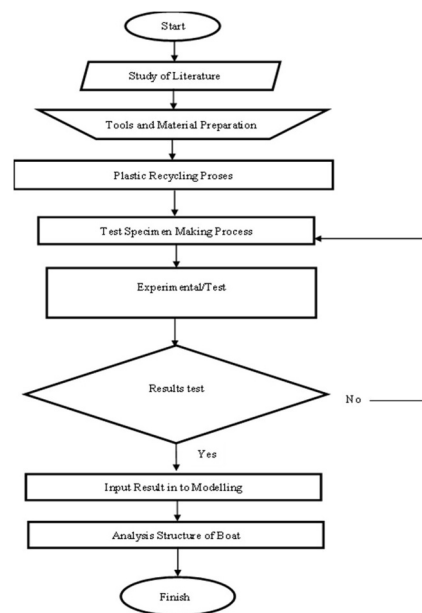


Fig. 3. Reserach Flow diagram

4 Research Experiment

Some of the tests carried out are as follows:

4.1 Tensile Test

The test aims to determine the strength of the material based on the resistance of a material to the tensile load of a test material. Tensile testing is carried out by adding the load slowly, which then increases in length which is proportional to the working force. Materials that cannot withstand relatively low stress are brittle materials.

4.2 Bending Test

This test can also be referred to as testing the flexibility of the material to a centre of gravity attached to two supports. Tests are carried out to determine whether the material is deformed or not by two opposing forces at the same time

4.3 Impact Test

This test is carried out to determine the brittleness or ductility of a material to be tested by sudden loading with static test equipment.

4.4 Design of Test Specimen

The specimen design used is in accordance with the ASTM standard. For tensile test using ASTM D368, bending test using ASTM D790 3, and impact test using ASTM D256.

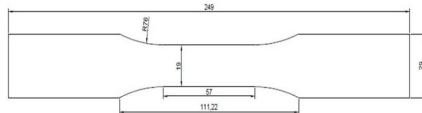


Fig. 4. Tensile Test Specimen Design

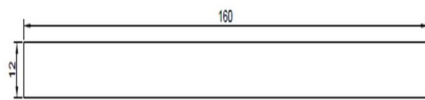


Fig. 5. Bending Test Specimen Design

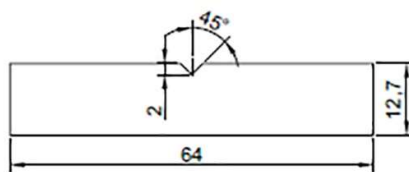


Fig. 6. Impact Test Specimen Design

4.5 Experimental Tools

The following are the tools used and have international standards and have been calibrated

