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O T T A W A February 25, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2007.

Comparison of Two Moulding Sands. Factors to Consider in Purchasing Core Sand.

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Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Introduction:

On November 5, 1945, P.M. Laboratory Report No. 7810, "Comparison of Two Moulding Sands," was released. This report (issued to Warden King Limited, Montreal, Quebec) pointed out that, although both sands submitted would be suitable for making cores for grey iron castings, Sample No. 2 required about three times as much core oil as Sample No. 1. Upon receipt of this report Warden King Limited conducted further work on these two sands which confirmed the findings of these Laboratories. In an effort to determine whether the difference

(Introduction, cont'd) -

in screen analysis was the cause of this difference in oil consumption, Sample No. 2 was selectively screened by Warden King Limited to the same sieve analysis on Sample No. 1. Even with the same size of grains, Sand No. 2 required more oil than Sand No. 1. These Laboratories were requested, verbally, to determine, if possible, the cause of the difference between the two sands, and to indicate the most important factors to consider in purchasing core sand.

Sufficient amounts of the two sands originally submitted remained to complete this investigation.

Explanation of Difference Between the Two Sands:

Tensile Tests -

The sands were tested with a basic mix of 1 per cent bentonite, 1 per cent cereal flour, and 1 per cent core oil. Sample No. 2 was tested in three different conditions:

(1) As received.
(2) After being washed.
(3) After being screened to the same screen analysis as No. 1, and washed.

The following tensile results were observed:

Sample		Tensile Strength, p.s.i.
No. 1, as received	-	164.5
No. 2, as received	-	54.0
No. 2, washed	-	82.0
No. 2, washed and screened	-	107.0

Photomicrographs -

Photomicrographs of samples Nos. 1 and 2 are shown in Figures 1 and 2 respectively. Sample No. 2 has been selectively screened to the same sieve analysis as No. 1.

Void Space and Base Permeability -

The void space of the two sands was calculated from the true and apparent densities. Sand No. 2 has been screened to the same analysis as Sand No. 1.

(Explanation of Difference Between the Two Sands, cont'd) -

Sample No.	Base Permeability	Density True	Density Apparent	Per cent Voids
1	96	2.61	1.78	31.8
2	115	2.70	1.71	36.7

Discussion:

It is evident, from the tests, that Sample No. 2 can be beneficiated by washing, by screening, or by washing and screening. Even after washing and screening, however, it does not give as high a tensile strength as Sample No. 1. The angular grain shape of Sample No. 2 is the main cause of the excessive amount of core oil which must be used to produce a core with a satisfactory tensile strength.

Factors which are adversely affected by the more angular grain shape of Sample No. 2, lowering its tensile strength are:

(1) The specific surface is greater for angular sand grains than for rounded ones. A larger amount of oil is required to cover the greater surface area of the angular grains.

(2) The surface contact area is less for angular sand than for rounded sand, because it does not pack so well. Since in this case the dry angular sand contains 36.7 per cent voids and the rounded sand has 31.8 per cent voids, it is evident that the angular sand has a smaller surface contact area. In a paper on the influence of grain shape, "The Effect of Grain Shapes on the Moulding Properties of Synthetic Moulding Sands," by W. Davies and W. J. Rees, in The Refractories Journal, March 1945, the importance of the ability of a sand to pack was demonstrated. Bond was added to similarly graded sands in proportion to the specific surface, but the more angular sand still had a much lower tensile strength than the rounded one. This was attributed to the lower surface contact area of the

(Discussion, cont'd) -

angular sand.

In "Modern Core Practices and Theories," published by the American Foundrymen's Association in 1942, H. W. Dietert States, on Page 5, that perfectly rounded grains usually give the greatest permeability, have the least contact area, and give the lowest green bond. This indicates that the optimum grain shape is a smooth grain but not a round one. A practical test of moulding properties, such as green bond, tensile strength, and flowability, is the best way of determining whether it has a favourable grain shape.

(3) The flowability of angular grains is less than that of smooth ones, as the friction between grains is greater. This further decreases the density of the rammed sand, and hence its surface contact area. The effect of low flowability is to make the corners of cores less dense than the main body. As the corners of cores are subject to the most severe conditions in casting, low flowability is often the cause of metal penetration.

Effects of Angular Grains:

(1) To lower the green bond of the sand.
(2) To lower the baked strength.
(3) To increase the mulling time.
(4) To decrease the apparent density of the dry unbonded sand.
(5) To increase the permeability.
(6) To lower the flowability by increasing the friction between grains.
(7) To increase the friability of green and baked cores.
(8) To make cores more difficult to strip.

Important Factors in Core Sand Selection:

(1) Refractoriness -

The sand should be stable under thermal shock. Sands which spall, crack or fuse when subjected to the shock of molten metal are unsuitable for core work. The degree of refractoriness required depends on the metal being cast. A highly refractory sand which would be suitable for steel should not be used for cast iron if other less refractory but satisfactory sand is available at a lower price.

