Jurnal Dinamis
Journal homepage: https://talenta.usu.ac.id/dinamis

Effect of Forging Process on Impact Strength in Brass Materials

Rakhmad Arief Siregar[1], M. Yusuf Rahmansyah Siahaan[1], Amru Siregar[1], Ahmad Yunus Nasution[2]

[1] *Department of Mechanical Engineering, Faculty of Engineering, Universitas Medan Area, Medan, 20155, Indonesia*

[2] *Department of Mechanical Engineering, Faculty of Engineering, University of North Sumatra, Medan, 20155, Indonesia*

*Corresponding Author: rakhmadarief @staff.uma.ac.id

ARTICLE INFO

Article history:

http://doi.org/10.26594/register.v6i1.idarticle

ABSTRACT

Brass material which generally has low corrosion properties and low frictional forces is very suitable for use as a construction material, piping, ammunition sleeves, jewelry and household appliances. Knowledge of strengthening the mechanical properties of brass materials is needed. In this study, the brass material was forged so that it experienced a volume reduction of 44% at three forging temperatures namely room temperature (28°C), 350°C and 450°C. To observe the impact strength, the brass material specimens were tested using the Charpy Impact tester. The ratio of energy absorbed for forged and unwrought brass specimens was observed using linear regression. The results of physical observations of the fracture pattern show a complete fracture, and the form of a grained fracture. which can be classified as brittle.

Keyword : Brass, Charpy Impact Test, Forging. Ratio of Energy Absorbed.

ABSTRAK

Bahan kuningan yang umumnya memiliki sifat korosi yang rendah dan gaya gesek yang rendah sangat cocok digunakan sebagai bahan konstruksi, perpipaan, lengan amunisi, perhiasan dan peralatan rumah tangga. Pengetahuan tentang penguatan sifat mekanik bahan kuningan sangat diperlukan. Pada penelitian ini material kuningan ditempa sehingga mengalami penurunan volume sebesar 44% pada tiga temperatur tempa yaitu temperatur ruang (28°C), 350°C dan 450°C. Untuk melihat kekuatan impak, spesimen material kuningan diuji dengan alat Charpy Impact tester. Rasio energi yang diserap untuk spesimen kuningan tempa dan tidak tempa diamati menggunakan regresi linier. Hasil pengamatan fisik pola patahan menunjukkan patahan utuh, dan berupa patahan berbutir. yang dapat dikategorikan rapuh.

Kata Kunci : *Kuningan, Uji Dampak Charpy, Penempaan. Rasio Energi yang Diserap.*

1. Introduction

Brass, which is an alloy of copper (Cu) and zinc (Zn), is widely known as a corrosion-resistant material that is widely applied in the fields of construction, piping, ammunition casings and because it looks similar to gold, it is widely used in jewelry and household appliances. The Brass Age is not known in the history of the use of metals first, there is the Copper Age, and the Bronze Age and finally the Iron Age. The absence of the Brass Age is thought to be due to the relatively more difficult manufacturing process. [1-3]. The use of Brass materials in industrial technology in Indonesia has many applications. Products such as valves, wire, LPG gas components, brass pipes, brass plates, electronic components, construction ornaments, and the handicraft industry have been manufactured in various small and medium industries. Today's increasingly modern technological developments demand an increase in the mechanical properties of brass. For instant, in bullet casings that is an alloy of brass with composition of 60% Cu and 40% Zn, at high pressure and temperature, after firing it was observed that the strength was reduced by 2% [3]. This is due to the distortion that occurs in the microstructure of the brass and also the lack of zinc (Zn) after being fired. More detailed research on bullet and sleeve standards has been carried out at the National Institute of Standards and Technology (NIST), United States [4-8].

