METAL MATRIX COMPOSITES (MMCs)

Presented By:

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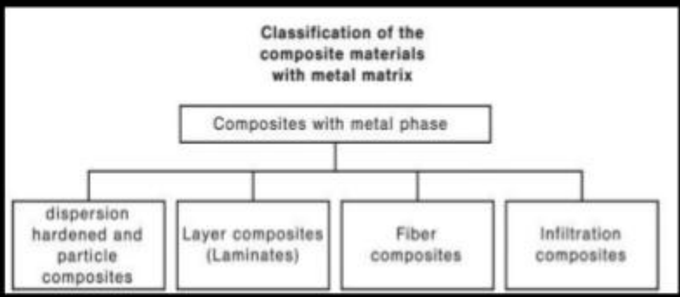
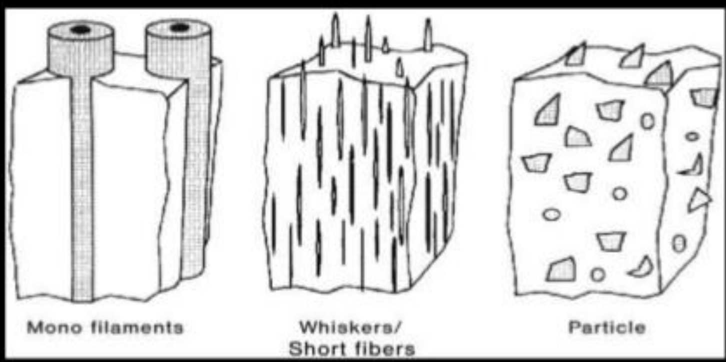
INTRODUCTION

- Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density.
- To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest.
- Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys.

CLASSIFICATION OF METAL MATRIX COMPOSITE





METAL MATRIX COMPOSITES (MMCs)

- A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal.
- The other material may be a different metal or another material, such as a ceramic or organic compound.
- When at least three materials are present, it is called a hybrid composite.

COMPOSITION

- MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix.

- For example, carbon fibers are commonly used in aluminum matrix to synthesize composites show.

MATRIX

- The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous.

- This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together.

- The matrix is usually a lighter metal such as aluminum, magnesium, or titanium, and provides a compliant support for the reinforcement.

REINFORCEMENT

- The reinforcement material is embedded into the matrix.
- It is used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity.
- The reinforcement can be either continuous, or discontinuous.

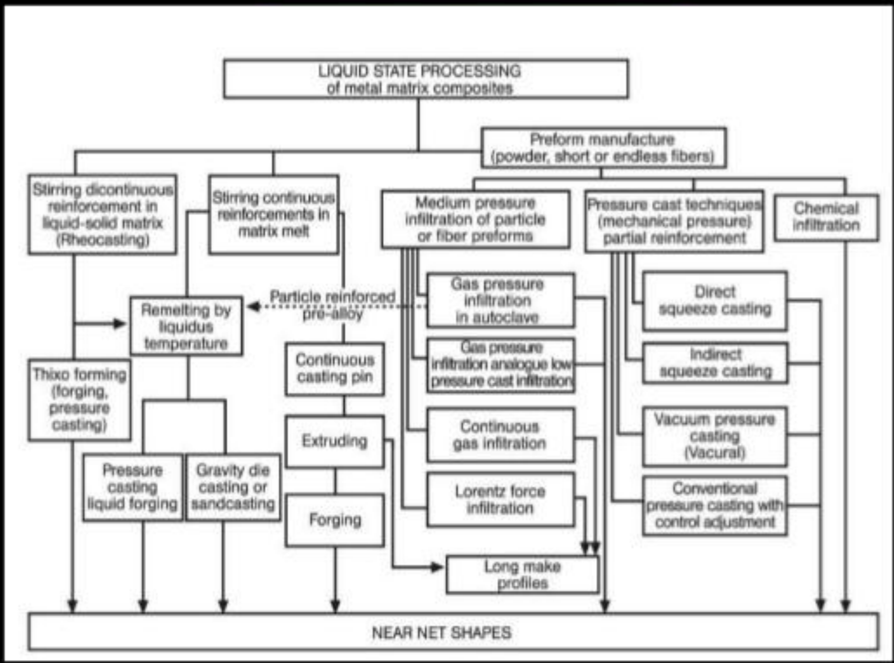
Reinforcements for metal matrix composites have a manifold demand profile, which is determined by production and processing and by the matrix system of the composite material. The following demands are generally applicable:

