11th K1-MET Scientific Exchange Day

2022-04-20, Montanuniversität Leoben

Franz-Josef-Straße 18, Leoben 8700, Austria

Location: Erzherzog-Johann-Auditorium, Main building, first floor

Main goal of the Scientific Exchange Day (SED) is to present current research activities and results within the COMET K1-MET program. Furthermore, the SED represents an opportunity to stimulate the interactions between the scientific and the company partners of K1-MET with plenty of time for discussions.

09:00 - 09:30 Come together, Registration

09:30 - 09:40 Welcome and Introduction (CSO Prof. Johannes Schenk)

Session 1: Presentations from the Research Areas

(Maximum time target: 20 min. Presentation, 10 min. Discussion)

Chairperson: Prof. Dr. Rüdiger Deike (University Duisburg-Essen)

09:40 - 10:10 Research Area (RA) 2: Valentin Wiesinger (K1-MET / University of Applied Sciences - Upper Austria): Influence of the slag on the remelting behaviour, energy consumption and non-metallic inclusions during Electro Slag Remelting

10:10 - 10:40 RA 3: Thomas Wolfinger (K1-MET): Hydrogen based fine ore reduction

10:40 - 11:10 RA 4: Markus Bösenhofer (K1-MET / TU Wien)
Coal reactivity under blast furnace conditions - Experiments and CFD

11:10 - 11:30 Break

11:30 - 12:00 RA 1: David Algermissen (FEhS Institut für Baustoffforschung)
Modification of BOF slag to a GBFS like material and settling behavior of granules in fayalitic slags

Session 2: Success Stories from K1-MET

(Maximum time target: 20 min. Presentation, 10 min. Discussion)

Chairperson: Dr. Valentina Colla (Scuola Superiore Sant'Anna)

12:00 - 12:30 Wolfgang Reiter (K1-MET)
Development of a scalable burner and dust feeding system within the RecoDust-process

12:30 - 13:30 Lunch

13:30 - 14:00 Andreas Spanlang (voestalpine Stahl)
Development of an Integrated Plant Simulation Model of the Midrex® Process

14:00 - 14:30 Damir Kahrimanovic (K1-MET)
Recurrence CFD - One step closer to simulation-based process monitoring

14:30 - 14:35 Closing words (CSO Prof. Johannes Schenk)

14:35 - 15:00 Closing coffee

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Abstracts Session 1

Research Area (RA) 2: Valentin Wiesinger (K1-MET / University of Applied Sciences - Upper Austria)

"Influence of the slag on the remelting behaviour, energy consumption and non-metallic inclusions during Electro Slag Remelting"

The effect of different slag compositions with a wide range of electrical conductivities was investigated regarding their general remelting behaviour, such as slag movement, slag surface temperature, and slag skin thickness as well as their impact on the removal of non-metallic inclusions. The results show a strong impact on the remelting behaviour as well as on the specific energy consumption and indicate, that a similar metallurgical behaviour is feasible despite large differences in the energy consumption.

Research Area (RA) 3: Thomas Wolfinger (K1-MET)

"Hydrogen based fine ore reduction"

The Project P3.6 "FluidRed" is dedicated to the development of a low carbon direct reduction technology for the direct use of iron ore concentrates with a grain size smaller than 150 µm. The idea is a fluidized bed using hydrogen or hydrogen-rich gases as reducing agent and iron ore concentrates in a cross-current flow. The product is Hot Direct Reduced Iron, which will be directly fed into a melting aggregate, e.g., Electric Arc Furnace, or compacted in a briquetting press for transport. The objective was and still is to develop and operate a pilot plant to confirm the proof-of-principle shown in lab scale experiments at the Chair of Ferrous Metallurgy (Montanuniversitaet Leoben).

Research Area (RA) 4: Markus Bösenhofer (K1-MET / TU Wien)

"Coal reactivity under blast furnace conditions - Experiments and CFD"

Application of multi-scale, multi-physics Computational Fluid Dynamics (CFD) to lab scale equipment provides a unique possibility to obtain additional insight to the occurring phenomena and can help to understand and explain experimental results. Reproducing blast furnace conditions in a lab scale set-up and extracting coal reactivity data under these conditions is a challenging task. Suitable CFD models can support the verification of the prevailing conditions in such equipment.

