Studies on Properties of Al-Sic MMCs for Making Valves for Automobile Components - A Technical Review

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Abstract

Material science and Engineering has experienced a tremendous growth in the field of micron and Nano composites developed with enhanced chemical, mechanical and physical properties. Aluminum based Metal matrix composites (MMCs) are appropriate material for engineering sector which are prepared by powder metallurgy and casting method. The present work describe that Al-SiC composite as possible alternate materials with its unique capacity to give required properties for different engineering applications. In this paper, describe the microstructure of Al-6061-T6 (Aluminum alloy) and SiC- 1200 mesh (Silicon carbide powder) composites having 0, 5, & 15volume percentage are produced by Stir casting method (Liquid metallurgy Route). Mechanical Tests like microstructure, Hardness, Strength etc. will be conducted. After developing MMCs compared properties with various existing material and result revealed that can use this composite material for making valves.

Keywords- MMCs, Stir Casting Method, Valves, Properties

I. INTRODUCTION

A. Composite Material

It is a truism that technological of development depends on advances in the field of materials. A composite material (Composition material) is material made from two or more constituent material with significantly different physical and chemical properties that when combined developed a material with different characteristics from the individual components. There are two main classification of constituent materials are matrix and reinforcement. The matrix material supports & surrounds with reinforcement materials by maintain their relative positions. The reinforcement imparts its special mechanical and physical properties to enhance the matrix properties. So, composite material is a combination of a matrix and a reinforcement which gives good properties to the properties of the individual components.

A composite materials work together to give the composite unique properties may be preferred for many reasons like strong, light weight and less expensive than traditional material. The main advantage of modern composite material is light weight as well as strong. When we choose an appropriate combination of matrix and reinforcement material from develop a new material can be made that sure meets the requirement of particular application. Although the resulting product is more efficient. Strong, stiff and light composites are also very attractive materials for aerospace, automobile, marine applications. The strength and lightness of composites has made particularly attractive for transportation. They are also be safer more economical and more environmentally friendly.

1) Types of Composite Material

1) Composite building materials such as cement, concrete.
2) Fiber reinforced composite (Fibrous composite)
– Single-layer composite including composite having continuous or discontinues fiber reinforced in same orientation and properties in each layer.
– Multi-layer composite including laminates and hybrids composites with multi layers.
3) Metal reinforced composite (Particle composite) including ceramic and metal matrices.
4) Natural and man-made composite materials
5) Carbon fiber and glass fiber reinforced composite materials

B. Metal Matrix Composite (MMC)

A metal matrix composite (MMC) which consists of in soluble alloying with two or more constituents in order. They will be obtain a combination of properties which can't be achieved by main matrix materials. The main difference between composite and an alloy is, in composite constituent materials are insoluble in each other whereas in alloys constituents materials are soluble in each other. After developing a new material which has different properties from their constituents. The ceramic particles reinforced with

metallic matrix are termed as new generation material and these can be tailored and engineered with specific required properties for specific requirements in engineering purpose.

MMCs are combined of one being with metal matrix necessarily such as aluminum, manganese, iron, cobalt, and the other materials may be ceramics like oxides, carbides or other different metal phase such as lead, molybdenum, tungsten,. Among them various matrix materials aluminum alloys are well selectable because of light weight, and appropriate mechanical properties such as hardness, strength, toughness, impact resistance, etc. The melting point of the aluminum is high enough to assure many application requirement. Silicon carbide is the mostly used reinforcement because of its good corrosion resistance, high melting point and good compact with aluminum alloys.

C. Advantages of MMCs

1) Better strength to weight ratio
2) Excellent wear resistance
3) High performance
4) Lower creep rate
5) Good fatigue resistance

D. Limitations of MMCs

1) Difficult for machining
2) Consistency of material properties

E. Application of Composites

1) Aircrafts- Elevators, Doors, and Panels of air planes.
2) Space- High gain antenna and Remote manipulator arms.
3) Marine- Propeller vanes, gear cases, fans, blowers, valves, condenser shells and
4) Strainers.
5) Automotive- Engine blocks, Clutch plates, frames, piston rods, Valves & valve
6) Guides, rocker arm cover & suspension brakes.
7) Chemical industries- Composite vessels for liquid & natural gases, raked bottles for
8) Fire service and storage tanks.
9) Construction- tunnel support, roads and bridge structure.

