AN EVALUATION OF THE PNEUMATIC LIME INJECTION BENEFITS FOR THE PRODUCTION OF C82D2 STEEL BY ELECTRIC ARC FURNACE

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TRADITIONAL PROCEDURE

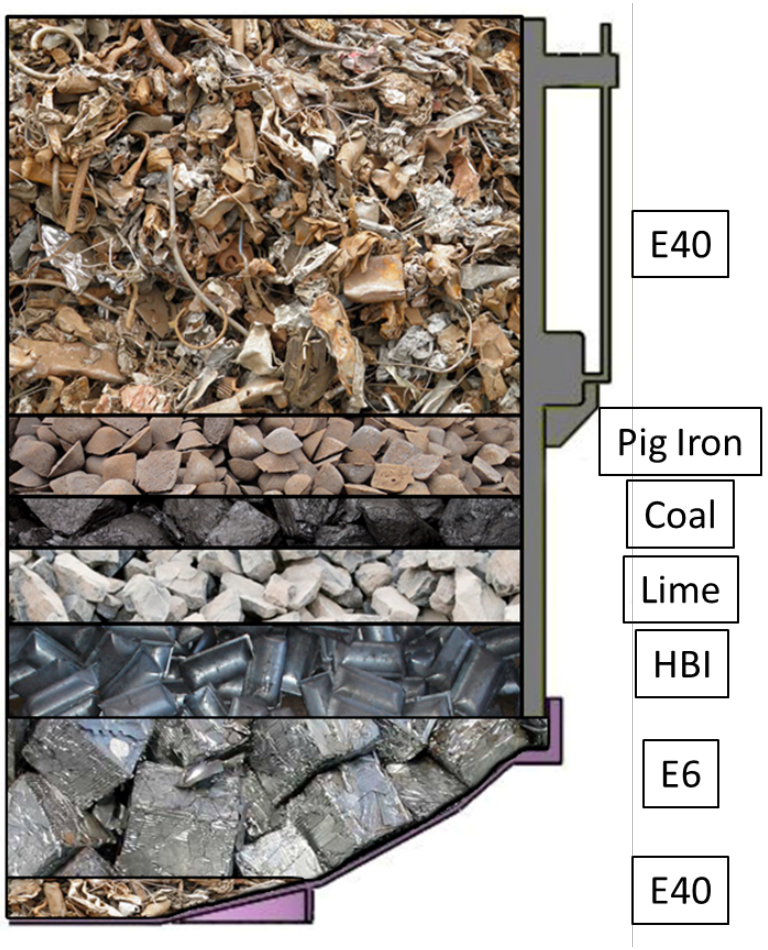
Lime added in form of **lumps**

Essential for a

Proper bath chemistry

Slag foamability

Bath dephosphorization



PNEUMATIC INJECTION

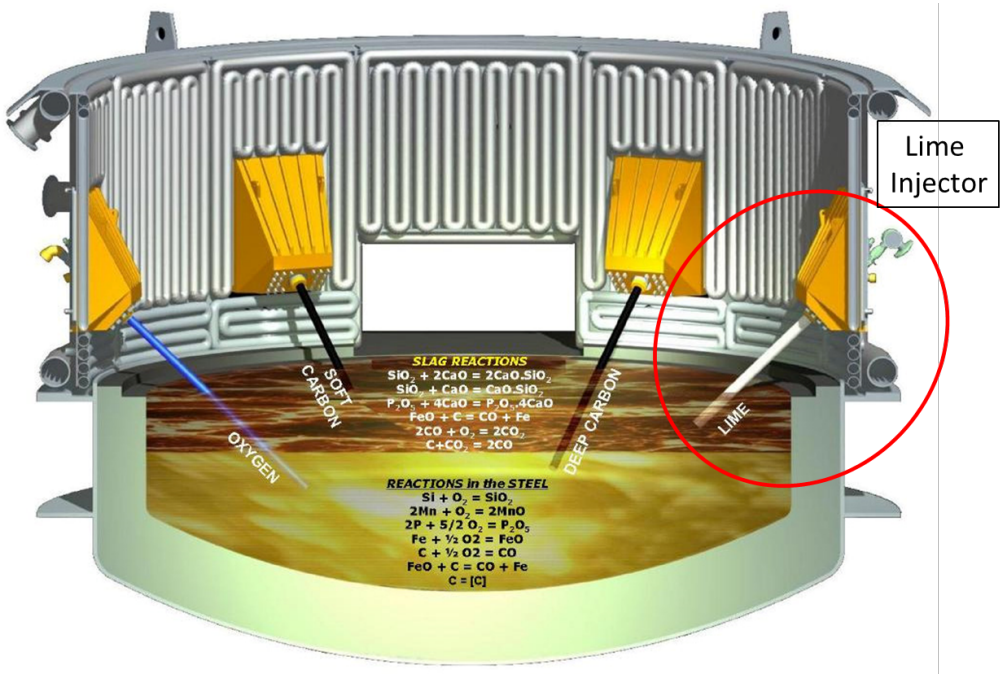
Lime injection allows to achieve

Consumptions reduction

Foaming benefits

Operational cost benefits

Environmental benefits

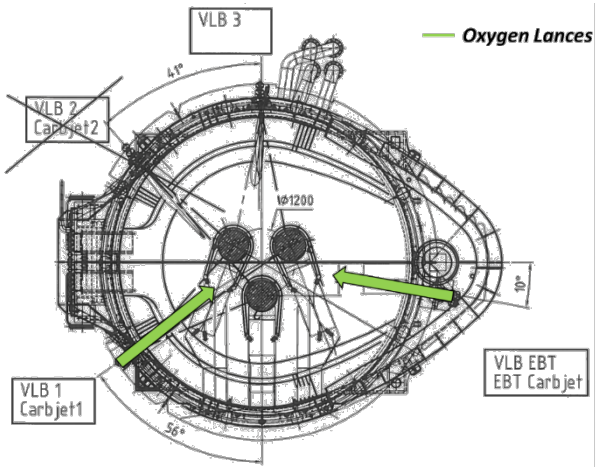


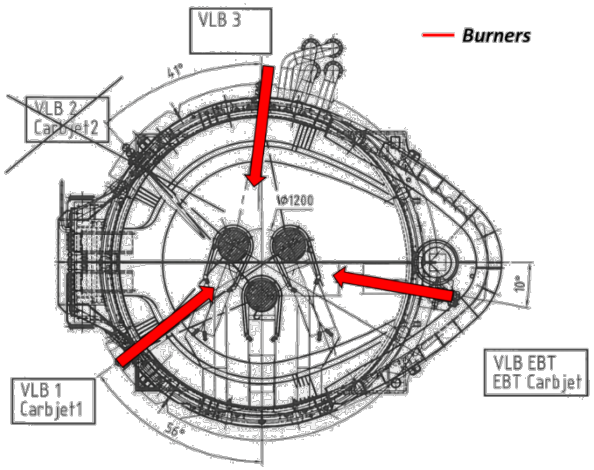
Evaluate and validate the benefits of injecting lime compared to the traditional practice for the production of special steels

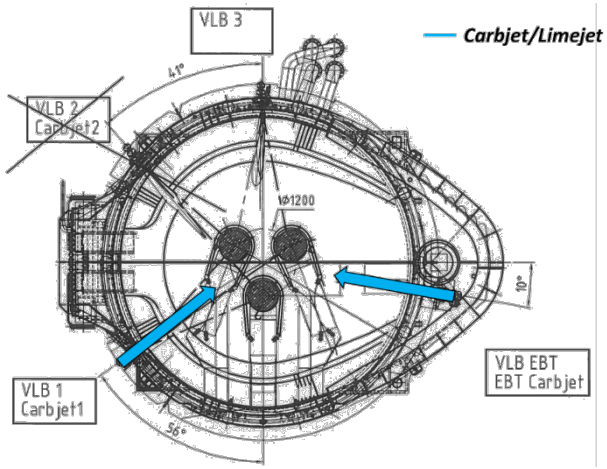
AIM

EAF FEATURES

90 t Top-Charge EAF → **Multi-Point Injection System** → **Lime VLB1 and VLB EBT**







