

Kinetic Ceramics, Inc.

Precision Lathe PZT Servo



Square Profile Cut While Spindle Rotates
at High Speed



Fast Tool Servo



Turnkey Fast Tool Servo System

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A versatile Fast Tool Servo has been developed by Kinetic Ceramics for machining non-rotationally symmetrical components. The cutting tool is driven by a piezoelectric mechanism allowing surface features to be cut in a part turning at upwards of 6,000 rpm.

The servo can be fitted to any lathe including high precision diamond turning machines, forming a supplementary fast 'Z' axis. Typical axis bandwidths for such lathes are in the order of 10Hz, but the FTS provides a bandwidth of up to 1000Hz, allowing the machining of complex shapes on a range of materials at high spindle speeds. Although the technology was developed for direct machining of contact lenses and casting molds, parts that have been successfully machined range from optically clear lens molds to contoured automotive pistons. Better than 12 nm rms. surface finish can be routinely produced and cut depths to 400 microns (.016 inches) are possible.

Extremely fast response coupled with substantial output force and high rigidity were principal requirements for the actuation system. The fast tool servo utilizes state of the art piezoelectric technology, along with a patented mechanical amplification mechanism to achieve these goals. The marriage of mechanical amplifier and piezoelectric actuators has permitted a heretofore laboratory technology to break out into mainstream usage in industry.

Thermal expansion effects in metal structures can be of the same order as the output motion from a piezoelectric actuator, potentially causing tool offset. In the Fast Tool Servo T-lever amplifier, thermal changes cause equal expansion and contraction in both support paths, resulting in no net output displacement.

The output from the T lever is coupled to a tool beam that mounts the cutting tool. The motion of the tool beam is confined to a single axis motion. A mechanical motion amplification ratio of 14:1 is obtained after "straightening" in the output stage. The T lever amplifier has low rotational inertia and high rigidity; resulting in a first resonant frequency above 1,000 Hz.

Feedback control

A double feedback loop is used to linearize the output motion with respect to the control signal over a broad frequency range. A high bandwidth inner loop does most of the work by monitoring the amount of electrical charge stored in each PZ actuator and generating an error signal that is summed with the control signal. The charge loop requires no special stability compensation since it is first order and hence unconditionally stable. A position loop is constructed around the charge loop, with its position sensor mounted on the tool beam.

This fast Z axis lathe accessory is rapidly gaining acceptance. To date more than 150 Kinetic Ceramics Fast Tool Servos have been placed in the field for high volume production manufacturing of challenging shapes in plastics, aluminum, brass and nickel. The entire system including the piezoelectric actuators is demonstrating extremely durable in 24 hours a day manufacturing environments.

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