International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume: 3 | Issue: 4 | May-Jun 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 - 6470

Effect of Sintering Temperature on Mechanical Properties of Aluminum Composites

Mohd Quasim Khan

Mechanical Engineering, SRM Institute of Science and Technology, Chennai, Tamil Nadu, India

***How to cite this paper**:* Mohd Quasim Khan "Effect of Sintering Temperature on Mechanical Properties of Aluminum Composites" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-4, June 2019, pp.1278-1282, URL: https://www.ijtsrd.com/papers/ijtsrd25073.pdf

IJTSRD25073

ABSTRACT

Using Al, Al_2O_3 and SiC, different types of composites have been prepared in this experiment. Green compacts of Al composites were made at a compressing load of 1 ton and 2 ton respectively. These compacts were sintered at two different sintering temperatures of 400 ^{0}C and 450 ^{0}C in an oxygen free environment using muffle furnace for one hour followed by annealing process which took 12 hours. Sintered compacts were then sintered to micro-structural examination and mechanical properties evaluation. Higher hardness has been attained for the composites containing 2.5% SiC. Attempts have been made to describe the influence of sintering temperature on the microstructure and properties of Al-Al_2O_3-SiC composites. Samples are prepared of 100% Al, 97.5% Al- 2.5% Al_2O_3, 92.5% Al - 7.5% Al_2O_3, 95% Al - 2.5% Al_2O_3 – 2.5% SiC, 92.5% Al - 5% Al_2O_3 – 2.5% SiC, 95% Al – 5% Al_2O_3. The main objective of this experiment is to determine the factors that can increase hardness of Al composites.

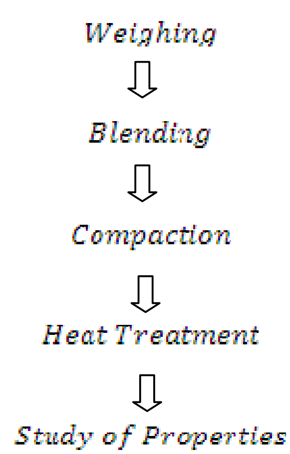
Keywords: *Sintering, weighing, blending and composites*

INTRODUCTION

Composite materials have become a necessity for modern technology due to their physical and mechanical properties. In recent years, particle reinforced metal matrix composites (MMCs) have become popular for their advanced application [1]. The properties of MMCs depend on factors such as matrix material, volume fraction, size, shape and hardness [2].

Aluminum and its alloys possess excellent properties such as low density, good plasticity and ductility [3]. The manufacturing of AL products is economical and they are corrosion resistant [4]. The products made up of Al are easy to handle, workable and corrosion resistant [5]. Al products find better applications in automotives and aeronautics due to their light weight. Silicon Carbide has a tetrahedral structure of carbon and silicon atoms with strong bond in crystal lattice which makes it very hard. They are acid resistant up to 800 ^{0}C, and have a better resistance to thermal shocks due to higher thermal conductivity with lower expansion and high strength [3]. Young's modulus of Al and SiC are 70 GPa and 400 GPa. Coefficient of thermal expansion is $24*10^{\wedge-6}$ /^{0}C and $4*10^{\wedge-6}$ /^{0}C. yield strength of 35 GPa and 600 GPa respectively [6]. For better mechanical properties investigation, when SiC particulate is added, there is an improvement in hardness and sliding wear resistance [7]. Al - SiC alloy composites exhibit longer fatigue lives than unreinforced Al alloy in lower stress state but showed reduced fatigue lives at elevated stress state regardless of their reinforcement fractions [8].

Aluminum metal matrix composites with high specific stiffness and high strength can be used in long term applications in which saving weight and corrosion resistance are important features such application include high speed machinery, high speed rotating shafts, robots and automotive engines. The characteristic property of aluminum powder is its excellent compressibility, density factor which includes 85% of theoretical density can be achieved at about 40 MPa uniaxially compacting pressure, so in this experiment powder metallurgy has been used which is economical with respect to other methods. Given flow chart shows different process involved in this experiment



WEIGHING

The powders are accurately measured with the help of weighing balance. It is an extremely sensitive, accurate and advance balance. It is fitted with chambers to reduce the effect of air flow which might negatively affect the readings.

