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EFFECT OF CHROMIUM REINFORCEMENT ON MECHANICAL BEHAVIOR OF ALUMINUM MATRIX COMPOSITES

Monowar Wadud Hridoy[1], Deepok Kumar Sarkar[2] and Md.Kawsar Sajib[3]

[1,2] Department of Mechanical Engineering, City University, Bangladesh
[3] Department of Mechanical Engineering, Chittagong University of Engineering and Technology (CUET), Bangladesh
mwhridoycuet59@gmail.com[1], dksppallob@gmail.com[2], cuetkawsar@gmail.com[3]

Abstract- *A composite is composed of at least two materials, which combine to give properties superior to those of the individual constituents. Now-a-days the composites have a lot of scope in various fields such as mechanical, aeronautical, marine as well as electrical because of its improved mechanical properties like hardness, toughness, compressive strength and tensile strength etc. Composites were developed to improve the performance of conventional aluminum matrix which cannot meet the requirement of modern engineering products. This research work dealt with composite metallic materials containing aluminum alloy as a matrix and chromium as reinforcement. The reinforcement weight fractions were 4%, 8% and 12% of chromium respectively. The specimens were fabricated by using the stir casting method. After manufacturing the specimens, mechanical behaviors of those specimens were studied by carrying out tensile test, compression test and hardness test. Finally, various mechanical properties of the composite were compared with those of base metal. It is found that the reinforcement of chromium enhanced the mechanical properties of base metal matrix.*

Keywords: Composite, Aluminum Matrix, Reinforcement, Tensile and Compression Test, Stir Casting.

INTRODUCTION

Metal matrix composites (MMCs) are reinforced with other metal, ceramic or organic compounds. They are prepared by dispersing the reinforcement particles in the matrix. Reinforcements are usually provided to enhance the features of the base metal like strength, hardness, tensile, conductivity etc. Aluminum and its alloys have chosen most attention as base metal in metal matrix composites due to their low density, good corrosion resistance and high thermal and electrical conductivity [1]. They offer a large variety of mechanical properties depending on the chemical composition of the Aluminum matrix. The reinforcements should be stable in the given working temperature and non-reactive too. Aluminum MMCs are widely used in aircraft, aerospace, automobiles and various other fields. Since the improvement of elevated execution components for automobile, aerospace, defense, marine & other citable industrial elements to the achievement of facilities for games and recreation the field of material of all foundation Al composite is prospective to still keep at grow. Aluminum metal matrix composite (AMC) now have an evidence expansion manuscript as effectual “high-tech” ingredients in an area of applications. AMC utilization gives important opportunity along with executive benefits, financial benefits and environmental benefits. Engineering durability of AMCs in a number of applications have been well-documented. Particle reinforced aluminum matrix composites of all the AMCs, build maximum amount of composites generated and utilized on amount and weight base. AMCs are made by “PM /stir cast/melt Infiltration/spraying/in situ processing techniques” at industrial level [2]. Chromium is one of the best alloying elements because mechanical properties such as tensile strength, compressive strength, hardness of this alloy increases with increase of proportion of chromium reinforcement up to a certain limit. Using the stir casting method, the Aluminum alloy matrix composites reinforced with chromium can be successfully done which concentrates on current studies. The main objective of this research work was to fabricate the MMCs material successfully by adding chromium as particulates. The reinforcement weight fractions are 4%, 8% and 12% of chromium respectively. The specimen was fabricated by using the stir casting method. After manufacturing the specimen, mechanical behaviors of these specimen were studied by carrying out tensile test, compression test and hardness test and compared mechanical properties with its base metal.

