THE ROD MILL IN THE PULP AND PAPER INDUSTRY[1]

By
John D. Rue[2]
and
Sidney D. Wells[3]

New ways of attacking current problems and better means of producing old results in a given industry may often be found in an examination of the methods and equipment of quite unrelated industries. This general principle is admirably illustrated in the application to pulp and paper making operations of the rod mill, which for several years has been standard equipment for grinding ore in the mining industry.

During the last two years the Forest Products Laboratory has operated, as a part of its experimental equipment, a rod mill of "semicommercial" size. It has proved to be an excellent means of reducing to fiber wood chips, cereal straw, and flax straw, after the material has been softened by mild chemical treatments; it has also been used successively in reducing knots and screenings resulting from the chemical pulping processes. Besides acting as a grinder, it also serves as a continuous beater which effects hydration without excessive rupture of the fibers.

Description

The rod mill, as applied to pulp and paper production, may be briefly described as a hollow cylinder mounted

---

[1]Published in Paper Trade J., Sept. 16, 1926.

[2]Formerly in charge, Section of Pulp and Paper, U.S. Forest Products Laboratory, Madison, Wis.

[3]Formerly engineer in forest products, U.S. Forest Products Laboratory, Madison, Wis.

on hollow trunnions placed horizontally, so as to rotate about its long axis. The cylinder is lined with steel plates or with a special soft rubber lining inserted in the form of plates interchangeable with those of steel.

The cylinder is filled to nearly half its capacity with steel rods. The rods are only a few inches shorter than the inside length of the mill and lie parallel to the axis of rotation. They are free to tumble, but are always in a position essentially parallel to each other as the mill rotated, the upper rods cascading continuously down the surface of the rod bed.

Operation of the Mill

Reducing Softened Chips to Pulp

The shattering effect produced by a free-falling rod is desirable in grinding mineral, but is to be avoided in reducing softened chips to pulp. The mill is therefore rotated somewhat more slowly than is the practice in grinding ore. The mill installed at the Forest Products Laboratory is 3 feet in diameter and 5 feet in length, inside measure, and for experimental purposes is rotated at speeds varying from 17 to 28 r.p.m. It is charged with 3800 pounds of steel rods. A mill recently installed in a commercial plant manufacturing semichemical pulp is 6 feet in diameter and 12 feet in length. It contains 42,000 pounds of steel rods and is rotated at 14 r.p.m. The diameter of the rods ranges in both cases from 2 to 3 inches.

The chips are fed continuously by some suitable means through one trunnion of the mill, the ground pulp flowing out through the opposite trunnion. Sufficient water is fed with the chips to form a pulp suspension of 4 to 8 per cent at the outlet.

The laboratory mill is equipped with a 15 horsepower motor. It consumes approximately 12 horsepower when operating at 28 r.p.m. and 8 horsepower at 19 r.p.m. The large mill requires approximately 90 horsepower to operate it at 14 r.p.m. The refining is done chiefly by the rods moving under the force of gravity. Since the major portion of the power is consumed in lifting the rods, very little difference can be noted in the power requirement whether the mill contains pulp or not. For practical purposes the power necessary to grind a ton of wood chips is thus determined by the rate of feed, which in turn is dependent upon the nature of the wood, the degree to which the chips have been chemically softened, and the amount of hydration of the pulp which may be desired.

The following table shows some comparative figures for the capacity and power requirements of the Laboratory mill and the commercial mill operating on approximately the same material, viz., softened gum wood chips:

	Small mill	Large mill	Ratio of large to small mill
Capacity per 24 hours (tons)	0.5	10	20 to 1
Power required (horsepower)	12	90	7.5 to 1
Power per ton (horsepower) days	24	9	0.38 to 1

The figures in the table are indicative of the order of magnitude in the two cases, but their accuracy is limited by a lack of exact knowledge of the degree in which the respective conditions of the chips and the pulp are comparable. There has been no favorable opportunity for very accurate experimental comparison as yet. It is of special interest to note that the large mill operating on chemically-softened extract chestnut chips has been shown in continuous operation to have a capacity of 15 tons per 24 hours, representing a consumption of 6 horsepower-days per ton of pulp.

Reducing Knots and Screenings to Pulp

Knots and screenings are readily reduced to pulp by the rod mill. From qualitative tests made with the Laboratory mill it is estimated that a 6 by 12 foot mill would have a capacity of from 10 to 20 tons per 24 hours, according to the character of the rejects to be ground. The power consumption would be only 4.5 to 9 horsepower-days per ton. Even with the low power requirement, considerable hydration is effected during the grinding operation. The indications are that much of the necessary beating to which refined screenings are usually subjected can therefore be eliminated and the product made fully equal if not superior to that obtained by the most careful beater and jordan treatment.

The Rod Mill As A Beater

The value of the rod mill as a beater was revealed in a test made in 1924 by the Laboratory in cooperation with a manufacturer of Mitscherlich sulphite papers. By a single passage through the mill, Mitscherlich sulphite was hydrated sufficiently for the formation of a greaseproof paper. Both the bleached and the unbleached pulps give satisfactory results. The paper made on the Laboratory's 15-inch fourdrinier was exceptionally strong for a greaseproof and responded unusually readily to the blister test. The hydration was accomplished with less shortening of the fibers than is common in the beater preparation of greaseproof stock, and the pulp was consequently much freer on the paper machine wire.

This beating test was largely qualitative, and no accurate determination of power requirements was made. The indications were, however, that not more than 25 horsepower-days would be needed to convert a ton of Mitscherlich pulp in the laboratory mill to the high degree of greaseproofness attained. If the 6 by 12 foot mill bears the same relation to the small mill in its performance as a beater that it does as a refiner of chips, it should have a capacity of from 10 to 15 tons of completely greaseproof paper every 24 hours and a power consumption of 9 to 6 horsepower-days per ton.

The company for over a year has operated a rod mill 5 feet in diameter by 10 feet in length on pulp used in the manufacture of a paper which is not sufficiently hydrated to respond to the blister test. The power consumption of this mill was reported by the company to be less than 3 horsepower-days per ton and the product superior to that prepared in beaters.

In the manufacture of both sulphite and kraft wrapping papers it is probable that the rod mill will find desirable application. Little opportunity has thus far been found, however, for studying the value of the mill in those grades of papers.

For the best results in the use of the mill as a beater, further knowledge must be gained as to the optimum conditions of operation as influenced by such factors as relative quantities of pulp and water, rate of feed, speed of rotation of the mill, total rod charge, and size and density of the rods. An investigation of the factors just named is under way.