**Section 3**

**Powder manufacture**

1- **Mechanical Methods:**

   **A. Crushing**

Crushing is the first step of powder manufacturing. A crusher has an arm that moves the jaws backward and forward to crushing material to a size small enough to fall from the bottom of the jaws.

This type of crusher can be as large as 3 m across, producing powders of 5 cm at the outlet or as small as 10 cm across, producing powders of 1 mm at the outlet. It is commonly used in large-scale mining operations. Figure 1

B- **Grinding (Milling)**

When considering ceramic powders, we generally find relatively narrow size distributions are desired with the mean size.
To meet these needs various types of mills are used, including

(1) mills with balls, pebbles, and rods as the medium;

(2) high-speed peripheral mills;

(3) fluid energy mills.

Fluid energy mills are able to produce the very finest powders. Figure 2 shows the various types of grinding equipment.
FIG2 Crushing and grinding equipment. (a) Jaw crusher, (b) gyratory crusher, (c) vibratory mill, (d) fluid shear mill, (e) pin mill, (f) fluid jet mill, (g) hammer mill, and (h) ball mill.

<table>
<thead>
<tr>
<th>TABLE 1 Types of Size-Reduction Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaw crushers</td>
</tr>
<tr>
<td>Gyratory crushers</td>
</tr>
<tr>
<td>Heavy-duty impact mills</td>
</tr>
<tr>
<td>Roll crushers and shredders</td>
</tr>
<tr>
<td>Tumbling media mills</td>
</tr>
<tr>
<td>Stirred media mills</td>
</tr>
<tr>
<td>Vibratory media mills</td>
</tr>
<tr>
<td>Fluid shear mills</td>
</tr>
</tbody>
</table>

This energy is a sum of the energy required

(1) to move the machine, its kinetic energy, and friction;

(2) to move the material, its kinetic energy, plastic and elastic deformation, and internal friction;

(3) to break the material into smaller particles.

In almost all cases, the energy required by the mills shown in Figure 4.3 is very poorly utilized.

The energy required to break the material is often less than 1% of the total energy needed to run the mill. The energy, $E$, required to grind material into a smaller particle size, $L$, from size, $L_0$, can be described by [6]:

$$E = - \int_{L_0}^{L} \frac{C}{L^n} \, dL$$

where $C$ is a constant.
- **Ball mills**: Ball mills, also known as centrifugal or planetary mills, are devices used to rapidly grind materials to colloidal fineness (approximately 1 micron and below) by developing high grinding energy via centrifugal and/or planetary action.

- **Roll Mills**: In Three Roll Mills, the material to be milled is placed between the feed and center rolls. Each adjacent roll rotates at progressively higher speeds. For example; the feed roll may rotate at 30 rpm, the center roll at 90 rpm and the apron roll at 270 rpm. Material is transferred from the center roll to the apron roll by adhesion. The dispersion is achieved by the shear forces generated between the adjacent rolls. The milled material is removed from the apron roll by a knife that runs against the roll.
Stamping mills: A stamp mill is a type of mill machine that crushes material by pounding rather than grinding, either for further processing or for extraction of metallic ores. Breaking material down is a type of unit operation.
C-Throwing: This method is in casting the molten material (in degrees just above the melting point) in the form of a liquid stream through the air or a soft perimeter neutral atmosphere, where it is then dropped into the water. When freezing occurs in the air, the resulting particles are spherical shape, either when it occurs in the water consists of particles feathery shape.

D- Condensation:

A method for preparing powder granules by a liquid condensation process comprising preparing a slurry by mixing powders, a binding agent and a binding agent soluble solvent, dropping the slurry to a binding agent insoluble solvent to fix the binding agent so that the binding agent can not be released to a surface of a droplet of the slurry, coagulating the droplet by solvent exchange between the soluble solvent inside the droplet and the insoluble solvent at the surface of the droplets, and separating the coagulated droplet from the insoluble solvent, drying it and completely removing a residual solvent.
E- Atomization: Used to produce powders of materials with low melting point. The process taking place by passing molten through a small hole and then subjected to a compressed air stream, making article breaks to Jesmt of the very soft, so it freezes directly due to the speed of heat leaking them. When using air (or gas) or water.

This method is a method for the production of powders of particles different sizes by controlling the following factors:

A - the size of the hole that passes through the molten metal.
B - the temperature of the molten metal and the flow velocity.
C - temperature, speed and type of ablation factor (air or inert gas).

The Particle size can be calculated from the following equation:

\[ D = \frac{C}{V \sin \alpha} \]

where \( V \) the speed of the water used, \( C \) constant depends on the type of material and design private system and \( \alpha \) is the angle of spray.