WC/Co Tools Replacement with Ceramic Matrix Composites

Sebastian Balos¹, Magdalena Szutkowska², Maria Luisa Grilli³, Maria Letizia Ruello⁴

¹University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, 21000 Novi Sad, Republic of Serbia
²Institute of Advanced Manufacturing Technology, Centre of Materials Engineering and Sintering Techniques, ul. Wroclawskas 37a, 30-011 Kraków, Poland
³Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Casaccia Research Centre, Via Anguillarise 301, 00123 Rome, Italy
⁴Università Politecnica delle Marche, Department of Materials, Environmental Sciences and Urban Planning (SIMAU), Via Brecce Bianche 12, 60131 Ancona, Italy

WC Replacement problem

- WC particles bonded with Co represent one of the crucial critical raw materials for European Union
- WC/Co tools are of great importance for machining
- Co can be replaced by Ni
- W can be partially replaced by Al₂O₃

WC/Co Advantages

- WC/Co main advantage is the convenient combination of hardness and fracture toughness:
  - Fracture toughness can be in the order of 5 – 25 MPa²/³ depending on the Co content
  - Flexural strength around 2000 MPa

Alternative 1: Ceramics reinforced with whiskers

- Whiskers are short fibers with a diameter of 0.2 – 1 µm and the length of 5-50 µm, usually SiC
- The main impact on the ceramic matrix is the increase in fracture toughness
- This can be used for increasing the attractiveness of cheap ceramics, such as Al₂O₃
  - Al₂O₃ reinforced with whiskers can reach fracture toughness of around 10 MPa²/³, which is within the WC/Co values, but flexural strength is up to 800 MPa

Alternative 2: Nanoceramics

- Nano particles (up to 100 nm) incorporated into micro or even nano powder ceramics.
- A cheaper alternative to whiskers
- Potentially lower fracture toughness, but a higher flexural strength

Alternative 3: Combined ceramic based composites

Combined whiskers and nano particles: Al₂O₃ + SiCw + TiCnp

- [Table III of Mechanical Properties of Nanocomposites]

SUMMARY:

- Ceramics reinforced with whiskers, nanoceramics and combinec ceramicbased composites can be an alternative to WC/Co tools
- Partial replacement is possible at this state of art, for less stressed cutting tools (fine machining)
- Rough machining has still to be done with WC/Co tools due to their superior combined mechanical properties