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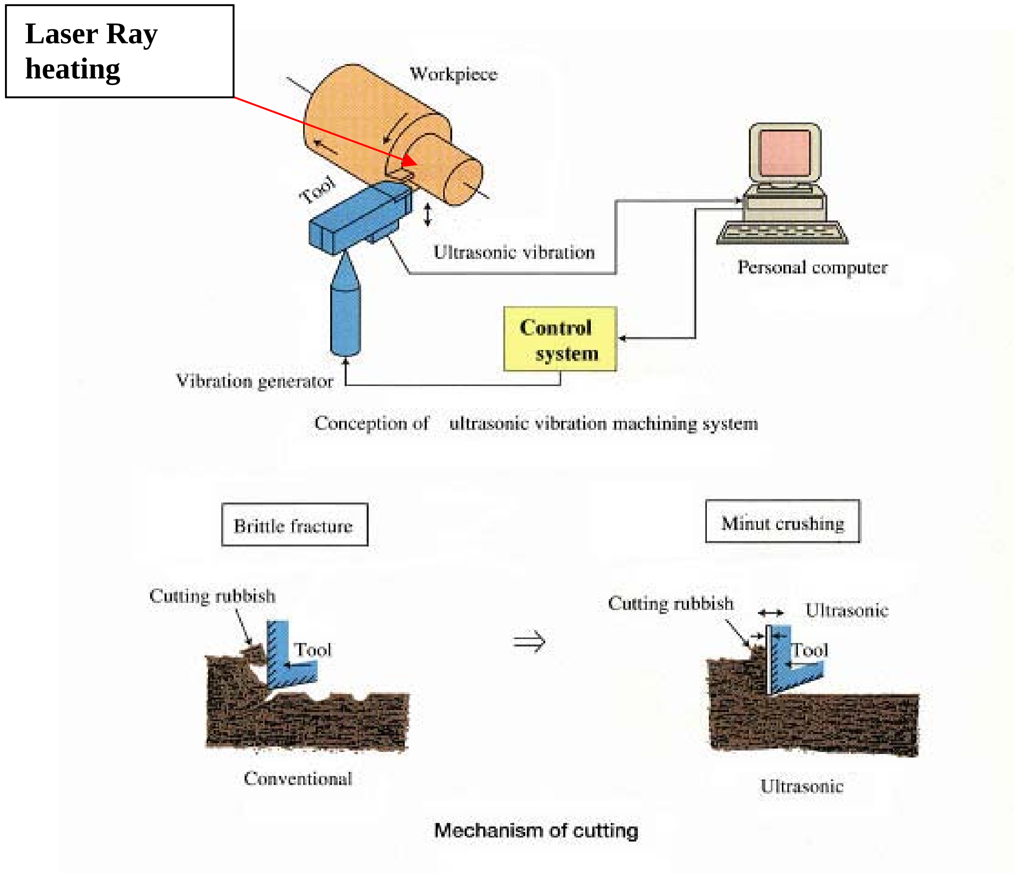
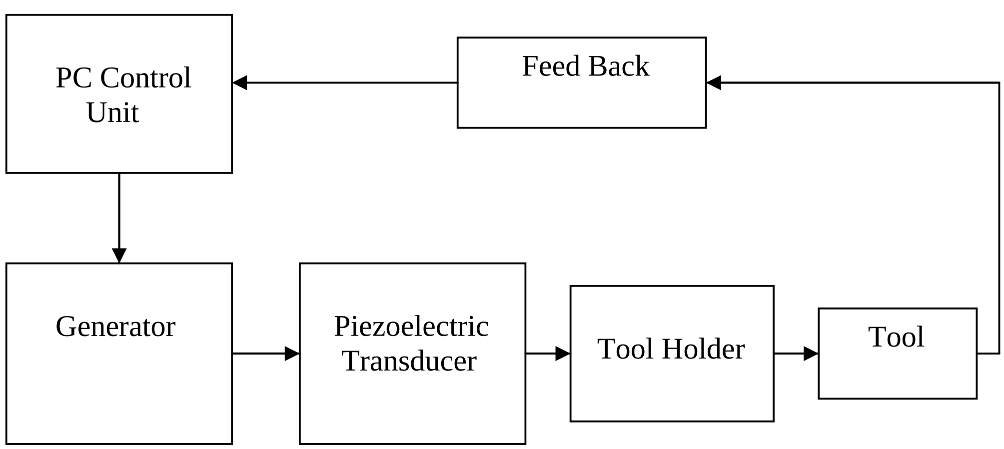
Ultrasonic Vibration Machining and Drilling with High Efficiency and Accuracy for Less Machinable Materials and New Materials

