Unit Operations Involving Particulate Solids for Chemical Engineers (CHE 454A)

Assignment-2 (2023-24 II)

Q-1. A material is crushed in Blake jaw crusher such that the average size of the particle is reduced from 50 mm to 10 mm with the consumption of energy 13 kW/(kg/s). What would be the consumption of energy needed to crush the same material of average size 75 mm to an average size of 25 mm.

a) Assuming Rittinger's law applies?
b) Assuming Kicks's law applies?

Which of this result would be regarded as being more reliable and why?

Ans.

a) 4.33 kJ/kg
b) 8.87 kJ/kg

Q-2. A crusher was used to crush a material with a compressive strength of 22.5 MN/m^2. The size of the feed was -50mm + 40 mm and the power required was 13 kW/(kg/s). The screen analysis of the product was:

Size of aperture (mm)	**Amount of product (%)**
Through 6	All
On 4	26
On 2	18
On 0.75	23
On 0.5	8
On 0.25	17
On 0.125	3
Through 0.125	5

What power would be required to crush the 1 kg/s of a material of compressive strength 45 MN/m^2 from a feed -45mm + 40 mm to a product of 0.5 mm average size?

Ans. P = 47.8 kW

Q-3. A standard crusher is used to reduce the size of chunks obtained from a mica ore. Assuming the ore is pure mica, calculate the power required to reduce the size from 45 mm to 0.5 mm for a feed rate of 100 ton/hr. The crushing efficiency while reducing the size of the particle by half is given as 2%. The mechanical efficiency is 5%.

Surface energy of mica is 120 mJ/m^2. Density of mica particles is 2883 kg/m^3. Assume sphericity to be 1 for both feed and product. Use Rittinger's law.

Ans: 13.72 kW

Q-4. It is desired to crush small particles of in a ball mill of 1.4 m in diameter, operated at 0.75 Hz. However, operators report unsatisfactory crushing. As an expert in crushing equipment what do you perceive as the problem and what modifications would you suggest?

Q-5. Sugar is ground from the crystals of which it is acceptable that 80% pass a 500 μm sieve (US-standard sieve no. 35), down to a size in which it is acceptable that 80% passes a 88 μm sieve (no. 170) and a 5 HP motor is found just sufficient for the required throughput. If the requirements are changed such that the grinding is only down to 80% through a 125 μm (no. 120) sieve but the throughput is to be increased by 50% would be the existing motor have sufficient power to operate the grinder ? Assume Bond's law applies.

Ans. P = 5.42 HP
The existing motor would be expected to have insufficient power to operate the grinder.

Q-6. A ball mill 1.2 m in diameter is run at 0.8 Hz and it is found that the mill is not working satisfactorily. Should any modifications in the condition of operations be suggested?

Ans. The operating speed of the ball mill should be halved. As optimum speed (23 rpm) of the ball mill is 60% of the critical speed, but the current operating speed is 48 rpm.

Q-7. In a cement manufacturing unit, 36 tonne/h of calcite of 5-cm size is fed to a gyratory crusher. Screen analysis from the crusher shows a surface area of product of 61.7 m^2/kg. The crushed material is then subjected to fine reduction in a hammer mill. Mill product analysis indicates a surface area of 740 m^2/kg. Rittinger's number for calcite is 75.9 m^2/kJ. Efficiency of the grinder is 30%. The crusher and grinder are driven on the same shaft (by an electric motor) whose transmission efficiency is 90%. If 480 hp is fed at the other end of the shaft, compute the efficiency of the crusher.

Density of calcite = 2.65 g/cc and Specific surface ratio for feed =3.5.

Ans: 25.3%

Q-8. in a ball mill of 2000 mm diameter, 100 mm diameter steel balls are being used for the grinding presently for the material being grounded. The mill is running at 15 rpm. At what speed will the ball mill have to run if the 100 mm balls being replaced by 50 mm balls, all other conditions remaining same?

Ans. N =14.77 rpm