STUDY OF FORMATION AND MODIFICATION OF INCLUSIONS IN AL-KILLED CA-TREATED STEEL

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Topics

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- Conclusions
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Introduction

- Calcium alloys are widely employed to control composition, distribution and morphology of oxide and sulfide inclusions in steels.

- Many factors have influence on steels castability. The control of inclusions is only one among these factors; however, it is very important for improving castability.

- Higher quality requirements for the production of special steels (remarkably those intended for automotive industry).

Introduction

- Furthermore, such steels are considered critical in relation to their production in steel mill, since contents of some of their elements such as Al, S, Ca, and O must be controlled.

- There are few studies found in the literature on calcium treatment for aluminium-killed steels with sulfur contents higher than 0.015 % (engineering steel with improved machinability).

Introduction

- Computational thermodynamics shows to be an excellent tool for comprehending physico-chemical phenomena which occur in steelmaking, and, moreover, it can help engineers from industrial plant taking decision.

- In this way, it is essential to study the phases formed in inclusions - including the composition of each phase in terms of oxides and sulfides - for aluminium-killed steels with high sulfur contents.

Introduction

The general purpose of this work is the study of non-metallic inclusions in Al-killed Ca-Treated SAE 8620 steel.

The specific purposes are:

1) To obtain the phases and compounds formed in the inclusions as a function of composition and casting temperature adopted for the SAE 8620 steel grade.

2) To establish conditions of steel chemical composition for the formation of less harmful inclusions to the steel castability.

Material

SAE 8620 steel is classified by SAE-AISI as nickel-chromium-molybdenum steel, which is a low alloy steel, used in components under the cementation process.

SAE 8620 steel makes part of a series of steels for cementation, which have sufficient hardenability to be oil-quenched, acquiring, in their core, good values of ductility.

They are employed for gear building sets, pieces for light works, small mechanisms, pins, etc, generally, materials which present as the most important characteristic wear resistance.

Material

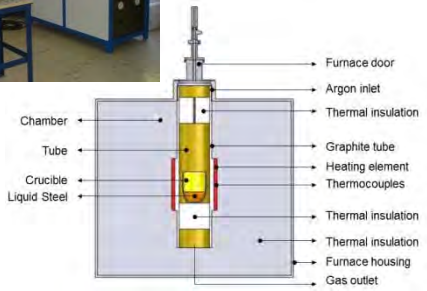
Chemical composition for SAE 8620 steel experiments and industrial trials (mass %).

	C	Si	Mn	S	Al*	Ca*	Cr	Ni	P	Ototal*
E1	0.18	0.25	0.86	0.035	**90**	**8.4**	0.51	0.476	0.015	**33.5**
E2	0.20	0.21	0.90	0.041	**102**	**6.3**	0.52	0.488	0.015	**26.3**
E3	0.18	0.24	0.87	0.022	**178**	**6.7**	0.51	0.483	0.015	**26.3**
E4	0.18	0.27	0.87	0.023	**241**	**12.3**	0.51	0.476	0.014	**28.8**
E5	0.18	0.27	0.87	0.019	**293**	**12.9**	0.51	0.476	0.015	**31.8**
P1	0.20	0.23	0.77	0.021	**290**	**9.0**	0.44	0.470	0.015	**25.0**
P2	0.21	0.26	0.86	0.020	**330**	**13.0**	0.48	0.480	0.016	**18.0**
P3	0.21	0.26	0.89	0.026	**340**	**12.0**	0.50	0.470	0.016	**14.0**
P4	0.19	0.25	0.78	0.021	**250**	**16.0**	0.45	0.460	0.014	**20.0**
P5	0.20	0.25	0.83	0.024	**250**	**10.0**	0.46	0.450	0.014	**23.0**

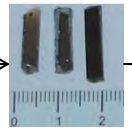
*Al, Ca and Ototal (total oxygen) in ppm.
E = Laboratorial experiments.
P = Plant trials.

