International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Fabrication and Testing of an Aluminium a356 Alloy Base Composite Blend with Al_2O_3 Particle

Gyanendra Singh[1], Akash Singh[2]

P. G. Student Department of Mechanical, Engineering Invertis University Bareilly

Abstract: ***Aluminium is quite a new material and the production of aluminium alloy castings has greatly increased in the last recent years. Nowadays, there is a continuous market requirement to produce lighter vehicles and to increase fuel efficiency, therefore roughly two thirds of all aluminium castings production is within the automotive field. Even though the applications of aluminium in this scenario are considerable, some aspects affecting the quality and the soundness of cast products are still not fully understood. Aluminium matrix composites with Al_2O_3reinforcements give superior mechanical & physical properties. Their applications in several demanding fields like automobile, aerospace, defense, sports, electronics, bio-medical and other industrial purposes are becoming essential for the last several decades. Various manufacturing processes e.g. stir casting, ultra-sonic assisted casting, compo-casting, powder metallurgy, liquid infiltration are being utilized for the production of the aluminium matrix composites. These composite materials possess improved physical and mechanical properties e.g. lower density, low coefficient of thermal expansion, good corrosion resistance, high tensile strength, high stiffness, high hardness and wear resistance. This paper reviews the characterization of mechanical properties with production routes of powder metallurgy and castings for aluminium matrix- Al_2O_3 composites. Reinforcing aluminium matrix with much smaller particles, submicron or nano-sized range is one of the key factors in producing high-performance composites, which yields improved mechanical properties. The A356 belongs to a group of hypo eutectic Al-Si alloys and has a wide field of application in the automotive and avionics industries. It is used in the heat treated condition in which is an optimal ratio of physical and mechanical properties is obtained. The alloy solidifies in a broad temperature interval (43 ºC) and is amenable to treatment in the semi solid state as well as casting [1,2]. Forthis reason it is the subject of rheological investigations. The study of the wear behavior of the particle reinforced aluminum matrix composite developed using different fabrication techniques done by many researchers is discussed in this chapter. The work of this review paper is planned with the aim keeping in view the gap in the study, which act as the base of further investigation.***

Keywords: automotive, avionics, fabrication, matrix, property, etc.

1. Introduction

Light metal casting is an integral component of today's modern economy with applications found in virtually any technological sector, though in particular automotive and aerospace. Metallurgists are constantly working to develop improved alloys through combinations of chemistry and processing.

Three decades of intensive materials research have provided a wealth of new scientific innovation to synthesize special materials with enhanced efficiency with low manufacturing cost to fulfill the long pending demands of the engineering sector. A new system of materials containing hard particulates embedded in a metal matrix have exhibited superior operating performance and improved tribological behaviors.Among MMCs, aluminium alloy based composites had shown the significant improvement in the mechanical, thermal, electrical and wear properties to cater the demand of the industries. Al alloys are termed as versatile materials to be used for numerous engineering applications because of its better machining, joining and processability. In addition to this, low cost, increased strength to weight ratio and other environmental friendly characteristics of Al alloys make them a preferable material in engineering applications [3]. Among the aluminium alloys, Al-Si alloy is well known casting alloy having high wear resistance, low thermal expansion coefficient, good corrosion resistance with improved mechanical properties over a wide range of temperatures.

The grain refiner elements modify the Si morphology from coarse to lamellar (fine), thus enhancing the mechanical properties [1]. Different researcher developed numerous composite materials by using different type of matrix, reinforcement size, shape and volume as well as suitable processing technique depending upon the requirement and application. In order to achieve the optimum properties of the metal matrix composite, the distribution of the second phase in the matrix alloy must be uniform, and the wettability or bonding between these substances should be optimized. [2]. Rao and Das [4] prepared cast aluminium-alumina composites by incorporating alumina particles while stirring the molten alloy with an impeller.