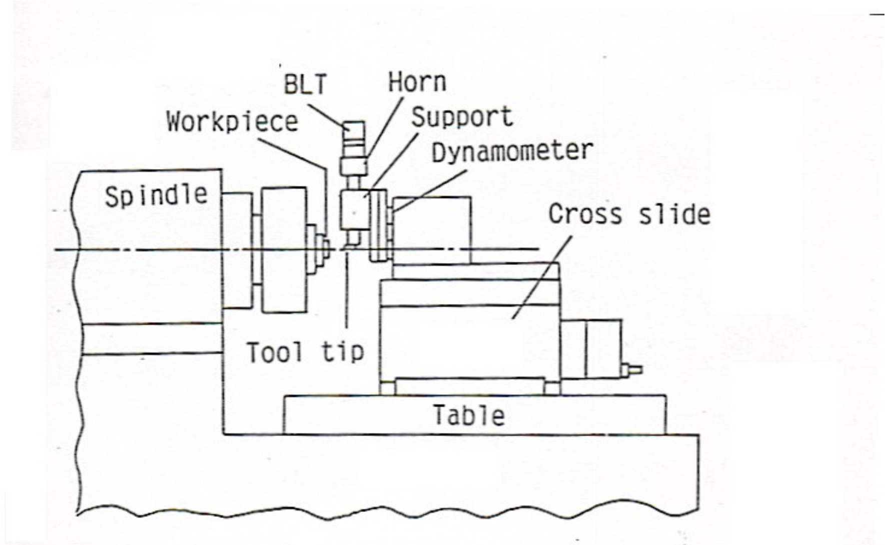
Fine ceramics have excellent heat resistance and corrosion resistance. However, the development of a new machining technology is an urgent subject because the machinabilities of the ceramics are low. The technology, which machines ceramics in high efficiency and accuracy, is developed by assisting the ultrasonic vibration to the machining as a method of solving this subject. In this research, the ultrasonic vibration of the frequency of 20 kHz to 60 kHz and more are used. Damage by the brittle fracture is controlled by making cutting rubbish a corpuscle; -as a result, a high-quality machining is aimed at.

Construction of machining database on cutting of less machinable materials and new materials assisted by ultrasonic vibration

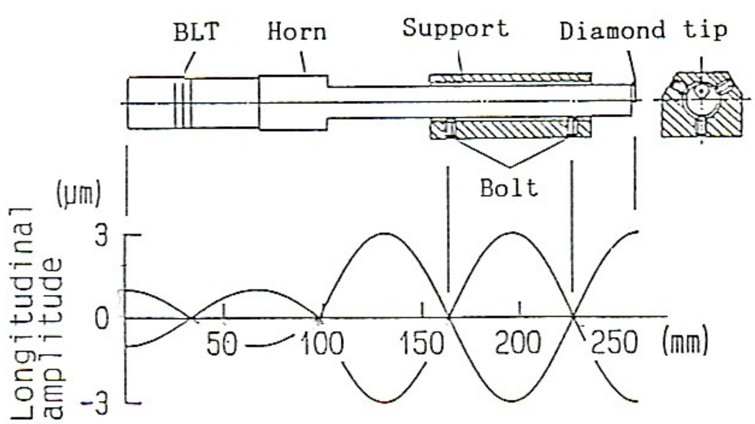
The same technique in some cases can be combined with focused, high power laser beam, for enabling temporary thermal material-softening. The laser beam is concentrated in the zone of cutting; -just in front of a cutting tool.


Laser Ray heating
Workpiece
Tool
Ultrasonic vibration
Personal computer
Control system
Vibration generator
Conception of ultrasonic vibration machining system
Brittle fracture
Minut crushing
Cutting rubbish
Tool
Cutting rubbish
Ultrasonic
Tool
Conventional
Ultrasonic
Mechanism of cutting

