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Investigation of Mechanical Properties of Sic, Fly-Ash Reinforced Aluminium Alloy Hybrid Composites

Maraparambil Ramachandran[1], Dr. K.K.Padmanabhan[2]

Principal, Technical Education Dept, Government Polytechnic College Manjeri,

Kerala & Research Scholar Karpagam Academy of Higher Education Coimbatore, Tamilnadu, India[1]

Professor, Department of Mechanical Engineering, Karpagam Academy of Higher Education Coimbatore, Tamilnadu, India[2]

Abstract: Aluminium alloys like Adc12 widely used for making composites which were cheap and easily available. It is easy to melt, forge and cast. Fly ash which is easily available and cheap material. Managing and reusing fly ash meant for control of environmental pollutions. Sic and fly ash added to the ADC12 alloys and a new composite were prepared. Composite used here manufactured by squeeze casting techniques by varying the process parameters such as Sic/Fly-ash ratio, melting temperature, squeeze pressure and die temperature. Three levels set up are considered. The experimental trails are reduced to nine by Taguchi L9 orthogonal array. Mechanical properties of Composite Specimens manufactured and base metal estimated by various testing, then compared and analysed.

Keywords: Squeeze casting, ADC12 alloy, Fly-Ash, Hybrid Composite.

I. INTRODUCTION

Aluminium and aluminium alloys having density of about 2.7g/cc, light weight , good malleability and formability, high corrosion resistance, high electrical and thermal conductivity and high machinability and workability are widely used in automotive industries(1&2).However in the engineering applications, pure aluminium and its alloys still have some problems such as relatively low strength, unstable mechanical properties and porosity defects due to gases dissolved during melting processes (3).The microstructure can be modified and mechanical properties can be improved by alloying, cold working and heat treatment. (4). Porosity can be eliminated to a high end by squeeze casting method (5,6,7). The use of aluminium alloy composites in aerospace and automotive engine components increases very rapidly due to their high weight to strength ratio, low density, low

Thermal expansion coefficient, low maintenance and high temperature resistance (8). The aluminium alloys are mostly reinforced with Al_2O_3, B_4C and TIC and fabricated by stir casting, centrifugal casting, and powder metallurgy process. In this study squeeze casted composites made from adc12, sic, fly ash were subjected to different tests to shows mechanical properties. Micro structural characterization of composite was also done. Heat treatments on composites significantly affect the micro structural developments of it causing relieving of stress. Some researchers published good papers on ADC-12/SIC with or without heat treatment and discussed their results and gave some suggestions about metal matrix composites.

The objective of this research was to develop a composite manufactured from ADC12 alloy matrix and with Sic particle reinforcement and fly ash using squeeze casting process (squeeze pressure 20Tons, 25Tons and 30Tons) and to study the mechanical properties, microstructure characterization and wear properties (9).ADC12 alloy a Japan standard aluminium alloy widely used for aeronautical and automobile applications which has high specific strength, hardness and easy to manufacture. Silicon carbide usually added to improve the mechanical properties of composites.

Fly ash consists of SiO_2, Al_2O_3, and Fe_2O_3 and oxides of Mg, Ca, Na, K etc. as major and minor constituent respectively and have spherical shaped particles Fly ash has the specific gravity in the range of 0.6-2.8 gm/cc. It considered being an industrial waste and by-product of coal burning which is easily available in bulk quantity and cheap. Now a days it used for many industrial uses and research being conducted to explore more (10, 11).

Hardness and tensile test indicated that squeeze cast specimens exhibited higher mechanical properties than base metal ADC12.This was mainly due to applied pressure which resulted in effective filling of melt and the die cavity. In addition, the squeeze process is noted to be suitable for effective processing ADC12alloy.

II. SAMPLE PREPARATIONS

ADC12 alloys were used as the matrix material. Silicon Carbide and fly ash were used as reinforcement materials with different weight ratios. Samples were prepared using squeeze casting machine by considering the process parameters such as reinforcement ratio, melting temperature squeeze pressure and die temperature. In this work, three-levels on each process parameters such as Sic/Fly-ash weight ratio, melting temperature, squeeze pressure and die temperature were applied. The process parameters and their selected levels are shown in Table1. In the case of four parameters at each three levels, the traditional experimental design would require 81 experiments. However, in the current design of Taguchi L9 orthogonal array, the experimental trails are reduced to nine (25,26and27).The experimental lay out for process parameters using L9 orthogonal array is shown in Table 2.

