Improvement In Deoxidation Practice With The Introduction of High Dimensional Aluminum Cored Wire at SMS-II, Rourkela Steel Plant, Rourkela

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Cored Wire Injection

- Injection of a thin steel tube containing the additive into the metal bath of a ladle refining station.
- Generally used for volatile or toxic elements such as calcium, boron, carbon, sulphur, lead etc. with 9-13 mm diameter.

Background

- For special quality steelmaking EAF is no longer essential ; BOF with faster ladle refining facilities being used worldwide more & more.
- Gradually shifting major refining operation to ladle for increasing shop productivity

Development of High Dimensional Cored Wire and High Speed Wire Feeding Machine

Introduction

- The project was sponsored by Dept. of Scientific and Industrial Research (DSIR), New Delhi under PATSER (Programme Aimed at Technological Self Reliance) assignment.

- Project executed at Rourkela Steel Plant with the help of RDCIS, SAIL and M/S Ardee Business Services Pvt. Ltd.

Introduction

- The maximum diameter of cored wire used in the world was 13-16 mm.
- Developed high dimensional cored wire of 25 mm diameter.
- 25 mm diameter allows for feeding around four times the material per meter of wire as compared to 13 mm wire
- Designed compatible wire feeder machine to feed the wire

Contd.

Introduction

- Since the wire was difficult to bend, the vertical wire feeder machine designed with vertical flipping wire wound from inside.
- Installed in the existing facilities without major modifications.

25 mm High Dimensional Al Cored Wire

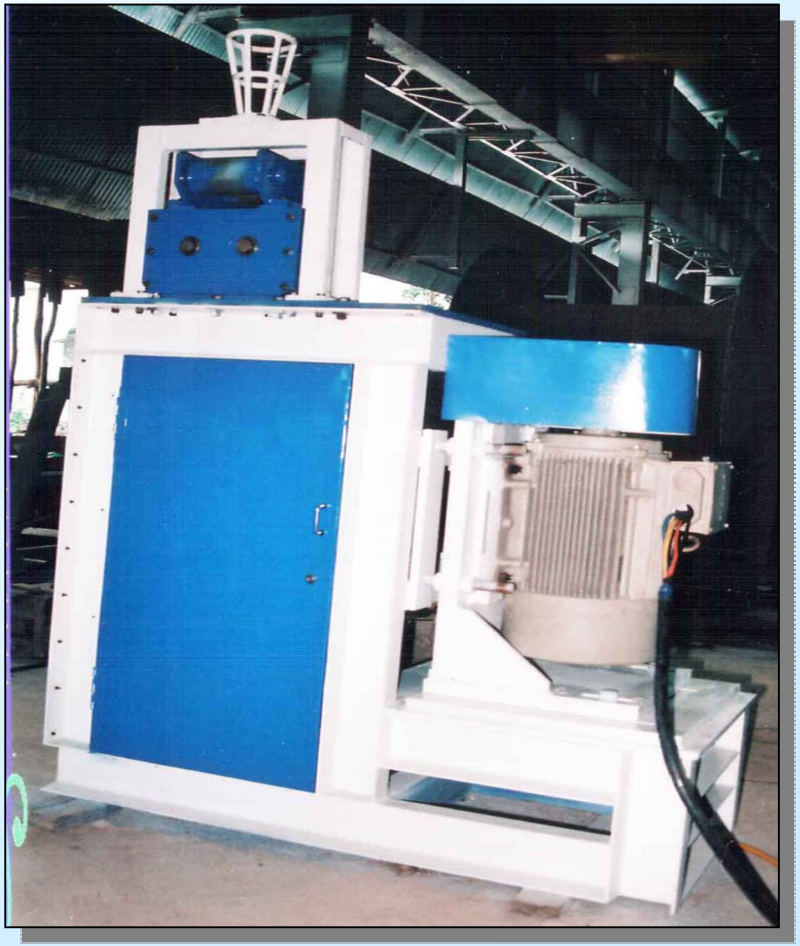
- Filled with Al in granular form of min 98% purity
- Bulk density : 1.7 g/cc.
- Powder content 650g ±5 g per meter length
- Al Granules of max. 2 mm size.

