Example 2 :

A material is crushed in a *Blake jaw crusher* such that the average size of particle is reduced from 50 mm to 10 mm with the consumption of energy of 13.0 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 Kick's law applies?

Which of these results would be regarded as being more reliable and why ?

Solution

a) Rittinger's law.

This is given by:

$E = K_R f_c[(1/L_2) - (1/L_1)]$

Thus : $13.0 = K_R f_c [(1/10) - (1/50)]$

and: $K_R f_c = (13.0 \times 50/4) = 162.5$ kW/(kg mm)

Thus the energy required to crush 75 mm material to 25 mm is:

$E = 162.5[(1/25) - (1/75)] = 4.33$ kJ/kg

b) Kick's law.

This is given by:

$E = K_K f_c \ln(L_1/L_2)$

Thus: $13.0 = K_K f_c \ln(50/10)$

And : $K_K f_c = (13.0/1.609) = 8/08$ *kW/(kg/s)*

Thus the energy required to crush 75 mm material to 25 mm is:

$E = 8.08 \ln(75/25) = 8.88$ *kJ/kg*

The size range involved by be considered as that for coarse crushing and, because Kick's law more closely relates the energy required to effect elastic deformation before fracture occurs , this would be taken as given the more reliable result .

3. Surface Area Formed by Grinding

When a uniform particle is crushed , after the first crushing the size of the particles produced will vary a great deal from relatively coarse to fine and even to dust. As the grinding continues, the coarser particles will be further reduced but there will be less change in the size of the fine particles. Careful analysis has shown that there tends to be a certain size that increases in its relative proportions in the mixture and which soon becomes the predominant size fraction .

The new surface produced was directly proportional to the energy input. For a given energy input the new surface produced was independent of :

(a) The velocity of impact ,

(b) The mass and arrangement of the sample ,

(c) The initial particle size , and

(d) The moisture content of the sample .

For example , wheat after first crushing gives a wide range of particle sizes in the coarse flour, but after further grinding the predominant fraction soon becomes Most reactions are related to the surface area available, so the surface area can have a considerable bearing on the properties of the material. The surface area per unit mass is called the specific surface. To

calculate this in a known mass of material it is necessary to know :

• the particle-size distribution

• the shape factor of the particles.

The particle size gives one dimension that can be called the

Typical Dimension, D_p of a particle. This has now to be related to the surface area. We can write, arbitrarily:

$V_p = pD_p^3$ $\qquad$ $A_p = 6qD_p^2$

Where

V_p is the volume of the particle.

A_p is the area of the particle surface

D_p is the typical dimension of the particle

q is factor of the particle geometries.

And , The ratio of surface area to volume is:

$$A_p/V_p = (6q/p)D_p = 6\lambda/D_p$$

$$A_p = 6\lambda V_p/D_p$$

λ=q/p is a shape factor . It has been found, experimentally

For example ,

	V_p	A_p	Specific Surface V_p/ A_p	λ
Cube	D_p^3	$6D_p^2$	$6/D_p$	1
Sphere	$\pi D_p^3/6$	πD_p^2	$6/D_p$	1

A number of particles(N) is :

$$N = \frac{m}{m_p} = \frac{m}{\rho_p V_p}$$

Where :

m is a total mass of particles

m_p is a mass of particle

ρ_p is a density of particles

So total area of the mass of particles (A_t) is:

$$A_t = NA_p = \left[\frac{m}{\rho_p V_p}\right]\left[\frac{6\lambda V_p}{D_p}\right]$$

$$A_t = \frac{6\lambda m}{\rho D_p}$$

Example 3 :

In an analysis of ground salt using Tyler sieves, it was found that 38% of the total salt passed through a 7-mesh sieve and was caught on a 9-mesh sieve. For one of the finer fractions, 5% passed an 80-mesh sieve but was retained on a 115-mesh sieve. Estimate the surface areas of these two fractions in a 5 kg sample of the salt, if the density of salt is 1050 kg/m3 and the shape factor is 1.75.

Aperture of Tyler sieves ,

7 mesh = 2.83 mm

9 mesh = 2.00 mm

80 mesh = 0.177 mm

115 mesh = 0.125 mm .

Solution :

Mean aperture 7 and 9 mesh = 2.41 mm = 2.4 x 10^{-3}m

Mean aperture 80 and 115 mesh = 0.151 mm = 0.151 x 10^{-3}m

A_t = (6 x 1.75 x0.38 x 5)/(1050x 2.41x10^{-3})

A_t = 7.88 m^2

A_t = (6 x 1.75x 0.05 x 5)/(1050 x 0.151x10^{-3})

A_t = 16.6 m^2.