TABLE 1: 4 PARAMETERS 3 LEVELS –EXPERIMENTAL DESIGN

PARAMETERS	Level 1	Level 2	Level 3
Reinforcements ratio	2.5% Sic 7.5% Fly-ash 90% ADC12	5% Sic 5% Fly-ash 90% ADC12	7.5% Sic 2.5% Fly-ash 90% ADC12
Melting temperature (°C)	600	625	650
Squeeze pressure (Tons)	20	25	30
Die temperature(°C)	100	150	200

TABLE 2: TAGUCHI L9 ORTHOGONAL ARRAY DESIGN

Trials	Parameters			
	Reinforcements	Melting temperature(°C)	Squeeze Pressure (Tons)	Die temperature(°C)
1	2.5% Sic 7.5% Fly-ash	600	20	100
2	2.5% Sic 7.5% Fly-ash	625	25	150
3	2.5% Sic 7.5% Fly-ash	650	30	200
4	5% Sic 5% Fly-ash	600	25	200
5	5% Sic 5% Fly-ash	625	30	100
6	5% Sic 5% Fly-ash	650	20	150
7	7.5% Sic 2.5% Fly-ash	600	30	150
8	7.5% Sic 2.5% Fly-ash	625	20	200
9	7.5% Sic 2.5% Fly-ash	650	25	100

III. TESTINGS

Squeeze casting machine shown in fig:1 of the bottom pouring vertical type used to manufacture composite. The machine has the temperature range 990°c, 1000°c & 1150°c.So it is suitable for aluminium, magnesium, and silver and gold. Its capacity in industrial scale is 50, 100, &200kg. All the specimens were tested at room temperature for various tests. Tensile strength were evaluated on computerized Universal testing machine at a strain rate of 0.5 mm/min. Hardness strength were evaluated on Rockwell hardness testing machine.

The specimens were being machined for tensile test as shown in Table3 and polished to their standardized sample cross-section. It has two shoulders and a gauge (section) in between shoulders. Hardness measurements as shown in Table.4 quantify the resistance of a material to plastic deformation. Indentation hardness tests compose the majority of processes used to determine materials hardness. Spectro analysis of the ADC12 conducted as shown in Table 5 to analysis chemically. Tensile test as shown in Table 6 and hardness test as shown in Table.7 to determine tensile properties and hardness properties of ADC12 also conducted.

TABLE 3: TENSILE TEST REPORT OF SPECIMENS

Sample ID	1	2	3	4	5	6	7	8	9
Load at yield KN	7.388	10.498	6.689	6.825	7.644	6.757	7.15	6.752	7.393
Elongation at yield mm	3.618	6.208	3.580	3.525	3.473	4.840	4.559	4.291	5.190
Yield stress N/ mm^2	116.134	162.475	104.918	108.001	121.779	105.972	109.938	105.657	116.214
Load at peak KN	9.278	13.135	9.936	10.511	11.325	10.790	10.958	8.470	9.300
Elongation at peak in MM	4.326	7.325	4.792	4.810	5.569	6.551	6.211	5.014	6.023

Tensile strength N/ mm^2	145.833	203.293	155.842	166.326	180.415	169.229	168.476	132.544	146.187
Load at break KN	9.278	0.021	0.026	0.162	0.015	0.126	0.040	8.470	3.639
Elongation at break in MM	4.326	7.427	4.819	4.899	4.657	6.632	6.227	5.014	6.101
%Reduction area	1.11	1.54	0.89	1.11	0.89	2.65	2.40	1.11	1.33
%Elongation	1.29	1.43	0.60	0.49	1.14	1.26	0.97	1.80	1.43

