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Methodology of Geometry Testing and Measuring of Oversized Machine Tool Components and Their Verification Using the FEM Method

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Abstract: The paper deals with the issue of geometric precision measuring at large parts (especially at castings having big dimensions) in their manufacturing stage. The large parts of machine-tool frames are required to have their geometric tolerances in thousandths of millimetres. The production or cooperation abilities of the particular company must be adapted to these demands and it is also necessary to adapt the company metrological equipment and measuring procedures to them. The standard measuring equipment cannot be used in most cases, because the particular parts are too large. For this reason, it is necessary to search such methods and procedures which enable to perform measuring with the relevant result. It could be considered to use e. g. 3D scanners. Unfortunately, their measuring precision has not reached the required tolerances up to now. For example, the HandyPROBE 3D scanner measures with the precision of 0,022 mm [1].

Introduction

The size of geometric tolerances can be presented on the example of the vertical machining centre column, see Fig. 1. The straightness tolerance is 0,005 mm and the flatness tolerance is 0,01 mm, when the guideways are approx. 2000 mm long.

To provide measuring of the column, the measuring methodology was elaborated by means of the available means and devices to enable the check of the ground guideways. The measuring jig was designed for measuring, this measuring jig has the basic carrying part which the holders are attached to. These holders are specified to fix the dial gauges. The carrying part has five tilting supports which are located in two rows and their spacing is 300 mm. When measuring is performed, the jig moves along the column and measuring is performed in steps by 300 mm.

Fig. 1: CAD model of column

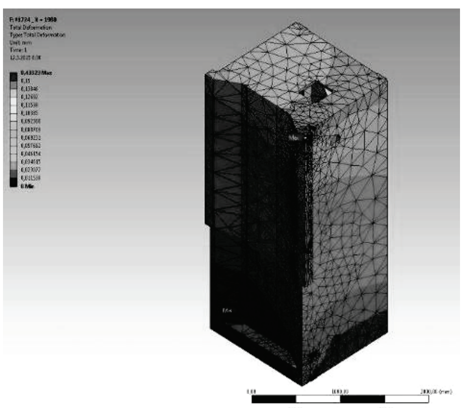

Fig. 2: Deformation of column

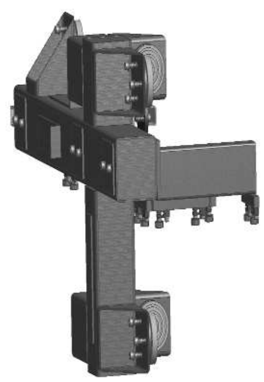

Fig. 3: Gauges holders

The jig slight turning in relation to the initial value is measured in the particular measuring positions by means of the laser and two water levels. The water levels and laser are located on the carrying part of the measuring jig. Using the values obtained in this way, it is possible to determine the shape of the column guideways which the tilting supports move along.

There are altogether 8 dial gauges located in the holders. These dial gauges are set to zero at the measuring beginning and they measure successively the profile of the column guideways, while the jig moves. The dial gauge zero setting is performed on the precise measuring plate so that perpendicularity and parallelity can be guaranteed in relation to the check plate. The values measured by means of the water levels and laser are added to the values measured by means of the dial gauges. The measured column can be also loaded statically and measuring can be performed at loading in the horizontal position as well as in the vertical position. The problems at these load tests consist in the fact that it is very difficult to deform the parts (to load them by force), when these parts are freely located on the floor, etc. (thus, if they are not assembled on the machine). On the contrary, when the parts are assembled in the machine frame, it is not possible to measure the deformations of the parts to the whole extent (one frame part always covers another frame part).

Summary

Measuring of the external impacts (machining accuracy, geometric precision, etc.) of the internal force effects at the machine-tool motion axes (moving of big masses) was implemented in dependence on the design made by the paper authors within the prototype tests, research and development activities of TOSHULIN, a. s company. Measuring was performed at those machines, where the authors participated by the FEM calculations (see Fig. 2) [2] and design work (design of the jig, etc.). E. g. at the machine with the rotating screw, the author created the just measured horizontal motion axis (X-axis), the whole machine frame and other functional units. Moreover, this machine also enables to influence the dynamic properties of the machine frame by utilization of the materials damping vibrations and noise, which is also based on the knowledge obtained at the research activity performed by TOSHULIN, a. s. company and on the experiments designed by the authors of this paper. The numerical simulation of this experiment is performed in [3].

The measured data (by measuring device, see Fig. 3) serve not only to provide the column check according to the manufacturing drawing but also to compare the calculated values by means of the FEM calculations. These calculations serve for the analysis of the machine behaviour as the whole unit as well as for the analysis of the particular parts of the future machine, which shall enable the precise and stable machining. The measured data serve to assess correlation with calculations. The modifications at grinding are also performed in accordance with the measuring data so that the better results can be reached at the geometric tolerances.

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