Success Story
COMET

MPPE
Materials, Processing and Product Engineering
Programme: COMET – Competence Centers for Excellent Technologies
Programme linie: K2-Centres
COMET subproject, Laufzeit und Projekttyp:
Cutting tools (A5.16-01), 01/2012-12/2014, multi-firm

Cutting simulations for better cutting tools

To prevail in the international competition of industrial production sites an ever-increasing demand for productivity needs to be satisfied. This leads to a need for knowledge-based design of cutting tools. A prerequisite for this is quantitative information on the involved tool loads and the corresponding material reaction. To this end in a COMET project a worldwide unique computer simulation model was developed that uses experimentally determined material data of the hard metal substrate and the hard coatings as input parameters. The predicted location of tensile residual stresses that are detrimental to tool performance was verified with advanced experimental techniques.

Increase material strength to decrease part weight

To increase the efficiency of products in terms of cost and energy there is a constant aim for a weight decrease of moving parts in cars. To assure the functionality of components the strength and mostly also the wear resistance of used materials is increased. This puts exorbitant stresses on cutting tools used for shaping the components. In machining processes such as milling (Fig.1) and turning, the component shape emerges by the removal of chips that form at the sharp cutting edges of indexable inserts.

Computer simulation facilitates the design of durable cutting tools

Cutting inserts are tools with a complex architecture. They consist mainly of a thin film coated high-strength hard metal. The used hard metals are composite materials with a high content of hard phase (tungsten carbide) and a metallic binder phase which is typically cobalt with a volume fraction of 10 % The wear resistance of cutting inserts is enhanced by the application of an only several micrometer-thick hard coating. In industrial application the cutting edge has to endure elevated loads that trigger wear and fatigue which subsequently leads to the formation of cracks and tool failure. The efficiency and lifetime of cutting tools strongly depends on the complex interaction of tool load and the corresponding tool material response.

Main factors that influence the tool loads are e.g. material properties of the cut material, cutting edge geometry, the depth of cut and the cutting speed. The reaction of the tool to this load is in turn depending on the properties of the different tool material components.

Up to today, the development of cutting tools was based mainly on a trial and error strategy. A prerequisite for a knowledge-based tool design is an advanced computer simulation model capable of predicting the tool load situation for a certain cutting application. To this end the so-called “finite element (FE) simulation” is used. It represents a calculation method that is also applied in other product development processes.

In close cooperation with the hard metal and hard coating manufacturers Ceratizit Austria and

Federal Ministry of Science, Research and Economy
Austrian Ministry for Transport, Innovation and Technology

Ceratizit Luxemburg the MCL developed an advanced FE simulation model for cutting tool design. The necessary input data for the model such as elastic, plastic and thermal material properties of hard metal and hard coating were determined at the MCL via advanced experimental methods.

Fig. 1: Ring-shaped cutting tool with indexable inserts for the production of a crankshaft (© Ceratizit Austria).

Residual stresses in cutting inserts were measured with the aid of a high-tech instrument a so-called synchrotron that produces high-energy x-ray radiation. Tensile stresses that are detrimental to tool lifetime were measured at exactly the same position in milling inserts as predicted by the simulation model. This successful comparison of theoretical prediction and experimental evidence enables now the knowledge-based virtual evaluation of changes in the tool architecture.

Impact and effects

The validated simulation model facilitates the speedup of development processes for hard coated cutting tools for specific cutting applications.

Ceratizit expects a rise in efficiency of coated hard metal tools of about 30 % triggered by the project. The project is a good example of how the buildup of unique know-how can help to preserve high-tech industrial production and research in Austria.

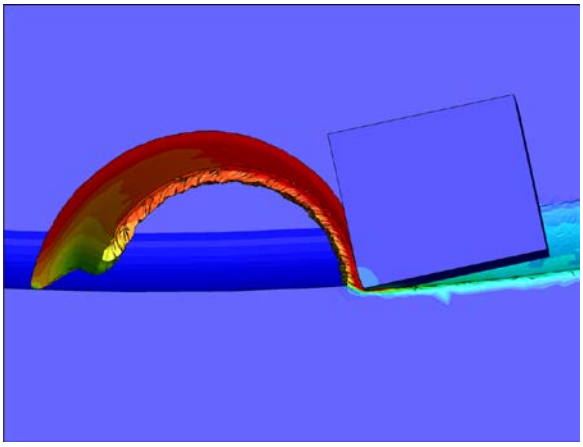

Fig. 2: Three-dimensional finite element simulation of a cutting process (© MCL).

Kontakt und Informationen
MPPE/ A5.16 „Cutting tools“

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