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REDUCTION OF FIRMLY-CEMENTED SANDSTONE TO GRAIN SIZE BY ROLL CRUSHER AND MULLER MIXER

by

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MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

The results of the work outlined in this report indicate that the Simpson muller mixer is superior to the Sturtevant roll crusher as a milling unit for the reduction of firmly-bonded sandstone to grain size. The best sand, both from a physical and chemical standpoint, was produced with the Simpson mixer when operated at 85% solids. The sand product from this particular test contained relatively few compound or fractured grains. The majority of grains were well-rounded. The ferric oxide content of this sand, at 0.05%, represented a reduction of 37.5% and the alumina, at 0.08%, a reduction of 87.3% when compared with the respective feed analyses (0.08% Fe_2O_3, 0.63% Al_2O_3).

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INTRODUCTION

Sandstone is composed of grains of quartz cemented with silica, iron oxide, clay, or other bonding material. The individual grains of quartz generally are rounded to sub-angular in shape and very pure. Most of the impurities inherent in sandstone are contained in the bonding cement that occurs as a coating on the quartz grains and in interstitial spaces between the grains. A small portion of the total impurities occurs as minute particles within the actual quartz grains.

In processing sandstone to produce sand for use in the glass, artificial abrasives, foundry, and other industries requiring high-purity sand, it is essential first to reduce the sandstone to a size at which most, preferably all, of the quartz grains are free without fracturing or otherwise reducing the individual grains. The next step is to scrub or scour the free grains of quartz to remove adhering impure coatings and particles of cementing material. The impurities included within the individual quartz grains, unless magnetic, cannot be removed without reducing the grains to a size at which these impurities would be free. Since reduction of the individual grains is undesirable, and since the total impurity contained within the quartz grains is very low, no special effort usually is made to remove these included impurities.

Attrition scrubbing may be utilized to remove a large percentage of clay and similar soft bonding cements;

however, iron oxide stain generally will not respond to attrition scrubbing and therefore must be removed by acid leaching. A siliceous bond is very difficult to remove as this type of cement generally is very hard and firmly bonded to the quartz grains. In certain instances the cementing material may not be objectionable, for example, when the bond is largely siliceous and relatively free of impurity. However, in most cases, the cementing material contains objectionable impurities and should be removed. Also, because the bonding cement occupies the spaces between the grains, it is usually irregular in shape and tends to make the individual quartz grains appear more angular than they actually are. Well-rounded quartz grains are preferred by most foundries for moulding and casting purposes.

The present investigation was undertaken primarily to determine which of two units, a Sturtevant roll crusher or a Simpson muller mixer, would produce the better reduction of a firmly-bonded sandstone to grain size without excessive fracturing of the individual quartz grains. The feed for each unit was minus 1/4 in. plus 20 mesh. In addition, several tests were conducted in the Simpson mixer with minus 20 mesh sand to determine whether this unit could be used to effectively reduce the iron and alumina contents of this material.

SAMPLE EXAMINATION AND PREPARATION

A typical sandstone of the Potsdam series was selected for this investigation. The sample used in this work consisted of 200 lb of minus 1 in. sandstone obtained from an operating quarry in southern Quebec.

This sandstone is composed of rounded to sub-angular grains of quartz firmly bonded by a complex silica-alumina cement. The chief impurities are alumina, which occurs in the silica-alumina cement, and iron which occurs as an iron oxide coating on many quartz grains and as grains of pyrite, some very minute, that are firmly bonded to quartz grains.

TEST PROCEDURE

The sandstone was reduced to minus 1/4 in. by jaw crusher and separated into minus 1/4 in. plus 20 mesh and minus 20 mesh fractions by a Rotex screen. Samples of the plus 20 mesh sandstone were prepared for wet and dry reduction in the Sturtevant roll crusher and Simpson muller mixer. Samples of the minus 20 mesh sand were selected for wet and dry scrubbing tests in the Simpson mixer.

Roll Crusher Tests

A double roll, laboratory model Sturtevant crusher was used for these tests. Each roll was 5 in. in width by 8 in. in diameter.