Special Steels → **3 Buckets** → **Selected Scraps** → **C82D2/ C82D2+Cr**

EXPERIMENTAL PROCEDURES

Operational Profiles

STD → 100% lime in lumps

INJ1 → Injected lime

INJ2 → INJ1 + 400 kg lime in lumps

Steel grade	Procedure	N° of heats
C82D2 C82D2+Cr	STD	231
	INJ1	160
	INJ2	163

Analyzed Data

CaO Consumption

Electrical Consumption

O_2 and CH_4 Consumption

Slag Amount

Slag Sampling

At the beginning of refining

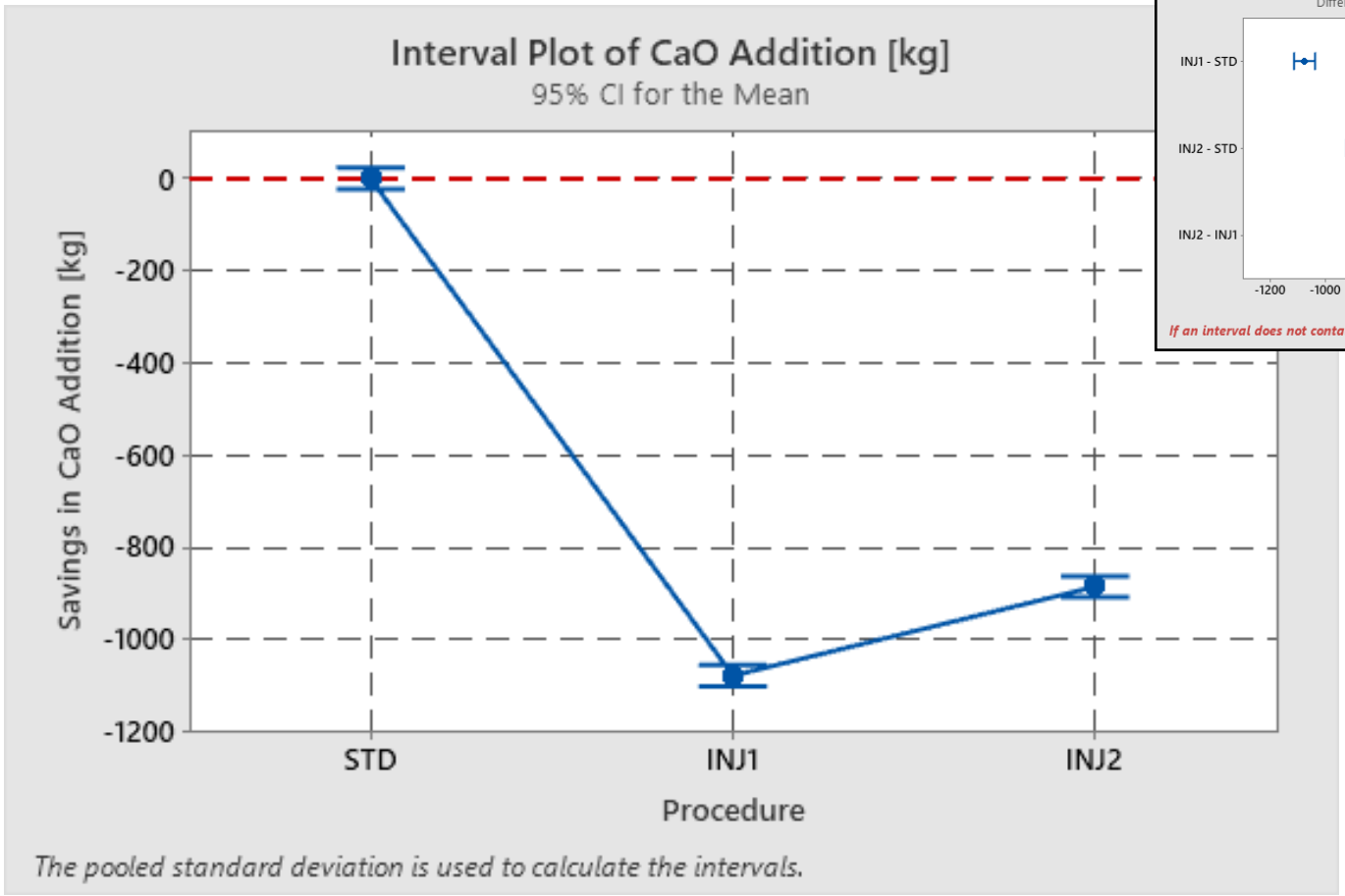
At the end of refining

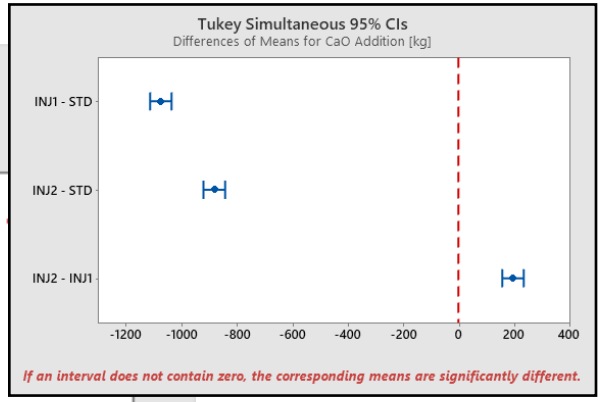
Foamability Analysis

Isothermal Solubility Diagram (ISD)

