Mill Base Studies

Mr. L. M. Smith, Lab.
Mr. G. W. Kidder, Plant
Dr. P. B. Evans, Lab.
Mr. R. L. Selby, Lab.
Mr. W. P. Colio

Dr. R. B. Davis, Flint
Mr. G. E. Conde, Parlin
Dr. H. H. Hopkins, Wilm. D-7026

C-1



Philadelphia Laboratory
July 26, 1946

MEMORANDUM REPORT NO. M-6[illegible]



## BALL MILL GRINDING

Previous studies of ball mill grinding have shown that efficient grinding requires a cascading action. (A Manual of Ball Milling E.D. 884 and Glass End Mill Grinding Study - Flint 1936) In the presence of liquid of low viscosity (one centipoise) cascading is present up to about 90% of critical speed where the critical speed is the theoretical speed at which the outer row of balls will be carried around the mill due to the centrifugal action of the mill. Recommended plant practice is to grind at about 60 to 75% of critical speed.

Studies carried out at the Philadelphia Laboratory with the glass end mill indicate that with high viscosity bases cascading does not occur at speeds as high as 65% of critical speed. The following equations relate the approximate maximum speed for cascading (or most efficient grinding), to the viscosity of the base being ground.

| | |
|---|---|
| 5' Mill | Cycles per hour = 1850 - 0.5 $\eta$ |
| 6' Mill | Cycles per hour = 1650 - 0.45 $\eta$ |

$\eta$ = viscosity of base in centipoises at temperature of grind. The above equations apply to bases of density of about one and to mill speeds of 35% of critical or higher. They were derived from data obtained with a 1.5' mill.

The results of the study indicate that with mill bases of high viscosity (1500 centipoises or more) the cascading action is diminished and inefficient grinding results.

Reducing the ball size from 5/8" to 3/16" reduces the cascading and to retain a similar pattern, it is necessary to reduce the base viscosity by about 80%. Therefore, when ball size is reduced the expected increase in efficiency will be observed only if the mill base viscosity is very low.

To obtain a cascading action with pebbles, it is necessary to reduce the liquid viscosity to a lower level than in the case of steel balls. Even with a low density liquid, the viscosity should not exceed 400 cp. and with the high density mill bases now being ground, this is probably high. There may be little difference in many cases between stirring in a vat and grinding in a mill as far as grinding action is concerned.

The use of the concept of critical speed as a criterion of cascading action in a mill may have imparted a false sense of security and led to the development of bases which cannot possibly be ground by a cascading action. Plant studies should be made to determine the limiting speeds and viscosities for grinding by cascading action.

In ball mill grinding by a cascading action there is a portion called the "dead space" in which the balls move at a reduced speed. From the appearance of the glass end mill in operation using a mixture of small and large steel balls the liquid moves through this space continuously and no loss in efficiency occurs through isolation of a portion of the base in this section of the mill. The presence of a "dead space" is probably of less importance than mill speed and base viscosity in determining grinding efficiency. Products prepared by ball mill grinding are often inferior in quality to similar products prepared in a W. & P. mixer or by the Flint Process. This poor quality is sometimes related to inferior dispersion and this in turn may be caused by the use of inefficient ball mill grinding conditions. Complete dispersion will be more readily obtained if the base being ground is relatively low in density and low in viscosity (under 1000 centipose).

Arrangements are being made to draw up a program for a plant study of the important factors discussed above.

PHILADELPHIA LABORATORY

S. C. Horning

S. C. HORNING

SCH-mhl