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Study on Microstructure and Mechanical Properties of Al7068 Reinforced with Silicon Carbide and Fly Ash by Powder Metallurgy

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ABSTRACT

The paper deals with detailed study on microstructure and mechanical properties of aluminum 7068 reinforced with fly ash and silicon carbide by powder metallurgy, aluminum 7068, silicon carbide and fly ash were taken in powder form of required size and mixed together in varying proportion according to specification and compacted with pressure of 400MPa using hydraulic press to make samples and then samples were sintered at 600°c for 2 hours, the samples were tested for density, compressive strength, hardness and microstructure was analyzed using scanning electron microscope, energy dispersive x-ray study was carried out in order to confirm presence of silicon carbide and fly ash in aluminum matrix.

KEYWORDS: Al7068, Fly Ash, Silicon Carbide, Powder Metallurgy, Mechanical Properties.

1.INTRODUCTION

Aluminum is a chemical element with the symbol Al and atomic number 13, Aluminum has a density lower than those of other common metals, at approximately one third that of steel. It has a great affinity towards oxygen, and forms a protective layer of oxide on the surface when exposed to air, It is soft, non-magnetic and ductile, The global production of aluminum in 2020 was 60 million metric tons, It exceeded that of any other metal except iron (1,300 million metric tons), Aluminum is almost always alloyed, which markedly improves its mechanical properties, For example, the common aluminum foils and beverage cans are alloys of 92% to 99% aluminum, The main alloying agents are copper, zinc, magnesium, manganese, and silicon with the levels of other metals in a few percent by weight.

The major uses for aluminum metal are in packaging, building, construction, transportation, machinery, equipment and wide range of other applications, composite is a material obtained by combining two or more materials, composites are composed of resins, reinforcement, fillers and additives, composites are made to reduce cost, increase strength, hardness or other properties.

Aluminum 7068 alloy can be reinforced with various materials, but in present work we are using silicon carbide and fly ash, silicon carbide provides high thermal conductivity and low coefficient of thermal expansion for aluminum alloy, fly ash which is low cost by-product and waste, reduces overall weight and

density of aluminum alloy, the objective of present work is to make composites of aluminum 7068 with silicon carbide and fly ash, and to examine microstructure and mechanical properties.

2.LITERATURE SURVEY

Yashwant Kumar T, et al. (2016)

In his paper has studied properties of aluminum 7075 and boron carbide composite prepared by powder metallurgy, Al7075 composite reinforced with boron carbide (0, 5,10, 15) wt% was produced by powder metallurgy technique, specimens were prepared by varying boron carbide content and sintering temperature, wear analysis revealed addition of boron carbide increased wear resistance, also increased hardness and compressive strength.

Sathisha R C, et al. (2021)

In his paper has studied properties of Al7003 reinforced with 6% silicon carbide, here Al7003 was taken as base material and then reinforced with silicon carbide, stir casting method was used to prepare samples, after the preparation of required sample, mechanical properties such as tensile strength, compressive strength, hardness and microstructure were studied, tensile strength and hardness was found to increase with 2% and 4% silicon carbide.

Praveen Kumar, et al. (2016)

In his paper has studied mechanical characteristics of Al7005 reinforced with glass fiber and fly ash, the combination has resulted in better properties, 1-3% glass fiber, 2-6% fly ash was added, tensile strength & compressive strength increased on addition of glass fiber, microstructure analysis was done.

Rajesh purohit, et al. (2012)

In his paper studied fabrication of aluminum silicon carbide composite through powder metallurgy, samples were made using powder metallurgy, various properties such as hardness, density, compressive and tensile strength of aluminum silicon carbide composite was found to increase with increase in wt% of silicon carbide from 5 to 10 weight percent.

3.PROBLEM STATEMENT AND OBJECTIVE

The study of literature survey reveals that lot of work has been done on aluminum metal matrix composites, after review of literature following gaps were found.

- Limited amount of work has been done on aluminum metal matrix composites using powder metallurgy.
- No work has been done on Al7068, fly ash and silicon carbide composite by powder metallurgy.

During the study of literature survey many gaps were found, so the present work try to rectify those problems and prepare aluminum composite with better mechanical properties.

4.METHODOLOGY

Preparation of samples by powder metallurgy

For preparation of samples, aluminum 7068 was taken as base metal, reinforcement such as fly ash and silicon carbide were used, fly ash was obtained from thermal power plant and filtered to get particle size of 30 micron, silicon carbide of size 800 grit was used.

