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Investigation of the Impact Strength of MC Blue Material Due to Temperature Variations

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ABSTRACT

Researchers carried out experimental testing on the MC Blue using the charphy impact method. The MC Blue specimen was developed in a local workshop in Medan City, North Sumatra for three variations of testing temperature, namely normal temperature 31ºC, temperature 50ºC, and temperature 100ºC. The aim of this research is to determine the impact energy and impact strength values of MC Blue due to dynamic loads. The results of test data analysis show the mechanical characteristics of impact resistance with the highest value occurring in specimens at a temperature of 100ºC of 56.696 Joule at an average impact energy and an average impact strength value of 0.438 J/mm^2. Meanwhile, the lowest charphy impact resistance was shown by the normal temperature model of 31ºC of 17.975 Joule for the average impact energy value and the average impact strength value was 0.139 J/mm^2. Temperature variations have a concrete impact, there is an increase in impact energy on the MC Blue with a linear regression equation y = 19.361x + 2.1467 and the impact strength value experiences a relevant increase due to temperature differences with a linear regression equation y = 0.1495x + 0.0163.

Keyword: MC Blue, Charphy Impact Method, Temperature Variation, ASTM D6110-10 standard, Linear Regression.

ABSTRAK

Peneliti telah melakukan pengujian eksperimental terhadap material MC Blue dengan metode impak charphy. Spesimen MC Blue mengikuti standard ASTM D6110-10 dikembangkan di bengkel lokal Kota Medan, Sumatera Utara untuk tiga variasi temperatur pengujian adalah temperatur normal 31ºC, temperatur 50ºC, dan temperatur 100ºC. Tujuan penelitian ini yaitu untuk mengetahui nilai energi impak dan kekuatan impak material MC Blue akibat beban dinamis. Hasil analisis data uji menunjukkan karakteristik mekanik ketahanan impak dengan nilai tertinggi terjadi pada spesimen temperatur 100ºC sebesar 56.696 Joule pada energi impak rata-rata dan nilai kekuatan impak rata-rata adalah 0.438 J/mm^2. Sedangkan ketahanan impak charphy hasil terkecil ditunjukkan model temperatur normal 31ºC sebesar 17.975 Joule untuk nilai energi impak rata-rata dan nilai kekuatan impak rata-rata adalah 0.139 J/mm^2. Variasi temperature memberikan dampak secara konkret terjadi peningkatan energi impak terhadap material MC Blue dengan persamaan regresi linear y = 19.361x + 2.1467 dan nilai kekuatan impak mengalami peningkatan yang relevan akibat perbedaan temperatur dengan persamaan regresi linear y = 0.1495x + 0.0163.

Keyword: MC Blue, Metode Impak Charphy, Variasi Temperatur, Standard ASTM D6110-10, Regresi Linear.

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1. Introduction

Technological developments in machine component elements in recent decades have increasingly required them. Metal material is still the main choice in selecting materials for making machine element components. Natural resources for metal materials are becoming less available, so the manufacturing industry is starting to switch to using polymer materials. Plastic is a synthetic polymer material made through a polymerization process. Polymers are produced by combining many monomers into one molecular chain [1-3].

The implementation of polymer materials in industrial technology is widely applied to automotive products, airplanes, ships, sports equipment and electronic equipment [4-6]. MC Blue material is a type of plastic material that is widely used in the engineering field. MC Blue material has the advantages of low specific gravity, excellent mechanical strength, wear resistance, dimensional stability, and easy to shape [7][8]. The development of increasingly modern technology currently demands improving the mechanical properties of materials to evaluate product quality, meet high quality standards, identify problems in the production process, increase efficiency, reduce production costs, develop new products with better performance and wider applications [9]. To improve the mechanical characteristics of the MC Blue material, a heating process is carried out using temperature variations and material composition variations. This research was carried out using the Charphy impact method to increase the results of material tests due to dynamic loads. The aim of this research is to determine the value of impact energy and impact strength based on test data analysis.

