THE ROD MILL IN THE PAPER INDUSTRY[1]

By
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In January, 1924, a Marcy rod mill was tried out on a batch of half digested wood chips submitted by the Forest Products Laboratory of Madison, Wisconsin. The results were such that the work has since been carried out on an increasingly larger scale to the extent that it now appears that a considerable proportion of the work of beating and pulping in the paper industry will eventually be carried out by this means. A recent installation was started in operation at Port Angeles, Washington, and the performance of this unit is worthy of attention. Before going into these details, however, it will greatly facilitate the understanding of the points to be brought out if a description of the essential features of the Marcy rod mill is first given.

Figures 1 and 2 show exterior views of a 5 by 10 foot Marcy rod mill built for paper mill work. This size of mill is mounted on a trunnion at each end. The inlet trunnion is relatively small in diameter as compared to the diameter of the rod mill and is provided with suitable means for feeding the material to be treated into the mill. The outlet trunnion, however, is much larger in diameter so that the material after it has been properly treated finds ready egress from the mill. By means of the large outlet there is very little material backed up in the mill and the level of the material therein is so low that there is practically no buoyant effect exerted upon the rods.

Figure 3 shows an interior view of a typical Marcy rod mill and illustrates the action of the rods therein when in operation. On account of the large outlet the mill is provided with a splash door which prevents the rods from working out of the mill and the splashing out of the material that is being treated. The splash door is mounted on a suitable swinging bracket arrangement in the manner of the door of a modern vault which makes it possible to open the door at any time during the operation of the mill in order to observe

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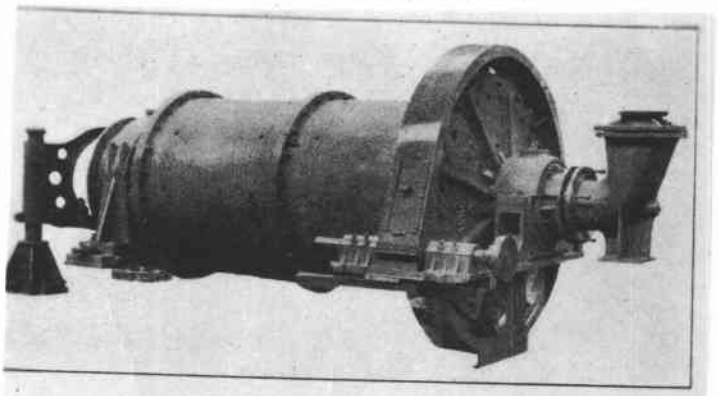

FIG. 1
Inlet and Driving End of Marcy Rod Mill.

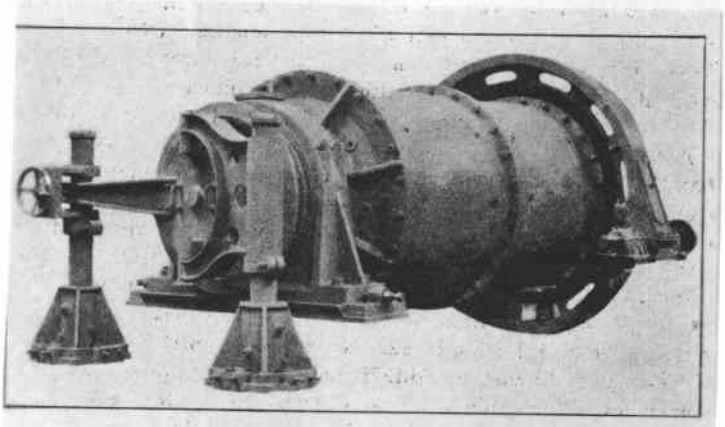

FIG. 2
Discharge End of Marcy Rod Mill.

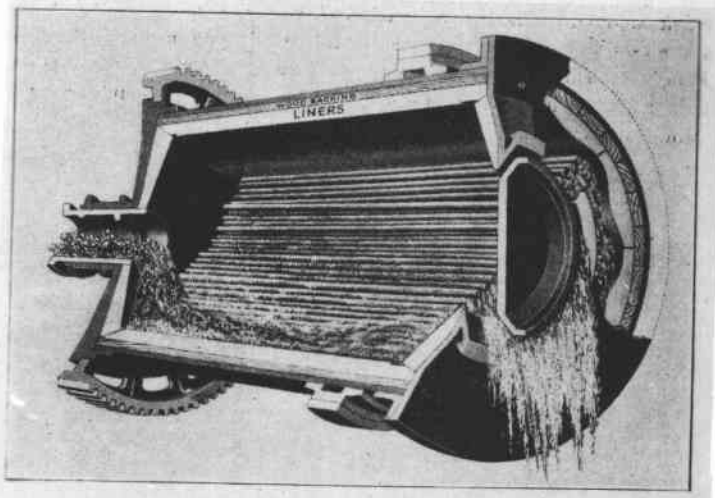

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FIG. 3
Interior View of Marcy Rod Mill.

the operating conditions and also the condition of the grinding medium or lining. This arrangement is also very convenient for replacing rods as they are worn out and portions of the lining that may need attention. In addition to the features mentioned above, the interior surfaces of the ends of the mill are slightly conical in shape. This feature provides what is called an internal feed pocket and makes it possible to feed large amounts of material into the spaces between the rods without any obstruction. Without the internal feed pocket much of the material would reach a considerable distance into the mill before it worked between the rods and received its proper treatment. This would produce uneven grinding and ununiform product. The same advantages possessed by the internal feed pocket are also a feature of the conical shape of the interior surface of the discharge end. It enables the prepared material to emerge freely from between the rods and pass out of the outlet without any restriction whatever. The metal lining of the rod mill is mounted with a wood backing which absorbs the shock produced by the falling rods and reduces to a very large extent the noise of operation. When stainless steel lining is used the wood backing completely separates the shell from the contents of the mill and prevents, thereby, contamination with iron.