- Low density,
- Mechanical compatibility (a thermal expansion coefficient which is low but

Chemical compatibility,

- Thermal stability,
- High Young's modulus,
- High compression and tensile strength,
- Good process ability,
- Economic efficiency.

PRODUCTION AND PROCESSING OF METAL MATRIX COMPOSITES



MECHANICAL PROPERTIES OF MMCs

- lower coefficient of thermal and electrical conductivity

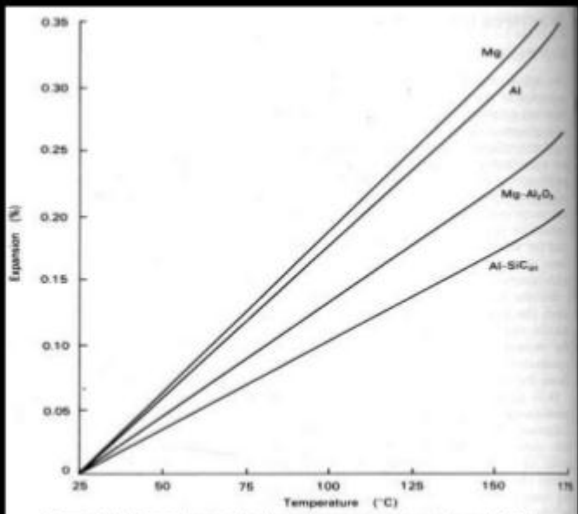


Figure 3.8 Comparison of the thermal expansion of metals and MMCs.

STRENGTH OF MMCs

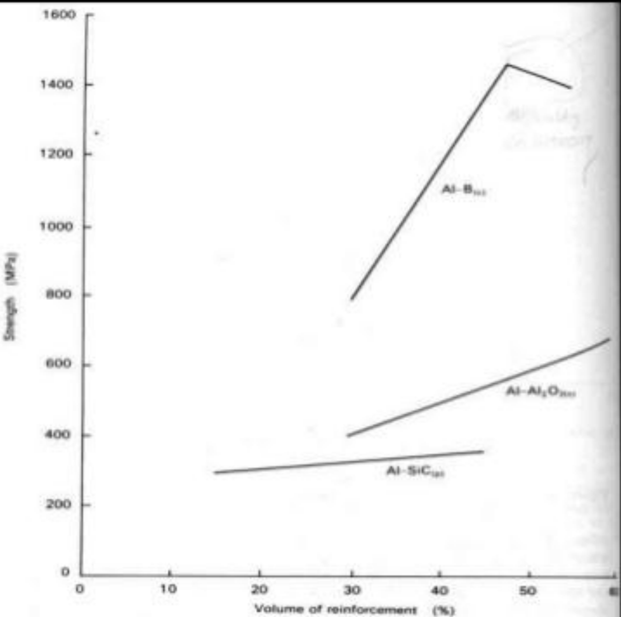


Figure 3.12 Effect of volume of reinforcement on the tensile strength of aluminium alloy matrix composites. 'c' and 'p' refer to continuous fibre and particulate composites respectively. The values for 'c' composites are longitudinal strengths.