Wire Feeder Machine

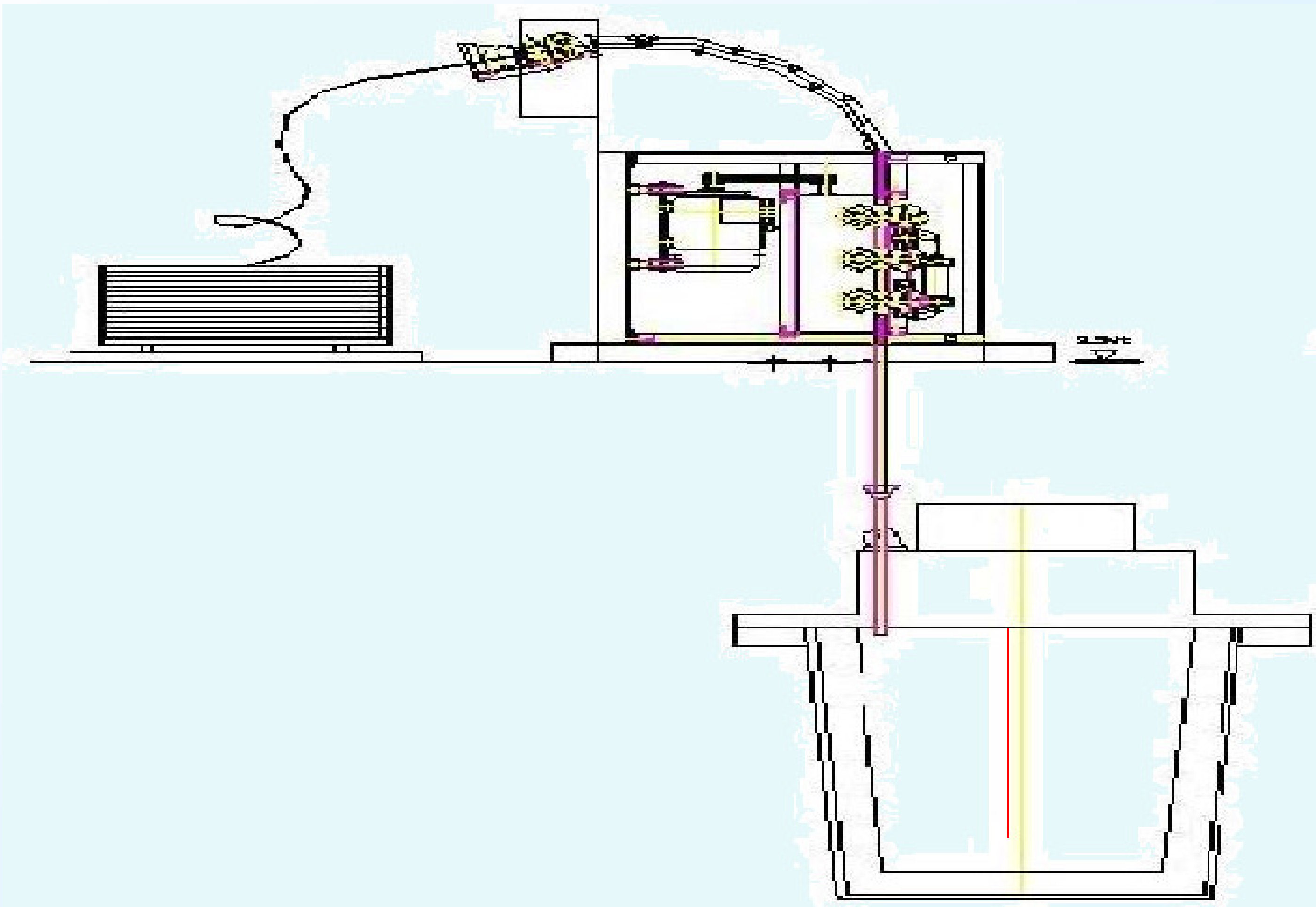
- Suitable for feeding wire Dia. upto 25mm.
- Maximum wire feeding speed of 300 mts/min i.e. 195 kg Al /min.

