BEARING SUPPORTS AND THE ASSEMBLAGE ERRORS OF THE BALL SCREWS OF THE NUMERICAL CONTROL MACHINE TOOLS

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1. INTRODUCTION

The research directions of the feed kinematical linkages of the numerical control machine tools make reference, in general, to the static and dynamic parameters of the axis: the positioning accuracy, path error, minimum and maximum feed rates and the dynamic stability in terms of vibrations.

These static parameters differ in function of the type of the feed kinematical linkage. The study and research of feed kinematical linkages refer to improving the positioning accuracy in function of: the slide-guideway friction, feed kinematical linkage rigidity, assemblage errors, positioning of the final element towards the mobile element and its guideways, location of the measurement system in case of both direct and indirect measurement, the backlash of the feed kinematical linkage.

Another parameter subject to researches consists of the path error. This parameter is only encountered at contouring feed kinematical linkages. Practically, in case of such linkages, besides the positioning accuracy, sometimes measured under load (cutting forces), the path error occurs too. The influence of the transient time on the path error is an important problem along with obtaining a high positioning accuracy and a good stability of the axis. Knowing the influence of the transient time in function of the rigidity of the feed kinematical linkage, of the slide-guideway friction coefficient, of the thermal deformations, of the measurement system, etc. is a determining aspect for increasing the performances of the CNC machine tools. If in case of the positioning feed kinematical linkages and linear machining the transient duty does not impose conditions, thus giving the possibility for obtaining the axis stability through a long response time, as the only parameter is the positioning accuracy, in case of the contouring feed kinematical linkages the behaviour at transient duty comes up in addition, where the requirements on the feed kinematical linkage are much higher.

2. BEARING SUPPORTS AND ASSEMBLAGE ERRORS ON BALL SCREWS

With a view to obtaining a good rigidity of the feed kinematical linkage, an important role is held by the nut supports and bearing supports of the ball screw. The main components of the feed kinematical linkage that produce elastic deformations are: the support of the ball screw thrust bearing; the thrust bearing; the ball screw nuts; the ball screw itself; the nut support. Fig. 1 shows the deformation of the ball screw itself, ***ΔSp*** related to the length, when a thrust force Fa = 1000 Kp acts on the ball screw

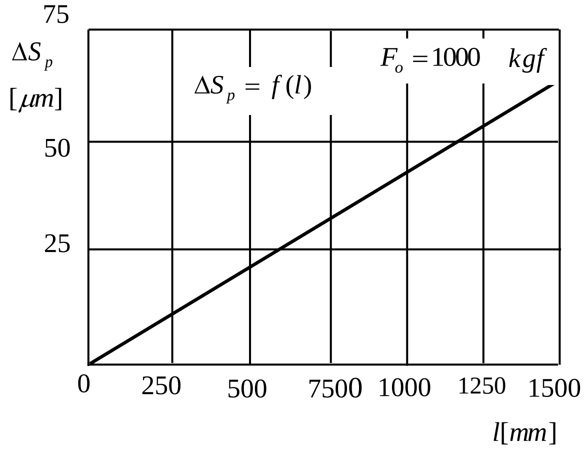

Figure 1. Positioning non-accuracy in function of the ball screw length.

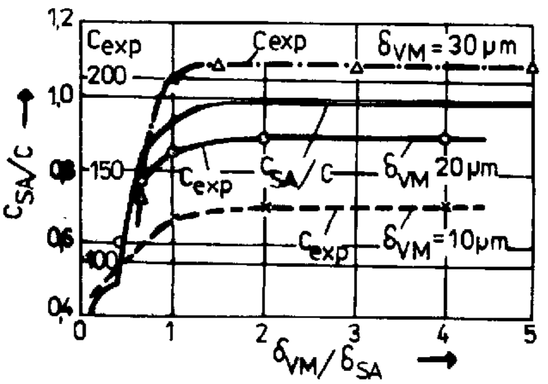

Figure 2. Rigidity in function length of the frontal runout.

