EXPERIMENT NO 3

Particle reduction by Ball milling

Objective:

To achieve particle reduction of a ceramic powder using planetary ball mill.

Basic Theory:

- Milling, mechanical impaction using hard balls, is a classic approach to fabricating powders from brittle materials.
- A jar mill consists of a cylindrical jar filled with balls and the material to be milled.
- As the jar rotates, the balls continuously collide with the material, crushing it into powder.
- The impact stress required to fracture a brittle material in milling relates to the defect structure and sensitivity to crack propagation.
- A balance between coalescence and fragmentation is achieved during milling, which leads to a rather stable average particle size.

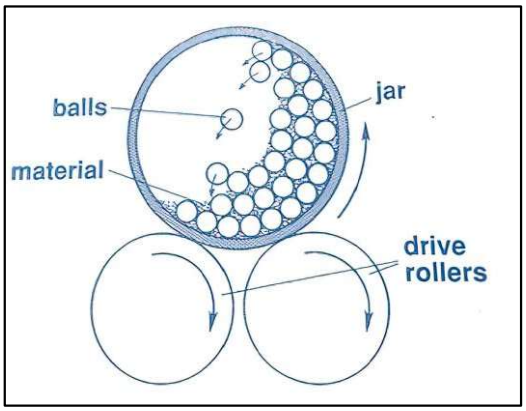


Figure 3.1: A view of the action in a jar mill. The jar is rotated on its side and the impact of the failing balls grinds the material into a powder.

Planetary Ball Mills

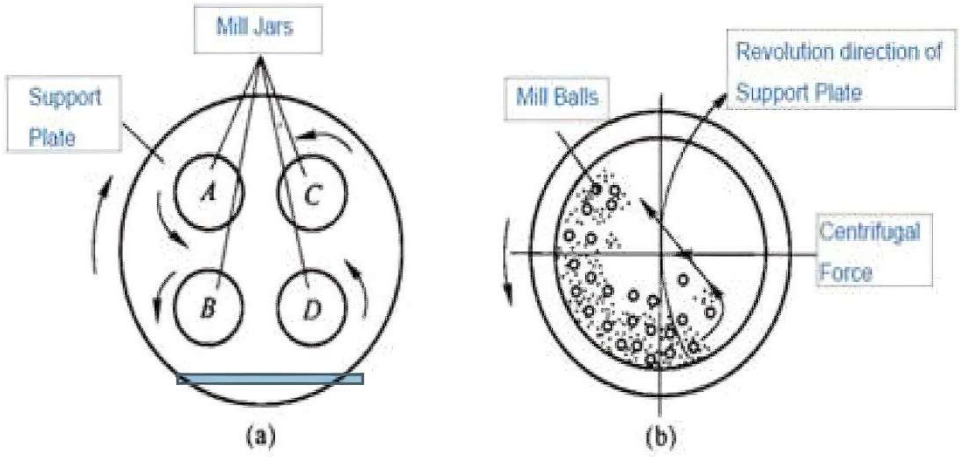
- Planetary Ball Mills are used wherever the highest degree of fineness is required.
- Apart from the classical mixing and size reduction processes, the mills also meet all the technical requirements for colloidal grinding and have the energy input necessary for mechanical alloying processes.
- The extremely high centrifugal forces of the Planetary Ball Mills result in very high pulverization energy and therefore short grinding times.
- Planetary ball mill consists of at least one grinding jar, which is arranged eccentrically on a so-called sun wheel. The direction of movement of the sun wheel is opposite to that of the grinding jars.

- The difference in speeds between the balls and grinding jars produces an interaction between frictional and impact forces, which releases high dynamic energies.
- The interplay between these forces produces the high and very effective degree of size reduction of the planetary ball mill.
- Both wet and dry grinding is possible in planetary ball mill. For ultrafine milling wet grinding is preferred because in dry grinding there is a problem of agglomeration.

Apparatus used:

- Al_2O_3 (alumina) 10g
- Tungsten Carbide balls, 10mm diameter, 100g
- Toluene (Process control agent)
- Planetary ball mill

Retsch PM 200 Planetary Ball mill



Working Principle of Planetary Ball Mill

(a) The overall layout of pleanetary ball mill; (b) Ball Mill Jar horizontal section.