Table 1: Composition of sample

S. No	Aluminum %	Alumina %	Silicon Carbide %
1	100	-	-
2	97.5	2.5	-
3	95	5	-
4	92.5	7.5	-

Table 2: Load and temperature variations given to final product

S. No	Load (Tonnes)	Temperature (^{0}C)
1	1	400
2	2	450

- Density of Al = 2.7 gm/cm^3
- Density of alumina = 3.95 gm/cm^3
- Density of SiC = 3.21 gm/cm^3
- Height = 10 mm
- Diameter = 18 mm
- Volume = 2.54 cm^3

- Sample 1:

1. Q= 1*2.*2.54 = 6.858 gm
2. Q(Al) = 0.975*2.7*2.54 = 6.686 gm
3. Q(Alumina) = 0.025*3.95*2.54 = 0.2508 gm

BLENDING

A single powder may not fulfill all the required properties and hence powders of different material with wide range of mechanical properties are blended to form a final product. Blending has also been carried out due to following purposes: it imparts uniformity in the shapes of powder particles, it facilitates mixing of different powder particles to impact wide ranging physical and mechanical properties, lubricants can be added during blending process to improve the flow characteristics of powder particles and dyes and binders can be added to the mixture of powder particles to enhance the green strength during the powder compaction process.

COMPACTION

A trend has been observed in the field of aluminum based composite materials to employ SiC as reinforcement material in developing composites of unique properties. In present study, an attempt has been made to fabricate the unreinforced Al and its composites were synthesized using powder metallurgy manufacturing route with blending, pressing, and sintering allows the near net shape fabrication of precision parts.

The powder compaction process can be described as a forming of any type of powder material by compaction in a container to a desired component shape. This is followed by heating to a temperature which is usually below the melting point to perform sintering of green impact. As the feedstock for this process is in the form of fine particles or powder, the parts produced in this way are then usually assigned to powder metallurgy process. A finished product has been made by compaction process and is done by CTM, compact testing machine which shows the composition of materials and moulds in particular size. The load applied is 1 ton and 2 ton respectively and dwell time for load being 10 seconds.

SINTERING

Sintering is a process of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquefaction. Sintering happens naturally in mineral deposits or as a manufacturing process used with metals, ceramics, plastics and other materials.

A muffle furnace's primary attribute is that it has separated combustion and heating chambers. Features like preheat sections, binder removal sections, multiple zone control, low or high dew point features and turn-key automatic pusher systems makes this furnace a versatile solution suitable for sintering.

ROCKWELL HARDNESS TEST

In Rockwell, B type scale is being chosen to measure hardness of structure in terms of HRB, using 1/16 inch diameter steel sphere and load of 100 kgf is applied and indentation is done by using 0.002 mm.

Table 3: Results from Rockwell hardness test

COMPOSITION	TEMPERATURE (^{0}C)	LOAD (TONNES)	HRB 1st Reading	HRB 2nd Reading	AVERAGE
100% Al	450	1	20.8	920.8	20.8
	400		19.4	19	19.2
	450	2	28.2	28	28.1
	400		20.3	24.4	22.35
97.5% Al and 2.5% Al_2O_3	450	1	22.1	21.5	21.8
	400		20.6	20.9	20.75
`	450	2	25.5	24.1	24.95
	400		16.6	18.4	17.5
92.5% Al 7.5% Al_2O_3	450	1	26.3	24.1	25.2
	400		19.4	18.6	19
	450	2	24.2	25.6	24.9
	400		21.8	21.3	21.55
95% Al - 2.5% Al_2O_3 – 2.5% SiC	450	1	21.1	24.3	22.7
	400		19.7	19.5	19.6
	450	2	23.2	23.6	23.4
	400		21	23	22
`92.5% Al - 5% Al_2O_3 – 2.5% SiC	450	1	32.7	30.9	31.8
	400		24.9	26.8	25.85
	450	2	33.4	34.2	33.8
	400		28	29.5	28.75

