CERAMIC

Ceramics are classified as inorganic and nonmetallic materials that are essential to our daily lifestyle. Ceramic and materials engineers are the people who design the processes in which these products can be made, create new types of ceramic products, and find different uses for ceramic products in everyday life.

Fig 01: Ceramics Product

Ceramics are all around us. This category of materials includes things like tile, bricks, plates, glass, and toilets. Ceramics can be found in products like watches (quartz tuning forks- the time keeping devices in watches), snow skies (piezoelectric-ceramics that stress when a voltage is applied to them), automobiles (sparkplugs and ceramic engine parts found in racecars), and phone lines. They can also be found on space shuttles, appliances (enamel coatings), and airplanes (nose cones). Depending on their method of formation, ceramics can be dense or lightweight. Typically, they will demonstrate excellent strength and hardness properties; however, they are often brittle in nature. Ceramics can also be formed to serve as electrically conductive materials, objects allowing electricity to pass through their mass, or insulators, materials preventing the flow of electricity. Some ceramics, like superconductors, also display magnetic properties.

Ceramics are generally made by taking mixtures of clay, earthen elements, powders, and water and shaping them into desired forms. Once the ceramic has been shaped, it is fired in a high temperature oven known as a kiln. Often, ceramics are covered in decorative, waterproof, paint-like substances known as glazes.

Composition

Some ceramics are composed of only two elements. For example, alumina is aluminum oxide, Al_2O_3, zirconia is zirconium oxide, ZrO_2, and quartz is silicon dioxide, SiO_2.

Other ceramic materials, including many minerals, have complex and even variable compositions. For example, the ceramic mineral feldspar, one of the components of granite, has the formula KAlSi 3O 8.

CERAMIC PROCESSING

Step #1: Milling & Raw Material Procurement

The raw materials used in the process are milled materials typically found in mining sites that have been reduced from a large size to smaller sizes or even in some cases, pulverized depending upon the end product. The idea is to liberate any impurities in the materials allowing for better mixing and forming which in essence produces a more reactive material when firing.

Step #2: Sizing

The materials that have undergone the milling and procurement process must be sized to separate desirable material from non-usable. By controlling the particle size, the result will give you proper bonding and a smooth surface on the finished product. This can be accomplished using Fine Mesh Vibratory Sifting Equipment. Screen deck sizes vary depending on slurry thickness and the percentage of the solids present in the mix.

Step #3: Batching

This part of the process can also be known as "blending" which calculates amounts, weighing and initial blended of the raw materials. For consistent material flow into a pub mill hopper, Vibratory Feeders can be applied in the process.

Step #4: Mixing

To obtain a more chemically and physically homogeneous material prior to forming, the constituents of the ceramic powder is combined using the method of mixing. Most often, pug mills are the preferred piece of machinery used in this step of the process when dealing with dry mixes. It is also important to add binders or plasticizers as well. For wet slurry mixtures, a filter press would remove the water from the slurry and yield the clay body from the mix. For these wet mixtures, deflocculates and antifoaming agents are added to improve the processing of the m

Step #5: Forming

For this step, the materials such as dry powders, pastes or slurries are consolidated and molded to produce a cohesive body of whatever end product is desired. In the particular case of dry forming, vibratory compaction can be used to achieve the desired shape. For molds of a smaller scale with a lighter load, Vibratory Jogger Tables may be desired.

Step #6: Drying

The formed materials hold water and binder in its mix that can in turn cause shrinkage, warping or distortion of the product. Generally convection drying is the most commonly used method in which heated air is circulated around the ceramic piece that alleviates the risk of such imperfections in the final product.

Step #7: Glazing

Referring back to traditional ceramics, this step is added to the process prior to firing. Typically, the glaze consists of oxides that give the product the desired finish look. The raw materials are ground in a ball mill or attrition mill. The glaze can be applied using the spraying or dipping methods.

Step #8: Firing

Also known as sintering or densification, the ceramics pass through a controlled heat process where the oxides are consolidated into a dense, cohesive body made up of uniform grain. Some general points to remember about different types of firing end products:

- Short Firing Time gives you a final product that is porous and low density.
- Short – Intermediate Firing Time results in fine-grained, high-strength products.
- Long Firing Time produces a coarse-grained product that is creep resistant which means the material will not distort when under a load for an extended period of time.

CERAMIC PROPERTIES

The properties of ceramic materials, like all materials, are dictated by the types of atoms present, the types of bonding between the atoms, and the way the atoms are packed together. This is known as the atomic scale structure. Most ceramics are made up of two or more elements. This is called a compound. For example, alumina (Al_2O_3), is a compound made up of aluminum atoms and oxygen atoms.

