(726) Effect of Ca-Si-Zr Addition on the Inclusion Morphology and Mechanical Properties of Micro-alloyed Steel Plates at Rourkela Steel Plant

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I. Introduction

The effect of inclusions on the mechanical properties of microalloyed steels, specially toughness, is mainly due to their size, shape and distribution in the final product.[1] The control of inclusion plasticity and thereby inclusion shape may be achieved by small addition of elements like rare earths, calcium, zirconium etc.[2] In this report, an attempt has been made to study the behaviour of sulphide shape control by addition of varying amounts of a complex deoxidizer Ca-Si-Zr alloy at Rourkela Steel Plant. Bend and impact properties of the steel have been correlated with the quantity of Ca-Si-Zr added.

II. Experimental Procedure

Table 1 shows the chemical composition of the steels used in this investigation. Five experimental heats were made in BCH furnaces. Ca-Si-Zr alloy chips were added in the mould during teeming. Ingots from these heats were rolled to slabs after soaking at a temperature of 1 300 - 1 320 °C. Slabs were subsequently rolled to 12/25 mm thick plates in the 4-high Plate Mill after reheating at a temperature of 1 280 - 1 300 °C. Samples for tensile as well as bend testing were cut transverse to the direction of rolling.

III. Results and Discussion

The bend properties are considerably improved with addition of 2.5 kg of Ca-Si-Zr/tonne as given in Table 2. Charpy V-notch values (CVN) have been determined on longitudinal as well as transverse samples at -20 °C as shown in Table 2. Addition of 2.5 kg Ca-Si-Zr/tonne has given best results under the plant conditions. Lower or higher additions led to deterioration in impact values.

Plenty of elongated sulphide stringers are present (Photo. 1) in the sample from the non zirconium treated cast No. 6202C. In the case of addition of 2.5 kg Ca-Si-Zr/tonne cast Nos. 5389A and 5682D, the inclusions are either globular or tending towards globularization shown in Photo. 2.

The volume fraction of inclusions in minimum in case of steel with 2.5 kg of Ca-Si-Zr additions/tonne, Scan-ing Electron Microscope (SEM) study also reveals the presence of globular/oval shaped inclusions in case of cast No. 5682D.

Table 1. Steel compositions (wt%).

Cast No.	C	Mn	P	S	Si	Nb	V	Zr	Ca-Si-Zr (kg/t)
6202C	0.08	1.20	.023	.034	.033	.038	.047	-	Nil
7937A	0.17	1.35	.028	.035	.170	.044	.045	.033	2.0
5389A	0.14	1.24	.028	.029	.020	.024	-	.044	2.5
5682D	0.09	1.22	.024	.030	.020	.036	-	.048	2.5
6150D	0.13	1.35	.024	.030	.025	.042	-	.058	3.0

IV. Conclusions

(1) The addition of Ca-Si-Zr alloy to micro-alloyed steel eliminated highly elongated MnS inclusions.

(2) Addition at the rate of 2.5 kg of Ca-Si-Zr/tonne of steel during teeming in the mould enabled to modify the sulphide inclusions into globular shapes.

(3) Addition of Ca-Si-Zr in amounts either lower or higher than 2.5 kg/tonne did not bring about desired sulphide modification.

(4) Globular sulphides obtained by Zr addition significantly improved the bend and charpy V-notch impact properties.

REFERENCES

1) T.J. Baker and J.A. Charles: The Iron and Steel Institute, London, (1971), 79.
2) H. Little and W.J.M. Henderson: The Iron and Steel Institute, London, (1971), 182.

Table 2. Mechanical properties.

Cast No.	Y.S. (kg/mm^2)	UTS (kg/mm^2)	%E	Bend	CVN at -20 °C (M-kg) L	T
6202C	46.0	57.0	26	1.5 t	1.33	1.17
7937A	42.3	55.6	20	1.5 t	1.17	1.00
5389A	45.6	55.7	28	close	8.67	2.83
5682D	40.0	51.1	27	close	8.33	3.50
6150D	48.8	62.1	22	3 t	7.50	2.00

L = Longitudinal T = Transverse

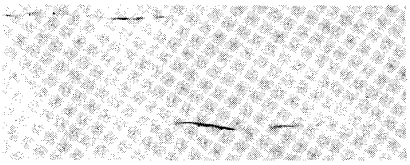

Photo. 1. Sulphide stringers in Zr free steel, 500 X.

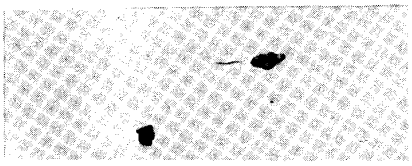

Photo. 2. Globular sulphides in Zr treated steel, 500 X.