DETERMINATION OF GREEN HARDNESS AND STRENGTH OF AL-15 % Pb –FLY ASH METAL MATRIX COMPOSITES

[1] SEELAM PICHI REDDY, [2] BOLLA RAMANA, [3] A. CHENNAKESHAVA REDDY

[1.] Department Of Mechanical Engineering L.B.Reddy College Of Engg, Mylavaram, A.P
[2.] Vikas College of Engineering & Technology, Nunna, Vijayawada
[3]. Department Of Mechanical Engineering, Jntuh College Of Engineering Hyderabad

seelamspr@yahoo.co.in,ramana_bolla@yahoo.com,dr_acreddy@yahoo.com

ABSTRACT *: Aluminum -15 % lead with 0 to 20 weight % Fly Ash powder mixtures were prepared by mixing the required amounts of powders in a suitable blender. The powder mixtures were compacted at 200, 300 and 400 MPa compaction pressure in a single action steel die into pellets of 9 mm diameter. Silicone fluid mixed with graphite powder was used as die wall lubricant. Effect of compaction pressure on green hardness and strength were determined. With the increase in compaction pressure there is an increase in hardness and strength. However, there is a decrease in strength with the increase in weight % of fly ash.*

Keywords: Fly Ash, Compaction Pressure, Green Hardness, Compressive Strength

1. INTRODUCTION

Aluminum is a remarkable material which posses a combination of properties needed for various applications. Its use is increasing because of its lightness, corrosion resistance, good formability and ability to provide a range of mechanical properties by alloying and heat treatment. During the last few decades the aluminum based bearing materials were developed to overcome deficiencies like low strength and low operating temperature of white metal bearings. Among the aluminum based bearing materials, aluminum 20 % tin alloy posses high fatigue strength, good surface properties, good corrosion resistance and finds application in high speed car engines. When compared to tin, lead is found to be more effective as soft phase addition in aluminum matrix and confer better embedabillity to a bearing alloy [1]. In addition, lead has low modulus of elasticity, hardness and cost compared to tin. Thus, aluminum-lead alloy represent a quite attractive alternative when compared to more commonly used aluminum- tin alloys. It has been reported that 10 % is the minimum acceptable lead content of an aluminum alloy if bearings of leaded aluminum are to be operated without an over lay under very thin oil film conditions. From the powder metallurgical characteristics of aluminum-lead mixtures, it was reported that Al-15 % lead alloy has minimum spring back and maximum green strength [2]. Hence 15 % lead has been added to aluminum.

Fly ash, a particulate waste material formed as a result of coal combustion in thermal power plants has been successfully dispersed into cast and wrought aluminum to make aluminum alloy fly ash composites. The addition of fly ash to aluminum decreases the energy content, material content, cost, density, coefficient of thermal expansion, and increases hardness, wear resistance and stiffness [3-19]. Hence this low cost and readily available particulate reinforcement is added to Al-15% Pb alloy to prepare Al-15%Pb-fly ash metal matrix composites.

The production of Al-Pb-fly ash composites by the casting process is restricted since they are likely to exhibit segregation and non uniform distribution because of the wide differences in the densities of the individual particles. Hence, the powder metallurgy technique has been chosen as the processing method to prepare Al-15%Pb-fly ash composites.

2. EXPERIMENTAL DETAILS

Commercially pure (99%) aluminum powder supplied by M/s S.D.Fine Chem.Ltd., Mumbai, India and lead powder (99.5% pure) supplied by M/s Loba Chemicals, Mumbai, India were used in the present investigation. Fly ash was collected from Dr. Narla Tata Rao Thermal Power Station, Ibrahimpatnam, Krishna District, Andhra Pradesh, India. The size, distribution and shape of the powder particles were evaluated using scanning electron microscopy [20]. Mixtures of Al-15 weight % lead with 0 to 20 weight % fly ash were prepared. These were mixed in a mixing chamber fixed and rotated eccentrically in a lathe machine. Compacts of 9 mm diameter were prepared. The powder mixtures were compacted at pressures ranging from 200 to 400 MPa using an uniaxial hydraulic press. Silicone fluid spray is used as an effective die wall lubricant.

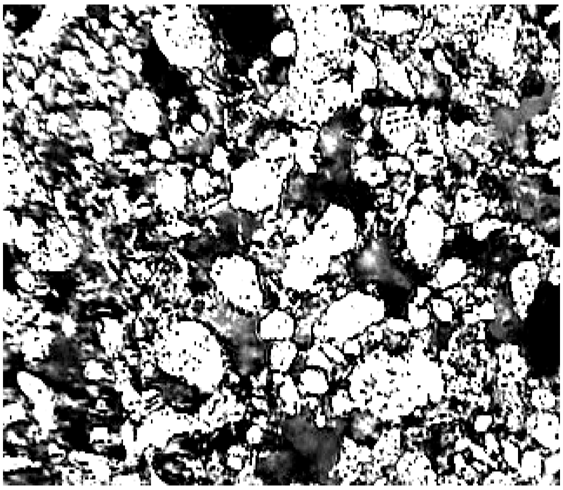

Figure.1: Microstructure of Al-15 % Pb-05 % Fly Ash Compacted at 200 MPa.

