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Production of Composite using Squeeze Casting of ADC12 Alloy with Sic and Fly-ash

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

Principal Government Polytechnic College Manjeri,

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

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

Abstract: Automobile indusry especially car industry require much less weight parts along with improoved mechanical and physical properties to save fuel which reduces environmental concern .ADC 12 alloys very cheap and widely and easly available.ADC12 alloy composite with sic and fly-ash filler material were prepared by squeeze casting method .Sqeeze casting overcome many drawback in composite manufacturing gives porous free composite without much comprimise in mechanical properties of the composite.

Keywords: Squeeze Casting, Adc12 Alloy, Silicon Carbide, Fly- Ash

I. INTRODUCTION

Most of the modern and advanced engineering application requires materials with unusual combination of properties like light weight, high strength, high stiffness, superior wear and corrosion resistance that cannot be met by the conventional materials. This is particular materials in aerospace, automotive and marine applications. Composites are the advanced and adaptable materials to replace the conventional materials which give superior and unique mechanical and physical properties as it combines the most desirable properties of its constituents while suppressing their least desirable properties. Aluminium is cheap with high stiffness/density and strength/density ratios having damage tolerance. Aluminium automotive parts satisfy both these combinations of properties at cost for a particular need. Wear resistance and high thermal conductivity of aluminium MMC's enable disc brake rotors and brake drums, with weight savings on the order of 50% to 60% Silicon carbide reinforced aluminium alloys has the highest strength to weight ratio. High proportion of silicon carbide to aluminium alloy is difficult to machine and more wear to the cutting tool, increases the machining cost.

A composite material composed of two or more micro or macro constituents differs in form, chemical composition and are insoluble each other. The motto to design composites is to achieve high specific strength, high specific stiffness, and superior wear resistance. The properties are dependent on the intrinsic properties of constituents, the size, shape, orientation, weight fraction and distribution of the reinforcing phase. The composite materials are mainly used in automobile and aerospace industries where Aluminium Matrix Composite (AMCs) were especially used. MMCs provide the specific mechanical properties necessary for elevated and ambient temperature applications. The performance of metal-matrix composites is superior in terms of improved physical, mechanical, and thermal properties. The performance advantages of metal matrix composites are their tailored mechanical, physical, and thermal properties that include low density, high specific strength, high specific modulus, high thermal conductivity and good fatigue response, control of thermal expansion, and high abrasion and wear resistance. The reduced weight and improved strength and stiffness of the MMCs are achieved by various monolithic matrix materials.

The benefits of ADC12 aluminium alloy are excellent cast ability and high mechanical properties. It has easy turbulent flow, which causes porosity defect, and it cannot normally be heat treated because of the surface blister and the pore expansion at high temperatures. To solve the problems of ADC12 aluminium alloy, a semi-solid die casting process is selected. Alloys having this course exhibit low ductility because of the brittle nature of the large silicon plates. Rapid cooling greatly refines the microstructure and the silicon phase assumes to be of fibrous form results that both ductility and tensile strength are much improved. Composite materials have matrix phase and a reinforcement phase. Composite materials are made from two or more materials which when formed together shows improved characteristics as in individual components. Individual components remain separate within the finished structure, new

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material exhibit stronger, lighter and comparatively low cost. The use of Silicon carbide and Fly ash increases stiffness, strength and dimensional stability ,toughness and impact strength, heat deflection temperature, mechanical damping, chemical wear and corrosion resistance, modify electrical properties, reduce permeability to gases and liquids, weight and cost and decrease thermal expansion.