It consists of :

- Gear Box, Drive Rolls, Pinch Rolls, Pneumatic Cylinders etc.
- AC Infinitely variable speed drive.
- PLC for automatic control and for interlocking with plant operations.
- All necessary electrical and mechanical accessories.



Arrangements for the Trial



Trial

- The high dimensional wire feeder machine was installed in Converter A of SMS-II, RSP.
- Continuous argon purging with controlled flow during addition of cored wire was carried out using On-Line Purging (OLP) system.
- Total purging duration including wire injection period maintained at minimum 4 minutes matched with the calculated mixing time for complete homogenization of the bath.
- Measured active oxygen content of steel before and after addition of Al cored wire.

Contd….

Trial

- Measured oxygen potential of slag before and after addition of Al cored wire .
- Based on the initial oxygen potential in the steel as well as slag , required quantity of wire was added.
- Instant slag oxygen potential measurement system (Celox-Slac) used for taking immediate corrective measures for slag deoxidation.
- Wire feeding speed optimized at 80 – 85 m/min (52 - 55 Kg Al /min)
- Conducted more than 200 trials.

Results

- For correct evaluation of results, depending of deoxidation process , all the steels are divided into three major grades.

- Consumption of Al reduced by around 20 % depending upon the grades of steel.

- Achieved lower Aluminium consumption with optimum purging.

Contd….

Results

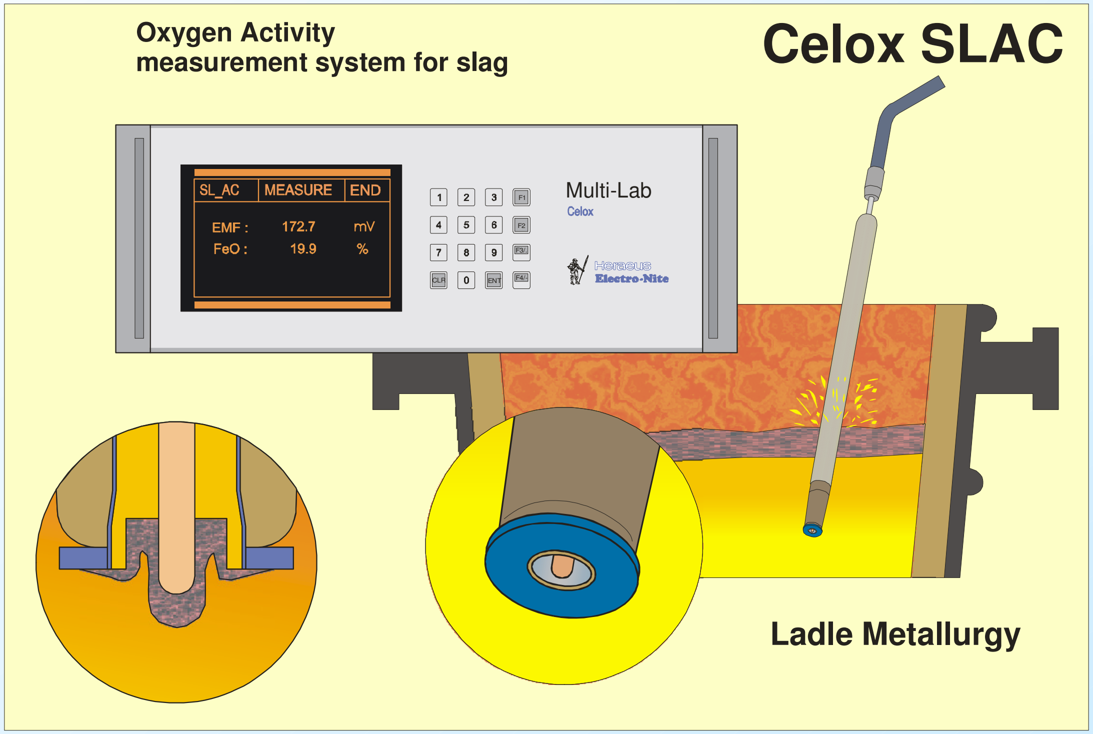
- The average temperature drop was approx 5^0C as compared to 12 - 16^0C for old practice.
- This is achieved due to faster dissolution of Al powder as compared to aluminum bar/solid wire addition.
- Aluminium fading with heats treated with Aluminium cored wire was lower compared to conventional heats indicating further possible reduction in aluminium consumption.

