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Use of Acrylonitrile Butadiene Styrene and Polylactide Filaments as Basic Materials for Marine Technology Prototype

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--***ABSTRACT***--

The making of prototypes is an activity that will almost always be carried out in the development of marine technology. So far fiber and silicon are the most commonly used materials in the manufacture of prototypes, which are chemical synthetic materials. Following the trend of these technologies, there are currently several types of new materials such as ABS filaments and PF in 3D printing (3DP) which are becoming widely used materials. So that this study aims to introduce these technologies 3DP in the activities of making marine technology prototypes can be an alternative in the acceleration, flexibility and development of production, and reduce the use of synthetic chemicals into synthetic organic materials and or recycled materials. The results of the research conducted show that the material from ABS is suitable for use in prototyping using 3DP.

KEYWORDS: *3DP, Filament, Prototype, ABS and PF*

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I. BACKGROUND

Technological and transportation developments make the industrial atmosphere increasingly competitive. Business actors and industries are competing to find the best and most innovative materials and technology with quality, price, speed, availability and flexibility (Liou 2008). These conditions spurred research efforts and technology development that were very intensive in almost all fields. Various models and concepts are created and developed so that the development of production is able to adjust to market dynamics.

Prototyping is a downstream activity of the research and development effort. Prototype is an approach taken to develop, test, and improve ideas at an early stage before being implemented on a larger scale of production (Thinkpublic and Nesta 2011). The making of prototypes in modern industries has entered the era of rapid prototyping. Era where prototype-making technology is at the fastest, sophisticated and accurate point. The core of this technology is direct printing model automation through printing machines layer by layer model. To support the printing process to run quickly and precisely, it is necessary to use printing materials that have quality and impact that are friendly to the environment, the quality possessed by printing materials (filament) must also have the right standards.

Therefore, it is necessary to test new materials which are currently developing as alternative materials in the research and development of the marine industry technology. Nowadays new materials such as ABS filaments and PF in 3DP are becoming widely used materials. Introducing these technologies in the activities of making marine technology prototypes can be an alternative in the acceleration, flexibility and development of production, and reduce the use of synthetic chemicals into synthetic organic materials and / or recycled materials. As explained earlier, the purpose of this research is to introduce a 3-dimensional print method and to test the filament in making marine technology prototypes.

II. METHODOLOGY

Tools and materials

The materials needed in this research include the mechanical and electrical components of the printer Specifications of aluminum frames, print size (XYZ): 235 x 235 x 250 mm, thickness of filament layer 0.05 - 0.3 mm, print speed 60-120 mm / sec , nozzle: 1 with a diameter of 0.4 mm and the overall dimensions of the machine 440 x 465 x 450 mm.

The filaments used in this study are PF filaments (polylactic acid or polylactide) and acrylonitrile butadiene styrene (abs). Both of these materials come from thermoplastic groups which have properties that are easily formed when heated and become solid again when cooled. The advantages of thermoplastic material are that it can be recycled or reprocessed repeatedly so that it is more environmentally friendly.

ABS materials are produced from fossil fuels and cannot be biodegradable (biodegradation). ABS consists of 15-35% acrylonitrile, 5-30% butadiene and 40-60% styrene. ABS is stronger than pure polystyrene. Styrene has a shiny plastic effect, while butadiene, a rubber substance, provides durability even at low temperatures. ABS can be used in a temperature range of -20 ° C to 80 ° C. ABS material is the choice of engineers and for professional application purposes because ABS is strong, flexible and has good machinability and temperature resistance. The colors of ABS materials on the market are blue, yellow, red, gray, green, black and white.

PF material has many choices of colors both solid and translucent and shiny so it is interesting to display. If the proper cooling of this material allows printing at a higher speed than ABS. This material is widely used for home printing, hobbies, and is used in schools. PF is the right material for you beginner 3D printer users. With the help of a fan on the right 3D printer it will help the cooling process get better and prevent the occurrence of crooked printing compared to other materials. After printing you can finish your model with sanding or can also paint directly into PF with acrylic type paint. This material is child-friendly and environmentally friendly and can be easily decomposed into compostable because it is based on corn starch (Triwibowo, 2015).

The prototype made in this study was an RC boat. RC boats are chosen because they represent the most common aspects in the marine technology industry, because they are applied directly to the surface of the water, are small in size, and have a control system. The designs made will be printed each made from PF and ABS.

