Tribology and Mechanical Behavior of Coatings and Engineered Surfaces
Room Town & Country B - Session E1-3-WeA

Friction, Wear, Lubrication Effects, and Modeling III

Moderators: Noora Manninen, Oerlikon Balzers, Oerlikon Surface Solutions AG, Liechtenstein, **Andreas Rosenkranz**, Andreas Rosenkranz, Universidad de Chile

2:00pm **E1-3-WeA-1 Critical Materials-Free Cermet Coatings by Thermal Spraying: Sliding and Abrasive Wear Behaviour (Virtual Presentation)***, **Giovanni Bolelli (giovanni.bolelli@unimore.it)**, Unimore, Italy* **INVITED**

Cermet coatings provide resistance against sliding and abrasive wear in e.g. petrochemical valves, papermaking rolls and blades, pump parts, rotary joints and sliding elements of high-speed automatic machinery, etc.

The better-known compositions are based on WC and/or Cr_3C_2. WC-Co-based compositions possess excellent wear resistance at room and moderate temperatures; however, they present two types of criticalities. W and Co are regarded as critical raw materials by many industrialized countries, due to the risk for supply shortages (primary production being concentrated in few manufacturing countries) together with their strategic relevance. On the other hand, Co is now labelled as probable human carcinogen (cat. 1B). This increases the workplace safety requirements. There might also be risks for end-users if fine particulate debris is released. Synergistic effects between Co and WC increase further the inhalation health risk.

Cr_3C_2-NiCr, employed for high-temperature applications and/or corrosion resistance, could alleviate the issues with W and Co, despite the hazardousness of Ni itself, and the potential release of volatile Cr compounds during spraying. However, its low-temperature wear resistance is no match for WC-based materials.

This contribution summarises the authors' recent research on potential alternatives, following two distinct approaches:

-Coatings from commercially available or experimental powder formulations based on WC with Co-free (or nearly Co-free) matrices based on Ni (e.g. WC-NiMoCrFeCo) and/or Fe (e.g. WC-FeNiCrMoCu, WC-FeCrAl).

-Coatings where both Co and WC are replaced. The work has mostly been focused on TiC-based compositions with matrices such as Ni-20Cr, Fe-Cr-Al, or Fe-Ni-Cr alloys.

Results obtained so far show that, in sliding wear applications and/or under corrosive conditions, WC-based hardmetals with Co-free matrices can be a viable replacement for WC-CoCr, matching or sometimes even surpassing its performance. The sliding wear resistance of TiC-based coatings is intermediate between WC-CoCr and Cr_3C_2-NiCr ones, and they are serviceable up to at least 400 °C. So, they could suit a range of low- to intermediate-temperature applications, when the extreme wear resistance of WC-based materials might not be needed. Drawbacks and limitations to be overcome include the tendency of TiC-based formulations to oxidize during thermal spraying, which induces brittleness and impairs the resistance to coarse particles' abrasion.

2:40pm **E1-3-WeA-3 Tribological Behavior of Zirconium Coated Ti-6Al-4V by Pack Cementation***, **Beyza Öztürk (beyza.oeztuerk@dechema.de)**, L. Mengis,* DECHEMA Research Institute, Germany*; D. Dickes, U. Glatzel,* University of Bayreuth, Germany*; M. Galetz,* DECHEMA Research Institute, Germany

The Ti-6Al-4V alloy is used in aerospace, automotive or biomaterial applications due to its excellent mechanical strength and corrosion resistance as well as biocompatibility. However, its poor tribological behavior limits its applications. In this study, zirconium coatings are produced on Ti-6Al-4V by pack cementation process at 700, 900 and 1050 °C for 5 h with the goal to form ZrO_2 on the surface. After that, coatings are examined by optical microscopy (OM), electron microprobe analysis (EPMA) and X-ray diffraction (XRD) techniques. The wear behavior of uncoated and zirconium coated Ti-6Al-4V against Si_3N_4 is studied under dry sliding conditions in the temperature range of RT-600 °C using a ball-on-disc tribometer. Finally, the wear mechanism of the tribopair is investigated by scanning electron microscopy with an energy dispersive X-ray analyzer (SEM/EDX) and profilometry.

3:00pm **E1-3-WeA-4 Study of Electrochemical and Tribological Properties of Electrophoretic Deposited Thin and Thick Graphene Coatings on Pure Titanium Substrate***, **Madhusmita Mallick (madhusmita1509@gmail.com)**, A. N,* Indian Institute of Technology (IIT), Madras, India

Titanium and its alloys have been used widely in various sectors owing to their exceptional properties of light weight, high strength and biocompatibility. However, their poor abrasion and corrosion resistance behaviors are major cause of concern. To mitigate these problems, graphene protective coatings were applied. Therefore, this study focusses on improvement of both corrosion and wear resistance properties of commercially pure-Ti (grade 2) by electrophoretic deposited (EPD) graphene coatings. The effects of different coating thickness and morphology on the electrochemical and tribological performance were investigated. The test results revealed that the smooth and compact microstructure of thin graphene coating of thickness 2.16 µm exhibited superior corrosion resistance and lubricating properties (COF=~0.02) compared to thick graphene coating of thickness 11.8µm (COF=~0.17). However, thick graphene coating demonstrated higher durability of its lubricating behavior and good wear resistance property. Nevertheless, both graphene coatings showed significant improvement in both corrosion and wear resistance properties of bare Ti substrate for various industrial applications.

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