95% Al – 5% Al_2O_3	450	1	28.2	27.8	28
	400		20.2	18.8	19.5
	450	2	2.7	21.2	22.95
	400		15	17.2	16.1

The Rockwell hardness of the investigated materials increases with increase in SIC contents. Increasing the sintering temperature has a positive effect on hardness of sintering materials. Hardness effect is result of higher density level obtained by sintering at temperature 450 ^{0}C and formation of Al_2O_3 particle distributed uniformly in whole temperature.

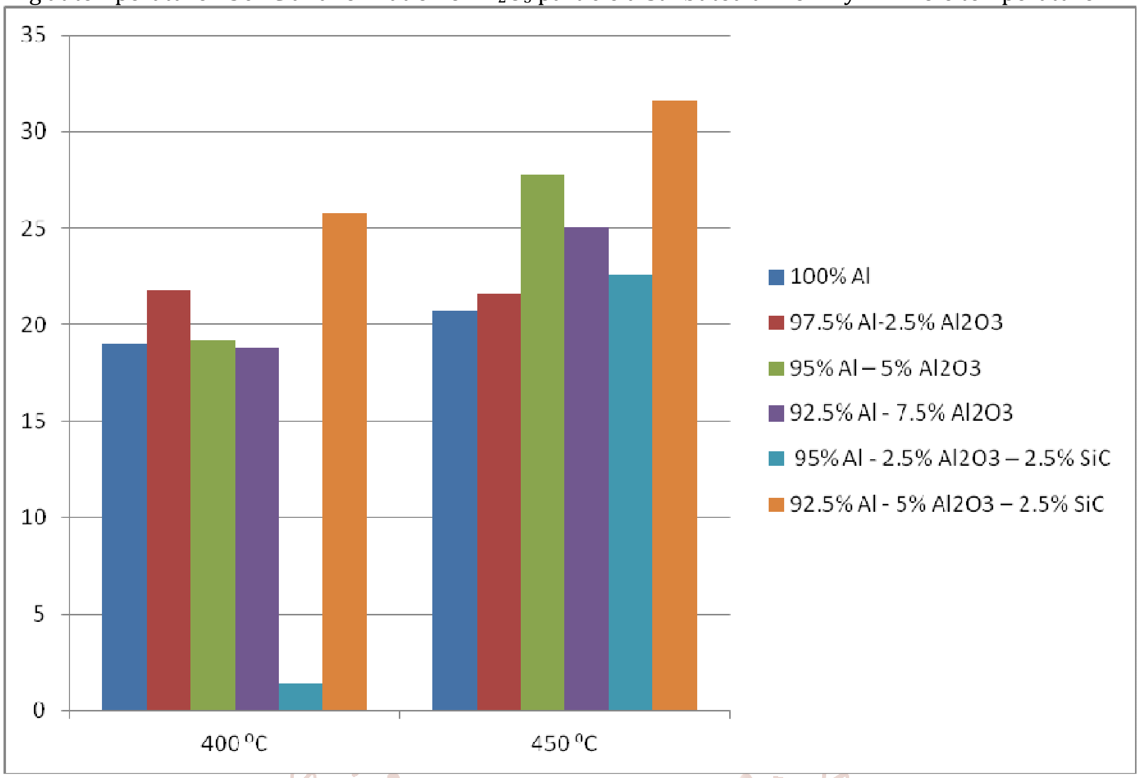


Figure 1: HBR vs. Temperature for 1 tonne

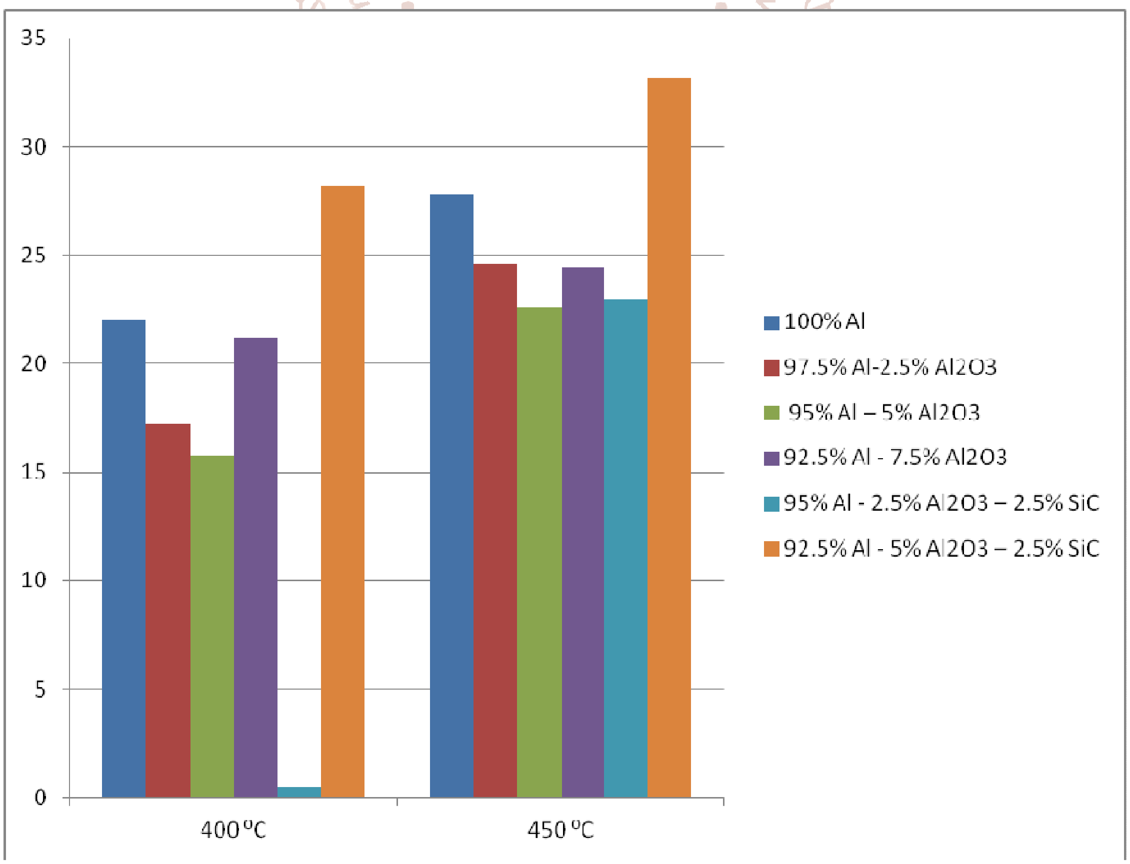


Figure 2: HBR vs. Temperature for 2 tonne

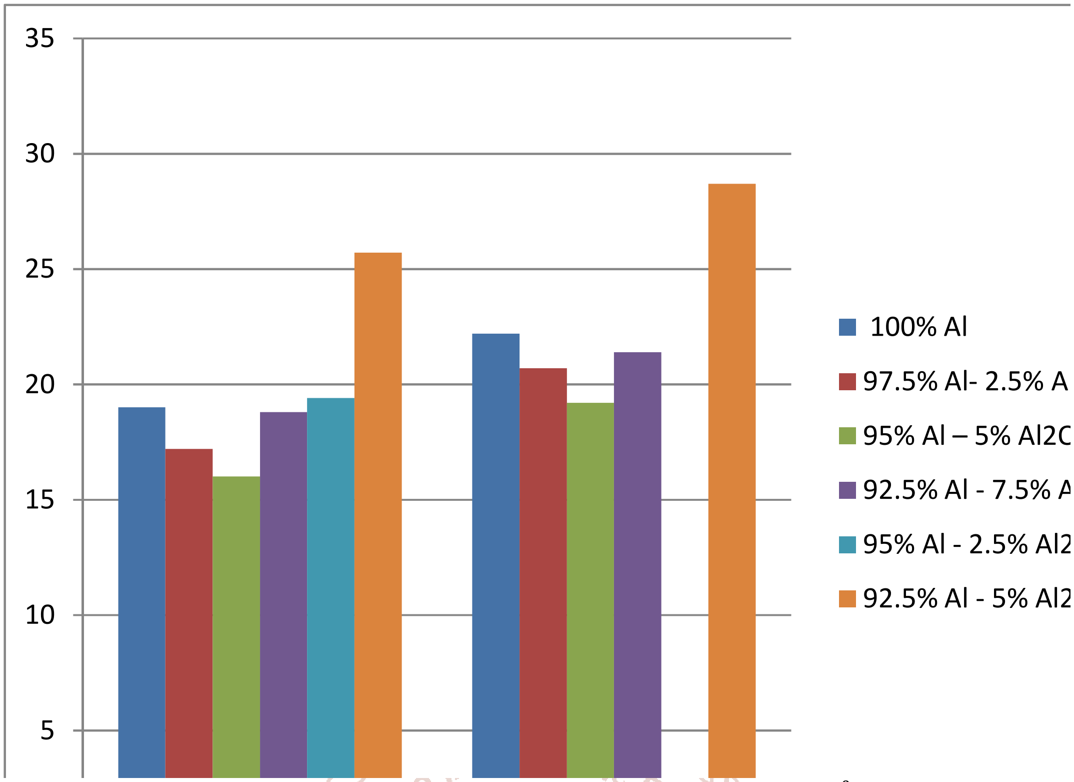


Figure 3: Hardness vs. load for different composition at 400 ^{0}C

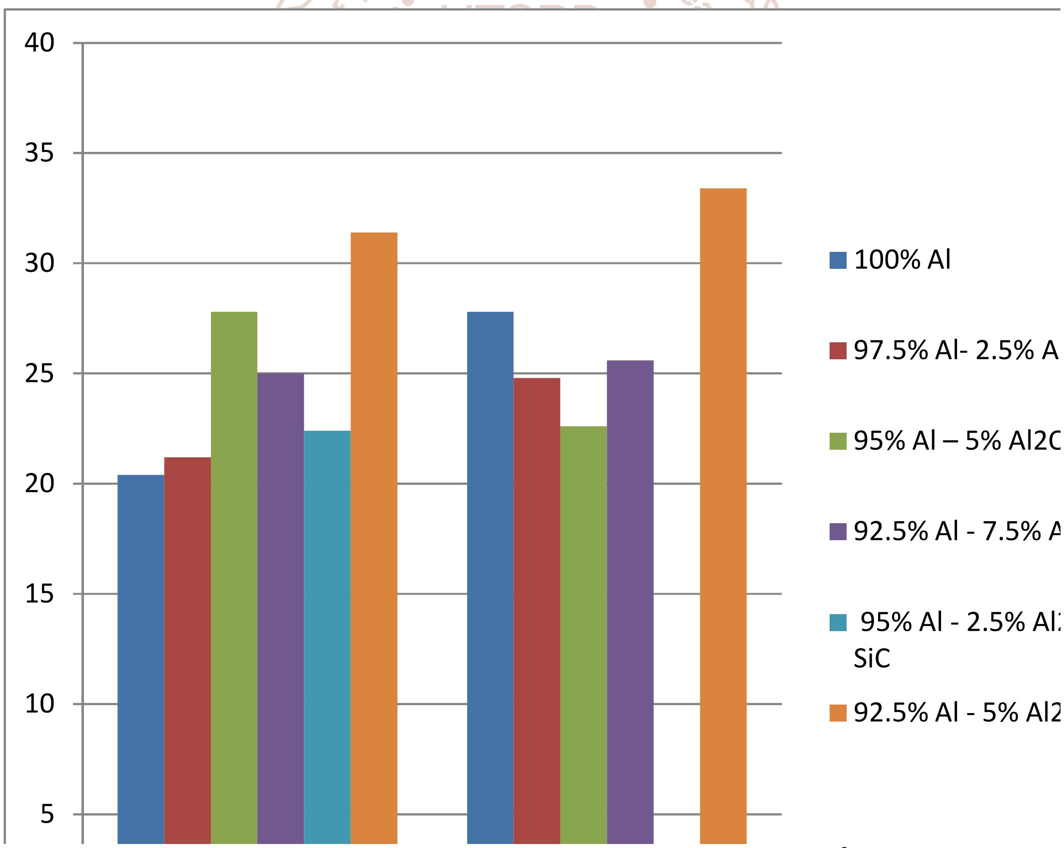


Figure 4: Hardness vs. Load for different composition at 450 ^{0}C

