International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.6, pp 3272-3275, Aug-Sep 2014

ICMCT-2014 [10th – 12th March 2014]
International Conference on Materials and Characterization Techniques

The characterization and behavior of Al2014 reinforced with Al_2O_3 fabricated by powder metallurgy

Vikram Singh Gaharwar[1], V.Umashankar[2]*

**School of Mechanical and Building Science,
Vellore Institute of Technology, Vellore (Tamil Nadu), India.**

***Corres.author: vikramsinghrits01@gmail.com**

Abstract: Aluminum reinforced with Al_2O_3 gives very good physical and mechanical properties. Generally they are used in field of automobile, biomedical, aerospace, industrial applications, etc. Alalloy`-Al_2O_3 composite material possess improved mechanical and physical properties like high hardness, low density, high electrical conductivity, etc. This paper is presenting the results of the study of Al2014 reinforced with Al_2O_3 and fabricated with powder metallurgy process. Process was carried out using L9 orthogonal array with three levels of reinforcement % by wt., compacting pressure and sintering temperature and time Influence of processing parameters hardness, sintered density and electrical conductivity .Electrical conductivity is not showing a linear relationship with respect to process parameters. The findings will lead to the necessity of further optimization which may enable suitable applications for the composite.
Key words: Al-Al_2O_3 Composite, L9 array, microstructure, powder metallurgy.

1. Introduction and Experimental:

Aluminum possesses quite attractive properties like low density, high thermal and electrical conductivity. The addition of Al_2O_3helps in improving the modulus behavior and strength properties in the MMC's. Metal matrix composite are well define way to determine the mechanical properties like hardness, density, electrical conductivity, wear resistance, etc [1]. Recent research showed 2XXX Aluminum alloys is one of the most common aluminum alloy used as metal matrix [2].The amount, size and distribution of reinforced particles play very important role enhancing or limiting the overall property of composite material [1]. Reinforcing the Al_2O_3 particles in micro range is the major factor in producing high performance composite, which yield improved mechanical properties [3]. The potential of composite material, as microscopic combination of dissimilar material has been recognized in unlimited possibilities of moderation and combination of desired properties of constituents [4][5].

The aim of this paper is to make metal matrix composite with Al_2O_3 as reinforcement with powder metallurgy route. The results are taken for hardness electrical conductivity and density and the results are analyzed with the help of L9 orthogonal array, also micro-structural observation has been carried out.

1.1 Sample Preparation:

Material which is used for experiment is Al2014 with different weighted percentage of Al_2O_3in powder form. Al_2O_3 grain size has been taken in a range of 30-35 micron which is gently mixed with Al2014. Al2014 contain 90.4-95 % Aluminum, 3.9-5 % Copper, 0.5-1.2 % Silicon, 0.4-0.2 % Manganese, 0.2-0.8 % Magnesium, 0.15 % Titanium, 0.25 % Zinc, 0.7 % Iron and 0.1 % Chromium (by percentage weight), and Al_2O_3 contains 52.92% Al, 47.07% Oxygen. Al_2O_3 has been reinforced with weighted percentage of 3%, 5%, and 7% with base material Al2014.

1.2 Development of Composite:

The base material Al2014 has been taken gas atomized powder form with grain size of 35 micron which is mixed with different weighted percentage of pre-weighted Al_2O_3 by using planetary mill for 10 minute at 50 rpm. After mixing process 9 specimen have been made of according to L9 array table. The mixture of the powder is fabricated with powder metallurgy technique in which powder is compacted by uniaxial cold compacting machine by using cylindrical die of 20 mm dia and 10 mm height at different pressure, according to L9 array. Compacted material was sintered in the furnace in which reaction is carried out in controlled atmosphere of nitrogen. The specimen has been sintered at different temperature which is according to L9 arrays. After sintering, the specimen has been allowed to cool in atmospheric temperature for half an hour and new weight and height of specimen have been measured. Orthogonal L9 array has been adopted for define the properties of composite material. This all experimental setup contain 4 different parameter; reinforce percentage (A1), pressure (A2), sintering temperature (A3), and sintering time (A4). Process parameters and their respective level have been described in a following table (1).

