A COMPERATIVE STUDY OF SiC REINFORCEMENT EFFECT ON MECHANICAL AND PHYSICAL PROPERTIES OF Al2024-SiC AND Al6061-SiC COMPOSITES PRODUCED BY POWDER METALLURGY METHOD

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Abstract: In thıs study, metal matrıces composite samples, Al2024 and Al6061, has been produced by powder metallurgy. Their partıcle sıze are 40 µm and 45 µm respectively and 12.5 µm partıcle sıze SiC powder helping with powder metallurgy. The diameter of chrome steel ball used in technique was 10 mm and weight ratio was 6:1. A homogeneous micrp structures have been obtaıned after SEM observatıons. Physıcal and mechanıcal properties has been defined by theorıtically and experimentally. Also, porosity, hardness and thermal conductıvity of the composites have been ınvestigated ın thıs study. As a result, ıs has been achıeved that ıncreasıng of SiC content ıncreased the amount of pore ın composite and thıs ıncrease caused decrease ın the mıcrohardness.

Keywords: composite, powder metallurgy, SiC, hardness strength, porosity.

Introduction

Allthough metals are used commonly in many industries, technologıcal progress is increase day by day and the industries need more superıor feature materials then metals. This materials called by composite materials and manufacturing of composites are increased because of their success. Composite materials are more superior than metals and they are reinforced materials. High strength and able to work with high temperatures are most prefable properties are composite materials. Usage areas of composite materials are extended as their advanced properties and various manufacturing methods.

Composite materials are obtained by adding of second phase on the single component materials like metal, ceramic or polymer. When choosing reinforcement material of composites, should be consider of mechanical properties. Aliminum and Al alloys are used for matrice materials and SiC, B_4C , Al_2O_3 , are used for reinforcement element generally. SiC has high strength, resistance and high density so that prefable for reinforcement element in many industries.

Metal matrices composites, must have some advanced physical propertie such as high thermal conductivity, homogeneous micro structure, high strength for giving this properties to composites (Erdemir 2015). To specify properties of composites, there are some numeric and experimental methods. For instance, the hardness of samples are determined by Vicker Hardness method.

Al2000 and Al6000 series are commonly used series in metal matrices composites. Al 2000 series is consist of copper element. Strength of Al2000 is more than the others. Heat treatment processes are usable for this series. Al 2000 series are used frequently in aviation sector (Wu 2014).

On the other hand, Al6000 series contain Mg and Si elements. The most suitable series for aging process. Shaping ability is very high and after treatment, clean surface is obtained.

In lıterature, there are many theoritical and experimental studies about physical and mechanical properties of Al2000 and Al6000 series which are produced by powder metallurgy method. Mechanical and physical properties are played important role for determining microstructure of composites. Also, both of series have good mechanıcal properties and these are important parameters in production process and products.

In thıs study, the effect of SiC reinforcement on mechanical and physical properties of Al2024/SiC and Al6061/SiC composites produced by powder metallurgy method is researched, literature rewiev is done and results are disscussed and studied. In literature rewiev, based articles published in the year of 2015 and 2016 and

the obtained datas are timely. And finally, there are actual photos which are used in specify of mechanical and physical properties of Al2000 and Al6000 alloys (Ates 2011).

Materials and Methods

Ih thıs study, effect of SiC reinforcement on mechanical and physical properties of Al2000 and Al6000 series and the results are disscussed comperatively for both series.

SiC is used reinforcement element as average microsize 12,5 **µ**m, 40 **µ**m grain size Al2024 and 45 **µ**m Al6061. Their physical, chemical properties and compositions are given in the (Table1), (Table2), and (Table3) (Wu 2014).

Table 1. Physical and chemical compositions of Al2024 and Al6061 series.

Element	Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn	Al
Al2024	0.10	5.3	0.5	0.4	0.3	0.50	0.15	0.15	Balance
Al6061	0.04-0.35	0.15-0.4	0.7	0.8-1.2	0.15	0.4-0.8	0.15	0.25	Balance

Table 2. Physical and chemical properties of Al2024, Al6061 and SiC.

		Al2024	**Al6061**	**SiC**
Physical properties	Density (g/cm^3)	2.83	2.7	3.22
Chemical properties	Thermal Conductivity (W/mK)	196	167	120

Tablo3. Chemical composition of SiC.

Element	SiC	Fe_2O_3	C	SiO_2	Al_2O_3
%	94.0	0.10	4.5	0.70	0.70

In the Erdemir and friends study, average size of 40 and 45 **µ**m, and %5 reinforcement rate of SiC is mixed to obtain homogeneous mixture and they used for production of Al2024-SiC and Al6061-SiC by powder metallurgy method. And then obtained compositions are grained at 300 rpm speed for 10 hours. Chrome steel balls are used and their radius are 10 mm. Powder weight ratio determined as 6:1 and grain process was done in toluen solution because of prevent oxidation. Finaly, grained powders collected to 2, 5 and 10 hours interval and graining process was completed. SEM photos before grain process of Al6061 and SiC powders are shown (Yao 2015).

