USE OF DIFFERENT GRADED BRASS DEBRIS IN EPOXY-RESIN COMPOSITES FOR IMPROVING MECHANICAL PROPERTIES

Younis Khalid Khdir[1], Gailan Ismail Hassan[2]

[1&2]Erbil Polytechnic University (EPU), Erbil, Technical Engineering College, Erbil
[1&2]Ishk university, Erbil, Iraq
[1]younis.khdir@epu.edu.krd, [2]gailan_hareri@epu.edu.krd

doi:10.23918/iec2018.28

ABSTRACT

This study deals with the brass debris which is obtained through matte smelting and refining of brass or different machining process like grinding operation, to use as filler in epoxy-resin composites. The common uses options for brass debris are recycling, and production of value-added waste products. In this study random mixing processes to prepare (Epoxy / brass) composites done by using brass debris of three different grades with different grain size (600, 800 and 1180) µm as reinforcement in epoxy resin with different weight percentages (2%, 4%, 6% and 8%) respectively. Using tensile and impact test to evaluate the mechanical properties of the prepared composites. Results show that with coarse grain size of brass debris added to epoxy resin, it is very important to decrease the amount of weight percentage added to it, so as to improve the tensile or impact properties of (Epoxy / Brass debris) composites. On the other hand a very low weight percentage (2%, 4%, 6%, 8%) of metal brass debris which there is no significant improvement in toughness, noticed that can significantly reduce the impact absorbed energy (impact toughness) of the composite samples. The best value of the toughness can be obtained with the epoxy-BD600 and weight percent of 8%. This research includes processing procedure, and study of the mechanical behavior of grades of such brass debris filled epoxy-resin composites. This paper concluded that the possibility of utilize of brass debris as secondary filler element for the preparation of composite materials and producing the bras debris such as added-value products.

Keywords: Waste Utilization, Debris, Composites, Epoxy Resin, Reinforcement.

1. INTRODUCTION

Using debris of waste materials obtained during matte smelting and refining of different machining process like grinding operation, to use as filler in epoxy-resin composites. In our study we focused on brass debris, because of there is limited studies using this type of filling. The best options for brass debris are recovery of waste metal, recycling, and production of composite products. The advantage of these type of composites is that they are strong and light. By choosing a suitable combination of matrix and filler material, a new composite can be made that exactly has a property which is suitable for the requirements of a particular application.

Yun Liu et al., (2016) used Cu-doped graphene (graphenit-Cu) as a filler to prepare epoxy composite, in his research to study the effect of Cu-doped graphene on the thermal properties of epoxy composites, they concluded that adding graphenit-Cu had slight effect on the thermo-mechanical properties of epoxy composite materials [1]. Keong et al., (2017) used municipal solid waste (MSW) is incineration ash, which is rich in a mixture of oxide and carbonate ceramics, as fillers for composite materials. [2]. Li and Cui (2016) focused on improving the mechanical properties of epoxy base material by adding of an amino-terminated hyper branched polymer (ATHBP) grown on glass fiber [3]. Chang et al., (2015) investigated the characterization of tungsten-epoxy composites for ɤ-rays radiation shielding by blending epoxy resin through adding different weight percent of tungsten powder [4]. Lee et al., (2016) studied using of polyethersulfone as filler material to increase the thermal and mechanical properties of triglycidyl-p-aminophenol epoxy resin [5]. Yang et al., (2016) used simple hot-press with vacuum treatment to prepare silk fabric reinforced epoxy composites so as to achieve a maximum volume fraction of reinforcement, 70% silk. They investigated mechanical properties so that the flexural strength increased linearly by increasing silk volume fraction from 30 to 60 volume % but diminished slightly at volume 70%. [6]. He et al., (2011) showed impact strength of ceria-epoxy resin composites adding the ceria nanoparticles with different shapes and sizes added to epoxy resin. [7]. Goud and RAO (2011) investigated the fibre content effect on the mechanical properties of unidirectional Roystonea regia natural-fibre-reinforced epoxy composites. [8]. Couillard and Peter (1997) studied the behavior of bending fatigue on one-dimensional, continuous-carbon-fiber/epoxy composite strands by producing a maximum strain. They determined that this type of composite did undergo fatigue and at high strains, damage occurred through matrix cracking, fiber breakage, and interfacial shear failure [9].

