**Grinding**

There are two main forms of grinding:

♣ Dry grinding when the water content is 34% water by volume

♣ Wet grinding with the addition of >34% water by volume

Between 1% and 34 the slurry is very difficult to handle and grinding is inefficient. In some plants, an initial grinding process may be followed by some form of classification such as flotation or magnetic separation, which in turn is followed by a second grinding process. This approach tends to eliminate at an early stage a good portion of the gangue . It is not possible to achieve the particle size needed through a single grinding phase unless coarse output is required. When a coarse product is required, crushed materials are transported to a rod mill via a conveyor belt and the output is delivered from the rod mill. This is essentially an open circuit. Grinding machines in the mineral industry are of tumbling mill type. These mills exist in a variety of kinds such as ball, rod, pebble, autogeneous, semi-autogeneous, etc. Grinding action is induced by relative motion between the particles of media - the rods, balls or pebbles and the particles themselves. High compression roll mill and fluid energy mills are recent developments in comminution technology. There are two different types of motion of media particles in the mill, namely, cascading and cataracting generating from the tumbling motion of the mill. When the particles move along the inner surface of the mill shell, lifted up, loses contact with the surface and travel downward in a trajectory through the empty space inside the mill resulting in an impact on contact with the inner surface again, the motion is called cataracting. This motion produces fewer amounts of fines.

Grinding of the crushed ore is almost always performed in cylindrical rotating mills, which are filled about half full of steel or iron balls, steel rods, or some other form of grinding medium. The grinding medium might also take the form of ceramic balls, flint pebbles, or for autogenous grinding, the fraction of ore between about 50 and 200 mm in diameter. In semi-autogenous grinding, steel balls about 125 mm in diameter are charged into the mill to occupy approximately 8 to 10% of the mill volume and supplement the grinding produced by the large pieces of ore in the mill. The interior chambers of all these mills are lined with easily replaceable liners whose thicknesses range from 50 to about 250 mm when installed. Wear of these liners, as well as the wear of the grinding balls and rods, is a major item of expense in most ore processing operations. The crushed ore fed into the grinding mills is almost always mixed with water so that the grinding is done in a slurry containing about 75% solids. The ore is ground to at least 0.3 to 0.7 mm in diameter, although some operations require the ore to be ground to finer particle sizes (e.g., 0.04 mm). The ground ore is then passed through the classifiers, from which incompletely ground ore is returned to the grinding mills, while the rest is passed on to the separators. Primary grinding can also be performed in two stages. The first stage might use a rod mill, with rods 75 to 100 mm in diameter, which reduces the ore from 15 to 25 mm down to about 1.5 mm. After this grinding operation, the ore goes to a ball mill where it is reduced to about 0.3 mm in diameter or finer. Autogenous or semi-autogenous grinding may in many instances be followed by a second stage of grinding in a ball or pebble mill. Asst. Prof. Dr. Ayşe KALEMTAŞ GRINDING Wet versus dry grinding Because of the dust problems associated with grinding solids (health, explosion, and fire hazard, mechanical losses, etc), grinding is usually carried out in water. Presence of water in the product does not harm subsequent separation processes, since most of these operations are carried out in water. Wet grinding advantageous - requires less power per ton of material ground than dry grinding. Dry grinding consumes more energy because the fine particles adhere to the balls, forming a layer that causes the solids to occasionally slide between the balls without fracture. The disadvantage of wet grinding, however, is that there is more wear

**Milling**

Milling produces a particular particle size distribution and deagglomeration of fine powders. Physical processes include impact, shear between two surfaces, and crushing by a normal force between two hard surfaces. There are two broad types of ceramic raw materials that require milling. These are classified as lumpy and powdered ceramics. Lumps result from mining, fusion, and sintering. These are usually premilled by the supplier and are available in various screen sizes. Depending on your requirements, these may require further milling in the lab. Mined materials include talc, shale (clays), bauxite, and quartz. Fused materials include fused alumina, magnesia, mullite, and zirconia. Some materials are more difficult to mill than others. Generally, the order of difficulty from the most difficult to the least difficult is densefused materials, sintered materials, and precipitated powders. Although one might not expect this, glasses are very difficult to mill to micrometer sizes, but they are easy to crush to granules.

**Ball Milling**

Ball Mill grinds a material by rotating a cylinder with hard balls, causing them to fall back into the cylinder and onto the material to be ground. The impact of balls is important for reduction in size of the particles. Ball milling is mostly used for brittle materials. The diameter of the mill

decides the speed of the mill. Generally, the rotational speed does not exceed 20 RPM. Diameter of cylinder is inversely proportional to the rotational speed. The larger the diameter, the slower the rotation. If the speed is too high, it begins to act like a centrifuge and the balls do not fall

back, but stay on the perimeter of the mill. Figure 1 shows the schematic of various mechanisms of crushing the ceramic powder. These are roll crushing (figure 1a), ball mill (figure 1b) and hammer milling (figure 1c).

In roll crushing method, there are basically two rollers; one is fixed roller and the other is adjustable roller on which the lumps of ceramic raw material are dropped through hopper. When roller starts rotating, the raw material is pressed inside the roller as shown in figure 1a and fine particles of ceramic powder are obtained on the other side. The size of the powder can be varied as per the requirement. This can be done by changing the space between the rollers through adjustable roller using adjustable screw.

In case of ball milling as shown in figure 1b, black sphere represents balls of some harder material and the green balls represent the ceramic particles. The ball mill rotates continuously and the collision between harder balls and ceramic particles occurs repeatedly and ceramic powder is prepared.

In hammer milling process, a hammer is rotated inside the chamber and large size lumps of raw ceramic are crushed into very fine ceramic powder. As shown in the figure 1c, there is a grain hopper from where raw material is moved into the chamber through delivery device. There are four independent hammers attached to the rotor. Raw material is hammered down and fine ceramic powder is taken away.







Figure 1 Mechanical preparation method, to obtain ceramic particles: (a) roll crushing (b) ball mill and (c) hammer milling