In 3D printing, because it uses the principle of stereolitography or layer by layer, the design process must be done using at least two software. The first software is used to make solid designs, and other software is used to break solid designs into layers. Desainsolid RC boat in this study was made using Design Spark Mechanical software, an open source software for FDM (3D) printing from Design Spark. Whereas to break it down into stereolitography (STL) using Cura software.

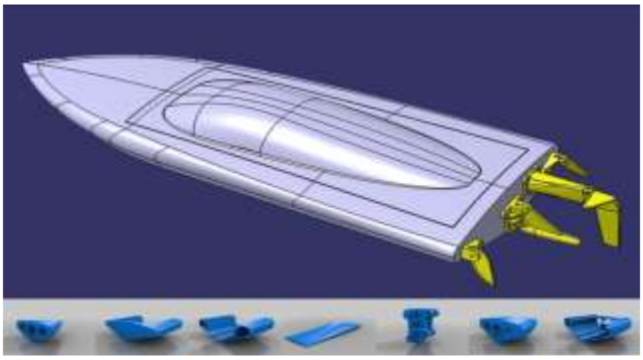


Figure 1. RC boat design that will be printed in research

Analysis Method

Print Test

After the machine is assembled, the next important thing to do is to test the print to find out whether the component functions and machine precision are good enough or not. The test results determine what settings and calibrations should be done next before printing the desired object

Advanced Test and RC Boat Printing

After the engine function is able to work properly, the next step is to do further testing before finally printing the desired prototype. This advanced trial is to determine the suitability of external factors that affect temperature.

Plan Analysis

Cost Analysis

It is done by comparing the average time needed to print objects with the same volume and slicing parameters (in the coating process with Cura) between ABS filament and PF.

Strength Analysis

If possible, further testing can be done that is more specific to find out the durability and flexibility of the print. Flexibility of control can be known by giving the motor to the printout and testing it on the water. Whereas to find out the quality of resistance of each PF and ABS specimen, a tensile test and flexural test can be carried out. The tensile test method was carried out using the ASTM 638-02a standard, while the bending test was carried out using the ASTM D790 standard (Savvakis, et al., 2014). The following are the test methods that will be applied to measure the quality of resistance of each test specimen

a) Tensile Strength, tensile test to determine the tensile strength of the material to be tested. Tensile strength is the maximum stress that a material can hold when stretched or pulled, before the material is broken (Savvakis, et al., 2014).
b) Tensile Modulus, tensile test to determine tensile modulus or also known as elastic modulus, which aims to determine the size of the rigidity of an elastic material which is characteristic of a material (Szykiedans and Credo, 2016).
c) Tensile Elogation, tensile elogation is a stretch experienced by a material when pulled in tension. Tensile elongation is a measure of both elastic deformation and PFstic deformation, and is generally expressed as a percentage. This is used together with stress and strain values to help determine the mechanical properties of a material when conducting a tensile test (IPC, 2018)
d) Flexural Strength, flexural strength, also known as modulus of rupture, is a measure of resistance to fracture, when a sample is flexed. The tested specimens will have good flexural strength if they are not easily broken when bent (Novais, et al 2009)
e) Flexural Modulus, flexural modulus (flexural modulus) is an intensive property which is calculated as the ratio of stresses to strain in bending deformation, or the tendency of the material to resist bending (Novais, et al 2009)

III. RESULTS AND DISCUSSION

3D Engine Performance

In general, the machine can function properly. Because this is a new method, so many parameters that are beyond calculation greatly affect the performance of the engine as well as the quality of the print. Among these problems, which deserve attention are:

a. Room temperature, In general, both machines used to print prototypes made from PF or ABS require temperature consistency. places with temperatures above room temperature are strongly recommended to be a workshop where the printing process takes place. This condition is especially needed for printing ABS materials.
b. Quality of Extruder, An extruder is a series of small components that serve to heat the filament. Just a little interference, can cause the quality of the print to decrease. Examples of damaged extruders can be seen in Figure 2.