Papargyris et al., (2008) studied composite manufacturing techniques using conventional and microwave heating methods to prepare carbon fibre/epoxy composites to compare their mechanical and physical properties. Based on the mechanical testing similar values of the flexural strength for the two types of carbon fibre/epoxy composites were obtained [10]. Biswas and Satapathy (2010a, 2010b) fabricate hybrid composites from bamboo fiber epoxy matrix composites with various weight proportions of red mud to study erosion characteristics in comparing with glass-epoxy composites under same test conditions. They concluded that even the bamboo based composites behave relatively inferior mechanical properties, their performance of erosion wear is better than the glass fiber reinforced composites. [11, 12]. Kim et al., (2013) prepared fiber reinforced epoxy/hybrid silica composite to study their mechanical properties by adding super fibers such as aramid fiber. They confirmed that the effect of the epoxy/hybrid silica on the mechanical properties affecting in a demand for a resin system with very good mechanical properties [13]. In this work, brass debris was combined with epoxy resin by handily cold process technic to prepare different composites with various weight percent of brass debris and different size of reinforcement. The aim of this research is development of a composite with higher tensile strength as compared with pure epoxy and in the other hand we can use the wasted materials such as brass debris. The reinforcement particles distributed over the epoxy resin randomly and homogenous, to prepare these specimen for tensile and impact tests. In the experimental procedure we explained the fabricating all of these composites. And in results explained well in next section, and the conclusions of this job were written in the last paragraph.

2. EXPERIMENTAL DESIGN
2.1. MATERIALS

Transparent epoxy (Sikadur -52) is used as matrix which is a liquid of low viscosity as compared with other thermosets and its converted to solid state by adding hardener (Sikadur -52 hardener) at ratio of 2:1 the technical properties of Sikadur -52 according to the data sheet of Sika company are listed in Table 1.

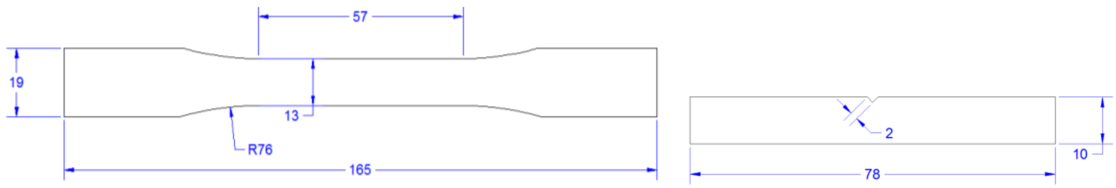
TABLE 1.
Technical properties of Sikadur -52, according to data sheet of the company.

Compressive Strength	Flexural Strength	Tensile Strength	Pot life	Density	Viscosity
53 MPa for 10 days at 20˚C	50 MPa at 20˚C	25 MPa	~ 120 min at 5˚C ~ 10 min at 30˚C	1.1 kg/l at 20˚C	~ 1200 MPa at 10˚C ~ 430 MPa at 20˚C

While the reinforcement are brass debris with different grain size (600, 800 and 1180 µm) with different weight percentages (2%, 4%, 6% and 8%) respectively. These different grain size prepared by using sieve analysis (or gradation test) is a practice or procedure used to assess the particular size distribution of a granular material. It is a simple technique of particle sizing.

2.2. PREPARATION OF BRASS DEBRIS-EPOXY COMPOSITES

A series of brass debris reinforced epoxy composites has been manufactured using simple cold techniques. The composite was made using a steel mold according to standard specifications ASTM D638, the specimen size is shown in figure 1a for tensile test. The Universal Tensile Machine LY-1066A was used to test the specimen for tensile tests. And for impact test according to standard specification ISO 179, the specimen dimension explained in the figure 1b. The LY-XBD-5 Electric Charpy Impact test machine was used for impact tests, at room temperature



(a) (b)

FIGURE 1. Specimen of (a) tensile test, (b) of Charpy Impact test, all dim. in mm.

