The Effect of Heat Treatment to the Erosion Rate of Brass Composite

Aminnudin Aminnudin*, Solichin Solichin

Department of Mechanical Engineering, Faculty of Engineering, Malang State University,
Jl Semarang 6 - Malang Indonesia 65143
**Corresponding author: aminnudin.ft@um.ac.id*

ABSTRACT

Brass composites can be improved their mechanical properties by the heat treatment process. The improvement of the mechanical properties of this technique is expected to increase the resistance of the composite to erosion that occurs in the environment of flow water. Brass composites used are composites with fly ash 5, 10, 15, and 20%. The heat treatment process was carried out using electric furnace without protective gas. Composite heat up to 350°C and 400°C for 30 min. and quenching with water. Before and after the erosion test, the weight of the test specimen was weighed with analytical scales. The treatment process affects the tensile strength of brass composites. The heat treatment process of brass composites with 5% fly ash at 350 °C produces the highest tensile strength. Erosion rate testing on brass composites showed the lowest erosion rate occurred on brass composites with 5% fly ash and heat treatment at 350°C.

Keywords: *Brass, composite, erosion rate, fly ash*

I. Introduction

Water turbine blades work in a water environment require materials that are not only corrosion resistant but must also be resistant to erosion [1]. Corrosion at the blade is mainly due to being constantly submerged in water, in a water environment the corrosion can occur faster than in the air environment. The erosion process that occurs on the blade is caused by solid objects carried in the flow of water that enters the turbine. Solid particles that are often carried are sand particles [2].

One of the metals suitable for turbine blade material is brass [3][4]. Brass has medium strength but has excellent corrosion resistant in water environment. The strength of brass can be increased by adding particles as reinforcement. One of the reinforcement materials used is fly ash [5]. Fly ash is the remains of coal combustion in steam power plants. The addition of fly ash by as much as 15% will increase the strength of the brass [6].

The mechanical properties of brass composites can be improved by the heat treatment process [7] [8]. The heat treatment process can increase the hardness of brass composites, while it can also increase the toughness of the composite [9]. The process of treating heat on a brass composite by heating the composite for 30 min. will increase the hardness and ductility of the composite [6].

Water turbines work in a water environment (submerged), receiving continuous shock and friction (erosion) loads. The water environment causes the material to become more easily corroded, besides that because it receives shock and erosion loads, the material used

DOI: 10.17977/um016v4i12020p037

must have resilient properties and be resistant to erosion. One suitable material is brass which has corrosion resistant properties and is quite resistant to erosion. In this research, erosion resistance testing at brass composite after heat treatment.

II. Material and Methods

The brass composite used in this study uses brass as a matrix and fly ash as a strengthening. Brass is an alloy of copper (Cu) with zinc (Zn) as the main alloying. The composition of fly ash used as strengthening can be seen in Table 1, and the brass composition for composites can be shown in Table 2. This is brass composition before processed to composite.

Table 1. Fly ash composition

Materials	Composition (%)
Aluminium (Al)	9.8
Barium (Ba)	0.57
Calsium (Ca)	27.4
Chromium (Cr)	0.075
Cumprum (Cu)	0.057
Ferro (Fe)	30.8
Magnesium (Mg)	3.0
Manganese (Mn)	0.32
Mercury (Hg)	0.2
Molibden (Mo)	2.1
Nickel (Ni)	0.04
Potassium (K)	1.79
Re	0.3
Silicone (Si)	21.6
Sr	0.3
Titanium (Ti)	1.24
Vanadium (V)	0.049
Yb	0.05
Zink (Zn)	0.04

Table 2. Brass composition

Materials	**Composition (%)**
Aluminium (Al)	0.8
Calsium (Ca)	0.11
Chromium (Cr)	0.046
Cumprum (Cu)	48.73
Ferro (Fe)	0.707
Manganese (Mn)	0.045
Nickel (Ni)	0.61
Phospor (P)	0.1
Scandium (Sc)	0.081
Silicone (Si)	0.39
Zink (Zn)	26.0

Composites are made by melting brass in a gas smelting furnace. Fly ash is put into brass liquid according to the specified weight. The mixture of fly ash and molten brass is stirred using an electric stirrer with a rotating speed of 500 rpm. The testing process is carried out on specimens with a size of 20 X 20 mm and a thickness of 5 mm. Brass composites tested were are casting composites, composites after heat-treated at 350 and 400 °C. The heating process is carried out in an electric furnace without protective gas, with holding time at 30 min. The electric furnace has a maximum temperature of 1100 °C with a maximum electricity power 10 kVa.

The abrasives test was done to determine the durability of the material against abrasives from water and solid particles. In this test equipment, the water from the water tank is pumped with a water pump. The water pump flows towards the nozzle to get high speed. At the nozzle, there is mixing water with sand from the mixing tank. The mixture of water and particles hit the surface of the test specimen at high speed. Before and after the erosion test the specimens were weighed using analytical scales

Fig. 1. Abrasive test apparatus

The abrasive test carried out in the laboratory of materials at the Department of Mechanical Engineering, State University of Malang. The abrasive test apparatus has ¼ Hp water pump and water tank capacity is 80 liters. Maximum water pressure is 4 atm. Tensile testing is carried out using a tensile testing machine with ASTM E8 standards. The tensile test machine has a maximum load capacity of 30 kN.