II. ALUMUNIUM DIE CASTING ALLOY (ADC12)

Aluminium-Silicon alloy (ADC12) is selected as matrix alloys the chemical compositions of aluminium alloy were analyzed using glow discharge spectrometer

Table 1: Specification of ADC12

PROPERTY	ADC12 Alloy
Density, g/cm^3	2.76
Thermal Conductivity, W/m K	10-40 at 1100^{0}C
Specific Heat, J/K	96.2
Elastic Modulus, G Pa	68.90
Coefficient of Thermal Expansion, K^{-1}	31.1x10^{-6}
Poisson Ratio	0.33

III. SILICON CARBIDE

The SiC particles used as reinforcement are sieved using standard sieving practice through different grades of sieves in a vibratory sieving machine, with an aim to get particles within the size range.

Table 2: Properties of Silicon Carbide

Mechanical properties	SI/ Metric Imperial	SI/Metric	(Imperial)
Density	Gm/cc(lb/n3)	3.1	(193.5)
Porosity	%(%)	0	(0)
Colour	--	black	--
Flexural Strength	M Pa (I b/in2*10^3)	550	(80)
Elastic Modulus	G Pa (I b/in2*10^6)	410	(59.5)
Shear Modulus	G Pa (I b/in2*10^6)	--	--
Bulk Modulus	G Pa (I b/in2*10^6)	--	--
Poisson's Ratio	--	0.14	(0.14)
Compressive Strength	M Pa (I b/in2*10^3)	3900	(566)
Hardness	Kg/mm^2	2800	--
Fracture Toughness	M pa*m$^{1/2}$	4.6	--
Maximum Use Temperature (no load)	C(F)	1650	(3000)

IV. FLY ASH

Fly ash consists of SiO_2, Al_2O_3, and Fe_2O_3 as major and oxides of Mg, Ca, Na, K etc. as minor constituent, its particles are spherical shaped have specific surface area between 250 and 600m2/kg, specific gravity 0.6-2.8 gm/cc. A byproduct of coal combustion available in large quantities at low costs reduces the cost of composites reduces cost, decreases density and increase hardness, stiffness, wear and abrasion resistance, improves the maintainability, damping capacity, coefficient of friction etc .

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V. SQUEEZE CASTING

Squeeze casting combines the advantages of both casting and forging , used to produce fine grained less or eliminated porous quality castings with improved mechanical micro structure. Squeeze casting carried out in squeeze casting machine which involves mixing of preheated reinforcement with molten matrix material prepared with the help of furnace and stirring mechanism .Melt is poured directly into the die fitted on the squeeze casting setup. Pathway tube from furnace to squeeze casting setup pre heated .The temperature of this heating system is controlled by control panel. Hydraulic press is squeeze the casting at desired pressure with suitable motorized hydraulic power pack and digital pressure indicator. Pressure is maintained to the required level until solidification completed.

TYPE	BOTTOM POURING (VERTICAL TYPE)
Temperature Ranges	900°C, 1000°C & 1150°C (Suitable for Aluminium, Magnesium, Brass, Silver & Gold
Capacity	Laboratory Scale 2 & 5k Industrial Scale 50,100 & 200 kg (As per customer's requirement
Heating chamber	Stainless steel or Incorrect (as per the temperature ranger)
Stirrer	Mechanical high speed stirrer (2000 RPM) High frequency vibrator
Heating element	Al & APM
Atmosphere	Vacuum, Oxidizing (normal) & inert with Argon, O2,Nitrogen and Hydrogen
Controlling equipments	ON/OFF PID & Program controllers with data acquisition system
Special Features	Pour to cast by Gravity casting, Vacuum casting, Squeeze casting, Rotary centrifugal casting