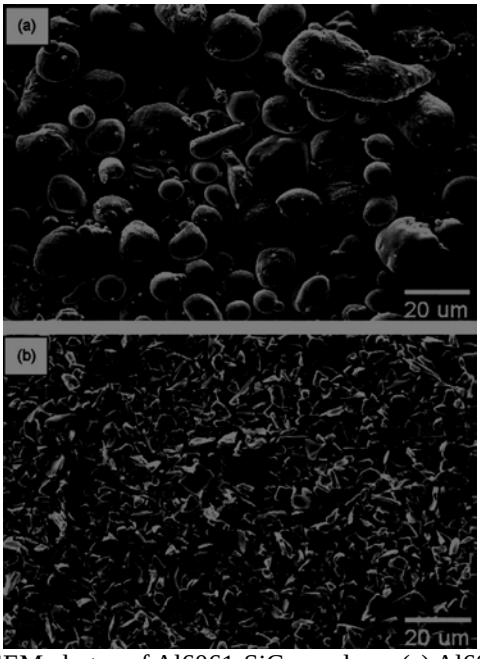

Figure 1. SEM photos of Al6061-SiC powders . (a) Al6061 (b) SiC

In the another study, Parvin and friends investigated Al2024-SiC and Al6061-SiC composites fracture surfaces produced by powder metallurgy with Scanning electron microscope (Hassani 2014). SEM pictures , which are showed in Figure2, its seen that grainin time is increased, composites are distributed homogeneously. Also, SiC was homogeneously distributed both Al series and increasing SiC reinforcement weight ratio, homogeneous structure obtained fast (Shaga 2016).

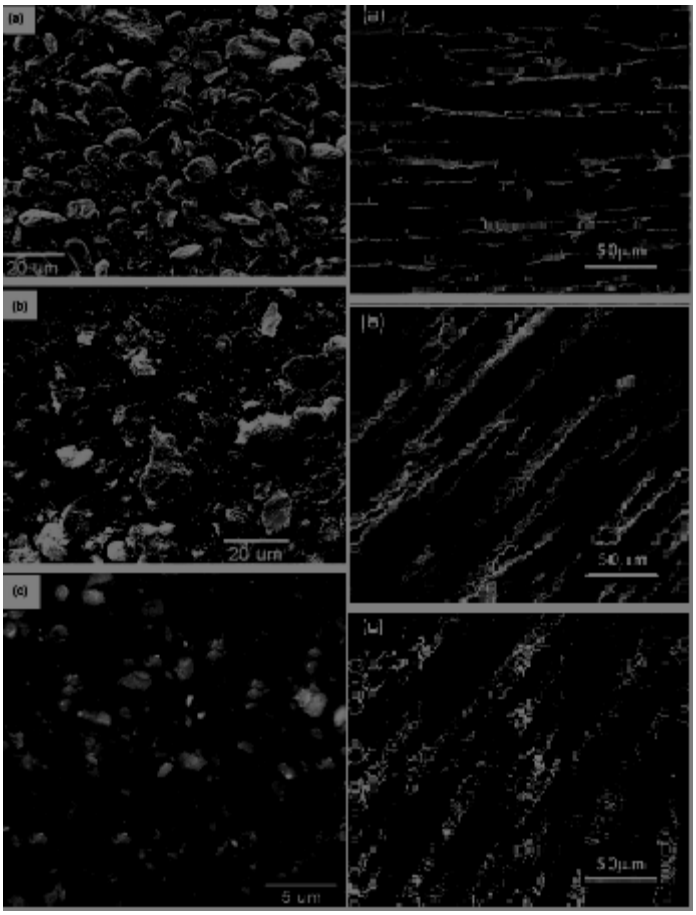

Figure.2 Al 6061-SiC ve Al2024-SiC composites's SEM photos. (a) 2, (b) 5, (c) 10 hours after graining.

Relative density measurement is done by Arshimed method comparing theoritical and experimental density, their values are nearly same. All of compiled studies given that theoritical density values obtained to %85-90. This results are good for this study.

Porosity measurements of components are done firstly calculation of theoritical density and then calculation of experimetal density of all component composites by Arshimed method. Secondly, porosity values are calculated by the formula (Cao 2016).

In the another study, X-ray diffraction specrtroscopy is used for microstructure characterization and determining phase distribution. SiC is added different weight ratios on composites, than XRD models are obtained both Al series. They are shown in Figure below. According to the models, microchemical structures and including element are determined also.

