Development of a Blast Furnace Model in gPROMS with Thermodynamic Process Depiction by Means of the Rist Operating Diagram

Andreas Spanlang[1], Bernd Weiss[2], Walter Wukovits[3]

[1]K1-MET GmbH Metallurgical Competence Center, Linz, Austria Contact: andreas.spanlang@k1-met.com
[2]Primetals Technologies Austria GmbH, Iron- and Steelmaking Technology and Innovation, Linz, Austria
[3]TU Wien, Institute of Chemical Engineering, Vienna, Austria

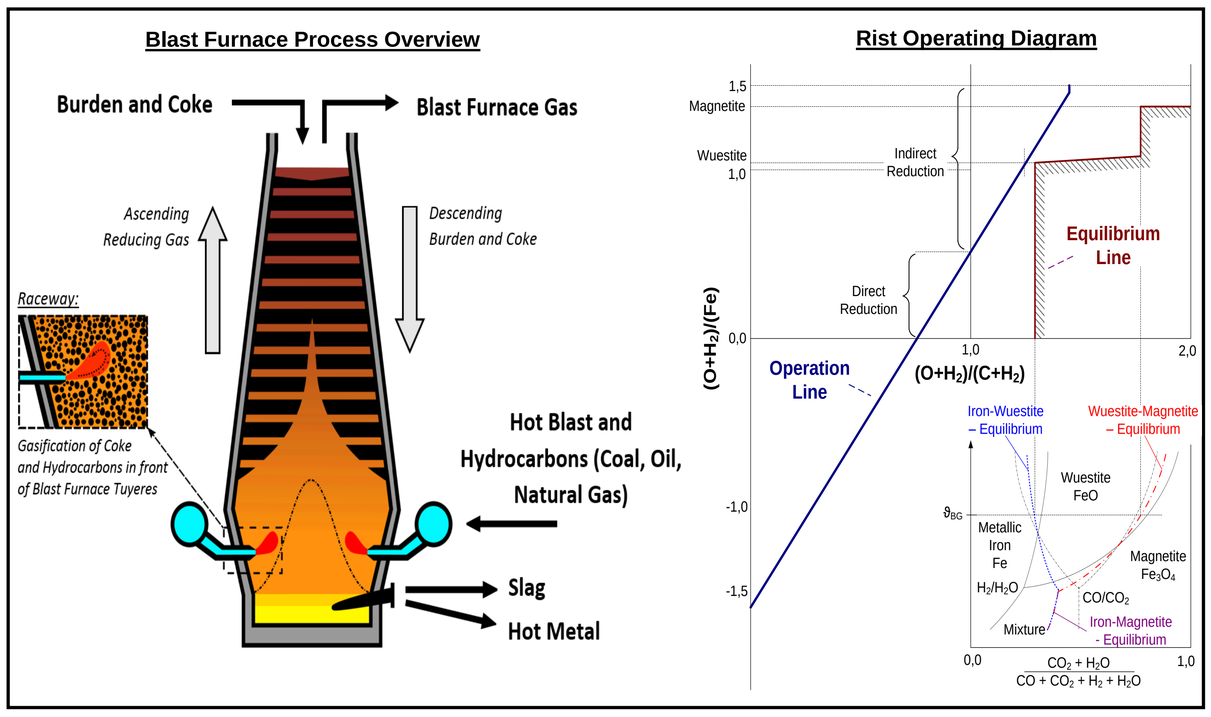
Introduction

The traditional blast furnace route is the worlds most important process for the production of hot metal. A wide range of different mathematical models has been developed in the past. As an alternative an analogue representation of the blast furnace process is given by the Rist operating diagram. The target of this work is the development and validation of a comprehensive blast furnace model in gPROMS.

Blast Furnace Process

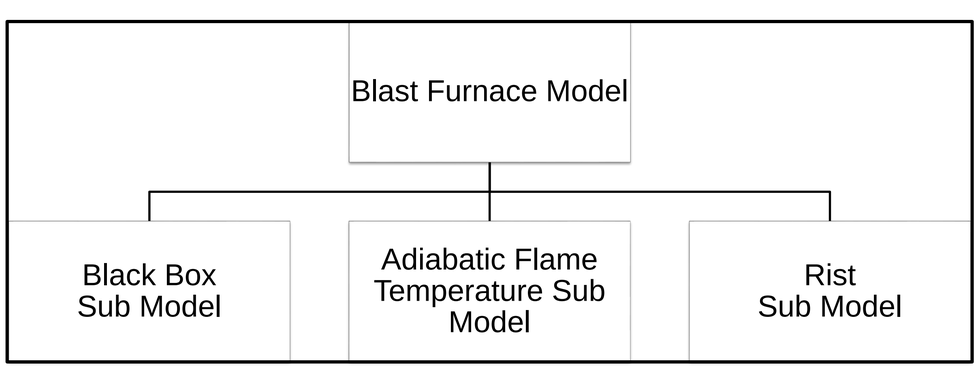
The main system inputs of a blast furnace are iron oxides, coke, additives, hot blast and substitute reducing agents in order to produce liquid hot metal, slag and blast furnace gas. It can be described as a counter current, multi-phase heat and mass exchange reactor which combines three main process units:

- Reduction reactor
- Gasification reactor
- Smelting oven

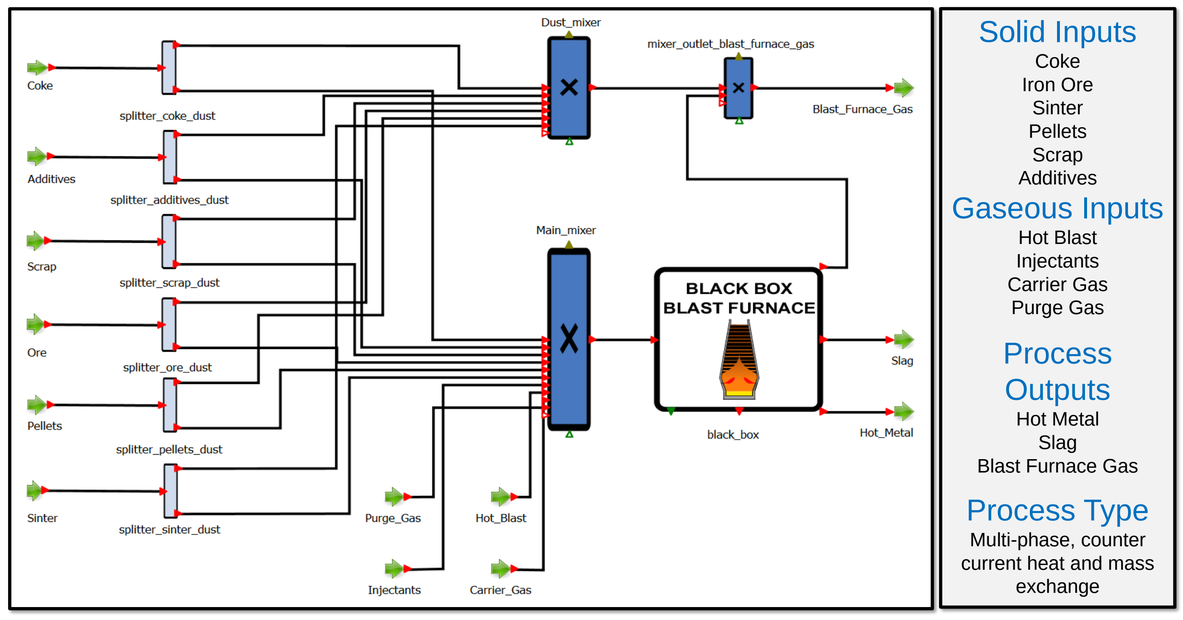


The energy required to maintain stable operation is provided by gasification of coke and hydrocarbons within the raceway in front of the blast furnace tuyeres. Main parameter to describe this process is the raceway adiabatic flame temperature (RAFT).The Rist operating diagram provides a graphical representation of balances of carbon, oxygen and hydrogen. These elements contribute in formation and utilization of reducing gas during in the blast furnace process.

gPROMS Modelling



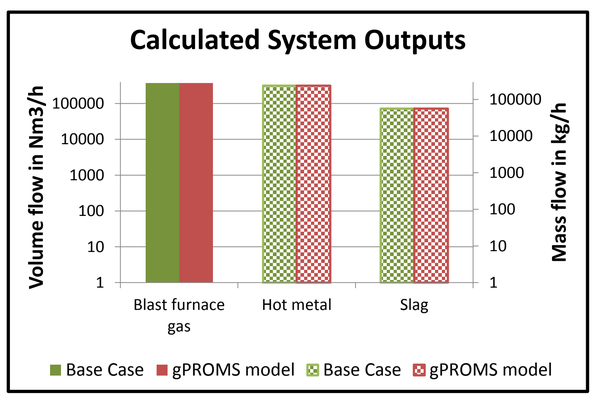
The sub models and process flow sheet required for the blast furnace model were created in the environment of the gPROMS ModelBuilder. The model is based on the use of three parallel calculation layers which are implemented through gPROMS sub topologies. The material flows of the blast furnace process are depicted by the main sub topology layer. A black box model is used on this sub topology for the chemical and physical transformation of burden, coke, hot blast and injectants into blast furnace gas, slag and hot metal. It is based on mass and energy balances of involved components and elements. The second sub topology layer is used for the calculation of the RAFT. For this task, the material stream information of hot blast and injectants is used. The third sub topology layer is required to construct the Rist operating diagram in order to investigate the thermodynamic conditions of the blast furnace process. It incorporates all solid, liquid and gaseous input streams of the black box model.

