CSC-RUB PhD Project Proposal

Title: Application-oriented optimization of high-alloy tool steels through statistical microstructural reconstruction and design

Sector of research: Materials Science and Engineering

Degree awarded: Dr.-Ing. / PhD

Keywords: statistical characterization; optimization; high-alloy tool steels; stereology; finite element analysis; powder metallurgy

Supervisor of PhD project: Prof. Dr.-Ing. Sebastian Weber, e-mail: sebastian.weber@rub.de

Research focus of supervisor:

The focus of my research is related to metallic materials, particularly high-alloy Fe-base systems. At the chair of materials technology, we develop new materials and optimize existing ones, assisted by several simulation methods, including the necessary manufacturing processes. A particular emphasis of my work is in the field of high-alloyed PM steels produced by inert gas atomization, hot isostatic pressing and additive manufacturing. Furthermore, high-nitrogen and high-interstitial steels are developed and investigated intensively including both, conventional and powder metallurgy. A conjunctive aspect of all research topics at the chair of materials technology is the correlation of chemical composition, primary processing, thermomechanical treatment, material and energy consumption, resulting microstructures and properties. Besides, all relevant aspects of technical application including aspects of circular economy are considered.

Publications:

Microstructural Changes During Short-Term Heat Treatment of Martensitic Stainless Steel--Simulation and Experimental Verification, Norina Schmidtseifer and **Sebastian Weber**, Metallurgical and Materials Transactions A (2021), Volume 22A, Issue 8, DOI: 10.1007/s11661-021-06280-y

Uncovering process-structure relationships associated to the hot isostatic pressing of the high-speed steel PMHS 3-3-4 through novel microstructural characterization methods, Santiago Benito, Johannes Boes, Michele Matsuo, **Sebastian Weber**, Werner Theisen, Materials & Design (2021), Volume 208, 109925, DOI: 10.1016/j.matdes.2021.109925

Hard Cladding by Supersolidus Liquid Phase Sintering: An Experimental and Simulation Study on Martensitic Stainless Steels Peter Kayode Farayibi, Michael Blüm and **Sebastian Weber**, Metallurgical and Materials Transactions A (2020), Volume 21, Issue 5, DOI: 10.1007/s11661-020-05953-4

Development of a recycling strategy for grinding sludge using supersolidus liquid phase sintering, Jonas Hankel, Sebastian Jäger and **Sebastian Weber**, Journal of Cleaner Production (2020), Volume 263, DOI: 10.1016/j.jclepro.2020.121501

A Computational Approach to the Microstructural Design of High-Speed Steels, Gero Egels, Nils Wulbieter, **Sebastian Weber**, Werner Theisen, Steel Research International (2019), Volume 91, Issue 5, DOI: 10.1002/srin.201900455

Summary of research plan (ca. 300 words):

Background: We use tool steels to shape other materials to our convenience and thus constitute the backbone of modern manufacturing processes. They face cyclic mechanical loads and temperatures, and operate in corrosive and highly abrasive environments. These boundary conditions directly specify that tool steels must exhibit a precise application-driven balance of strength and toughness; two stark contrasting properties. In addition, cost-efficiency, scarcity, and environmental concerns render the tailored alloy development particularly challenging. With so many operation-related variables and numerous degrees of freedom in the manufacturing and processing spaces, computational optimization methods appear to be the preeminent means to fulfilling this overarching task. The combination of finite element analysis (FEA), microstructural characterization and reconstruction (MCR), thermodynamic simulations, and flexible optimization routines presents a thoroughly encouraging possibility. Nevertheless, recent studies on the relation between processing parameters, microstructural features and macroscopic properties revealed that the current applied models do not account for all critical pieces of the puzzle.

Study objective: The goal is to develop a flexible tool steel optimization platform wrapping finite element method models, artificially generated microstructures, and thermodynamic simulations of the manufacturing and heat treatment steps.

Expected Results: The developed optimization platform and artificially generated microstructure models will provide both (i) a novel way to approach application-oriented material design, and (ii) provide insightful data to understand the complex relations between chemistry, processing, microstructure, properties, and system performance.

Methods: finite element analysis; numerical optimization; thermodynamic, diffusion and nucleation simulations; statistical characterization

Candidate Requirements:

- Outstanding program achievement in Materials Science and Engineering
- Substantial knowledge of the physical metallurgy of Fe-base materials
- Thorough understanding of thermomechanical finite element analysis.
- Solid MATLAB® and Python programming skills.
- High level of spoken and written English.

Motivation for CSC application: The successful candidate will be working at the Chair of Materials Technology (Lehrstuhl Werkstofftechnik, LWT) at the Ruhr-University Bochum. LWT belongs to the School of Mechanical Engineering and is part of the Institute of Materials (IM) as well as of the Materials Research Department (MRD) at the RUB. At LWT and IM, the successful candidate will find all state-of-the-art processing and characterization methods in the field of Materials Science and Engineering with a particular emphasis on technologically relevant metallic materials. Besides the excellent technical equipment and facilities, we offer the opportunity to work in a new and exciting field of research, in an open, appreciative and constructive working atmosphere. We aim to provide students with an international and interdisciplinary platform to conduct high-level scientific research.