VI. COMPOSITE PREPARATIONS

Well Stirred melt Poured from furnace in continuous stream, into the die. Pressure is applied at various pressures by hydraulic pressure assembly (20-30), which gives quality. Melting of the ADC12 alloy was carried out at temperature 780°C in graphite crucibles using an induction furnace. The composite was prepared by the stir casting method. The method composes of dispersing the second phase particles on to the vortex of the molten alloy. The vortex was created with the help of a rotating mechanical stirrer its rotation was maintained around 500 to 600 rpm. The Sic particles were heated to 600°C in a graphite crucible in a muffle furnace which introduced into the molten alloy by churning action of the stirrer. A baffle is used in the melt along the sides of the crucible to obtain uniform stirring. Great amount of turbulence produces in the flow pattern and induces better mixing of the Sic particles in the melt. After the complete addition of Sic particles, the speed of the stirrer is brought down to 200- 400 rpm and the stirring continued for 3-5 minutes. The temparature of molten mixture is brought down to 680°C to provide ultrasonic vibration to mixture for proper mixing. When the alloy reaches semi pasty stage the surface is covered with a fluxing agent. After the surface is again cleaned and the temperature of the melt is increased to 760°C to take care of the minimum absorption during bubbling. The stirrer is then withdrawn from the melt. The composite melt was then solidified into a cast iron permanent die.

VII. CONCLUSION

Cars contain an average of 132 kg of Aluminium components and industry is working on new improved Aluminium alloys and solutions .Body structure , chassis and suspension in smaller mass produced cars, sport and luxury cars, presently aluminium is mostly used . Especially designed and processed Al-Mg-Mn 5000 alloys and newly developed high Mg contents improve mechanical and corrosion properties and roll clad materials provide innovative alternatives. For hang-on parts like hoods, doors, and fenders, precipitation New alloys meet highest requirements on formability and age hardening characteristics. Besides Aluminium new high strength steels, magnesium and plastics or composites were tested in advanced multi material concepts that exploit the material potential of all light-weight materials. Aluminium has proven to be the ideal light-weighting material allowing weight saving in mass production within reasonable costs limits and without compromising safety.

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The tensile strength value was 281.13 MPa for alloy which increases to 299.97 MPa for 10% Sic composite. On further increases in Sic reinforcement the tensile value decreases to 283.04 MPa. Improvement of around 7% in the tensile strength in case of 10% Sic composite and almost same in 15% Sic composite. It is understood that dispersion of fine Sic particles of size (2µm) in aluminium alloy matrix tends to reduce the tensile properties as during tensile deformation.The soft aluminium matrix will elongate and the Sic particles which are very hard are not deformed at the same rate as the matrix does. This non uniform deformation of matrix and hard particles results into development of cracks at the interface. Hence decohesion and void formations are the main reason. The variation of Compressive strength of the alloy and the composites, compressive strength value was 484.39 MPa for alloy which decreases to 373.39 MPa for 10% Sic composite and on further increases in Sic reinforcement to 15%, the Compressive strength value decreases to 353.04 MPa.

Increase in Sic percentage, dispersion of Sic particles in aluminium alloy matrix tends to reduce the compressive properties as during compression, the soft aluminium matrix will compress and the Sic particles which are very hard are not deformed at the same rate as the matrix does. Non uniform deformation of matrix and hard particles results into development of cracks at the interface, hence lower the compressive strength of composites and variation in hardness of the alloy and the composites. Hardness of the composite increases with increase in concentration of Sic .The value of hardness being 50 HRB for alloy which increases to 55 HRB for 10% Sic composite and 58 HRB for 15% Sic composite. There is an improvement of around 10% and 16% in the hardness of the composites as compared to the alloy. The dispersion of Sic particles in aluminium alloy offer resistance to deformation of the matrix. A good interface between the Sic and aluminium matrix always give rise to higher hardness value. 15% Sic particles in aluminium matrix shows highest hardness values amongst all the variation of impact strength of the alloy and the composites. The impact strength for alloy was 7.3 Nm which decreases to 5.7 Nm and 5.0 Nm respectively for 10% and 15% Sic composite. The impact strength value indicates that impact strength decreases with increase of Sic concentration in the composites. Hard ceramic particles and soft matrix reduces the energy absorption capability of the material. More the dispersion of Sic particles lesser is the impact strength. Sudden impact breaks the interface between the particles and the matrix and decohesion produces new surfaces and the energy is released. Aluminium alloy matrix material absorb the impact energy without fracturing.

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