II. CHARACTERIZATION OF MECHANICAL PROPERTIES AND MICROSTRUCTURE OF ALUMINIUM ALLOY-SIC COMPOSITES

R. S. Rana, V. K Soni, [1], has found that Mechanical properties (Tensile strength, compression strength, hardness) and microstructure of aluminium alloy (5083) – SiC (35µm) composites are fabricated by stir casting method. In stir casting method, Aluminium melt by 760°C and mechanical stirring at 500rpm for 10 min. Using N2 Gas for degassing of melt. Mechanical properties like tensile & compressive strength, and hardness increases with increase in weight % of SiC. Also hardness of composite is higher than unreinforced alloy. In recent years aluminium alloys are widely used in automotive industries due to light weight, good formability, high corrosion resistance and high electrical and thermal conductivity. However, the poor mechanical and tribological properties of pure aluminium alloys limit its wider range of applications. The mechanical properties can be improved by addition of ceramic particles like SiC, Al2O3 etc. AMCs combine the metallic properties of matrix alloys (ductility and toughness) with ceramic properties of reinforcements (high strength and high modulus) and lead to higher strength in tension and compression and higher service temperature capabilities The results shows that Aluminium matrix micron (3, 5, 8 and 10 wt. %) SiCp composites have been successfully fabricated by ultrasonic assisted stir casting process. The experimental density is nearer to the theoretical density of composites. Porosity of composites could be decreased significantly due to the ultrasonic treatment and nitrogen degassing. The elastic modulus of Al-SiCp composites increases with increase in the weight % of SiC particles. The elastics modulus of composites with 10 wt. % micron SiCp is 8.6 % higher than that of the AA 5083 Al alloy. Tensile strength increases with increase in wt. % of SiC particles. The compressive strength increases with increase in wt. % of SiC particles. The hardness of the composites is higher than that of the un-reinforced alloy and hardness of the composites increases with increasing weight percent of the SiC particles.

III. DEVELOPMENT AND WEAR ANALYSIS OF AL- NANO SIC COMPOSITE AUTOMOTIVE CAM

R. S. Rana, V. K Soni[2], has studied in Material science and engineering which has experienced a tremendous growth in the field of Micron and nanocomposites developed with enhanced chemical, mechanical and physical properties. Cam has been fabricated by Ultrasonic assisted Stir casting process. Different weight % of Nano SiC (1, 2, 3 and 4 wt. %) were used for synthesis of composites and composite Cams. Hardness of composites was measured. Further Al-SiC_p Composite cams have been tested for

accelerated wear at different time intervals. Results shows that the Al-micron SiC_p Composite Cam were having the almost same wear resistance as the existing Alloy steel Cam. However weight of composites cam was 1/3 of the alloy steel cam.

Automotive cam were developed by using Al (5083) and SiC (35µm- 10% & 40nm- 1, 2, 3, 4% weight) composite material having the almost same wear resistance of 10% wt composite and existing steel which has been fabricated by ultrasonic assisted stir casting method. Second stirring the composite with ultrasonic probe with 1200 watt power & 20.20 kHz frequency were used. Weight of Al-SiC composite cam measured less than the alloy cam. Al- 4% wt. Nano Sic composite shows highest of hardness (79 BHN) which is higher than 10% wt. Micro SiC composite.

IV. ADVANCED ALUMINUM MATRIX COMPOSITE: THE CRITICAL NEED OF AUTOMOTIVE AND AEROSPACE ENGINEERING FIELDS

Dinesh kumar koli, Geeta agnihotri and rajesh purohit[3] has studied the applications of aluminium matrix composite materials which are growing continuously in the field of automotive and aerospace because of their superior physical, mechanical and tribological properties as compared to base alloy. Composite materials with metal matrix material e.g. aluminium or magnesium are finding broad level applications in many industries because of their lower density, better wear and corrosion resistance, high strength to weight ratio, good formability, high hardness, high thermal shock resistance, high modulus, high fatigue strength etc. In automotive industry they are being used in various parts e.g. pistons, cylinders, engine blocks, brakes etc. Aluminium based composites reinforced with micro/nano SiC, Al_2O_3, B_4C, TiB_2, ZrO_2, SiO_2 and graphite particles, changes the micro-structural characteristics that develop superior mechanical and physical properties appropriate for automotive/aerospace applications.