Tensile and Impact composite samples were prepared by pure epoxy matrix (rate of 2:1 base to hardness) into both impact and tensile molds then distribute the different grades of brass debris (600 µm, 800 µm and 1180 µm) with weight percentages (2, 4, 6, and 8%) manually into both kinds of mold. The prepared tensile and impact samples (Epoxy-BD600), (Epoxy-BD800) and (Epoxy-BD1180) properties shown in Table 2.

TABLE 2.
Specifications of the prepared specimen for tensile and impact tests

No.	Symbol	Refinement	Weight fraction of Refinement WtR %
1	Epoxy	-	-
2	BD 600	brass debris of grain size 600 µm	2%, 4%, 6%, 8%
3	BD 800	brass debris of grain size 800 µm	2%, 4%, 6%, 8%
4	BD 1180	brass debris of grain size 1180 µm	2%, 4%, 6%, 8%

Both tensile and impact samples were left for one week at room temperature to be cared as shown in figure 2.

(a) (b)

FIGURE 2. Samples of prepared specimen of (a) tensile and (b) impact tests for 600 µm

3. RESULTS AND DISCUSSION

3.1. TENSILE TEST

We noticed that the fracture occurred in different areas, this phenomenon can be interpreted physically, because of the random distribution of brass debris particles and the agglomeration of some particles in some location while the density of these particles change from a location to another microscopically. The results as in figure 3a, 3b, 3c and 3d indicated that the tensile strength of the brass debris-epoxy composite increased as compared with the pure epoxy, and the elongation also increased for different sizes of reinforcement (600, 800 and 1180 μm) and different weight percent (2, 4, 6 and 8%) because of the increasing bonding area between the brass particle and epoxy resin. The existence of brass particles leads to more elongation and more strength also. Noticed that the enhance of tensile properties reaches the maximum value at Epoxy-BD600 with 8% of brass debris weight percent and the tensile strength become 48.9 MPa, as compared for pure epoxy which is 33,65 MPa. Where for the composite Epoxy-BD800 with 6% of brass debris weight percent the tensile strength reaches the maximum value of 49.16 MPa which is little greater than the tensile strength of Epoxy-BD600. Also we found that the maximum tensile strength can be obtained by the Epoxy-BD1180 with brass debris weight percent of 2% and become 45.95 MPa. And for other composite such as Epoxy-BD800 with brass debris weight percent of 6% can reach the maximum tensile strength.

