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EXAMINATION OF SULPHIDE INCLUSIONS IN STEEL CASTINGS

by

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PHYSICAL METALLURGY DIVISION

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SUMMARY OF RESULTS

Following a request for information on the type of sulphides present in three mild steel heats and an evaluation of their deoxidation practice, test bars were chemically analyzed and a metallographic examination was carried out.

The results showed that in general, the sulphides were of Type III with some grain boundary formation still in evidence. The total aluminum of one heat was found to be excessively high (0.24%) and it was pointed out that aluminum contents approaching 0.10% and over can result in 'rock candy' fractures.

It was recommended that the aluminum addition should be lowered to about 2 lb/ton and the calcium-manganese-silicon raised to 2 or 3 lb/ton.

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INTRODUCTION

On December 11, 1963, three test bars were submitted to the Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys by Mr. J. Gallant of Canadian Unitcast Steel Limited, Sherbrooke, P.Q. Information was requested on the type of inclusions found in the bars and also an evaluation of the deoxidation practice based on the findings.

In a covering letter dated December 6, 1963, it was explained that the three bars were from three different heats of mild steel made in their acid electric furnace and were furnished in the full anneal condition. As regards furnace practice, silico-manganese was used as a block with ferromanganese and ferrosilicon in their respective order. Calcium-manganese-silicon and aluminum were used as final deoxidizers in the ladle in the ratio of 1/2 and 2-1/2 lb/ton, respectively.

The steels were being made to ASTM Specification A-352, Grade LCB, which calls for a Charpy impact (keyhole notch) of not less than 15 ft-lb at -50°F. It is imperative that the Type II grain boundary chain sulphides be avoided if this specification is to be met, and hence the correct deoxidation practice must be employed.

EXAMINATION

Chemical Analysis

Drillings were taken from each bar and gave the following analyses.

Composition, Per Cent

Heat No.	C	Si	Mn	S	P	Total Al	Acid Insol Al	Total N
16072	0.24	0.61	0.76	0.037	0.027	0.07	0.006	0.010
16082	0.25	0.75	0.76	0.037	0.029	0.08	0.006	0.007
16086	0.27	0.52	0.65	0.036	0.025	0.24	0.006	0.009

It will be noted that heats 16072 and 16082 show aluminum contents well above the recommended minimum to avoid Type II sulphides and these contents indicated fairly good recoveries of the order of 56% and 64%, respectively. It is believed, however, that it is better to aim for a total content of around 0.05%. With total aluminum contents approaching 0.10% and over, there is an increasing hazard of embrittlement by the formation of aluminum nitride resulting in "rock candy" fractures. In aiming for 0.05%, however, the recovery should be reliable enough to ensure that contents lower than 0.04% will be avoided.

Heat 16086 was excessively high in total aluminum and this would suggest that something like 7 lb/ton had been added rather than the 2-1/2 lb/ton quoted. This figure of 0.24% was checked and verified by spectrographic analysis. Such an amount of aluminum should be avoided at all times for the reason stated above.

METALLOGRAPHY

Specimens were cut, polished, and examined in the unetched condition. Photomicrographs of typical fields are shown in Figures 1, 2 and 3.

The three test bars generally showed Type III sulphides and a random dispersion although traces of grain boundary formation were still apparent. It is also worth mentioning that careful scrutiny at high magnification showed small needle-like inclusions which were believed to be aluminum nitrides. These were most noticeable in heat 16086 and substantiate the warning of such formation with high aluminum content.

SUMMARY

1. All heats had essentially Type III sulphides randomly dispersed but with some grain boundary configuration still in evidence.

2. Discounting heat 16086, which was excessively high in total aluminum, the recoveries of aluminum additions were more than sufficient for the production of Type III sulphides.

3. Generally speaking, the deoxidation practice, based on the type of inclusions produced, was fairly good but still open to improvement. Just as care should be taken to ensure sufficient aluminum to avoid Type II sulphides, then care must also be taken to prevent

overdoing this addition in order to avoid the hazards of "rock candy" embrittlement. This is especially so where slow cooled, heavy sections, are involved.

4. The calcium-manganese-silicon addition quoted at 1/2 lb/ton would seem to be too low to be of any use; the usual foundry practice is to add at least 2 lb/ton.

RECOMMENDATIONS

1. The calcium-manganese-silicon addition should be raised to 2 or 3 lb/ton and the aluminum addition lowered to 2 lb/ton.