III. Results and Discussions

The results of the tensile test of brass composites after the heat treatment process can be seen in Figure 2. Hardness in brass composites occurs in brass composites and 5% fly ash with heat treatment at 350°C. In comparison, the lowest tensile strength occurs in brass composites with 20% fly ash which is heat-treated at 400°C. Generally, the tensile strength of brass composites which are heat-treated at 350°C has a higher tensile strength than those treated heat at 400°C. This happens because in the heat treatment process at 400°C the grain growth [6] and make the tensile strength decreases.

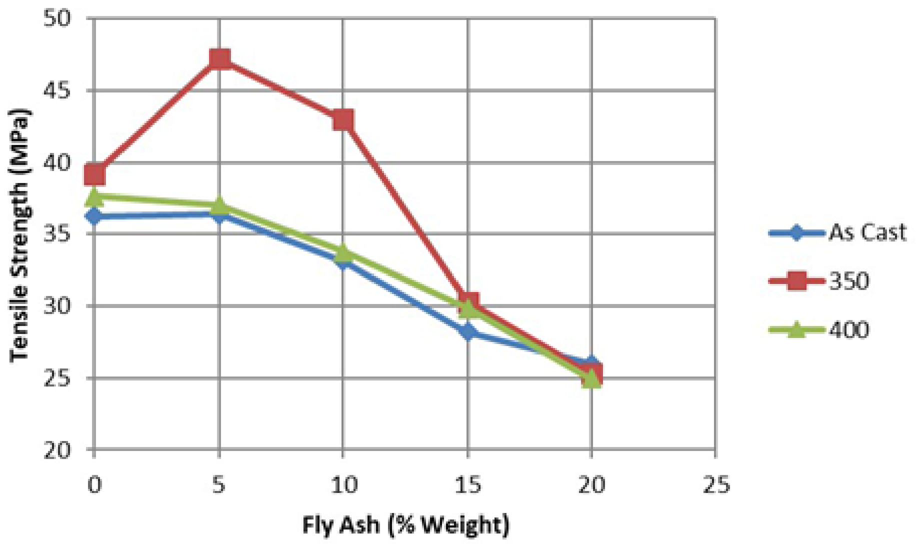

Fig. 2. Tensile strength of brass composite

The highest tensile strength of brass composites is 47.21 MPa, i.e. brass composites with 5% fly ash which are heat-treated at 350°C. The results of erosion testing on brass composites can be seen in Figure 3. Lower erosion rates indicate better material resistance to corrosion. The lowest erosion rate occurs in brass composites with 5% fly ash which is heat-treated at 350 °C.

The increasing tensile strength of brass composites is caused by changes in the composite microstructure [6]. The heat treatment process at 400 °C resulted in larger grain size compared than heat treatment at 350 °C [6]. Increasing in grain size of metals will reduce the hardness and tensile strength of the metals [10][11]. This explains why the tensile strength of brass hail composite heat treatment at 400 °C is lower compared to heat treatment at 350 °C.

The results of erosion testing on brass composites can be seen in Figure 3. Lower erosion rates indicate better material resistance to corrosion. The lowest erosion rate occurs in brass composites with 5% fly ash which is heat-treated at 350 °C. The lowest erosion rate on the brass composites occurs on the brass composites with 5% fly ash and heat-treated at 350 °C, the erosion rate is 0.0211 mg/min. The higher erosion rate occurs on the brass composites without heat treatment (as cast) (0.030 mg/min.). Generally, the lower erosion rate occurs on the brass composites heat-treated at 350 °C.

Tensile strength greatly influences the erosion rate of brass composites. The higher the tensile strength of the composite, the lower the erosion rate. This rate of erosion is not only influenced by the tensile strength but also by the hardness and ductility. According to Aminnudin (2018) [6], the highest hardness and ductility of brass composites are found in brass composites with 5% fly ash. Erosion rate on composites with heat treatment 400 °C is higher than composites with heat treatment 350 °C because of its lower tensile strength and lower ductility. This complies with previous research by Aminnudin (2018) [6].