Figure 2. The damaged extruder, the nozzle head has leaked

In this study, the extruder used was a very standard quality extruder made from brass. This extruder can be used to print a variety of materials but is limited to non-abrasive materials, such as: PF, ABS During the study, 4 extruder units were damaged due to several factors, including:

1) Damage due to shipping process
2) The cable connected to the motherboard is often disconnected
3) Temperature sensor connected to a nozzlehead error
4) Leaks in the head nozzle so that the filaments accumulate and dry in this section
5) Clogged or blocked at the nozzle hole

It is strongly recommended to use an extruder with a stainless steel or hardened steel nozzle, especially for prototypes that will be applied.

a. Print / heatbed quality

In order for the printing process to take PFproperly, a rigid machine frame and a solid print bed position are needed. Problems arise when printing one type of filament from a different vendor. The filament attaches and is difficult to remove, causing damage to the print bed.It is suggested to use a magnetic print base so you don't need to use conventional clips that cause the print bed to shift easily. The print bed used is also easily curved so that it requires repeated nozzle position calibration

b. Machine Frame

As mentioned in the previous point, a rigid framework is needed so that vibration does not cause a shift in print beds & extruders or other components. The framework used in this study is made of iron and has very good solidity.

Test Process

The trial process is carried out in the following stages:

a. Integrate machine parameters and specifications in software slicing, as can be seen in Figures 3 and Figures 4

Figure 3. Adjustment of engine specifications on Cura

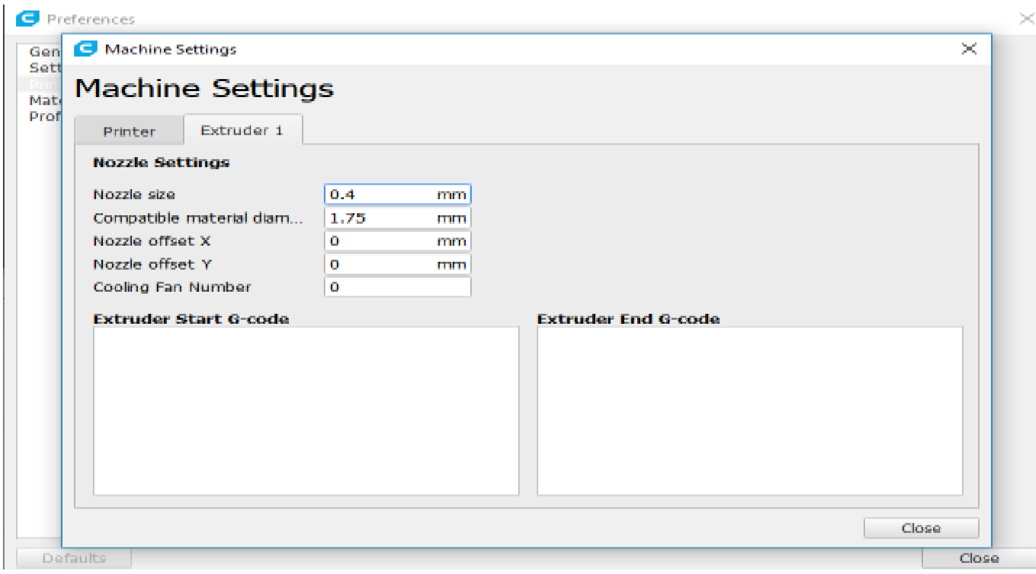


Figure 4. Adjustment of extruder specifications on Cura

This integration is very important to do, so that the commands entered can be executed in accordance with the limits / specifications of the machine.

b. Print test objects

This process is very important to know the best settings of at least 13 setting parameters in the Cura software as can be seen in Figure 5.