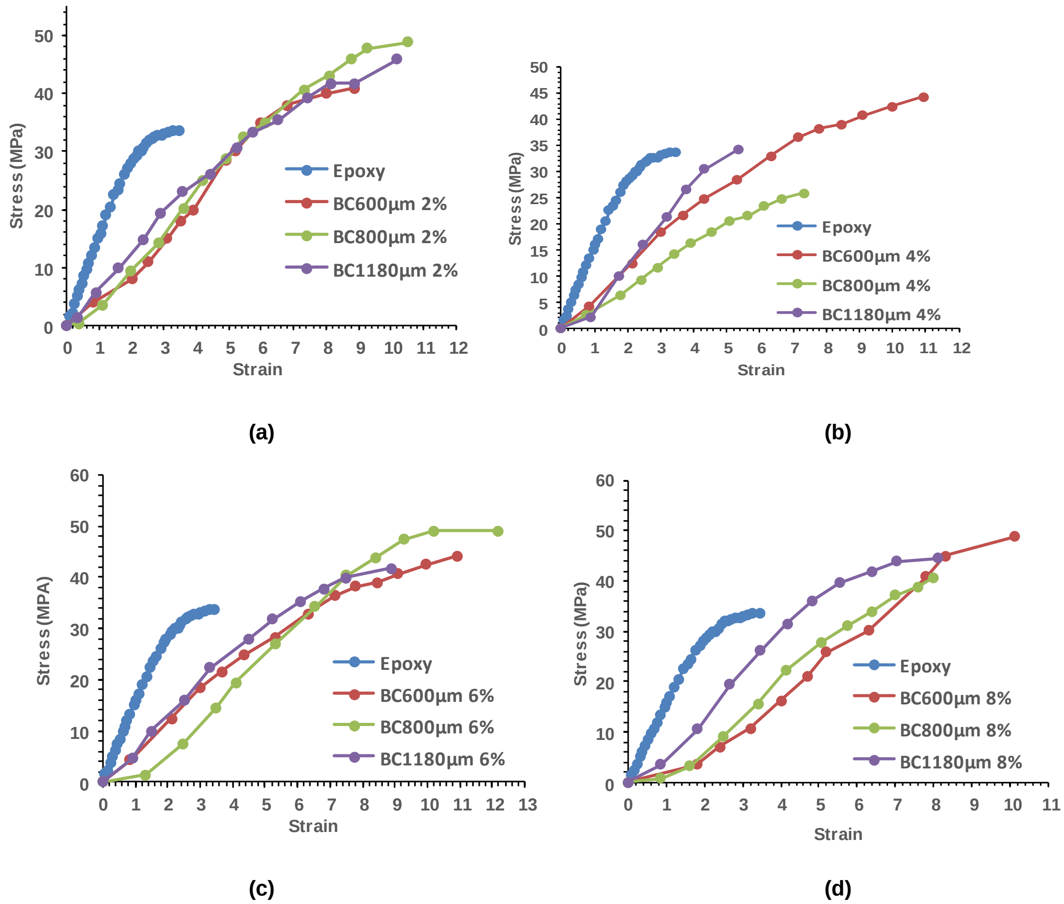


FIGURE 3. Stress-Strain curves of Epoxy and BD (600,800 and 1180 µm) for weight percentage (a) 2%, (b) 4%, (c) 6%, and (d) 8%

Comparing all the combined results explained in figure 4. According to the practical data obtained, we found that the overall maximum tensile strength can be reached by the composite Epoxy-BD800 with 6% of brass debris weight percent, as noted in the figure and reaches 49.16 MPa which is very important to be selected to produce a composite with higher tensile strength properties. Understanding of the mechanical properties of composite materials is very important for scientific professions and technical. This knowledge leads to select the suitable composite material. The materials test provides the essential data in a quantified manner. We can conclude that with increasing the grain size of the brass debris added to pure epoxy matrix, it is suitable to decrease the amount of weight percentage added. And the best of all specimen is 6 wt% (Epoxy-BD800) because it's has the highest value of maximum stress (49.16 MPa) with the highest value of strain (12.17 mm/mm). According to the result of this research, it is able to use the waste materials such as brass debris to fabricate new developed composite with higher tensile strength which can be used for different purpose.

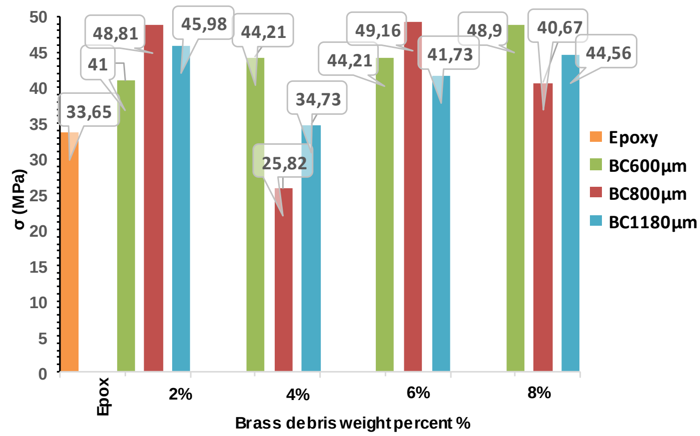


FIGURE 4. Maximum stress value of [(Epoxy-BD600), (Epoxy-BD800) and (Epoxy-BD1180)] for all weight percentage (2, 4, 6 and 8%)

3.2. IMPACT TEST

The second group of the tests is impact test. We noted that the entire specimen is broken in the notch location, for different size of reinforcement composites and different weight percent of brass debris. The results as indicated in figures 5a, 5b, 5c and 5d showed that the toughness of the composites increase with increasing the size of the reinforcement, till 800 µm, and after that any increasing in the reinforcement size leads to slight decrease in the toughness values because of the randomly distributed of the brass debris particles in the epoxy resin.