2. LITERATURE REVIEW

Several researches have been carried out by the researchers based on this idea. The results of the mechanical properties of aluminum alloy composites reinforced with chromium was investigated by P.I Ferreira. In that research the tensile strength, elongation and microstructure were observed. The result was the tensile strength of that aluminum alloy composites increases with the increase in %wt. of Al_2O_3 up to a certain limit but elongation decreases [3-5]. Another work which was done by C.G. McKamey [6], who has fabricated MMCs containing Aluminum alloy, chromium. The composites were fabricated by varying the wt. %fraction of chromium (2%, 4% & 6%). The result has shown that ultimate tensile strength, elongation increases with increasing wt. percentage of chromium. D D Zhu has investigated the physical properties of Ti-48 at-% Al alloy reinforced with Cr. The composition was Cr (2%) + Al alloys (rest) and Cr (4%) + Al alloys (rest) [7-8]. From the result, it was shown that hardness was increased with increasing wt. percentage of Cr. C.G. McKamey and C.T. Liu prepared Fe-28Al and Fe-28Al-4Cr (at. %) by arc melting and drop casting, using commercially pure aluminum and iron [9]. Tensile tests in different condition were performed on an Instron testing machine in air at room temperature. A new method of recycling aluminum and aluminum-alloy chips is presented by J.Z Gronostajski [10]. The method has been applied to the production of composites, characterized by good strength properties at elevated temperatures. As a reinforcing phase the FeCr powder with particle size below 75 μm was used, the amount of that phase was changed from 6 to 14 wt. %.

3. MATERIALS AND EXERIMENTAL PROCEDURES

Chromium (Cr) and Aluminum AA1100 were mixed at certain % of Cr using stir casting method. Chromium particles were prepared to mix with alloy shown in fig.1.

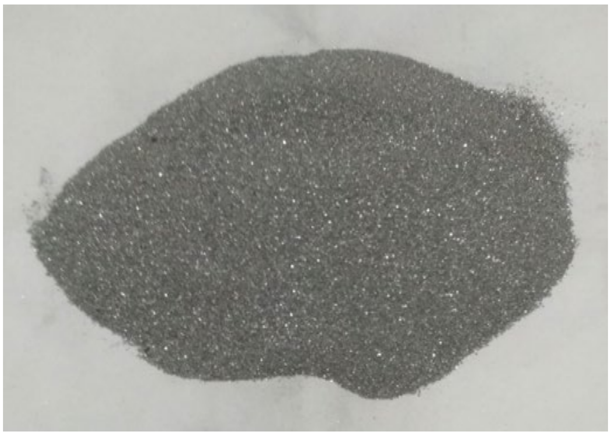

Fig.1: Chromium (Cr) before mixing

Initially, Aluminum alloy were charged into the graphite crucible. At first the alloy was heated to about 750ºC till the entire alloy in the crucible was melted in the furnace. After the molten metal was fully melted, it was stirred manually in order to remove porosity, bubbles inside of aluminum alloy. The stirrer made up of stainless steel was lowered into the melt slowly to stir the molten metal. In another crucible the reinforcement particles chromium was preheated to 1000°C for 1 hour before incorporation into the melt. Figure 2 shows the furnace into which a crucible was placed with alloy for melting in the laboratory.

Fig. 2: Preparation of Aluminum Alloy

The preheated reinforcement particles were added into the molten alloy at a constant rate during the stirring time. The stirring was continued for another 5 min even after the completion of particle feeding. Constant stirring is necessary in order to uniform mixture. For analyzing different composition of composites mainly prepared by Cr and Aluminum alloy (AA-1100) are given below in fig.3:

- Specimen 1: Only Aluminum alloy AA1100.
- Specimen 2: Aluminum alloy AA1100 fabricated with 4% of each Chromium.
- Specimen 3: Aluminum alloy AA1100 fabricated with 8% of each Chromium.
- Specimen 4: Aluminum alloy AA1100 fabricated with 12% of each Chromium.

Fig. 3: Fabricated Specimen for Tensile Test

4. RESULT AND DISCUSSION

Different tests were carried out such as tensile strength, compressive strength and hardness test and plotted against reinforcement in fig.4, fig.5, fig.6 and fig.7.

4.1 Tensile Strength Test

The tensile testing of the metal matrix composite was carried out on the Universal testing machine. Standard specimens with an area of (mm^2) were used to evaluate tensile strength & % elongation. The parallelism of the properties of the composite material was created along with the commercially pure Al 1100. Tensile strength indicates how the material will respond to forces being applied in tension. Tensile test is a fundamental test of mechanical where a safely made samples are loaded in a very controlled manner when ascertained the applied load. These types of tests may be performed under ambient or controlled (heating or cooling) conditions to determine the tensile properties of a material. Table 1 represents the tensile strength and % of elongation of all the specimens.