In the process of producing a fine brass product using casting, grain size affects the use of mold [9]. They concluded that the grain size of the brass in the green sand mold was larger than that in the metallic cold mold. As the grain size decreases, the strength of cold-cast brass increases and the tendency of the casting to crack also decreases, resulting in a denser, harder, and stronger product. Research on experimental strengthening of materials on metals, alloys, and composites are still widely studied [10-15]. In this study, brass materials were forged at 28°C, 350°C, 450°C and tested for energy absorption using the Charpy impact tester. The tempered specimens were kept at a reduced volume size of 44%. Comparison of Impact Energy and Impact Strength for three variations is approached by a linear regression equation.

2. Methods

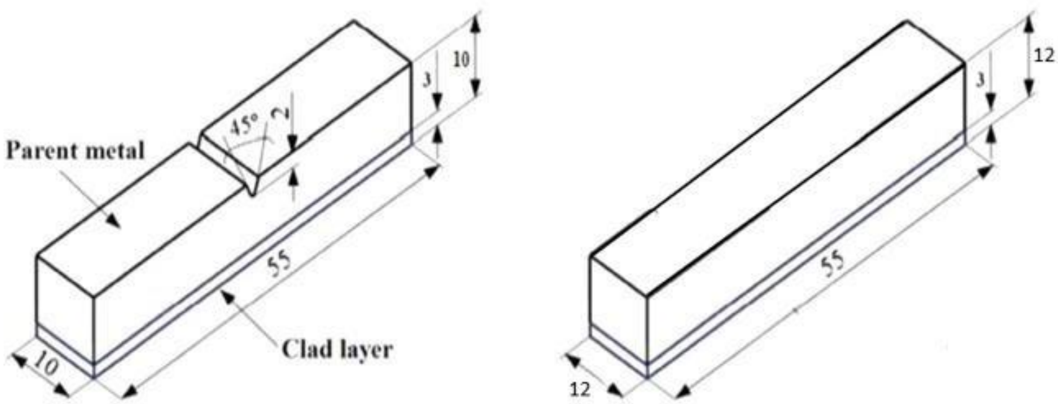
Brass Material

The intensity of copper metal is 60-96% by mass and the rest is added to zinc metal to produce brass metal. Copper as the main variable forming brass metal makes brass material antiseptic. This study used brass material purchased directly at an engineering materials store in Medan City, North Sumatra with a size of 150 mm L x 55 mm W x 12 mm T, qty = 1 pc and a size of 65 mmL x 55 mmW x 10 mmT, qty = 1 pc as shown in Fig.1.

Figure 1. Brass material.

Forging Process

Forging is a metal forming process which is a deformation process of changing the geometry of a material where the workpiece receives a compressive force. Emphasis can be done with shock pressure or pressure gradually (slowly). The pressing process will produce the shape of the workpiece that is in accordance with what is desired [16-17]. The brass material for the forging process has been cut with a hacksaw tool with a size of 55 mmL x 12 mmW x 12 mmT as many as 9 pcs as material test specimen plans. The 6 material test specimens were heated using a furnace where 3 specimens were maintained to a temperature of 350°C while 3 other specimens were at temperature of 450°C which measured uting an infrared thermometer display indicator as shown in Figure 3 and Figure 4. Furthermore, 3 other material test specimens without heating (room temperature). Then all brass specimens were subjected to the forging process with shock pressure repeatedly until ASTM E23 standard sizes [18] were obtained for the Charpy method impact test which can be seen in Fig.2.



(a) ASTM E23 impact test specimen size **(b) Specimen size before forging process**

Figure 2. Specimen size in mm for the charpy method impact test.

In Fig.2(a) is the geometric shape of the specimens for the impact test for both with and without forging process. The initial dimensions of the brass material before forging process are shown in Fig.2(b). The volume reduction is around 44% for all specimens with forging process.

Figure 3. Test specimens for brass material heating process in the oven.

Figure 4. Infrared thermometer tool.

