Ceramic-metal composites as tool materials for friction stir welding of high melting metals

Summary

The Doctoral thesis topic focuses on the study and development of potential ceramic-metal composites as tool materials for friction stir welding of high melting point metals, like steel, stainless steel etc. The work assumes both theoretical (modulation of processes, simulation etc.), as well as practical (materials characterisation, wear testing, welding tests etc.) tasks. The project addresses the following research topics: (1) to define the most promising ceramic#metal composites as tool materials for friction stir welding of high melting point metals and (2) to improve the understanding of the FSW welding processes and FSW tool wear mechanisms. The project results will be validated by the industrial partner.

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

Description

Friction stir welding (FSW) as solid-state welding technique, in comparison with other welding methods, has low environmental impact and ensures high quality of joints welding difficult-to-weld metals (e.g., stainless steel, aluminium, copper etc.) in the conditions of proper welding regimes. FSW application is widening in the transport industries, automotive, aerospace and other industries. Tool materials along with their mechanical properties are critical for a high quality of FSW joints and process efficiency. The selection of FSW tool material depends on the joining workpiece metal, joint geometry (base metal thickness) and processing parameters. In addition, from the outlook of economic importance and supply risk, utilisation of abundant and non-toxic raw materials will be essential in the future manufacturing value chain.

Therefore, the main motivation of the proposed doctoral project stems from the need to develop, select and use reliable, durable, and cost-effective tool materials for the FSW of high melting point metals. The goals of the project are to improve understanding of tool degradation and tool-workpiece interaction mechanisms and based on this knowledge to develop “green” FSW tools (wear resistant, recycling of powder metallurgy based materials) for a wide range of application conditions. The solutions proposed within the scope of the project will pave a way for significant increase of tool lifetime by improving the tool material and tool geometry.

The results of the study will provide answers to crucial problem in FSW of high melting point metals related to the potential of replacing conventional tools materials (consumable and non-consumable electrodes) with “green” (non-toxic) and “abundant” not containing critical raw materials alternatives. Throughout his/her studies, the PhD candidate will employ various powder metallurgical technologies/techniques, characterisation methods and FSW technologies. Additionally, the PhD candidate must publish as author or 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 engineering or Materials engineering;
- Adequate understanding of how phase composition of a material affects its properties, microstructural evolutions during welding and wear mechanisms;
- 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 FSW;
- Knowledge and experience in the field of ceramic materials and powder metallurgy;
- Experience with optical and scanning electron microscopy;
- Experience with different mechanical and wear testing.

We offer:

- Excellent opportunities for performing high quality research during 4-year PhD position;
- An informal, supportive 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 (abbreviation EM) 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 EM 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) development of FSW tools; (g) technology of additive manufacturing of TiC-Fe cermets.

For further information, please contact Mart Kolnes mart.kolnes@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/715 or scan the the code on the left with your smartphone.