Properties Evaluation of Al-Sic Powder Metallurgy Preforms

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Abstract:

The urge for efficient materials in aviation and automotive industry created a great scope for development of metal matrix composites by alloying and use of vide range of reinforcements. In the present study, Al-4Cu, Al-4Cu-2SiC, Al-4Cu-0.5Mg andAl-4Cu-0.5Mg-2SiC alloy -composites are prepared through powder metallurgy route. Mechanical alloying was done for sufficient time to obtain homogenous composition. The homogenous powder mixture is compacted and pressure less sintered at 500°C for 1 hour in continuous flow argon gas atmosphere. The relative density of the sintered preforms is found to be 90% approximately after sintering. Sintered preforms are used as work piece materials for deformation study. The stress strain curve is obtained during the deformation process. The effect of alloying and the reinforcement on the stress strain curve of the composites was reported.

Keywords: *Deformation,Workpiece,Sintering, Preforms, Powder metallurgy*.

I. INTRODUCTION

Aluminum with its special properties like high durability, lightweight, high ductility, malleability and nonmagnetic gives a great scope for applications in vide range of industries. Aluminum is known for its low density to volume ratio and its corrosion resistant nature. Aluminum has about one-third the density and stiffness equal to which made aluminum and its alloys as promising materials in various applications. Aluminum and its alloys can be machined, cast, drawn and extruded. Alloying and composite preparation with the combination of aluminum metal improved the material properties for wide range of applications [1].

Aluminum metal matrix composites gained great scope for applications within aerospace, defense, automotive industries and various other fields. The continuous increase in demand for light weight, fuel efficiency and comfort in auto industries lead to the development of advanced materials such as metal matrix composites (MMCs). Aluminum MMCs have a great application potential in automotive engineering components i.e., braking systems, piston rods, piston pins, pistons, structural frames, valve spring caps, brake discs, disc brake caliper, brake pads, cardan shaft, engine heads etc. Axle tubes, reinforcements, blade, gear box casing, turbine, fan and compressor blades are some other significant applications in military and civil aviation for Aluminum MMCs. MMCs and alloys are extensively used over metals as they offer higher specific properties (properties/unit weight) of strength, stiffness, higher specific modulus, thermal stability, tribological properties and various other mechanical properties which enhances the product performance[1, 2].

Powder metallurgical (PM) components tend to have better properties than their counterparts made through other conventional manufacturing processes. The advantages through powder metallurgy over other production techniques are, the process is rapid, economical suitable for high volume production with less contamination of parts from powders. Products with high strength, wear resistance, homogenous composition with close dimensional tolerance are possible with this route. Porous products can easily be produced depending upon the requirement in the application by varying the process parameters [3].

PM comprises of powder mixing or blending for homogenous mixture, compaction followed by pressure less sintering. The density levels obtained after sintering are always much less than the theoretical densities. This is because of the difficulty in elimination of pores completely. Presence of such micropores always hinders the performance of the material. This may be because the pores may act as the sites of origination of cracks during operating conditions. Elimination of these micropores in sintered components demands for subsequent deformation processing of preforms such as forging, extrusion etc. Among these processes forging is economic and effective method to improve density with enhanced mechanical properties with homogenous structure [4].

Some limitations during hot working are oxidation, surface decarburization of billets, excess die wear, poor surface finish and induction of thermal stresses. Because of all these cold working has been gaining great importance in recent times [5-7].Effect of temperature maintained during deformation on the deformation behavior of Al-4Cu-0.5Mg-2%SiC composite is reported. Extent of straining increased with the extent of strain [8].Narayanasamy. [9-12] have done significant amount of research work on Al-SiC composites during cold upsetting. They reported the effect of particle size and percentage addition of second phase powder material reinforcement SiC on workability studies.

In the present study the deformation study of Al-4Cu, Al-4Cu-2SiC, Al-4Cu-0.5Mg and Al-4Cu-0.5Mg-2SiC is done at constant strain rate. This is to evaluate the effect of alloying and the reinforcement on the deformation behavior of the alloy and alloy-composite.