From figure 1, among all samples, the ample containing 92.5% Al - 5% Al2O3 – 2.5% SiC has a maximum hardness value for 1 ton of load. It can be conclude that the hardness increases with an increase in temperature. From figure 2, among all samples, the sample containing 92.5% Al - 5% Al_2O_3 – 2.5% SiC has maximum hardness value for 2 tonne load. It can be concluded that hardness increases with increase in temperature and with increase in load, hardness increases. From figure 3, it can be concluded that at constant temperature, on increasing the load, hardness value increases respectively. From figure 4, it can be concluded that, at constant temperature, the hardness increases as load increases.

CONCLUSION

The Rockwell hardness of the investigated materials increases with increment in SiC content. Hardness increases with an increase in sintering temperature. High strength and hardness have been exhibited for aluminum composites containing 2.5% SiC irrespective of 1 ton or 2 tons of compressive loads. From the microstructure we studied that uniform distribution of reinforcements into matrix material and also it shows the size of reinforced particles. Due to the improved particle-matrix interfacial bonding at higher sintering temperature, the composite showed better properties.

REFERENCE

[1] Dewan Muhammad Nuruzzaman, Farah Fazira Binti Kamaruzaman, and Nasrah Binti Mohd Azmi, Effect of Sintering Temperature on the Properties of Aluminium-Aluminium Oxide Composite Materials, International Journal of Engineering Materials and Manufacture (2016) 1(2) 59-64.

[2] Fang, C. K., Fang, R. L., Weng, W. P., and Chuang, T. H. (1999). Applicability of ultrasonic testing for the determination of volume fraction of particulates in alumina-reinforced aluminum matrix composites. Materials Characterization, 43(4), 217-226.

[3] Rajesh Agnihotri and Santosh Dagar, Mechanical Properties of Al-SiC Metal Matrix Composites Fabricated by Stir Casting Route, ISSN: 2576-8816.

[4] A. Gökçe, F. Fındık, Mechanical and Physical properties of sintered aluminum powder.

[5] Suryanarayanan K., R. Praveen, S. Raghuraman, Silicon Carbide Reinforced Aluminium Metal Matrix Composites for Aerospace Applications: A Literature Review, Vol. 2, Issue 11, November 2013.

[6] Manoj Singla1 , D. Deepak Dwivedi1 , Lakhvir Singh2 , Vikas Chawla3*, Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite, Vol. 8, No.6, pp 455-467, 2009.

[7] Dasgupta, R., & Meenai, H. (2005). SiC particulate dispersed composites of an Al–Zn–Mg–Cu alloy: Property comparison with parent alloy. Materials Characterization, 54(4-5), 438-445.

[8] D M Nuruzzaman and F F B Kamaruzaman, Processing and mechanical properties of aluminium-silicon carbide metal matrix composites.