- hard,
- wear-resistant,
- brittle,
- refractory,
- thermal insulators,
- electrical insulators,
- nonmagnetic,
- oxidation resistant,

- prone to thermal shock, and
- Chemically stable.

TYPES OF INDUSTRIAL CERAMIC MATERIALS

Alumina Ceramic

Alumina is one of the most widely used advanced ceramic, and is made from aluminum oxide. This ceramic can be made via different types of manufacturing processes including isotactic pressing, injection molding and extrusion. Finishing can be accomplished by precision grinding and lapping, laser machining and a variety of other processes.

Fig 02: Alumina Ceramic Product

Physical Properties

- Good electrical insulation
- High mechanical strength
- Excellent wear resistance
- Excellent corrosion resistance
- Low dielectric constant

Applications

- Pump seals and other components
- Wear resistant inserts
- Insulating washers or bushings
- Semiconductor components
- Aerospace components
- Automotive sensors

- Electrical or electronic insulators.

Fig 03: Wear Resistance

Steatite Ceramic

This advanced ceramic is made from magnesium silicate and is a popular choice of material for insulators for electrical components. Other properties of steatite include excellent dielectric strength, low dissipation factor, and high mechanical strength. Further, due to Steatite's excellent insulating properties it is used in thermostats and many other electrical household products.

Fig 04: Steatite Ceramic Product

Physical Properties

- Relatively high mechanical strength
- High volume resistivity at elevated temperatures
- Excellent dielectric strength
- Low dissipation factor

Applications

- Supports for heating elements
- Electrical insulators
- Stand-off insulators
- Lighting insulators (supports, bases, etc.)
- Spacers
- Insulating washers or bushings

Zirconia Ceramic

Made from zirconium oxide, this ceramic has excellent strength and a high resistance to corrosion, wear and abrasion. Since it has a high tolerance to degradation, zirconia is the material of choice in the manufacturing of bearings and grinding. Further due to its high resistance to developing cracks, commonly referred to as ‘fracture toughness’, zirconia is used in structured ceramics, automotive oxygen sensors and dental ceramics.

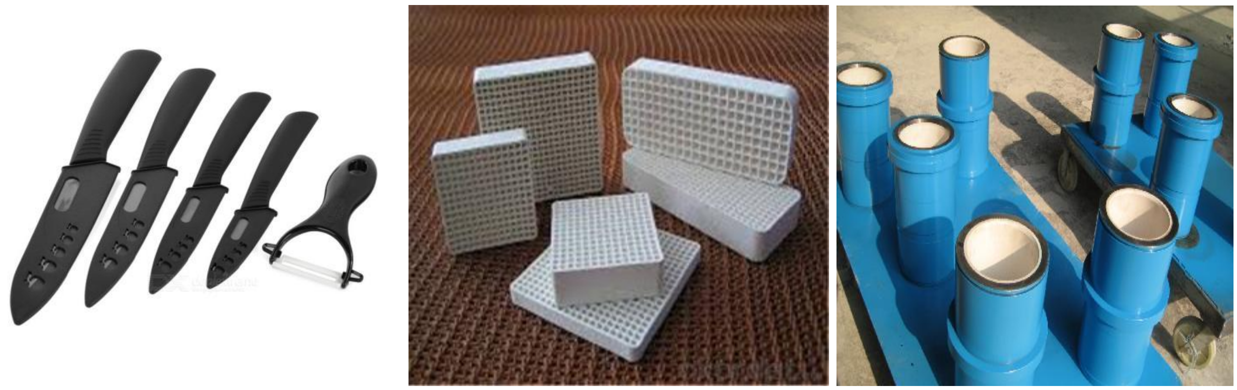

Fig 05: Zirconia Ceramic Product

Physical Properties

- Excellent strength
- Very high fracture toughness
- Excellent resistance to wear and abrasion
- Excellent corrosion resistance

Applications

- Pump components
- Cutting instruments and tools
- Valves
- Bearings
- Filters

Cordierite Ceramic

Cordierite typically occurs in contact of argillaceous rocks. Cordierite has a very high thermal shock resistance and thus widely used in high temperature industrial applications such as heat exchangers for gas turbine.

Physical Properties

- Good thermal shock resistance
- Low thermal expansion
- Low thermal conductivity
- High dielectric strength

Applications

- Household Appliances (Insulators)
- Heating element supports
- Refractory supports in ovens or kilns
- Thermocouples

Mullite Ceramic

Mullite is a very rare silicate material, formed at high temperatures and low pressure conditions. Its properties include

- Low thermal expansion
- Low thermal conductivity
- Excellent creep resistance
- Suitable high temperature strength
- Outstanding stability under harsh chemical environments.

It is commonly used in thermocouple protection tubes, furnace muffles and kiln rollers.