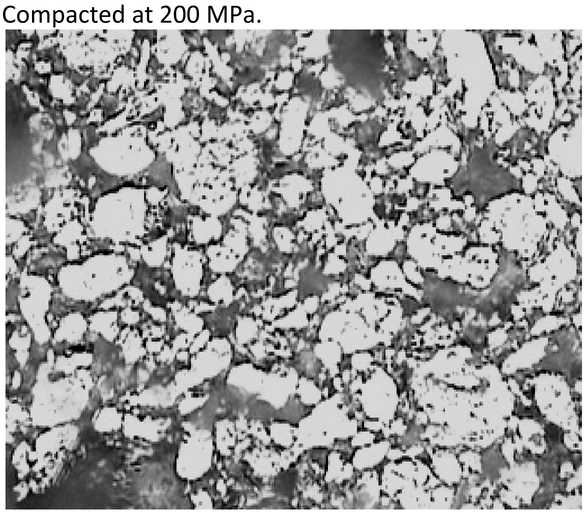

Figure.2: Microstructure of Al-15 % Pb-05 % Fly Ash Compacted at 300 MPa.

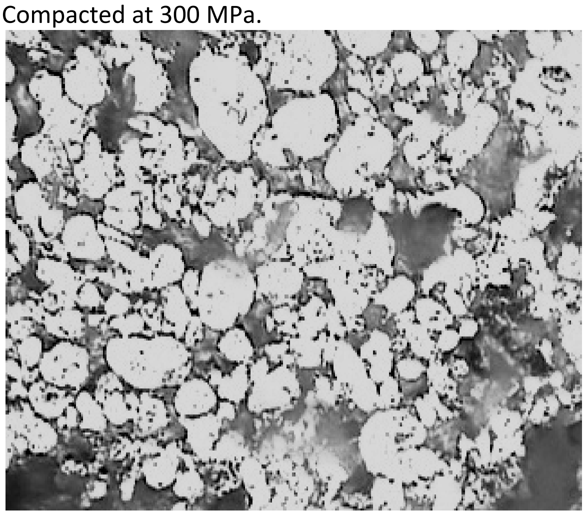

Figure.3: Microstructure of Al-15 % Pb-05 % Fly Ash Compacted at 400 MPa.

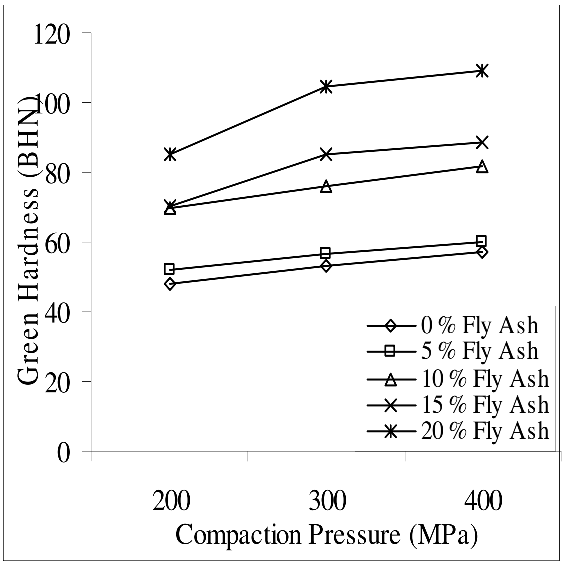

Figure 4: Effect of Compaction Pressure on Green Hardness for Al-15% Lead with 0 to 20 Weight % Fly Ash.

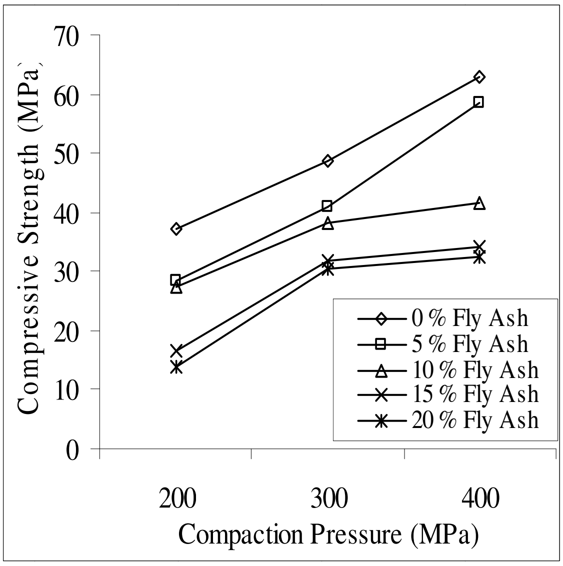

Figure 5: Effect of Compaction Pressure on Green Compressive Strength for Al-15% Lead with 0 to 20 Weight % of Fly Ash.

