Mechatronics Concept

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VARNSDORF TOS

Výzkumné centrum pro strojírenskou výrobní techniku a technologii

ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

AUTOMATIC MEASUREMENT OF MACHINE DEFORMATION AND ITS AUTOMATIC CALIBRATION

To achieve a high degree of accuracy, machine tools and their axes of motion are calibrated after installation and at regular service intervals. The calibration of the machine measures the inaccuracy in the axes motion and the subsequent creation of a calibration (compensation) table is used to eliminate this inaccuracy. Such a table contains corrective values for each axis of motion based on its travel motion, thus compensating for any inaccuracies in the assembly and production of the machine's actual parts. The main drawback of this method of enhancing the machine's accuracy is the time-consuming calibration process, which requires the connection of external measuring elements, including the presence of an experienced expert. This requirement, in terms of time and technical expertise, usually causes the calibration process to happen less frequently (only a few times a year) and therefore it often can't occur on a regular basis vis-a-vis the current state of the machine, for example, during one shift.

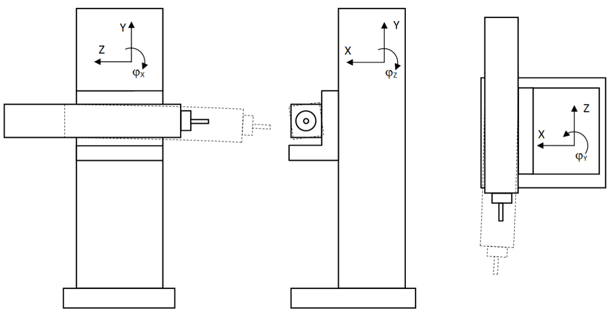
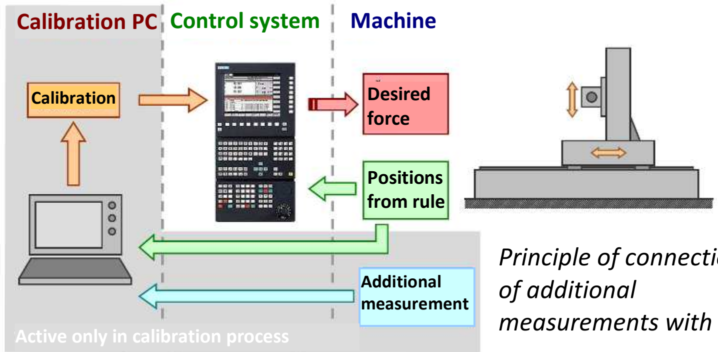


Illustration of possible deformation of the machine in the event of the slide extension on the WRD150 machine

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. Such devices enable the highly efficient and automated calibration of a machine without the necessity for any external intervention. The operator simply enters the compensation cycle, which performs extension of the individual axes of motion, recording deviations from the original (calibrated) state as part of the measuring process. This record then forms the basis for creating a new compensation table for the given axis of motion. The advantage of this technology is its ability to save time and the simplicity of its use - thus allowing the calibration of a machine several times during a shift (for example always before the completion of a machined surface).



Principle of connection of additional measurements with the

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.

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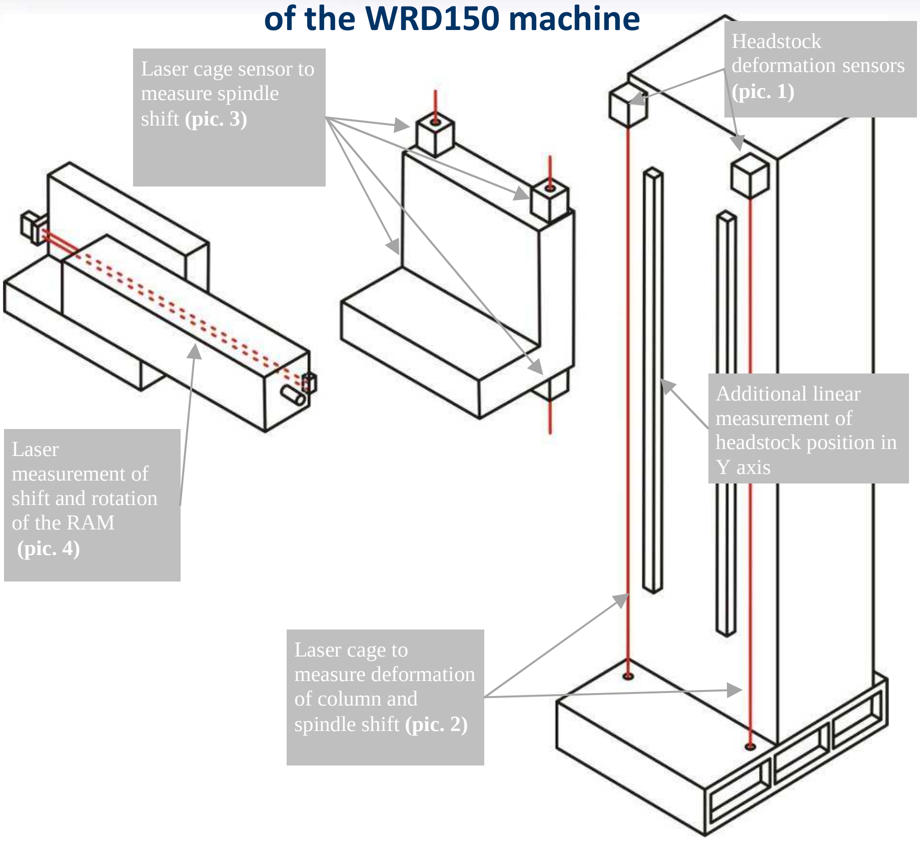
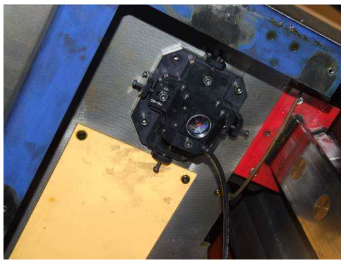
Schematic representation of the built-in additional measurements of deformation of the load bearing structure of the WRD150 machine



Pic. 1 – Headstock deformation sensors

Pic. 2 – Unloaded composite frame with laser cage

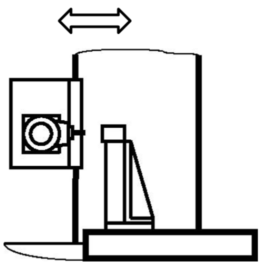


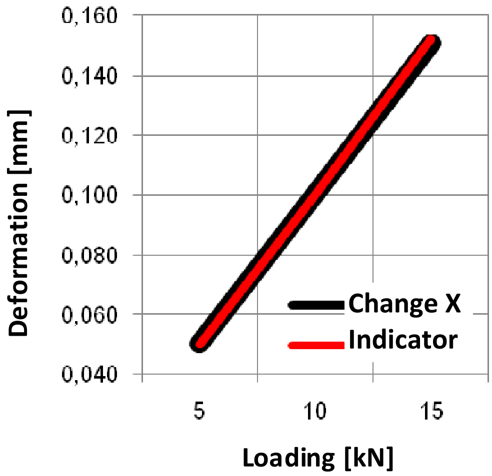
Pic. 3 – Laser cage sensor to measure headstock shift

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 duri the measurement process with a dial indicator and measurements set into machine.





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