The particles were added in the molten metal during mixing and thus the process of stir casting emerged. In addition to this mixing of non- wetting particles into alloys was promoted by addition of alloying elements such as magnesium during the composite synthesis. Prasad et al. [5] began the practice of introducing particles to semi-solid alloys at a temperature between those of the solids and the liquids for the alloy. Wear behavior of ceramic particle(s) reinforced AMCs has been studied by several workers. It includes reinforcement of SiC, Al_2O_3, TiC, C, B4C, fly ash, TiB_2, Al_3Zr etc. either singly or in hybrid way. The brief summary of their study has been given in this review paper.

Significant work in the area of thermal analysis has been done on identifying the effects that chemical changes, such as the composition of Si and Cu, have on the resultant thermal curves and microstructural/mechanical properties. This sort of work has led to accurate baselines and fraction solid information for alloys solidified at quasi-equilibrium rates. An area that requires further study, however, is the evolution of fraction solid information as cooling rates increase. Rapid cooling, in the presence of adequate feeding conditions, is generally desirable in industry because it generates highly-refined grain structures and allows alloying elements to remain dissolved in the matrix as opposed to intermetallic precipitation.

However, in order for thermal analysis to aid alloy development at increased rates, new hardware and mathematical models need to be created. This thesis is focused on the experimentation and subsequent analysis of samples and thermal data generated using new hardware accessories developed for the Universal Metallurgical Simulator and Analyser Technology Platform (UMSA).

Composites are combinations of two materials in which one of the materials, called the reinforcing phase, is in the form of fibre sheets or particles and are embedded in the other material called the matrix phase. The primary functions of the matrix are to transfer stresses between the reinforcing fibres/particles and to protect them from mechanical and/or environmental damage whereas the presence of fibres/particles in a composite improves its mechanical properties such as strength, stiffness etc.

2. Fabrication of Al-a356 Alloy With Al_2O_3

The commonly used matrix materials are Al, Zn, Cu, Mg, etc. and reinforcement materials are Al_2O_3, Gr, ZrO_2, etc. The particle size, volume fraction, shapes of the particles very much influence the mechanical properties of composite materials. The earlier researchers worked on Al/Al_2O_3, Al/Al_2O_3, Al/Gr reinforced material, which enhances the physical and mechanical property of the composite material. Davidson studied on mechanical behaviour of 6061 aluminium alloy reinforced with copper coated and uncoated AlO particles.

(A)

(B)

Figure 1: Raw material :- (A)Al_2O_3 Granules and (B) Al-a356 Granules

Figure 2: Stir Casting Apparatus Instrumentation

Stir cast method is practically easy, cost is less, and uniform distribution of the reinforcement into matrix alloy is possible. Stirring was carried out at semi solid condition and all the particles were easier to incorporate in matrix alloy.

After solidification this is our product and it need some lathe machining operation such as- turning, facing, taper turning etc.

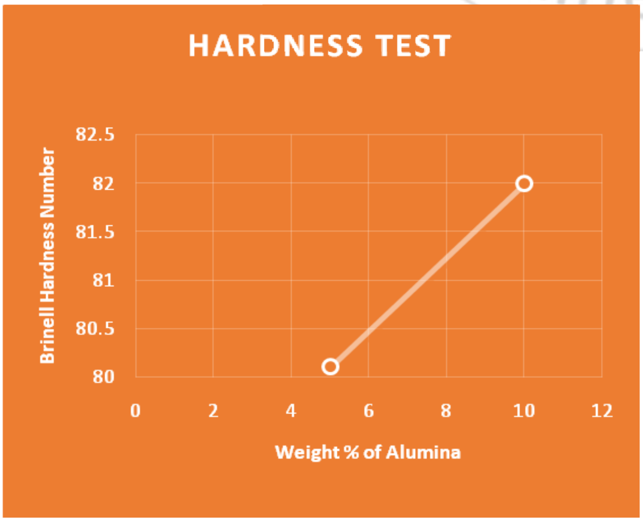
Figure 3: Al composite bar after solidification