Table 1: Tensile strength and Percentage of elongation of all the specimens.

Specimen	Tensile Strength (Mpa)	Elongation (%)
Al-1100	70.35	0.7
Al-1100 + 4% Cr	75.61	1.65
Al-1100 + 8% Cr	79.71	1.83
Al-1100 + 12% Cr	78.35	0.66

First of all, applied force was calculated, then area. Finally, dividing the force with area strength was found. The fig. 4 depicts the tensile test of composite material. It was found that the Ultimate tensile strength was increasing from 70.35 MPa to 79.71 MPa while the % of reinforcement increasing, up to 8% of reinforcement. After a certain limit while the percentage of reinforcement increased then the ultimate tensile strength had decreased at 12% reinforcement. The probable reason behind that might be due to the presence of any weak portion in the specimen as the breaking of specimen occurred first at the weak section while tensile testing. Thus, the tensile strength automatically falls.

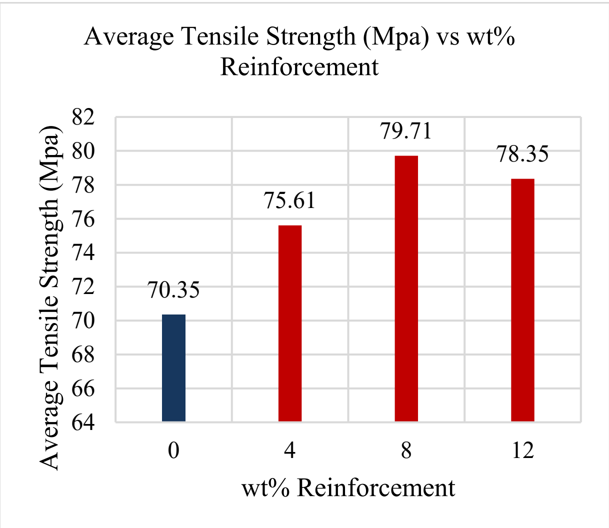

Fig. 4: Variation of Tensile Strength with respect to Reinforcement

The percent elongation was increasing with wt. % of mixing agent up to a certain limit while sometimes it decreased with increasing wt. % of mixing agent indicated fig. 5. That might be due to the non-uniform mixing of the component added. As at the time of tensile testing if some portion of the entire specimen remains weak due to porosity, non-uniformity then the breaking of the specimen would be occurred first at that portion and thus the elongation as well as the tensile strength might be lower as expected.

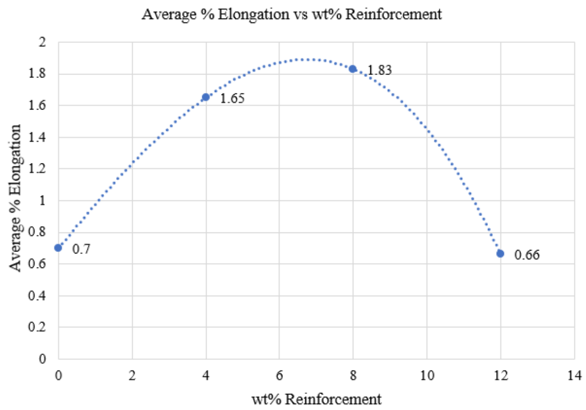

Fig. 5: Elongation Vs wt. % of Reinforcement

4.2 Compressive Strength and Hardness Test

For testing the compressive strength of the material, some specimens were needed to be drawn for creating the pattern for molding. The length of the specimen was around 5 cm and diameter were around 2.5 cm as per ASTM recommendation. Similarly, for the hardness test, the tensile test specimen was used. Hardness is a nature of a material, not a fundamental physical property. The Brinell method invested a preset test load (*P*) to a carbide ball of constant diameter (*D*) which was taken place for a preset time period and then removed. Brinell microscope or optical system was used for measuring impression across at least two diameters – usually at right angles to each other and these results were averaged (*d*). The table 2 represents the compressive strength & hardness of the specimens. Ball diameter was 5 mm used for this test and load applied 750 kg.

