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Experimental investigation of Aluminium alloy hybrid metal matrix composites reinforced with B_4C and Gr

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ABSTRACT

Aluminium alloy hybrid composites are a innovative cohort of metal matrix composites that have the potentials of satisfying the current anxiety of advanced engineering relevance. These anxiety are met due to enhanced mechanical properties, amenability to conformist dispensation technique and possibility of plummeting manufacture cost of aluminium hybrid composites. In this investigational study, Aluminium alloy (LM25) based boron carbide (B_4C) and graphite (Gr) particle reinforced hybrid composite materials were manufactured by stir casting. The casted specimen involve in mechanical testing like hardness and tensile test as per ASTM standards.

Keywords: Metal matrix composites, Stir casting, hardness, Tensile test, Micro-structure

INTRODUCTION

The augmenting demand for luminosity weight, low-priced, energy saving, inflexible and strapping material in aircraft, space, defence and automotive applications has enthused a progressively increasing stab to extended composite material. Nowadays, Metal Matrix Composites (MMCs) are under serious consideration to replace conventional materials for a large number of structural applications such as aeronautical / aerospace, transportation, defence and sports industries because of their superior properties [1]. The different reinforcing materials used in the development of AMCs can be classier into three broad groups, which are synthetic ceramic particulates, industrial wastes and agro waste derivatives. The final properties of the hybrid reinforcement depend on individual properties of the reinforcement preferred with the matrix alloy [2, 3, 4]. In addition, the dispensation path approved for combined AMCs depends on the environment of the matrix alloy and reinforcing materials which also impudence the final properties of AMCs [4, 5, 6, 7]. This is because most of the parameters put into consideration during the design.

LM25 is commonly applied are marines, chemical, food and electrical for illustration benefit abundant additional wide-ranging uses. It is widely utilized in the automobile industries where Engine cylinder blocks, heads, and other parts are consistently shined in this aluminium alloy. LM25 is intentions a suitable machinability [8]. LM25 aluminium alloy having a density of 2.68 gm/cm3 and protuberant possessions like, heat conduction, toughness, weight etc., be preferred as the pedestal matrix due to its convention in automobile pistons. In the function of growing the wear resistance of this piston alloy, B_4C particles of 200 mesh sizes were preferred as reinforcement. This B_4C has the low density (2.52 gm/cm3), privileged hardness

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comparative to SiC and Al_2O_3, outstanding chemical and thermal permanence (9), which formulates it as a proper reinforcement to improve the wear performance of the alloy. This graphite density 2.26 g/cm3 and the hardness of the composites diminish as the % of graphite (Gr) increases (10).

Based on the study, to augment the hardness and tensile properties for automotive tenders, LM25 aluminium alloy matrix reinforced with 5 wt% of B_4C and 5 wt% of Gr particles remained formed by stir casting route.

EXPERIMENTAL SETUP

Stir casting

The spectroscopy analysis was carried out for LM25 aluminium alloy and its chemical composition was given in Table 1.

Table 1: Chemical composition of LM25 aluminium alloy

Elements	*Si*	*Fe*	*Cu*	*Mn*	*Mg*	*Cr*	*Ni*	*Sn*	*Ti*	*Pb*	*Ca*	*Sb*	*Zn*	*Al*
%	7.23	0.73	0.12	0.14	0.29	0.02	0.02	0.01	0.02	0.01	0	0	0.14	Balance

Stir casting method was used for the manufacture of the composite owing to its cost-effectiveness (Mishra et al., 2012). Primarily matrix material was tended to the graphite crucible in addition to liquefy in an electric furnace. The melted liquefy of the alloy acquires position in an immobile gas atmosphere, which shuns chemical reaction along with constructs a hum casting. Subsequently accomplish the molten metal circumstance, preheated reinforcements was additional repeatedly to the molten metal as well as stirred constantly at 350 rpm for 6 minutes to ensure uniform distribution of reinforcement particles of molten metal. The molten metal liquefy was then dispensed at the temperature of 780°C into preheated (330°C) steel moulds of dimensions 100 × 14 mm and allowed to solidify.

Micro-structural investigation

The composite specimen linger intellectual for abolish garbage nearby on the surface. Particle distribution vestiges expected at the optical microscopes. The casting process remained inspected under the optical microscope to conclude the reinforcement pattern of shine structure. A section remained cut from the castings. They remained grained using 100 grit silicon carbide paper tracked by different grades of emery paper before optical surveillance the samples were instinctively sophisticated and etched by Keller's reagent to attain a better disparity. The specimens' lingered portrait on different magnifications to demonstrate the incidence of reinforcements and its distribution of the metal matrix assorted rudiments/amalgam which were present in the graphite with boron carbide are intricate to discriminate by optical micrographs.

Hardness measurement

Micro hardness testing is a method for measuring the hardness of a material on a microscopic scale. Micro hardness was calculated by using MVH-II digital micro hardness tester as shown in Figure 1. A precision diamond indenter is frightened into the material at loads from an only some grams to 1 kilogram. The intuition length, calculated microscopically along with the applied load is used to estimate a hardness value. The indentations are characteristically finished by means of either a square based pyramid indenter or an elongated, rhombohedral-shaped indenter.