Figure 4: After solidification of Al composite

3. Results and Discussion

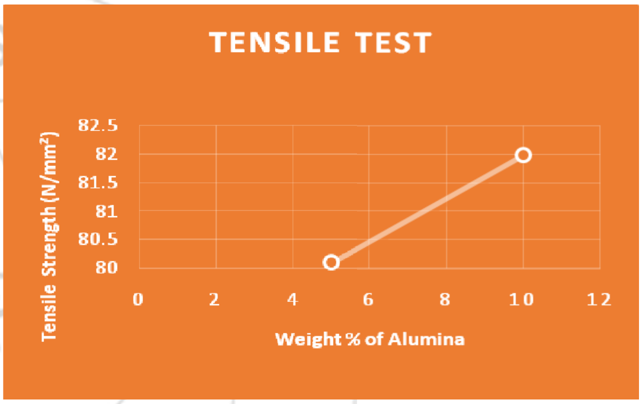
1) **Brinell Hardness Test:** There are two aluminium composite sample, one with 5% reinforcement and other with 10% reinforcement of alumina with aluminium alloy a356 alloy matrix.

Figure 5: Brinell Hardness Testing Machine



2. Tensile test: There are two aluminium composite sample, one with 5% reinforcement and other with 10% reinforcement of alumina with aluminium alloy a356 alloy matrix.

Figure 6: Universal Testing Machine



4. Scope of the Present Investigation & Conclusion

By reviewing the literature on the aluminium metal matrix reinforced materials, it was observed that reinforcement of the variety of ceramic particulate have been studied in details. Even the tribological and wear properties with various types of reinforcement material, e. g. Al_2O_3, SiC, TiB_2, graphite have been discussed in a review article[6]. The interest in natural mineral reinforced composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Natural minerals like garnet, zircon, rutile, sillimanite etc. can be used as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to others ceramics used for the manufacturing of composites [7. The literature review reveals that comparatively less work has been done on the reinforcement of Al matrix with minerals. Moreover, in the published articles, the tribological studies of the mineral reinforced composites with the variation of particles size and amount of reinforcement have not been studied in a systematic manner. The wear characteristics at high temperatures and also under the high applied loads need to be explored for high temperature structural applications. Limited work has been done on rutile reinforced aluminium matrix composites.

To bridge this gap it is planned to study the wear properties of Al alloy reinforced with rutile mineral in various concentrations 5%, 10%, 15% and 20wt.% and with the variation of different particle sizes with fine sized particles (50-75µm) and coarse sized particles (106-125µm). Tribological behaviour of the samples has been studied under different loading conditions varying from 9.8N to 49.0N and under various temperatures ranging from 50^{o}C to 300^{o}C. Microstructural analysis of the prepared samples and the worn surfaces and debris has helped in determining the type of wear mechanism responsible for the loss of material during the dry sliding.

References

[1] N. Wang, Z. Wang and G.C. Weatherly, "Formation of Magnesium Aluminate (spinel) in Cast SiC Particulate-Reinforced Al (a356) Metal Matrix Composites", Metall. Mater. Trans., 23 (1992) 1423-1431.
[2] J. Hashim, L. Looney and M.S.J. Hashmi, "Metal matrix composites: production by the stir casting method", J. Mater. Proces. Technol.,92 (1999) 1-7.
[3] S. Ray, "Review Synthesis of Cast Metal Matrix Particulate Composites", J. Mater Sci.,28 (1993) 5397-5423.
[4] Rao R N, and Das S. "Effect of SiC content and sliding speed on the wear behaviour of aluminium matrix composites". Mater. Dsgn.,32 (2011) 1066-1071.
[5] P. R. Prasad, S. Ray, J. L, Gaindhar and M L Kappor, "Mechanical properties of Al-10% Cu alloy particulate composites", Scr. Mater., 19 (1985) 1019-1022.
[6] 6.S.K. Chaudhury, C.S. Sivaramakrishnan and S.C. Panigrahi, "A new spray forming technique for the preparation of aluminium rutile (TiO2), ex situ particle composite", J. Mater. Proces.Technol., 145 (2004) 385-390.
[7] J. Zhang and A.T. Alpas, "Wear Regimes and Transitions in Al2O3 Particulate-Reinforced Aluminium Alloys", Mater. Sci. & Engg. : A, 161 (1993) 273-284.