MSE-401

Classification of composites

Dr. Alka Gupta

According to the matrix material

- **Metal Matrix Composites** (reinforced metals, cermets, alloys) - **MMC**
- **Polymer Matrix Composites** based on macromolecular substances (reinforced polymers) - **PMC**
- **Ceramic Matrix Composites** (ceramic and other inorganic composites: ceramics, glass, carbon) - **CMC**

According to the structure or geometry of the reinforcement:

- **Dispersive composites**: It contains very fine particles.
- **Particulate composites**: (particulate, granular) it contain larger particles of regular shapes (spheres, platelets) or irregular shapes.
- **Fibrous composites:** It contains long or short fibers that may be oriented or disoriented because

of various origins (glass, carbon, polymeric, textile, etc.)

*** In practice, composites are classified according to the geometric shape on a particulate and fiber composites.

Basic types of composites:

- Traditional/Conventional composites-
  a. alloys
  b. materials with a paint or finished surface
  c. dispersion
  d. layered (laminated) materials
- **New composites**
  a. associated materials (sandwiches)
  b. fiber reinforced systems
  c. granular systems (large particles)
  d. penetrated systems

Properties defining a composite

- The characteristics of the phases - mechanical properties, isotropy and anisotropy of phases, ...
- The volume of the phases - the geometry and arrangement of phases in the system
- The interaction with a surrounding environment

- The history of a material - it should be taken into account how phase composites were created, material aging etc.

Metal matrix composites (MMC):

The preparation of each of the composite materials is based on the nature of its components. All materials have their positive and negative properties, but by preparing composites (from them), we usually try to change them. The assessment of the advantages and disadvantages of these materials are always presented in the context of other used materials, resp. composites.

- **The advantages of the metal matrix**
  1. high strength and toughness
  2. usability at higher temperatures
  3. non-absorbability
  4. improved/higher radiation resistance
  5. they do not absorb or release gases into the surrounding area
  6. mostly non-flammable
  7. they conduct electricity and heat well
  8. the possibility of welding (them) to each other and with other metals
  9. higher hardness and wear resistance

10. resistance to surface damage, and more

- **Disadvantages of the metal matrix**
  1. more complex production
  2. relatively underdeveloped technology of production
  3. high specific weight, density
  4. typically a higher price
  5. little experience with maintenance and disposal
  6. worse formability
  7. some are subject to corrosion

Polymeric matrix composites (PMC):

Composite materials with a polymer matrix can be divided into several basic groups. We distinguish composites based on: plastics, bitumen, asphalts and tar

The advantages of plastics:

1. Low weight (0.8 to 2.2 $g.cm^3$), density (1600-2000 $kg.m^3$) compared to steel (7800 $kg.m^3$) or aluminum (2700 $kg.m^3$), it means they are lightweight.
2. Advantageous mechanical properties that can be modified as required to obtain substances that are hard, soft, porous, abrasion resistant, elastic and more
3. Insulation properties (low thermal conductivity - 300 times lower than aluminum), thermal insulation,

electrical insulation (not current) and sound insulation properties

4. Easy workability, formability
5. Good tolerance of different fillers, can hold a large amount of filler
6. Good chemical resistance
7. The possibility of colouring, high durability/lifetime and easy maintenance

Disadvantages of plastics:

1. low resistance to high temperatures (thermoplastics can be used up to 100 °C, thermosets withstand slightly more)
2. high coefficient of volume expansion (3 to 15 times larger than metals, and 20 times greater than ceramics)
3. low strength that decreases with the temperature and low modulus of elasticity (tensile modulus)
4. easily flammable (low ignition point, the production of dense smoke, toxicity), electrostatic charging
5. ease reaction with atmospheric oxygen which causes aging and aging due to solar radiation
6. swelling with water and associated change of volume
7. Not all plastics are the same (have the same properties to the same extent).

Ceramic or glass matrix composites (CMC):

Ceramics are inorganic non-metallic materials with a heterogeneous structure. They consist of glass, pores and minerals of different compositions. Material based ceramics have high strength at elevated temperatures and are resistant to oxidation. Their main disadvantage is their brittleness.

- **Advantages of ceramic composites:**

1. low coefficient of thermal expansion
2. higher hardness
3. low density
4. higher temperature and corrosion resistance and even wear resistance
5. higher melting point and the stability of mechanical properties in a wide temperature range

- **Disadvantages:**

1. low fracture toughness
2. brittleness
3. difficult reproducibility of complex shapes
4. difficult bonding of ceramics with each other and with other materials as well

Reference

IMANAKA, Y. et al. Advanced Ceramic Technologies & Products. Tokyo: Springer, 2012. ISBN-431-53913 978-4-1, ISBN-431-54108 978-4-0 (eBook).