Mechatronics Concept

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MACHINE DEFORMATION MEASUREMENT TO INCREASE ACCURACY WHEN MEASURING WORKPIECE

A common feature of modern machine tools is the ability to measure a workpiece directly in the machine. Workpiece touch probes are widely used for this purpose by being clamped into the place where one would normally put a tool, where they are able to evaluate with precision the moment the probe end comes into contact with the workpiece, at which point it sends this information to the control system. The main advantage of this measuring technique is its flexibility, as there is no need to move the workpiece to the coordinate measuring machines and the touch probe is stored directly in the tool magazine. On the other hand, a significant disadvantage of this measurement technique is its limited precision, since the probe does not include measurement uncertainty caused by the imperfect geometry of the machine and possible deformation (mechanical, thermal, etc.). All these factors become an integral part of measurement errors when the workpiece is measured with the touch probe.

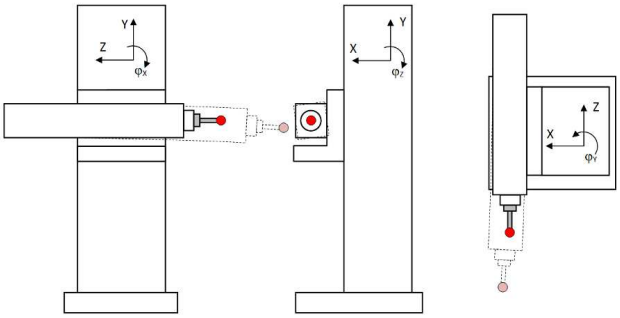
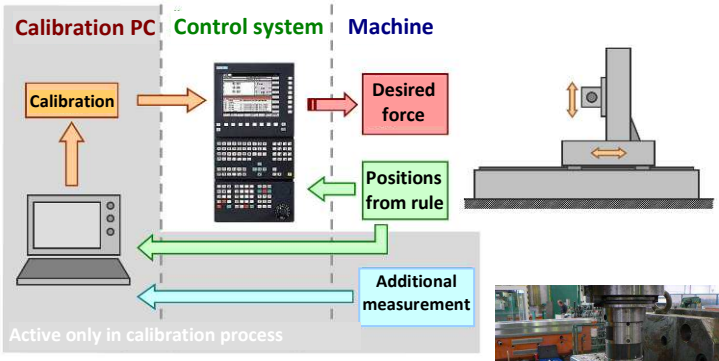


Illustration: possible deformation of WRD150 machine with extended RAM using a touch probe

It is for this reason that TOS VARNSDORF, together with the Research Center for Machinery Production Engineering and Technology at the Czech Technical University in Prague, has developed equipment and technology that can be used to measure the deformation and geometry of the machine, which is directly integrated into the design of the machine. The device is able (when measuring with the touch probe) to continuously monitor certain distortions and errors of geometry in the axes of movement of the machine and correct for deviations obtained from standard measurements. The touch probe measurement results are thus largely free of inaccuracies due to the actual construction of the machine and caused by possible loading.



Principle of connection of additional measurements with the control system

The technology of the built-in measuring of deformation and geometry of the machine has already been implemented on the WRD150 duo machine. The principle of this method is the straightness of the laser beam, which creates an ideal plane, and the redundancy of the conventional measuring members.

Measuring with a touch probe on a WRD150 machine

<u>The main elements of the additional measuring system consist of the following:</u>

- **Laser cage to measure headstock deformation and spindle shift in the X and Z axes**

  Part of the X-axis slide is a composite unloaded frame made up of a carrier and a distributor of the laser beam (laser cage base). The headstock and the spindle make up a system of optical sensors (optical prism and PSD member) measuring the position of the incident laser beam. The optical sensors on the headstock measure the deformation of the end of the headstock against the slide and the optical sensors on the spindle measure the deformation (shift) of the spindle in the directions X, Z, φY, φZ against the slide. The measurement resolution reaches values below 1 µm.

- **Additional linear measurement of the spindle position in the Y axis**

  The measurement uses, together with the traditional linear ruler of the Y axis, the spindle displacement difference in the front and rear part of the headstock to calculate the spindle rotation in the direction φX.

- **Laser measurement of the shift and rotation of the end of the RAM against the spindle**

  The equipment consists of a separate unit (transmitter and receiver) mounted on the spindle plate and the reflector located at the end of the slide. The transmitter is a laser beam source and the receiver system consists of optical sensors (optical prism and PSD member), which evaluate the relative shift of the reflector at the end of the slide in the directions X, Y, φX and φY. The resolution of the power measurement of linear displacement is less than 1 micron.