TABLE 4: HARDNESS TEST REPORT OF SPECIMENS

Sample	Observed Values, HRB			
	1	2	3	average HRB
01	37	40	39	39
02	35	38	37	37
03	28	30	31	30
04	35	37	40	38
05	32	35	36	34
06	34	35	35	35
07	38	40	41	40
08	38	39	38	38
09	25	28	30	28

TABLE 5: SPECTRO ANALYSIS REPORT OF ADC12

Al	86.70
Si	9.890
Fe	0.656
Cu	1.608
Mg	0.184
Cr	0.032
Ni	0.071
Zn	0.552
Sn	0.000
Ti	0.050
Pb	0.109
Ca	0.006
Be	0.000
Sr	0.001
Zr	0.005
Bi	0.002
Ga	0.000
Mn	0.136

TABLE 6: TENSILE TEST REPORT OF ADC12

Load at yield KN	2.385
elongation at yield in mm	1.962
Yield stress N/ mm^2	82.69
Load at peak kN	3.732
Elongation at peak mm	2.612
Tensile strength N/ mm^2	129.392
Load at break KN	3.732
Elongation at break mm	2.612
%Reduction area	3.27
%Elongation	2.08

TABLE 7: HARDNESS TEST REPORT OF ADC12

ADC 12	Observed Values, HRB			
	1	2	3	average HRB
01	45	46	48	46

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Figure 1: Squeeze casting machine

IV. RESULTS AND DISCUSSION

Figure 2: casting samples

ADC12, Sic and Fly Ash hybrid composite manufactured by squeeze casting machine set up in the experimental design of Taguchi L9 orthogonal array, accordingly 9 specimens were prepared as shown in fig:2. Tested all the specimens and base metal for strengths and hardness. Tensile strength varies with composition, squeeze pressure, melting temperature and die temperature shows very high in the sample which has high rate of fly ash and showed up to 203.293N/mm^2 (sample number2,7.5% fly ash)which is 63.65% higher than that of base metal (129.392N/mm^2).It is observed that tensile strength is minimum (sample number 8) when the squeeze pressure is low and die temperature is high. Maximum load at yield point is 10.498 KN (sample number 2) which is more than 4 times higher than that of ADC12 base alloy (2.385kN).It is found that all composite specimens being made shows higher yield points. Elongations at yield were 6.208 mm which was above three times higher than that of base metal (1.962mm). Yield stress 162.475N/ mm^2 which were double that of base metal (82.69N/ mm^2). Load at peak 13.135 KN which were 4 times higher than base metal (3.732kN).Elongation at peak 7.325 mm which were higher than base metal (2.612mm).Load at break 9.278 kN (sample1) which were less than base metal (3.732 KN).Elongation at break were 7.427mm which was higher than base metal (2.612mm).Percentage reduction in Area were2.65 at sample 6 which was less than base metal (3.27).Percentage Elongation were 0.49 in sample 4 and high rate was 1.80 which both was less than ADC12.
Rockwell Harness test is performed on all the 9 samples and base metals. The lowest hardness value of the composite prepared is 28HRB (sample number 9) which is 39.131% less than base metal. The highest hardness value is 40HRB (sample number7). which is 13.04347 % less than that of base metal. HRB is 40 at sample 7which is less than adc12 (HRB 46).

V. CONCLUSION

ADC12, Sic and fly ash hybrid composite prepared by maintaining alloy weight constant throughout (90%) and by changing the weight ratios of Sic and fly ash but total weight percentage remains 10% using squeeze casting machine set up. Nine numbers of specimens were prepared, they being tested for their mechanical properties. Since the cost of fly ash very cheap and hence the cost of composite not increases very much. So fly ash can be considered as better material to obtain good mechanical properties. The highest values of squeeze pressure and alloy melting temperatures were determined. Also, it is found that slow cooling of the melt, achieved by increasing the die temperature, is required to improve the mechanical properties of the composite.

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BIOGRAPHY

Maraparambil Ramachandran- The author having experience from 1989 to 1998 as Lecturer,1998 to 2005 as HOD in polytechnic colleges, 2000 to 2005 as workshop Superintendent in Engineering college and from 2005 to till date as principal in polytechnic colleges, in technical education department Kerala.