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EXAMINATION OF MACHINE TOOL SLIDEWAY COMBINED WITH PRESSURE CHAMBERS

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Abstract: This paper deals with the preliminary functional testing of a novel combined slideway type. In order to improve the accuracy of a portal-type milling machine to be designed as part of a departmental project, special unloaded guideway designs have been investigated, resulting in a slideway structure relieved with hydraulic pressure chambers. A measuring bench was set up to check the amount of the relief. Based on the primary measurements performed, it is proven, that the pressure chambers relieves the load by providing a suitable sliding surface.

Keywords: *hydraulic, slideways, machine tool, pressure chamber, load relief*

1. Introduction

The departmental consortium partner has repeatedly proposed several horizontal and vertical slideway designs in which the slideway surfaces is supplemented with hydraulic pressure chambers. The design, location and function of the hydraulic pressure chamber are different for each version. A common feature of the solutions is that the resulting gap oil is collected and drained within the pipeline structure. According to the consortium partner, during operation, a fluid flow is created in the narrow gap formed between the beam and the guide surface of the pressure chamber guide ring at the sealing surfaces defining the pressure chambers, the gap flow providing a constant gap size in a self-regulating manner. Because the beam moves on a lubricant film, there will be minimal feed force. The leak oil is collected by an outer ring and conducted through a manifold into the tank. A low (few bar), constant pressure in the chambers would be provided by a hydro-pneumatic unit.

This type of guideway is referred to in the literature as partially unloaded slideways [1]. A partially unloaded slideway is a construction in which a pressurized lubricant, such as air or lubricant fluid, is placed between the sliding surfaces to reduce the load on the sliding surface, thereby moving a heavy body smoothly with minimal friction loss. High-precision machining of parts is required to prevent air leakage and to avoid a drop in compressed air pressure. Furthermore, the surfaces of air-relieved slideways tend to float when the surface pressure is relieved. For this reason, oil-relieved slideways came to the fore in the early stages of development [2].

With the incompressible fluid, the lubrication of the sliding lines is as good as with the compressed air version, while the stiffness of the construction is much higher. The hydrostatic effect is much easier to obtain with oil, since the manufacturing accuracy of these slideways surfaces, does not have to be as strict as when compressed air is used. *Figure 1* represents a perspective view of an oil-lifted guideway. The pockets used to reduce the load are not simple pressure pockets, but hydrostatic chambers with a pressure-reducing function. At high speed feed motion, these hydrostatic pockets eliminate the phenomenon of floating due to hydrostatic action. In this way, it is possible to compensate for the excessive movement that occurs at high speed feeds, which is the biggest problem with partially floating guideways.

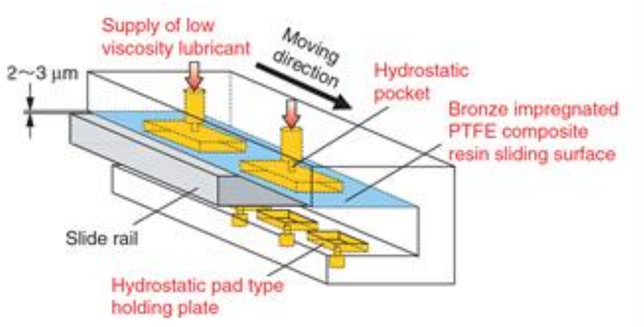

Figure 1
Operating principle of the oil-lifted guideway

2. SETTING UP THE MEASURING BENCH

To perform the measurements, an earlier device developed for testing rolling blocks was modified. With this device it was possible to inspect 8 rolling blocks at same time. Leaving the test frame, block clamping and loading system, the pressure chamber specimens can be inspected to determine the pressure at which the force required to move the beam decreases under a pre-set load, and during measurements the operation of the oil drainage channels can be checked. The specimens are located on the polished side surfaces of a central rectangular beam with 2-2 blocks on each conductive surface *(Figure 2)*. The 4-4 specimens were mounted on a motherboard in a "V" shape (negative prism shape). One base plate is attached to the stand, the other is placed on a beam placed on the lower base. The motherboards are surrounded by load rings.

Test specimens are supplied from a common hydraulic circuit, so that the same pressure will be applied in each pressure chamber and the same hydraulic force will be generated in each test specimen. The leakage fluid collecting channels are discharged separately for each block, so it is easy to observe if a leakage starts in one of the slippers. The force exerted on the slippers facing each other in pairs can be created by tensioning a steel ring supported in the nest at the load center of the specimens.