II. Experimental Procedure:

The Al, Cu, mg and SiC powder particles are used as precursors for the preparation of composites. Powder compaction is done by using 25 Ton capacity manual pellet press. All the compositions are milled for sufficient time period to ensure homogeneous composition. Al-composite mixture is compacted in 20 mm diameter high strength tool steel die, where the punch moves freely in axial direction. The prepared green preforms are placed in stainless steel crucible which is placed inside the tube furnace. The same is then subjected to a heating cycle in the presence of continuous flowing argon gas. Preforms are sintered in a tubular furnace (Swamequip, Chennai, India). During sintering, the green compacts are heated up to 550ºC at the rate 10ºC/min and allowed to sinter at this temperature for 1 hour prior to furnace cooling. Flow of argon gas is maintained at a constant rate during the sintering process till the composite preforms reached room temperature. The Vickers hardness of sintered and strained performs are determined on micro Vickers hardness tester (SCHIMADZU).A load of 500g and 15 seconds of dwell time is used for each micro hardness test. An average of 6 readings for each sample are reported in the present study.

The sintered composite preforms of different compositions are used as raw materials for deformation study. The stresses applied and strain produced are measured at each interval were recorded to produce the stress strain curve. Compression is the mode of deformation test used in the present study. This is to evaluate the effect of compositional changes on the deformation behavior during the process of deformation. Deformation process is progressed upto an evolution of visual crack on the bulge, which is considered to be finally densified preform. Deformation of composite preforms are performed in a 40Ton hydraulic press (SVS hydraulics, Hyderabad, India) at room temperature. The dimensional measurements are noted down after each deformation step to calculate the strain behavior.

III. Results and Discussion:

The SEM micrographs of precursors Al, Cu and Mg used for preparation of Al-Cu-Mg powder preforms are shown in fig. 1. The Al powder particles used as matrix in composites prepared are 40µm and irregular shape. While the size of Cu and Mg particles are around 30-40 µm and of irregular shape. The surface of the Cu particle appeared to be rough while continuous striations were observed on the surface of the Mg powder particles.

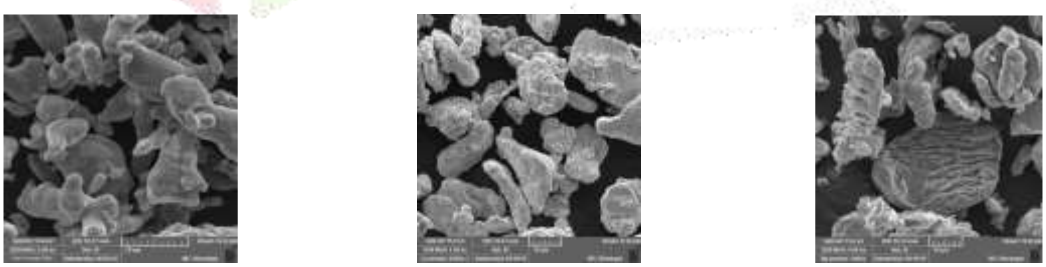

Fig. 1: SEM micrographs of raw powders

The hardness of the sintered alloy and alloy composites were shown in fig. 2. The hardness of the Al-4Cu alloy preform was measured to have 36Hv. With the addition of 2wt% SiC reinforcement particles the hardness slightly increased to 38.6Hv.The alloying addition of 0.5wt% Mg to the Al-4Cu the hardness increased to 49Hv which recorded an increase of 36% approximately. With the addition of 2wt% SiC to Al-4Cu-0.5Mg the hardness further increased to 49.9Hv which is very low. The increase in hardness with the alloying addition og Mg is due to the inherent toughness nature induced by Mg to the Al-4Cu matrix.