Impact Testing

Impact test is a test using impact loading. The impact loading is a process of absorption of large energy from the kinetic energy of a load that strikes the material specimen. A standard Charpy Impact Testing Machine type CI-30 TORSEE test equipment with a capacity of 30 kg-m is used as shown in Fig.5. The impact testing process for brass materials prepared was 12 test specimens of which 6 test specimens were forged brass material with oven heating, namely 3 specimens at a temperature of 350°C, 3 specimens at a temperature of 450°C, 3 test specimens for forged brass material without heating process at room temperature and 3 test specimens for brass material without forging without heating process.

Figure 5. Test tool Charpy Impact Testing Machine type CI-30 TORSEE.

Impact energy shows the amount of energy that can be absorbed by the test specimen so that the test specimen fails. Equation 1 is used to calculate the impact energy according to the charpy impact method. While the value of the material impact strength is obtained based on equation 2 [19].

$$W_c = m_p \,.\, g \,.\, L_p \,(\cos \alpha_r - \cos \alpha_o) \quad (1)$$

$$a_{cU} = \frac{W_c}{b\,.h} \quad (2)$$

3. Results and Discussion

The brass material test specimens were carried out in 4 variations, namely 2 variations of brass material forging process with an oven heating process temperature of 350°C and a temperature of 450°C, 1 variation of brass material forging process with no heating process, and 1 variation of brass material without forging process with no heating process. The resulting material test specimens follow the standard size of ASTM E23 impact test specimens with the Charpy method. The impact test results for each variation are shown in Table 1.

Table 1. Data from the analysis of impact testing of brass materials.

No.	Forging process	Volume reduction (%)	Impact Energy		Impact Strength	
			W_c (Joule)	Average (Joule)	a_{cU} (J/mm^2)	Average (J/mm^2)
1	No forging	0	10,,86	11,51	0,14	0,14
2			11,25		0,14	
3			12,43		0,16	
4	Room temperature 28 ºC	44	13,56	15,51	0,16	0,19
5			15,84		0,20	
6			18,12		0,23	
7	Temperature 350 ºC	44	23,52	27,04	0,29	0,34
8			27,16		0,34	
9			30,44		0,38	
10	Temperature 450 ºC	44	35,67	37,43	0,45	0,47
11			37,38		0,47	
12			39,23		0,49	

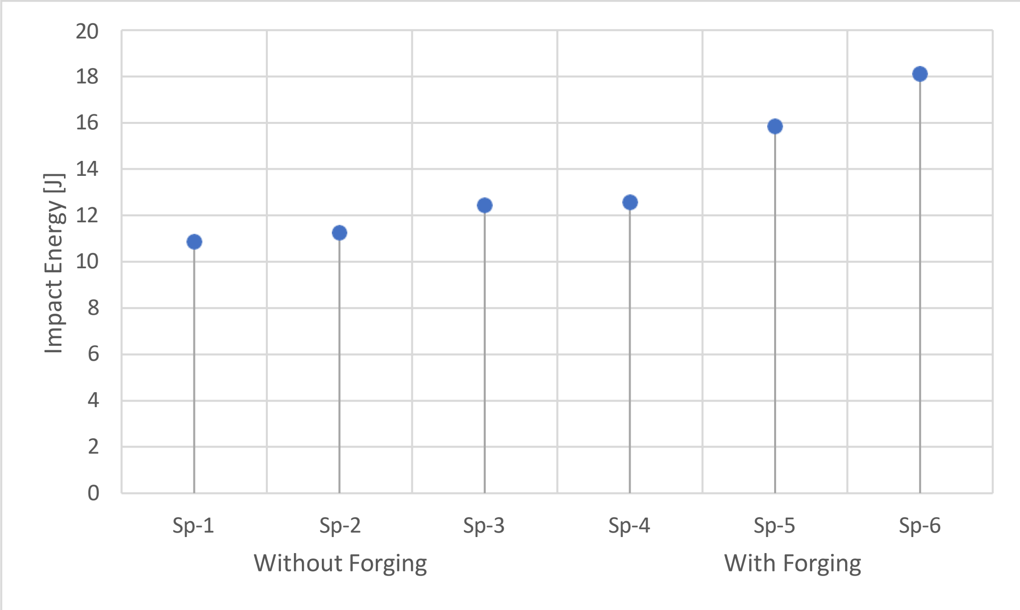


Figure 6. The comparison of impact energy of brass material at room temperature.

