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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA

TECHNICAL MEMORANDUM NO. 28 OF 1966.

TESTS CARRIED OUT TO DETERMINE THE INFLUENCE OF THE FINENESS OF THE MEDIUM ON THE OPERATION OF THE D.S.M. CYCLONE IN THE FUEL RESEARCH INSTITUTE PILOT PLANT.

by

S.F. STREICHER.

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INTRODUCTION:

The dense medium cyclone unit, supplied by the Dutch State Mines, which was installed in the FRI Pilot Plant in Pretoria during 1957, had the following principal dimensions:

Cyclone diameter	:	14"
Feed Inlet	:	2¾" diameter
Vortex tube	:	5-29/32" diameter
Apex aperture	:	3" diameter

When the unit was first tested it was found impossible to effect a separation despite wide variations in the specific gravity of the medium suspension in the feed. Under all conditions only a small proportion of sinks were obtained (±5%). It was observed that the difference between the specific gravities of the underflow and the overflow was always of the order of 0.6 to 1.0.

The difficulties experienced were discussed with representatives of the Dutch State Mines and they were of the opinion that the Rooiberg medium milled to approximately 90% minus 200 mesh used in these tests was probably too coarse.

They stated that normally the difference between the overflow and underflow specific gravities of a cyclone should not exceed 0.2, and recommended that the magnetite should be milled to 95% -45 μ if a lot of middling is present in the coal. The size distribution of the magnetite recommended for use in the cyclone is given in Table 1.

Table 1.../

TABLE 1.

SIZE DISTRIBUTION FOR MAGNETITE RECOMMENDED BY D.S.M.

-5μ	5-8%
-12μ	17-25%
-30μ	50-70%
-50μ	78-92%
-75μ	94-99%
-100μ	99-100%

Tests were then done on Rooiberg magnetite milled for an additional period of 5 hours, but efficiencies obtained in these tests with the finer medium were still relatively poor and the difference between the overflow and underflow specific gravities was still of the order of 0.6.

Subsequently the apex aperture of the cyclone was changed from the original 3" diameter to 5½" diameter and the probable errors obtained under these conditions, even with the coarser medium, were rather better than the figure normally guaranteed by the D.S.M.

It was then argued that seeing that satisfactory results could be obtained with the coarser medium it was not desirable to mill the medium so fine as to comply with the D.S.M. specification (with respect to the difference between overflow and underflow specific gravities) because:

(a) Milling costs in practice would be excessive.

(b) Medium consumption would be liable to be high owing to loss of the finest particles.

(c) Medium recovery equipment (at that time a "Spinner cone) at the Pilot Plant could not handle finer medium efficiently.

At a later stage Foskor magnetite was substituted for the Rooiberg magnetite originally used, and it was found that 3 hours milling was necessary to produce a product containing approximately 90% to 95% minus 200 mesh material. This medium, when used in the cyclone with a 5½" diameter apex aperture gave satisfactory results although the difference in overflow and underflow specific gravities was still about 0.4 and the cut point was slightly lower than the specific gravity of the suspension fed to the cyclone which is unusual for dense

medium.../

medium cyclones.

Facilities for the determination of the size distribution of the magnetite in the sub-sieve range did not exist at that time so that this distribution was not known for medium used in the cyclone at the Pilot Plant.

As these facilities are now available it was decided to do a series of tests in the cyclone in order to determine the influence of the fineness of the medium on the operation of the cyclone.

THE TESTS.

It was decided to do three washing tests under similar conditions, the only variable being the milling time of the medium used. For the first test the Foskor medium was milled for 1½ hours only, i.e. half the normal milling time. For the second test medium milled for the normal time of 3 hours was used, and for the third test a separate batch of magnetite milled for 6 hours, i.e. double the normal milling time was used.

During each test a sample of the medium in circulation was taken and analysed for particle size distribution.

Results of these analyses are given in Table 2.

TABLE 2.

SIZE DISTRIBUTION OF MEDIUM USED IN TESTS.

Test No.	324	325	326
Milling Time	1½ hrs	3 hrs	6 hrs
Particle Size Distribution			
-5μ	10%	12%	23%
-12μ	29%	35%	68%
-30μ	66%	76%	94%
-44μ (325 mesh)	76%	88%	98%
$+44\mu$	24%	12%	2%

The size distribution of the three samples is shown graphically in Figure 1.

A float and sink analysis of the feed coal used in these tests is reported in Table 3.

These three tests were repeated at a later date in order to verify the results obtained in the first three, but no size distribution analyses were done on the medium used in the second series.

Washing.../

Washing results obtained in these tests are reported in Table 4.