The clearance between the rolls was adjusted to 1/16 in. and two samples of the minus 1/4 in. plus 20 mesh sandstone, one dry, the other slightly wet (90% solids), were reduced by a single pass through the rolls. The plus 20 mesh material from the dry sample was separated by screening and passed through the rolls a second time.

Samples of the reduced sandstone were selected for sieve and chemical analysis. Samples for chemical analysis were washed free of slimes (minus 150 mesh) and dried, and the introduced iron was removed by a small hand magnet before the samples were submitted to the chemical laboratory.

Muller Mixer Tests

An 18 in. Simpson mixer, equipped with two, 2½ in. by 9 in. muller wheels, was used for these tests.

Representative portions of the minus 1/4 in. plus 20 mesh sandstone and of the minus 20 mesh sand were treated dry, at 85% solids, and at 65% solids, each for a 30-minute period.

Samples of all products were obtained for sieve and chemical analysis. The samples for chemical analysis were washed free of slimes (minus 150 mesh) and dried, and the introduced iron was removed by a small hand magnet before they were submitted to the chemical laboratory.

Examination of Products

Corresponding mesh fractions of the products from each test were compared under a binocular microscope. All products were examined carefully to determine:

1. The degree of breakdown of the sandstone to grain size.
2. Any tendency towards fracturing of individual

quartz grains.

3. The shape of the quartz grains.

RESULTS

Sieve and Chemical Analyses

Sieve analyses of all products follow in Tables 1 and 2. Chemical analyses are listed in Table 3. Graphs of the sieve analyses are shown in Figures 1, 2 and 3 following Table 3. The sieve analysis of the minus 20 mesh sand from the Rotex screen, which approximates the natural grain size of the original sandstone, has been plotted on each graph for comparative purposes.

TABLE 1

Sieve Analyses and Product Recoveries
- ¼ + 20 Mesh Sandstone

Sieve Fractions	Product Recovery-Weight Per Cent					
	Feed	Sturtevant Roll Crusher		Simpson Muller Mixer		
		Dry	90% Solids	Dry	85% Solids	65% Solids
+14	77.6	18.2	14.9	12.3	6.5	5.0
-14+20	6.8	11.5	4.5	3.4	2.2	1.4
-20+28	6.1	11.9	5.9	5.9	5.2	3.6
-28+35	4.1	15.5	10.9	11.9	12.2	12.9
-35+48	1.8	16.3	15.8	22.0	23.5	24.0
-48+65	1.8	13.9	16.7	23.2	26.1	28.6
-65+100	1.1	5.5	10.4	10.2	12.2	13.3
-100+150	.2	4.5	15.6	5.6	5.5	5.0
-150	.5	2.7	5.3	5.5	6.6	6.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 2

Sieve Analyses and Product Recoveries
-20 Mesh Sand

Sieve Fractions	Product Recovery-Weight Per Cent			
	Feed	Simpson Muller Mixer		
		Dry	85% Solids	65% Solids
+28	1.1	1.0	1.4	0.8
-28+35	14.7	10.9	10.3	10.5
-35+48	28.2	27.6	25.2	25.9
-48+65	27.7	29.2	29.0	29.7
-65+100	11.9	13.5	14.5	14.9
-100+150	6.3	5.8	7.4	7.9
-150	10.1	12.0	12.2	10.3
Total	100.0	100.0	100.0	100.0

TABLE 3

Chemical Analyses of Products

Product	Analyses - %	
	Fe_2O_3	Al_2O_3
Minus ¼ in. plus 20 Mesh Sandstone (washed on 150 mesh sieve)		
Feed	0.08	0.63
Products from Sturtevant Roll		
Dry test	0.08	0.19
Wet test (90% solids)	0.05	0.11
Products from Simpson Mixer		
Dry test	0.06	0.13
Wet test (85% solids)	0.05	0.08
Wet test (65% solids)	0.05	0.10
Minus 20 Mesh Sand (washed on 150 mesh sieve)		
Feed	0.05	0.14
Products from Simpson Mixer		
Dry test	0.04	0.10
Wet test (85% solids)	0.04	0.06
Wet test (65% solids)	0.04	0.07

