"The study on controlling inclusions on the Properties of Cast Al SiC Metal Matrix Composit "

By
Dr. Nandita Gupta,
Professor, Department of Foundry Tech. ,NIFFT, Ranchi National Institute of Foundry & Forge Technology, Hatia, Ranchi, Jharkhand, India.

Introduction

❑Metal matrix composites,in general, consist of continuous or discontinuous fibers, whiskers, or particulates dispersed in a metallic alloy matrix.

❑They consist of two or more materials where one of which should be metal.

❑These reinforcements provide the composite with properties not achievable in monolithic alloys.

❑Most commonly used metal matrix are : Al, Mg, Ag, Ti, Ni, Cu.

❑Reinforcement used are ceramic like Silicon carbide, Graphite,

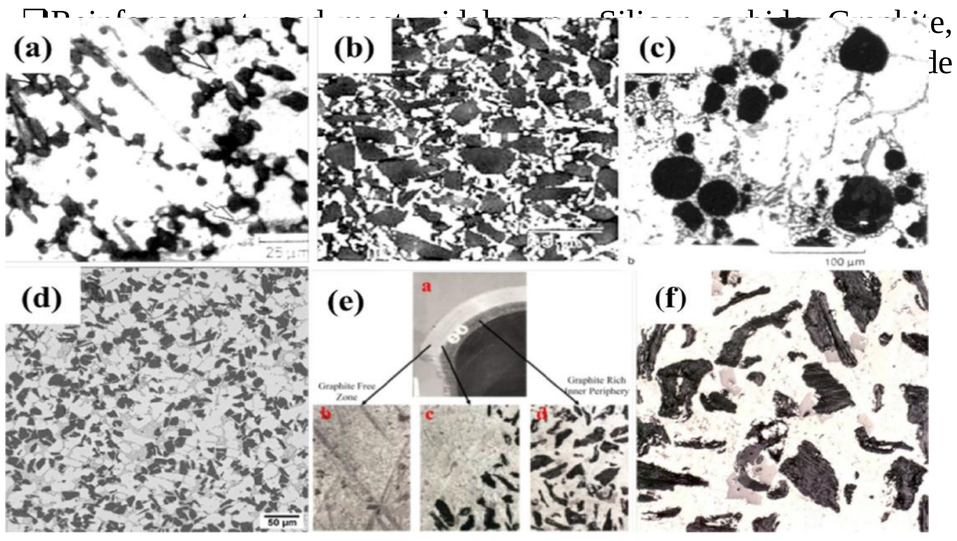

Figure 1. (a) microstructure of Al–Si/Saffil fiber, (b) A356/SiC composites, (c)Al–Si/ 20 vol% spherical Al_2O_3p, (d)silicon carbide particle-reinforced aluminum compos- ite, and (e–f) Al–Si/20 vol%–graphite particle composite.

Importance of Nano particle in Metal Matrix

❑Nano particles are used as one of the phases in the metal matrix nanocomposite.

❑Nano particles have size in the range of 1-100 nm.

❑MMC have superior mechanical and metallurgical properties compared to monolithic alloys.

❑When nanoparticles are properly incorporated in the metal matrix, the metal matrix composite so formed has better mechanical properties in terms of high yield point, high hardness, high wear resistance, high Young's Modulus.

❑We also get better metallurgical properties in terms of refined fine grain microstructure

Table 1.0 Mechanical properties of AMCs with different conventional reinforcements

Matrix	Reinforcement , Content (%vol.)	Yield strength Re (MPa)	Tensile strength Rm (Mpa)	Elongation (%)
Al	-	64	90	21
Al	SiC20	117	220	10
2014 T6	-	429	476	7.5
2014 T6	SiC10	457	508	1.8
6061 T6	-	275	290	18
6061 T6	SiC15	290	340	5.5
6061 T6	SiC20	345	410	4.9
6061 T6	SiC30	380	435	1.8
6063 T6	-	160	190	18

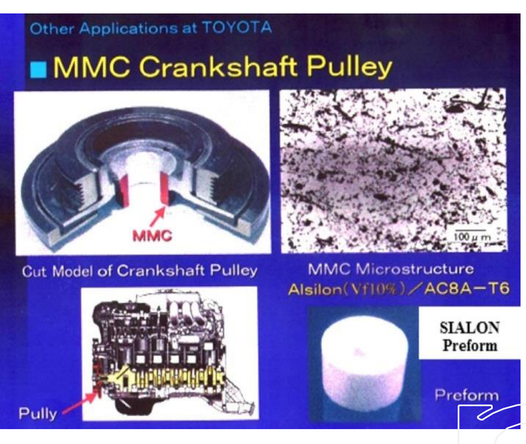

Figure 2. MMC crankshaft pulley made by infiltration of SIALON preform with aluminum.