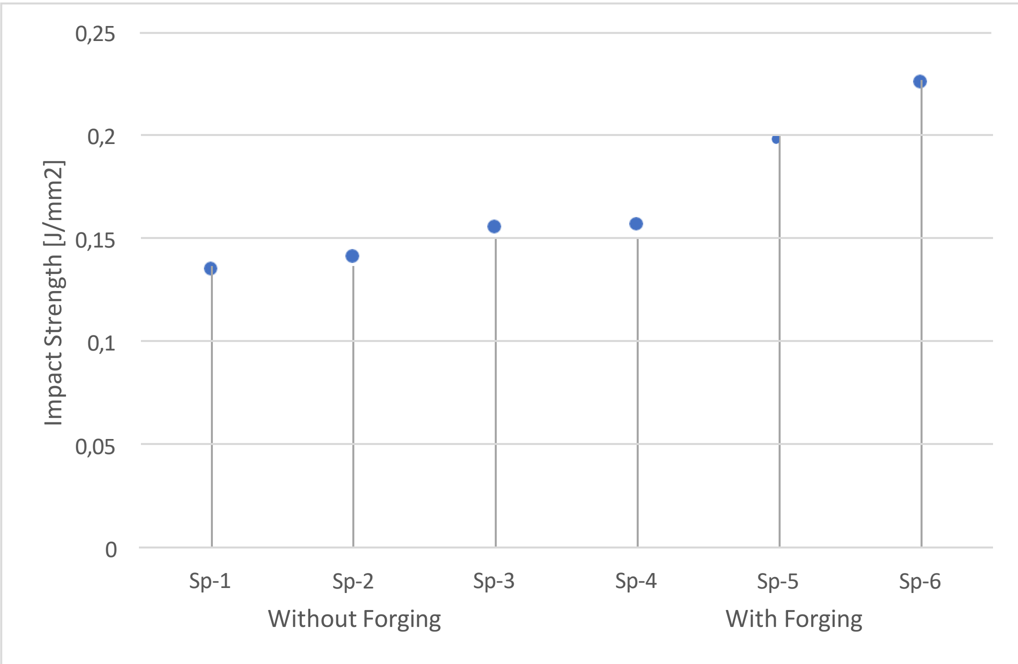


Figure 7. The comparison of the impact strength of brass materials at room temperature

Figures 6 and 7 inform that brass materials with different treatments in the formation of test specimens experienced an increase in material characteristics at the same room temperature when the impact charpy test process was carried out by 35%. While the material volume data due to the forging process to adjust to the ASTM E23 standard size has changed by 44% which is attached in Table 1.