Conclusions

- **Developed 25 mm Aluminium Cored Wire and suitable wire feeding machine.**
- **Process technologies established for faster deoxidation .**
- **Faster deoxidation resulted in reduction of treatment time as well as consumption of deoxidiser.**

THANK YOU

- Magnesia stabilised zirconia cell is used as electrolyte in the Celox SLAC probe.
- The probe is immersed through the top slag into the steel bath.



- A small amount of slag will cover the zirconia electrolyte.
- The measurement of the oxygen activity in slag is made by means of an electro-chemical cell.

D/12-99-13 9:55	1/TYPE : S	2/P : 1	1/DIG	4/TE-	5/31+	HT-NO. : 1	

SI_ac	MEASURE	END

EMF :	172.7	mV
FeO :	19.9	%

Noise : 53.0 mV
Shape : 2.6 mV
Slope : 0.0 mV

F1-main-menu	F2 - Heat No.	F3 - Print Screen	F4 - Quality 1

MIXING TIME

- The theoretical calculation has been carried out to assess the mixing time for homogenization in the ladle. The formula for the calculation is as follows

$P_H = P_{atm} + \rho_L g H$

$= 1.023 \times 10^5 + (7.2 \times 10^3) \times 9.81 \times 2.5$

Where, $P_{atm} = 1.023 \times 10^5 \ Nm^{-2}$

$\rho_{steel} = 7.2$ tonnes/m^3

H = Bath height in ladle = 2.5m

$P_H = 2.788 \times 105 \ N/m^2$

Logarithmic mean pressure,

$$P_M = \frac{P_H - P_{atm}}{\ln \{P_H / P_{atm}\}}$$

$$= \frac{2.788 \times 10^5 - 1.023 \times 10^5}{\ln \{2.788 \times 10^5 / 1.023 \times 10^5\}}$$

$$= 1.7599 \times 10^5 \ N/m^2$$

$Q_M = Q^* (P_{atm}/ P_M)^* (T_L/298)$

Where,

Q_M = Logarithmic mean flow rate of gas

Q Gas flow rate = 200 lpm = 0.003 m^3 / sec

P_{atm} = 1.023×10^5 N/M²

P_M = 1.7599×10^5 N/m²

T_L = 1577° + 273° = 1850°

So, $Q_M = 0.003^* (1.023 \times 10^5 / 1.7599 \times 10^5)^* (1850/298)$

= 0.01083 m^3 / sec

Now stirring rate

$$\acute{\varepsilon} = (Q_M \rho_L g H x 10^3) / V_L$$

Where,

$Q_M = 0.01083\ m^3/s$

$H = 2.5m$

$V_L = \pi/4\ (3.3)^2 \times 2.5\ m^3$

$$\acute{\varepsilon} = (0.01083 \times 9.81 \times 2.5 \times 10^3) / \pi/4\ (3.3)^2 \times 2.5$$

