Effect of EAF slag basicity and chromium content on steel-slag equilibrium

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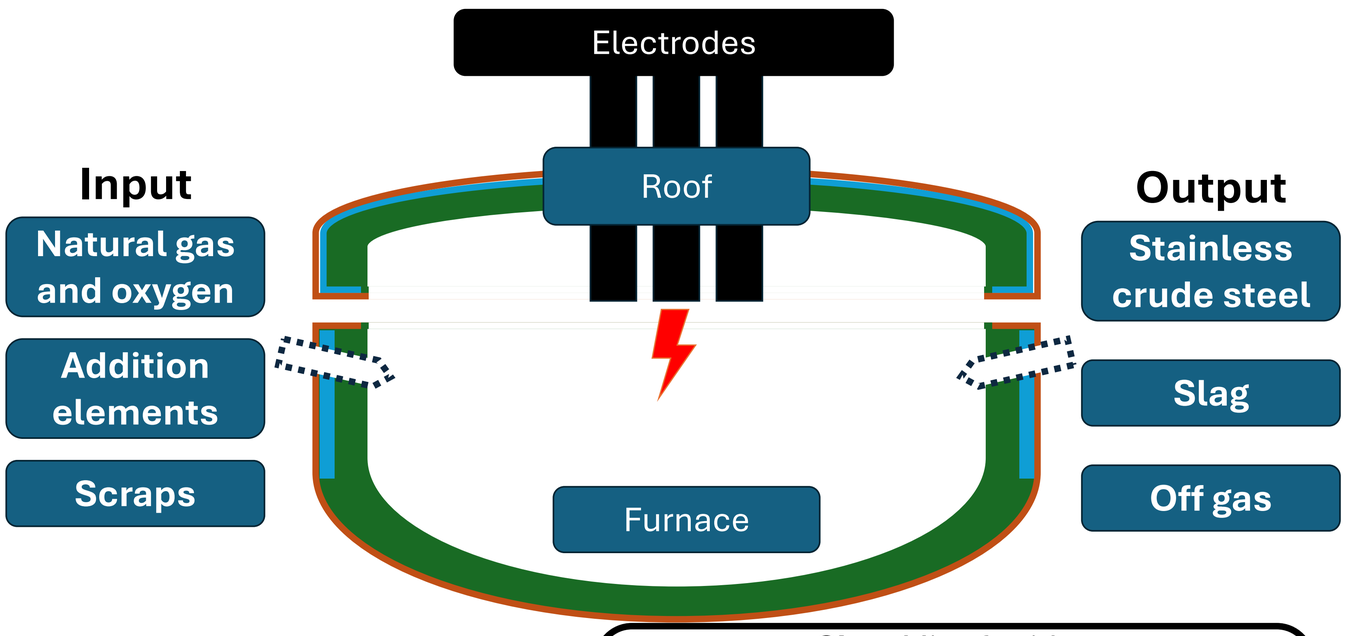
Introduction

Nowadays, stainless steel (an iron alloy with at least 11 wt.% of chromium to protect against corrosion) is used everywhere (construction, transport, etc.).

To produce stainless steel, scraps are melted in an Electric Arc Furnace (EAF), where electric arcs are produced between electrodes and the scraps. A numerical model could improve this process.

The Centre of Research of Metallurgy has a model for carbon steel based on thermodynamic considerations. It needs to be adapted for stainless steel by modifying the expressions of steel – slag equilibrium.

