Review Article

FABRICATION OF METAL MATRIX COMPOSITE BY STIR CASTING METHOD

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ABSTRACT

Several technical challenges exist with casting technology yet it can be used to overcome this problem. Achieving a uniform distribution of reinforcement within the matrix is one such challenge, which affects directly on the properties and quality of composite material .In the present study a modest attempt would be made to develop Aluminium based silicon carbide particulate MMCs with an objective to develop a conventional low cost method of producing MMCs and to obtain homogenous dispersion of ceramic material. To achieve these objectives two step-mixing method of stir casting technique has been proposed and subsequent property analysis has been made. Aluminium (98.41%) and SiC(320-grit) has been chosen as matrix and reinforcement material respectively. Experiments are planned for conducting varying weight fraction of SiC (in the steps of 5%) while keeping all other parameters constant. The results would be evaluated by Tests-Hardness, Impact (including micro-structure) for this 'development method'. The trend of hardness and impact strength with increase in weight percentage of SiC would be observed and recommendation made for the potential applications accordingly.

KEYWORDS: MMC(Metal Matrix Composites),SiC (Silicon Carbide)

INTRODUCTION

A composite material is a material consisting of two or more physically and/or chemically distinct phases. The composite generally has superior characteristics than those of each of the individual components. Usually the reinforcing component is distributed in the continuous or matrix component.

When the matrix is a metal, the composite is termed a metal-matrix composite (MMC). In MMCs, the reinforcement usually takes the form of particles, whiskers, short fibers, or continuous fibers.

Objectives for Development

The reinforcement of metals can have many different objectives. The reinforcement of light metals opens up the possibility of application of these materials in areas where weight reduction has first priority. The precondition here is the improvement of the component properties. The development objectives for light metal composite materials are:

- Increase in yield strength and tensile strength at room temperature and above while maintaining the minimum ductility or rather toughness,
- Increase in creep resistance at higher temperatures compared to that of conventional alloys,
- Increase in fatigue strength, especially at higher temperatures,
- Improvement of thermal shock resistance,
- Improvement of corrosion resistance,
- Increase in Young's modulus,
- Reduction of thermal elongation.

Classification of the composite materials with metal matrix

Metal matrix composites can be classified in various ways. One classification is the consideration of type and contribution of reinforcement components in particle-, layer-, fiber- and penetration composite materials. Fiber composite materials can be further classified into continuous fiber composite materials (multi- and monofilament) and short fibers or, rather, whisker composite materials

Comparison of SiC with Si

SiC has always been noted for its excellent mechanical properties, specifically, hardness and wear resistance. In terms of hardness, SiC has a Mohs hardness of 9, which compares favourably with values for other hard materials such as diamond (ten) and topaz (eight). In terms of wear resistance, SiC has a value of 9.15, as compared with 10.00 for diamond and 9.00 for Al2O2. SiC is not attacked by most acids and can only be etched by alkaline hydroxide bases (i.e. KOH) at molten temperatures (>600°C). SiC does not melt, but sublimes at about 1800°C. The surface of SiC can be passivated by the formation of a thermal SiO2 layer, even though the oxidation rate is very slow when compared with Si.

The above properties are not generally polytype dependent. A comparison of the fundamental material properties of 3C-SiC, Si and 6H-SiC demonstrates the large potential of SiC MEMS as compared to silicon MEMS when applied in harsh environments.

Present Theories & Practices

T.R. Vijayaram, S. Sulaiman,(2005) defineSqueeze forming process is a special casting technique that combines the advantages of traditional high pressure die casting, gravity permanent mold die casting and common forging technology. It is a relatively new casting process. It is otherwise called squeeze forming, liquid forging, liquid pressing, extrusion casting, liquid metal stamping, pressure crystallization and corthias casting. The above said process was first discovered by the Russians and later it was developed in countries like USA, Europe and Japan. This advanced casting method is applied for processing of both ferrous and non-ferrous materials besides composites.

The major advantages of this technology are elimination of porosity and shrinkage, 100% casting yield, attainment of greater part details, good surface finish, good dimensional accuracy, high strength to weight ratio, improved wear resistance, higher corrosion resistance, higher hardness, resistance to high temperature, improved fatigue and better creep strength.