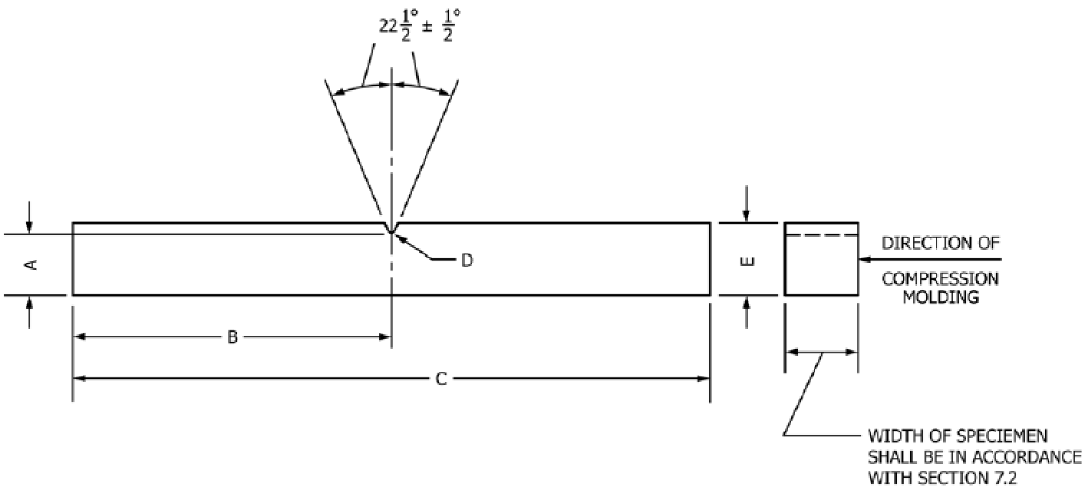
2. Method

Material production processes that are free from internal stress, such as injection molding and extrusion molding product processes, are polyamide produced through a casting process, namely MC Blue. This material exhibits excellent mechanical strength, wear resistance, and dimensional stability. This research uses MC Blue with an experimental method [10], namely charphy Impact Testing to determine the impact energy and impact strength values analytically based on equation 1 and equation 2.

$$W = m_p \, . \, g. \, l_p \, (\cos \alpha_o - \cos \alpha_i) \tag{1}$$

$$\sigma = \frac{W}{b.h} \tag{2}$$

The specimen form was developed in a local workshop in Medan city, North Sumatra following the ASTM D6110-10 standard as shown in Figure 2.1 [11][12]. The process of forming the specimen is carried out by machining in stages, starting with the cutting process using a hacksaw machine and continuing with smoothing the specimen area with a milling machine to achieve a size according to material testing standards, then the final stage is making notches using a scrap machine.



	mm	in.
A	10.16 ± 0.05	0.400 ± 0.002
B	63.5 max	2.50 max
	61.0 min	2.40 min
C	127.0 max	5.00 max
	124.5 min	4.90 min
D	0.25R ± 0.05	0.010R ± 0.002
E	12.70 ± 0.15	0.500 ± 0.006

Figure 2.1. ASTM D6110-10 Charphy Impact Test Specimen Size [11][12].

Table 2.1 is data on 3 MC Blue behavior models totaling 9 Charphy impact test specimens with dimensions of 125 mmL x 12.7 mmW x 12.7 mmT to obtain the effect of temperature on the impact energy and impact strength values in the implementation of MC Blue in the engineering field [13][14]. The heat resistance value of MC Blue is 120-150^{o}C, so the researchers adjusted the temperature variations for charphy impact testing using normal temperatures, 50^{o}C and 100^{o}C. This experimental test uses a charphy impact machine with a capacity of 300 Joule, specifically for specimens at temperatures of 50^{o}C and 100^{o}C heated in an oven [15].

Table 2.1. Model variation data for the MC Blue specimen

No.	Specimen Code	Temperature Variations (^{o}C)	Number of specimens
1	1TMB	Normal	3
2	2TMB	50	3
3	3TMB	100	3

The charphy impact testing step begins by placing the specimen on a material stand where the notch is parallel to the center point of the pendulum, then setting the pendulum arm at an initial angle of 147 degrees which can be seen in Figure 2.2 and Figure 2.3. After the settings have been completed, the charphy impact testing process can be carried out by recording the final angle results which are displayed as in Figure 2.4.

Figure 2.2. Position the test specimen at the center point of the pendulum.

Figure 2.3. Position of the pendulum arm is 147 degrees.

Figure 2.4. Final angular position after testing the specimen.

3. Result and discussion

MC Blue specimens with temperatures in sequence are normal temperature, 50^{o}C and 100^{o}C. Test data analysis has been carried out based on equation 1 and equation 2. Room temperature measurements in the testing process obtained a value of 31^{o}C as the normal temperature. Evaluation results to identify which temperature model has the lowest response to the impact energy and impact strength values of the MC Blue. Detailed data on the charphy impact test results for each temperature variation are presented in table 3.1 and table 3.2.

Table 3.1. MC Blue impact charphy test results data

No.	Specimen Code	Temperature Variations (^{o}C)	Observation Result	
			Starting Angle (degrees)	Final Angle (degrees)
1	1TMB1	Normal 31		138
2	1TMB2			137
3	1TMB3			136
4	2TMB1			130
5	2TMB2	50	147	129
6	2TMB3			128
7	3TMB1			121
8	3TMB2	100		120
9	3TMB3			119

It is reflected that the data in table 3.1 shows that specimens at a temperature of 100^{o}C has the best charphy impact resistance characteristics with a final angle of 119 degrees compared to other temperature variations. Meanwhile, the lowest charphy impact resistance occurred in specimens at a normal temperature of 31^{o}C, which was 138 degrees. Heat treatment on the MC Blue specimen resulted in increased charphy impact resistance characteristics with an average final angle of 129 degrees and 120 degrees respectively, temperature 50^{o}C and temperature 100^{o}C.

