Modelling of Waste Heat Recovery and Water-Steam Power Generation Systems of Integrated Metallurgical Plants in gPROMS

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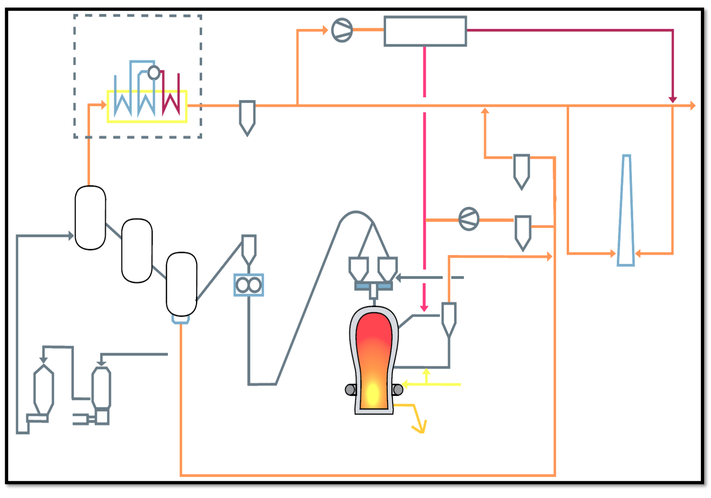
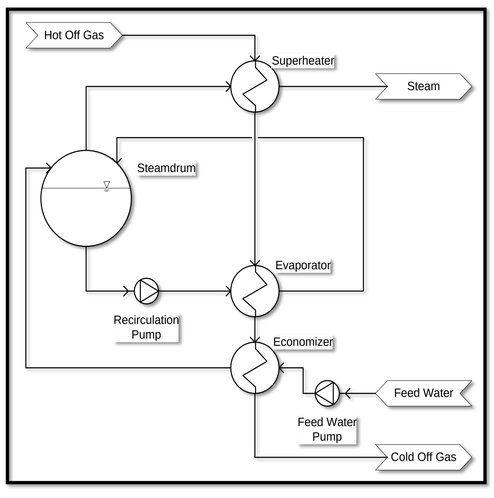
Introduction

Iron and steel production are among the most energy intensive industry sectors and therefore have a significant impact on global green house gas emissions. The demand for energy efficient production technologies increases due to the worldwide adoption of the Paris Agreement to limit global warming. Effective use of waste heat and residual process gases are therefore key technologies for modern steel works. The target of this work is the development of a model library for the simulation of waste heat recovery and water-steam power generation processes within the environment of the gPROMS ModelBuilder.

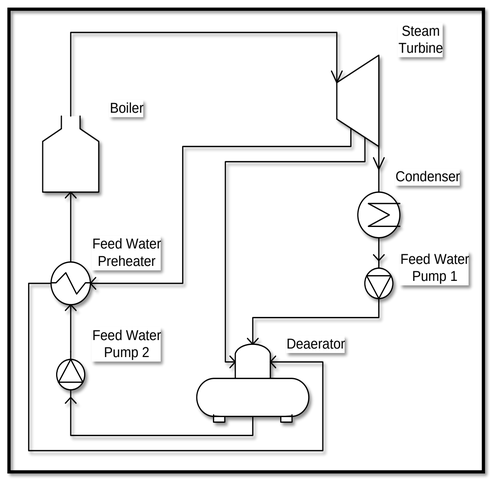
Process Description

Apart from Corex®, Finex® is the only industrially proven alternative to the conventional blast furnace route for the production of hot metal. A key aspect of this technology is the separation of reduction and melting processes steps. Reduction of fine iron ore is carried out in fluidized-bed reactors while melting of this pre-reduced material as well as gasification of coal to produce reduction gas are located in a melter-gasifier. The generated export gas exits the fluidized-bed reactors at temperatures of over 400 °C and is a valuable by-product due to is relatively high calorific heating value. In order to make use of its sensible heat, the Finex® process is equipped with a waste heat recovery steam generation system.



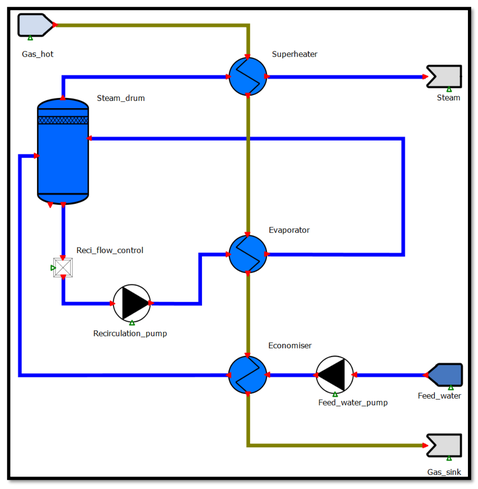


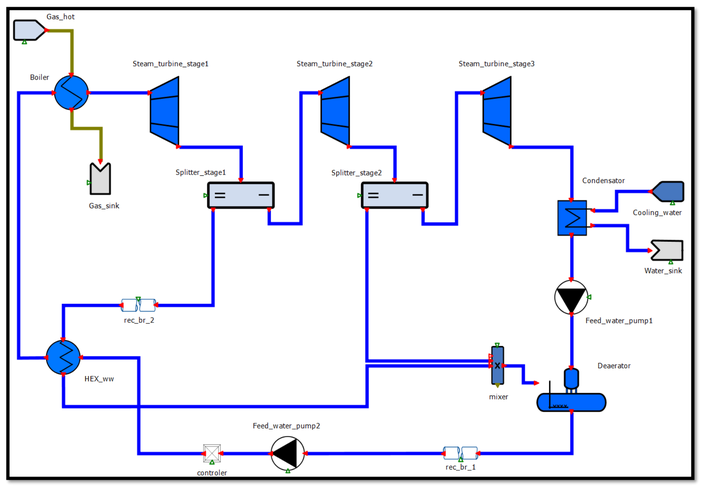
This system can be characterized as a forced circulation steam generator (boiler). The hot off gas is directed through of a series of water-gas heat exchangers while its sensible heat is transferred to the feed water which evaporates to steam in the course of this process. The produced steam is supplied to the steam network of the steel plant. A common way to utilize process gases in Corex®, Finex® and blast furnace based plants is the production of electric energy by means of water-steam cycle power generation. In this case, process gas is used as energy source of a steam generation boiler. The produced steam is directed to a steam turbine where it is expanded in order transfer its energy to an electric generator. After condensation, the resulting water is pumped the boiler thus completing the cycle. Possible extensions and improvements to this basic process include for example the application of a deaerator or feed water preheaters using steam from the turbine at varying pressure levels.