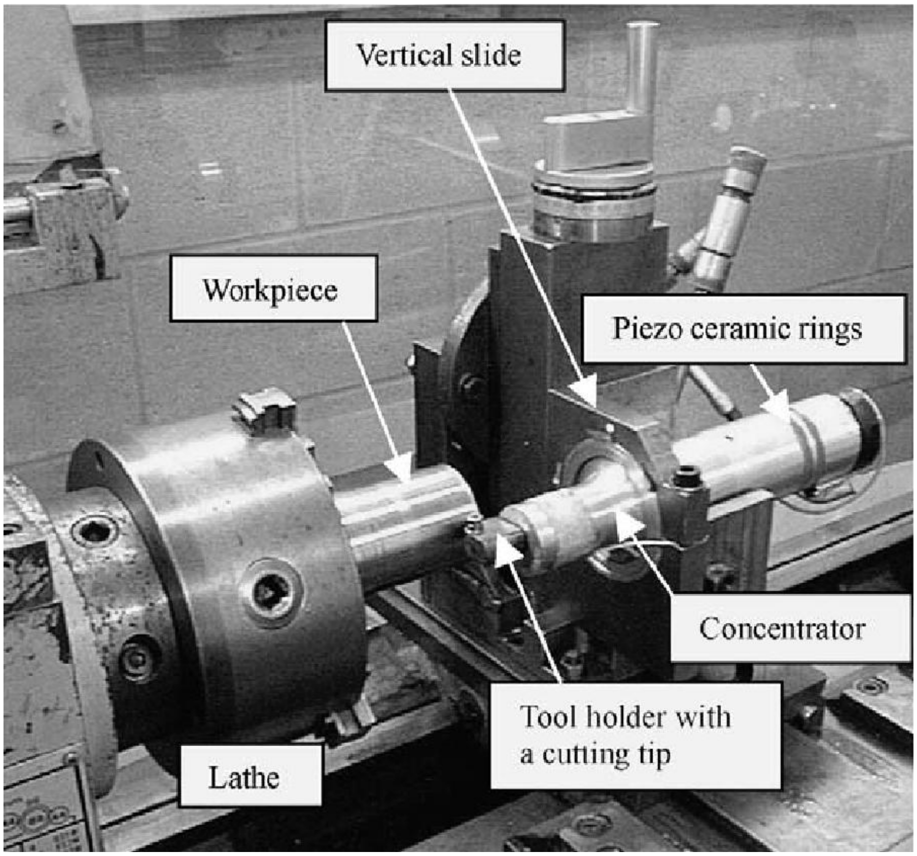

PC Control Unit
Feed Back
Generator
Piezoelectric Transducer
Tool Holder
Tool

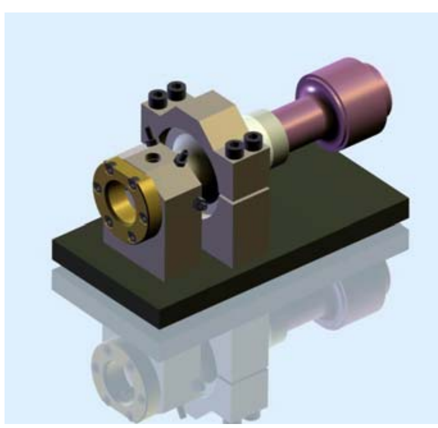


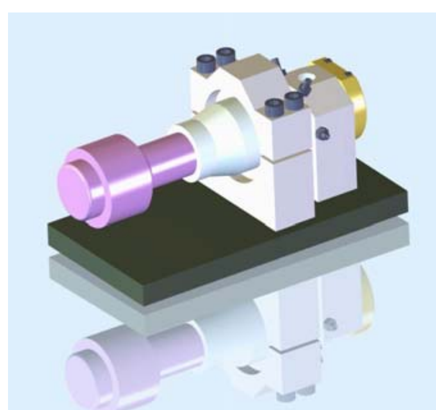
1 Schematic illustration of ultraprecision turning machine equipped with ultrasonic vibration tool.



Ultrasonically vibrated tool and resonant mode of vibration.


Vertical slide
Workpiece
Piezo ceramic rings
Concentrator
Tool holder with
a cutting tip
Lathe