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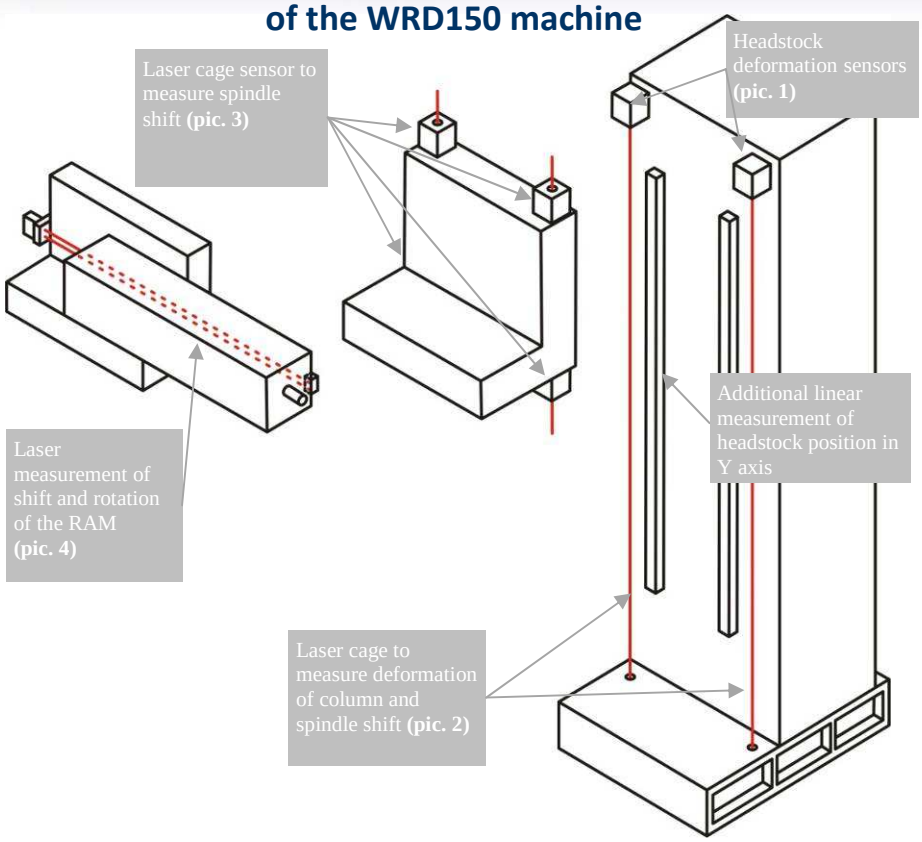
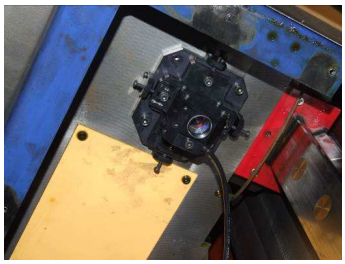
Schematic representation of the built-in additional measurements of deformation of the load bearing structure of the WRD150 machine



Pic. 1 – Headstock deformation sensors

Pic. 2 – Unloaded composite frame with laser cage

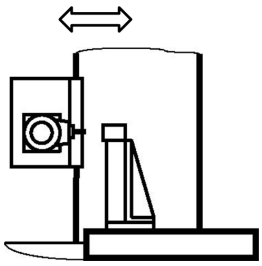


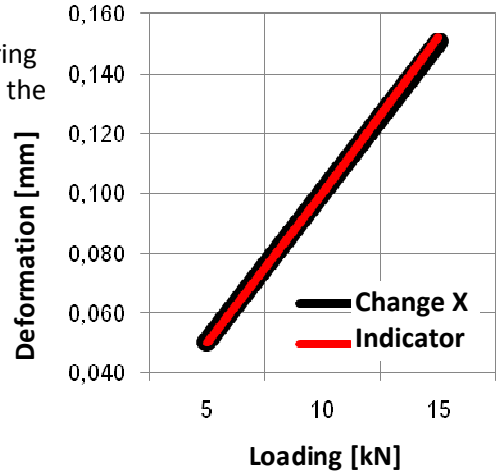
Pic. 3 – Laser cage sensor to measure headstock shift

Pic. 4 – Laser measurement of shift and rotation of the RAM end

Effect of the additional measurement is further demonstrated by the results of machine loading tests at the point of the tool in the direction of the X axis.

The machine deformations plotted in the graph depend on the loading during the measurement process with a dial indicator and measurements set into the machine.





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