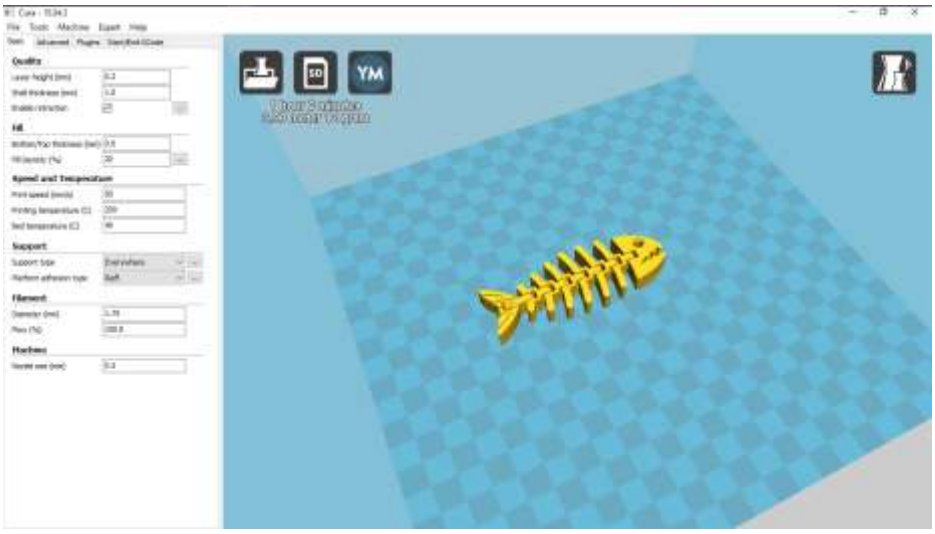


Figure 5. Object Test 1, articulated fish

The most tested parameters include the layers of thick ness / height, Shell thickness, Fill Density, Printing Speed, and Temperature. These parameters greatly affect the quality of the printout, and can be used as a separate research topic.

This thought was realized in the trial process, and is a crucial thing to do in the future. So ideally, before this research can be carried out experimental design will be continued with ANOVA to determine the best parameter settings in the printing process.

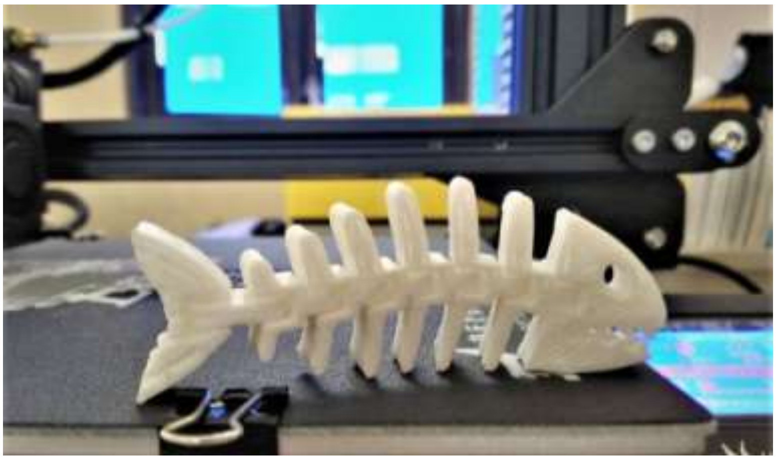


Figure 6. Printed test object 1, articulated fish

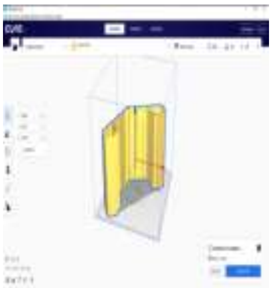
The testing process is then repeated by printing various objects that have different thickness, solidity, and dimensions. From the results of the repetition, important information is obtained as follows:

1) Print bed with conventional clips easily shifts
2) Clogged easily. Clogged is usually caused by filaments that harden, and cannot melt at the target temperature (PF 200-210oC, and ABS 240-250oC)
3) The thermistor cable is prone to error
4) Need to repeatedly calibrate the printbed nozzle distance
5) Difficult to condition temperature
6) Must clean the print bed regularly
7) Must regularly check belt tension on the roller

8) Keep the tip of the filament inserted into the extruder in a tapered condition (with side cut)
9) If you want to replace the filament, it's better to do it in hot conditions (hotpull)

Printing Process

The printing of the main object of the study as the design found in Figure 1 was carried out in parallel between PF and ABS materials. The printing time and the amount of filament spent were as shown in Table 3 for PF and Table 4 for ABS. The time shown in Tables 3 and 4 is the estimated time calculated by the software slicer (Cura), while the actual time needed to print an average of ± 5-10%.

								
Object 1			Object 2			Object 3		
22:01 hour	240 g	80,59 m	20:37 hour	209 g	70,23 m	22:21 hour	224 g	75,24 m
								
Object 4			Object 5			Object 6		
20:29 hour	206 g	69,17 minute	9:24 hour	88 g	29,46 m	5:57 hour	53 g	17,71 m

								
Object 1			Object 2			Object 3		
22:03 hour	215 g	81,44 m	21:39 hour	196 g	74,18 m	22:13 hour	199 g	75,

								18 m
								
Object 4			Object 5			Object 6		
15:59 hour	142 g	53,58 minute	8:55 hour	80 g	30,38 m	5:57 hour	47 g	17,71 m

The total time needed to print prototypes of RC boats (Figure 7) made from PF is 98 hours 169 minutes or 100 hours 49 minutes, while the mass of filaments spent is 1,020 grams (342.4 meters). Then, for prototypes made from ABS, it takes 93 hours 226 minutes or 96 hours 46 minutes, while the mass of the filament is 879 grams (332.47 meters). These data form the basis for calculating costs as shown in Table 5.