(2) Grain Size -

The grain size and permeability should be chosen to suit the type of work being done.

(3) Size Distribution -

For maximum permeability and strength a fairly narrow size distribution is desirable. This makes it possible to use a sand with a higher A.F.A. fineness number and obtain a better surface finish. A sand with 80 to 90 per cent of the grains falling between 50 and 100 mesh is most commonly used.

(4) Grain Shape -

Grain shape has a profound influence on the properties of core sand, but it is difficult to define and measure. The simplest means of determining whether or not a sand has a satisfactory grain shape is to test the actual moulding properties of the sand. Suitable properties to test would be green and baked tensile strength, mulling time, flowability, and ability to strip.

(5) Freedom from Foreign Matter -

Core sand should be free from dirt, clay, and organic matter. The moisture content should be low, to permit proper moisture control to be maintained in the foundry and to prevent the sand from freezing in the winter.

(6) Uniformity -

It is important to choose a sand from a source sufficiently large to insure uniformity in successive orders. If this is not done, foundry practice will have to be modified after each new shipment of sand is received.

CONCLUSIONS:

1. Sample No. 2 requires more bond than Sample No. 1 because:

(i) It has not been washed.

(ii) It has an undesirable screen distribution.

(iii) It has an unfavourable grain shape.

2. Sand should be purchased with consideration to the following points:

(i) Refractoriness.

(ii) Grain size.

(iii) Grain distribution.

(iv) Grain shape.

(v) Freedom from clay, organic matter, and moisture.

(vi) Uniformity.

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(Figures 1 and 2 follow, on Page 7.)

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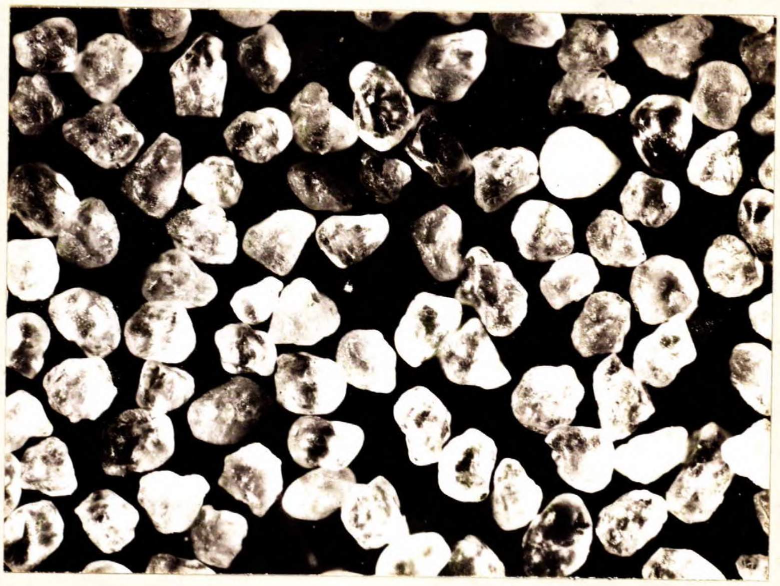
Figure 1.



X25.

SAMPLE NO. 1.

Sub-angular to round; smooth grains.

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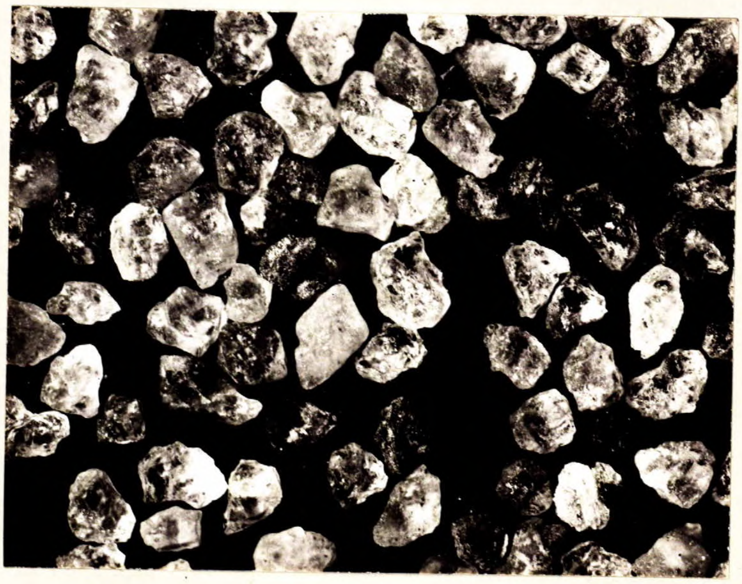
Figure 2.



X25.

SAMPLE NO. 2.

Sub-angular to angular; rough grains.
Sample screened to same size as No. 1.

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