gPROMS Modelling

In the first development stage, a basic waste heat recovery system for the Finex® process was set up in the gPROMS ModelBuilder simulation platform. Based on the metallurgical model library created by Primetals Techologies and TU Wien, several modified as well as newly developed unit operation models were introduced in order to depict the specific process steps of the energy recovery system. The main emphasis was placed on the physically correct and numerically robust implementation of water-steam conditions. This was achieved by using the Multiflash foreign object interface of the gPROMS ModelBuilder as an interface to IAPWS-95 property data.





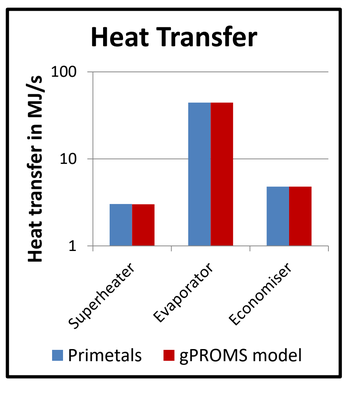
A steam drum model was used for the separation of liquid water and steam. In addition to this, water-gas heat exchanger models were implemented for preheating and evaporation of feed water as well as superheating of steam.

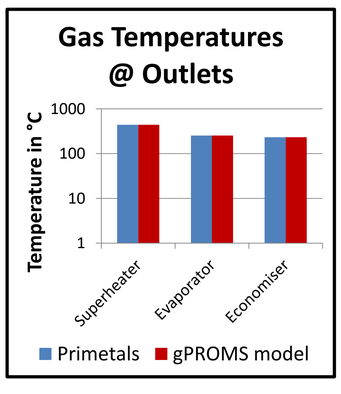
In order to extend the range of possible applications, the model library was further extended in the second development stage with deaerator, steam turbine, condensator, pressure control valve and water-water heat exchanger models. Based on this, it was possible to simulate several different water-steam cycle power generation system set ups with varying complexity.

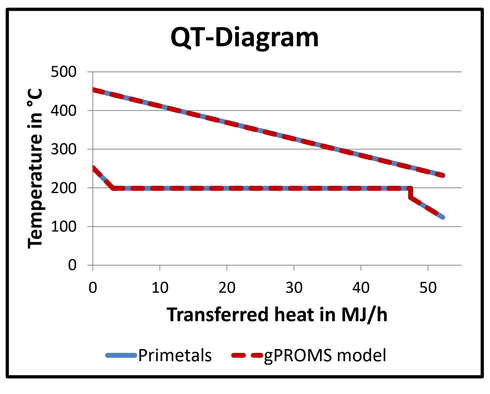
Simulation Results

The created models were validated based on calculation tools provided by Primetals Technologies and well established third party power plant simulation software.

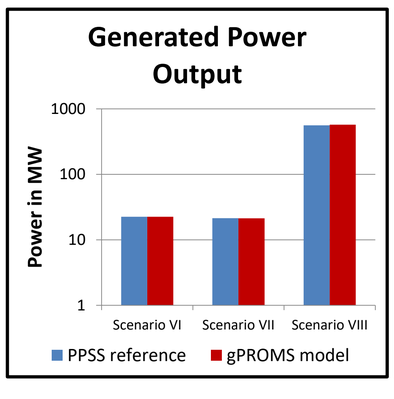
Waste Heat Recovery System:

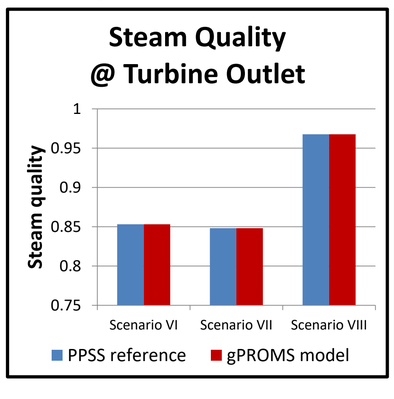


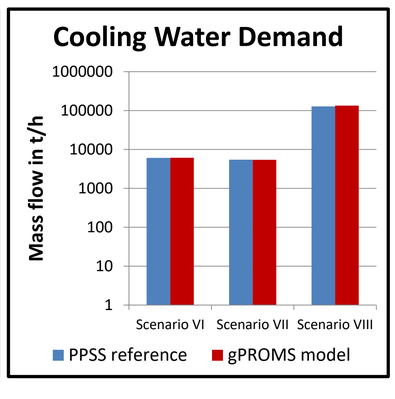




Water-Steam Power Generation Cycle:







Conclusions and Outlook

- A model library for the simulation of waste heat recovery and water-steam cycle power generation within metallurgical plants was created in gPROMS ModelBuilder.
- The simulation results are in good accordance with corresponding target values.
- Simulation of an existing power plant block is envisaged for further investigations.

Acknowledgements

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