Properties of Materials
BTM 2413

CHAPTER 7:

Ceramica, Glass and Cermets

by

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Introduction

- Aims
  - To make aware the role of ceramics, glass and carbides in engineering applications….

- Expected Outcomes
  - Identify the nature, properties, microstructure and manufacturing methods of ceramics
  - Identify the properties, applications of glass, concrete and carbon products…..
  - Explain the microstructure, grading and selection criteria of cemented carbides

- Other related Information

- References

- Kenneth G Budinsky & Michael G Biddinsky, Engineering Materials: Properties and Selection, Ed 9, Prentice Hall

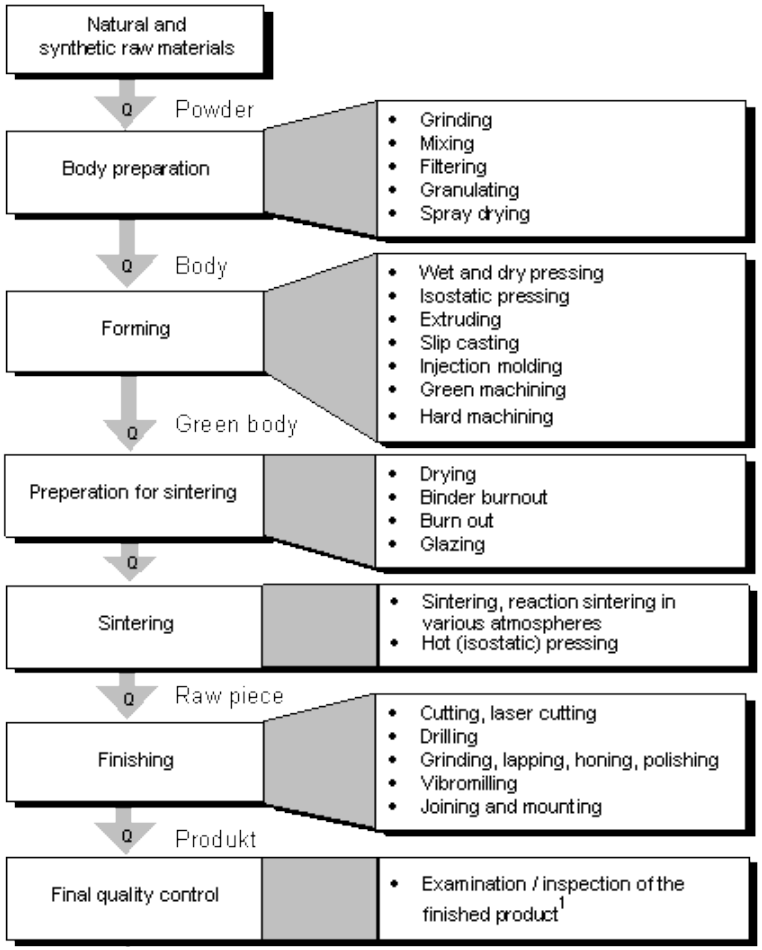
Ceramics

- Ceramic is an inorganic non-metallic solid formed by either metallic or non-metallic compounds. It is first shaped and subsequently hardened by heating to elevated temperatures. In general, they exhibit properties like hardness, corrosion-resistant and brittleness.
- The classical examples of traditional ceramics are pottery, china clay, stoneware, earthenware, porcelain, etc

Advanced Ceramics

- Advanced ceramics are usually formed using oxides, non oxides or combinations of non oxides and oxides. Clay is generally not a constituent.
- Typical oxides used are alumina (Al_2O_3) and zicronis (ZrO_2).
- Non-oxides used in advanced ceramics are compoundsa like carbides, borides, nitrides and silicides, for example, boron carbide (B_4C), silicon carbide (SiC) and molybdenum disilicide ($MoSi_2$).
- As on today advanced ceramic materials are well developed. We use it in many day to day applications, from fridge magnets to many industrial applications. Its industrial applications include the metal production and processing industry, electronics, automobile and aerospace industry.

How ceramics are made?



Ceramic: Properties

- lower density,
- high hardness value,
- high mechanical strength,
- Stiffness,
- Wear resistance,
- Corrosion resistance,
- weathering resistance,
- Higher range of working temperature,
- low or high thermal conductivity,
- good electrical insulation and
- dielectric and ferroelectric properties.

Comparison: Ceramic, Metals and Polymers

	Ceramic	Metal	Polymer
Hardness			
Elastic modulus			
High temperature strength			
Thermal expansion			
Ductility			
Corrosion resistance			
Resistance to wear			
Electrical conductivity			
Density			
Thermal conductivity			

 Tendency to high values

 Tendency to low values

Carbon Products

- Carbon with valence 4 can behave as metal or as nonmetal
- In its cubic form it is our hardest material diamond
- In its hexagonal form it is graphite, soft weak substance that is used as lubricant
- Industrial carbon graphite products are usually combinations of amorphous carbon, graphite and an impregnant to improve strength

Carbon Graphite Products: Properties

- They sublime and do not melt when overheated
- Are electrical conductors
- Can be easily machined
- Low hardness
- Low tensile strength
- Brittle
- Have distinct temperature limits when used in air
- All grades are proprietary; there are no standard grades

Applications

- Carbon products are used for motor brushes, electrodes, battery cores, heating elements, rocket components and casting models
- Brushing seals and wear inserts (in Machine design)
- Graphite has been used as a dry-film lubricant
- Graphite bearings can be used for temp up to 316 deg C

Cemented Carbides: Cermets

- Tungsten carbides and titanium carbides normally not used as solid sintered ceramics (like aluminum oxide or magnesium oxide); rather they are used as composites bonded with metal binder such as nickel Co, Cr, Mo.
- Materials that are composites of metals and ceramics are called cermets
- Cemented carbides are harder than any tool steel
- Excellent resistance to low stress abrasive wear
- The metal binder allows impact resistance of cemented carbides to be better than ceramics

Glasses

- Sand is used in making glass. It is made by heating ordinary sand (which is mostly made of SiO2) until it melts and turns into a liquid. The melting temperature of sand is quite high (1700°C or 3090°F)
- When molten sand cools, it doesn't turn back into the gritty yellow stuff as in the original state. It undergoes a complete transformation and an entirely different inner structure is developed. Irrespective of cooling intensity, it never quite sets into a solid. Instead, it becomes a type of frozen liquid or what materials scientists refer to as an **amorphous solid**.
- It's like a cross between a solid and a liquid; some crystallinity similar to solids and randomness of molecules similar to that of liquids..

Properties

- Glasses are harder than many metals
- Glasses have tensile strength Mostly within 29 to 70 Mpa.
- Glasses have low ductility; they are brittle
- Have low thermal expansion coefficient as compared to many metals and plastics (0.54 to 9x10-6 cm/cm deg C)
- Low thermal conductivity compared to metals (3x10-3 cal/cm deg C)
- The amorphous glass have a modulus of elasticity in the range of 62 to 76 Gpa
- Glasses are good electrical insulators