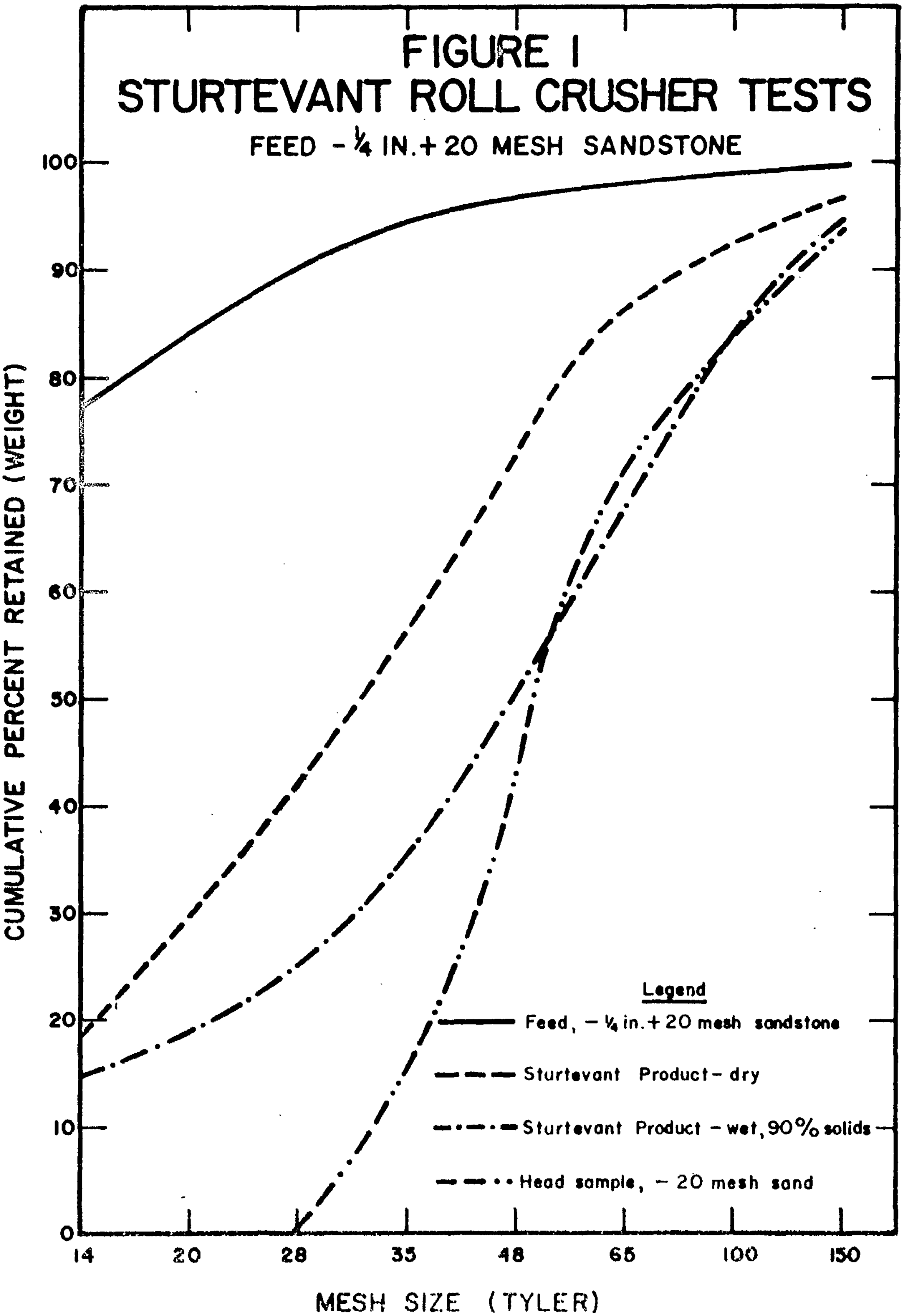
FIGURE I
STURTEVANT ROLL CRUSHER TESTS
FEED - ¼ IN. + 20 MESH SANDSTONE
CUMULATIVE PERCENT RETAINED (WEIGHT)
100
90
80
70
60
50
40
30
20
10
0
14
20
28
35
48
65
100
150
MESH SIZE (TYLER)
Legend
Feed, - ¼ in. + 20 mesh sandstone
Sturtevant Product - dry
Sturtevant Product - wet, 90% solids
Head sample, - 20 mesh sand