Stainless steelmaking: Electric arc furnace (EAF)(1)



Slag: Mix of oxides

Purposes:

- To protect the refractory
- To help for refining step
- To protect steel thermally from the outside

Methodology

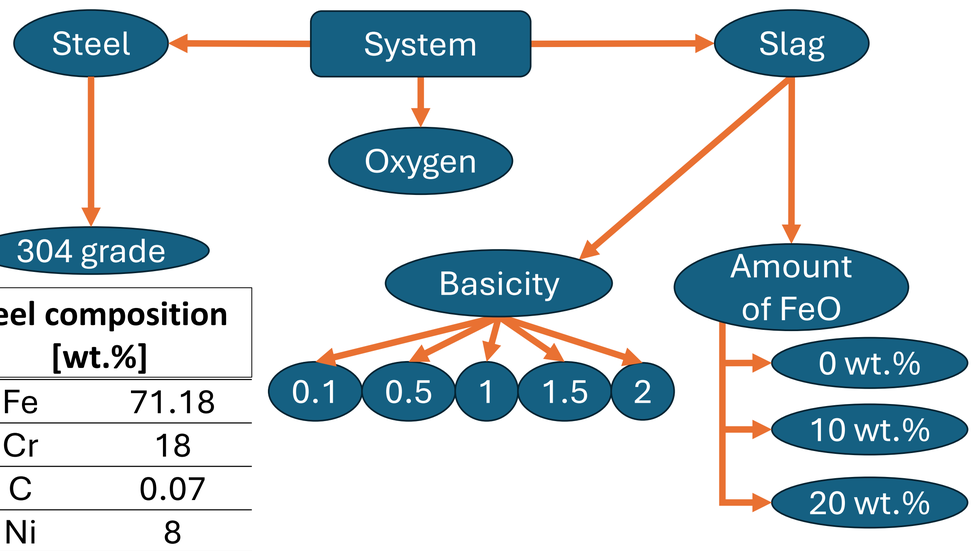
Calculate the equilibrium steel - slag → K=f(composition, basicity, temperature) → Add in the model → Verification with experimental data (APERAM)

$$aA + bB \rightleftharpoons cC + dD \quad K = \frac{a_C^c \cdot a_D^d}{a_A^a \cdot a_B^b}$$

- To extract the activity of elements in steel and slag from Thermo-Calc and calculate the equilibrium constants for the reactions
- To calculate the trend line to obtain Log(K) = f(temperature, composition of the steel, slag)

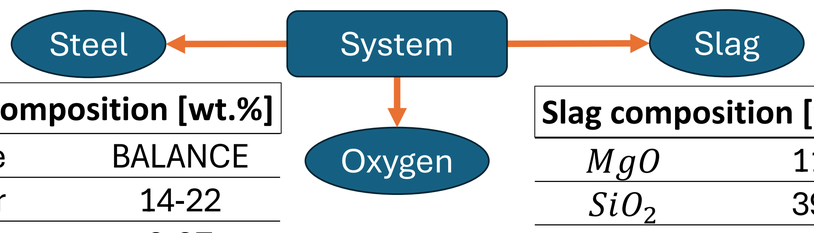
Study on basicity of slag

Important property of the slag to achieve its purposes ⟹ $Basicity = \frac{wt.\%\ CaO}{wt.\%\ SiO_2}$