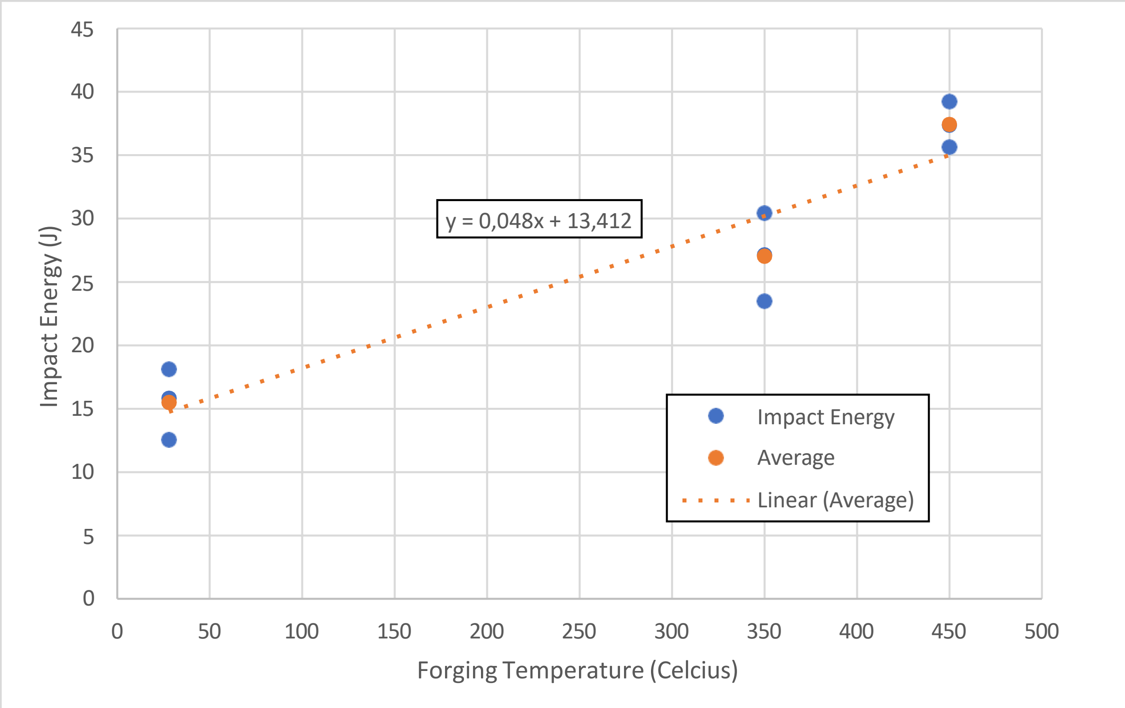


Figure 8. Effect of forging temperature to impact energy of brass material.

Brass material with 3 temperature variations of the forging process as shown in Fig.8 that the effect of temperature has a significant increase in impact energy, this can be seen according to the gradient linear equation y = 0.048x + 13.412. While the value of the impact strength of the brass material also experienced an increasing effect due to temperature variations with the linear gradient equation y = 0.0006x + 0.1676 which can be seen in Fig.9.

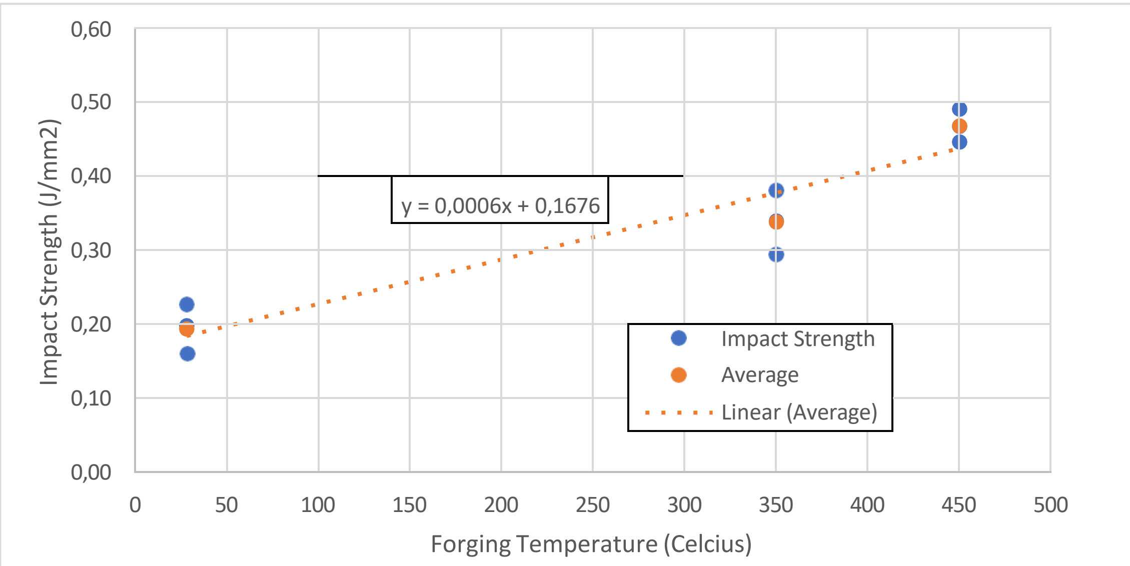


Figure 9. The effect of forging temperature to the impact strength of brass material.