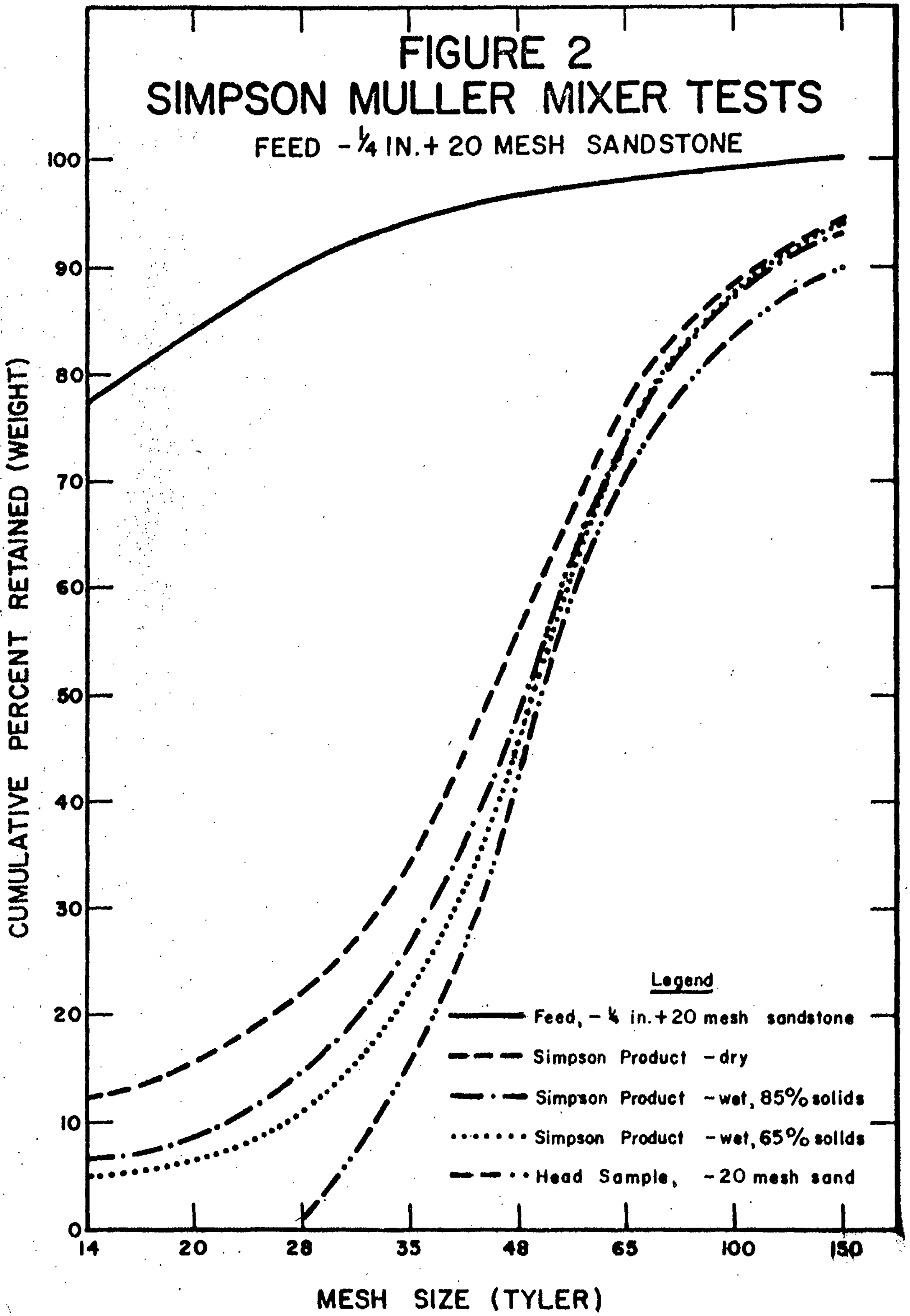
FIGURE 2
SIMPSON MULLER MIXER TESTS
FEED -¼ IN.+ 20 MESH SANDSTONE
CUMULATIVE PERCENT RETAINED (WEIGHT)
0
10
20
30
40
50
60
70
80
90
100
14
20
28
35
48
65
100
150
MESH SIZE (TYLER)
Legend
Feed, -¼ in.+20 mesh sandstone
Simpson Product -dry
Simpson Product -wet, 85% solids
Simpson Product -wet, 65% solids
Head Sample, -20 mesh sand