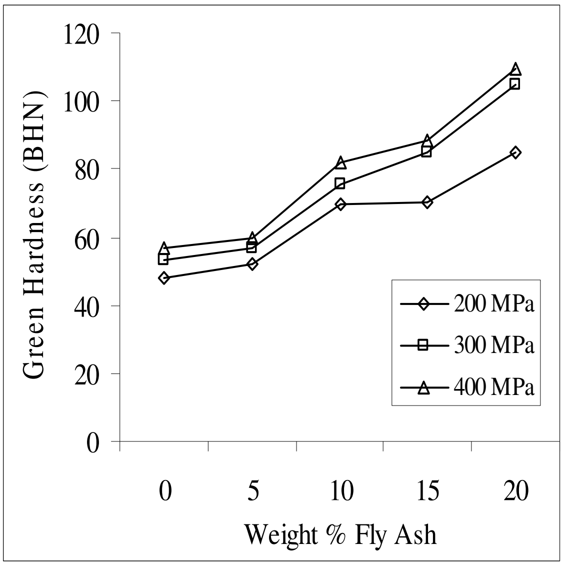

Figure 6: Effect of Weight % Fly Ash on Green Hardness for Al-15 % Lead Composites Compacted at Different Compaction Pressures.

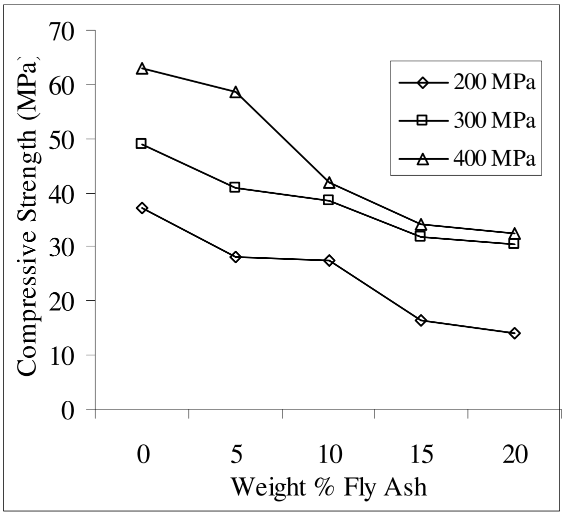

Figure 7: Effect of Weight % Fly Ash on Green Compressive Strength for Al-15 % Lead Composites Compacted at Different Compaction Pressures.

3. RESULTS AND DISCUSSIONS

The effect of compaction pressure on green hardness and green compressive strength is shown in Figures 4 and Figure 5 respectively. These figures indicate that both the green hardness and green strength increases with the increase in the compaction pressure. The initial increase in pressure causes effective packing of particles and void filling. Higher compacting pressures results in more particle contact and plastic deformation leading to cold welding of particles. These together results in a sort of grain boundary development as seen in compact made at higher pressure. This is clearly evident from the microphotographs shown in Figures 1, 2 and 3. For low compaction pressure the area of contact between the particles is less and it increases with the increase in compaction pressure and hence low compacting pressure may lead to partial welding of particles leading to voids and poor green strength and hardness.

The effect of weight % fly ash on the green hardness and strength is shown in Figure 6 and Figure 7 respectively. An increase in hardness with the increase of weight % of fly ash and a decrease in strength with the increase in weight % of fly ash is observed. The increase in hardness with the increase in weight % of fly ash is due to hard fly ash particles which are basically alumino-silicates. Similar results were reported by Dean Golden [9] and R.Q.Guo et. al [21].

The effect of weight % fly ash on the green compressive strength is shown in Figure 7. A decrease in compressive strength is observed with the increase in weight % of fly ash. This is due to poor interfacial bonding between the fly ash particles and aluminum-lead matrix.

4. CONCLUSIONS

1. Aluminum-Lead-Fly Ash metal matrix composites are prepared by powder metallurgy technique using single action die compaction process.
2. The green hardness and compressive strength increased with the increasing compaction pressure.
3. Green hardness increased with the increase in weight % of fly ash.
4. Compressive strength decreased with the increase in weight % of fly ash.

5. REFERENCES

[1] Pratt, G.C., “Materials for Plain Bearings” International Materials Reviews, V. 18, 1973, p. 62

[2] D.Nath, R.Bolla and S. Chandra,” Compacting Behaviour of Al- Pb Mixtures”, Powder Metallurgy International, V.24, 1992. p. 84.