During a research stay at the Combustion Research Facility of the Sandia National Laboratories, a digital twin of Sandia's Pressurized Entrained Flow Reactor (PEFR) was created. The twin was then used to investigate gasification experiments of coal char particles previously conducted in the PEFR. The modelling results revealed significant inhomogeneity in the temperature and flow field and residence times deviating from plug flow assumption, vastly influencing the evaluation of experimental data, e.g., extraction of kinetic parameters. These lessons learned are incorporated into sophisticated evaluation methods for a new Alternative Reducing Agents (ARA) Reactor jointly developed by voestalpine Stahl, voestalpine Stahl Donawitz, Primetals Technologies Austria, TU Vienna, and K1-MET.

Research Area (RA) 1: David Algermissen (FEhS)

"Modification of BOF slag to a GBFS like material and settling behavior of granules in fayalitic slags

A modification of BOF slag can produce a new product, that is suitable for the cement industry. By using reducing agents and optimizing the basicity with a following water granulation, the slag becomes latent hydraulic properties, like a Granulated Blast Furnace Slag (GBFS), to substitute Portland cement in the cement industry. Therefore, this material can save CO_2 emissions and natural resources. Also, the

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optimization of metal output in the copper industry is investigated. Minimizing the metal granules in fayalite slags increases the efficiency of a process and saves energy and resources.

Abstracts Session 2

Wolfgang Reiter (K1-MET)

„Development of a scalable burner and dust feeding system within the RecoDust-process“

The RecoDust process treats dusts from the Basic Oxygen Furnace (BOF) containing ~1 wt.% of the valuable metal iron from the entire crude steel production. These dusts, often contaminated with heavy metals, such as zinc, are currently landfilled, partially internally recycled, or processed by external companies. In any case, a pre-treatment is necessary, e.g., to fulfil transport requirements.

With this background, the RecoDust-process was developed as joint research activity between voestalpine Stahl, Montanuniversitaet Leoben (Chair of Thermal Processing Technology), and K1-MET. RecoDust allows the direct use of BOF dusts without any additional treatment by separating the BOF dust feed into two main fractions, which are an iron rich slag and a zinc rich filter dust. In a pilot plant, operated in the technical center of the Chair of Thermal Processing Technology at the Montanuniversitaet Leoben, first campaigns were executed with a throughput of 100-250 kg/h. Extensive dust characterizations and pneumatic conveying tests were carried out for the upscale to a target size of 1,000 kg/h. Together with the German E.S.C.H. GmbH, a pneumatic conveying system was developed with natural gas acting as fuel and transport medium. This new burner/dust unit is currently used to get the design for a 1,000 kg/h industrial plant. After the installation of the whole pneumatic conveying system at the pilot plant, test trials were done successfully.

The RecoDust-process is considered as part of an economic and resource-saving plant management and therefore contributes to a zero-waste strategy regarding dust management of an integrated steel plant.

Andreas Spanlang (K1-MET / voestalpine Stahl)

“Development of an Integrated Plant Simulation Model of the Midrex® Process”

Since its start-up in 2016, the Midrex® plant of voestalpine Texas LLC has steadily increased HBI production rates and product quality levels. To ensure optimal daily operations, reliable raw material data, process condition measurements, and continuous process optimisation are required. All these aspects are managed with the help of existing Level 1 and Level 2 automation systems. Until recently, a comprehensive representation of the full Midrex® process was however not available. For this purpose, the decision was made to develop a predictive plant model, which would be able to depict the complete process chain including reformer, top gas scrubber, heat exchangers, and compressors.

The development process of the plant model was divided into several work packages directly focusing on the proper implementation of the separate unit operations first. This was supported by an extensive analysis of plant data and a review of existing process control schemes. In the following, the overall plant model was set up and calibrated.

After being introduced on site, the plant model has successfully been used to assist in daily operation, for the investigation of possible measures to improve HBI quality and during the planning phase for several plant tests. In the next development phase, additional functionality shall be added to the plant model to improve on its predictive capabilities.

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Damir Kahrimanovic (K1-MET)

“Recurrence CFD - One step closer to simulation-based process monitoring”

Due to the highly complex calculation and interpolation algorithms, conventional CFD is only able to simulate relatively short periods of time. In industrial applications, these periods are even shorter due to the large and/or complex geometries and the constantly increasing demands on the mesh fineness. For this reason, a novel approach was proposed, which saves computational time for variables that have recurring patterns on smaller time scales (e.g., velocity, pressure, turbulent quantities). Only variables that change on larger time scales are calculated, thus decreasing the computational time down by several orders of magnitude.

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