

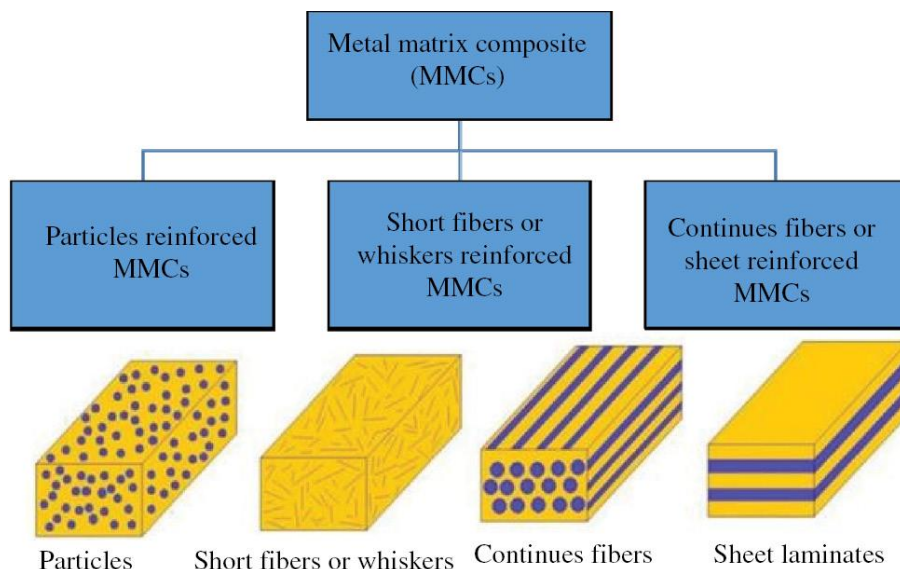
METAL MATRIX COMPOSITES

Metal matrix composites (MMCs) are composite materials containing at least two constituent parts – a metal part and a material or a different metal part.

The metal matrix is reinforced with the other material to improve strength and wear. Most metals and alloys make good matrices.

Matrix - This is usually composed of a lighter metal such as magnesium, copper, titanium, or aluminum. In high-temperature applications, cobalt and cobalt-nickel alloy matrices are common.

Reinforcement- Continuous carbon, boron, silicon carbide, or ceramic fibers are some of the materials that can be embedded in a metallic matrix material. Reinforcement can be in the form of particles, short fibres, whiskers, sheets or continuous fibres.



The following are some key properties of MMCs:

- Fire resistant
- Operate in wider range of temperatures
- Do not absorb moisture
- Better electrical and thermal conductivity
- Resistant to radiation damage
- Do not display outgassing
- Low CTE and light weight
- Good damping and high compression strength
- High specific stiffness and strength.

Manufacturing Process

A. Solid State Methods

Solid state methods, as the terminology implies, typically involves two or more solid materials, and these materials are often sandwiched together or infused via thermal or mechanical means. Powdered materials can also act as the matrix material, and these powders are often used to coat the outer layers of a base or reinforcing material.

i. Powder Blending / Powder metallurgy and Consolidation

Powder blending and consolidation is when a manufacturer takes a powdered metal and some discontinuous reinforcing material, mix them together, and then bond them through a process of compaction, degassing, and thermo-mechanical treatments (often through isostatic pressing or extrusion).

ii. Foil Diffusion Bonding

Foil diffusion bonding is when the manufacturer takes copious layers of some metal foil and then sandwiches long fibers from another material between each layer.

B. Semi-Solid State Methods

Semi-Solid Powder Processing

Semi-Solid Powder Processing is a process where a powder mixture is heated up to a semi-solid state and pressure is applied to form the composites.

C. Liquid State Methods

i. Electroplating and Electroforming

Electroplating and electroforming is a method when a solution containing metal ions loaded with reinforcing particles are co-deposited forming the composite material.

ii. Stir Casting

Stir casting is a method where a discontinuous reinforcement is stirred into molten metal and it creates a composite when it solidifies.

iii. Pressure Infiltration

Pressure infiltration is where a molten metal is infiltrated or impregnated into the reinforcement through a technique involving pressure (typically in the form of gas).

iv. Squeeze Casting

Squeeze casting is a process where molten metal is injected into a form with reinforcing fibers pre-placed inside of it.

v. Spray Deposition

Spray deposition is a process where some molten metal is sprayed onto a continuous fiber substrate.

vi. Reactive Processing

Reactive processing is processing involving a chemical reaction where one of the reactants forms the matrix and the other forms the reinforcement.

D. Vapor Deposition Methods

Physical Vapor Deposition

Physical vapor deposition is a process where the reinforcing fiber material is passed through a thick cloud of vaporized metal (coating it).

Applications

The following are some of the most common application areas of composite metal matrix materials:

- Pushrods for racing engines
- Carbide drills
- Tank armors
- Automotive industry - disc brakes, driveshaft, engines
- Aircraft components - structural component of the jet's landing gear
- Bicycle frames
- Space systems
- High density multi-chip modules in electronics
- Parts in particle accelerators
- Attach plates for high-speed robots

Examples of Metal Matrix Composites

Most of the composites available in the market are usually classified under the following:

Aluminium MMC - These composites make use of aluminium as the base metal matrix. Examples include aluminium-graphite composite, and aluminium-beryllium composites .

Magnesium MMC - Magnesium is another excellent matrix material for composites. Some products in this category include magnesium-silicon carbide (Mg-SiC), magnesium-aluminium oxide (Mg-Al₂O₃) and magnesium-titanium carbide (Mg-TiC).

Titanium MMC - Pure titanium is already a strong material in itself, but its composite form may enhance its superior strength.

Other MMCs - Other less common but highly useful matrix base materials used for composites include copper, cobalt, nickel, or a combination of metals. Meanwhile, some of the most common reinforcing materials used are carbon fibre, silicon carbide, alumina, and boron.

Aluminium – carbon (Al-C)

It is fiber reinforced composite. The material is used in the antenna supports, mirrors and other optical devices and radio engineering. This enhances the accuracy of the reading mode devices without using power compensation effect of the thermal stresses. It is possible to use this composite on space platforms where there are cyclic changes in working conditions: being in the shadow of the Earth or in the full sun light.