Figure 3. A359/20 vol%--SiC_p composite brake rotor for an electric vehicle

Matrix

❑Many composite materials are composed of just two phases; one is termed the matrix, which is continuous and surrounds the other phase which is termed as reinforcement.

❑The choice of matrix material depends mainly on the application temperature, density, required strength level and cost criteria of the intended applications.

❑Other factors such as ductility, fatigue resistance, electrical conductivity and fracture toughness are dependent on the selected matrix material. Classification of matrix has been represented below.

❑Polymer matrix composites (PMCs)

❑Metal matrix composites (MMCs)

❑Ceramic matrix composites (CMCs)

Depending upon Size, Shape &MMC are classified into three broad categories, depending upon aspect ratio of reinforcing phase arrangement of Nano Particles

❑ Unidirectionally aligned long fibers. embedded in matrix

❑Short fiber reinforced composite

❑ Particle composite

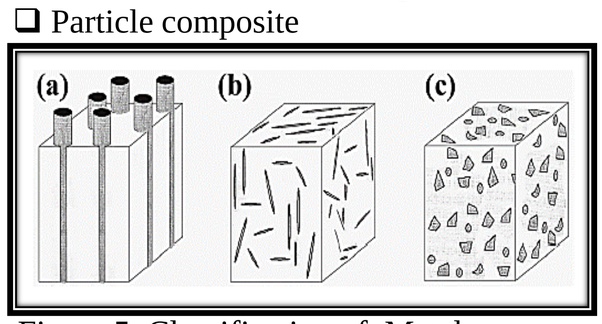

Figure 5. Classification of Metal Matrix Composite

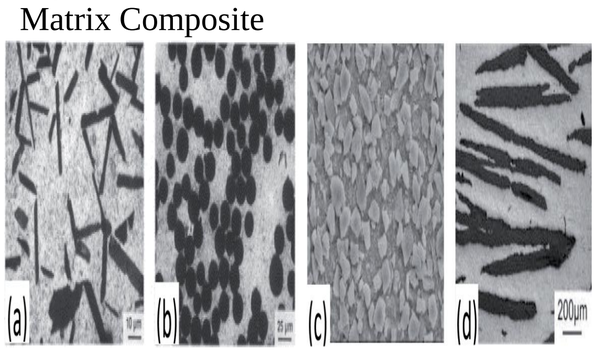

Figure 6 Typical microstructures of AlMMCs. (a) Al/Al_2O_3 platelets. (b) Al/Al_2O_3 continuous fibres. (c) Al/SiC_p. (d) Al/graphite with 20 vol.% graphite flakes taken along the basal plane

Fiber reinforced MMC are the most expensive to produce among all MMC.

Particulate reinforced MMC are leas expensive to produce among all MMC.

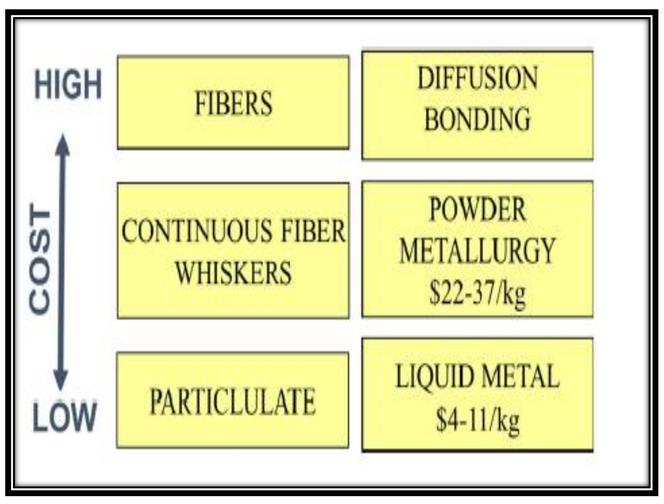

Figure 7.Comparison of Reinforcement used in Metal Matrix Composite

Reinforcement:

The reinforcement material is embedded into a matrix. The reinforcement does not always serve a purely structural task, but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity.