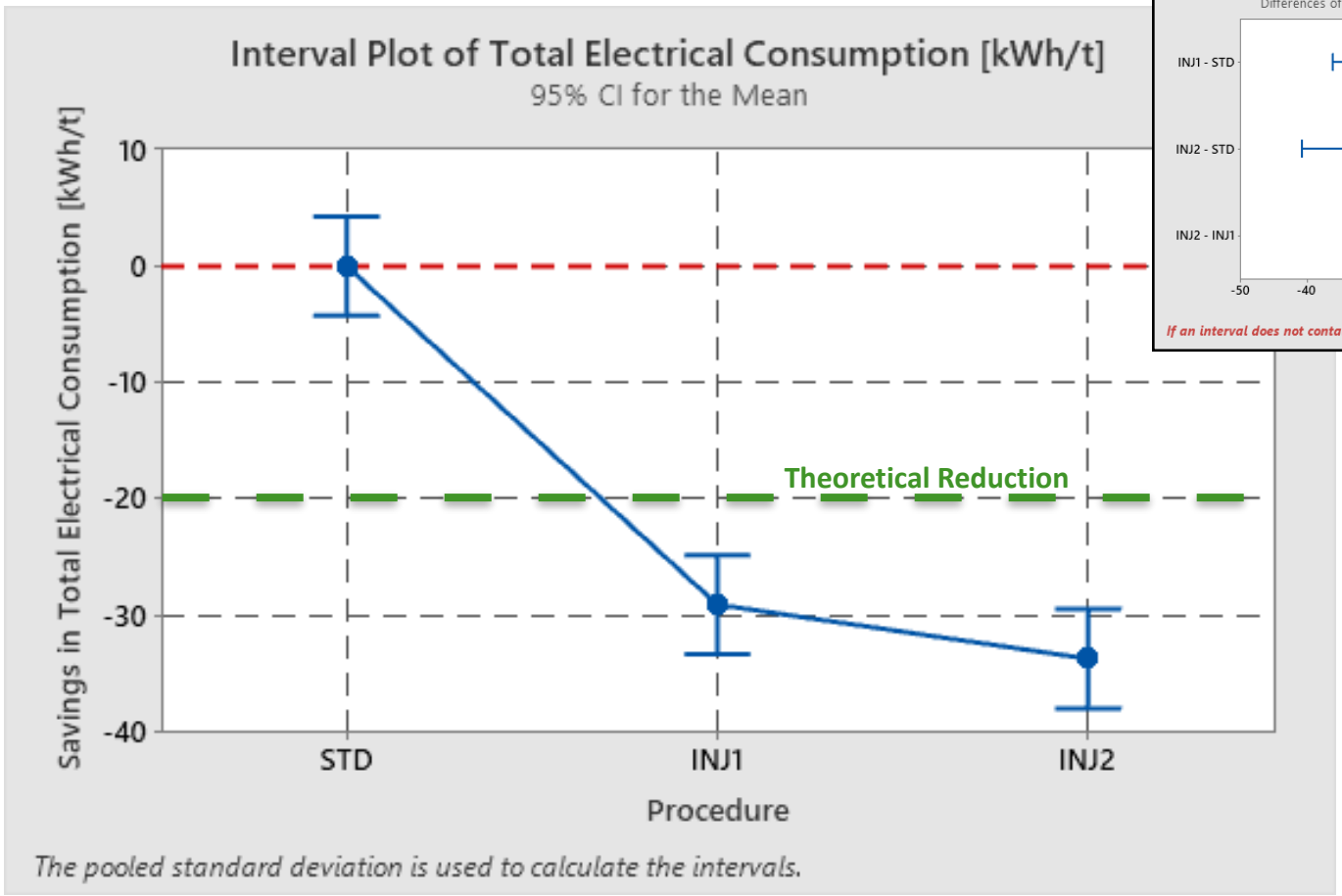
Total Harmonic Distortion (THD)

