FABRICATION OF CERAMIC MATRIX COMPOSITES BY LIQUID PHASE INFILTRATION

The methods of fabrication of Ceramic Matrix Composites, utilizing infiltration of a liquid into long continuous fibers, are as follows:

- **Infiltration of molten ceramic**
- **Slurry Infiltration Process (SIP)**
- **Reactive Melt Infiltration (RMI)**
- **Polymer Infiltration and Pyrolysis (PIP)**

Infiltration of molten ceramic

Infiltration of molten ceramic into a fiber preform is limited by low viscosity of molten ceramics and by high temperature causing chemical interaction between the molten matrix and the dispersed phase (fibers). This process (similar to Liquid state fabrication of Metal Matrix Composites) is sometimes used for fabrication glass matrix composites.

Slurry Infiltration Process (SIP)

Slurry Infiltration Process (SIP) involves the following operations:

- Passing fibers (tow, tape) through a slurry containing particles of the ceramic matrix;
- Winding the fibers infiltrated by the slurry onto a drum and drying;
- Stack of the slurry impregnated fibers in a desired shape;
- Consolidation of the matrix by hot pressing in Graphite die at high temperature.

Reactive Melt Infiltration Process (RMI)

Reactive Melt Infiltration Process (RMI) is used primarily for fabrication of silicon carbide (SiC) matrix composites (Fabrication of Ceramic Matrix Composites by Liquid Silicon

Infiltration (LSI)). The process involves infiltration of carbon (C) containing preform with molten silicon (Si). Infiltration is usually capillary forced. Carbon of the impregnated preform reacts with liquid silicon, forming silicon carbide (SiC). Resulting matrix consists of silicon carbide and some residual silicon.

When liquid aluminum (Al) is used for infiltration of a preform in oxidizing atmosphere, alumina-aluminum (Al_2O_3 – Al) matrix is formed (Fabrication of Ceramic Matrix Composites by Direct Oxidation Process).
Reactive Melt Infiltration method is fast and relatively cost effective. Materials fabricated by RMI method possess low porosity and highthermal conductivity and electrical conductivity.

Polymer Infiltration and Pyrolysis (PIP)

Polymer Infiltration and Pyrolysis (PIP) involves the following operations:

- Fiber preform (or powder compact) is soaked with a soft (heated) polymer, forming polymeric precursor.
- The polymer is cured (cross-linked) at 480 ºF (250 ºC).
- The polymer precursor is then pyrolyzed at 1472-2372°F (800-1300°C). As a result of pyrolysis the polymer converts to ceramic. Pyrolysis causes shrinkage of the matrix material and formation of pores (up to 40 vol.%).
- The pyrolyzed polymeric cursor may be hot pressed for densification. Hot pressing is limited by possible damage of fibers.
- Infiltration – pyrolysis cycle is repeated several times until the desired density is achieved.

Matrices consisting of carbon, silicon carbide, silicon oxycarbide, silicon nitride and silicon oxynitride may be fabricated by PIP method.

The following materials are used as polymers in Polymer Infiltration and Pyrolysis method:

- Thermosets (thermosetting resins);
- Pitches or other carbon-containing liquids for fabrication of carbon matrix;
- Polycarbosilane, Polysilastyrol, Dodecamethylcyclohexasilan for fabrication of silicon carbide matrix.

Polymer Infiltration and Pyrolysis method are simple low temperature methods, which allow production of intrinsic parts.

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