Young's Modulus of MMCs

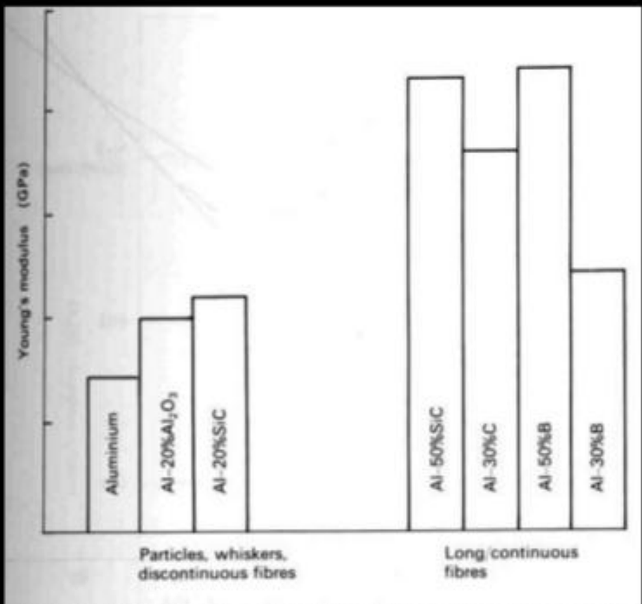


Figure 3.9 Effect of reinforcement on the Young's modulus of aluminium.

- higher thermal deformation resistance

$$= \frac{\text{thermal conductivity}}{\text{thermal expansion coefficient}}$$

- low fatigue resistance

- Reinforcement-matrix interface

  Extensive interaction

  Strong ⇨ high strength

APPLICATIONS OF METAL MATRIX COMPOSITES

I.	Drive shaft for people and light load motor vehicles (Fig. 1.61) [65]:	
	Material:	AlMg1SiCu + 20 vol.% Al_2O_3P
	Processing:	extrusion form cast feed material
	Development aims:	– high dynamic stability, high Young's modulus (95 GPa) – low density (2.95 g cm^{-3}) – high fatigue strength (120 MPa for $n = 5\times10^7$, $R = -1$, RT) – sufficient toughness (21.5 MPa $m^{1/2}$) – substitution of steels
II.	Vented passenger car brake disk (Fig. 1.62) [65]:	
	Material:	G-AlSi12Mg + 20 vol.% SiC_P
	Processing:	sand- or gravity die casting
	Development aims:	– high wear resistance (better than conventional cast iron brake discs) – low heat conductivity (factor 4 higher than cast iron) – substitution of iron materials
III.	Longitudinal bracing beam (Stringer) for planes (Fig. 1.63) [66]:	
	Material:	AlCu4Mg2Zr + 15 vol.% SiC_P
	Processing:	extrusion and forging of casted feed material
	Development aims:	– high dynamic stability, high Young's modulus (100 GPa) – low density (2.8 g cm^{-3}) – high strength ($R_m = 540$ MPa, $R_{P0.2} = 413$ MPa, RT) – high fatigue strength (240 MPa for $n = 5\times10^7$, $R = -1$, RT) – sufficient toughness (19.9 MPa $m^{1/2}$)
IV.	Disk brake calliper for passenger cars (Fig. 1.64) [67]:	
	Material:	Aluminium alloy with Nextel ceramic fibre 610
	Weight reduction:	55% compared to cast iron.

THE MOST IMPORTANT MMC SYSTEMS

- Aluminum matrix
- Continuous fibers: boron, silicon carbide, alumina, graphite
- Discontinuous fibers: alumina, alumina-silica
- Whiskers: silicon carbide
- Particulates: silicon carbide, boron carbide
- Magnesium matrix
- Continuous fibers: graphite, alumina
- Whiskers: silicon carbide
- Particulates: titanium carbide
- Copper matrix