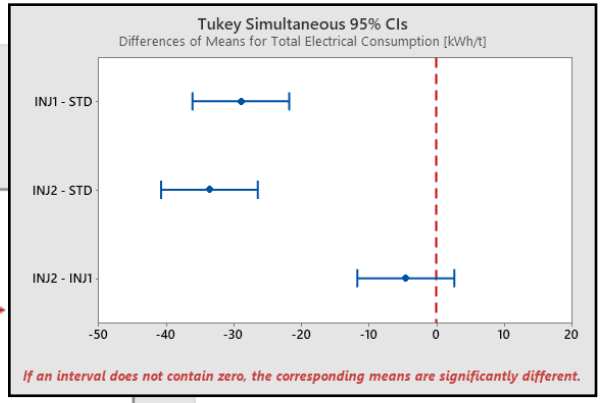
CaO CONSUMPTION



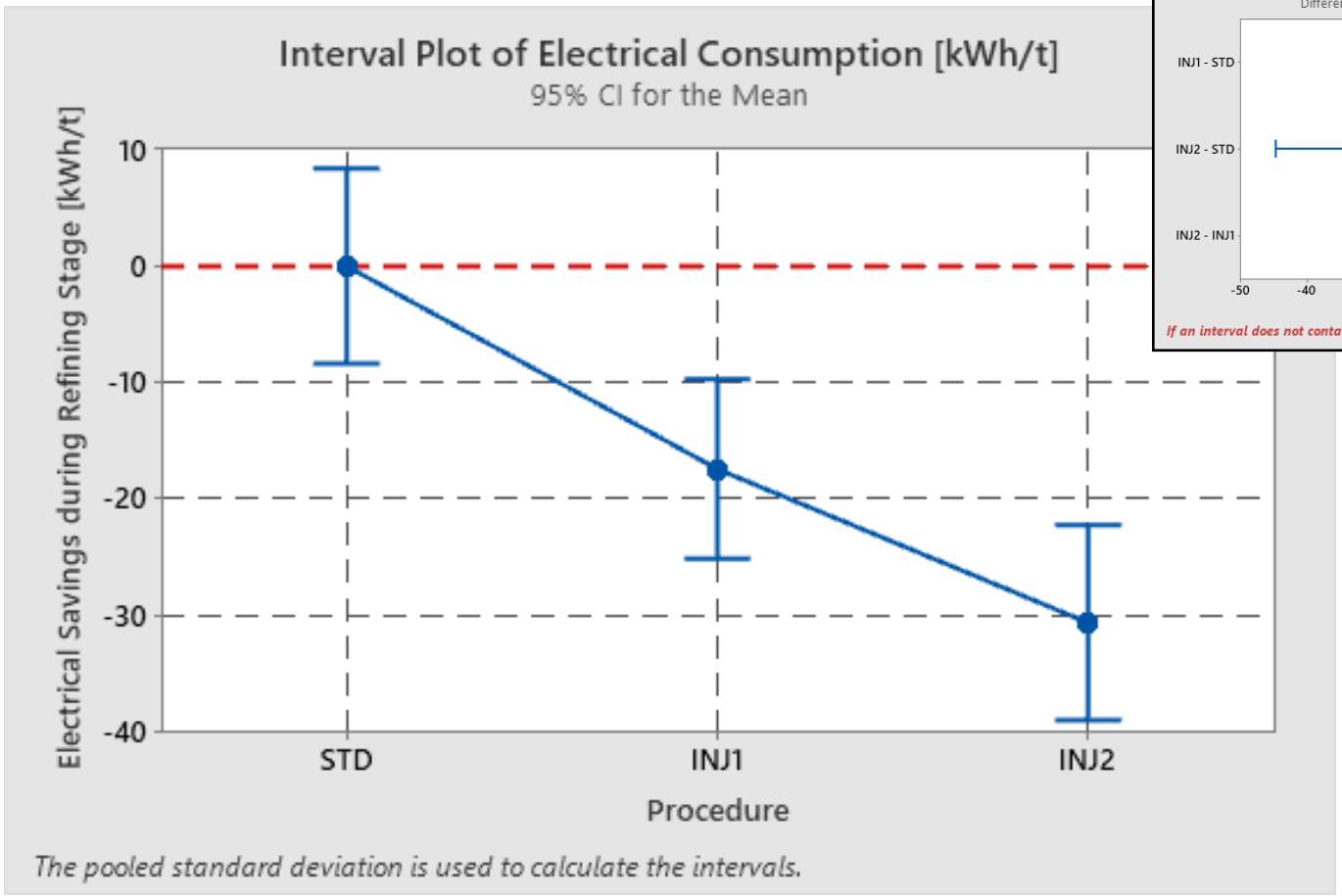


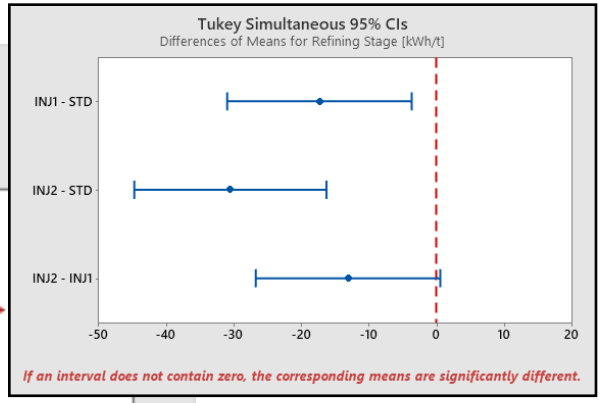
TOTAL ELECTRICAL CONSUMPTION



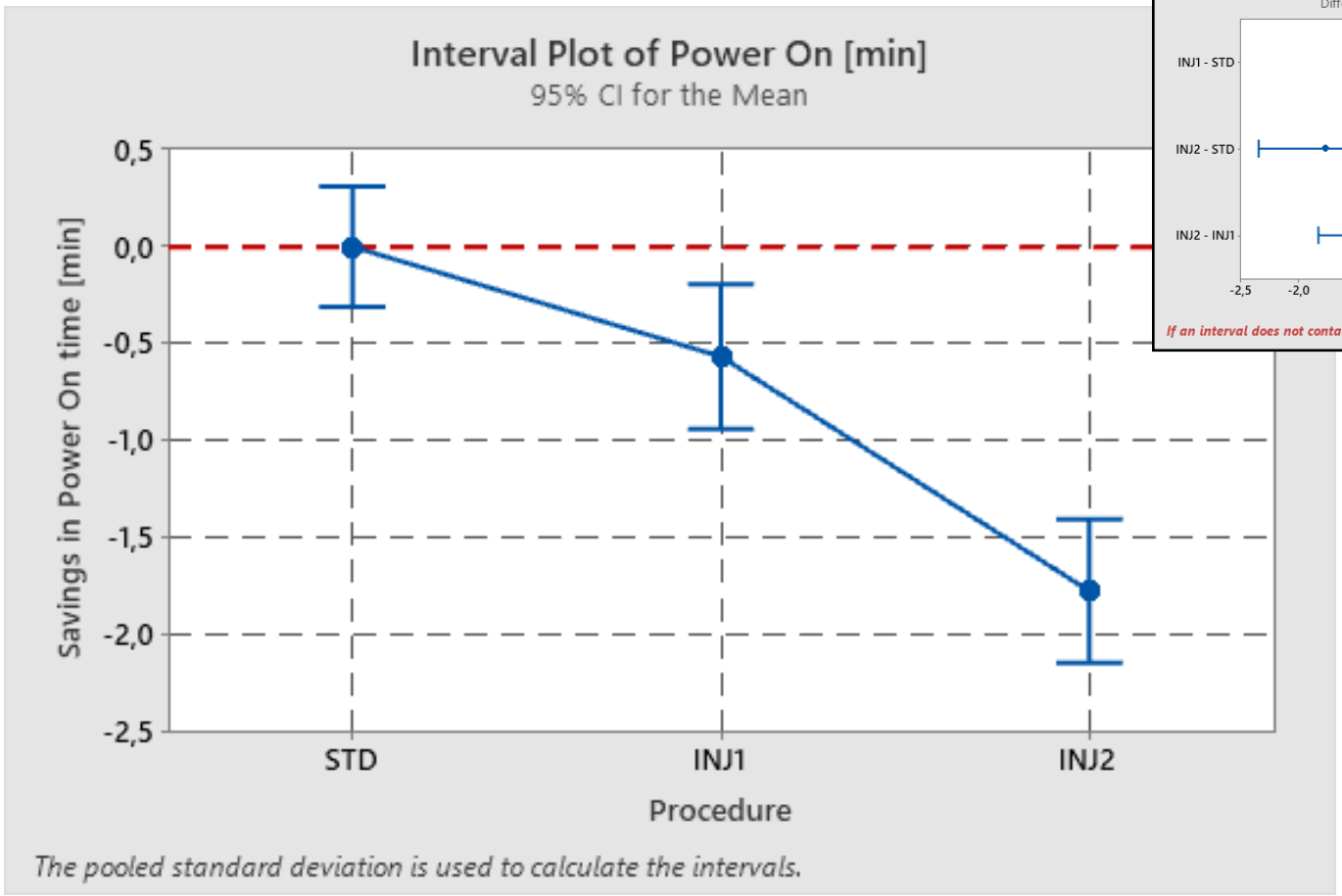


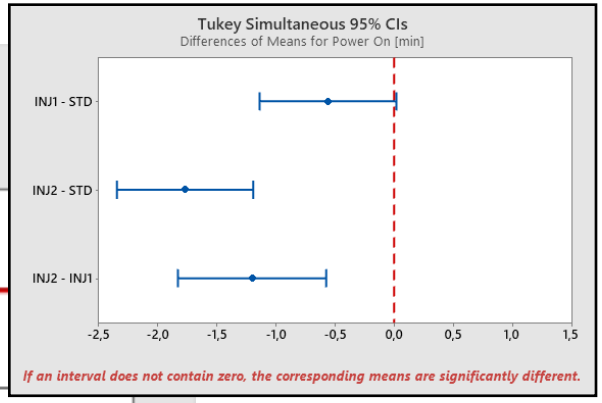