Steel composition [wt.%]	
Fe	71.18
Cr	18
C	0.07
Ni	8
Si	0.75
Mn	2

Study on chromium content

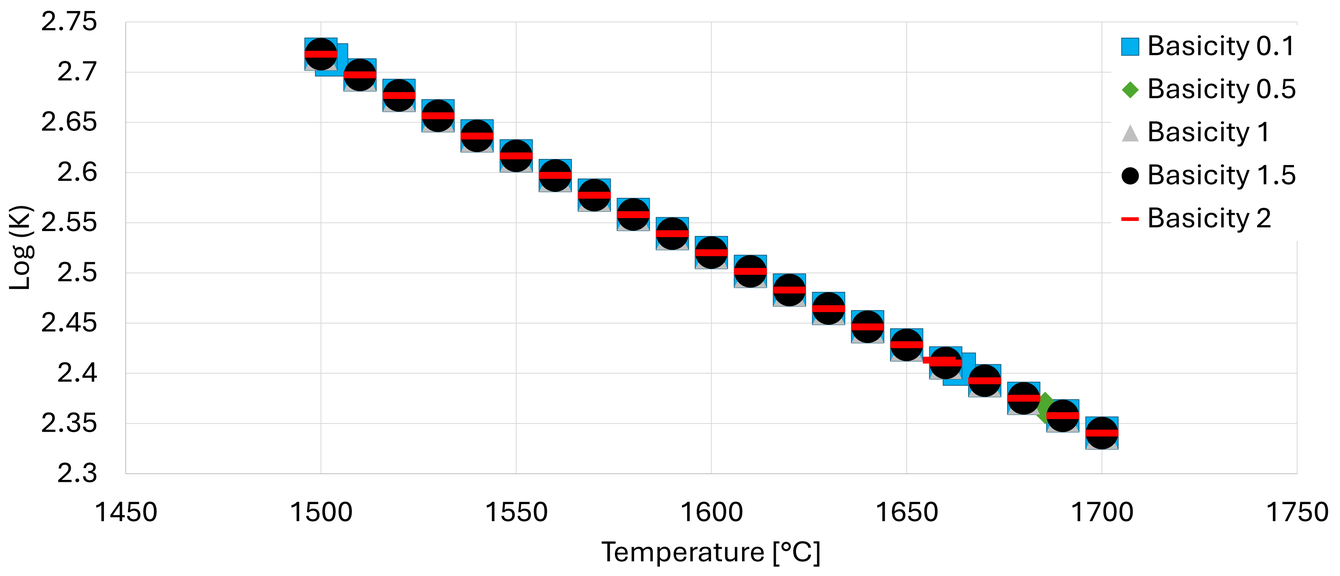


Steel composition [wt.%]	
Fe	BALANCE
Cr	14-22
C	0.07
Ni	8
Si	0.75
Mn	2

Slag composition [wt.%]	
MgO	11
SiO_2	39
CaO	50

Results

Log (K) vs Temperature 0 wt.% FeO and 18 wt.% Cr



Reactions	0 wt.% FeO
$(FeO) + [C] \rightleftharpoons Fe + CO \uparrow$	$Log\ (K) = -1.48 \cdot 10^{-7}\ T^2 + 5.11 \cdot 10^{-4}\ T + 5.16$
$(FeO) + [Mn] \rightleftharpoons Fe + (MnO)$	$Log\ (K) = -1.89 \cdot 10^{-3}\ T + 5.54$
$(MnO) + [C] \rightleftharpoons [Mn] + CO \uparrow$	$Log(K) = 1.92 \cdot 10^{-3}\ T + 5.45 \cdot 10^{-3}$
$2\ (FeO) + [Si] \rightleftharpoons 2\ Fe + (SiO_2)$	$Log(K) = -6.90 \cdot 10^{-3}\ T + 18.95$
$2\ (MnO) + [Si] \rightleftharpoons 2\ [Mn] + (SiO_2)$	$Log(K) = -3.14 \cdot 10^{-3} T + 7.89$
$3\ (FeO) + 2\ [Cr] \rightleftharpoons 3\ Fe + (Cr_2O_3)$	$Log(K) = -4.88 \cdot 10^{-3}\ T + 12.75$
$3\ [Si] + 2\ Cr_2O_3 \rightleftharpoons 3\ SiO_2 + 4\ [Cr]$	$Log(K) = -1.10 \cdot 10^{-2}\ T + 31.39$

( ) in slag [ ] in steel ↑ in gas

Conclusion

- Mathematical expressions of Log(K) as a function of temperature are found for many reactions between steel and slag
- Basicity of the slag, the iron oxide and the chromium content do not affect the equilibrium significantly

Perspectives

- To study the effect of other elements on the steel - slag equilibrium (**e.g.** C, Ni, Si)
- Experimental trials to validate the model adaptation

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Acknowledgement

I want to thank the CRM for the model and the Walloon region for the funding (Convention: 8948)

References

(1) J. Muract, "MAN01052 – Electric Arc Furnace - steeluniversity," Jul. 2016. [Online]