Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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Annals of DAAAM International

STRESS ANALYSIS OF A ROLLING SLIDEWAY

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Abstract: *A combined numerical and experimental study of the stresses in the grinding elements of a rolling slideway is described in this paper. The analysis was carried out using the finite element method and the photoelasticity technique for different cases of loading corresponding to common working operating conditions. Agreement between calculated and measured results was good and the area with maximum stress in each case was predicted with reasonable accuracy. The results of the study should find important use for a proper design of the rolling slideways in terms of high reliability.*
Key words: *stress analysis, FEM, photoelasticity, rolling slideway*

1. INTRODUCTION

The qualitative leap registered lately in machine-tool building industry can be estimated mainly by the increasing of the processing accuracy, of the kinematic precision and of the dynamic performance of the machine-tools in terms of reducing energy consumption. In order to achieve these performances, new machine parts have been developed, examples being the driving screws, the guides and the transmissions with intermediate elements (Ito, 2008; Nicolescu, 2009). All these machine structures are subjected to complex loads that occur during service. In order to properly design them and to increase their reliability in operation it is necessary to know the state of stress in the component elements. This analysis, based on the classical methods of mechanics of materials, the theory of elasticity (Rusu-Casandra, 2008) or the finite element method, requires several simplifying assumptions regarding the geometry of the structure, the way of applying the loads, the mechanical behavior etc. As a result, the behavior of structures resulting from calculation differs from reality sometimes. Therefore, more accurate knowledge of the state of stress in the machine components is necessary.

Correspondingly, this paper presents a comparative study of the stress state in the guiding elements of a rolling slideway (Fig.1). The analysis was performed using two methods, a computational and an experimental one respectively. On evaluating various alternative methods of experimental analysis, the photoelastic technique (Iliescu & Atanasiu, 2006). has been chosen in order to validate the mathematical model of calculation obtained with the finite element method.

2. NUMERICAL CALCULUS

A finite element analysis was performed using SOLIDWORKS software (***2010). The model representing a cross section through a rolling slideway, with a Poisson's ratio value applicable to photoelastic materials, was loaded through a system of levers in two separate ways: a) with the weight P_H=640N applied in the horizontal plane, in five different sections corresponding to common working operating conditions; b) with the weight P_V=800N applied in the vertical

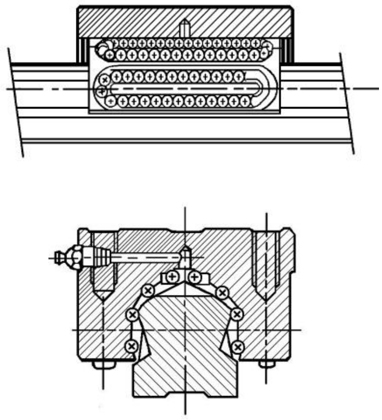

Fig.1 Rolling slideway

plane. Both the boundary conditions and applied loads used for the finite element model were chosen to be similar to those of the photoelastic model. The contour plots of the principal stress σ_1 for the model subjected to the force P_H applied in one of the five investigated sections are shown in Fig.2, and for the model loaded with P_V in Fig.3 respectively.

3. PHOTOELASTIC INVESTIGATION

The two elements of the photoelastic model of the rolling slideway (the sled and the guide prism) were cut from a DINOX-010 plate of 0.5mm thickness, at a scale 1:2, while the balls were modeled by cylindrical rollers made of plexiglass. The processing of these components was made with high precision, so the interference to be minimal. The loaded photoelastic model was examined in the polarized light from a circular polariscope. Figure 4 shows the isochromatic patterns photographed for the model subjected to force P_H applied in the same section as for the case presented in Fig.2. Fringe-patterns obtained in the model loaded with the force P_V are shown in Fig.5.

In all six investigated cases it was noticed that the values of stresses in the guide prism is much smaller in comparison with the ones in the sled, the latter taking over the load transmitted by the machine-tool. Therefore the principal stress distribution σ_1 on the unloaded boundaries was determined only for the sled. In Fig.6 and Fig.7 are plotted the curves of the principal stress σ_1 on the interior contours of the sled for the cases of loading shown in Fig.4 and Fig.5 respectively.

