TOOL MATERIALS FOR HIGH SPEED CUTTING PROCESS

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Background problems

One of the main factors of production engineering development is environmentally-friendly machining, minimal lubrication technique, high speed machining. Cutting tools are viewed as critical part of the overall machining system for making continued improvements in overall productivity. Cutting tool producers are continually obligate to modify their products in order to perform at high speeds, cut deeper, and prolong tool life for increasingly rigorous operating conditions and for machining of different materials difficult for cutting. The main modification of ceramic tool products are related with whiskers reinforcing and obtaining fine grained microstructures of materials. The products containing unwholesome materials are produced and purchased. For example, cobalt, widely used for production of cutting tools, is classified as toxic. The tests of people, who were exposured to a mixture of cobalt with carbides or diamond, showed an excess risk of bronchopulmonary cancer and skin allergies.

. Hard-metals still control almost 50% of the market. Polycrystalline diamond compacts, ceramics and cubic boron nitride compacts still represent only about 7-8 % of the cutting tool market. CVD (Chemical Vapor Deposition) PVD (Physical Vapor Deposition) and others ceramic coatings have been commercially available for about 30 years. Coatings reduce frictional heat and promote longer tool life. In situation where the hardened workpiece does not have roughness or other interruptions, the coated inserts offer good cutting properties and lower cost. Otherwise the using of ceramic sintering materials is more advantageous.

New workpiece materials, difficult to cut, cause the tools become more susceptible to wear, because their temperature rises with frictional heat. To prevent such a temperature rise, coolants are applied to the tools. The main tendency is to stop using coolants in machining process. The result has been a growing demand for more thermally resistant tools. Ceramic tools have mainly been used as environmentally-friendly cutting tools, because they have particularly high temperature limit and allow dry cutting without or with limited quantity of coolant.

Benefits

The main aim of the grant is to develop the integration of research groups in Poland for future research projects related with **high quality, environmentally-friendly ceramic cutting materials** (nanomaterials, functionally graded materials, ceramic coatings and others) and responses to developments in European environmental and health legislation. The major negative aspects of the ceramic inserts are their brittleness, poor resistance to thermal shocks and a lack of wetting by most liquid alloys. Generally, the cutters do not hold up well to interrupted cuts or thermal shock; there is problem with the ceramic cutters joining to body frame of tools. However, actually there are new technological possibilities improving the ceramic cutting materials properties such as nanopowders sintering, whiskers addition, or new chemical composition. It is possible to design materials with high hardness and improved fracture toughness while ceramic materials could become the main group of cutting materials. The main benefit of the project is to increase the knowledge about new ceramic cutting materials, about possibilities of the ceramic properties improving.

Objectives

The main objective is to create the scientific platform which is crucial for the development of new generation of ceramic cutting materials and tools. The research program, therefore, will focus on four main issues: 1) new methods of obtaining ceramics, 2)improving ceramic properties, 3)wetting and

interfacial phenomena in processing of cutting tools and 4) materials and tools characterization.

The research will give attention to such industrially important ceramics as alumina, nitrides, carbides, borides, diamond, cBN, cermets, their mixtures and ceramic coatings.

Scientific programme and innovation

The grant is constructed around the four objectives listed above. The first objective is addressed to the technological problems of production of nanoceramics, FGM, ceramic composites using advanced methods of the materials manufacturing. The second objective is devoted to different methods of improvement in materials properties, including fracture toughness, thermal shock resistance and brazing properties. This objective is directed to scientists working on design of new materials. The third objective will met through investigation of structural characterization of interfaces in new materials. Last objective is addressed to complex investigation of properties of new generation cutting tool materials including, their physical, mechanical, tribological and cutting properties as well as high temperature stability and thermal shock resistance.

The innovation of this grant is the development of a new family of cost-effective and environmentally-friendly ceramic materials for cutting tool applications, especially dedicated to the high speed machining of the difficult to cut materials for the high efficiency processing and good quality of machining workpiece.

Organization

The scientific program of the project will be structured into five Working Groups (WG) as follows:

WG1 - will realize the tasks related with scientific and technological knowledge of new ceramic materials forming (compaction) and obtaining (the pressure sintering, the reactive sintering etc) and phenomena accompanying these methods.

WG2 - will focus on the theoretical modeling of materials and properties (thermodynamic methods, mechanical methods, etc), phenomenological description of wetting and interfacial phenomena in ceramics powders, ceramic-metal systems, reaction analysis, the choice of the brazing solder and reactions with the potential workpieces, structural characterization at different length-scale levels.

WG3, WG4 and **WG** 5 - will focus on complex investigation of various properties, including physicochemical and mechanical properties (WG3), tribological properties (WG4), simulation, modeling and cutting properties, optimizing machining (WG5).

The partnership of this grant is based on interdisciplinary problems existing in the field of processing and utilization of cutting tools, presenting multiphase materials. Thus various research groups specializing in ceramic synthesis, composite materials, liquid state materials science, high temperature interfacial phenomena as well as materials characterization and design will be involved. The results obtained by each working group will be collected in database that will be fruitful for the industrial companies in Europe.

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