The mill at Port Angeles was of 5 by 10 foot dimensions, provided with a manganese steel lining backed with wood and charged with 3-inch and 2-1/2-inch high carbon steel rods 10 feet long. The mill was driven by a 100-horsepower supersynchronous motor. The mill was run at a speed of between 17 and 18 revolutions per minute and it was operated on unbleached hemlock sulphite supplied by two pneumatic stock thickeners which supplied stock at a consistency of about 4-1/2 per cent. Various weights of rod charge were used, but it was finally found that a rod charge of between 13 and 15 tons gave the maximum output and did not show any signs of cutting the fibers. A feed of 35 tons of pulp per day was first tried but it was found that at this rate the degree of beating given the pulp was not sufficient for the purpose desired and the rate of feed was finally reduced to 17 tons per day. The consistency of the stock entering the mill was found to have a vital influence on the quality of the product and also on the amount of beating. Strength tests were made on the pulp obtained from the rod mill at various consistencies and it was found that when operating at a rate of 17 tons of pulp per day the following strength figures were obtained:

Table 1.--Effect of consistency on beating by rod mill

Marcy 5 by 10 foot rod mill

Consistency of pulp 17 tons fed per 24 hours	Mullen test strength factor
Per cent	Points per pound
4.25	0.514
4.5	.502
6.34	.542
7.32	.607
8.55	.606
9.29	.579

It is evident from the above that the most desirable consistency for operation is between 7-1/2 and 8-1/2 per cent. The strength factor of the stock before it entered the rod mill was 0.385. The increase in test of 17 tons of pulp per day from 0.385 to 0.607 was accomplished in the rod mill with the expenditure of only 70 horsepower. Previous work at the plant had shown that two 1,000-pound beaters requiring 100 horsepower raised the test of this quantity of pulp from 0.385 to 0.460. The subsequent passage of the beater pulp through a jordan taking 100 horsepower raised the test to 0.575. It is consequently apparent that the rod mill with the consumption of only 70 horsepower is capable of performing a slightly greater beating effect than the beater-jordan combination requiring a power consumption of 200 horsepower. The combination of the rod mill, two beaters and one jordan, requiring 245 horsepower in all, was capable of producing a sheet of test board calipering 0.01375 inch, which gave an average Mullen test of 156 points. This is equivalent on the basis of the previous tests to 0.88. By operating the beaters on a Sunday it was found that it would be necessary to use ten 1,000-pound beaters requiring 500 horsepower, and one jordan requiring 75 horsepower to produce a board of equal strength at the rate of 17 tons per day. It is evident from the above that the use of the rod mill will make possible savings in power of from 50 to 70 per cent over present methods with the standard type of beater and jordan.

In the operation of the mill at Port Angeles it was found that under average operating conditions there was sufficient cooking acid in the washed unbleached pulp to cause

some discoloration in its passage through the rod mill. When operating continuously at a consistency above 7 per cent, however, the amount of discoloration was considerably reduced and was not sufficient to cause complaint in the manufacture of the grades of product desired. Where discoloration is objectionable it is entirely feasible to provide mills with stainless steel lining and rods, and under such conditions discoloration is entirely avoided.

In connection with the application of the Marcy rod mill to paper-making problems in general, the various sizes of mills available are of interest as well as the operating conditions, power consumption, and output for various types of product. The following table (Table 2) is offered to give this information and with it is provided a key for interpreting the output of the mill when operating on various materials or to produce various products.

Table 2.

Size of mill	Speed of mill	Horse-power	Rod charge	Output of mill, per 24 hours, degrees of beating as measured by minutes in standard pebble test				On ground screenings
				10	30	60	100	
Feet	R.p.m.		Tons	Tons	Tons	Tons	Tons	Tons
3 by 6	25	15	2.5	2	1.2	0.7	0.5	0.3
4 by 8	20	38	7	16	7	4	3	2
4 by 10	20	42	9	20	8.5	5	3.5	2
5 by 10	16	70	14	40	17	10	7	5
5 by 12	16	84	17	48	20	12	8.5	6
6 by 12	14	110	24	68	28	17	12	8.5
6 by 14	14	128	28	80	34	20	14	10
7 by 15	12.5	160	38	120	50	30	21	15

The amounts of beating as expressed in minutes in the pebble mill are given below (Table 3) for various types of product on the assumption that all the beating is done in the rod mill and the jordan is used solely for breaking up clots or lumps and to shorten the fiber to the degree necessary.

Table 3.--Average beating in pebble mill required for various types of product

Book paper, English finish	10 minutes
Book paper, lithograph	20 minutes
Ordinary sulphite wrapping	30 minutes
Strong sulphite wrapping	30 minutes
Semiparchment	60 minutes
Full parchment	100 minutes
Ordinary kraft	40 minutes
Extra strong kraft	80 minutes
Sulphite, sulphate, or soda screenings	40 minutes
Straw, lime cooked	20 minutes
Chemically softened wood chips	40 minutes

From the preceding table (Table 3) it is evident that the rod mill is capable of application to a great variety of uses in the paper industry. It is capable of pulping, beating, grinding and refining, and it can be used to advantage to supplement or supplant the equipment usually used to carry on any of these operations. It is a much more rugged machine than any heretofore used for the purpose and parts subject to wear can be replaced in a matter of minutes where it is usually a matter of days with beaters and refiners. It is furthermore not subject to breakage from foreign material entering the mill and in every way it shows marked advantages over the devices commonly used in the industry.