$$= 12.42 \text{ Watts/Tonnes}$$

Mixing Time, $t_{mix} = 600 \times \acute{\varepsilon}^{-0.4}$

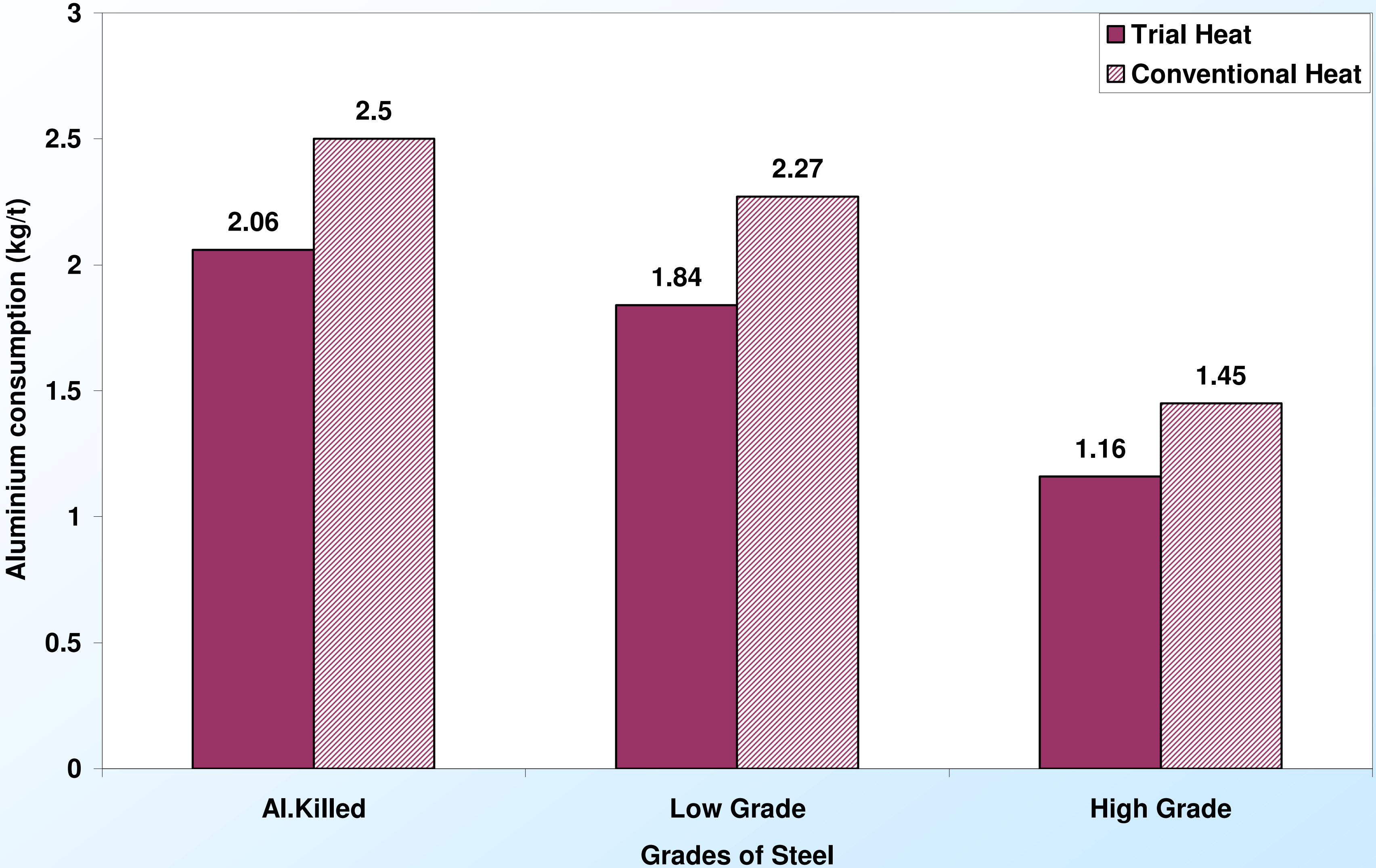
$$= 600 \times (12.42)^{-0.4}$$

$$= 219 \text{ sec}$$

$$\sim 4 \text{ min.}$$

- From the above calculation, it can be inferred that the mixing time for the ladle will be about 4 minutes with a flow rate of 200 lpm. However this calculation is based on single phase i.e. steel. In the presence of slag, which is in normal practice, the mixing time will be slightly higher

