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A COMPARATIVE PHOTOELASTIC INVESTIGATION ON THE STRES STATE IN THE FLANKS OF SOME SCROLLER SHAFTS

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This paper presents a comparative experimental study aimed at the design of scroller shafts of special shapes. The study was carried out by photoelasticity technique on the stress state in the flanks of two types of scroller shafts, for an extreme situation met in practice - the selflocking of the shaft.
The result of the performed study led to the correction of flanks geometry, resulting an optimal shape for the new type of the designed shaft.

three dimensional photoelasticity technique, circular polariscope, isochromatic fringes, stress state.

1. INTRODUCTION

The scroller shafts which are parts of some technological equipment have the function to transport the material to be processed from the supply to the injecting or cutting compartment, by developing a certain compression force that provides the required pressure for a constant flow rate evacuation.

In order to carry out this function, the scroller shafts are made with variable geometry (the step is decreasing and the height of the flanks is increasing towards the compression compartment). The stress state in the flanks is different from one coil to another due to the variation in the geometry of the structure, and it is difficult to calculate it even with numerical methods, because the forces that occur are hard to be evaluated.

In order to design scroller shafts of special shapes in a new stuctural view, this paper presents a comparative experimental study, carried out by three dimensonal photoelasticity technique, on the stress state in the flanks of two types of scroller shafts. The two models (fig. 1) were designed as structures with metallic insertion, composed of a central steel shaft with hexagonal section, on which the scroller of thermoplastic material was injection moulded. Experiments have been carried out for an extreme situation met in practice - the selflocking of the shaft.

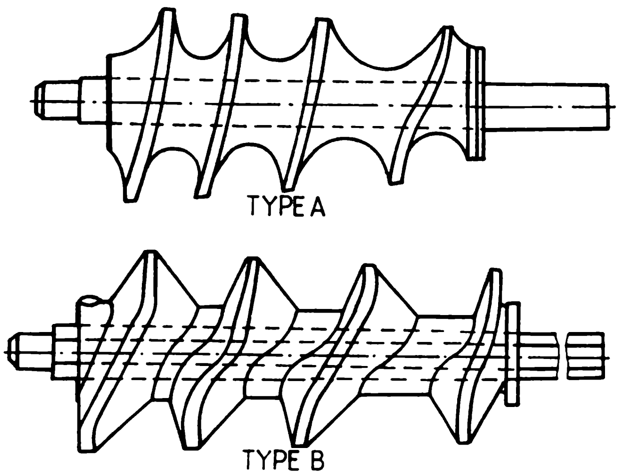


Fig. 1

2. PHOTOELASTIC MODELS

These have been made of ARALDITE - D at a 1:1 scale, by cold casting in moulds of silicone rubber. The stresses in the shaft were fixed by using the "freezing technique". The material to be processed was simulated by textile pieces imbued with silicone oil, put in through the feeder and transported in the processing compartment using the crank.

The machine was fed until the shaft was selflocked. Under these loading circumstances the whole assembly was heated slowly in an oven up to 85°C. It was maintained approximately one hour, afterwards the feeder was fully loaded and the material was compressed with 40 N weight; a weight $P_1 = 10$ N was placed on the crank, which produced a torsion moment $M_t = 2$ Nm in the shaft.

Afterwards, with loads still maintained, the oven was slowly cooled at a rate of 5° C per hour down to room temperature. After cooling each model was sectioned longitudinally with two planes, resulting a central slice with thickness $t_1 = 5$ mm, that contained the central longitudinal plane of the model.

Together with the photoelastic model in the oven was also placed a disc with the diameter $D = 73$ mm and thickness $t = 7$ mm, made from the same material as the model, diametrically compressed with a force $P = 20$ N. The disc followed the same thermal cycle as the model, and was used to calibrate the material, resulting the stress photoelastic constant of the material (F_σ).

3. EXPERIMENTAL MEASUREMENTS

The flat slices that resulted after the section of the models were examined in a circular polariscope with monochromatic light. Figure 2 presents the isochromatic pattern photographed for the two investigated sections.

For the calibration of the photoelastic material, the disc was examined in the polariscope, establishing with the Tardy method the fractional value of the fringe order ($N = 2{,}52$ n fringes).