4. CONCLUSION

The stress analysis of a model of a rolling slideway, performed numerically (Fig.2 and Fig.3) and experimentally (Fig.6 and Fig.7) for five cases of loading in the horizontal

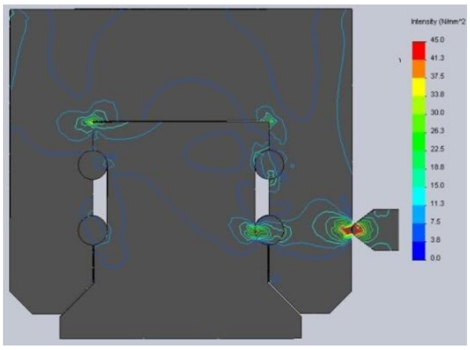

Fig.2 Contour plots of the principal stress σ_1 for load P_H

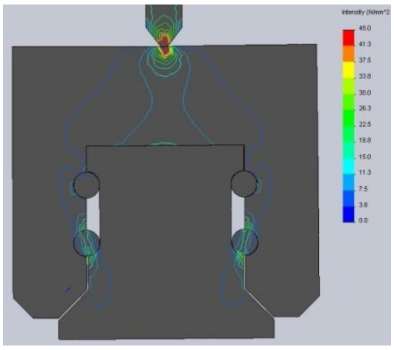

Fig.3 Contour plots of the principal stress σ_1 for load P_V

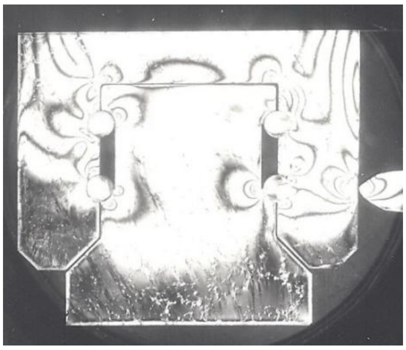

Fig.4 Isochromatic patterns for load P_H

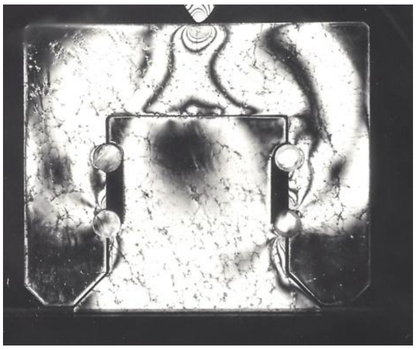

Fig.5 Isochromatic patterns for load P_V

plane and one case of loading in the vertical plane led to the conclusions:

a) In all cases it has been found that the load is mostly taken over by the sled, the values of stresses in the guide prism being much smaller.

b) The maximum stressed area for loading in horizontal plane is in the interior of the sled, on the force side. Studying all five cases, it was remarked that the values of the principal stress σ_1 in this area increase as load moves downwards, the highest stress occurring when force P_H is applied on the lower end of the sled (Fig.8).

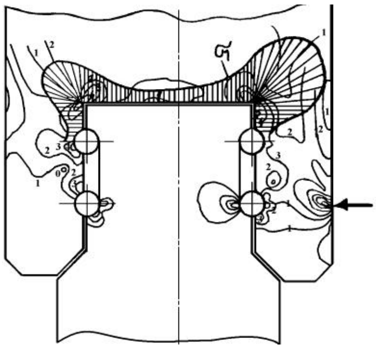

Fig.6 Principal stress σ_1 for load P_H

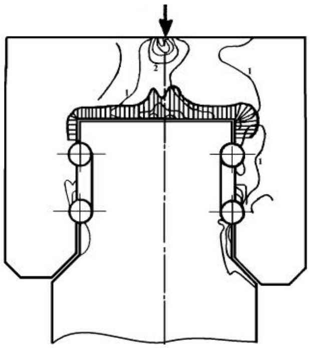

Fig.7 Principal stress σ_1 for load P_V

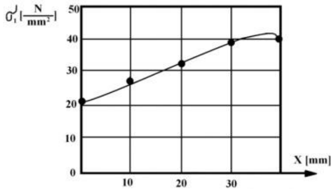

Fig.8 Variation of σ_1 with the movement of P_H

c) The loading in vertical plane shows a tendency of deformation of the sled, that makes the contact between the sled and the guide prism take place at the top, in the central area. As a result, in this region will appear sliding friction forces that will affect the normal movement of the sled. At the same time, due to the deformation the sled will open, the interference between the sled and rollers will increase and the rollers will no longer be involved in rolling motion. Therefore, in such situations, it is necessary to make an appropriate adjustment of these interferences.

d) No noticeable discrepancies occur between theoretical and experimental results.

As further work, with the more accurate information regarding the stress state offered by this study, it is possible to correct the shape and dimensions of the elements of rolling slideways and finally obtain a reduction of the material consumption in terms of high reliability.

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