Tools	Specification																																																								
<p>Tensile Test</p>	<p>RTF-2410 (Floor type)</p> <p>Details test category: (category) test load</p> <table border="1"> <tr> <td>Load</td> <td>100kN (10t)</td> <td>15kN (1.5t)</td> <td>50kN (5t)</td> <td>1kN (100kg)</td> <td>5kN (500kg)</td> <td>10kN (1t)</td> </tr> </table> <p>Device configuration: </p> <p>① Load cell: 100kN (R-14) 15kN (UR-10N-D) 50kN (UR-50N-D) 1kN (UR-10N-D) 5kN (UR-50N-D) 10kN (UR-10N-D) ② Universal joint: 100k (JUP-100) 15k (JUP-15) 50k (JUP-50) 1kN (JUP-10) 5kN (JUP-50) 10k (JUP-10) ③ Grip: 100k (GR-100) 15k (GR-15) 50k (GR-50) 1kN (GR-10) 5kN (GR-50) 10k (GR-10)</p>	Load	100kN (10t)	15kN (1.5t)	50kN (5t)	1kN (100kg)	5kN (500kg)	10kN (1t)																																																	
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<p>Bending Test</p>	<p>Compression for plastics</p> <p>Product code: J-CF-500N</p> <p>Max. load: 50kN (5t)</p> <p>Test material: Molded material / Plastic emission / Normal plastic</p> <p>Resolution error: ±0.01</p> <p>Testpiece size: 100 x 100 x 10 / 100 x 100 x 10 / 100 x 100 x 10 / 100 x 100 x 10 / 100 x 100 x 10 / 100 x 100 x 10</p> <p>Other necessary (opt): Load sensitive plate and compression anvil (opt)</p> <p>Standards: JIS K 6911-1995, ASTM D 695, JIS K 7208-1995</p> <p>Swing reproducibility: ±10 → ±10°C</p>																																																								
<p>Impact Test</p>	<table border="1"> <thead> <tr> <th>SPECIFICATIONS</th> <th>IT406</th> <th>ITS42</th> <th>IT800</th> </tr> </thead> <tbody> <tr> <td>Pendulum capacity</td> <td>J</td> <td>542</td> <td>800</td> </tr> <tr> <td></td> <td>ft.lb</td> <td>400</td> <td>590</td> </tr> <tr> <td>Drop height</td> <td>m</td> <td>1.5</td> <td>1.5</td> </tr> <tr> <td></td> <td>ft</td> <td>5</td> <td>5</td> </tr> <tr> <td>Pendulum weight</td> <td>kg</td> <td>77</td> <td>62</td> </tr> <tr> <td></td> <td>lb</td> <td>60</td> <td>136</td> </tr> <tr> <td>Impact velocity</td> <td>m/s</td> <td>5.5</td> <td>5.5</td> </tr> <tr> <td></td> <td>ft/s</td> <td>18</td> <td>18</td> </tr> <tr> <td>Dimension* (WxDxH)</td> <td>mm</td> <td>2108 x 508 x 1854</td> <td>2108 x 508 x 1854</td> <td>2540 x 910 x 2320</td> </tr> <tr> <td></td> <td>in</td> <td>83 x 20 x 73</td> <td>83 x 20 x 73</td> <td>101 x 36 x 92</td> </tr> <tr> <td></td> <td>kg</td> <td>736</td> <td>785</td> <td>2631</td> </tr> <tr> <td></td> <td>lb</td> <td>1620</td> <td>1730</td> <td>5800</td> </tr> </tbody> </table> <p>Experimental used Type IT542</p>	SPECIFICATIONS	IT406	ITS42	IT800	Pendulum capacity	J	542	800		ft.lb	400	590	Drop height	m	1.5	1.5		ft	5	5	Pendulum weight	kg	77	62		lb	60	136	Impact velocity	m/s	5.5	5.5		ft/s	18	18	Dimension* (WxDxH)	mm	2108 x 508 x 1854	2108 x 508 x 1854	2540 x 910 x 2320		in	83 x 20 x 73	83 x 20 x 73	101 x 36 x 92		kg	736	785	2631		lb	1620	1730	5800
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Fig. 7. Experimental Tools

5 Experiment Result

5.1 Tensile Test

Sample	HDPE + RESIN				Temp Test: 27,7 C				Temp Recycle 140 C							
	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	4a	4b	4c	4d
Composition	2.5%	2.5%	2.5%	2.5%	5%	5%	5%	5%	7.5%	7.5%	7.5%	7.5%	10%	10%	10%	10%
Resin	97.5%	97.5%	97.5%	97.5%	95%	95%	95%	95%	92.5%	92.5%	92.5%	92.5%	90%	90%	90%	90%
Sectional Area	199.06	192.34	183.95	190.67	164.93	169.67	174.52	175.1	168.17	167.34	166.8	165.23	173.5	176.54	176.66	165.34
Max Load	2799.3	2768.23	2600.76	2789.9	2678.2	2789.2	2894.6	2876.9	3099.7	3102.3	3076.7	3002.3	3902.1	3900	3989.1	3765.4
Stress	14,063	14,3924	14,1384072	14,632	16,239	16,439	16,586	16,43	18,432	18,539	18,445	18,171	22,49	22,091	22,8066	22,774
Elastic Modulus	516.28	500.23	477.61	480.98	521.23	500.13	518.11	505.22	560.11	555.12	540.01	526.23	639.21	620.19	625.74	627.12
Strain	0.0272	0.02877	0.02960241	0.0304	0.0312	0.0316	0.032	0.0325	0.0329	0.0334	0.0342	0.0345	0.0352	0.0356	0.036086	0.0363
Elongation	1.72	1.73	1.75	1.75	1.78	2.1	2.29	2.46	2.5	2.6	2.6	2.6	3.46	3.32	2.94	3.23

