How to Size Smooth Roll Crushers

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Smooth roll crushers are widely used as secondary crushers, operating most effectively when set for size reductions in a ratio between 3 or 4 to 1. The feed supplied to these units varies from 13 to 102 mm in size and the product obtained ranges from 13 mm to about 20 mesh. Smooth roll crushers produce very few fines and absolutely no oversize.

The diameter of the rolls varies with the clearance between them, feed size, and the coefficient of internal friction of material to be crushed. Detailed calculations of this relationship may be found in *Unit Operations of Chemical Engineering*, (McCabe, W. L., and Smith, J. C., 1967, McGraw Hill, NY, Chapter 26, pg. 825).

The geometrical arrangement of the roll crusher is shown on the accompanying sketch. A relatively simple relationship between the diameter of feed, the roll, and the gap between them is as follows:

$$\cos \alpha = \frac{R + d}{R + r} \qquad (1)$$

where R = radius of roll (mm); d = the half-gap between rolls (mm); r = the radius of feed (mm); and α = the angle of friction. This equation may be rearranged as follows:

$$\cos \alpha = \frac{2R + 2d}{2R + 2r.} \qquad (2)$$

It is possible to insert other variables for greater convenience, namely: 2R = D (diameter of the roll in mm); 2d = S (the gap between rolls in mm); and 2r = k (the diameter of feed particles in mm). The rearranged equation looks as follows:

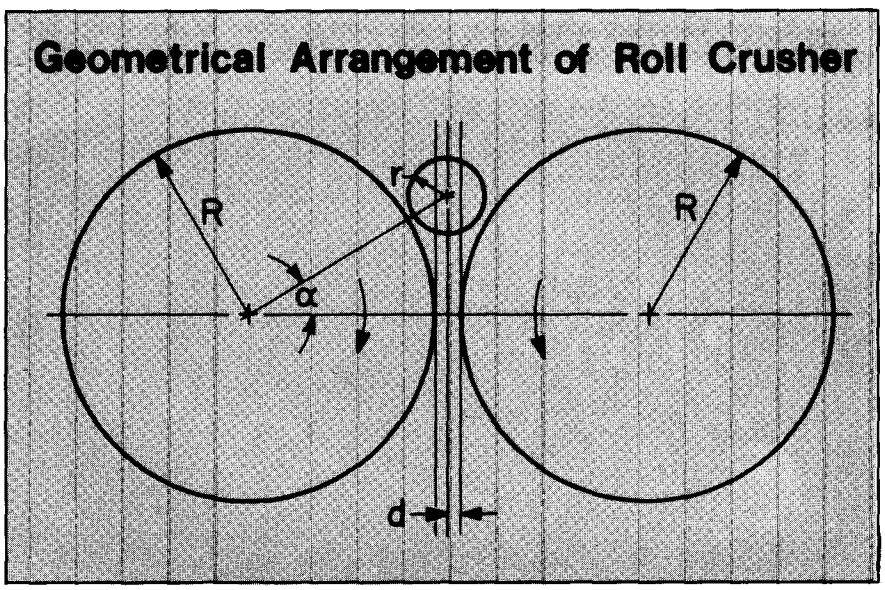
$$\cos \alpha = \frac{D + S}{D + k.} \qquad (3)$$

When taking into account that μ is the coefficient of internal friction of the crushed material, and the angle α is the angle of friction: $\mu = \tan \alpha$, α = arc tan μ, and $\cos \alpha = \cos$ (arc tan μ). After inserting the new value of cos α, and rearranging the equation for D, the final equation will be obtained:

$$D = \frac{\cos(\text{arc tan } \mu)K + S}{\cos(\text{arc tan } \mu) - 1.} \qquad (4)$$

Equation (4) gives the direct dependency of the roll diameter from the gap between the rolls, feed size, and the coefficient of internal friction of the material to be crushed.

The solution of the equation, while relatively simple, is nevertheless tedious and time-consuming. Therefore, a nomograph has been constructed which allows a graphic solution.



Using the Nomograph

The simple procedure in solving this problem is as follows:

Step 1. Find the intersection point of the lines of known values of K on the grid in the central part of the nomograph. Mark this point A.

Step 2. Connect point A with a ruler to the known value of S on the left-side scale. Extend this line up to the intersection point with the right-hand D scale. Read the final result D on this intersecting point.

Sample Calculation

It is known that a rock to be crushed has a coefficient of internal friction of 0.22. The average size of feed equals k = 460 mm. The size of the product desired is 11.1 mm (the size of product equals the gap between rolls, hence S = 11.1 mm). What is the proper diameter of rolls to be used for this operation?