THE ADVANTAGES OF MMCs

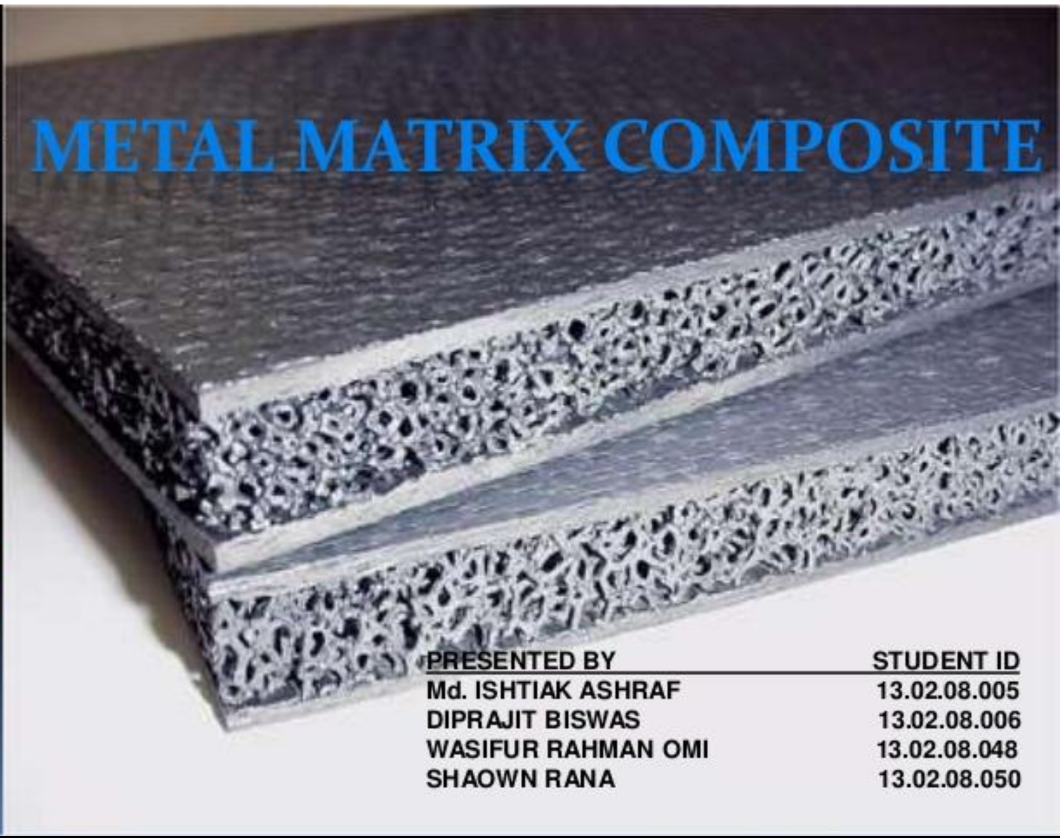
- Higher temperature capability
- Fire resistance
- Higher transverse stiffness and strength
- No moisture absorption
- Higher electrical and thermal conductivities
- Better radiation resistance
- Fabric ability of whisker and particulate-reinforced MMCs with conventional metalworking equipment.

THE DISADVANTAGES OF MMCs

- Higher cost of some material systems .
- Relatively immature technology .
- Complex fabrication methods for fiber-reinforced systems (except for casting).

CONCLUSION

- Metal matrix composites offer sufficient promise and have reached the degree of maturity that indicates an expansion of their use. To realize their full potential however these composites deserve greater attention and support.
- The numbers of MMCs currently are in various stages of development: these are boron/aluminum, beryllium/titanium, and boron/titanium, graphite/aluminum, and supper alloys reinforced with refractory metal.
- The boron/reinforced aluminum system is in most advanced stage of development and properly data for this system are sufficient for design in structural application.



METAL MATRIX COMPOSITE

PRESENTED BY	STUDENT ID
Md. ISHTIAK ASHRAF	13.02.08.005
DIPRAJIT BISWAS	13.02.08.006
WASIFUR RAHMAN OMI	13.02.08.048
SHAOWN RANA	13.02.08.050

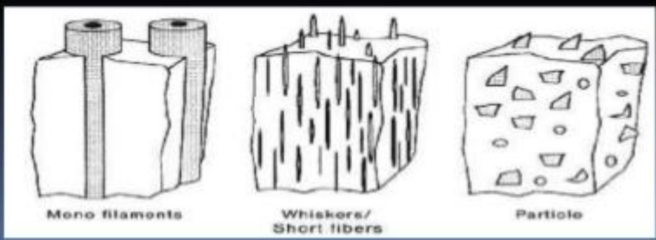
WHY WE USE MMC?

