

Publishable Summary

Summary Description of Project Context and Objectives

The ConTemp project "Self-Learning Control of Tool Temperature in Cutting Processes" was funded under the EC Seventh Framework Programme Theme 4: Nanosciences, Nanotechnologies, Materials and New Production Technologies, NMP2008-3.2.2: Self Learning Production Systems, Grant Agreement: CP-FP 228585. The main objectives were the development of a self-learning platform for analysis and estimation of process conditions and self-optimisation of different manufacturing tasks and the development of a new tool system that is easy to integrate into existing manufacturing systems incorporating a micro structured high performance-cooling device. The expected results are higher stability of the cutting process, longer tool life by minimised thermal shock, higher quality of the produced parts, reduction of sub-surface damage, less ecological impact by avoiding cooling lubricant and economical machining of new workpiece materials.

High-temperature alloys and composites put the tools under high thermal and mechanical strain. At the same time manufacturing technology must put a strong emphasis on environmental issues and sustainability, which challenges conventional cooling methods. With a closed internal cooling circuit contamination of the environment and the cooling fluid can be avoided. By using a self-learning adaptive process control it is possible to stabilise the machining conditions and control the tool temperature. This will not only improve part accuracies and productivity but also enable the economical cutting of a larger range of materials by minimising tool wear.

The ConTemp project has focused on controlling and stabilising the tool temperature. To make an effective temperature control possible it was necessary to develop a self-learning platform that analyses the process as well as a cutting tool that enables the machining system to monitor and influence the temperature of the workpiece and cutting tool to prevent part damage and tool wear. The control system will consider its knowledge of the material's cutting behaviour and the geometrical and kinematical parameters of the process to estimate dynamic process conditions. The knowledge base is fed during the process by constantly monitoring the measured temperatures. By estimating the process conditions the system is especially well suited for small batch production where time-consuming optimisation procedures can be reduced by the self-optimising control.

The ConTemp system constitutes the development of a new generation of high performance intelligent and environmentally friendly tools for turning operations. The optimisation of machining parameters such cutting speed permits the reduction of machining times and costs through a decrease of manufacturing times. With a closed internal coolant circuit, the cooling system is almost maintenance free and avoids external cooling lubrication. The prototype tool and cooling system developed in the project have demonstrated longer tool life and better surface qualities than state of the art coolant lubrication systems and tools.

Description of Work Performed and Main Results

Cooling lubrication is widely applied in cutting processes. However, conventional flood cooling causes environmental and health risks and high costs for coolant processing and disposal. An internally cooled cutting tool in combination with a self-learning control system was developed within the ConTemp project. This innovative system reacts to changing process conditions and keeps the

tool temperature constant. With a constant temperature gradient from the hot tool tip to the coolant channels in the cutting tool, thermal shock damage is minimised and the surface quality is enhanced, thus a better tool life can be achieved. A closed coolant circuit avoids the release of coolant into the environment and at the same time the coolant is not contaminated by the process, simplifying supply and disposal.

The newly developed tool system is based on a novel closed circuit internal micro-cooling device that enables an effective temperature control of the tool as well as the measurement of temperatures. In conventional processes with cooling lubricants, the temperature difference between the hot chips and the cooling lubricant leads to wear on the cutting edge of the tool caused by micro-cracks. This thermal shock damage is avoided by the internally cooled system and thus tool life and part accuracy are increased. Tool wear depends on the tool temperature. Due to different overlapping wear mechanisms, a wear minimum can be observed at a certain tool temperature. The combination of the internal cooling system as a sensor/actor system and a self-learning control allows a maximisation of tool life.

Final Results and Potential Impacts

The main results of the ConTemp project are:

- A self-learning platform with automatic analysis and estimation of process conditions and implemented self-optimisation of different manufacturing tasks
- A tool system with an integrated micro-structured high performance cooling device

The following potential impacts are expected as a result of the ConTemp project:

- Cost savings through increased tool life, avoidance of cooling lubricants and a reduced need for maintenance and cleaning
- Increased efficiency through the use of higher productivity cutting parameters and improved accuracy and surface integrity of products through adaptation of the tool temperature
- Minimisation of ecological damage and health risks