ENGINEERING

Beneficial Effects of Reagents in Solution on Wet Crushing of Rock

Earlier workers in this Department[1,2] have reported that substantial increases in the crushing efficiency of a drop-weight mill (stamp mill) may be achieved by pretreatment of the ore in aqueous solutions of certain reagents.

This work appears to have aroused interest, but, in the cases known to us, workers elsewhere have not been able to obtain significantly beneficial results[3,4]. In these latter investigations a ball mill was used, and it is of interest that the first exploratory work at Leeds was carried out with a ball mill; the results were not encouraging[2]. Possible reasons for this, and for the final choice of a drop-weight mill, have been discussed by Frangiskos[2]; arguments are based on the work of Rehbinder[5].

In view of these later findings it has been considered necessary to repeat some of the experiments reported by Frangiskos and Smith[1] with the drop-weight mill. The results are given in Table 1. Except for the actual rock samples (limestone) used, the experimental conditions are the same as those employed by Frangiskos and Smith. The amount of crushing achieved is measured in terms of the surface area of the product, determined by a gas-permeability method. The percentage increase shown in Table 1 is the extra amount of crushing achieved when the ore is pretreated in a solution instead of in distilled water. The beneficial effect with the particular samples of limestone used is even more pronounced than that observed by Frangiskos and Smith; their best results represented approximately a 50 per cent increase.

Table 1. Effect of Reagents in Solution on the Surface Area of Crushed Ore

Reagent (mgm./l.)	Sodium hydroxide		Sodium carbonate	
	Surface area of product (cm.²/gm.)	Percentage increase (pure water basis)	Surface area of product (cm.²/gm.)	Percentage increase (pure water basis)
0	247*	—	156	—
100	305	23·5	185	18·6
150	367	48·6	—	—
200	346	40·1	273	75·0
300	278	12·5	296	89·8
400	261	5·7	320	105·0
500	279	13·0	293	89·0
600	301	21·9	244	56·4
700	354	43·3	217	38·2
800	282	14·2	187	19·9

Charge to mill: 15 gm. limestone (−2·05 mm. + 1·40 mm.). Conditioning time in solution, 10 min. Weight of crushing head, 2,026·4 gm. Height of fall, 13·6 mm. Blows per min., 120. Total number of blows, 600.

* Initial surface area approximately 1·5 cm.²/gm.

It is suggested that the reason for the success of the drop-weight method of crushing in contrast to the ball mill is basically as proposed by Frangiskos and Rehbinder. The essential feature of the hypothesis is that embryo microcracks produced by stress on the solid are made permanent points of weakness by adsorption in them of ions or molecules from solution; it is assumed that the relative adsorption of water molecules is so small as to permit resealing of the microcracks. A drop-weight mill is likely to be more effective than a ball mill in producing microcracks.

Furthermore, the choice of method for assessing the amount of crushing (fineness of product) is important. Most of the new surface area produced is contained in the extremely fine sizes[6], and the conventional sieve analysis gives no measure of this. Results which have been assessed in terms of a sieve analysis might therefore indicate no beneficial effect of reagents in solution. The work in this Department was terminated in 1956 after three years work due to lack of financial support. Finance has now been made available for the project for one more year, but it seems to us a pity that further development work on the process may have to be carried out elsewhere.

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Hydrogen Diffusion in Water-accelerated Rolling Surface Fatigue

The pitting failure of rolling bearings is now generally regarded as a surface fatigue phenomenon, and recent work[1] has shown that the presence of water in mineral oil lubricants can accelerate the failure of ball-bearings manufactured from conventional *E.N.*31 steel. A possible mechanism for this phenomenon has been suggested by Grunberg and Scott[2]. The hypothesis is that vacancy-induced diffusion of hydrogen into the highly stressed surface material produces 'hydrogen embrittlement'. To test this theory, four-ball rolling tests[1,2] were carried out with a lubricating oil containing 6 per cent tritiated water of high activity (5 c./ml.). The rolling four-ball test produces a track on the driving ball in which pits are normally formed. The three driven balls are stressed to a lesser extent and usually do not show evidence of surface fatigue. Balls from tests using tritiated water were washed with acetone and partially immersed in a liquid scintillator (0·3 per cent 2,5-diphenyloxazole + 0·01 per cent 1,4[2-(5-phenyloxazolyl)]-benzene in toluene) and the activity counted using a (refrigerated) ECKO *N*612 unit. When the part of driving balls carrying the fatigued track was immersed in the liquid scintillator, counting-rates of between 1,000 and 2,000 counts/sec. were recorded. The unfatigued part of driving balls gave only counts of about 40 counts/sec. against the background count of 30 counts/sec. The activity in the fatigued tracks decreased with time and tended towards the background-level after about five days.

The preliminary experiments described provide support for the hypothesis that, in the presence of water, hydrogen penetrates into the material subject to surface fatigue. The decrease in activity with time can be ascribed to escape of tritium from the material.

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