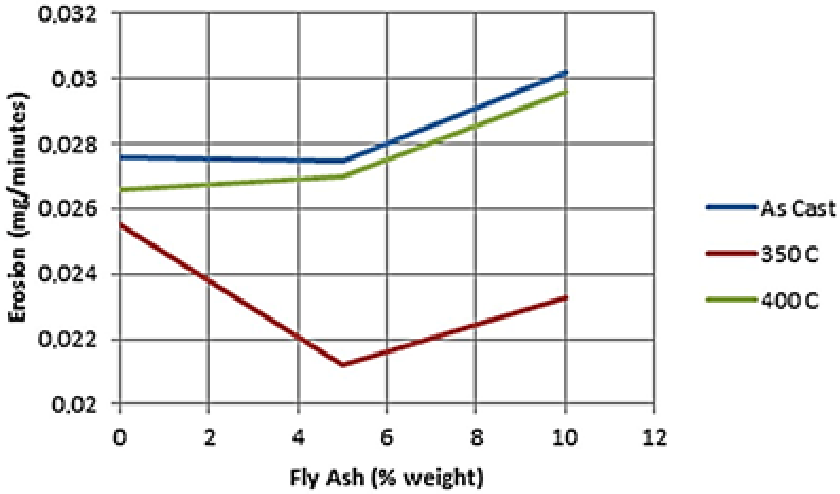

Fig. 3. Effect heat treatment to the erosion rate of brass composite

Erosion occurs on the material caused by impact energy on the material surface [12] [13]. Materials that have high ductility can withstand the impact, but the material is not resistant to scratch due to solid particles, so the erosion rate will increase. Erosion that occurs due to friction between the particle and the surface of the material continuously. The continues scratch on the material surface makes material released from the surface, this phenomenon make erosion rate high.

Hard materials are more resistant to scratches due to friction with solid particles in water, but the hard material cannot withstand the impact [14]. The impact of particle and composite surface will cause deformation on the surface of the material. On brittle materials, the maximum energy can withstand lower than ductile materials [3][10]. Therefore, metals with higher hardness are more easily released surface (erosion) than ductile metals.

The lowest erosion rate in brass composites occurred in composites that had the highest tensile strength [2]. This shows the composite also has a high ductility [6]. The ductility of brass composites with 5% fly ash content and heat-treated at 350 °C is higher compared to other brass fly ash composites [6].

IV. Conclusions

The treatment process affects the tensile strength of brass composites. The heat treatment process on brass composites with 5% fly ash at 350°C produces the highest tensile strength. Erosion rate testing on brass composites showed the lowest erosion rate occurred on brass composites with 5% fly ash and heat treatment at 350°C.

References

[1] W. D. Callister, *Materials science and engineering: an introduction*, 7th ed. Denver: John Willey and Sons, 2007.

[2] T.R.B.B. Acharya, C. Joshi, R. Saini, and O. Dahlhaug, "Sand erosion of Pelton turbine nozzles and buckets: A case study of Chilime Hydropower Plant," *Wear*, vol. 264(3–4), pp. 177–184, 2007.

[3] G.E. Dieter, D. Bacon, and G.L. Wilkes, *Mechanical Metallurgy*, SI Edition.

Singapore: Mc Graw-Hill Book Co, 1988.

[4] S. Kalpakjian, S.R.S.R. Schmid, and H. Musa, *Manufacturing Engineering and Technology*. Singapore: Prentice Hall, 2009.

[5] E. Yang, Y. Yang, and V.C. Li, "Use of high volumes of fly ash to improve ECC mechanical properties and material greenness," *aci mater. j.*, vol. 104 (6), pp. 620–628, 2007.

[6] A. Aminnudin and M.A. Choiron, "Heat treatment effect on metal matrix composite with brass matrix and fly ash," *MATEC Web Conf.*, vol. 204, pp. 1–8, 2018, doi: 10.1051/matecconf/201820405020.

[7] A. Loukus and J. Loukus, "Heat treatment effects on the mechanical properties and microstructure of preform-based squeeze cast aluminum metal matrix composites," *Int. J. Met.*, vol. 5, pp. 57–65, 2015.

[8] D.V. Hutton, *Fundamentals of Finite Element Analysis*, 1st ed. New York: Mc Graw-Hill Book Co, 2004.

[9] S.K.C.H.V. Satyanarayanaraju, R. Dixit, P. Miryalkar, "Effect of heat treatment on microstructure and properties of high entropy alloy reinforced titanium metal matrix composites," *Mater. Today Proc.*, vol. 18, pp. 2409–2414, 2019, doi: https://doi.org/10.1016/j.matpr.2019.07.088.

[10] D. Hull and D.J. Bacon, *Introduction to Dislocations*, 5th ed. Oxford, 2011.

[11] H.S. Baghbadorani, A. Kermanpur, A. Najafizadeh, P. Behjati, A. Rezaee, and M. Moallemi, "An investigation on microstructure and mechanical propertiesof a Nb-microalloyed nano/ultrafine grained 201 austenitic stainless steel," *Mater. Sci. Eng. A*, vol. 636, pp. 593–599, 2015, doi: 10.1016/j.msea.2015.04.001.

[12] F.Y. Cheng, *Erosion-accelerated corrosion in flow systems: the behavior of aluminum alloys in automotive cooling systems*. Cambridge: Woodhead Publishing Series in Metals and Surface Engineering, 2011.

[13] M.Y. Naz, N.I. Ismail, S.A. Sulaiman, and S. Shukrullah, "Electrochemical and dry sand impact erosion studies on carbon steel," *a Nat. Res. J.*, vol. 5, pp. 1–9, 2015.

[14] P. Nova K. and A. Macenauer, "Erosion-corrosion of passive metals by solid particles," *Corros. Sci.*, vol. 35 (1–4), pp. 635–640, 1993.