DISCUSSION.

A. Fineness of Medium.

A comparison between the data in Tables 1 and 2 shows that Foskor medium milled for three hours complies with D.S.M. recommendations in respect of particle size distribution. The same magnetite milled for 1½ hours contains too large a percentage of +325 mesh material, while the magnetite milled for 6 hours is much finer than recommended.

As far as the difference between overflow and underflow specific gravities are concerned, results reported in Table 4 show that only the magnetite milled for 6 hours fulfils the recommended specifications.

B. Cut Points.

According to the results reported in Table 4 there seems to be a definite tendency for the specific gravity of separation to increase as finer medium is used. This could be explained by the fact that the coarsest particles (+325 mesh) in the medium are expelled from the suspension under the large centrifugal force applied in the cyclone and that the effective specific gravity of the suspension is then lowered in accordance with the percentage of coarser particles present.

In commercial dense medium cyclones the cut points are normally found to be substantially ($\pm$0.2) higher than the specific gravity of the suspension fed to the cyclone. The fact that the cut points in this cyclone are about the same or even lower than the specific gravity of the feed must be attributed to some peculiarity of this cyclone probably due to the alteration of the apex aperture. This, however, is no major practical disadvantage.

Another interesting feature in connection with the cut points, which has been noted before, is that contrary to the usual trend, the cut points on the ¼" x ⅛" material in all six tests are lower than those on the ½" x ¼" size fractions. Normally one would expect the cut points to increase on decreasing size fractions in the feed. The tendency for the position to be reversed for the ½" x ¼" and the ¼" x ⅛" size fractions only cannot be explained.

C. Probable.../

C. Probable Errors.

The sharpness of separation as measured by the probable error appears to be affected only in the case of the coarsest medium ($1\frac{1}{2}$ hr milling) and then only slightly except in the case of the finest fractions in the feed ($\frac{1}{8}$" x 0.5 mm) where the deterioration is apparent.

CONCLUSION.

These tests indicate that the normal milling time of three hours for Foskor magnetite at the Pilot Plant is adequate to ensure optimum efficiencies in the cyclone and that there is no point in milling this magnetite for longer periods, which only may result in higher losses of magnetite due to lower recovery efficiency of the finer particles.

PRETORIA.
26th August, 1966.

S.F. STREICHER.
Principal Research Officer.

TABLE 3.

FLOAT AND SINK ANALYSIS OF FEED TO CYCLONE.

S.G. Interval	Size Fraction					
	$\frac{1}{2}$" x $\frac{1}{4}$"		$\frac{1}{4}$" x $\frac{1}{8}$"		$\frac{1}{8}$" x 0.5 mm	
	Yield		Yield		Yield	
	Fract. %	Cum. %	Fract. %	Cum. %	Fract. %	Cum. %
Fl.40	55.21	55.21	49.30	49.30	36.73	36.73
1.40 - 1.42	8.58	63.79	9.05	58.35		
1.42 - 1.44	6.89	70.68	7.32	65.67	12.55	49.28
1.44 - 1.46	5.49	76.17	5.74	71.41		
1.46 - 1.48	3.96	80.13	3.25	74.66	10.38	59.66
1.48 - 1.50	3.39	83.52	4.07	78.73		
1.50 - 1.52	2.05	85.57	2.02	80.75	6.47	66.13
1.52 - 1.54	1.84	87.41	2.21	82.96		
1.54 - 1.56	1.90	89.31	2.40	85.36	6.00	72.13
1.56 - 1.58	1.65	90.96	2.26	87.62		
1.58 - 1.60	1.63	92.59	2.02	89.64	7.15	79.28
S1.60	7.41		10.36		20.72	
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

Table 4..../

TABLE 4.

CYCLONE TEST RESULTS.

Test No.	324	325	326	328	329	334
Load t.p.h. approximately	15-17	15-17	15-17	15-17	15-17	15-17
Inlet Pressure lb/sq.inch	10-12	10-12	10-12	10-12	10-12	10-12
Milling Time - Hours	$1\frac{1}{2}$	3	6	6	3	$1\frac{1}{2}$
Feed - S.G.	1.54	1.54	1.54	1.54	1.54	1.54
Overflow - S.G.	1.30	1.34	1.48	1.50	1.34	1.31
Underflow - S.G.	1.77	1.74	1.61	1.62	1.74	1.78
$\frac{1}{2}$" x $\frac{1}{4}$" Coal						
S.G. of Separation	1.502	1.524	1.550	1.549	1.525	1.510
Probable Error	0.018	0.010	0.017	0.014	0.014	0.020
$\frac{1}{4}$" x $\frac{1}{8}$" Coal.						
S.G. of Separation	1.498	1.522	1.547	1.538	1.523	1.502
Probable Error	0.019	0.013	0.017	0.016	0.015	0.026
$\frac{1}{8}$" x 0.5 mm Coal.						
S.G. of Separation	1.519	1.528	1.562	1.552	1.526	1.524
Probable Error	0.046	0.024	0.026	0.031	0.031	0.042