2. Results and Discussion:

The successfully fabricated composite specimen is show in fig. (2). After sintering specimen has burrs over it, to remove these burrs emery papers of standard grades have been used, for mirror finishing polishing Disk type polishing machine has been used for polishing. Vernier calipers are used for measuring the height of specimen after polishing. Experimental result of different properties discussed below…

i) Density: Experimental measurement has been shown that there is a change in weight and height of the specimen after sintering. The weight of specimen has decreased and length has been increased. So the new density of composite has been shown in fig (2) with respective levels and defined by following formula-

$$\rho = \frac{m}{v}$$

ii) Electrical conductivity: Al- Al_2O_3 composite material has very good thermal stability as well as they are also excellent electrical insulator. These composite has been used for insulation component in electrical industries so far electrical conductivity has been concerned and result has been shown in fig(2) with respective levels. Electrical resistivity which is defined by following formula.

$$\rho = \frac{RA}{l}$$

Where R=resistance of specimen, A=area of specimen, l= height of specimen

Resistance has been found by using multi-meter device, after finding the resistivity inverse of resistivity will give the value of electrical conductivity (Siemens/m).

$$\sigma = \frac{1}{p'}$$ Where σ = electrical conductivity.

iii) Hardness: Rockwell hardness testing machine is used to find out the hardness of all 9 specimens. The 1/16 ball indenter is used along with the load of 100 kg which is enough best for Al composite material. Result of the hardness is shown in table (2) of orthogonal L9 array and result is validated in fig (2) with respective level.

iv) Microstructure: Microstructure of specimenshas been taken through the optical micro-scope of 200X magnification. Micro-structure of specimen has been taken for showing the distribution of alumina in Al- Al_2O_3 composite which is affected by temperature, pressure, time and reinforcement and shown in fig(1).

Fig. 1(a) Microstructure of specimen with 3% of reinforcement, 550 Mpa pressure, 500°C for 3 hours and Fig. 1(b) Microstructure of specimen with 5 % of reinforcement, 450 Mpa pressure, 500°C for 1 hour.

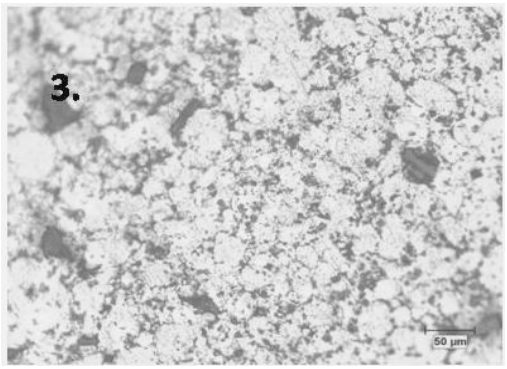

Fig. 1 (a)

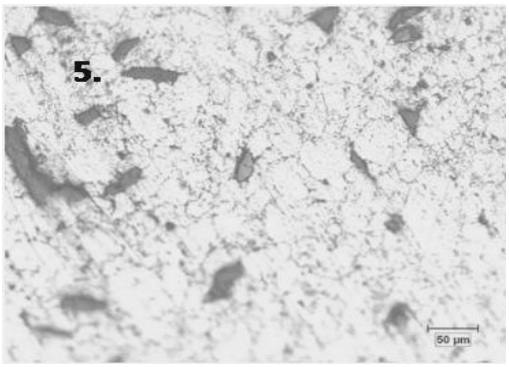

Fig.1(b)

Figure 2: a) Nine fabricated specimen, b) Variation of density with respective levels, c) variation of electrical conductivity with respective levels, d) Variation of hardness with respective level

