Titanium carbide-based cermets bonded with Fe-alloys for various wear and corrosive conditions

Summary

The proposed PhD thesis focuses on the study and development of titanium carbide (TiC) based ceramic-metal composites bonded with Fe-alloys thought for various wear and corrosive conditions. The work assumes both theoretical (phase modelling, etc.), as well as practical (synthesis of materials, characterisation, wear testing, etc.) tasks. The project addresses the following research questions: (1) what are the most promising chemical combinations of the binder phase of TiC-based cermets to ensure the wear and corrosive resistance and (2) to improve the understanding of the role of additional strong carbide forming elements on the microstructure formation of TiC-based cermets.

Research field:	Production and materials engineering, robotics, transport and logistics
Supervisors:	Dr. Kristjan Juhani Dr. Märt Kolnes
Availability:	This position is available.
Offered by:	School of Engineering Department of Mechanical and Industrial Engineering
Application deadline:	Applications are accepted between January 02, 2023 00:00 and January 22, 2023 23:59 (Europe/Zurich)

Description

The most recognised ceramic-metal composites are based on tungsten carbide (WC) cemented with more tough cobalt. Composites based on titanium carbide cemented with Ni and Ni-alloys are also known. However, from the outlook of healthcare, economic importance and supply risk, utilisation of raw materials like tungsten, cobalt and nickel should be reduced or replaced with other metals. In addition, substitution of critical raw materials (CRM) will be essential in the future manufacturing value chain. Unlike Co, classified in the EU as toxic critical raw material (CRM) and allergenic Ni, Fe is abundant and non-toxic alternative.

Therefore the main motivation of the proposed doctoral project stems from the need for W-, Ni- and Co-free biocompatible wear and corrosion resistant cermets replacing regular WC-Co hardmetals. The goals of the project are to improve understanding of structure formation processes and based on this knowledge, to develop Fe-alloys bonded TiC-based composites with tailored structure and performance for a wide range of application conditions. The solutions proposed within the scope of the project will pave a way for production and application of wear parts and tools made from “green” (healthcare and environmental safety considerations) and “abundant” (used raw materials considerations) wear resistant composites.

The results of the study will provide answers to crucial problem in the hard materials industry related to the potential of replacing conventional WC-Co hardmetals with W-, Ni- and Co-free TiC-based cermets with Fe-based binders as “green” (non-toxic) and “abundant” (not consisting CRM-s) alternative. Throughout his/her studies, the PhD candidate will employ various powder metallurgical technologies and characterisation methods. Additionally, the PhD candidate must co-author at least three scientific papers on the topic of the doctoral thesis, whereas two of which must be published in Q1 and/or Q2 (SCImago) journals. The PhD student is also expected to spend at least one semester at a research centre outside Estonia (through Erasmus+ or another program) during his/her study. Apart from that, the PhD student should be ready to supervise bachelor and/or master student(s), as well as to take part in other teaching activities.

Applicants should fulfil the following requirements:

- MSc. or an analogous degree in mechanical or chemical engineering;
- Adequate understanding of how microstructure features like grain size, etc., and phase composition of a material affect its properties e.g. mechanical properties, corrosion resistance;
- Is competent in phase diagrams, and can describe the microstructure formation on their base;
- A clear interest in the topic of the position;

- Excellent command of English;
- Strong and demonstrable writing and analytical skills;
- Capacity to work both as an independent researcher and as part of an international team;
- Capacity and willingness to provide assistance in organizational tasks relevant to the project.

The following experience is beneficial:

- Previous experience working with ceramic materials and/or powder metallurgy;
- Experience with optical and scanning electron microscopy;
- Experience with x-ray diffraction analysis;
- Experience with different corrosion tests.

We offer:

- Excellent opportunities for performing high quality research during 4-year PhD position;
- An informal and inclusive international working environment, green campus approach, a flexible schedule and modern office facilities located in Tallinn;
- Individual development and training opportunities;
- Opportunities for conference visits, research stays and networking with globally leading universities and research centres.

About the department

The department of Mechanical and Industrial Engineering focuses on the engineering side of self-driving vehicles, developing new material systems and coatings and additive manufacturing developments. The curriculums on Bachelor, Masters and Doctor level have hundreds of graduates each year.

The Wear Resistant Composites and Coatings research group in our department brings together leading scientists and PhD students to form a vibrant and collaborative environment for research into materials engineering. The R&D activities of the research group have been focused mainly on the following research topics and related industrial applications: (a) Co- and Ni-free WC-based cemented carbides with alternative (considering critical materials supply, environmental safety and healthcare aspects) Fe-based metallic binders; (b) W-free, TiC- and Ti(C,N)-based cermets with alternative Fe-based binders; (c) ceramic-matrix composites based on refractory compounds of Ti; (d) Fe-based composite hardfacings with ex situ and in situ synthesized carbide reinforcements; (e) diamond-based thin coatings; f) technology of additive manufacturing of TiC-Fe cermets.

Additional information

For further information, please contact Märt Kolnes mart.kolnes1@taltech.ee or visit https://taltech.ee/en/department-mechanical-and-industrial-engineering

To get more information or to apply online, visit https://taltech.glowbase.com/positions/616 or scan the the code on the left with your smartphone.