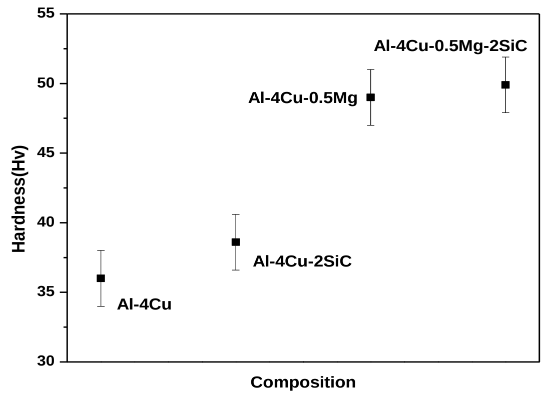

Fig. 2: Hardness of sintered powder performs

The stress strain curves of sintered powder preforms under compression deformation test was shown in fig. 3. Al-4Cu deformed to the maximum at lower stress levels than other compositions. This is due to the inherent ductile nature imparted by the alloying addition of Cu to the Al matrix. With the further addition of SiC to the Al-4Cu matrix the extent of strain decreased, while the stress required to deform increased. This trend of decrease in the Extent of strain is due to the SiC particles which inhibits the flow ability of the powder preform. The increase in stress required to deform was because of the toughness nature induced by the SiC particles to the composite which resists deformation. The alloying addition of 0.5wt% Mg to the Al-4Cu matrix further increased the toughness of the powder preform. This resulted in the decrease in the extent of deformation when compared to Al-4Cu, while increase in the stress required to deform because of increase in toughness due to alloying addition of Mg. Stress required to deform further increased with the addition of SiC to Al-4Cu-0.5Mg powder preform. The extent of strain dropped to 24.56% with increase in the stress required to deform in case of Al-4Cu-0.5Mg-2SiC powder preform. This because of the strain hindering nature by SiC particles and the toughness induced by both Mg and SiC in the preform.

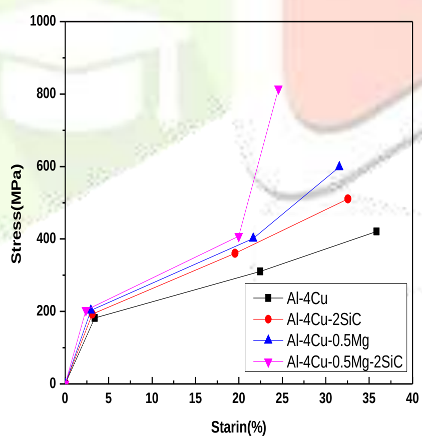

Fig. 3: Stress strain curves of sintered performs

IV. Conclusions:

From the results and the discussion above following conclusions were drawn

- The hardness of the alloy-composites increased with alloying addition of Mg and reinforcement addition of SiC particles.
- With The alloying addition of Mg the toughness increased which resulted in the stress required to deform.
- The addition of SiC particles to the preform the hardness and toughness increased, while the extent of straining decreased.
- With both alloying addition of Mg and SiC particle addition to Al-4Cu matix the hardness increased by 37% and toughness increased in the resulted alloy matrix Al-4Cu-0.5Mg-2SiC.

V.References:

1. A. RiazAhamed , P. Asokan and S. Aravindan, EDM of hybrid Al–SiCp–B_4Cp and Al–SiCp–Glassp MMCs, Journal Advance Manufacturing Technol (2009) 44;520–528.

2. M. Ramulu, G. Paul and J. Patel, EDM surface effects on the fatigue strength of a 15vol% SiC_P/Al metal matrix composite material, Composite structures 54 (2001); 79-86.

3.R.Chandramouli , T.K. Kandavel,D. Shanmugasundaram, T. Ashok Kumar, Deformation, densification, and corrosion studies of sintered powder metallurgy plain carbon steel preforms. Materials and Design 28 (2007); 2260–2264.

4. K. S. Pandey, Salient characteristics of high temperature forging of ferrous preforms. Key engineering materials, vols. 29–31. Switzerland: Trans Tech Publications; 1989. P; 465–86.

5. Olle Grinder, Cao Young Jia, YlvaNisson, Hot upsetting and hotrepressing of sintered steel preforms. In: Aqua N, Charles L, editors. Modern developments in powder metallurgy, vol. 15. p; 611–

6. Antes HW, Cold and hot forging of P/M preforms. In: S.M.E. international meeting, Philadelphia, Special Report, 71–01, April 1971. p; 1–22.