Methodology: Summary

Experiments



Samples



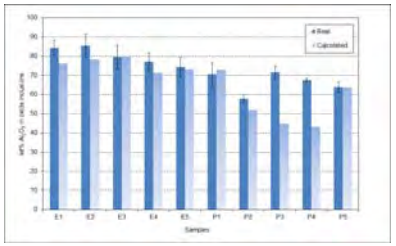
Plant trials

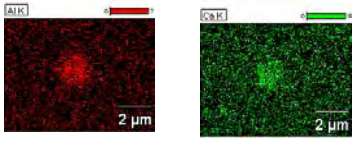
Analysis

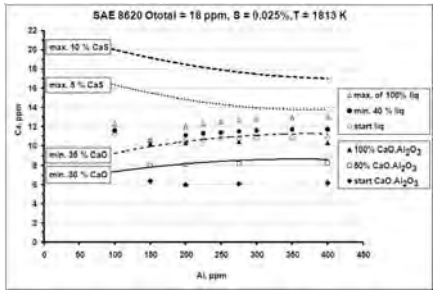
SEM/EDS

FactSage

Results

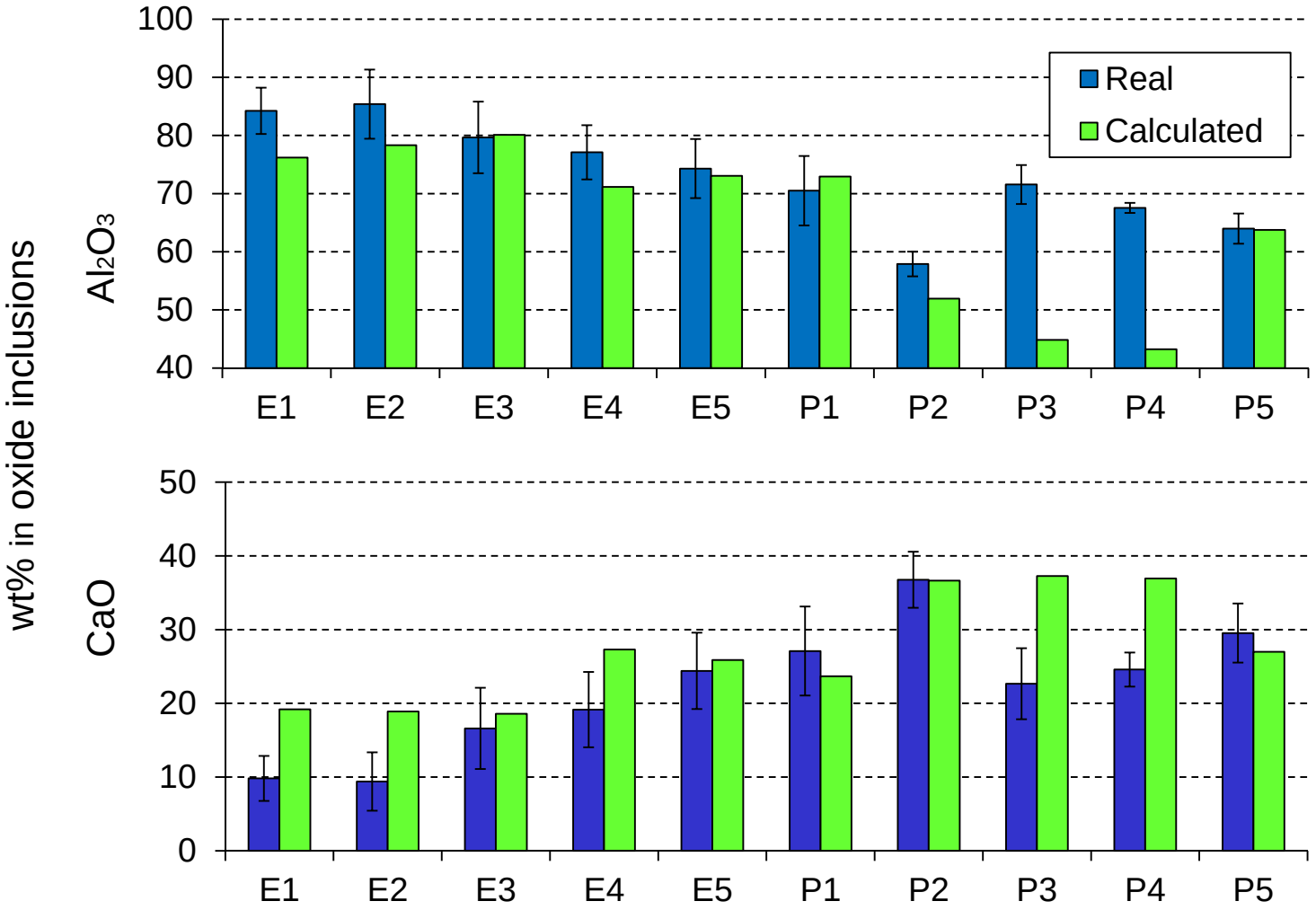






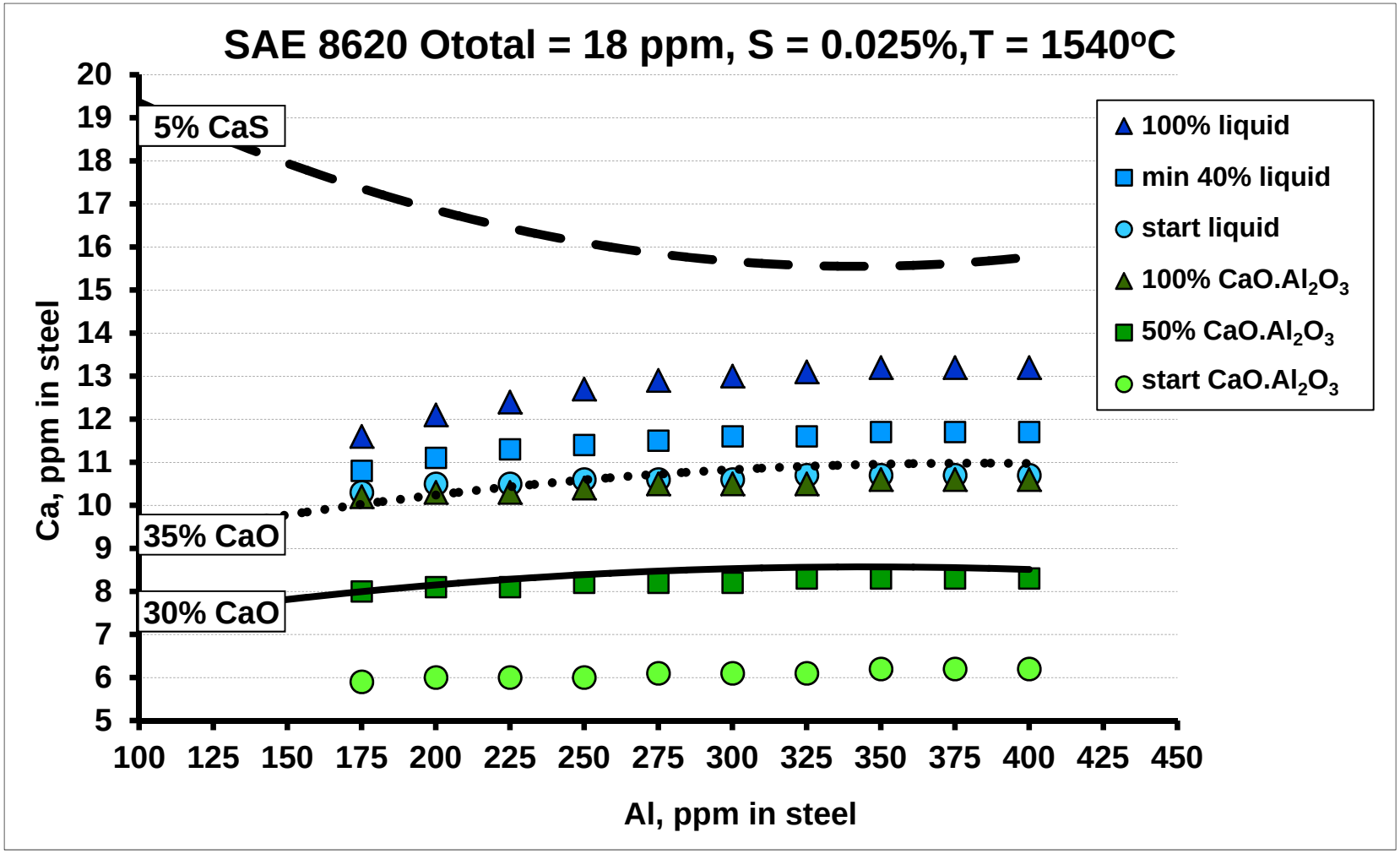
Results and Discussion

Mass percent of Al_2O_3 and CaO in oxide inclusions: Experimental "E" and Plant samples "P" versus thermodynamic simulations by FactSage.