Table 3.2. Data from analysis results of impact charphy MC Blue

No.	Specimen Code	Temperature Variations (^{o}C)	Analysis Results		Average	
			Impact Energy (Joule)	Impact Strength (J/mm^2)	Impact Energy (Joule)	Impact Strength (J/mm^2)
1	1TMB1	Normal 31	15.988	0.123		
2	1TMB2		17.964	0.139	17.975	0.139
3	1TMB3		19.974	0.154		
4	2TMB1		32.787	0.253		
5	2TMB2	50	35.042	0.271	35.052	0.271
6	2TMB3		37.328	0.288		
7	3TMB1		54.170	0.418		
8	3TMB2	100	56.688	0.438	56.696	0.438
9	3TMB3		59.230	0.457		

Table 3.2 states the results of the analysis of the impact energy and impact strength values of the MC Blue for 3 variations temperature. The distribution of impact resistance with the highest value occurred in the specimen at a temperature of 100°C of 56.696 Joule at an average impact energy and an average impact strength value of 0.438 J/mm^2. The smallest charphy impact resistance characteristic is shown by the normal temperature model of 31°C of 17.975 Joule for the average impact energy value and the average impact strength value is 0.139 J/mm^2. Figure 3.1 and Figure 3.2 show that temperature variations have a concrete impact, there is an increase in impact energy on the MC Blue with the linear regression equation y = 19.361x + 2.1467 and the impact strength value also experiences a relevant increase with the linear regression equation y = 0.1495x + 0.0163 due to the heating process at different temperatures, there is a change in the microstructural density of the MC Blue, providing more resilient mechanical properties against impact loads using the charphy method.

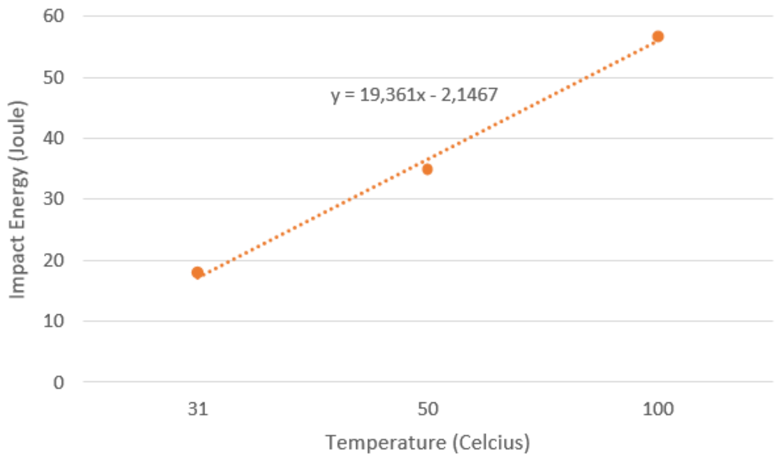


Figure 3.1. Effect of temperature on the impact energy of MC Blue material.

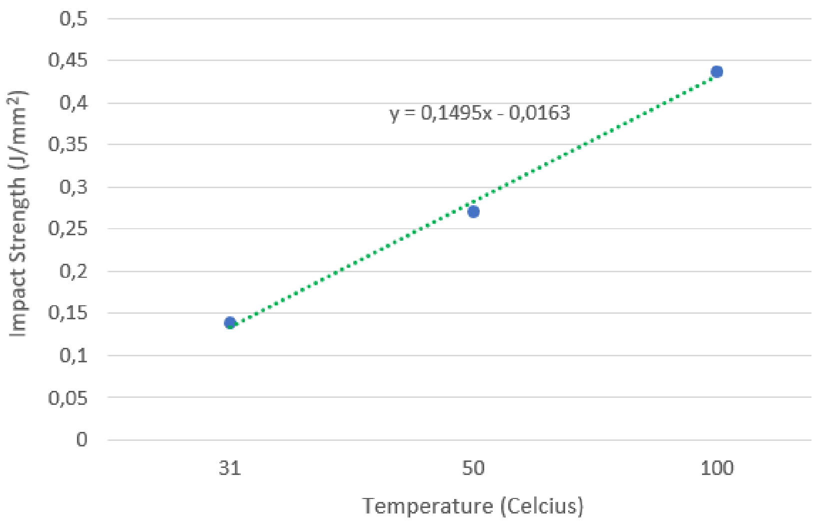


Figure 3.2. Effect of temperature on the impact strength of MC Blue material.

4. Conclusion

The experimental testing method with the charphy impact test was carried out in this research to investigate the effect of sequential temperature variations at normal conditions of 31°C, 50°C, and 100°C on the impact energy and impact strength values of the MC Blue material. The oven heating process on material test specimens with varying temperatures has a significant impact on the impact energy and impact strength values, this is because the heating process results in changes in the density of the material's microstructure to make it more resilient in accepting impact loads. Expansion of the impact energy value for the MC Blue material with the linear regression equation y = 19.361x + 2.1467 and increase in the impact strength value for the MC Blue material with the linear regression equation y = 0.1495x + 0.0163.

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