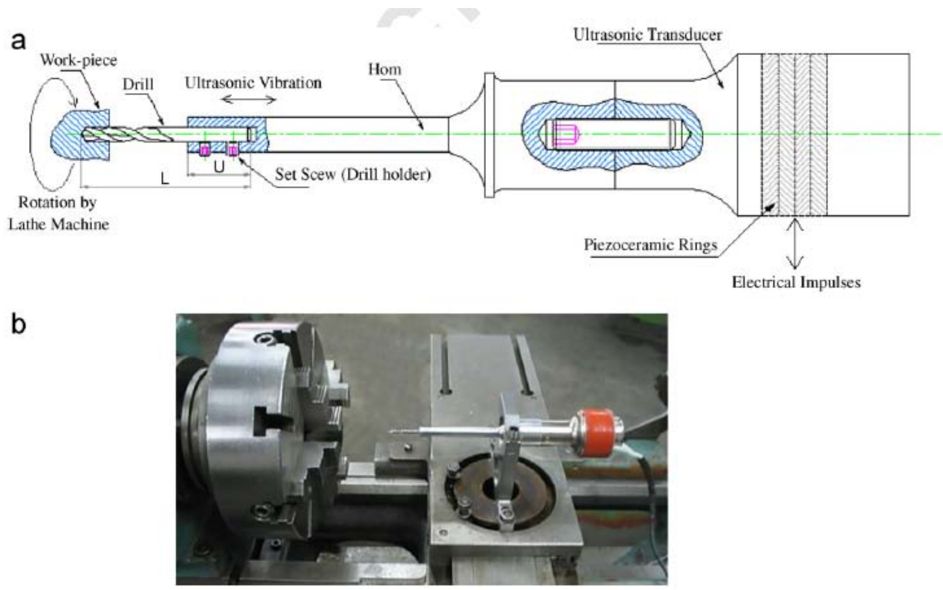


Fig. 1. (a) Scheme of the experimental set-up. (b) Experimental set-up for ultrasonic assisted drilling.

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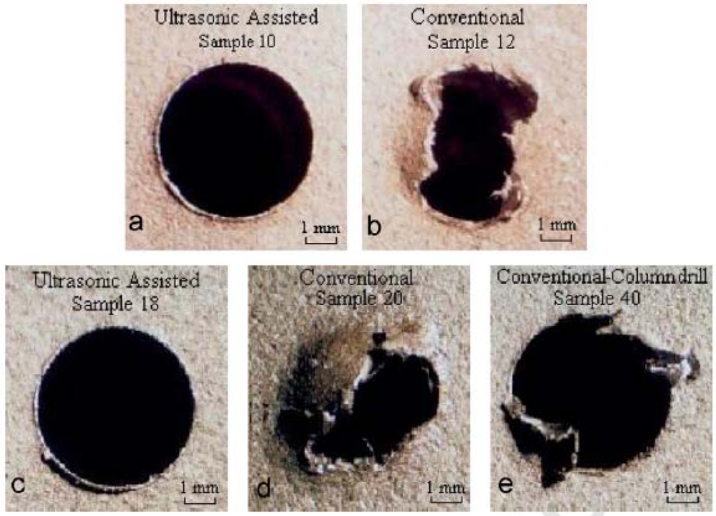

Fig. 2. Burr types samples at drill exit: (a) 250 RPM, 21 kHz, $f = 0.8$ mm/s, $A = 10\,\mu$m. (b) 250 RPM, $f = 0.8$ mm/s. (c) 350 RPM, 21 kHz, $f = 0.5$ mm/s, $A = 10\,\mu$m. (d,e) 350 RPM, $f = 0.5$ mm/s (A = amplitude, f = feed rate).

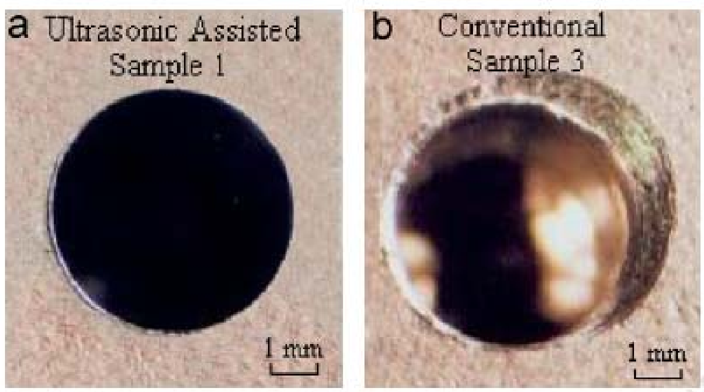

Fig. 12. Drill skidding samples at drill entrance: (a) 250 RPM, 21 kHz, $f = 0.5$ mm/s, $A = 10\,\mu$m. (b) 250 RPM, $f = 0.5$ mm/s.

