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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1966.

Investigation of Surface Roughness on Manganese Steel Castings.

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(Copy No. 10.)

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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Origin of Request and Object of Investigation:

On November 12, 1945, The Hull Iron and Steel Foundries Limited, Hull, Quebec, submitted four samples of sand for investigation. This sand had been used for heavy austenitic manganese steel castings. The surface of these castings was rough, and an investigation was requested to determine whether the cause of this roughness lay in the sand.

Description of Samples:

The samples were described by HISCO as follows:

Specimen No.	Pattern No.	Sand Mixture	Detail of Specimen
13	Sh.M.38	KENNEDY-TYPE TRULINE CORE SAND 2 gal. #57 sand 1 gal. silica flour ½ pt. (300 ml.) bentonite ½ pt. No Vein ½ pt. Truline (mixed by hand)	Heavy manganese steel. Good peel. Casting rough. Casting face of print of heel core.
14	Sh.M.38	OIL CORE SAND FOR HEAVY SECTION (MODIFIED) 50 gal. #57 sand 200 lb. silica flour 2 gal. No Vein 5 gal. bentonite 1½ gal. cereal 2 gal. oil	Heavy manganese steel. Good peel. Casting rough. Casting face of print of heel core.
15	Sh.M.38	OIL SAND CF. (HEAVY SECTION) 50 gal. #57 sand 150 lb. silica flour 4 gal. bentonite 1½ gal. cereal 2¼ gal. oil	Heavy manganese steel. Good peel. Casting rough. This is mould adjacent to Specimen No. 13.
16	Sh.M.38	OIL CORE SAND FOR HEAVY SECTION (MODIFIED) (Same as No. 14)	Sample from large inside core. Good Peel. Casting rough.

Macroscopic Examination:

The samples showed two zones, as seen in Figure 1:

1. The outer zone was fused. This had a pinkish shade, and the part next to the casting was glassy. The surface adjacent to the metal was particularly rough. This zone was from 3/8 to ½ inch thick.

2. The inner zone was similar to sand specimens from other steel castings. The sand had been baked hard, but appeared unaltered.

(Continued on next page)

(Macroscopic Examination, cont'd) -

Figure 1.

Outer zone

Inner zone

X-Ray Study:

X-ray diffraction showed only quartz. This method of examination will not detect the presence of glasses, which are amorphous.

Chemical Analysis:

The two zones analysed as follows:

	Manganese, per cent	Iron, per cent
Pink shade -	15.04	1.26
Grey shade -	0.05	0.76

Discussion:

There is evidently an interchange of silicon and manganese between the sand and the metal. The manganese oxide formed by this action slags with silica, forming a fluid glass. As the sand slags it loses its resistance to distortion, and the casting becomes rough.

Such high manganese indicates a considerable impoverishment of the metal. This would detract from the quality of the casting at the surface.

(Continued on next page)

(Discussion, cont'd) -

The chemical reaction is probably as follows:

(1) $SiO_2 + 2Mn \rightleftarrows 2MnO + Si - 19,700$ cal.

(2) $2Mn + 2SiO_2 \rightleftarrows 2MnSiO_3 + 14,600$ cal.

Thus, Equation (1) requires heat to maintain, and under conditions of equilibrium the concentration of manganese in the metal would probably be much greater than that of silicon. Equation (2) upsets the equilibrium, however, by supplying heat and removing one of the products of reaction ($MnSiO_3$), and the reaction moves to the right.

As silicon is a much more active element than iron there is much less tendency for the sand to pick up iron. The equation for iron pick-up is:

(3) $SiO_2 + 2Fe \rightleftarrows 2FeO + Si - 63,200$ cal.

(4) $2FeO + 2SiO_2 \rightleftarrows 2FeSiO_3 - 1,600$ cal.

There is, however, a slight tendency to pick up iron, as the concentration of iron in the castings is much greater than that of silicon. The equilibrium is also upset by the removal of $FeSiO_3$, preventing the reaction from moving to the left in Equation (3).

It is possible that close control of metal composition and pouring temperature would eliminate this trouble. As the reaction is endothermic, it is greatly accelerated by increased temperature. The use of about 1 per cent silicon in the metal would increase its fluidity and make it possible to pour the metal colder. The increased silicon content of the metal would also inhibit the reaction, by a resistance to further silicon pick-up.

References in the literature on the pouring temperature of manganese steel are scarce, as most foundries rely on the skill of the melter. Authorities do, however, emphasize the importance of pouring as cold as possible. The following are some extracts from articles on manganese steel:

(Discussion, cont'd) -

(1) "Pouring temperatures range from 1450° C. (2642° F.) for thin-walled castings to 1250° C. (2282° F.) for thick sections." (Making Hard Manganese Steel - Hermanns and Meihner, Foundry, April 15, 1945.) As the solidification point is usually given as 1345° C. (2453° F.), these are probably optical pyrometer readings.

(2) "Silicon in amounts up to at least 1 per cent promotes fluidity ..... and the silicon has no harmful effect on the steel. Indeed, some of the leading makers believe that silicon up to 1.50 and even 1.75 per cent increases the wear-resisting qualities of the steel." (Austenitic Manganese Steel Castings - John Howe Hall, Proceedings A.S.T.M., Vol. 32, 1932.)

(3) "It is important to keep the teeming temperature low, so as to minimize the attack on silicious linings and moulds." (Manganese Steel in Australia - D. Clark and J. Coutts, Trans. A.F.A., Vol. 40, 1932.)

If control of pouring temperature and of metal composition does not eliminate the attack on the sand, it is possible that the use of silica flour in the mould wash and facing will have to be discontinued. Silica flour is the most active form of silica, and would encourage manganese pick-up. A mould wash of the silicate type, such as mica wash, may prove satisfactory.

Conclusion:

The rough surface observed on the manganese steel castings is caused by manganese pick-up of the sand. This would appreciably lower the manganese content of the metal.

Suggestions:

1. Pour manganese steel castings at as low a temperature as possible.

2. Use a metal with about 1 per cent silicon content.

(Suggestions, cont'd) -

3. Use a mould wash of the silicate type (mica wash), rather than of the silicon flour type, for this metal.

4. Use as little silicon flour as possible in the facing sand for these cuttings.

5. Testing these suggestions on a laboratory scale should yield valuable information.

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