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EXPERIMENTAL AND NUMERICAL ANALYSIS OF UNIAXIAL AND MULTIAXIAL FATIGUE IN THE LOCK OF SCRAPER CONVEYOR CAST FROM ADI

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1. Introduction

The study presents and compares the results of experiments and numerical calculations of fatigue life of the cast lock of scraper conveyor used in the mining industry. The objective of the study was to determine the fatigue life characteristics of ADI in accordance with the methodology of low cycle fatigue testing (LCF) and its modified version (MLCF), including also fatigue life tests carried out directly on the casting of the lock. The state of stress in the casting caused by the effect of forces applied in the test equipment was determined by the finite element method (FEM). The obtained results were used in calculation of the fatigue life of the lock applying the selected hypotheses of multiaxial fatigue. The results of calculations were compared with the results of experiments, evaluating at the same time also the validity of the adopted hypotheses.

Locks operate as parts of conveyors for the underground mining transportation. In most cases they are forged from the low-alloy structural steel of 25HGNM grade (Fig. 1).

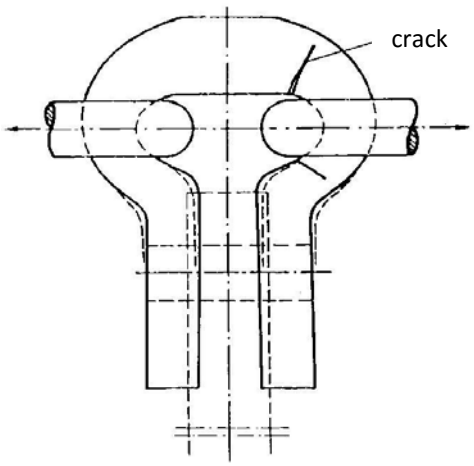

Fig. 1. The shape of the lock and the test mode of loading with deformation (dashed line) and direction of crack propagation during destructive testing [1, 2, 3]

The state of stress and strain in the numerical model of the lock corresponding to the mode of loading and the type of connection made has been discussed in earlier works [1, 2, 3]. The model of the lock examined in this study corresponds to the boundary conditions, which occur in the test equipment during cyclic loading of the casting done on an MTS 810 testing machine.

2. Experimental

The aim of the conducted experimental studies and numerical calculations was to compare the obtained results and choose the right criterion. Experiments consisted in fatigue testing carried out in the range of low cycles on samples of ADI at a loading cycle asymmetry coefficient R = -1 and in shape testing, during which the cast lock was subjected to fatigue loading. Because of the necessity to shorten the test time, the arms of the lock were not fastened with screws as is the case during the connector operation.

During positive cycles of stretching the lock with the applied force of 75kN, the fatigue shape testing has demonstrated that the average life of the lock was 168 cycles. For the numerical model, the same scheme of loading and mounting was designed as for the test model. As a result of numerical calculations made in an Abaqus program, the value of effort was determined for the entire casting of the lock (Fig. 2)

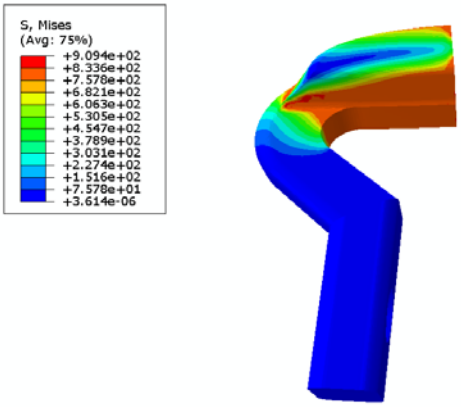

Fig. 2 Effort in the casting of the lock under the influence of a tensile force of 75kN applied in the test equipment

Using "fe - safe" software and the results of strength calculations, based on the above mentioned fatigue criteria, the durability of the cast lock was predicted. The result obtained for multiaxial fatigue criterion is shown in Figure 3.

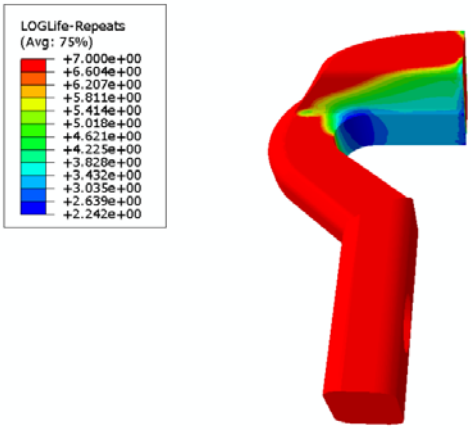

Fig. 3. The number of cycles to failure determined for the entire casting of the lock according to Morrow principal strain criterion of multiaxial fatigue. The results are expressed in decimal logarithms.

In the area of contact with the chain link, the fatigue of the material assumes its highest value reducing the durability of the lock to 174 cycles (log 2 N = 2.242), while in the remaining part of the casting the durability is practically unlimited and reaches 10^{10} cycles (log 2 N = 7). In a way similar to Figure 3 are distributed the durability areas for the remaining criteria, remembering that the uniaxial C-M criterion provides a durability of 123 cycles, while the value of average stress introduced to the S-W-T criterion reduces the predicted life even more, i.e. to 69 cycles. Comparing the obtained numerical results with the experimental ones it follows that the best result gives multiaxial criterion of principal strain.

4. Conclusions

1. The fatigue of the lock assumes its highest value in the area of contact with the chain link.
2. Regardless of the applied criterion, the areas of durability in the lock are distributed in a similar way remembering, however, that the value of average stress introduced to the S-W-T criterion gives the durability of 69 cycles, while according to the C-M criterion the durability amounts to 123 cycles.
3. Comparison of numerical calculations with experimental studies proves the validity of multiaxial criterion of principal strain.

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