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In drilling or cutting machines, there are frequently occurred problems in terms of chip formation and chip removal, burr formation at the cutter exit, tool stress, as well as process reliability and quality. These phenomena lead to think about making use of hybrid processes for drilling or cutting operations in order to intentionally alter the material characteristics in the chip formation area by overlapping additional energies.

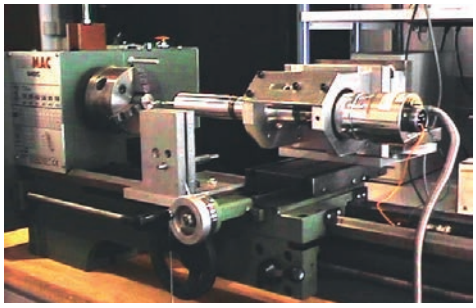

Fig. 1: Ultrasonic drilling assistance.

OBJECTIVE

In cutting or drilling operation, ultrasounds reduce the friction rate between two bodies in relative movement. Wear and friction are considerably diminished while the speed increases. The application of this technology required development and utilisation of specific ultrasound converters inducing oscillation within 1 to 100 KHz range.

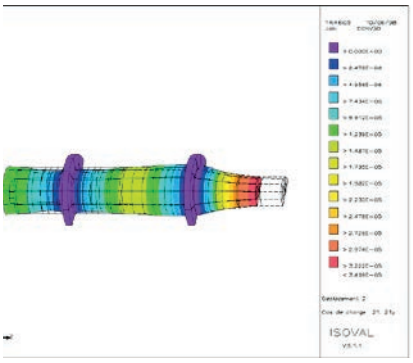

Fig. 2: Transducer simulation with ATILA.

CEDRAT TECHNOLOGIES SOLUTIONS

Sound and ultrasound transducers mainly use piezo-electric materials to achieve electromechanical conversion. There are three possible approaches when designing ultrasonic devices for machining assistance:

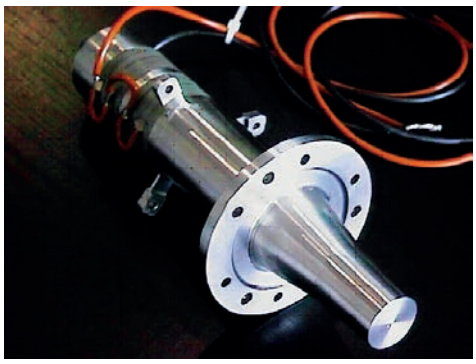

Fig. 3: Cedrat's ultrasound transducer.

> HIGH POWER ULTRASOUND TRANSDUCER: DRILLING ASSISTANCE

In this application the ultra-sound transducers are typically made of a piezo-electric converter such as PZT massive ceramic, a booster and a sonotrode (Langevin converter). They operate on mechanical resonance and relatively high frequency (20Khz typical). Each element is half wavelength operating. The density of vibratory mechanical power produced in that case is superior to any electromechanical device.

Cedrat Technologies makes uses of custom Ultrasonic Processors based on either standard or custom converter. According to the application, the sonotrode is optimised by computation of the adapted converter using ATILA active materials FEM software (Fig.2). The development might lead to an ultrasound transducer prototype (Fig.3) fully characterised and focused on drilling assistance of specific machine.

> LOW VOLTAGE PARALLEL PRE-STRESS ACTUATOR: CUTTING ASSISTANCE

PZT massive ceramics offer the most economical solution, but they required high operating voltage and are limited by the mechanical stresses and the electrical fields. Other materials such as multi-layered piezo-electric materials overcome this limitation: For low voltage applications, since their resonance required few volts to produce maximum distortions, they offer a low power consumption and a high potential of miniaturisation.

In addition they produce great displacement outside the resonance range of frequency. In that regards Parallel Pre-stressed actuator has been designed and integrated in a conventional glass cutting machine (Fig.4) for vibration assistance in the range up 10Khz.