The present articles highlights some of the new and exciting aluminium based composite processing and manufacturing technologies like reinforced with Micro/Nano SiC, Al_2O_3, B_4C, TiB_2, ZrO_2, SiO_2, and graphite material. All changes micro-structure characteristics that develop superior mechanical and physical properties appropriate for automobile and aerospace applications. The hardness of the composites including with UTS, impact strength, wear resistance were reviewed and on conclusion, it is discovered that as the reinforcement contents increased in the matrix material. The P/M technology with sintering is very important to achieve better propertied in aluminium matrix composites for automobile and aerospace applications.

V. DEVELOPMENT OF ALUMINIUM BASED SILICON CARBIDE PARTICULATE METAL MATRIX COMPOSITE FOR SPUR GEAR

P.B. Pawal & Abhay A. Utpat[4] has studied that MMCs are made by dispersing a reinforcing material into a metal matrix. They are prepared by powder metallurgy and casting, although several technical challenges exist with casting technology. Achieving a homogeneous distribution of reinforcement within the matrix is one such challenge, and this affects directly on the properties and quality of composite.

The aluminum alloy composite materials consist of high strength, high stiffness, more thermal stability, more corrosion and wear resistance, and more fatigue life. Aluminum alloy materials found to be the best alternative with its unique capacity of designing the materials to give required properties.In this work a composite is developed by adding silicon carbide in Aluminum metal by mass ratio 2.5%, 5%, 7.5% and 10%. The composite is prepared by stir casting technique. Mechanical tests such as hardness test, microstructure test are conducted. It is proposed to use this material for power transmitting elements such as gears which are subjected to continuous loading. Finally modeling and finite element analysis of gear is done using CATIA and ANSYS 14.0.In case of increased silicon carbide content, the hardness, and material toughness are enhanced. From the results it is concluded that composite material such as aluminum silicon carbide is one of the option as a material for power transmission gears.

Developed aluminum based metal matrix composite material for spur gear by using aluminum and silicon carbide particles due to weight fraction (2.5%, 5%, 7.5%, and 10%) made by stir casting method. Borax powder was added in small quantity to increase the wettability of SiC particles. Hardness of composite material increase with increase weight % of SiC. 0% weight of SiC (means only Aluminum) has measured 28.5 BHN and highest hardness of 10% weight of SiC was 60.3 BHN.

VI. TRIBOLOGY BEHAVIOUR OF ALUMINIUM HYBRID METAL MATRIX COMPOSITE

K. R. Padmavathi**[5]** has found that study about hardness and wear loss of Al-6061 reinforced with 15% weight of SiC and MWCNT due to weight fraction 0.5% and 0.1% weight. Specific wear rate decrease with the increase of the weight % of MWCNT and hardness increase with the increase of the weight % of MWCNT, but hardness of AL-SiC composite were measured higher than hybrid metal matrix composite. The stir casting method is found to be suitable. The stir casting method is found to be suitable to fabricate the hybrid Aluminium- SiC-MWCNT reinforced metal matrix Nano composites. Aluminium reinforced with SiC and MWCNT exhibits better dry abrasive wear resistance. For all values of the applied load, specific wear rate decreases with the increase of the % of MWCNT. Hardness of the composites increase as the hybrid ratio increases.

VII. CONCLUSION

The application of ultrasonic vibration on the composite during melting not only refined the grain structure of the matrix, but also improved the distribution of nano-sized reinforcement. The Al-micron SiC_p Composite Cam were having the almost same wear resistance as the existing Alloy steel Cam. However weight of composites cam was 1/3 of the alloy steel cam.The P/M technology with sintering is very important to achieve better propertied in aluminium matrix composites for automobile and aerospace applications. Hardness of composite material increase with increase weight % of SiC. Composite material such as aluminum silicon carbide is one of the option as a material for power transmission gears.

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