Tungsten-free TiC-based cermets with "green" iron-based binders

Summary

The aims of the doctoral thesis project are: (1) to improve understanding of the powder preparation (milling) and hot consolidation (sintering) of starting powders of Fe-alloys bonded TiC-based composites (cermets); (2) engineer and characterize the Fe-alloys bonded TiC-based cermets; (3) to develop of industrially applicable fabrication technologies (both conventional and additive manufacturing) for production of prototypes and products from developed ceramic-metal composites.

Research field:	Mechanical engineering
Supervisors:	Fjodor Sergejev Dr. Kristjan Juhani
Availability:	This position is available.
Offered by:	School of Engineering Department of Mechanical and Industrial Engineering
Application deadline:	Applications are accepted between June 01, 2020 00:00 and July 03, 2020 23:59 (Europe/Zurich)

Description

WC-Co hardmetals are widely used as cutting tools and wear resistant parts. The alternative materials are composites based on titanium carbide (TiC) and carbonitride (Ti(C,N)) cemented with Ni and Ni-alloys, also known as cermets. Co and W in hardmetals are critical raw materials (CRM) of the EU. Additionally in Europe Co have classified as toxic and Ni, commonly used in W-free cermets, allergenic and carcinogenic (REACH program), thus motivating to find alternative material systems for WC-based hardmetals. Therefore the motivation of planned doctoral study stems from: (1) raw materials supply and price and (2) healthcare and environmental safety considerations. Both are considered in Strategic Research Agenda of EuMaT. Substitution of critical raw materials (CRM) will be essential in the future manufacturing value chain. The main motivation of the proposed doctoral study is the need for W-, Ni- and Co-free biocompatible cermets replacing regular WC-Co hardmetals.

Using non-toxic titanium carbide and iron are possible solutions for replacing CRM-s in ceramic-metal composites. Fe and Fe-alloys as a prospective substitutes for Co and Ni as binder materials in ceramic-metal composites has so far largely been disregarded because of mechanical properties. However, it has advantages over Co and Ni, such as low cost, heat treatment potential, and high strength. Shortcomings related to processing could be improved by proper choice of components and preparation techniques.

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. The main outcomes generated during the study are: (1) developing new “green“ and reliable wear and corrosion resistant ceramic-metal composites and (2) related powder metallurgy technologies for their production.

Responsibilities and tasks:

- Prepare a research plan within the scope of the PhD project topic with the help of the supervisor and carry out research according to the plan.
- Actively present, disseminate and publish research results.

Qualifications:

- MA degree in Metallurgy or Materials Engineering with strong conceptual knowledge about Powder Metallurgy.
- Skills and experience in materials microstructural characterization (optical microscopy, SEM, XRD etc.) by use of quantitative methods.
- Good speaking and writing in English skills, as all the study and scientific communication, incl publishing, processed in English language.

The applicants should fulfill the following requirements:

- Materials testing skills are not prerequisite but beneficial as all produced cemented carbides will be tested for characterization of the materials mechanical properties: strength (TRS, fracture toughness, hardness), wear resistance (erosion, abrasion, adhesion, corrosion) and fatigue.
- Some industrial testing may be required also.

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