The results of observations from Figure 10 and 11 based on the physical impact test specimens of the charpy method on variations of brass materials forging processes and without forging processes show that the material breaks with brittle fractures so that brass materials are classified as brittle materials.

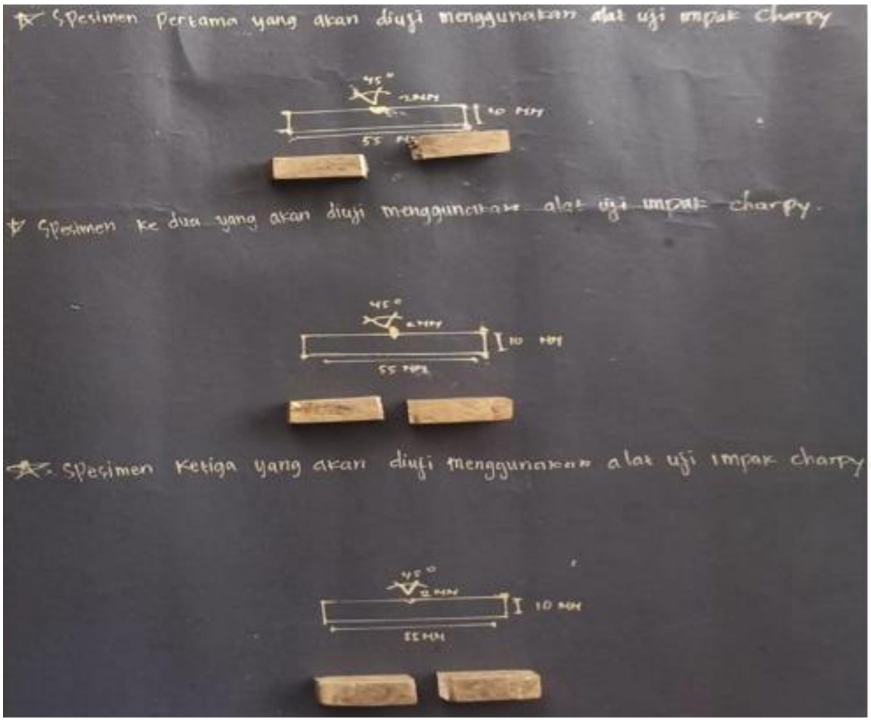


Figure 10. Physical form of fracture of brass material forging process.

Figure 11. Physical form of fracture of brass material without forging process.

4. Conclusion

This study has examined experimentally the effect of the forging process on brass materials with the following conclusions:

1. There is a strengthening of the ability of brass materials to absorb impact energy after being forged.
2. The temperature in the forging process is very influential in increasing the ability of brass materials to absorb impact energy.

Acknowledgment

Thanks are conveyed to the University of Medan Area which has assisted research in granting permission to use laboratory facilities for the manufacture of material test specimens and the University of North Sumatra for the availability of Charpy Impact Testing Machine facilities.

References

[1] W.D.Callister: Materials Science and Engineering-An Introduction, 5th Edition, John Wiley & Sons, 2000, 369.

[2] Brady G S 1991 Materials Handbook: an encyclopedia for purchasing managers engineers, executives and foremen (New York: McGraw-Hill Book Company Inc.)

[3] Abdalla Saif Eldin Mohammed, Analysis of Structural State of 60/40 Brass Cartridge Case (BCC) after Being Exposed to High Pressure and Temperature of Firing, Journal of Applied Sciences, 2019, 9, 710-724.

[4] Nabanita Basu, Rachel S. Bolton-King, Geoffrey Stewart Morrison, Forensic comparison of fired cartridge cases: Feature-extraction methods for feature-based calculation of likelihood ratios, Forensic Science International: Synergy 5 (2022) 100272.