The rigidity behaviour is also influenced by frontal runout of the bearing supporting surfaces, especially at low preloading rates of the thrust bearings. Researches have been done for this influence on a bearing having the inner diameter of 30 mm and provided with thrust ball bearings. Fig. 2 shows the rigidity behaviour of the thrust bearings upon assemblage in function of the frontal runout of the supporting surfaces of the bearings. The theoretical curve shows the decrease of rigidity caused by the frontal runout of the parts. If the preloading stroke δVM is lower than the frontal runout δsa, then the rigidity will decrease. By continuing the preloading increase, the rigidity of the bearing will no longer be affected by the frontal runout.

The measurements of the deformations are proving that there is a limit beyond which the rate of the frontal runout leads to a significant decrease of the bearing rigidity. Upon the assemblage of the ball screw and correct coupling of the nut housings to the slide it should result a good alignment of the position of the ball screw bearing, nut housings and guideways. Researches are specifying that in case of the alignment errors, high resistant forces occur near the bearings, that produce high inner stresses into the nuts and, through these, tipping of the slide. Fig. 3 shows the result of the researches on a ball screw of 50 mm diameter and 10 mm pitch and borne at both ends. It may be noticed the variation of the rotation torque in function of the slide travel. The external load is zero and the nut preloading force Fv = 1000 kP. Significant modifications of the torque are noticed at assemblage deviations δx, close to the bearings.

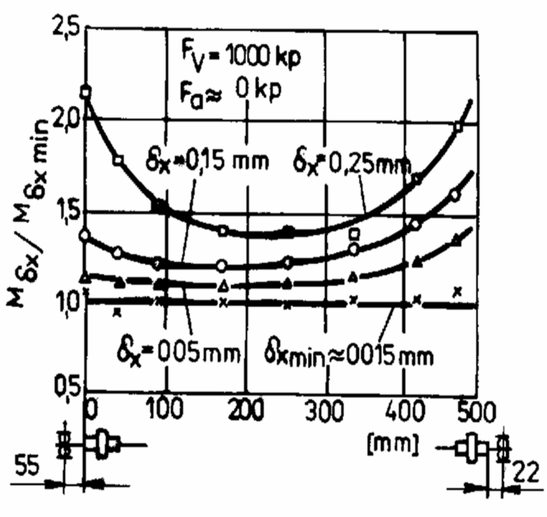

Figure 3. Variation of the torque on the ball screw at various assemblage errors.

Besides the non-favorable influence by limiting the life of the bearings, these assemblage errors are acting on the positioning accuracy.

Fig. 4 shows the results of the researches on the return backlash that increases along with the assemblage error while the slide is moving close to the ball screw bearings. Researches have been done on a ball screw of 50 mm diameter and 10 mm pitch. During these trials the rate of the preloading force in the nut has been decreased, 200 < Fv< 800 kP, by keeping constant the alignment error of the ball screw, δx = 0.15 mm. It may be noticed the increase of the return backlash while lowering the rate of the preloading force.

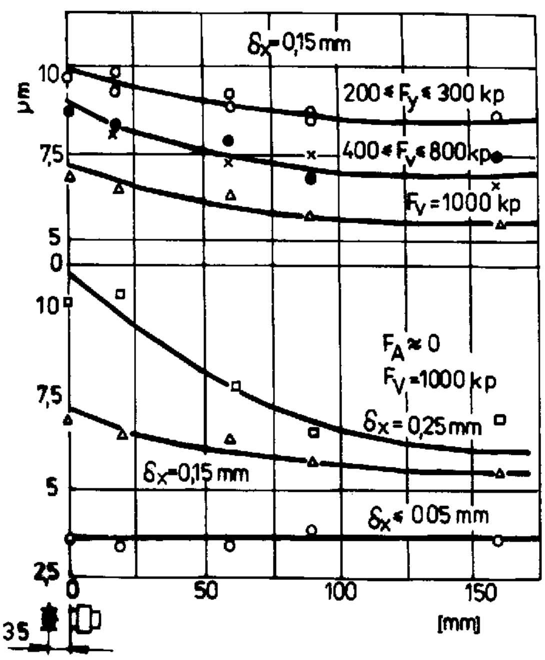

Figure 4. The return backlash at various rates of the assemblage error.