2. Excessive aluminum additions should be avoided.

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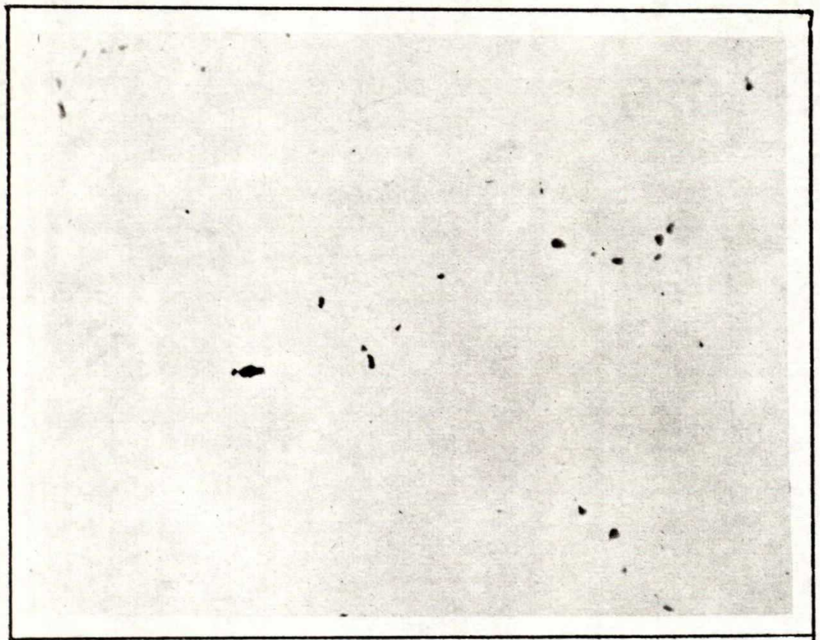

Figure 1. Sulphide Inclusions (Heat 16072) Unetched - X200

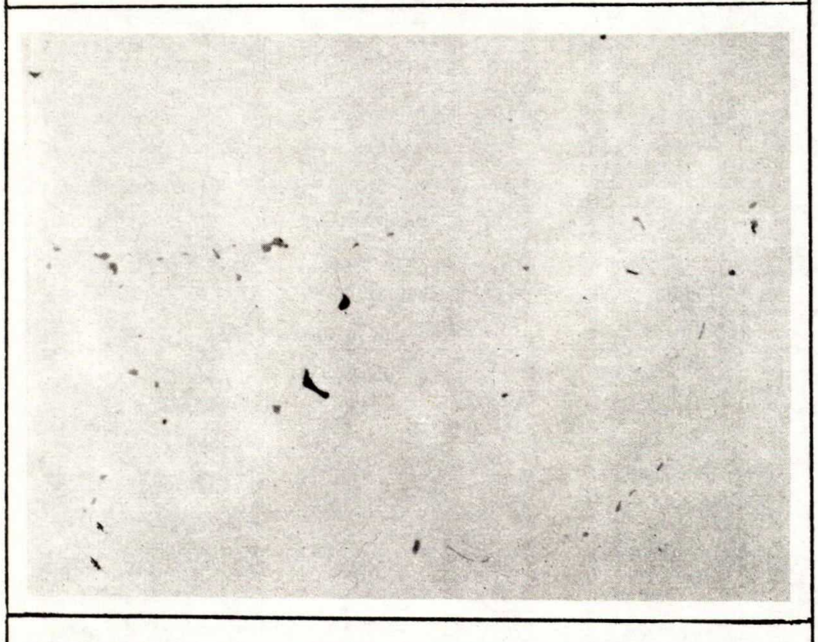

Figure 2. Sulphide Inclusions (Heat 16082) Unetched - X200

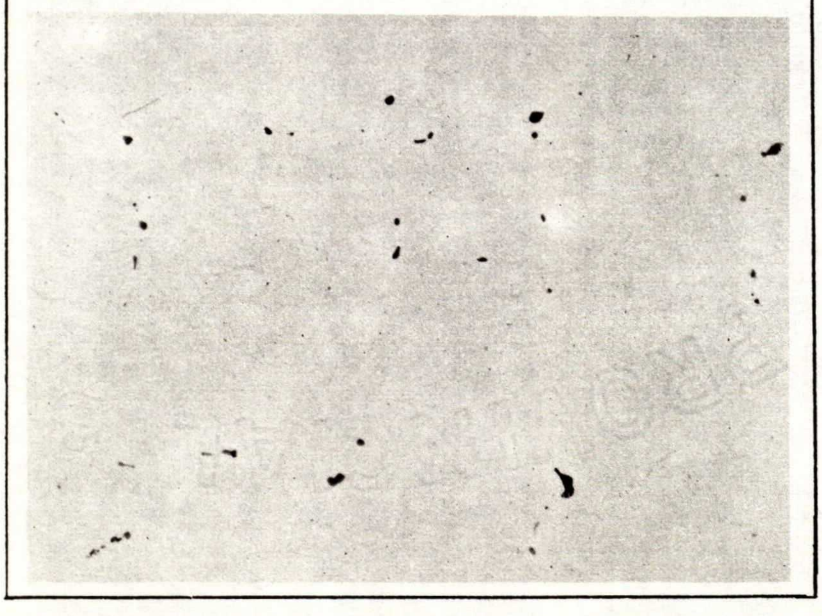

Figure 3. Sulphide Inclusions (Heat 16086) Unetched - X200