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EXPERIMENTAL MODEL FOR MEASUREMENT OF LINEAR AXES OF MACHINE TOOLS

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Abstract: *The design of the modular conception of linear axis with the ballscrew is described in this article. The aim of the experimental plant is to serve for checking of constructional and thermal influences for accuracy starting up the defined position.*
The elimination of errors resulted from the thermal influence of the detailed construction elements of machine tools can be seen. One of the main parts there is also the ballscrew, its support and the selection of the measuring equipment. The problems of the designing version, showed qualities and the accuracy starting up the linear axis position should be solved with the designed plants.

Keywords: *positioning accuracy, ballscrew, thermal load, compensation*

1. INTRODUCTION

The requirements for working precision of production machines which are increasing all the time force the producers to solve these problems. One of the possible ways is to use new technologies which can satisfy the increasing requirements of the clients and establish the producer´s market position against the competitors. To use the new technologies means to know well the qualities of each construction element of the proposed machine.

The linear axis with ballscrew is one of the important and most often used elements of machine tools. Under the term working accuracy is to be understood the linear axis positioning accuracy where the checking is given e.g. with the standard ISO 230-2 and the instruction VDI/DGQ 3441. According to the given process, the checking of positioning accuracy can be done and the ambient conditions influencing the checked value can be monitored.

One of the problems being all the time solved is the thermal stability of machine tools and their construction elements. (Marek & Marecek, 2003), (Marek & Marecek, 2004) and (Marek & Marecek, 2007) describe the thermal load influence by the detailed supports for rotation and translation motion and the usability screw support or work table translation depending on its warming. (Frank & Reuch, 2001) showed in his article the problems of screw warming and the final target accuracy according to the used measuring. (Junyong et al., 2010) made measuring of the linear axis with the ballscrew, with the dynamic and force loading.

An experimental plant on the basis of linear axis modular conception with the ballscrew was designed to monitor the positioning accuracy. On the linear axis, the ballscrew warming which means the constant problem in machine tool designing, and direct and indirect measuring accuracy, linear roller bearing and linear slide bearing influence, and if need be the ballscrew drive will be monitored.

The aim of the experimental plant is to verify hypotheses and to obtain data for elaborating of dissertation theses. After the project realization, the whole plant will be incorporated into the master´s study teaching with practical specimen and measuring.

2. REQUIREMENTS AND TARGET SETTING

The project aim is to design the linear unit which will make possible to measure and evaluate the chosen machine qualities with available equipment. The measuring principle is shown in Fig. 1. This is the question of positioning accuracy measuring influenced with the error of direct and indirect measuring. The laser interferometer ML 10 and an independent environmental compensator system EC 10 (range 0-40 meters, resolution 0,001 µm, maximum velocity ±1,0 m/s) of the company RENISHAW will be as etalon here. This measuring type was used by (Frank & Reuch, 2001) to verify the ballscrew warming influence to the positioning accuracy, according to the used measuring type. In the article (Marek & Marecek, 2004) the authors are monitoring thermal changes on the ballscrew in various working environment changes. Under these changes, there can be force loading, greasing method, linear speed change and acceleration, etc.

Some producers of machine tools prefer direct measuring system of linear axes where the interception of errors being directly in the work table position is the main advantage. The producers preferring indirect measuring system use this setting and know they are not able to intercept e.g. ballscrew free motion and wear. The caused errors are compensated with the help of their experience and knowledge of their system.

One of the aims will monitor such a behavior and correct these errors by the compensating method in the controlling system.

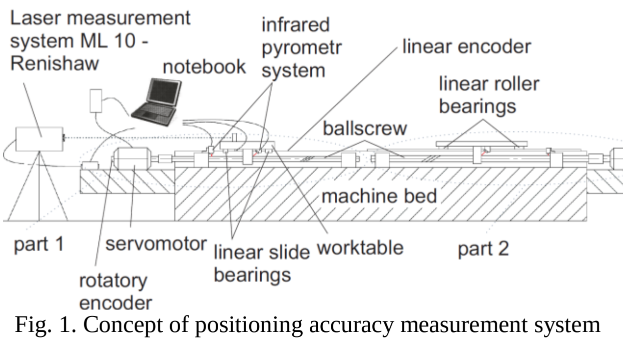

Fig. 1. Concept of positioning accuracy measurement system

Another point is to monitor the dynamic behavior of linear axis through the system transformation and to monitor e.g. bearing friction, thermal changes during external loading. The system change setting shall make modular design possible, through drive transformation directly with ballscrew or over belt gear. Stribeck curves by detailed bearings as well as the necessary forces for passive resistance surmounting shall be checked together with measuring of dynamic properties. The forces being usually substituted by a constant force at linear axis design would be substituted by more precise values, then.