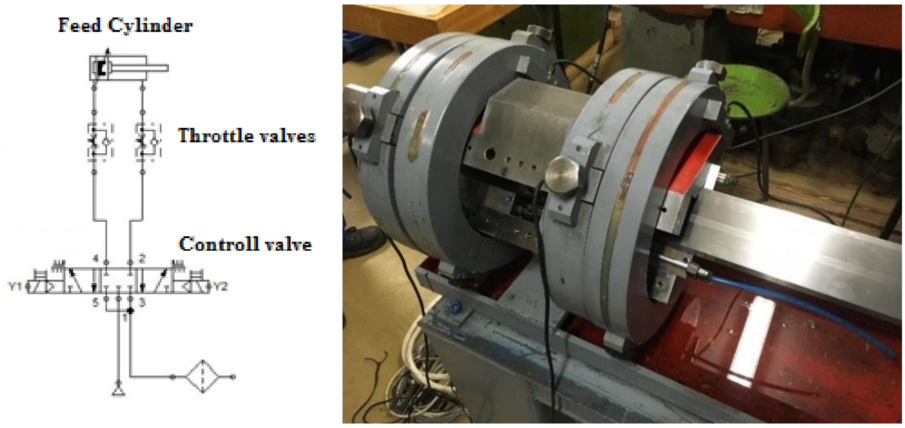

Figure 2

Hydraulic circuit of the test equipment feed cylinder and the assembled test equipment

3. Results of the measurements

The purpose of the test is to determine, if the load on the pressure chamber specimens gradually increases, at what chamber pressure is there a more significant decrease in the force in the feed force. The chamber pressure of the feed cylinder can be read with pressure transmitters connected to the hydraulic connections of the cylinder.

The load can be adjusted by the tightening torque of the support bolts of the load ring enclosing the specimens carrying the specimens, from which the magnitude of the preload can be recalculated by knowing the thread diameter and pitch of the support bolt. Expectable gap flow effects can also be evaluated later. But certain principles can be taken into consideration.

During the measurements, the unloaded state and the behavior under three tightening torques (5 Nm, 10 Nm and 15 Nm) were examined for the structure. As the chamber pressure was increased, it was visually inspected for oil leaks in the outlet pipes of the pressure chambers and, if so, to what extent. As a result of the increase in pressure, the load rings suffer an elastic deformation, which results in an increase in the slideway gap and thus in the start-up of the leakage oil. This leakage oil appears on the oil drain pipes as the pressure increases.

At chamber pressures of 0 and 5 bar, the starting pressure was not measured because both the cylinder and the line unit receiving element were significantly deformed even at a pressure of 20 bar. There was a risk of permanent damage to the equipment with higher forces. When checking the tightness of the slipper body sliding surface, it was observed that as long as there was a maximum dripping on the leaking line, there was no dripping on the side surface of the specimens, but when there is oil leakage on the leaking line, oil leakage also appears on the side surface.

Table 1
Measurement results and observations at a tightening torque of 15 Nm (4,9 kN preload)

Chamber pressure [bar]	**Cylinder pressure** [bar]				**Leakage**	**Observation**
	+ direction		**- direction**			
	p_1	p_2	p_1	p_2		
0	**20.2**	**2**	**2.5**	**19.7**	**Leakage did not appear.**	**Beam did not move.**
5	**20.2**	**2**	**2.5**	**19.7**		
10	**20.2**	**2**	**2.5**	**19.7**		
15	**20.2**	**2**	**2.5**	**19.7**		
20	**2.5**	**3.5**	**3.5**	**6.5**	**Before starting, some leakage outputs dripped. After starting, the drip was more intense, some outputs also showed flow on the cylinder side.**	**It started with stick-slip and then moved smoothly.**
25	**2.2**	**2.2**	**3.5**	**6**	**Intense flow on the cylinder side and a output on the other side, the rest were dripping.**	**Moved smoothly.**

4. SUMMARY

Partially unloaded combined guideway system was tested, with the help of a slideway structure unloaded with hydraulic pressure chambers. A measuring bench was set up to check the magnitude of the unloading. Based on the measurements, it can be seen that the counterforce can be created with hydraulic pressure chambers, which is suitable for relieving the friction guideway.

The system is very sensitive to the parallelism errors of the conductive surfaces, a few µm error already results in the appearance of the oil leakage. If the elastic deformation of the machine causes a parallelism error of a few µm, it will result in the early appearance of the oil leakage.

The amount of leakage oil increases with increasing chamber pressure. This is partly due to the fact that the higher pressure occurs a larger volume flow through the existing gap, and partly due to the higher loading force owing to the higher pressure, the load rings are more deformed and therefore the size of the gap increases. It takes significantly more force to start the carriage than to keep it moving.

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