On a slide with sliding guideways (counter ways are coated with Turcite) and an alignment deviation of the ball screw δx < 0.05 mm, the preloading force Fv = 600 kP, the influence on the positioning accuracy is low.

Similar researches have been carried out on the vertical deviation of the ball screw non-alignment. Fig. 5 shows the results of the researches on the return backlash of the slide in function of the travel. Diagrams have been drawn separately for various rates "f" of the vertical non-alignment. Researches have been done on a ball screw of 40 mm diameter and 10 mm pitch and the slide guiding was performed by means of roller guideways. The external force on the slide was Fa = 0.

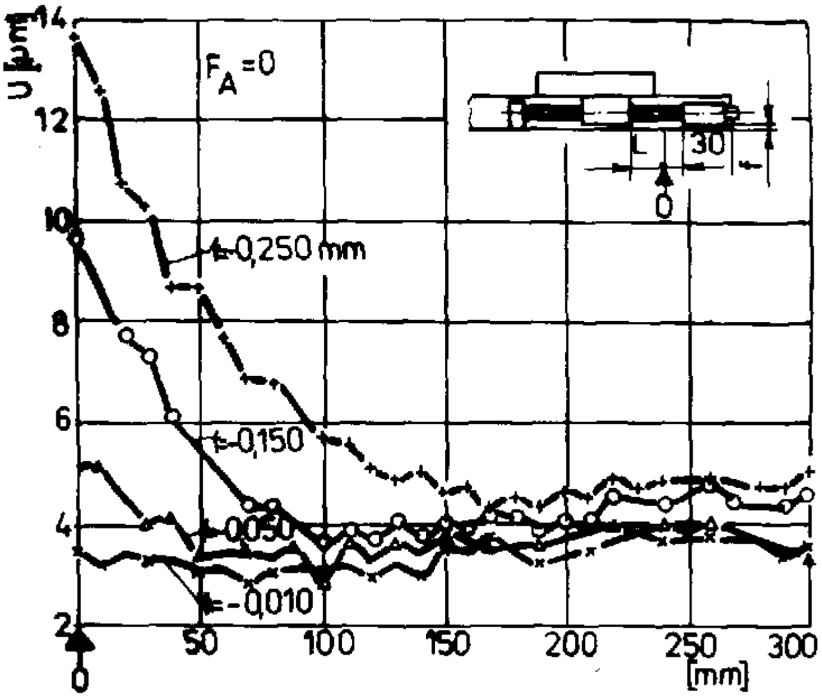

Figure 5. The return backlash at vertical assemblage errors of the ball

3. CONCLUSIONS

The careful assemblage of the feed kinematical linkages leads to decreasing the assemblage errors as well as negative effects on the positioning accuracy and the path error. The choice of the ball screw bearing type as well as the bearing support is an important problem for a CNC machine tool designer and builder.

In general, the design solutions chosen during the designing stage are also imposing the extent of difficulty of the assemblage and the assemblage errors, by default. Another factor that the designer has to consider is the optimal stability of the rates of the preloading force of the ball screw
nuts and thrust bearings. Also, the rates of the preloading force and of the slide-guide way friction are to be correlated.

All these factors specified in this work are into a total interdependence that makes the designer-builder duly establish the suitable design solutions with a view to obtaining a high positioning accuracy and a path error as low as possible.

References

1. Pressman, R. *Numerical Control and Computer Aided Manufacturing, New York, 1991.*

2. Cervenka. N., Reimbun. U. *Analyse des dynamischen Verhaltens einen Hochleitun, Maschinemarkt, nr. 84, 1993.*

3. Marusche, H. *Problems bein Walzschranbtreib als Antriebs und MeBelement în Werkzeugmaschinen, Maschinenbautechnik, nr 2, 1990.*

4. Nassirpour, G. *Statistical evolution of surface finish and relation stip to cutting parameters inturning, Machine Tool Design, nr. 14, 1999.*

5. Larsen, I. *Analysis of the state of research in cutting dynamics, Editura Tehnica , nr. 8, 1989.*

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