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PROFESSORSHIP FOR MODELING OF THERMOCHEMICAL CONVERSION PROCESSES

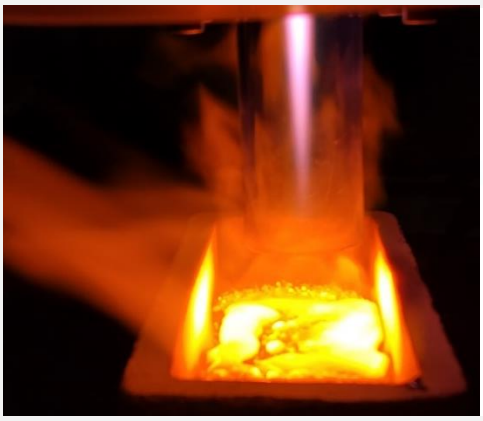
TITLE

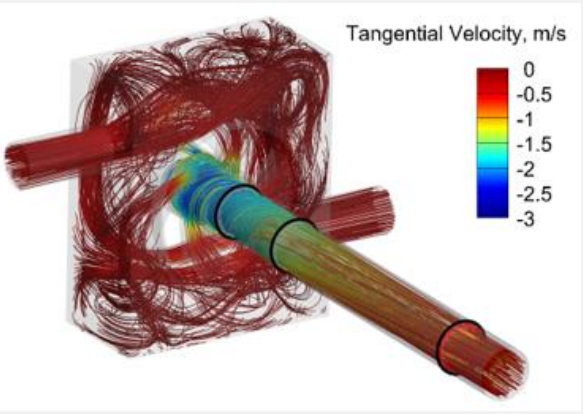
Model-based Investigation of Plasma-assisted MnO_2-Reduction

DESCRIPTION

Manganese is an important alloying element in steel production. At the same time, the recycling of raw materials and the transition towards a circular economy are becoming increasingly important. However, the reduction of manganese oxides into metallic manganese using hydrogen is thermodynamically limited. Therefore, alternative approaches involving highly reactive hydrogen plasma are being investigated to improve the reduction process. This project focuses on the model-based investigation of the in-flight reduction of manganese dioxide (MnO_2) using hydrogen plasma.

As a first step towards the construction of an experimental test facility, numerical simulations will be conducted to investigate the process and support the design of the experimental setup. The project will be carried out in collaboration with the Institute of Non-Ferrous Metallurgy and Purest Materials (INEMET), which will provide expertise in understanding the underlying processes and support regarding technical questions concerning metal oxide reduction. The main focus of the work, however, will be on the numerical modelling of the system. This part will be supervised by the Institute of Energy Process Engineering and Chemical Engineering (IEC), specifically the Chair of Modelling of Thermal Conversion Processes.





Requirements and qualifications:

- Basic knowledge of computational fluid dynamics (CFD) is beneficial, particularly experience with ANSYS Fluent.
- Experience in creating three-dimensional geometries using CAD software is required.
- A fundamental understanding of thermodynamics, fluid mechanics and physics is expected, specifically in the context of high-temperature processes.
- Knowledge of metallurgical processes, particularly the reduction of metal oxides, is beneficial.
- Simulations will be performed on the Freiberg High-Performance Computing (HPC) cluster; basic knowledge of Linux is therefore beneficial.

The scope of the work corresponds to a master or diploma thesis and may be undertaken by students in Faculty 4 or 5. The thesis can be written in English or German. The examiners of the thesis will be Prof. Andreas Richter (IEC-MTK) and Prof. Alexandros Charitos (INEMET).

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TASKS

The following work packages are to be completed as part of the thesis:

Work Package 1 – Literature Review

- Review of the current state of research on plasma-assisted reduction of metal oxides, with a particular focus on manganese oxides.
- Review of modelling approaches for plasma-based multiphase systems (gas–solid), with a focus on the Discrete Phase Model (DPM) and entrained-flow configurations.
- Identification and evaluation of suitable chemical reaction mechanisms for N_2–H_2 gas mixtures.
- Review of heterogeneous reaction mechanisms describing the reduction of MnO_2 by H_2.

Work Package 2 – Model Development and Extension

- Implementation and evaluation of the identified reaction mechanisms using the existing gas-phase plasma model.
- Extension of the existing gas-phase model to account for a discrete solid particle phase.
- Investigation of the following key parameters:
  - Temperature distribution within the reactor.
  - Particle trajectories, motion and residence times.

Key Research Questions

- Is the in-flight reduction of MnO_2 in a microwave plasma fundamentally feasible?
- What are the main limiting factors affecting the reduction process?
- Which modifications to the reactor configuration and operating conditions may be required to achieve effective in-flight reduction?
- Potential modifications that could be investigated:
  - Extending the reactor length or developing an alternative reactor design
  - Varying the particle size
  - Adjusting the gas volume flow rate and plasma power.

CONTACT



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