Table 1 Chemical composition of Al-7068

Elements of Al-7068	Weight%
Si	0.12
Fe	0.15
Cu	2
Mn	0.1
Mg	3
Cr	0.05
Zn	8
Ti	0.01
Zr	0.1
Al	86.47

Aluminum 7068, silicon carbide and fly ash samples were made by varying proportions, the powder of aluminum 7068, silicon carbide and fly ash were mixed in pot mill to ensure equal mixing, 2% stearic acid was added to improve bonding, a separate die and punch were made for compaction of mixed metal powders.

Table 2 The sample specification

Sample No.	Composition
1	Al7068 Pure
2	Al7068 + 0%FA + 4%SIC
3	Al7068 + 0%FA + 6%SIC
4	Al7068 + 4%FA + 0%SIC
5	Al7068 + 4%FA + 4%SIC
6	Al7068 + 4%FA + 6%SIC
7	Al7068 + 6%FA + 0%SIC
8	Al7068 + 6%FA + 4%SIC
9	Al7068 + 6%FA + 6%SIC
10	Al7068 + 8%FA + 0%SIC
11	Al7068 + 8%FA + 4%SIC
12	Al7068 + 8%FA + 6%SIC

compacting pressure of 400 MPa was put, green compacts of size 10 mm diameter and 12 mm height were prepared, the green compacts were sintered at 600°c for 2 hours in heating furnace, the composite of Al7068 reinforced with silicon carbide and fly ash were produced according to sample specifications showed in Table 2.

Fig1. Pot mill.

Fig 2. Compaction of sample using hydraulic press.

Fig 3. Raising Hearth Furnace.

Fig 4. Al7068 powder.

Fig 5. Silicon carbide powder.

Fig 6. Fly ash.

Fig 7. Compacting die.

Fig 8. Green samples.

Fig 9. Sintered samples

5.RESULTS AND DISCUSSION

1.Density

Density of a substance is its mass per unit volume, here density of samples is determined by measuring the weight and volume of the specimens.

Table 3 Density of samples

Sample No.	Green Density (g/cc)	Sintered Density (g/cc)
1	2.23	2.39
2	2.29	2.45
3	2.26	2.44
4	2.28	2.41
5	2.23	2.47
6	2.21	2.50
7	2.24	2.49
8	2.28	2.48
9	2.27	2.47
10	2.15	2.43
11	2.13	2.46
12	2.18	2.44

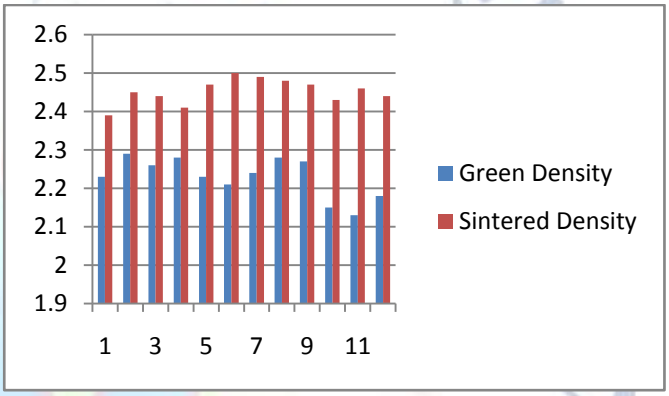

Fig 10. Graphical representation of Green and Sintered density in g/cc.

The sintered density and green density of the specimens show varying values of densities with different percentage of fly ash and silicon carbide,

After calculation of density of sintered and green samples, it was found that sintered samples increased in density when compared to green samples, the data is graphically shown in Fig 10.

2.Compression test

All specimens with varying properties were tested for compressive strength on digital hydraulic press the specimens had 10mm diameter and 12 mm height, the samples were placed in hydraulic press and load was applied untill fracture was observed and reading were noted down.

Table 4 Compression test results

Sample No.	Compressive stress in kg/mm2	Compressive stress in MPa
1	16.5	161
2	14.8	145.10
3	16.7	163.77
4	15.9	155.92
5	15.4	151.02
6	12	117
7	13.3	130.42
8	18.5	181.42
9	17.6	172.59
10	19.3	189.26
11	13.4	131
12	11.8	115.7

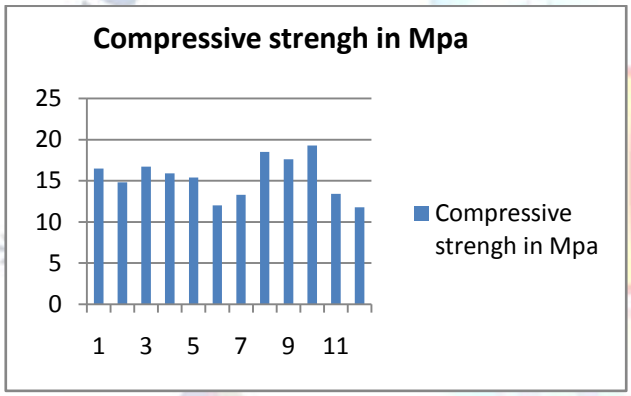

Fig 11. Representation of compression test results.