Fig. 8. Tensile Test of Recycle HDPE

Tensile test of type 2 recycles plastic (HDPE) and resin with a ratio of 97.5%: 2.5% resulted in different tensile strengths of 4 test specimens (1a-1d). The larger result is 14,632 and minimum is 14,063. Tensile test of type 2 plastic (HDPE) and resin with a ratio of 95%: 5% resulted in different tensile strengths of 4 test specimens (2a-2d). The larger result is 16,586 and minimum is 16,239. Tensile test of type 2 plastic (HDPE) and resin with a ratio of 92.5%: 7.5% resulted in different tensile strengths of 4 test specimens (3a-3d). The larger result is 18,171 and minimum is 18,539. Tensile test of type 2 plastic (HDPE) and resin with a ratio of 90%: 10% resulted in different tensile strengths of 4 test specimens (4a-4d). The larger result is 22,091 and minimum is 22,774. As per above data, it was obtained that the larger stress was found in the specimen with a ratio of 90%: 10% for type 2 plastic (HDPE) with the addition of resin. Detail stress and strain every specimen test, please see below graphic.

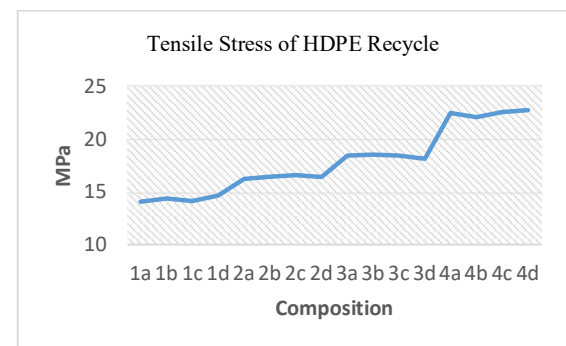


Fig. 9. Tensile Stress of HDPE Recycle

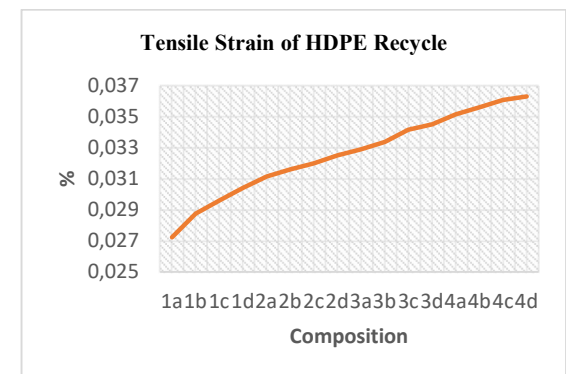


Fig. 10. Tensile Strain of HDPE Recycle

5.2 Bending Test

Sample	HDPE + RESIN				Temp Test : 27,7 C				Temp Recycle 140 C							
	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	4a	4b	4c	4d
Composition	2,5%	2,5%	2,5%	2,5%	5%	5%	5%	5%	7,5%	7,5%	7,5%	7,5%	10%	10%	10%	10%
HDPE	97,5%	97,5%	97,5%	97,5%	95%	95%	95%	95%	92,5%	92,5%	92,5%	92,5%	90%	90%	90%	90%
Sectional Area	330,93	325,58	325,79	320,11	317,31	317,02	317,36	320,11	318,45	318,34	320,12	318,97	320,01	323,12	323,33	320,51
Max Load	3094,9	3241,75	3172,997	3182,9	3202	3233,6	3254,2	3388,7	3367	3403,5	3517	3580,2	3676,1	4027,5	4137,826	3803,3
Stress	25,595	26,232	26,488	26,5	27,295	27,633	27,728	28,213	28,43	28,76	29,279	29,867	30,632	31,192	31,269	31,56
Elastic Modulus	3032,6	3200,46	955,22	962,96	970,23	976,23	960,12	950,23	940,11	930,03	919,99	909,72	902,91	890,09	870,12	860
Strain	0,0248	0,02622	0,0277297	0,0275	0,0281	0,0283	0,0289	0,0297	0,0302	0,0309	0,0318	0,0328	0,0339	0,035	0,035936	0,0367
Elongation	1,2	1,4	1,5	1,5	1,6	1,6	1,6	1,7	1,8	1,8	1,9	2	2,1	2,3	2,3	2,4