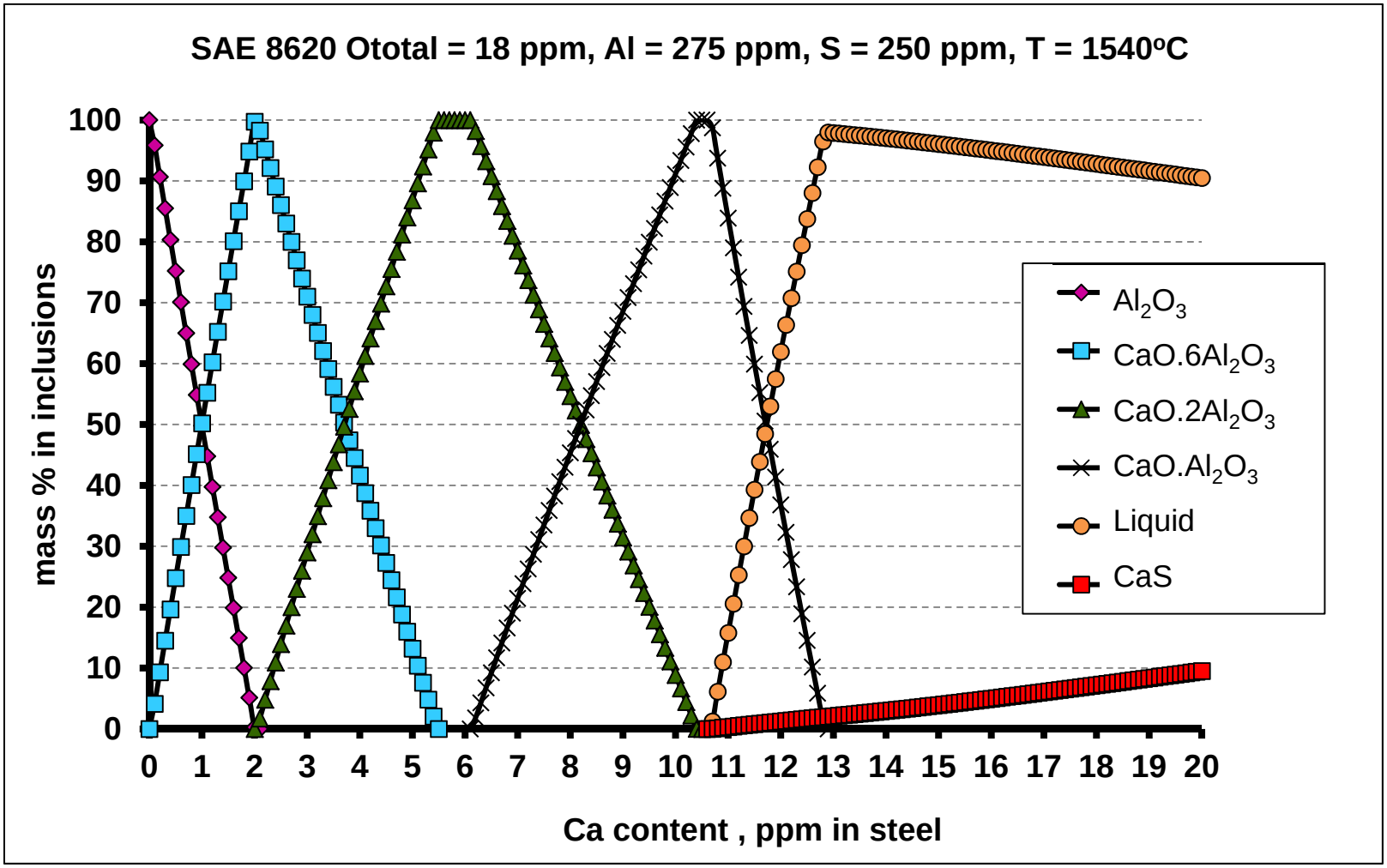
Results and Discussion

Liquid window for SAE 8620 steel, including formation curves of liquid fraction and $CaO.Al_2O_3$.



Results and Discussion

Mass percentage % of oxides and CaS in inclusions x SAE 8620 steel calcium content for Al = 275 ppm.



Conclusions

- For an mean Al content of 275 ppm for SAE 8620 steel, at T = 1540ºC, inclusions window with a minimum of 35% of CaO and a maximum of 5% of CaS is between 10.9 and 14.2 ppm of calcium.
- The curve of 35% of CaO from SAE 8620 steel liquid window practically coincides with the initial formation of the liquid phase.
- Between 200 and 300 ppm of Al, 100% of liquid is obtained at the middle of the window (between curves of 35% of CaO and 5% of CaS).

Conclusions

- For 275 ppm of Al, inclusions with 100% liquid phase in about 12.5 ppm of Ca can be obtained.

- It can be observed the modification of alumina inclusions by calcium, forming varied calcium-aluminates for different contents of Al and Ca under SAE 8620 steel conditions.

Conclusions

- As a general conclusion, a very good correlation was obtained between the thermodynamic predictions carried out in this study and the results obtained from the castability index of SAE 8620 steel produced by the continuous casting in the industrial plant.
- Thus, this research can contribute for the study of inclusions in other critical steels, as the employment of the methodology proposed here.

Acknowledgements

- The authors are grateful for the support provided by Gerdau Special Steels Brazil Charqueadas and Prof. Dr. Klaus Hack, GTT-Technologies - Germany, for the opportunity to show this work.

Thank you!

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