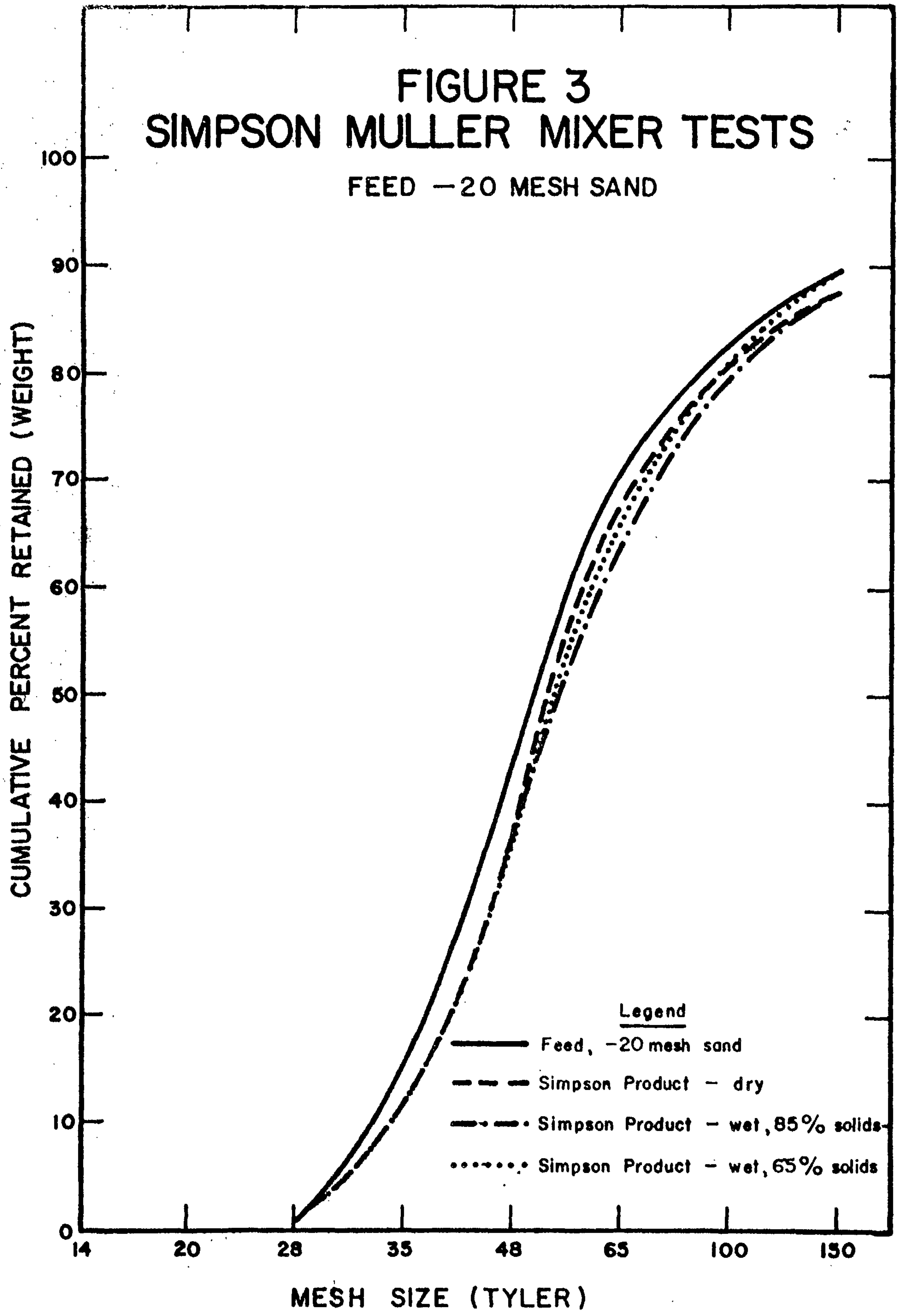
FIGURE 3
SIMPSON MULLER MIXER TESTS
FEED —20 MESH SAND
CUMULATIVE PERCENT RETAINED (WEIGHT)
0
10
20
30
40
50
60
70
80
90
100
14
20
28
35
48
65
100
150
MESH SIZE (TYLER)
Legend
Feed, -20 mesh sand
Simpson Product - dry
Simpson Product - wet, 85% solids
Simpson Product - wet, 65% solids