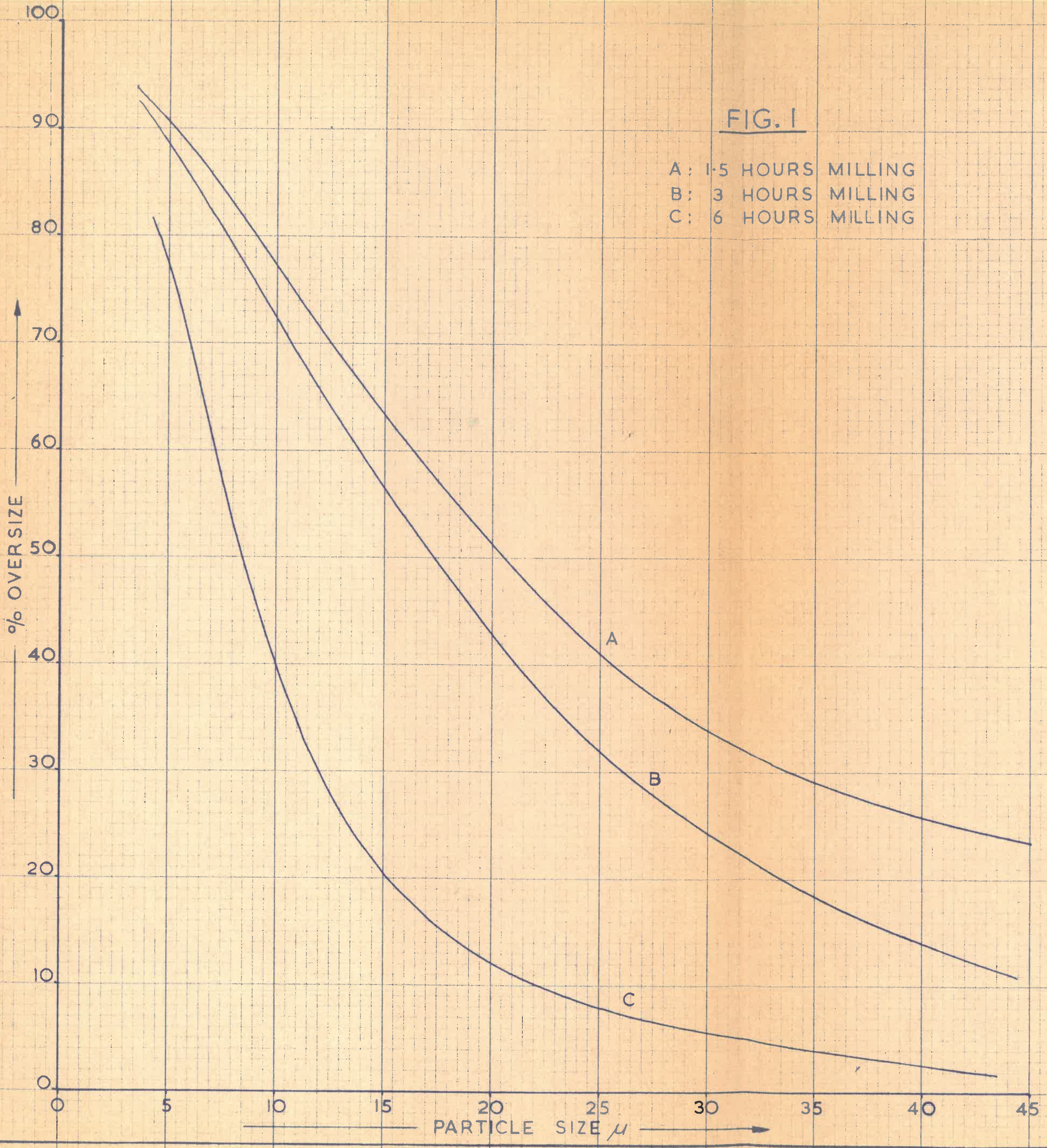
FIG. 1
A: 1·5 HOURS MILLING
B: 3 HOURS MILLING
C: 6 HOURS MILLING
% OVERSIZE
PARTICLE SIZE μ
0
10
20
30
40
50
60
70
80
90
100
5
15
25
35
45
A
B
C