[5] Song, J. F., et al., “NIST Random Profile Roughness Specimens and Standard Bullets,” Proc. of 2000 Measurement Science Conference (MSC), California, January 2000.

[6] Song, J. F., and Vorburger, T. V., “Development of NIST Standard Bullets and Casings Status Report,” NIJ Report 603-00, National Institute of Justice, U.S. Department of Justice, November 2000.

[7] Song, J. F., and Vorburger, T. V., “Proposed Bullet Signature Comparisons using Autocorrelation Functions,” Proceedings of 2000 NCSL, July 2000, Toronto.

[8] Song, J. F., et al., “Establishment of Measurement Traceability for NIST Standard Bullets and Casings,” Proc. 2001 Measurement Science Conference (MSC), Anaheim, CA, January 2001.

[9] M.M.Haque and A.A.Khan, Investigation on Structure and Properties of Brass Casting, J. Mater. Sci. Technol., Vol.24 No.3, 2008.

10] Yusrizha Syahid, Rakhmad Arief Siregar, dan M. Yusuf. R. Siahaan "Analisis Karakteristik Mekanik pada Komposit Kertas Kardus yang Diperkuat dengan Serat Batang Pisang ” Agrotekma: Jurnal Agroteknologi dan Ilmu Pertanian, vol. 6, no. 1, pp. 19-26, 2021.

11] Darwis Saragih, M. Yusuf. R. Siahaan, dan Rakhmad Arief Siregar "Analisis Kekuatan Mekanik Material Komposit Berserat Sabut Kelapa yang Berpeluang Diaplikasikan pada Pembuatan Spakbor Sepeda Motor” Agrotekma: Jurnal Agroteknologi dan Ilmu Pertanian, vol. 6, no. 1, pp. 27-33, 2021.

[12] Wahyu Hidayat, “Analisis Pengaruh Penambahan Unsur Nikel (Ni) Terhadap Sifat Mekanik, Struktur Mikro dan Ketahanan Korosi Paduan Tembaga Nikel (Cu-Ni) sebagai Material Alternatif Untuk Pengecoran Ball Valve”, *Repositori Institut Teknologi Sepuluh Nopember*, Kota Surabaya, 2017.

[13] Felyx B. Sihombing, M. Yusuf. R. Siahaan, dan Rakhmad Arief Siregar "Analisis Kekuatan Mekanik Material Komposit yang Berpeluang Diaplikasikan pada *Handle Rem* Sepeda Motor", JMEMME (Journal of Mechanical Enggineering, Manufactures, Materials and Energy), vol. 6, no. 1, pp. 86-93, 2022.

[14] Muliya Selamet, “Analisis Sifat Mekanik dan Struktur Mikro Alumunium Seri 6061 Hasil Proses Pengecoran dengan Variasi Penambahan Tembaga (Cu)”, *Repositori Universitas Negeri Malang*, Kota Malang, 2022.

[15] M. Yusuf. R. Siahaan, Rakhmad A. Siregar, Faisal A. Tanjung, dan Agung Saktiawan “Analisis Karakteristik Bahan Tembaga Akibat Pengaruh Proses Penempaan Terhadap Kekuatan Impak”, Jurnal RMME, vol 6, no. 1, pp. 99-105, 2023.

[16] Hosford, William F, Caddel, Robert M, Metal Forming Mechanics and Metallurgy, Third Edition, Cambridge – Inggris : Cambridge University Press.

[17] Ali Saifullah dan Mohamad Irkham Mamungkas, “Analisis Kekuatan Impact Al 6061 dengan Variasi Saluran Pengecoran pada Metode Sand Casting”, *Seminar Nasional Teknologi dan Rekayasa (SENTRA)*, Hal. 40-45, 2019.

[18] Standard Test Methods for Notched Bar Impact Testing of Metallic Materials, ASTM E23, 1 Juni 2018.

[19] Instron, Handbook Impact : Impact Test, Norwood – USA : Instron Engineering Corporation.