Fig.2 Aluminium consumption in different grades for trial & conventional heats



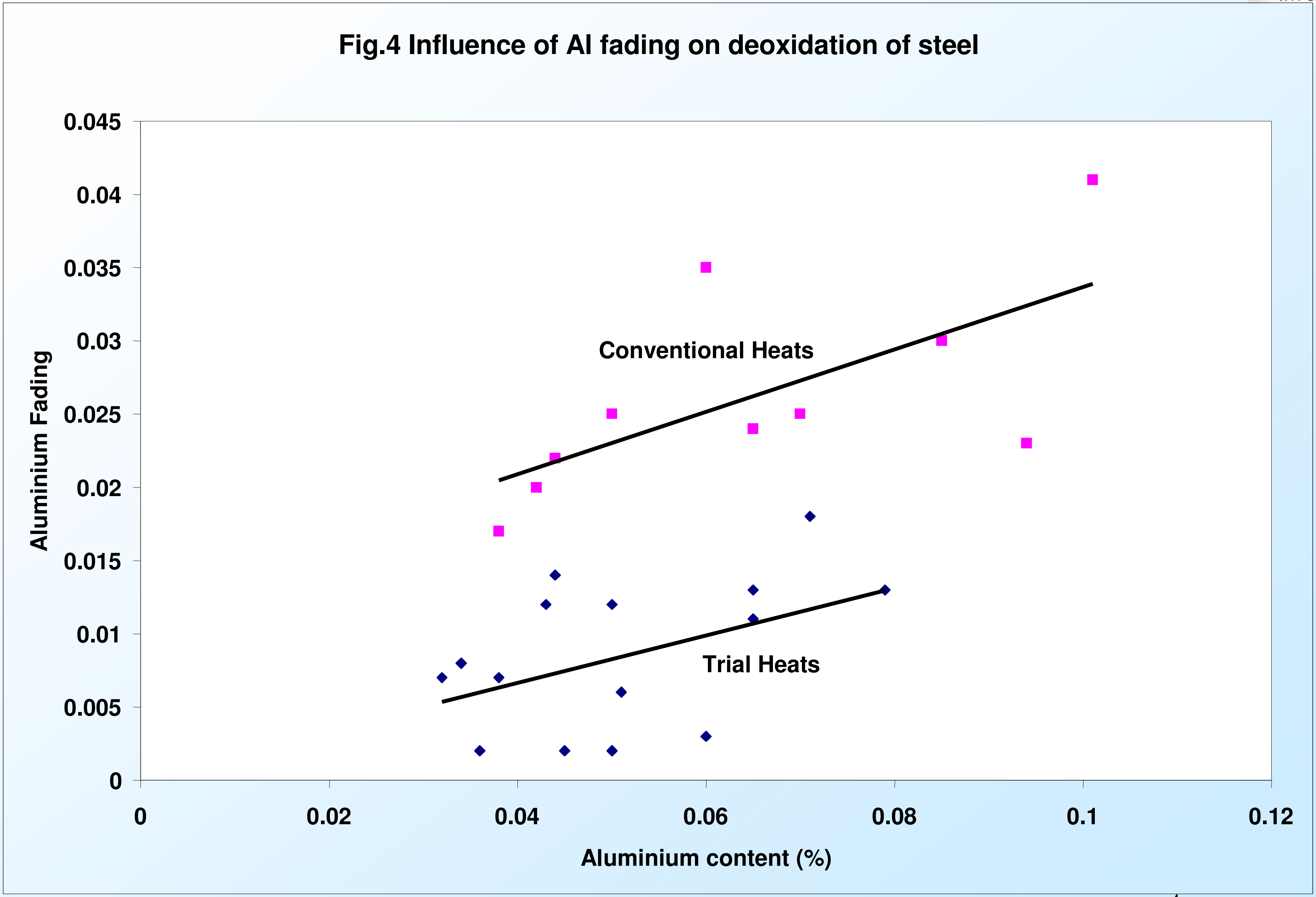


Fig.4 Influence of Al fading on deoxidation of steel
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Aluminium Fading
Conventional Heats
Trial Heats
0
0.02
0.04
0.06
0.08
0.1
0.12
Aluminium content (%)