ELECTRICAL CONSUMPTION (REFINING)





ELECTRICAL CONSUMPTION (POWER-ON)





ELECTRICAL CO_2 EMISSIONS SAVINGS

Main Savings

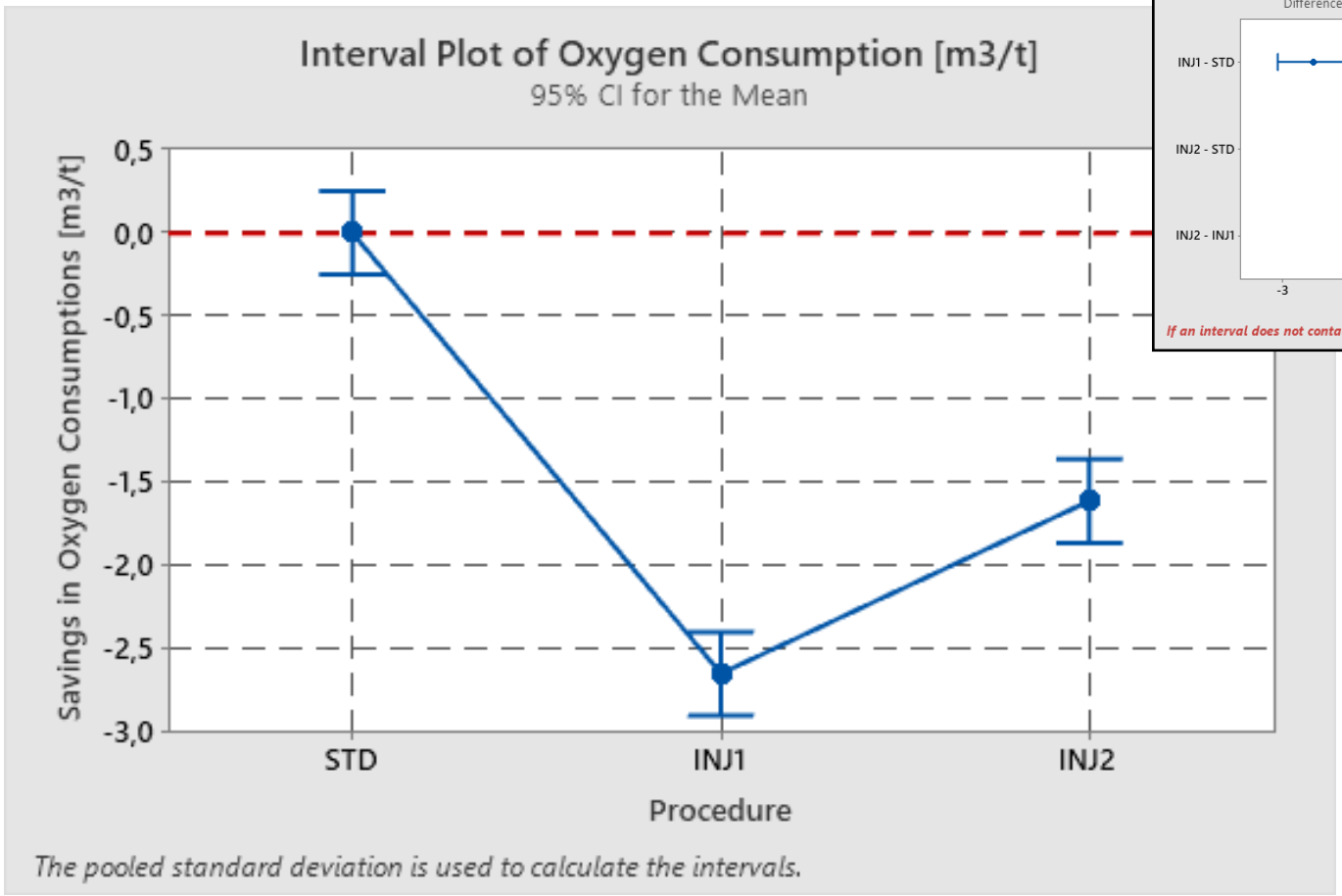
- Lime → ~950 kg
- Electrical → ~32.5 kWh/t
- Power-On → ~1.25 min/heat