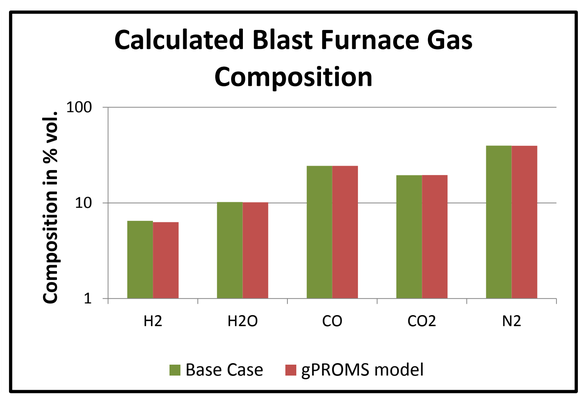


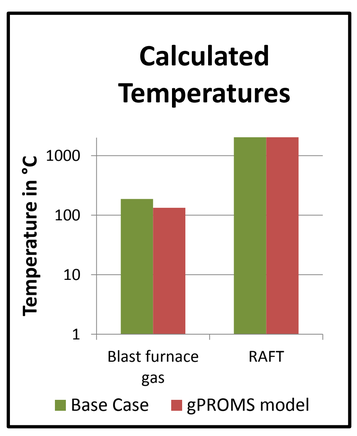
Since all calculation layers are assigned to the same hierarchical level, the interdependencies between the corresponding sub systems (blast furnace process, RAFT and Rist operating diagram) can be depicted through the use of a single mathematical model.

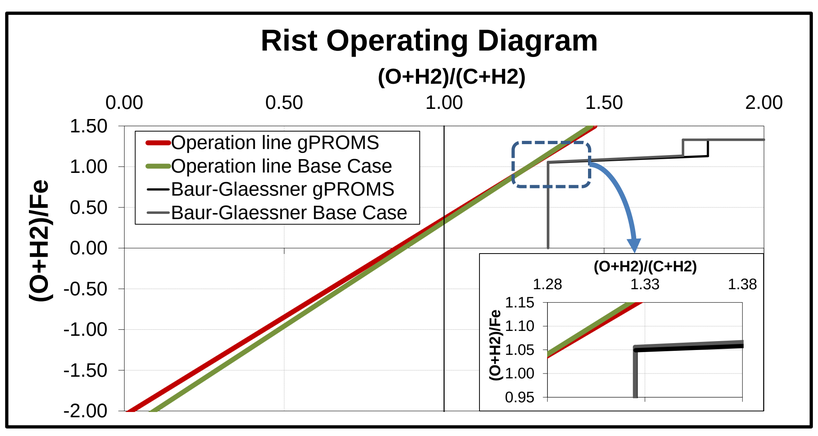
Simulation Results

The developed model was validated against well established calculation tools as well as plant data provided by Primetals Technologies. The main interest is focused on the calculated properties of the process outputs as well as on the corresponding Rist operating diagram.









Conclusions and Outlook

- The achieved simulation results are in good accordance with their corresponding target values.
- Potential applications of the blast furnace model include verification of existing metallurgical plants as well as investigation of new process variants.
- In the future, a multizonal implementation as well as an extension of the covered set of elements with respect to trace elements and alcalines are envisaged.

Acknowledgements

The authors gratefully acknowledge the funding support of K1-MET GmbH, metallurgical competence center. The research program of the competence center K1-MET is supported by COMET (Competence Center for Excellent Technologies), the Austrian program for competence centers. COMET is funded by the Federal Ministry for Transport, Innovation and Technology, the Federal Ministry for Science, Research and Economy, the province of Upper Austria, Tyrol, and Styria, the Styrian Business Promotion Agency.

Advanced Process Modelling Forum 2016 – London, United Kingdom, 20 – 21 April 2016

References:
- Geerdes M., Toxopeus H., van der Vliet C., 2009, Modern Blast Furnace Ironmaking - an introduction, IOS Press BV, Amsterdam
- Ottow, M., 1975. Eisen. In: Ullmann's Encyklopädie der technischen Chemie, Band 10, 4th ed., Verlag Chemie, Weinheim
- Peacey J.G., Davenport W.G., 1979, The Iron Blast Furnace - Theory and Practice, Pergamon Press, Oxford
- Rist A., Meysson N., 1967, A Dual Graphic Representation of the Blast-Furnace Mass and Heat Balances, Journal of Metals, 19, 50-59

Coordinated by
COMET Competence Centers for Excellent Technologies
FFG

Financially supported by
bmvit
bmwfw
SFG
Das Land Steiermark
Land Oberösterreich
tirol