Fig.11. Bending Test of HDPE Recycle

Bending test of type 2 recycle plastic (HDPE) and resin with a ratio of 97.5%: 2.5% resulted in different bending strengths of 4 test specimens (1a-1d). The larger result is 25,595 and minimum is 26,5. Bending test of type 2 plastic (HDPE) and resin with a ratio of 95%: 5% resulted in different bending strengths of 4 test specimens (2a-2d). The larger result is 27,295 and minimum is 28,213. Bending test of type 2 plastic (HDPE) and resin with a ratio of 92.5%: 7.5% resulted in different bending strengths of 4 test specimens (3a-3d). The larger result is 28,43 and minimum is 29,867. Bending test of type 2 plastic (HDPE) and resin with a ratio of 90%: 10% resulted in different bending strengths of 4 test specimens (4a-4d). The larger result is 31,56 and minimum is 30,362. After described above, it was obtained that the larger stress was found in the specimen with a ratio of 90%: 10% for type 2 plastic (HDPE) with the addition of resin. Detail stress every specimen test, please see below graphic.

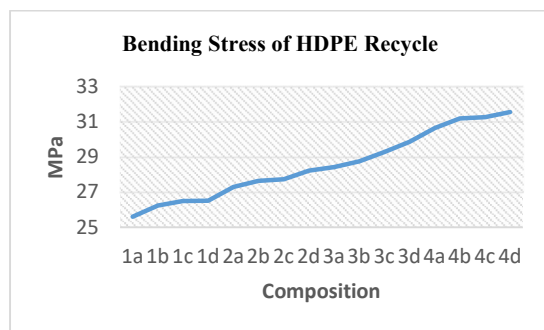


Fig.12. Bending Stress of HDPE Recycle

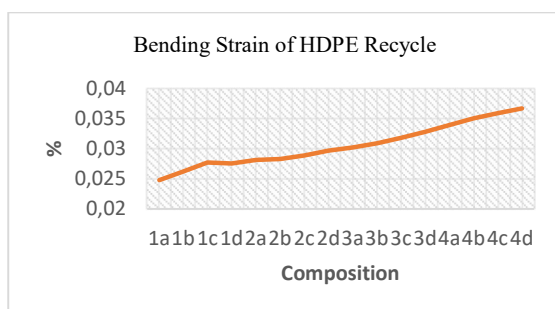


Fig.13. Bending Strain of HDPE Recycle

5.3 Impact Test

Sample	HDPE + RESIN				Temp Test : 27,7 C				Temp Recycle 140 C							
	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	4a	4b	4c	4d
Composition	2,5%	2,5%	2,5%	2,5%	5%	5%	5%	5%	7,5%	7,5%	7,5%	7,5%	10%	10%	10%	10%
HDPE	97,5%	97,5%	97,5%	97,5%	95%	95%	95%	95%	92,5%	92,5%	92,5%	92,5%	90%	90%	90%	90%
Impact (Joule)	1,6572	1,6698	1,6012	1,6915	1,38	1,3107	1,2415	1,2974	0,9649	0,8267	0,9048	0,8834	0,6887	0,6999	0,5507	0,6289