- High strength
- High stiffness
- Toughness
- Density
- Good wear resistance
- Damping capacity
- Specific modulus

CLASSIFICATION OF MMC

Composites with metal phase

- Dispersion hardened & particle composites
- Layer composites (Laminates)
- Fiber composites
- Infiltration composites



COMPOSITION

FIBER	MATRIX
Graphite	Aluminum
	Magnesium
	Lead
	Copper
Boron	Aluminum
	Magnesium
	Titanium
Alumina	Aluminum
	Lead
	Magnesium
Silicon carbide	Aluminum
	Titanium
	Super alloy (cobalt Base)

Manufacturing and Forming Methods

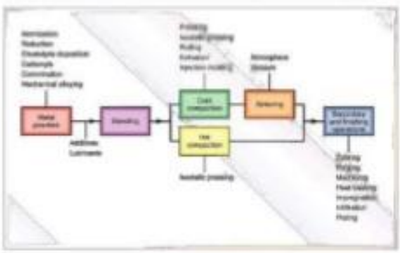
- **Solid state methods**
- **Semi-solid state methods**
- **Liquid state methods**
- **Vapor Deposition**
- **In-situ fabrication technique**

Solid state methods

1. Powder blending and consolidation

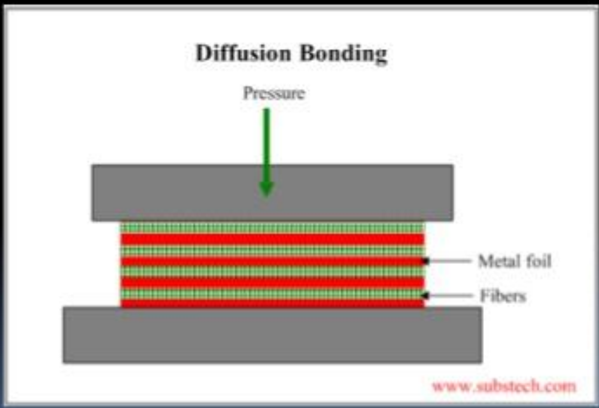
Powder metallurgy

- is the process of blending fine powdered materials, pressing them into a desired shape (compacted), and then heating the compressed material in a controlled atmosphere to bond the material (sintering).