D. Saraev, (2001), Analyzes 3D Finite element calculations comparing to axisymmetric calculations have been performed to predict quantitatively the tensile behaviour of composites reinforced with ceramic particles aligned in stripes. The analyses are based on a unit cell model, which assumes the periodic arrangement of reinforcements. The results are presented in such a manner that can be directly compared for all possible aspect ratios and inclusion volume fractions. It is indicated that varying the distance between the stripes when particle volume fraction is kept constant significantly influences the overall mechanical behaviour of composites. Whereas during elastic deformation 3D and axisymmetric formulations predict quantitatively similar results, the mechanical behaviour perpendicular to the stripe direction predicted by 3D and axisymmetric models may differ depending on the inclusion volume fraction.

J.W. Kaczmar, K. Pietrzak(2000), Studied the production methods and properties of metal matrix composite materials reinforced with dispersion particles, platelets, non- continuous (short) and continuous (long) fibers are discussed in this paper. The most widely applied methods for the production of composite materials and composite parts are based on casting techniques such as the squeeze casting of porous ceramic preforms with liquid metal alloys and powder metallurgy methods. On account of the excellent physical, mechanical and development properties of composite materials, they are applied widely in aircraft technology and electronic engineering, and recently in passenger-car technology also.

PROBLEM DEFINITION

Though, Metal Matrix Composite materials can be produced by many different techniques, the focus of the selection of suitable process engineering is the desired kind, quantity and distribution of the reinforcement components (particles and fibers), the matrix alloy and the application.

By altering the manufacturing method, the processing and the finishing, as well as by the form of the reinforcement components it is possible to obtain different characteristic profiles, although the same composition and amounts of the components are involved. The production of a suitable precursor material, the processing to a construction unit or a semi-finished material (profile) and the finishing treatment must be separated. The problem being addressed for the proposed work is to evolve a development process for the best mix of the alloying elements for AlSiC for deriving optimal mechanical properties for a given application.

METHODOLOGY

Experimental Method identified for the thesis work:

Step 1: Preparation of sand mould

Green sand or Molding sand as it is popularly known is used with binding material to form the cope and the drag or the cores of the mold

Step 2: Preparation of Specimen of various compositions

The alloying element SiC is mixed proportionately by weight in the ratio of 5%, 10%, 15%, 20%, 25%, 30%. The percentage of alloying element to be used is determined by literature review and history for development of this work

Step 3: Machining of specimen for test.

The material needs to be sized as a square section with a notch as specified by the relevant IS standard (for Charpy/ Izod Impact test later)

Step 4: Checking Hardness over `Hardness testing machine

Brinell Hardness Test to be carried out over `Llyod' testing machine

Step 5: Checking Impact Strength using `Charpy Impact testing machine'

Test for Impact Strength is carried out using the setup specified for Izod Impact Test

Step 6: Analysis and graphs

As per DOE/ Optimization to be conducted using Taguchi Method/ MiniTab

Various Experiments are planned to be conducted on MMC samples by varying weight fraction of SiC (5%, 10%, 15%, 20 %, and so on) and size of SiC particles (360 Grit) to analyze the casting performance characteristics of Al/SiC-MMCs.

Hardness

The Brinell hardness test shall be carried out over Brinell hardness tester. Six samples of Al/Sic-MMC's for different sizes and weight fraction of SiC particles shall be prepared. After test and hardness value on dial, the Brinell hardness values with reference to scale HRB shall be taken for all samples and shown by graphs.

Impact Strength

Impact Test to be carried out over Charpy Impact Testing Machine and results to be recorded. According to size and weight fraction of SiC particles Twelve Specimens Al/Sic-MMC's of Square cross-section of size (10X10X55) with single V-notches are planned. The size of V-notches is 45^o and 2mm depth.

Microstructure

Metallographic samples are normally sectioned from the cylindrical cast bars. A 0.5 % HF solution is used to etch the samples wherever required. To see the difference in distribution of SiC particles in the aluminium matrix, microstructure of samples are developed on Inverted type Metallurgical Microscope (Make: Nikon, Range-X50 to X1500). Micrograph of Al/Sic-MMC's samples for different Sizes (220 mesh, 300 mesh, 400 mesh) and weight fraction (5%, 10%, 15%, 20%,) of SiC particles. Optical micrographs shows the distribution of SiC particles within the matrix.

CONCLUSION

Following direct improvements could be gained

- Impotent of the casting quality by minimizing the entrapped air during the shot sleeve process
- Minimizing set up time during the start of casting process
- Optimization of the whole casting process by controlling filling with optimal plunger movement
- Shorter lead time during the tool designing process
- Less scrap and waste production when new design is taken on the use

FUTURE SCOPE OF WORK

The scope of this work can be extended to the following exercise:

- Use of Pressure Die Casting process for higher rate of production
- Use of Metal Injection Molding (MIM) for `Fe' based alloys

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