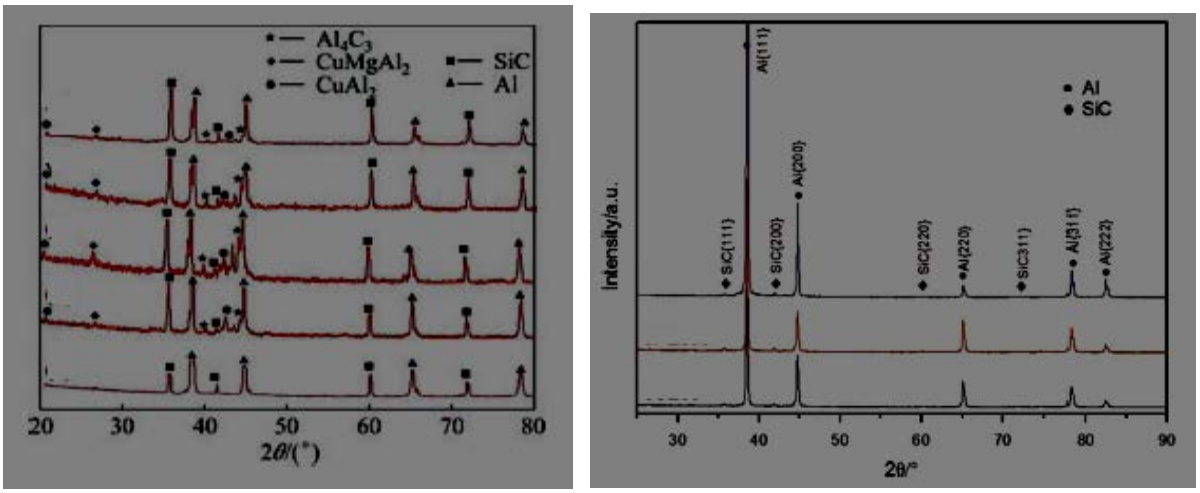

Figure.3 XRD models of Al6061-SiC ve Al2024-SiC composites in different weight ratios.

In thıs study, different analitical and numerical methods are shown which are used for determining physical and mechanical properties of metal matrices composites which is produced by powder metallurgy method. Also, density and hardness values are calculated byexperimental methods. Also, archimed method is used for determining porosity (Turkmen 2015).

Results and Discussion

In thıs study, effecct of SiC reinforcement on Al2000 and Al6000 series is investigated comperatıvely and lıterature rewiev collected and results are commented.

After studıes, Its clear that weıght ratıo of SiC reınforcement is affected porosity durıng productıon process of Al2024-SiC and Al6061-SiC composites. When, %5 of reinforcement volume ratıo of SiC ın metal matrix is increased, porosity of Al2024 is increased whereas porosity of Al6061 is decreased. For this reason Al6061 series has more clean surface than Al2024 series after heat treatment process.

Hardness experimentals of materials in compiled studies are done by Vicker Hardness testing method. The resul of experiments show that, ıncreasing amount of SiC is decreased hardness of material on Al6061-SiC composite. On the other hand, maximum hardness value of Al2024-SiC composite is obtained with %30 SiC weight ratıo ın composite. As, shaping processes are used frequently on Al600 series, decreasing hardness values are good charactheristic. On the series of Al2000, resistance strength is much more and this is important for industries.

Table.4 Hardness experiment of Al6061-SiC composite and percent porosity results.

SiC(vol%)	SiC size(µm)	Al6061 size(µm)	Hardness (VH)	Density (g/cm^3)	Theoritical density (g/cm^3)	Porosity (%)
45.8	12.5	45	153	2.73	2.93	0.932
55.9	12.5	45	86	2.61	2.98	0.874
66.3	12.5	45	42	2.44	3.03	0.803
45.8	12.5	45	176	2.78	2.93	0.969
55.9	12.5	45	155	2.71	2.98	0.898
66.3	12.5	45	67	2.42	3.03	0.833
45.8	12.5	45	157	2.84	2.93	0.950
55.9	12.5	45	135	2.68	2.98	0.909
66.3	12.5	45	47	2.53	3.03	0.797

Table.5 Hardness experiment of Al2024-SiC composite and percent porosity results.

SiC(vol%)	SiC size(µm)	Al2024size(µm)	Hardness (VH)	Porosity (%)
30	12.5	40	170	0.5674
40	12.5	40	225	0.5978
50	12.5	40	205	1.3811
60	12.5	40	180	2.0272
30	12.5	40	132	0.061
40	12.5	40	163	0.1925
50	12.5	40	155	0.2445
60	12.5	40	145	0.2015
40	12.5	40	175	0.59007

Finally, thermal conductivity of composites are studied experimental and theoritically. The result of experimental works, increasing SiC weight ratio, thermal conductivity of materials are increased both series. When the Al and SiC are combined in two series, thermal conductivity is reached the peak. Increasing thermal conductivity is contributed to both series of Aliminum for heat treatment processes.

SEM photos of composites show that SiC is dispersed in Al metal and its behaviour is appropriate for theoritical models. There is no heterogeneous wiev on Al2024-SiC and Al6061-SiC.

In compiled works, its clear that density of composite materials which are produced by powder metallurgy method, reach %85-90 of theoritical densities. Also, with high temperatures there is no change in micro structures of Al-SiC composites.

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