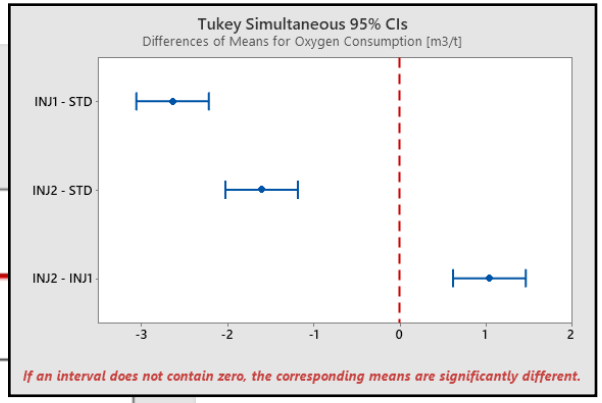
Assumptions

- Scrap Load → 88 ton
- Production → 4950 heat/year
- Eq. Factor → 0.2763 kg_{CO2}/kWh

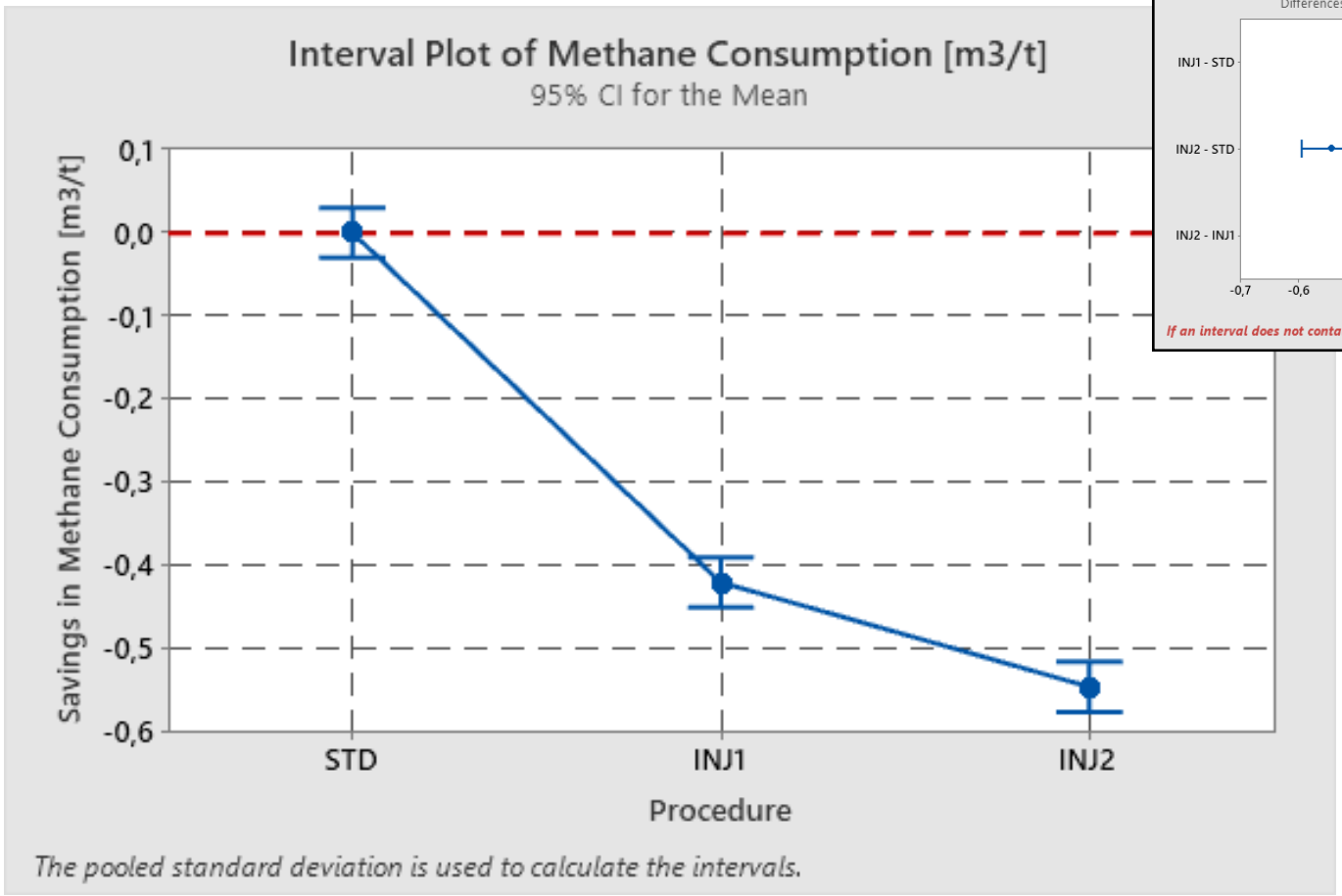
	INJ1	INJ2
Specific Savings [kWh/t]	30	35
Annual Savings [MWh/year]	13 068	15 246
Tons of Oil Equivalent saved	2443	2851
Tons of not emitted CO_{2eq}	3610	4212

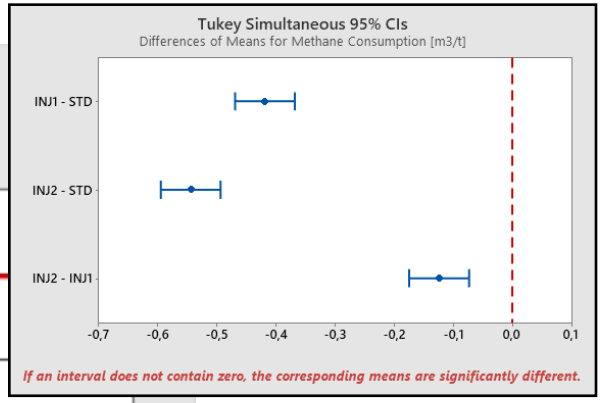
OXYGEN CONSUMPTION





METHANE CONSUMPTION





METHANE CO_2 EMISSIONS SAVINGS

Assumptions

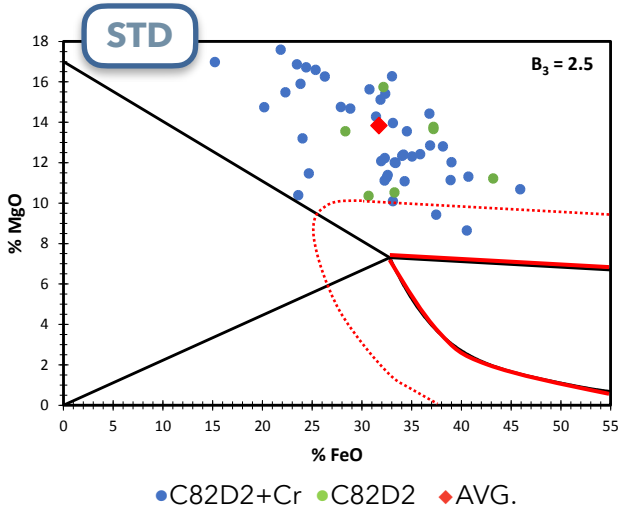
Scrap Load → 88 ton

Production → 4950 heat/year

Eq. Factor → 0.2763 kg_{CO2}/kWh

	INJ1	INJ2
Specific Savings [m^3/t]	0.4	0.55
Specific Savings [kWh/t]	4.38	6.02
Annual Savings [MWh/year]	1907	2622
Tons of Oil Equivalent saved	357	490
Tons of not emitted CO_{2eq}	417	574