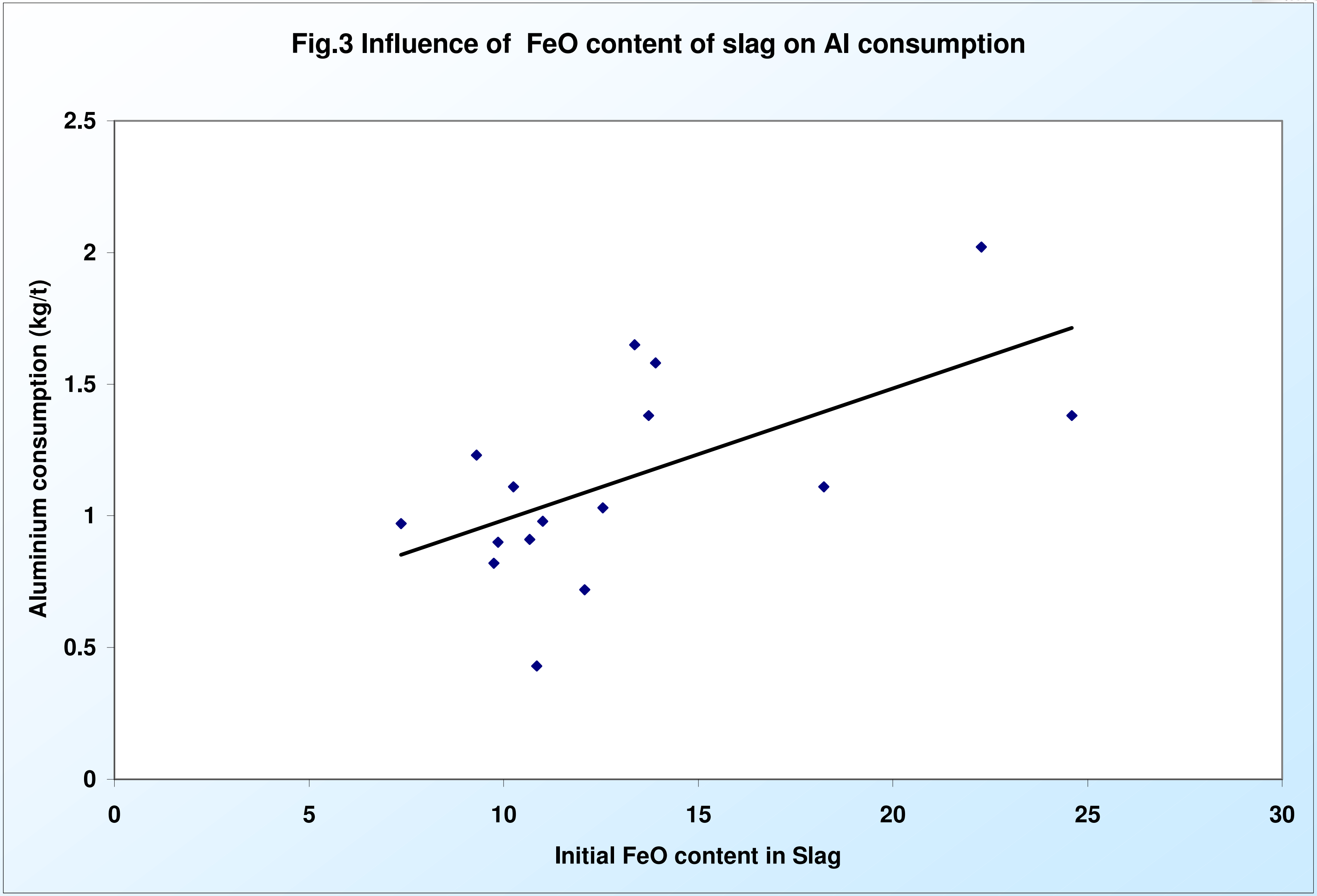


Fig.3 Influence of FeO content of slag on Al consumption
Aluminium consumption (kg/t)
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
Initial FeO content in Slag