3. DESIGN OF EXPERIMENTAL STAND

The design of the whole experimental plant is based on the correction of the cast iron machine bed of portal milling machine, shown on Fig. 2. The bed with the length of 2000 mm will be divided in two function parts - part 1 and part 2, shown on Fig. 1 where part 2 will be the table put on linear roller bearing and with drive over ballscrew (feed 800 mm). Further, it will be possible to make the ballscrew drive direct or over the belt gear. In the first bed part, the work table will be put on linear slide bearing driven by ballscrew with the same parameters. Again, it will be possible to connect the ballscrew drive direct or over the belt gear.

In various combinations of structural design the temperature will be measured in chosen places with the infrared pyrometer system of type MI Compact (ambient temperature 0 to 85°C, spectral response 5µm, system accuracy ±1% of reading or ±1°C, ±2°C for target temperatures <20°C) of the company RAYTEK. The other utilizable device of the type thermoIMAGER TIM 160 (ambient temperature 0-250°C, system accuracy +2% or +2°C, resolution (display) +0,1°C, real time recording at 100Hz) of the company Micro-Epsilon, will be used only at measuring starting point. It is determined for checking of the total temperature distribution on the testing plant or on the machine tool. With the help of thermoIMAGER the places on coupling, servomotor, linear roller bearings, linear slide bearings or inserted belt drive, will be monitored. The first place temperature reading will be on the ballscrew nut and the other one on the ballscrew support (Fig. 1). Information about the ballscrew temperature will be evaluated in notebook. The error originated from the rotatory encoder on the servo motors Control Techniques - 115UMC301CAAA (the maximum number of pulses per revolution of the simulated-encoder outputs 4096) and directs measuring RENISHAW - RGH22 linear encoder (resolution 0,5 µm) and directs measuring ESSA ILCV 1140 (accuracy ±5 µm) will be compared with given temperature. The evaluating will be made as a position-error diagram. Another result will be change monitoring in the time of linear axis operation (e.g. 0 hours, 2 hours, 6 hours).

The first part of linear axis is designed with direct drive, shaft coupling or servo-drive and belt gear with ballscrew put fixed on one end and free on the other one. The work table is put on linear slide bearing being taken of the original design. The second part of linear axis has the same concept as part 1, and the work table is put on linear roller bearings.

4. CONCLUSION

The suggested experimental plant is determined for monitoring and checking of linear axis qualities, with ballscrew. The monitored positioning accuracy will be evaluated on the type of design solution, operation time and thermal changes on ballscrew and type of used measuring system.

The error of positioning accuracy, temperature and time are to be seen from article (Frank & Reuch, 2001) and (Junyoung et al., 2010). The results obtained by measuring will further serve for prediction of linear axis positioning accuracy, with ballscrew, and its increasing with the help of compensating methods.

The obtained information of measured data is determined for positioning accuracy prediction. The elaborated data will be put to statistic analysis. The resulting values will be used for the model of suggested compensation. The necessary correction values will be derived from temperature dependence and deformation in the direction of ballscrew axis. The possibilities of utilizating more precise compensation methods appear together with new technologies and more efficient computer technology. One part of machine tool thermal interaction could be solved by using suitable temperature meters and a suggested algorithm. A higher precision on the work piece would be gained by precision increasing with positioning. Another advantage is using only indirect measuring, and thereby development space decreasing and acquisition price reduction for the measuring system.

By big machine tools where linear slide bearings are utilized first, and where there are problems with stick-slip effect, the results would serve for motion simulation. The first part of the experimental device shall monitor the behavior of measuring device and the control system evaluation just for such a behavior.

Another part of the research will be monitoring of losses and behavior of the detailed linear bearing types, where the losses originated in those detailed types will help to determine power-producing demands at machine tool motive axes (ECODESIGN of production machines).

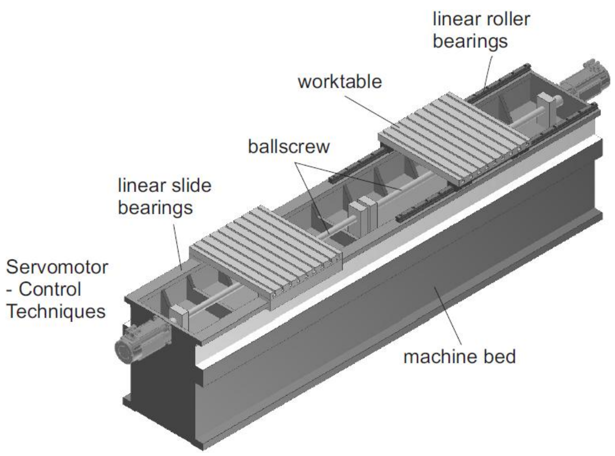

Fig.2. Machine bed of portal milling machine

The results of this research shall serve to solving similar directed problems for positioning accuracy increasing or production accuracy of machine tools and for decreasing of power-producing demands by motive axes.

The compensating methods themselves and using of mechatronic systems are one of the ways how to increase further working accuracy of machine tools.

5. ACKNOWLEDGEMETS

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