Solution: According to the procedure described, the proper diameter of crushing rolls is graphically determined at 1.43 m. □

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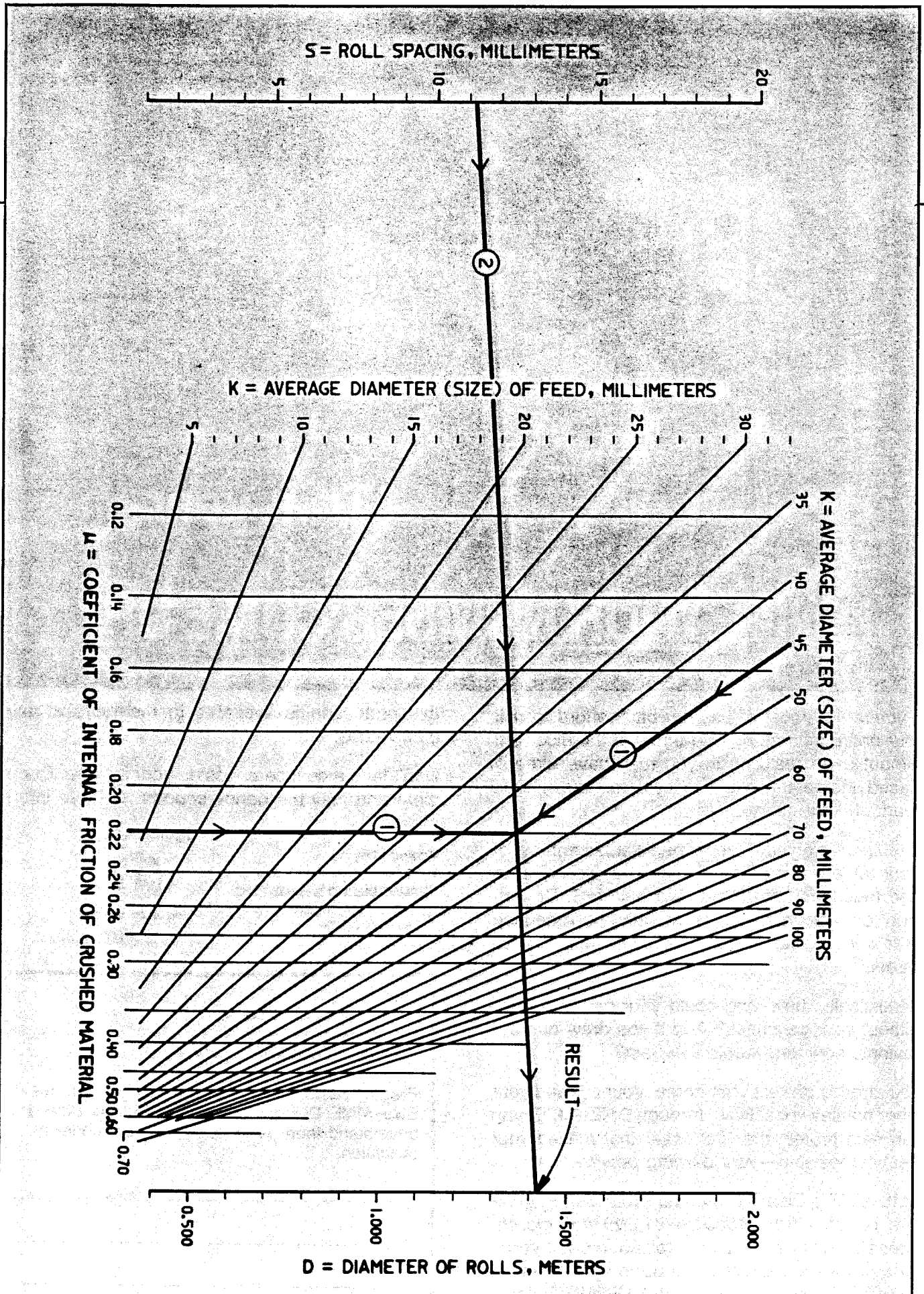
S = ROLL SPACING, MILLIMETERS
5
10
15
20
2
K = AVERAGE DIAMETER (SIZE) OF FEED, MILLIMETERS
5
10
15
20
25
30
K = AVERAGE DIAMETER (SIZE) OF FEED, MILLIMETERS
35
40
45
50
60
70
80
90
100
1
1
μ = COEFFICIENT OF INTERNAL FRICTION OF CRUSHED MATERIAL
0.12
0.14
0.16
0.18
0.20
0.22
0.24
0.26
0.30
0.40
0.50
0.60
0.70
RESULT
0.500
1.000
1.500
2.000
D = DIAMETER OF ROLLS, METERS