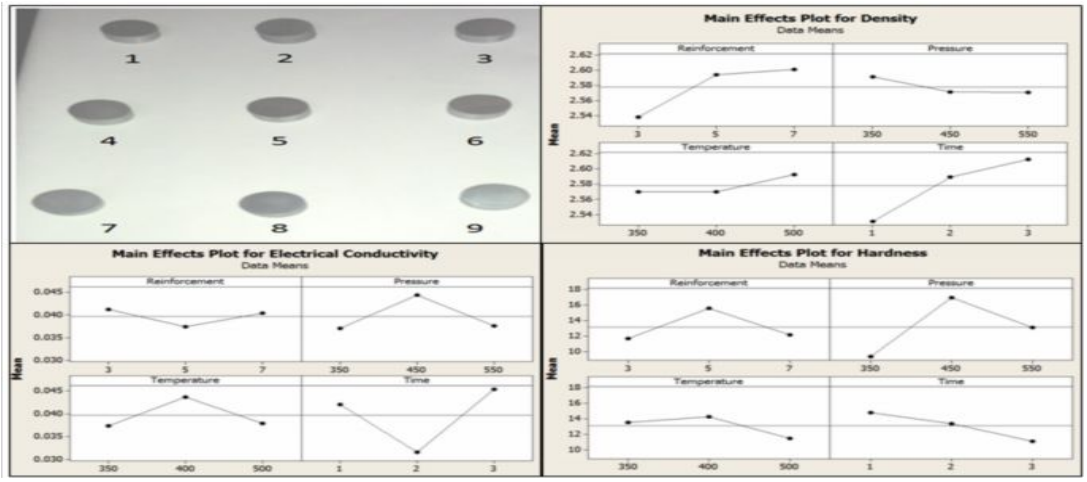

Table-1 Process parameter with respective level respective

S.No.	Symbol	Process Parameters	Level 1	Level 2	Level 3
1.	A1	Reinforcement %	3	5	7
2.	A2	Pressure (mpa)	350	450	550
3.	A3	Temperature (^{0}C)	350	400	500
4.	A4	Time (hrs)	1	2	3

Table-2 Representation of properties with process parameter in orthogonal L9 array

S No.	A1	A2	A3	A4	Hardness (Rockwell)	Density (gm/cm^3)	Electrical Conductivity (siemens/m)
1.	3	350	350	1	10	2.498	0.0386
2.	3	450	400	2	17	2.536	0.0419
3.	3	550	500	3	8	2.581	0.0431
4.	5	350	400	3	11	2.635	0.0445
5.	5	450	500	1	19.5	2.556	0.0428
6.	5	550	350	2	16.2	2.591	0.0250
7.	7	350	500	2	7	2.641	0.0280
8.	7	450	350	3	14.4	2.622	0.0485
9.	7	550	400	1	15	2.540	0.0447

2.1. Conclusion:

The Al- Al_2O_3 composite material with different weight percentage of alumina has been successfully fabricated by powder metallurgy process. Following results has been calculated by experimental studies-

i) Almost increase in every process parametershows significant increase in density.

ii) Process parameter of level 2 in L9 array give maximum value of hardness further more increase in process parameter hardness decreases.

iii) Change in every process parameter gives different value of electrical conductivity. Cold compacting pressure and sintering temperature of level 2 gives maximum electrical conductivity while reinforce percentage and sintering time of level 2 decreases the electrical conductivity.

iv) The well distribution of Al_2O_3 in Al- Al_2Ocomposite is increased as increasing the heating temperature in furnace as well as there is some effect of time also.

3. References:

1. Dinesh Kumar Koli, Geetaagnihotri and Rajesh Purohit "Property and characterization of Al-Al_2O_3 composite proceed by casting and powder metallurgy routes(Review), Vol-2, Issue-4 july 2013.
2. Zamri bin Yusoff ,ShamsulBahrin bin Jamaludin and KhairelRafezi Ahmad "The Effects of Ageing Condition on the Microstructure and Hardness of Al2009/SiC_w and Al2014/Al 2O3p" http://www.academia.edu/5611902/.
3. Ozdemir Ismail, Ahrens Sascha, Mu¨ cklichSilke, Wielage Bernhard. 'Nanocrystalline Al–Al2O3p and SiCp composites produced by high-energy ball milling', Journal of Materials Processing Technology, 2008, pp 111-118.
4. Miloš, K.: Dissertation: PulvermetallurgischHergestell-te Al-Werkstoffemit Al2O3-Teichenver staerkung, Tech- nischeUniversitaet Wien, 1994., Wien.
5. German, R.M.: Powder Metallurgy Science, MPIF, Princeton 1984.

*****