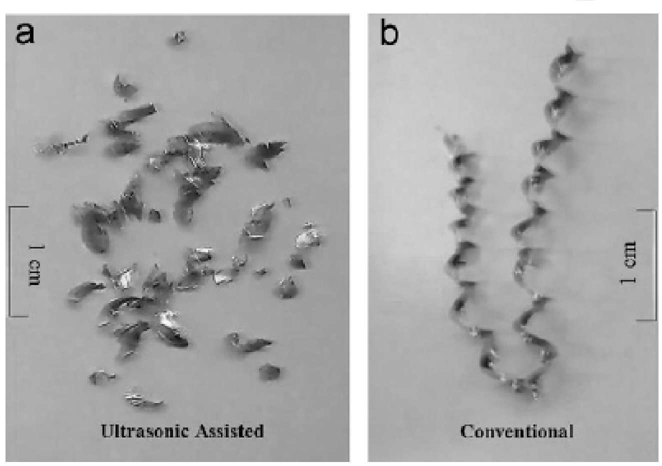

Fig. 13. Chip morphology: 250 RPM, 21 kHz, $f = 0.5$ mm/s (for UAD, $A = 10\,\mu$m).

The experimental equipment consists of the following:

- Universal lathe machine (Tabriz-TN40A): to perform drilling experiments.
- Column drilling machine (Tabriz-MR2): to perform drilling experiments.
- Generator (Mastersonic MMM generator-MSG.1200.IX): to convert 50 Hz electrical supply to high-frequency electrical impulses. The frequency range of the generator is 19.020 to 46.728 kHz and the frequency step is 1 Hz. The power of the generator is 1200 W and the maximum output current is 3 A.
- Laser displacement metre (Keyence LC-2430): to measure the amplitude of vibration. The sampling rate of this sensor is 50 kHz. The resolution is 0.01 mm and the laser beam spot is 12 mm.
- CNC three axial CMM machine (Cincinnati-DISK LK G80): to measure the hole cylindricity, hole circularity and hole oversize.
- Hand held surface roughness tester (Time group, TR200): to measure the surface roughness of the drilled holes.
- Toolmakers microscope (Olympus-STM): to observe the burrs at the cutter exit, which possesses a maximum magnification of 200 times with a resolution of 0.5 mm.
- Drill: Diameter of 5 mm, TiAlN-coated carbide drills (Dormer-R522) and TiN-coated carbide drills (Dormer-R550).
- Workpiece material: Inconel 738-LC ($45 \times 35 \times 8\,mm^3$).
- UAD performed without coolant (i.e. dry cutting).

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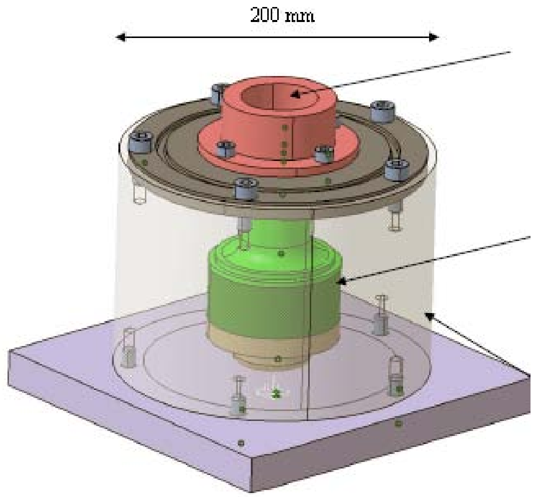
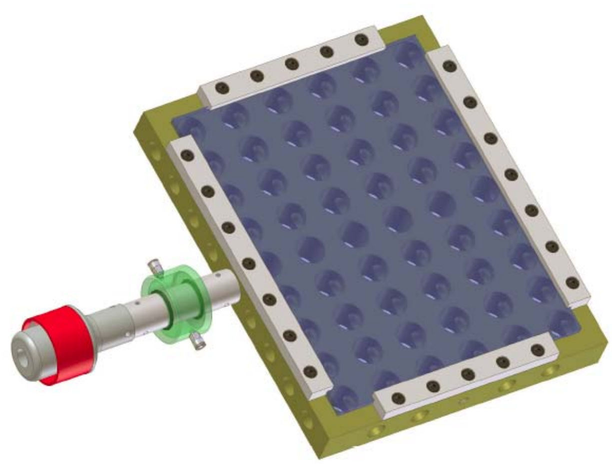
ULTRASONICALLY VIBRATED PLATFORMS: MMM TECHNOLOGY





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