Fig.14. Impact Test of HDPE Recycle

Impact test of type 2 recycle plastic (HDPE) and resin with a ratio of 97.5%: 2.5% resulted in different impact strengths of 4 test specimens (1a-1d). The larger result is 1,6012 and minimum is 1,6915. Impact test of type 2 plastic (HDPE) and resin with a ratio of 95%: 5% resulted in different impact strengths of 4 test specimens (2a-2d). The larger result is 1,2415 and minimum is 1,38. Impact test of type 2 plastic (HDPE) and resin with a ratio of 92.5%: 7.5% resulted in different impact strengths of 4 test specimens (3a-3d). The larger result is 0,9649 and minimum is 0,8267. Impact test of type 2 plastic (HDPE) and resin with a ratio of 90%: 10% resulted in different impact strengths of 4 test specimens (4a-4d). The larger result is 1,6915 and minimum is 1,6012. After described above, it was obtained that the larger stress was found in the specimen with a ratio of 97.5%: 2.5% for type 2 plastic (HDPE) with the addition of resin. Detail stress every specimen test, please see below graphic.

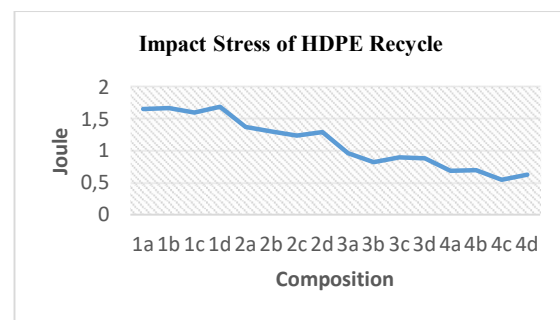


Fig.15. Impact Stress of HDPE Recycle

5.4 Strength of Fishing Boat

Modelling of fishing boat has been carried out used sample of Maxsurf model include frame, stiffener and web frames.

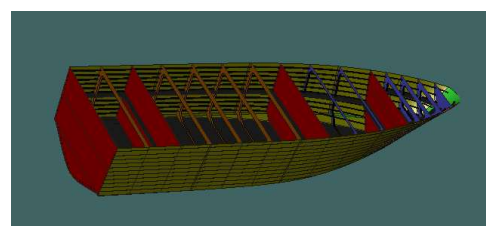


Fig.16. Modelling hull and structure of fishing boat

This boat has designed for 3 GT of fishing vessel with hull thickness, web frame and stiffener approximate 10 mm. After input all recycle material data into the software, strain of hull can be as per below figure

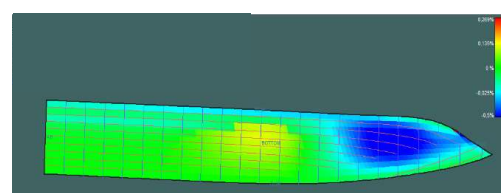


Fig.17 Strain with 3 GT Payload

Maximum strain has occurred in this model is 0,027

6 Conclutions

1. HDPE Plastic waste has recycled use mechanical method (with oven) and without pressure become HDPE recycle sheet with 10 mm thickness.
2. That recycle HDPE has been test as per international standard for plastic, tensile test use ASTM D368, bending test use ASTM D790, and impact test use ASTM D256.
3. Maximum tensile stress has occurred is 22,774 MPa and Maximum strain is 0,0363 for composition 90% HDPE recycle and 10% of Resin (yukalac 157), it is proven that the addition of resin increases the tensile strength.
4. Maximum bending stress has occurred is 31,56 MPa and maximum strain is 0,0367 for composition 90% HDPE recycle and 10% of Resin (yukalac 157), it is proven that the addition of resin increases the bending strength.
5. Maximum impact stress has occurred is 1,6915 MPa for composition 97.5% HDPE recycle and 2.5% of Resin (yukalac 157), it is proven that the addition of resin decreases the impact strength.
6. Additional of resin increase tensile as bending strength, while decrease of impact strength
7. Boat has designed for 3GT fishing boat
8. Maximum strain for 3GT fishing boat for 10mm thickness is 0,027
9. Comparing with figure 8, figure 11, figure 14 with margin 20%, Design 3GT boat with minimum 10mm thickness is recommended to use HDPE recycle with composition 90% HDPE recycle and 10% Resin (Yukalac 157). For designed fender and forepeak of boat use is recommended use pure recycle HDPE (100% of HDPE Recycle).
10. Future development is recommended to process HDPE plastic waste with pressure.

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