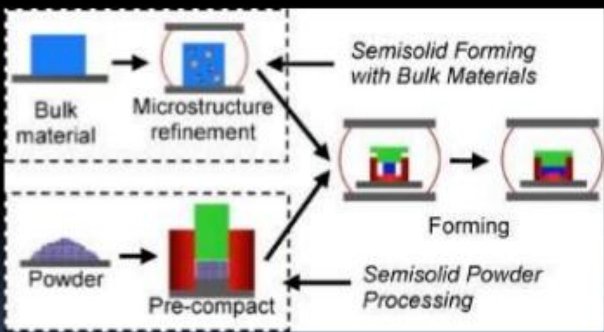
Solid state methods

2. Foil diffusion bonding



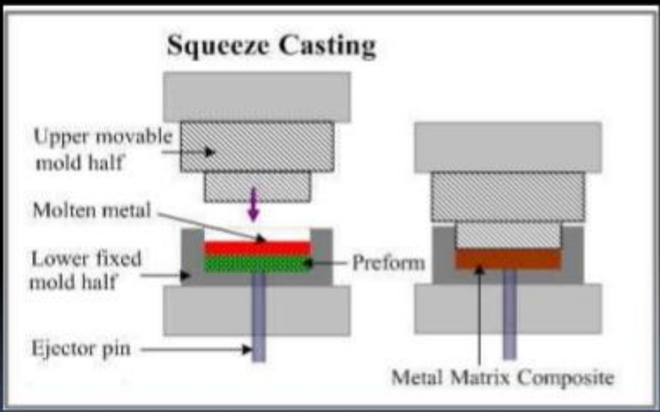
Semi-solid state methods

- Semi-solid powder processing



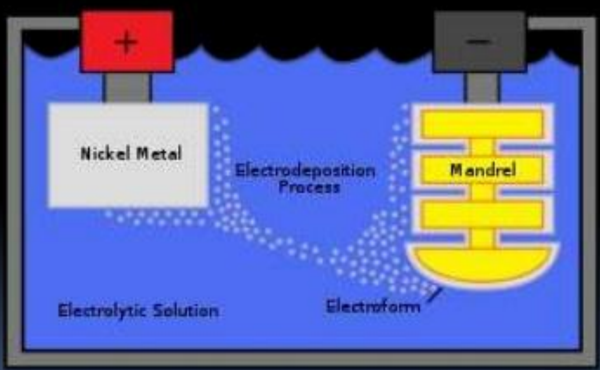
Liquid state methods

1. SQUEEZE CASTINGS



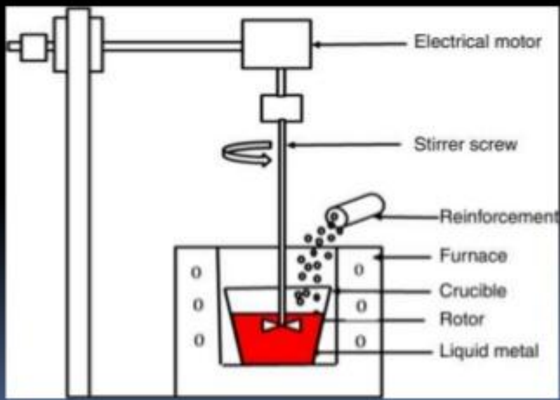
Liquid state methods

2. Electroplating and electroforming



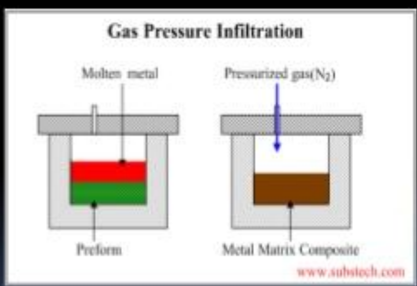
Liquid state methods

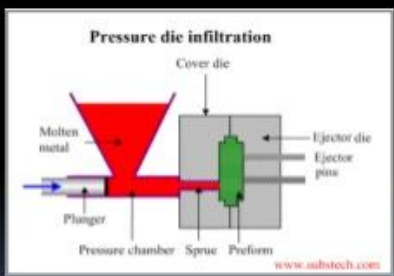
3. Stir casting



Liquid state methods

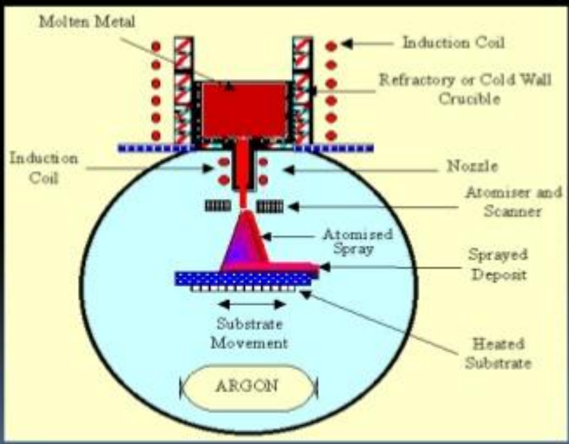
4. Pressure infiltration



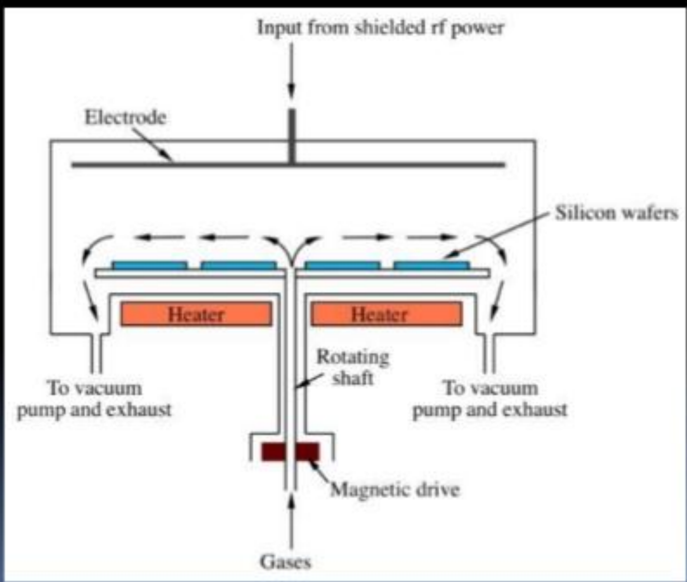


Liquid state methods

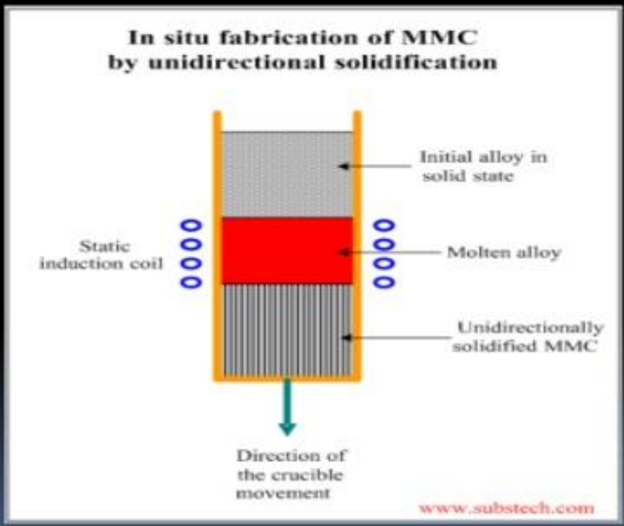
5. Spray deposition



Vapor Deposition



In-situ fabrication technique



APPLICATIONS OF MMC

- **Drive shaft**

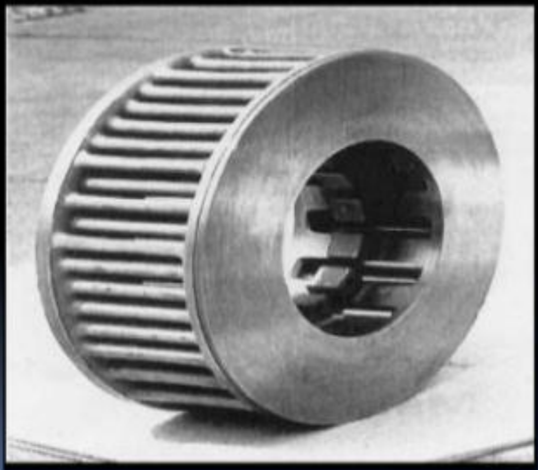
  Material : AlMg1SiCu+20% Al2O3P

  Processing : extrusion from cast feed material

- **Vented passenger car brake disk**

  Material : G-AlSi12Mg + 20% vol. SiCp

  Processing : Sand / Die casting



- **Longitudinal bracing beam for planes**

  Material : AlCu4Mg2Zr + 15 % vol. Cp

  Processing : extrusion or, forging of casted feed material.

- **Disk brake calliper for passenger cars**

  Material : Aluminum alloy with nextel ceramic fiber 610

  Weight reduction : 55% cast iron compared

- **Partial short fibers reinforced light metal diesel pistons**

- Honda has used aluminum metal matrix composite cylinder liners in some of their engines, including the B21A1, H22A and H23A, F20C and F22C

- The F-16 Fighting Falcon uses monofilament silicon carbide fibers in a titanium matrix for a structural component of the jet's landing gear.

- Al high gain antenna wave guides/boom for the Hubble Space Telescope