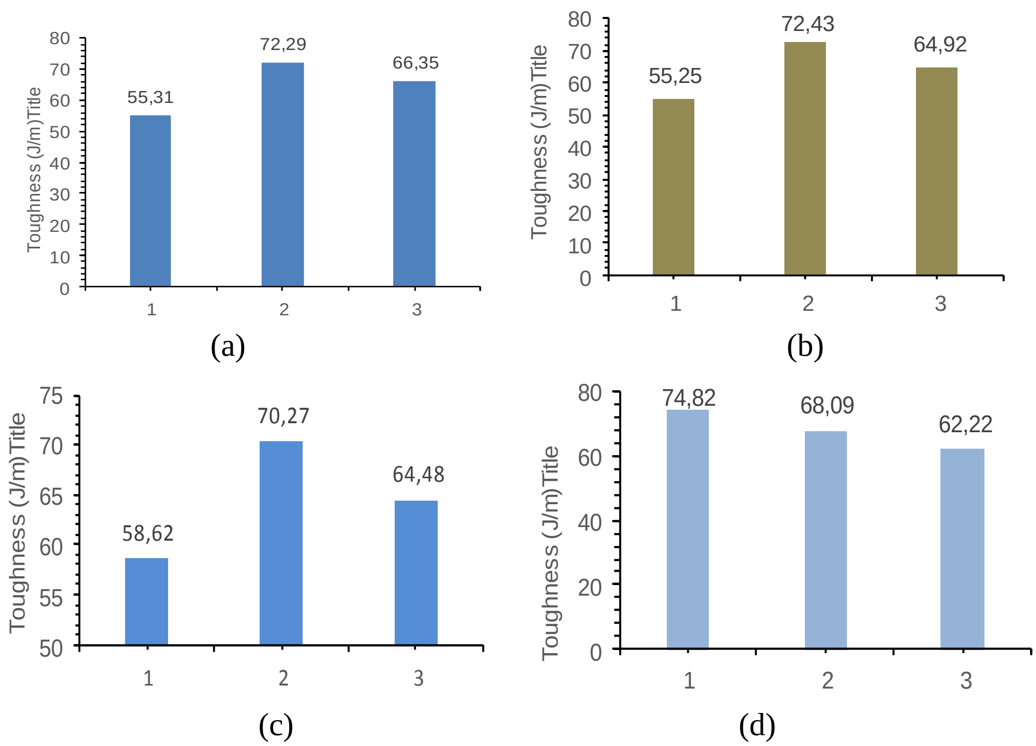


FIGURE 5. Impact Toughness of (a) 2%, (b) 4%, (c) 6% and (d) 8% for [(Epoxy-BD600), (Epoxy-BD800) and (Epoxy-BD1180)]

With increasing the weight percentage of the reinforcement particles to 8%, there is a slight decrease with increasing the particle size from 600 µm to 1180 µm as showed in figure 5d. Then if we compare all the results of toughness together with the toughness of pure epoxy see figure 6, we found that with different grades of brass debris (600 µm, 800 µm and 1180 µm) with weight percentages (2, 4, 6, and 8%), the best value of the toughness can be obtain with the epoxy-BD600 and weight percent of 8%. It is important to note that although change weight percentage addition of brass debris with different grain size, there are no significant improvement in toughness. Overall, Epoxy sample without any reinforcement has a higher toughness than the other samples. In general, there is no a significant effect for the toughness purpose for this type of composite.

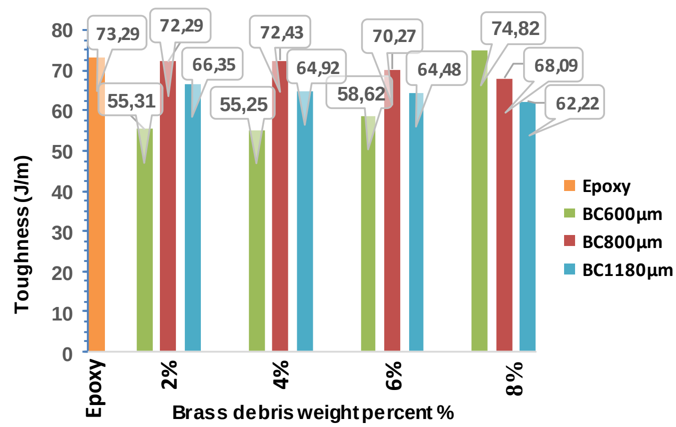


FIGURE 6. Impact Toughness of Epoxy reinforced by (Epoxy-BD 600, Epoxy-BD 800 and Epoxy-BD 1180 µm) for weight percentage (2%, 4%, 6% and 8%)

4. CONCLUSION

1. It is possible to fabricate a new epoxy composite using waste materials such as brass debris, with higher tensile strength.
2. With increasing grain size of added reinforcement to the epoxy resin, it is very important to decrease the amount of weight percentage added to it so as to improve the tensile properties of (Epoxy-Brass debris) composites.
3. It is important to note that there is no significant improvement in toughness, pure epoxy has a slight difference toughness than the other epoxy brass composites.
4. The best value of the toughness can be obtain only with the epoxy-BD600 and weight percent of 8%.