From the graph, it can be seen that sample no. 10 showed highest value of compressive strength of (189.26 MPa) for the composition Al7068 + 8% FA + 0% SIC.

3.Hardness test

Brinell Hardness test was done on samples to find their hardness.

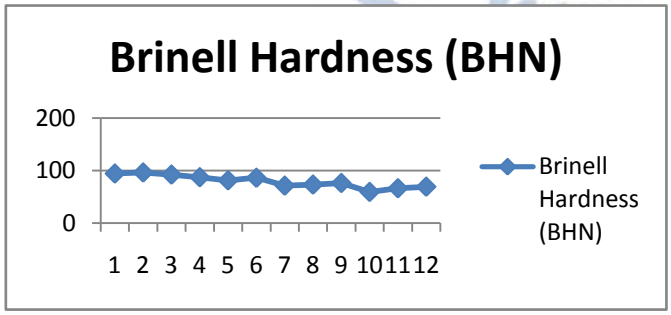

Fig 12. Representation of Hardness test results.

Table 5. Hardness of results

Sample No.	Brinell Hardness(BHN)
1	94
2	96
3	92
4	87
5	81
6	86
7	71
8	73
9	76
10	59
11	66
12	69

From the results, it is observed that the hardness of samples decreases as percentage of fly ash increases, hardness increases as weight percentage of silicon carbide increases, maximum value of Hardness obtained is 96 BHN for the composition of Al7068 reinforced with 0%FA and 4% SIC.

4.Scanning Electron Microscopy (SEM)

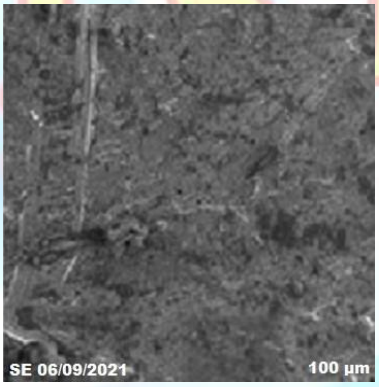

Fig 13. SEM image of Al7068

The SEM image of Al7068 is shown in figure 13 with no reinforcement, by seeing this figure it was observed that the sample was properly compacted and sintered without any pores.

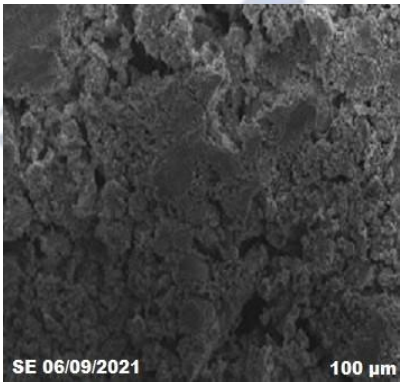

Fig 14. SEM image of Al7068 +0% FA +4% SIC sample.

The SEM image of Al7068+0%FA+4%SIC is shown in figure 14

In above figure it was observed that particles are properly integrated with each other, we can clearly see silicon carbide particles in aluminum matrix the magnification used is 100 µm.

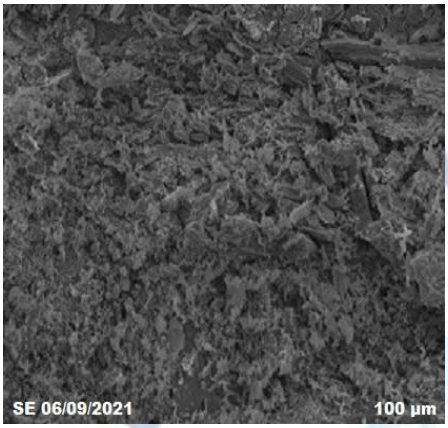

Fig 15. SEM image of Al7068+ 4%FA+4%SIC sample.

The SEM image of Al 7068+4%FA+4%SIC is show in figure 15 it was observed that the fly ash particles were completely submerged in aluminum matrix but silicon carbide reinforcement can be seen as bright particles as it has high atomic weight, it can be seen that pore size has reduced due to fly ash.