Reinforcements type:

1)Particle reinforcement

a. Large particle reinforcement

b.Dispersion strengthened reinforcement

2) Fibre reinforcement

a. Continuous [Aligned] reinforcement

b. Discontinuous [Short] reinforcement

3)Structural reinforcement

a. Laminates

b. Sandwiched panels

Figure

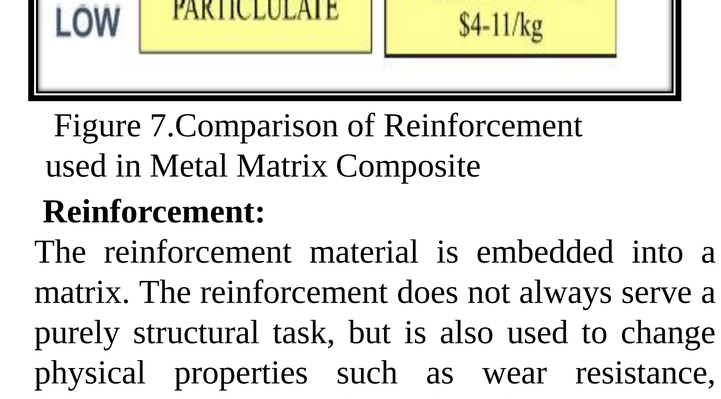

Figure 8. Typical microstructures of MMCs. (a) Cu/Cr co-deformed composite. (b) Ti-6Al-4 V/SiC monofilament. (c) NiAl/Mo in situ composite. (d) Mg/Al_2O_3 short-fibre composite. (e) Al/SiC particulate composite. (f) Co/WC cermet (source: [1]).

Applications of Composites in Automobile Industry

Several automotive components including piston, cylinder liners, brake rotors, connecting rods have been made out of Al composites.

❑The first commercial made automotive MMC component was a diesel engine piston produced by Squeeze casting.

❑For Al-SiC composite made brake rotor, weight saving of 50-60% of weight of cast iron is reported.

Manufacturing and forming methods

Solid state methods-

Powder blending and consolidation (powder metallurgy): Powdered metal and discontinuous reinforcement are mixed and then bonded through a process of compaction, degassing and thermo-mechanical treatment (possibly via hot isostatic pressing or extrusion).

Foil diffusion bonding: Layers of metal foil are sandwiched with long fibers, and then pressed through to form a matrix.

Liquid state methods-

Electroplating and electroforming**:** A solution containing metal ions loaded with reinforcing particles is co deposited forming a composite material.

Stir casting: Discontinuous reinforcement is stirred into molten metal, which is allowed to solidify.

Pressure infiltration**:** Molten metal is infiltrated into the reinforcement through use a kind of pressure such as gas pressure.

Squeeze casting: Molten metal is injected into a form with fibers pre placed inside it.

Spray deposition**:** Molten metal is sprayed onto a continuous fiber substrate.

Reactive processing: A chemical reaction occurs with one of the reactants forming the matrix and the other reinforcement.

Semi-solid state methods

Semi-solid powder processing: Powder mixture is heated up to semi-solid state and pressure is applied to form the composites.

Vapor deposition method-

Physical vapor deposition: The fiber is passed through a thick cloud of vaporized metal, coating.

Stir Casting- Molten metal is stirred with the help of mechanical stirrer or high intensity ultrasonic treatment in metal casting. Reinforced particles are dispersed in molten metal and solidify the composite melt.

Metal matrix used with stir casting: Al, Mg, Ag, Ti, Ni, Cu.

Reinforcement used with stir casting : Silicon carbide, Graphite, Silicon oxide, Aluminium oxide, tungsten carbide, Titanium diboride etc.

Squeeze Casting- It is one of the most popular method of producing nanocomposite in liquid phase.

In this method a pressing rod is forced against the melt containing the nanoparticles.

The composite produced are of good quality.

Figure 10 Schematic Representation of Stir Casting

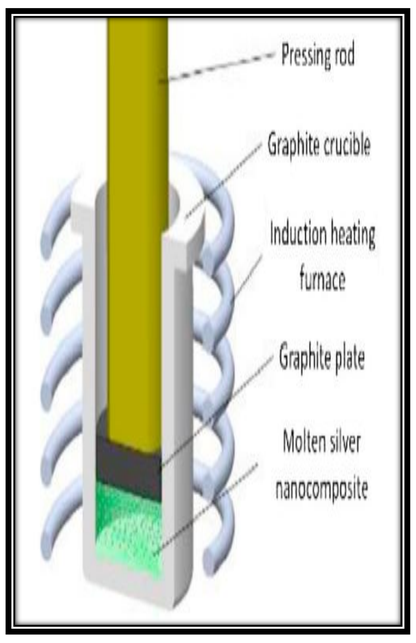

Figure-11 Squeeze Casting

Conclusion

❑In Flux assisted Liquid state processing SiC nanoparticles were fairly distributed and dispersed in Al-2Vol% SiC nanocomposite.

❑Better mechanical and metallurgical properties are observed in metal matrix composites compared to the pure metal.

❑Due to combination of properties like good wear resistance, high hardness, high yield point their growing use in automobile is inevitable.

❑Due to their stability at higher temperatures they can be a good option for applications involving high temperature.

❑The liquid processing of metal matrix composite is relatively cheaper compared to the other methods like solid state processing and gas state processing.

❑Properties which are not possible with pure metals or monolithic alloys can be achieved by metal matrix composites.