Procedure:

1. Fill the material and the grinding balls into the jar
2. Insert the grinding jar into grinding jar holder
3. Insert the spider into the brackets and clamp it by turning the red sleeve up
4. Set the parameters:
   - milling time
   - speed
   - interval time
   - pause time
   - and start the milling process (The PM 200 is started with the preselected milling time, speed and reversal of direction of rotation, the machine rotates with set interval time in one direction, comes to stop. After pause time has elapsed the machine starts again.)
5. Run the machine for one minute and observe it for abnormal vibration and noise (If the loading is unbalanced the machine can generate undesirable sounds and vibrations.) if found, switch off the machine and check the arrangement (Gross weight of cups, any loosen part etc.
6. Run the experiment for 10 hours and then allow sufficient time to reduce temperature to room temperature.
7. Open the milling chamber hood after pressing the open button and unlock.
8. Carefully take the grinding jars and take the powder out and clean it properly.

Precautions:

1. Make sure that milling cup is clamped before starting with the experiment.
2. All cups have same gross weight.
3. While feeding, opposite cups should be always fed in two stations planetary ball mill.
4. Precautionary measures should be employed while unloading the samples.

Lab deliverables:

1. What is the effect of the rotational speed on grinding?

Sol: The effect of rotational speed on grinding is that it increases the rate of material removal. This is because the higher the rotational speed, the more energy is transferred to the grinding media, which in turn causes them to break down the material more quickly.

2. What is the effect of ball to charge ratio on grinding?

Sol: The effect of ball to charge ratio on grinding is that it affects the size and shape of the particles that are produced. A higher ball to charge ratio will result in smaller and more uniform particles, while a lower ball to charge ratio will result in larger and more irregular particles.

3. What is the function of a wetting agent on grinding?

Sol: The function of a wetting agent on grinding is to reduce the surface tension, which makes it easier for the grinding media to wet and break down the material. This can improve the efficiency of the grinding process and produce finer particles.

4. List four types of grinding media.

Sol:

Grinding Media	***Description***
Balls	The most common type of grinding media, typically made of steel or ceramic.
Rods	Longer and thinner than balls, often used for fine grinding.
Vibratory media	Small pieces of metal or ceramic that are agitated in a vibrating container.
Fluidized bed media	Small particles that are suspended in a stream of gas or liquid.

Observations and calculations

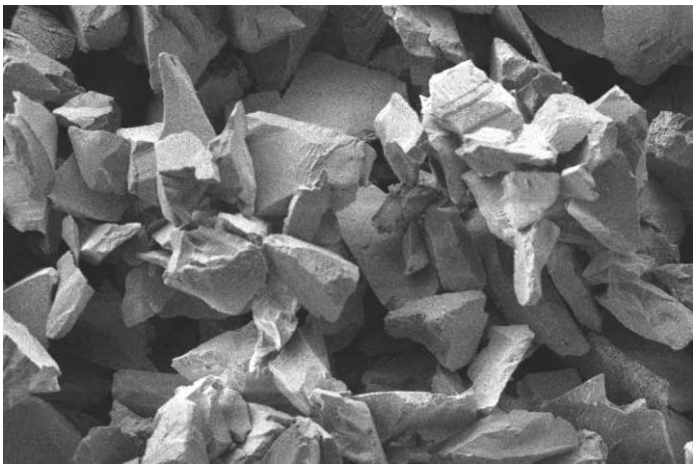
Powder: Ball ratio = 1:10

Balls diameter = 10mm

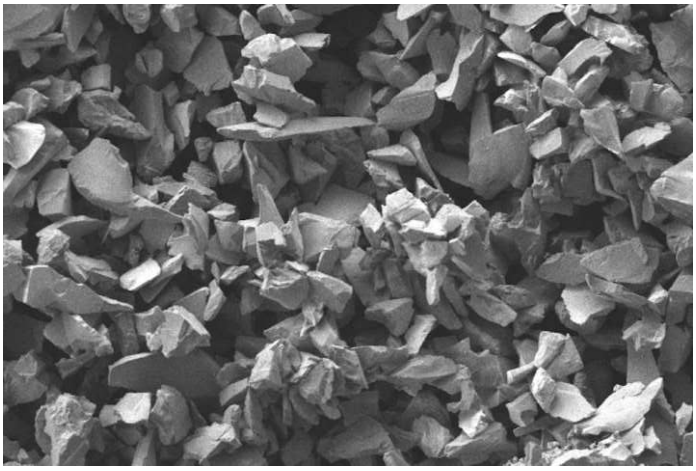
Balls are made up of Tungsten carbide.

Ball weight = 400 grams

Before milling:



After milling:



Conclusions:

We can fabricate powders from brittle materials using mechanical impaction with hard balls, and then have a look at before and after milling images. For this experiment we used PM 200 ball mill, filled 1/3rd of the vial, another 1/3rd with process control agent toluene rest 1/3rd free, ball milling was done for 10 hours.