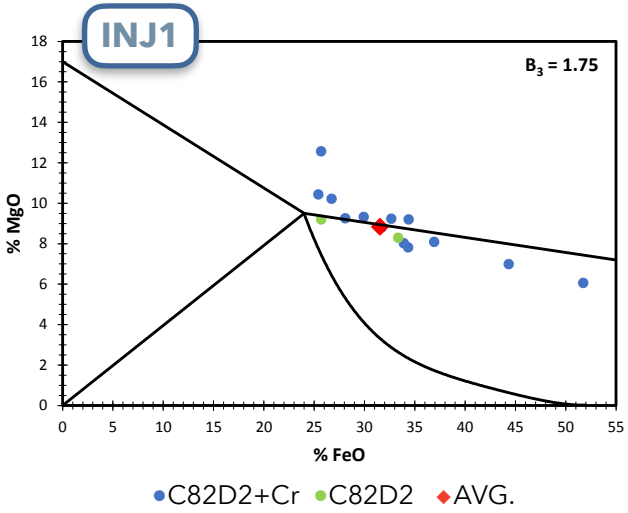
SLAG FOAMABILITY



Slag a bit "crusty"

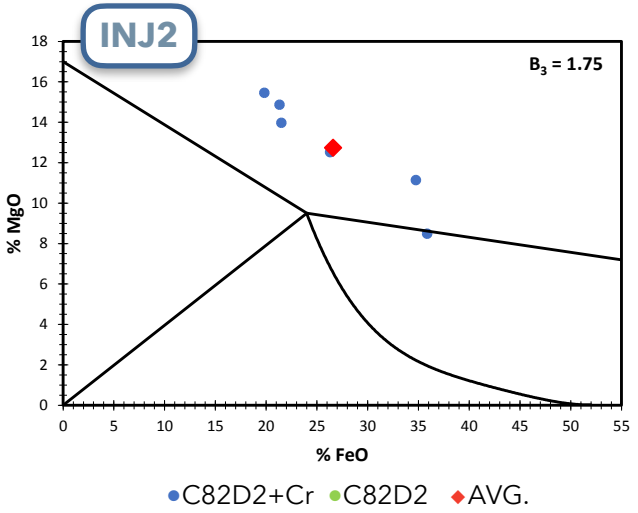
No optimum foaming

Erosion of the EAF roof



Near optimum foaming

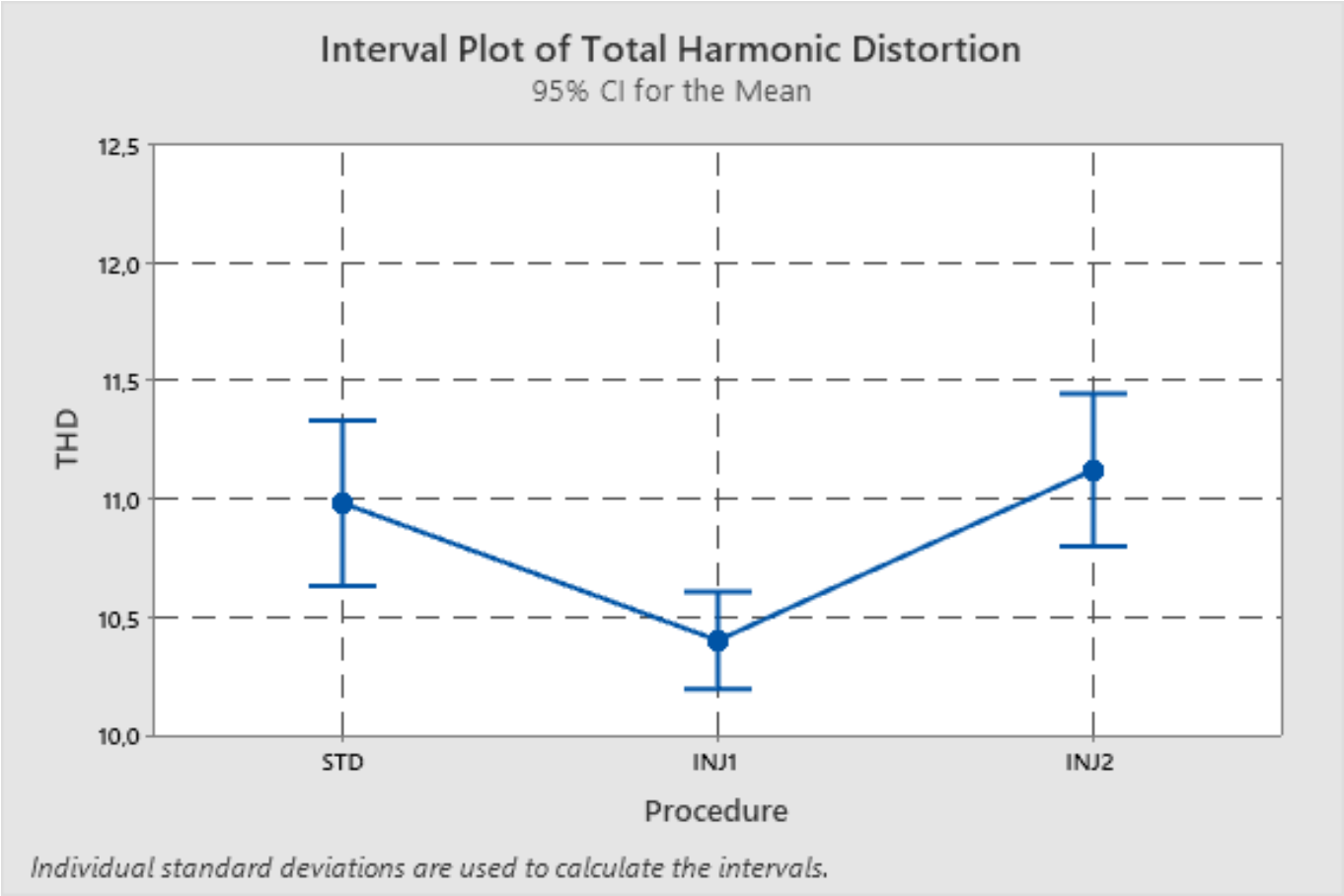
Refractory lifetime increased

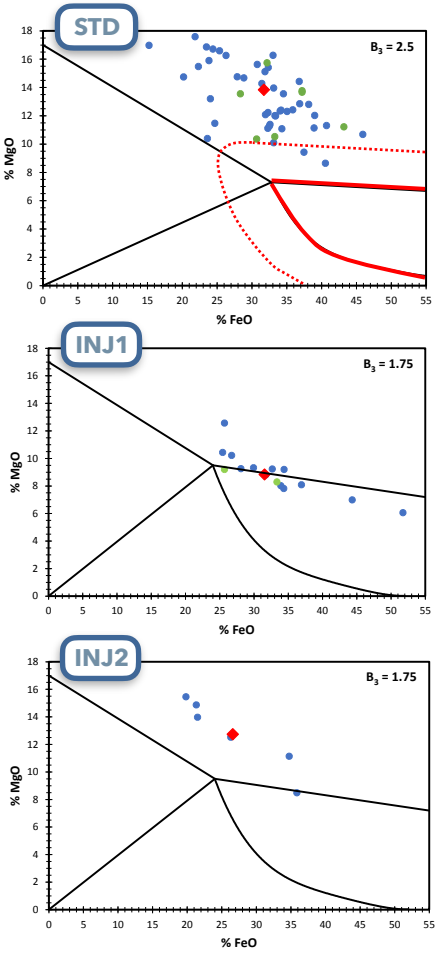


Far from optimal condition

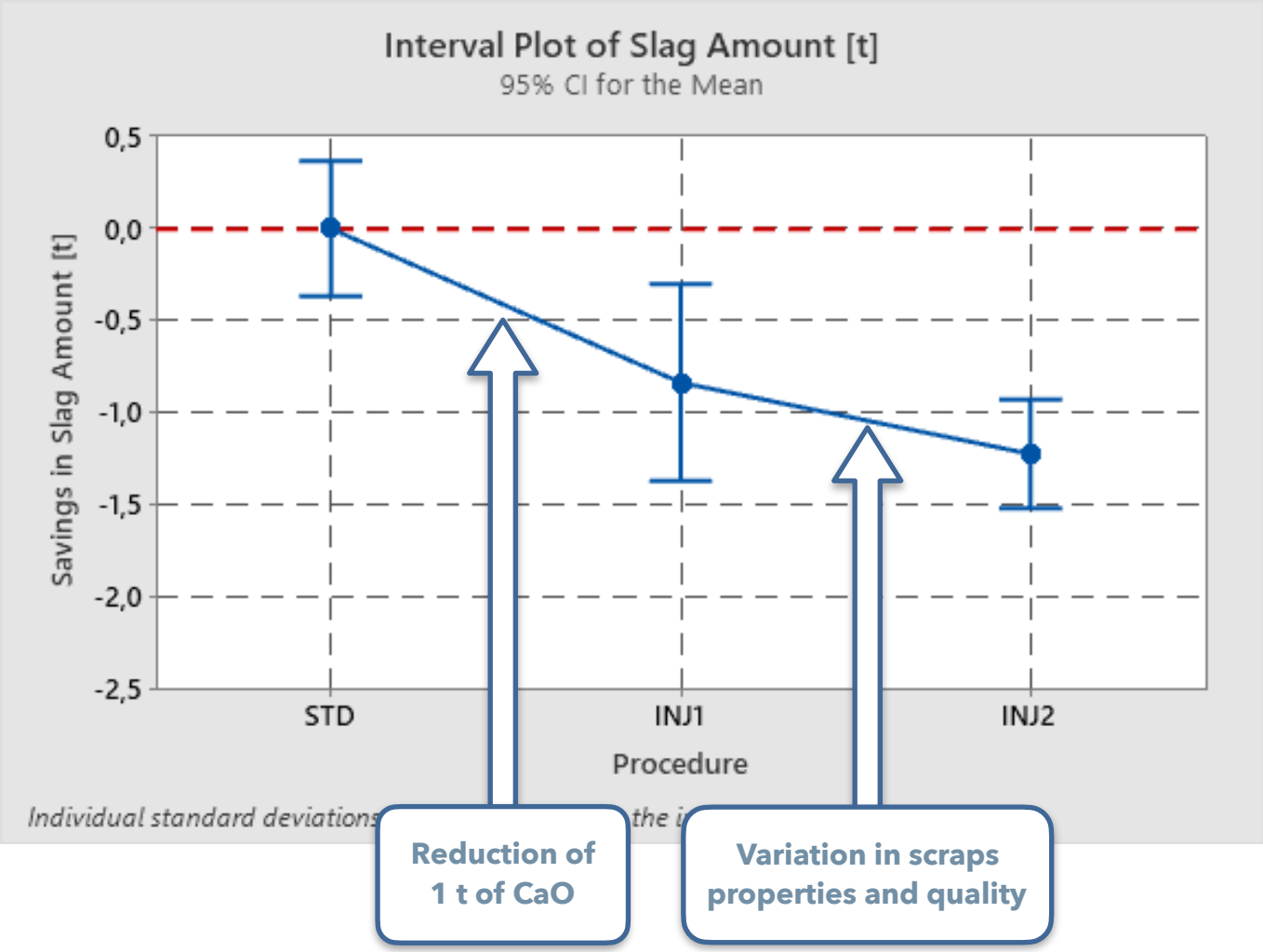
Slag composition in the range of possible slag foaming