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> LOW VOLTAGE AMPLIFIED PIEZO ACTUATOR: MARKING ASSISTANCE

Low voltage Amplified Piezo Actuator and specific versions such as Ultrasonic Piezo Actuator UPA25 are compact transducer for generating vibrations either in quasi-static or at resonance for large displacements in small size. They come as a standard products and produce 18µm vibration up to 25 kHz. Smaller UPA could be design with a resonance frequency range up to 100 kHz.

PERFORMANCE

These results are not exhaustive as many other sound and ultrasound transducers can be designed by CEDRAT TECHNOLOGIES starting with other standard converter or MLA based actuator to fit the need of specific machine tool.

> HIGH POWER ULTRASOUND TRANSDUCER: DRILLING ASSISTANCE

Ultrasonic transducer designed by CEDRAT TECHNOLOGIES for drilling assistance offers a quality factor of 480 and a coupling factor of 34%. From the experiments carried out on drilling machines, it was derived that Chip formation and cutting process at 21.5 kHz frequency and 26 µm amplitude vibrations produced in the cutting direction help in reducing cutting force and burr size, which is apparently a sign of quality improvement. In addition Ultrasonic it reduces cutting forces by 60%.

> LOW VOLTAGE PARALLEL PRE-STRESS ACTUATOR:

Cutting assistance A Parallel pre-stressed Piezoelectric Actuator (PPA20M) fixed behind the diamond cutting tool and make it vibrate up to 10 kHz. With a 10g diamond tool mass on PPA20M driven by the standard Linear Amplifier LA75C, experiments show more than 15 µm over 10 kHz bandwidth in PDP glass cutting. In addition this solution offers:

- Retrofit innovation at low cost
- Easy Integration
- No micro cracks, fragmentation or chipping

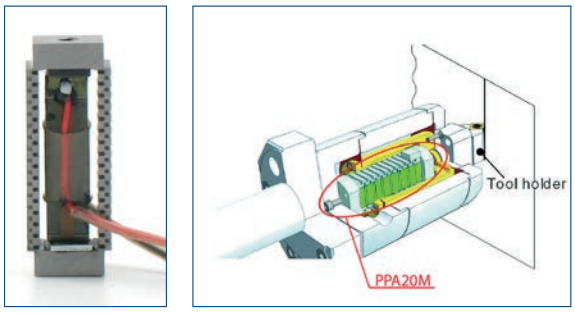

Fig. 4: Integration of a PPA in a cutting tool.

> LOW VOLTAGE AMPLIFIED PIEZO ACTUATOR: MARKING ASSISTANCE

Low voltage Ultrasonic Piezo Actuator associated with a marking tool was design and integrated into a TECHNIFOR engraving machine for process assistance:

Starting form a standard UPA25 CEDRAT TECHNOLOGIES delivered a device providing 18µm stroke at 25kHz. The result is a light and compact OEM sub-system with a high potential of integration, able to work at resonance or in quasi-static operation.

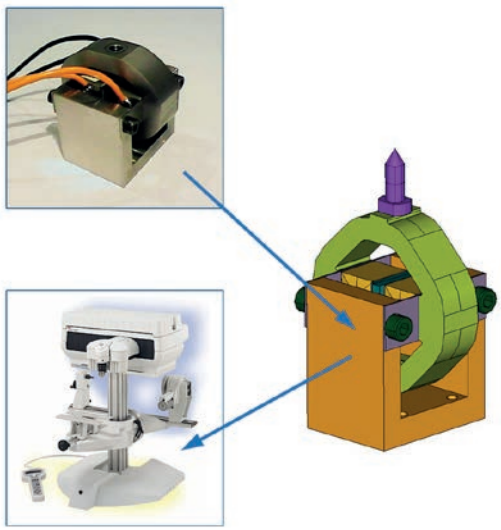

Fig. 5: Integration of an UPA in an engraving machine.

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