DISCUSSION OF RESULTS

The minus 1/4 in. plus 20 mesh product from the Rotex screen and the plus 20 mesh fractions of all products formed by reduction of this minus 1/4 in. plus 20 mesh sandstone were composed almost entirely of compound grains of firmly-bonded quartz. These plus 20 mesh fractions represented from 6.4 to 15.7% of the weight of the Simpson products, from 19.4 to 29.7% of the weight of the Sturtevant products, and 84.4% of the feed.

As indicated previously, it is desirable, in the production of sand from sandstone, to reduce the sandstone as completely as possible to its natural grain size. The natural grain size of this particular sandstone is approximately that of the minus 20 mesh sand removed from the jaw crusher product by the Rotex screen. Less than 10% of the weight of this product was composed of compound grains. These compound grains were largely confined to the plus 48 mesh fraction.

An examination of the graphs, Figure 1, indicates that the wet test in the Sturtevant crusher resulted in a product that, although a good deal coarser than the natural grain size of the sandstone, was much finer than the product from the dry test. A much closer approximation of the natural grain size was achieved by wet treatment in the Simpson muller mixer (see graph, Figure 2). Removal of the plus 20 mesh portions of the Simpson products would result in products that were very close to the natural grain size of the original sandstone.

Dry reduction of the plus 20 mesh sandstone in the Sturtevant roll crusher resulted in an angular-grained sand that contained large percentages of compound grains in the plus 48 mesh sizes. Wet reduction gave better results. Fewer compound grains were observed in the plus 48 mesh from the wet test, but the individual grains of quartz probably were as angular as those from the dry reduction test.

The product of the dry test conducted with the plus 20 mesh sandstone in the Simpson mixer was superior to that produced in the rolls because the quartz grains were more rounded and compound grains were largely confined to the plus 28 mesh sizes. Wet reduction in the Simpson mixer gave comparable results although the sand grains were much cleaner than those from the dry test. The products of the tests conducted at 85% solids and 65% solids were generally similar.

Some fracturing was observed in all tests but grain fracturing generally was not excessive. The minus 100 mesh fractions, representing up to 20% of the total sample weights, were composed of angular rather than rounded quartz grains. A large percentage of the total minus 100 mesh fraction probably can be attributed to the fine, interstitial quartz removed from the individual sand grains during milling.

Chemical analyses indicated that wet reduction of the minus 1/4 in. plus 20 mesh sandstone was superior to dry with respect to the reduction of iron, and especially alumina. The best results were obtained with the Simpson mixer. It is interesting to note that the Simpson test run at 85% solids resulted in a product that was superior chemically to that produced at 65% solids. At 85% solids the pulp concentration was such that an excellent scrubbing and scouring action was produced.

Most of the compound grains present in the minus 20 mesh sand from the Rotex screen were reduced to grain size by mulling in the Simpson mixer. Wet mulling was superior to dry since it produced a cleaner sand and a greater reduction of the alumina.

CONCLUSIONS

The results of this work indicate that the Simpson muller mixer is superior to the Sturtevant roll crusher for the production of high-purity, agglomerate-free sand from sandstone of the type selected for this investigation. Best results were obtained when operating the Simpson mixer wet at pulp densities in the order of 80 to 85% solids.

RKC/MK