TOTAL HARMONIC DISTORTION



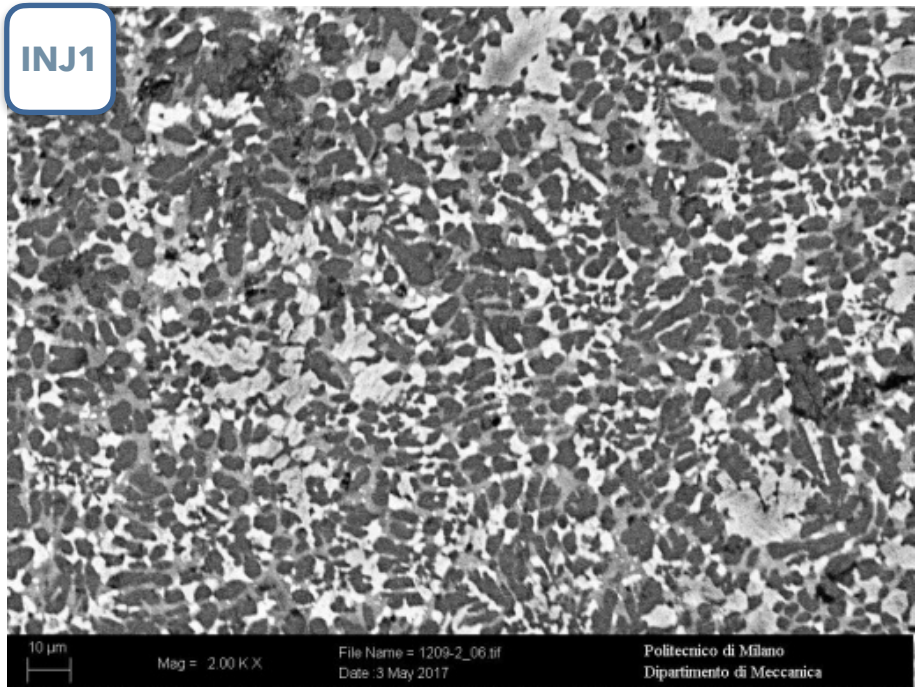


SLAG AMOUNT

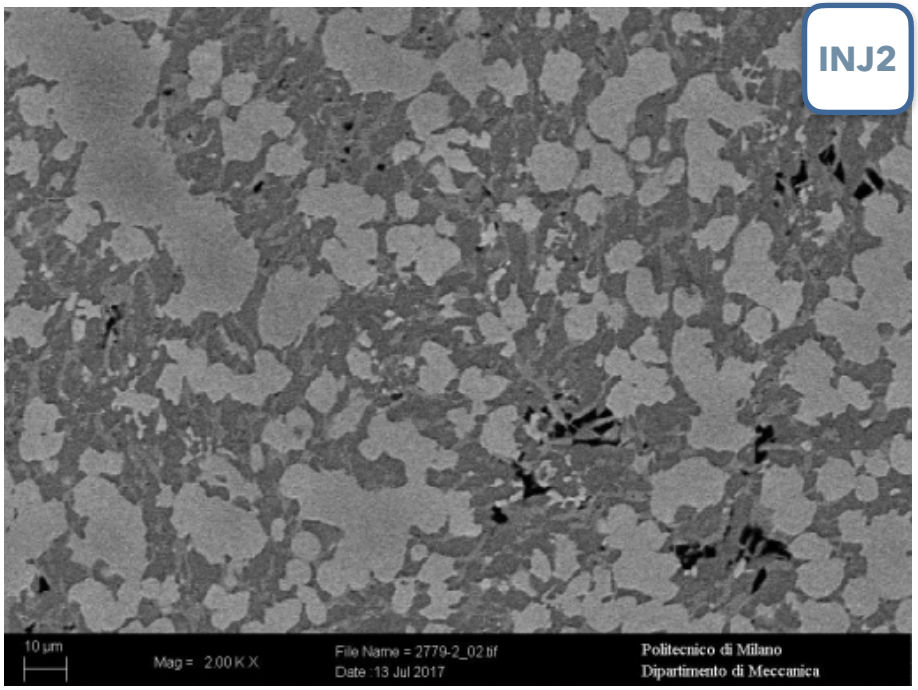

Interval Plot of Slag Amount [t]
95% CI for the Mean
Savings in Slag Amount [t]
0,5
0,0
-0,5
-1,0
-1,5
-2,0
-2,5
STD
INJ1
INJ2
Procedure
Individual standard deviations
Reduction of 1 t of CaO
Variation in scraps properties and quality

SLAG MICROSTRUCTURE

INJ1

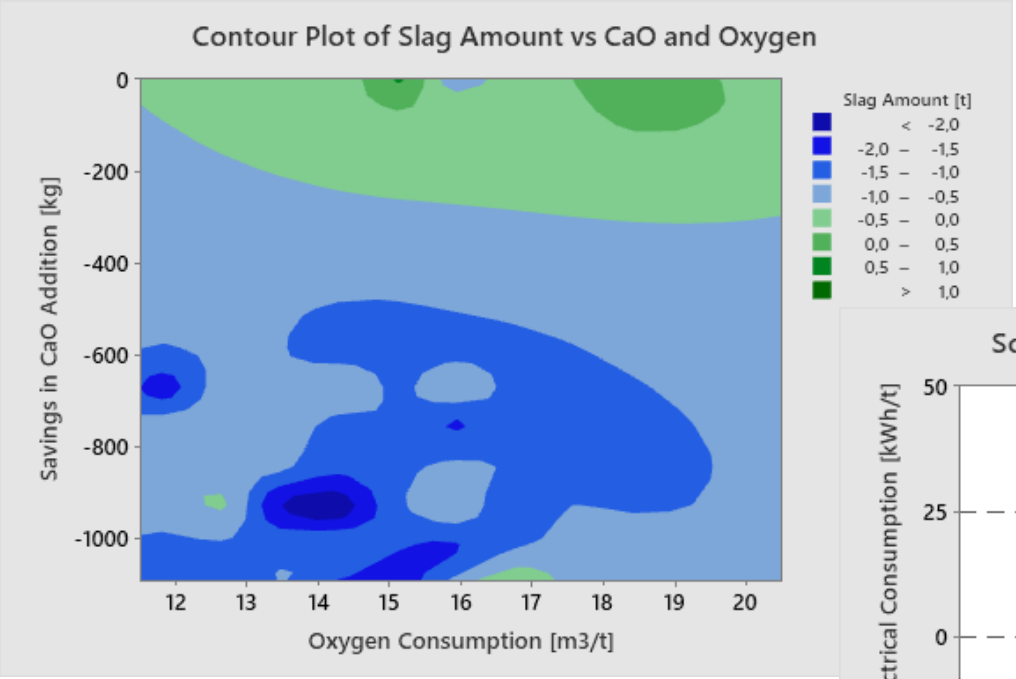


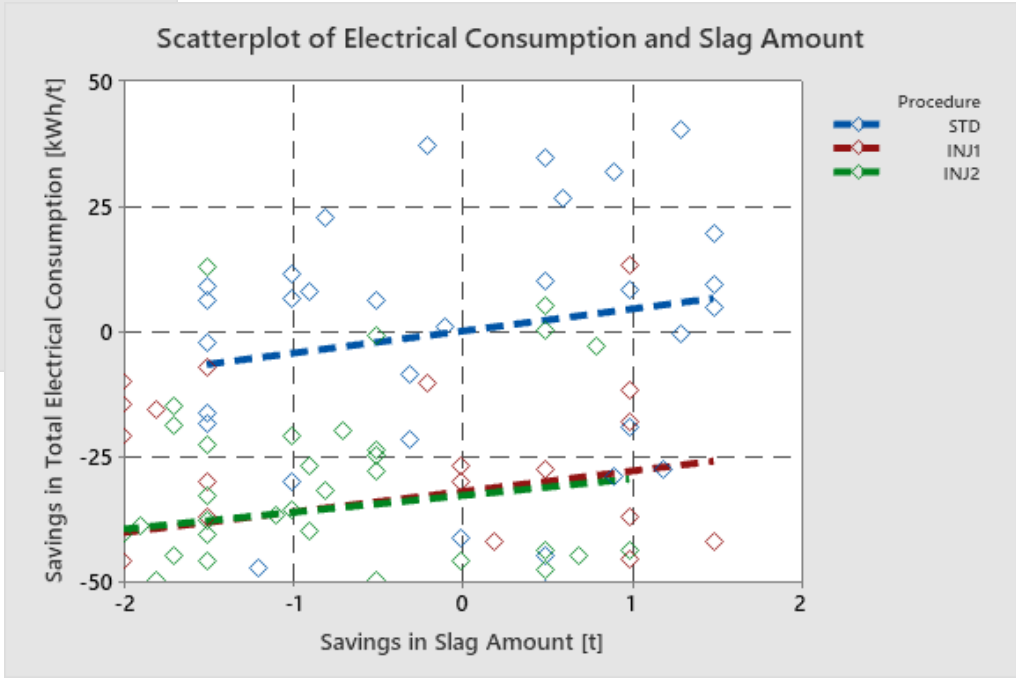
INJ2



Wüstite	→	Globular development (avg. size 2÷20 µm)
$3CaO \cdot SiO_2$	→	Development in 75% of samples
Brownmillerite	→	High fraction
INJ2	→	Coarser morphology (higher lime amount)

SLAG AMOUNT IMPACT





CONCLUSIONS

The main results of the new lime injection technique and the furnace parameters enhancements are summarized as follows:

- **Lime** → **decreased by ~1000 kg**
- **Electrical** → **decreased by 30÷35 kWh/t (65% during refining)**
- **Power-On** → **decreased by ~ 1.5 min**
- **O_2 and CH_4** → **decreased by 1.5÷2.5 m^3/t and ~0.5 m^3/t, respectively**
- **Slag foamability** → **best foaming for INJ1 procedure (validated by ISD and THD)**

Considering the **EPA carbon tax**[1] (30€/t_{CO2}) and the **social cost savings** according to the **Stanford University**[2] (185€/t_{CO2})

	INJ1	INJ2
Annual Savings [MWh/year]	14 975	17 868
Tons of Oil Equivalent saved	2790	3341
Tons of not emitted CO_{2eq}	4027	4786
[1]Carbon tax savings [€]	120 810	143 880
[2]Social cost savings [€]	744 995	887 260

[1] http://www.qualenergia.it/articoli/20160712-prezzo-della-co2-30-euro-tonnellata-la-proposta-francese-ETS

[2] Moore FC, Diaz DB. Temperature impacts on economic growth warrant stringent mitigation policy. Nat. Clim. Change 2015;5:127-131

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Thanks for your attention!

For any further information:

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