Figure 1 Vickers micro hardness tester

Tensile testing

The micro tensile test was conceded out in harmony with ASTM B-557M standards by means of dissimilar specimens as a dimension of 50 mm length and gauge length of 30 mm as shown in Figure 2 for each MMC's family. The cast specimens are arranged by the machining as per the standard. The micro-tension was approved out for the elongation, load capacity, tensile properties, with respect to the speed, for the sample, tensile readings trace. The digital tensometer among two perfunctory seize is used to hold the tensile specimen as shown in Figure 3.

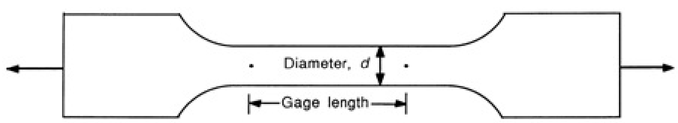

Figure 2 Tensile test specimen

Figure 3 Digital tensometer setup

RESULT AND DISCUSSION

Microstructure of the composite

The microstructure of the composite specimen and its tribological behaviour was evaluated.

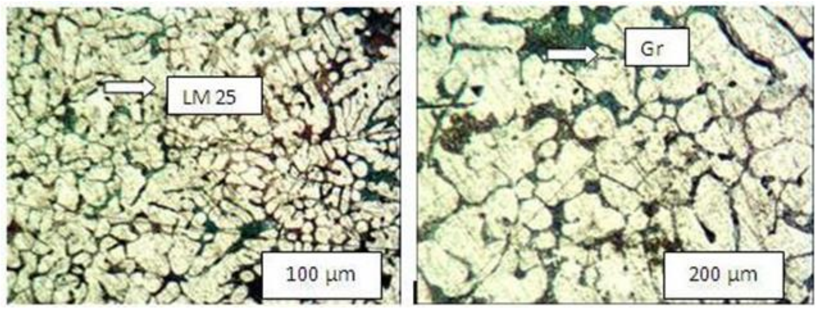

Figure 4 Optical microstructure of the aluminium alloy LM25 and reinforcement of 5% graphite and 5% of boron carbide with (a) 100×, (b) 200×

The appearance microstructures of LM25 aluminium alloy and reinforcement of 5% graphite and 5% boron carbide are shown in Figure 2 at magnifications of 100×, 200×. Micro structural investigation reveals that the particle distribution of the matrix was uniform. In this case, the presence of 5% boron adds an advantage by reducing the corrosion due to the reaction against aluminium with the graphite. It was clear that the 5% graphite reacted with the aluminium and arising Al_4C_3 carbide induces corrosion and its larger volume in relation to the substrates can cause squeezing it out from the matrix to the reinforcement. This led to breaking and degradation of the reinforcement, and finally led to deterioration of the strength properties. It may be due to the formation of boron carbide by the reaction against carbon and boron, and it results to augment in strength and hardness.

Hardess value

Table 2: Micro hardness Measurement value

Sample	Micro Hardness No.
LM 25	123
LM 25 + 5%B4C+5%Gr	137

A micro hardness tester MVH-1is used for the micro hardness measurement. To measure hardness specimen with dimension (10 mm X 12 mm) is prepared. The surface creature weathered generally necessitates a metallographic cease and it was done with the help of different grit size emery paper. Load used on Vickers micro hardness tester was 200 grams at 10X optical zoom with dwell time 20 seconds for each sample. The result of Vickers micro hardness test for alloy LM25 without reinforcement and the wt. % variation of different reinforcements such as C and B_4C in Al alloy MMCs are shown in Table 2.

Tensile test

Figure 5 shows the variation in micro tensile strength with the MMC's. It load value increase based on the reinforcement of graphite and boron carbide.

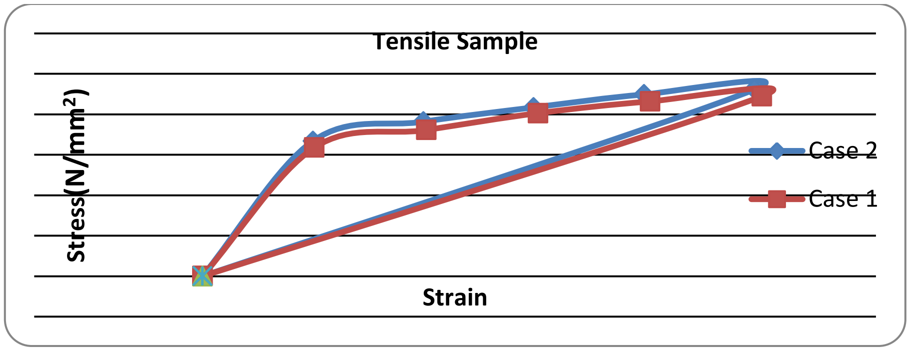

Figure 5 Stress vs strain curve of MMC's

CONCLUSIONS

It has been observed that the tensile possessions of the composites such as tensile strength, of the composites, are also deeply prejudiced by the adding together of reinforcement. The tensile strength of Gr and Gr/ B_4C reinforced hybrid particulate aluminium composites was deliberated and the maximum tensile strength observed is 225 N/mm2 at 5% of Gr and 5% of B4C. The tensile behaviour of SiC/Gr reinforced hybrid composites demonstrated improved results when contrasted with single reinforcement. From the studies of microstructure, it divulges that the uniform distribution of reinforcing particulates acquires position in the matrix.

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