CHAPTER-1

INTRODUCTION

Metal matrix composites (MMCs) have been observed to possess the ability to tailor their physical, mechanical and tribological properties for a given application. The particulate MMCs, which have isotropic properties, are easily adaptable to the current engineering design practice. It is possible to impart the near-net-shape for particulate MMCs by the powder metallurgy techniques. Among the metal matrix composites, the aluminum matrix composites have low density, high stiffness, low cost, ease of processing, low melting point, high workability, corrosion resistance, and availability of variety of alloy systems. Due to these properties, the aluminum metal matrix composites are being widely used in the automobile, aircraft, aerospace and electrical packaging industries.

1.1 BACKGROUND

The fly-ash is an inexpensive waste by-product obtained by the combustion of coal in the thermal power plants. The fly-ash consists of 61.75% silica (SiO$_2$) and 27.79% alumina (Al$_2$O$_3$) as the major constituents. In most of the aluminum metal matrix composites, the reinforcement is silica and/or alumina. The density of aluminum (Al) is 2.7 gram/cm$^3$. The density of fly-ash is 1.973 gram/cm$^3$ whereas the densities of silica and alumina are 2.648 gram/cm$^3$ and 3.95 gram/cm$^3$ respectively. The fly-ash is much lighter than aluminum,
silica and alumina. The fly-ash as a reinforcement material is likely to reduce the cost of aluminum based MMCs [1]. It is possible to use fly-ash as a reinforcement material in the aluminum MMCs in order to impart low density, low thermal conductivity, higher damping capacity, higher electrical resistance, improved machinability, and higher hardness or higher wear resistance to the resulting composite to meet specific requirements [2, 3, 4]. Hence, the fly-ash has been selected as the reinforcing material in the present research work.

The anti-welding, anti-scoring and other bearing characteristics of aluminum are inferior. These characteristics can be improved by the addition of discrete soft phase constituents like cadmium (Cd), indium (In), tin (Sn), lead (Pb), and bismuth (Bi). Among these materials, both Pb and Sn offer most attractive combinations of engineering properties, cost and availability. On account of this reason, both these materials are widely employed in the plain bearings. When compared to Sn, Pb is soft and has low modulus of elasticity and this confers better embedability and conformability as a constituent of bearing alloy. Also, Pb is cheaper than Sn. This is the reason for selecting Pb as an alloying element in the aluminum matrix material.

If the Al-Pb/fly-ash composites are produced by the casting techniques, these are likely to exhibit segregation and non-uniform distribution of particles. The reasons are: (i) wide difference in densities between Al, Pb and fly-ash particles, (ii) poor wettability between the fly-ash particles and Al-Pb matrix, and (iii) immiscibility
between Al and Pb. On the other hand, the powder metallurgy technique is capable of producing aluminum alloy matrix composites with improved uniform distribution of reinforcement particles. Hence, in the present work, the powder metallurgy technique has been adapted to prepare the Al-Pb/fly-ash composites. Even though, a lot of work has been carried out on aluminum powder metallurgy, there is not much information available on the compacting and sintering characteristics of Al-Pb/fly-ash composites. Keeping this background in view, the experimental investigations have been carried out on the Al-Pb/fly-ash composites prepared by the conventional powder metallurgical techniques.

1.2 IMPORTANCE

The importance of present work is the utilization of fly-ash as a reinforced material in the Al-based metal matrix composites. The significant technical justification is as follows:

- Aluminum and its alloys are widely used in the industries because of their low density, low melting point, good corrosion resistance, ease of fabrication and excellent mechanical properties.

- Pb is widely used as alloying additions to Al in order to improve its anti-welding and anti-scoring characteristics.

- Fly-ash is a particulate waste by-product obtained in thermal power plants; its utilization reduces its disposal cost and decreases the environmental hazards.
• Fly-ash as a reinforcing material is comparable to silica and alumina used in the metal matrix composites with respect to cost. Hence, its use reduces the overall cost of the metal matrix composites.

• The density of fly-ash is lower than that of silica and alumina. If the fly-ash is used in the metal matrix composites for manufacturing automotive components it is possible to reduce fuel consumption.

• If the addition of fly-ash to the metal matrix composites increases hardness and wear resistance, it is worth of present investigation.

1.3 SCOPE AND OBJECTIVE OF THE WORK

The significant information is not noticed during literature review on the compacting and sintering behavior of Al-Pb/fly-ash composite materials. The information on compacting and sintering of composite powder mixture as well as spring back behavior is vital in making high performance near-net shaped parts by powder metallurgy. In the present work, the following investigations are proposed for detailed study through the experimental work:

(1) Characterization of aluminum-lead-fly-ash powders.

(2) Design and fabrication of device for uniform mixing of powders.

(3) Preparation of green briquettes from aluminum-lead-fly-ash powders.
(4) Characterization of green briquettes by determining ejection pressure, green density, true porosity, spring back, green strength and green hardness.

(5) Sintering the green briquettes in an argon gas atmosphere and reporting on density, porosity, compressive strength and hardness.

(6) Metallography of powders, green and sintered briquettes.

1.4 METHODOLOGY

The Al-Pb/fly-ash metal matrix composites are prepared by the conventional powder metallurgy technique. The particle size and distribution of fly-ash particles are determined by the sieve analysis. The particle morphology is determined by the Scanning Electron Microscope (SEM). In the present work, two sets of material compositions have been used:

1. varying the content of fly-ash from 0 to 20wt% in steps of 5wt% with constant amount of 15wt% Pb, and

2. varying the content of Pb from 0 to 20wt% in steps of 5wt% with constant amount of 10wt% fly-ash.

Al-15% Pb alloy possess minimum spring back, maximum green strength and hardness [5]. The hardness of Al/fly-ash composites increases with the increase in fly-ash upto 10wt% [6]. Therefore, the first set of material compositions are chosen with a constant amount of 15wt% Pb and the second set of material composition are with a constant amount of 10wt% fly-ash.
The purpose of blending various powders is to produce uniform distribution of different powders. The powder compositions are mixed by dry method. The green briquettes are characterized by determining ejection pressure, spring back, green density, true porosity, green compressive strength and green hardness.

The sintering of green briquettes is carried out by using an electric resistance horizontal tubular furnace. Argon gas is chosen as the sintering atmosphere. The sintering is carried out at four different temperatures. The characterization of the sintered briquettes is carried out by determining density, porosity, compressive strength and hardness of all sintered samples.

1.5 PREVIEW OF THE DISSERTATION

The thesis is organized into eight chapters:

The current chapter provides the general background, scope and objective, and methodology of the present research work.

Chapter-2 on literature review presents the detailed discussion of the available literature on aluminum metal matrix composites, role of reinforcements in aluminum metal matrix composites, manufacturing processes for aluminum metal matrix composites, aluminum powder metallurgy, aluminum based bearing materials, Al-Pb bearing alloy, fly-ash and aluminum fly-ash composites.

The experimental procedures are discussed in the chapter -3. It gives the details of experimental methodology like powder mixing, compacting process, and sintering process.
Chapter - 4 provides the details of experimental results.

Chapter-5 gives the analysis and discussion on the compacting characteristics of Al-Pb/fly-ash composites.

Chapter-6 presents the analysis and discussion on the sintering characteristics of Al-Pb/fly-ash composites.

Chapter-7 presents the comparison of green and sintered properties of Al-Pb/ fly-ash composites and the manufacturing of bush.

Chapter-8 emphasizes the conclusions of the present work and gives focus on future scope of the work.