[3] Pradeep Kumar, J.L. Gaindhar and Suresh Holi, “Effect of Fly Ash Addition on the Quality of Al-11% Si Alloy Castings Produced by V-Process”, Journal of Manufacturing Science and Engineering, Transactions of the ASME, V. 120, Nov. 1998, p. 722.

[4] P.K.Rohatgi, R. Q.Guo, B.N. Keshvaram and D.M. Golden, “ Cast Aluminum, Fly ash Composites for Engineering Applications”, AFS Transactions, V.103, 1995,p.575.

[5] P.K.Rohatgi, D.Weiss and Nikhil Gupta, “Applications of Fly Ash in Synthesizing Low Cost Metal Matrix Composites for Automotive and other Engineering Applications”, JOM, Vol.58, No.11, 2006, p.71.

[6] P.K.Rohatgi, N.Gupta, and Simon Alaraj, “Thermal Expansion of Aluminum –Fly Ash Cenosphere Composites Synthesized by Pressure

Infiltration Technique", Journal of Composite Materials, Vol.40, No.13/2006, p.1163.

[7] S.Sarkar, S.Sen, and S.C.Mishra, "Studies on Aluminum- Fly Ash Composite Produced by Impeller Mixing", Journal of Reinforced Plastics and Composites, Vol.00, No.00/2008.

[8] M.B.Harun, S.R.Shamsudin, H.Yazid, Z.Selmat, M.S.Sattar and M.Jalil, "Effect of Fly Ash Particle Reinforcement on Microstructure, Porosity and Hardness In Al-(Si-Mg) Cast Composites", AJSTD, Vol.23, Issues 1 & 2, 2006, p.113.

[9] Dean Golden, "Ash alloys: Aluminum – Fly Ash Composites", EPRI Journal, Jan. 1994, p.46.

[10] Dr. Pradeep K. Rohatgi, "Aluminum – Fly ash Composites", Foundry Management & Technology, V.123. Oct.1995, p. 32.

[11] Pradeep K. Rohatgi, " Low – Cost, Fly – Ash – Containing Aluminum – Matrix Composites", JOM, Nov, 1994,p.55.

[12] P.K. Rohatgi, R. Q. Guo, H. Iksan, E.J. Borchelt and R. Asthana, "Pressure Infiltration Technique for Synthesis of Aluminum – Fly ash particulate Composite", Materials Science and Engineering A, V. 244, Mar. 1998, p. 22.

[13] P.K.Rohatgi, R.Q.Guo, P. Huang, H.Iksan and E.J. Borchelt, " Infiltration Processing and Mechanical Properties of Metal – Fly Ash Composites", The Minerals, Metals and Materials Society (TMS), Warrendale, PA USA 1996, p.103.

[14] P.K.Rohatgi, R.Q.Guo, P.Hauang, and S. Ray, "Friction and Abrasion Resistance of Cast Aluminum Alloy-Fly Ash Composites", Metallurgical and Materials Transactions A, V.28A, Jan. 1997, p. 245.

[15] R.Q. Guo, D. Venugoalan and P.K. Rohatgi, " Differential Thermal Analysis to Establish the Stability of Aluminum – Fly Ash Composites during Synthesis and Reheating", Materials Sceince and Engineering A, V.241, Jan.1998, p.184.

[16] Rohatgi P. K., Kim J.K., Guo R.Q., Robertson D.P. and Gajdardiziska Josifovska M, "Age-Hardening Characteristics of Aluminum Alloy-Hollow Fly Ash Composites", Metallurgical and Materials Transactions A, V.33, May 2002, p. 1541.

[17] J.Bienias, M.Walczak, B.Surowska, J.Sobczak, "Microstructure and Corrosion Behaviour of Aluminum Fly Ash Composites", Journal of Optoelectronics and Advanced Materials, Vol.5, No.2, June 2003, p.493.

[18] N.suresh, S.Venkateswaran, S.Seetharamu, "Influence of Cenosphere of Fly Ash on the Mechanical Properties and Wear of Permanent Moulded Eutectic Al-Si Alloys", Material Science-Poland, Vol.28, No.1, 2010, p.55.

[19] K.V.Mahendra, K. Radhakrishna, "Fabrication of Al-4.5% Cu alloy with Fly Ash Metal Matrix Composites and its Characterization", Material Science-Poland, Vol.25, No.1, 2007, p.57.

[20] Seelam Pichi Reddy, Bolla Ramana and Chennakesava Reddy A, "Compacting Characteristics of Al-15%Pb-Fly Ash Metal Matrix Composites", Journal of Manufacturing Engineering, March 2010, Vol.5, Issue 1, p.55.

[21] R.Q.Guo, P.K.Rohatgi and D.Nath, "Preparation of Aluminum-Fly Ash Particulate Composites by Powder Metallurgy Technique", Journal of Material Science 32, 1997, p 3971.