Table 5. Electricity costs and materials for printing research objects

Component	**Formula**	**PF Prototypes**	**ABS Prototypes**
Engine Power		100 Watt	100 Watt
Total print time		100,817 Hour	96,767 Hour
Total power	a*b	10081,7 wh	9676,7 wh
Kwh conversion	c/1000	10,0817	9,6767
Basic Electricity Rates		USD 0,102 /Kwh	USD 0,102 /Kwh
Total electricity costs used	d*e	USD 1,03	USD 0,99
The mass of filament used		1.020 gram	879 gram
Filament Prices		USD 10,49 (1 kg)	USD 10,49 (1 kg)
Cost of filament used	g*i	USD 10,7	USD 9,22
Printing costs for research objects	F+j	**USD 11,73**	**USD 10,21**

Based on these calculations, prototypes made from ABS are more efficient in the use of power and materials compared to prototypes made from PF. In theory, ABS material is also more suitable if used in open space because it is a plastic that will not be degraded, including in use in the water. It does not mean that prototypes made from PF are not suitable for use in open areas / waters, because not all regular PF are biodegradable. This is due to the large number of synthetic PF produced at low cost, especially from Chinese producers. While PF with high standards, is usually biodegradable which can dissolve in water at least within 40 days.

In this study it is unfortunate that prototypes made from ABS cannot be printed intact. This is because the ABS material requires the consistency of hot temperatures in the printing process Small objects can be printed under normal conditions (normal room temperature), while for large volume objects requires an enclosure. Enclosure can be made from at least acrylic. The better the print quality if the enclosure is made of materials that are resistant and can withstand longer heat.

Making enclosures requires additional costs which unfortunately are outside the research budget submitted and approved. This is also the same reason for the lack of flexible testing and testing of printed prototypes

IV. CONCLUSION

Making prototypes using 3D printers is highly recommended. Material efficiency and time are the reasons. Following the trend of the industrial revolution 4.0 is also a strong reason for the industry and marine technology study program to adapt this technology to its activities. ABS (Acrylonitrile Butadiene Styrene) material is highly recommended for standard use in teaching and learning activities, including for the production process of marine rides in shallow depths. Use of vehicles for waters that are more demanding specifications of machines (especially set extruders) and stronger filaments such as polycarbonate. It is highly recommended in the process of printing prototypes to be used in waters to increase layer thickness, shellness, and fill density, but will impact on decreasing printing speed (increasing production costs).

REFERENCES

[1]. IPC. 2018. IPC-TM-650 Test Methods Manual. Downloaded on 6 September 2018 on the page [https://www.ipc.org/TM/2.4.18.3.pdf]

[2]. Liou, Frank W. 2008. Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development. Edited by L. L. Faulkner. London: CRC Press (Tayor and Francis Group).

[3]. Novais, VR, Quagliatto PS, Bona AD, Correr-Sobrinho L, Soares CJ. 2009. Flexural modulus, flexural strength, and stiffness of fiber-reinforced posts. J Indians Dent Res, 20 (3), 2009

[4]. Savvakis, K., Petousis, M., Vairis, A., Vidakis, N., & Bikmeyev, A. T. 2014. Experimental Determination of the Tensile Strength of Fused Deposition Modeling Parts. Volume 14: Emerging Technologies; Engineering Management, Safety, Ethics, Society, and Education; Materials: Genetics to Structures. doi: 10.1115 / imece2014-37553

[5]. Szykiedansa, K and Credoa, W. 2016. Mechanical properties of FDM and SLA low-cost 3-D prints. Procedia Engineering 136 (2016) 257 - 262.

[6]. Thinkpublic, and Nesta. 2011. "Prototyping Framework. A Guide to New Ideas Prototyping. "In, 52.

[7]. Triwibowo, Sugiyanto.2015. Get to know 3D Printing. Downloaded on October 24, 2018, from: http://www.vedcmalang.com/pppptkboemlg/index.php/menuutama/mesin-cnc/1215-sugiyarto-5.

[8]. Yu, Yong Ze, Jin Rong Lu, and Jing Liu. 2017. "3D Printing for Functional Electronics by Injection and the Package of Liquid Metals into Mechanical Structures." Materials and Design 122. Elsevier Ltd: 80–89. doi: 10.1016 / j.matdes.2017.03.005.

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