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# More robust, with higher precision and longer lifetimes

Ceramic cutting tools developed with a dynamometer from Kistler


At the Milan Polytechnic, Giulia Giovannelli and the researcher Paolo Parenti are investigating ceramic cutting tools – with the help of a measurement solution from Kistler.

**TUSA, the Swiss machining specialist, is testing new microtools made of ceramic at the renowned Polytechnic University of Milan (Politecnico di Milano). This innovative material offers significantly longer lifetimes, but extensive testing is needed to optimize it. MicroDyn from Kistler, the world's smallest dynamometer, ensures that cutting forces are measured precisely so that performance parameters can be determined.**

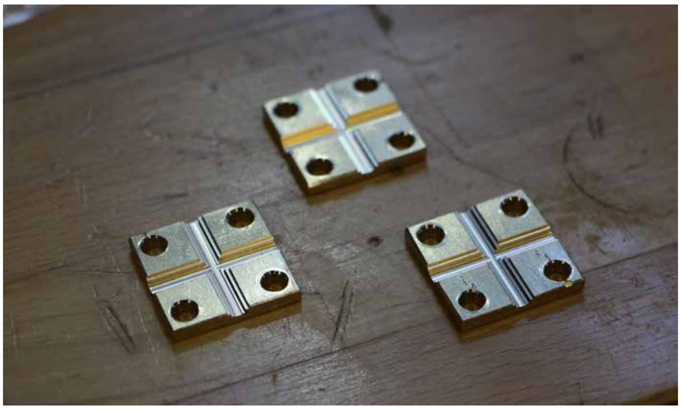
There's no doubt that ceramic is an exceptional material – as confirmed by its unique success story. It was used for pottery in the ancient world and then, as porcelain, it came to Europe from China in the 17th century (which is why we still call it "china"); this was followed by the advent of industrial ceramics in the 19th century. And now, the success story is set to continue as new application areas are developed and new material mixes and combinations are researched.

A tool specialist in the southern Swiss canton of Ticino has also begun to focus on ceramics recently: TUSA Precision Tools SA manufactures high-performance machining tools such as those used to make components for watches. Gennaro Teta of Omnino Technology, TUSA's development partner, explains: "Production of highly intricate components for watch movements has to meet the highest requirements, of course – the tolerances are sometimes in the micrometer range." Teta's attention was drawn to the potential of industrial ceramics in his quest for new ways to improve tool life and process reliability for his customers. Watch manufacture is one of the many sectors where the trend is moving towards highly automated, unmanned production. "But what's the point in being 10% faster if you can manufacture throughout the night at a slightly slower speed – knowing that the process is reliable?" Teta asks. Ceramic material is harder than steel, so it can offer significantly greater resistance to wear as long as the cutting forces are kept under control.

**Tool lifetimes can be up to thirty times longer**

Teta points out that the new materials can extend tool lifetimes by a factor of up to 30 while maintaining comparable precision. TUSA approached the renowned Polytechnic University of Milan in nearby Italy to assist with the development of these materials. "Industrial tests showed that ceramic tools could easily increase a tool's service life many times over. However, there are enormous variations depending on the substrate. This gave us the idea of collaborating with the Polytechnic to develop different ceramic mixes and – more specifically – to carry out tests on them," Teta continues.

At the Polytechnic's Faculty of Mechanical Engineering, Giulia Giovannelli and Paolo Parenti are carrying out research into new materials and innovative cutting tools under the supervision of Prof. Massimiliano Annoni and Prof. Nora Lecis. For their work, they are able to make use of electron microscopes, ultra-precision machining centers and special machines for tribological investigations. "In the test setup for TUSA, a micro-cutting tool is used to mill a brass plate. We're testing three different ceramic materials with two different sets of cutting parameters," Giovannelli explains. "The new MicroDyn from Kistler is helping



The brass plates undergo several machining processes with different apertures in order to acquire representative data.

Each ceramic material produces different process characteristics when the cutting tool is used.


Thanks to MicroDyn from Kistler, the world's smallest dynamometer, the cutting forces on the tool can be measured precisely at speeds of up to 120 000 rpm.

us to do this. Thanks to its very high natural frequency, it supplies very accurate values for force and torque in all three spatial directions, even at high speeds. The resultants across the three axes are then determined with the help of an algorithm. Roughly speaking, the lower this value is, the longer the tool life will be," Giovannelli adds.

> "We're testing three different ceramic materials with two different sets of cutting parameters. The new MicroDyn from Kistler is helping us to do this. Thanks to its very high natural frequency, it supplies very accurate values for force and torque in all three spatial directions, even at high speeds."
>
> Giulia Giovannelli, thesis student at Politecnico di Milano

Measuring just 30x30 mm, MicroDyn is the world's smallest dynamometer. Its very high natural frequency of 15 kHz on all three axes allows precise measurement of highly dynamic forces of up to 500 N, and calculation of the resultant torques up to 50 Nm. Measurements are taken directly on the individual cutting edges at speeds of up to 120 000 rpm. The piezoelectric crystal rings used for the measurement ensure high sensitivity and a very low response threshold. They are also installed in such a way that temperature influences are largely compensated. The measuring chain is completed by the LabAmp laboratory charge amplifier to provide efficient signal conversion and data acquisition.

**Crystal-clear test results thanks to precise measurements**

The investigations at the Polytechnic revealed that one of the three materials regularly displayed better characteristics for the forces generated. For cutting depths of 1.3 mm as well as 0.5 mm, the resultant force for ceramic material "B" was significantly below the values for "A" and "C." This result was all the more pleasing because the best surface quality was also achieved with tool "B." For Giulia Giovannelli, however, this is merely the beginning: "In the initial phase, we're only looking at shoulder milling here. The picture could look entirely different for slot milling, which is used to apply the main pattern to the brass plate."

Gennaro Teta is enthusiastic about the result: "This shows that we're on the right track, and that we have suitable material. The next step is to test the material in a realistic industrial environment – that's to say, on another machine. Then we shall see whether the values determined in the laboratory can be reproduced with similar cutting parameters. Of course, there's a long way to go before the material can be used in industrial production, but the first step has already been completed successfully."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