Table 2: Experimental observation of Compression & Hardness Test.

Properties	Al-1100	Al-1100 + Cr 4%	Al-1100 + Cr 8%	Al-1100 + Cr 12%
Compressive Strength (Mpa)	359.56	376.05	384.17	382.57
Hardness (BHN)	62.42	70.37	82.73	81

From the fig. 6 it was found that while the reinforcement percentage of material increased, the compressive strength increased from 359.56 MPa to 384.17 MPa up to 8% of reinforcement and then fell at 12%.

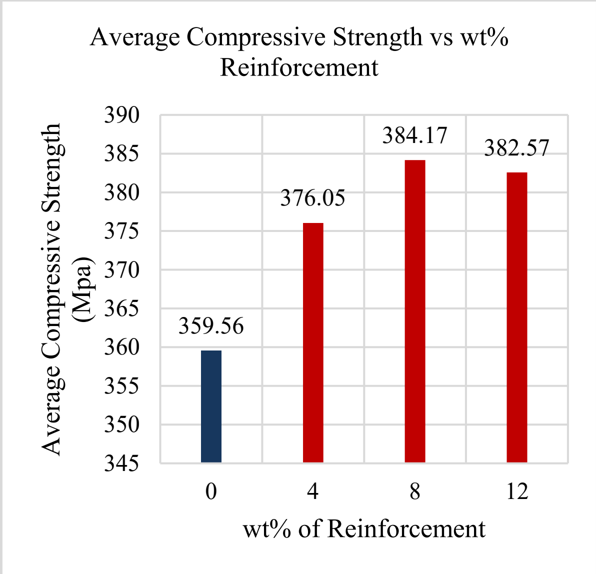

Fig. 6: Variation of Compressive Strength with respect to Reinforcement

While the chromium reinforcement increased, the hardness of composite material also increased from 62.41 BHN to 82.72 BHN, but at 12% reinforcement hardness decreased which is shown in fig. 7.

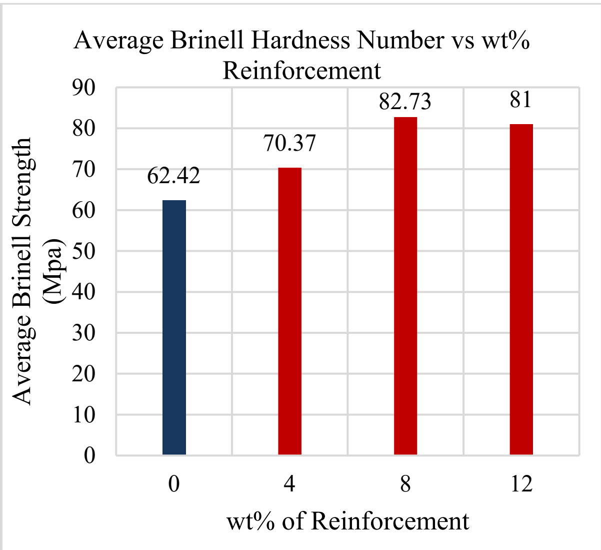

Fig. 7: Variation of BHN with respect to Reinforcement

5. CONCLUSION

Aluminum matrix composites have been successfully fabricated by stir casting technique with fairly uniform distribution of Chromium particles. From tensile test it was found that the tensile strength increased from 70 MPa to 79.71 MPa for 8% of reinforcement. The increasing rate was 13.9%. After that then it started to decrease. Also, it was observed that the compression strength increased from 359 MPa to 384 MPa. The increasing rate was almost 6.96%. After that, it started to decrease. It was appeared from this study that hardness of the proposed composites increased with an increase in weight percentage of Chromium up to a certain limit from 62 BHN to 82.72 BHN, after then it also started to decrease.

6. REFERENCES

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7. NOMENCLATURE

Symbol	Meaning	Unit
AMC	Aluminum matrix composites	-
MMCs	Metal matrix composites	-
ASTM	American Society for Testing Materials	-
A	Cross Sectional area	mm^2
σ	Stress	Mpa