ACKNOWLEDGMENTS

Thanks to engineer Mustafa Sabah, Goran Ghafur and Rawand Younis for their efforts helping us in the practical part.

REFERENCES

[1] Y. Liu, H. V., Babu, J., Zhao, A., Goñi-Urtiaga, R., Sainz, R., Ferritto, M., Pita, De-Yi. Wang, "Effect of Cu-doped graphene on the flammability and thermal properties of epoxy composites", Composites Part B: Engineering, vol. 89, pp. 108-116. 2016.

[2] G. C. Keong, M. H. B. M. Walad, O. W. Xiong, M. N. Haikel, C. H. Ling, R. K.S/O Ravichadran, L. T. Kiang, T. L. Hing, "A Study on Mechanical Properties and Leaching Behaviour of Municipal Solid Waste (MSW) Incineration Ash/Epoxy Composites", Energy Procedia, vol. 143, pp. 448-453. 2017.

[3] S. Li and C. Cui, "Enhancing the mechanical properties of epoxy resin by addition of an amino-terminated hyperbranched polymer grown on glass fiber", Journal of materials science, vol. 51, (4), pp. 1829-1837. 2016.

[4] L. Chang, Y. Zhang, Y. Liu, J. Fang, W. Luan, X. Yang, W. Zhang, "Preparation and characterization of tungsten/epoxy composites for γ-rays radiation shielding", Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, vol. 356, pp. 88-93. 2015.

[5] S.-E. Lee, E. Jeong, M. Y. Lee, M.-K. Lee, Y.-S. Lee, "Improvement of the mechanical and thermal properties of polyethersulfone-modified epoxy composites", Journal of Industrial and Engineering Chemistry, vol. 33, pp. 73-79. 2016.

[6] K. Yang, R. O. Ritchie, Y. Gu, S. J. Wu, J. Guan, "High volume-fraction silk fabric reinforcements can improve the key mechanical properties of epoxy resin composites", Materials & Design, vol. 108, pp. 470-478. 2016.

[7] X. He, D. Zhang, H. Li, J. Fang, L. Shi, "Shape and size effects of ceria nanoparticles on the impact strength of ceria/epoxy resin composites", Particuology, vol. 9, (1), pp. 80-85. 2011.

[8] G. Goud, and R. Rao, "Effect of fibre content and alkali treatment on mechanical properties of Roystonea regia-reinforced epoxy partially biodegradable composites", Bulletin of Materials Science, vol. 34, (7), pp. 1575-1581. 2011.

[9] R.A.A. Couillard, and P. Schwartz, "Bending fatigue of carbon-fiber-reinforced epoxy composite strands", Composites science and technology, vol. 57, (2), pp. 229-235. 1997.

[10] D. Papargyris, R. Day, A. Nesbitt, D. Bakavos, "Comparison of the mechanical and physical properties of a carbon fibre epoxy composite manufactured by resin transfer moulding using conventional and microwave heating", Composites science and technology, vol. 68, (7), pp. 1854-1861. 2008.

[11] S. Biswas, and A. Satapathy, "A comparative study on erosion characteristics of red mud filled bamboo–epoxy and glass–epoxy composites", Materials & Design, vol. 31, (4), pp. 1752-1767. 2010.

[12] S. Biswas, and A. Satapathy, "Use of copper slag in glass-epoxy composites for improved wear resistance", Waste Management & Research, vol. 28, (7), pp. 615-625. 2010.

[13] D. Kim, I. Chung, and G. Kim, "Study on mechanical and thermal properties of fiber-reinforced Epoxy/Hybrid-silica composite", Fibers and Polymers, vol. 14, (12), pp. 2141-2147. 2013.