Hot Rolling Behavior of Resulphurized Steels Improved With Manganese Sulphide Additions

by S. Feigenbaum

PRODUCERS of low carbon, high sulphur free machining steels have been plagued by surface defects characterizing hot rolled semifinished bars in these grades. Carbon contents in the 0.10 to 0.20 pct range are particularly troublesome. The difficulties have been ascribed to the formation in the grain boundaries of relatively low melting FeO-FeS inclusions that may become molten at soaking pit temperatures and produce the hot-short condition noted in these steels.

The importance of close control of ingot handling intervals for added sulphur grades has been well recognized. However, there are grades, C-1117 for example, that tend to exhibit poor surface quality even with favorable track and soaking pit times. Accordingly, attention was directed toward improving the hot rolling behavior of these steels by variations in steelmaking practice, specifically in the method of making sulphur additions.

The compound manganese sulphide has been proposed as an addition that may produce a more favorable type of nonmetallic inclusion in high sulphur steels. Results of experiments with this material were reported in 1948 by L. R. Silliman in *Open Hearth Proceedings,* AIME Vol. 31. Silliman presented data indicating fewer diversions and lower conditioning costs for the manganese sulphide treated steel, compared to tonnage made with the usual manganese and elemental sulphur. Recovery from manganese sulphide was reported somewhat better for sulphur but lower for manganese than under usual additions.

In the last year a substantial tonnage of resulphurized steel with manganese sulphide additions was made at Jones & Laughlin Steel Corp. Most of the work was confined to open hearth grades, although a limited number of Bessemer screw stock blows were treated. The manganese sulphide was in the form of lumps ranging from 2 to 5 in. in size. An average analysis of the material is: Manganese, 53 pct; sulphur, 32 pct; iron, 8 pct; silicon, 1 pct; and carbon, 0.5 pct max.

The compound is relatively light and porous in structure. The low bulk density is somewhat objectionable when it is necessary to shovel large quantities of material into the ladle, but does not appear to affect recoveries.

A limited number of heats were made in grades C-1115, C-1119 and C-1120, but the major portion of the tonnage was in C-1117 grade, because this analysis has been consistently troublesome on surface quality. All the sulphur addition on the manganese sulphide treated heats was obtained from the compound. The comparative heats were made with elemental sulphur additions. The grade is made in 29 in. round or 26½x28½ in. big end-up molds, preferably the former. The ingots ordinarily are rolled on a 44 in. high lift blooming mill to 8½x7 in., hot scarfed and rolled to large billets on a 28 in. three-high billet mill. A limited tonnage is rolled to small billets on a continuous mill.

During 1951, 4756 tons of grade C-1117 billets were rolled from manganese sulphide treated steel. The diversions on this tonnage were 22 pct less than for 18,779 tons of the same grade made with regular sulphur practice. Toward the end of 1951 and during 1952 changes in plant conditions contributed to generally improved metallurgical conditions in the making of resulphurized steels. However, it is interesting to note that the heats of C-1117 made during January and February 1952, still show 24 pct lower diversions than the steel made with regular sulphur. During this period the majority of tonnage was made with manganese sulphide and the use of this compound is now standard for C-1117 grade.

Experiments are in progress with manganese sulphide additions to other resulphurized grades such as C-1115, C-1118 and C-1120. However, the data available is not sufficient for presentation.

Micro examination of samples from rolled bars does not reveal any differences in structure or character of inclusions that could be ascribed to the use of manganese sulphide. It is quite possible that differences exist in the ingot that are obliterated in subsequent processing, and thus could not be detected in bar samples.

Recovery of both manganese and sulphur from manganese sulphide additions has been consistent, and is comparable to the efficiency obtained with sulphur and ferromanganese. The efficiency of ladle additions has been approximately 80 pct for manganese and 85 pct for sulphur. The figure for manganese is of course an estimate, since this element was derived from both manganese sulphide and ferromanganese.

The low carbon content of the manganese sulphide is a definite advantage in making any resulphurized grade that would normally require medium carbon ferromanganese to finish below the specified carbon maximum. In such cases the economics would clearly favor the use of the compound. For grades normally made with standard ferromanganese the justification for the use of manganese sulphide would depend upon the decrease in diversions and saving in conditioning cost. Individual circumstances would determine the course of action.

S. FEIGENBAUM is Assistant Metallurgist, Jones & Laughlin Steel Corp., Pittsburgh. This paper was presented at the National Open Hearth Steel Conference, Pittsburgh, Mar. 31 to Apr. 2, 1952.