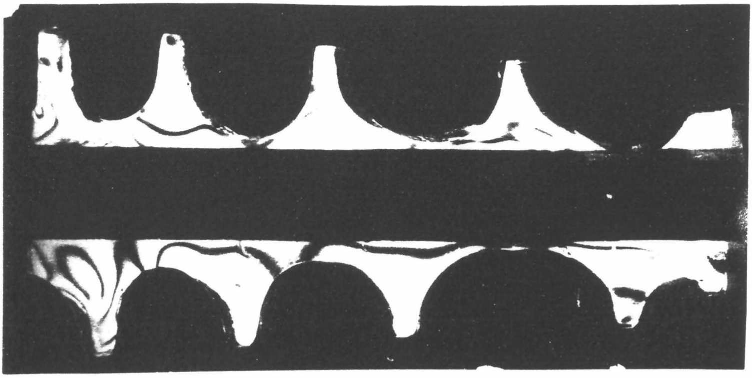
Using the expresion :

$$F_\sigma = \frac{8\,P}{\pi\,D\,t\,N} \qquad (1)$$

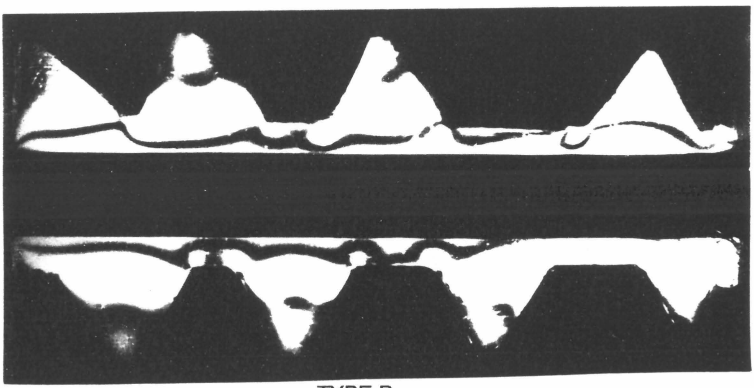
the value of the optic coefficient of the model was found to be :

$$F'_\sigma = t\,F_\sigma = 0{,}2765 \text{ N/mm fringe} \qquad (2)$$

Considering that the slices thickness that resulted after sectioning was $t_1 = 5$ mm, the optic coefficient was established for the model of slices :



TYPE A



TYPE B

Fig. 2

$$F_{\sigma m} = \frac{F'_{\sigma}}{t_1} = 0{,}0553 \frac{MPa}{f_r} \qquad (3)$$

In figure 3 are plotted the curves of the principal stresses difference $\sigma_1 - \sigma_2$ on the boundary of the two investigated models.

4. CONCLUSIONS

Studying these curves it can be observed that :

a) the value of the stresses is much lower in model type B compared to the model type A. Thus the stresses on the surface of the first coil flank that compresses the material in the processing compartment are 50% lower in type B compared to type A. On the other side of the same coil of the type B the stresses are 75% lower compared to type A.

b) small curvature radii (2 mm) between the flanks and the body of the shaft in type B have no significant influence on the distribution of stresses, therefore this area is not a stress concentrator.

c) the existence of a stress state (quite low) at the upper side of the shaft between coil 3 and 4 and the presence of very small stresses or even non existant (type B fig.3) at the lower side shows that this area of the shaft was placed in front of the feeder. The stresses at the upper side were produced by the compression due to the processed material, while at the lower side, where the shaft is not loaded, the stresses are very small.

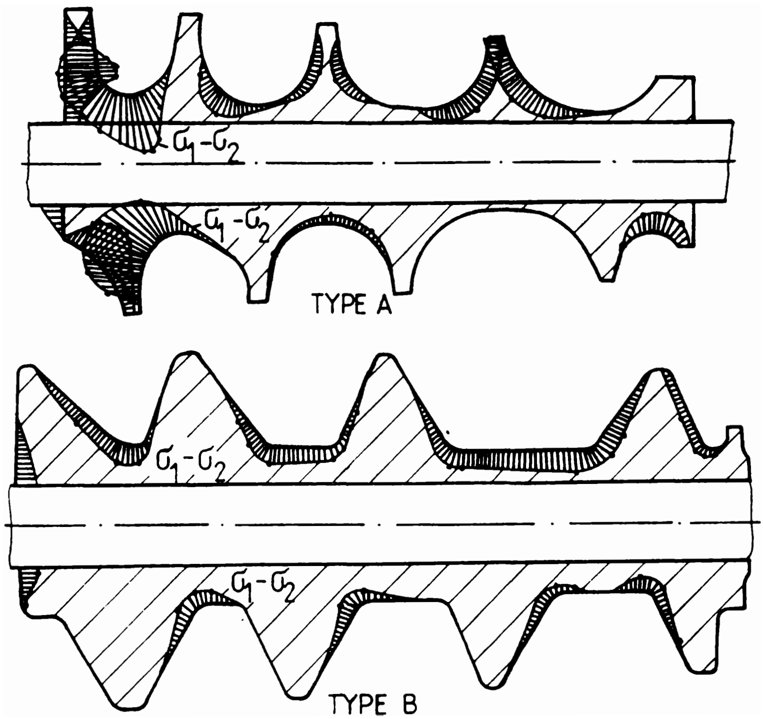


Fig. 3

The results of this study outline an oversizing of coils in type B. Therefore, one can estimate that the thickness of these coils may be reduced with up to 30%, maintaining the same curvature radii, without any significant rise in the value of stresses.

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