5.Energy Dispersive X-Ray Study(Edx)

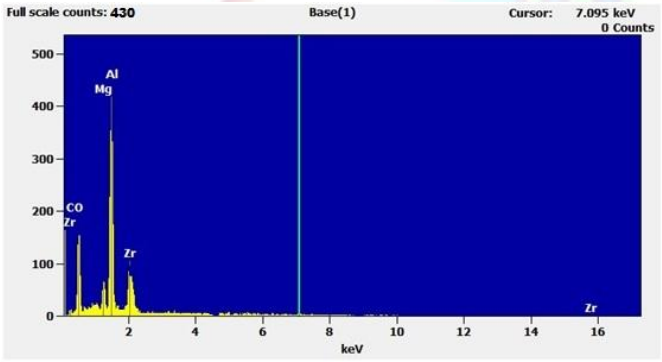

Fig 16.EDX of Al7068 sample.

From figure 16 which shows EDX of Al7068 we can say that graph matches with the chemical composition of standard aluminum 7068.

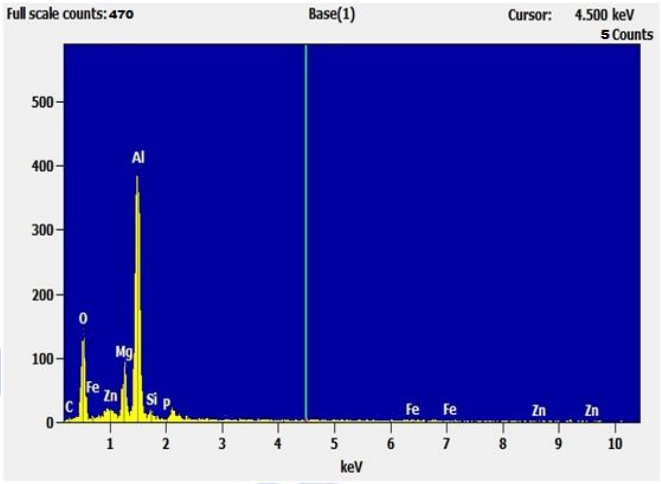

Fig 17. EDX of Al7068 +0% FA+4% SIC

From figure 17 which shows EDX of Al7068 +0% FA+4%SIC confirms the presence of silicon carbide in aluminum matrix we can see this through peaks presented in graph.

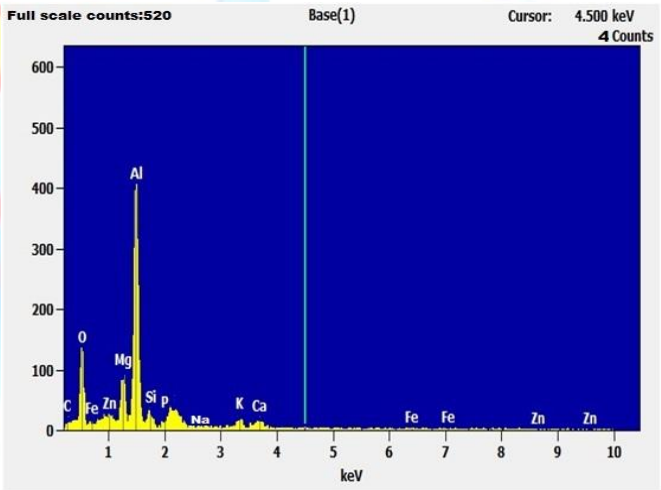

Fig 18. EDX of Al7068 +4%FA +4%SIC

From the figure 18. Which shows EDX of Al7068 +4%FA +4%SIC confirms the presence of silicon carbide and fly ash in aluminum matrix.

6.CONCLUSION

From the present work on aluminum 7068 composite, the following conclusion has been derived.

- The density of sintered samples was found to be great than green samples.
- From compression test it was found that aluminum 7068 reinforced with 8% fly ash had high compressive strength of 189.26 MPa, the compressive strength of aluminum 7068 increased with addition of fly ash.

- The hardness test shows that the hardness increase as percentage of silicon carbide increases, aluminum 7068 reinforced with 4% silicon carbide showed maximum hardness of 96 BHN.
- SEM analysis shows microstructure and binding of silicon carbide and fly ash with aluminum matrix
- EDX analysis of samples confirms the presence of silicon carbide and fly ash in aluminum matrix.

7.SCOPE OF FUTURE WORK

- Further work on aluminum composites can be done by using different series of aluminum metals like Al7003, Al7005, Al7075, Al6063 etc.
- Various other reinforcements can be used such as ceramic, fibers, metals can be used.
- Various additives can be used according to required specification and properties needed.
- Various tests can conducted on composites according to area of requirement.

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