INVESTIGATION OF GEOMETRY AND MECHANICAL SURFACE HARDENING EFFECTS ON SCREWS FATIGUE STRENGTH

N.Plavšić, R.Mitrović, A.Subić *

In case of screws subjected to fatigue load in tension, failure most frequently occurs at the beginning of the threads on the screw shank or at the fillet under the screw head. Because of geometric discontinuities, material and surface irregularities effect on the stress distribution, it is necessary to investigate various governing influences in order to achieve higher screw fatigue strength. This paper presents a comprehensive analysis based upon the results of experimental investigations carried out on screws, before and after surface hardening.

INTRODUCTION

Geometric discontinuities of mechanical parts, such as holes, grooves, notches and other changes in cross section, that affect the stress distribution, represent the most obvious points at which fatigue failures initiate. Stress concentration is also affected by all internal and surface irregularities.

Stress concentration is followed by local deformations which affect the growth of the initial crack. Once a crack has occurred at a point of discontinuity, the stress concentration effect becomes more significant and the crack propagates more rapidly until the final failure. Figure 1 shows the crack development process.

In the case of screws, subjected to tensile fatigue load, failure is most frequent at the beginning of the threads on the screw shank, in the thread at the nut face and at the fillet under the screw head. In order to achieve higher fatigue strength it is necessary to modify the screw geometry at all discontinuities and to apply appropriate mechanical surface hardening processes. An example of such a process is presented in Fig.2.

* Faculty of Mechanical Engineering, University of Belgrade

EXPERIMENTAL INVESTIGATION

Experiments are carried out on the connecting screw of motor crank-shaft, before and after surface hardening. For that purpose a servohydraulic pulsator (POZ - 0354, Schenck) had been used. A sample of the tested screw is shown on Fig.3, and the obtained results are presented in Table 1.

Table 1 Comparison of the results obtained for the mean load P_m = 28.5 kN, load amplitude P_a = ±3.5 kN and frequency of 90 Hz.

Test No	Number of Cycles N ($\times 10^6$)	
	Before Hardening	After Hardening
1	2.96	10
2	0.78	10
3	1.02	2.25
4	1.94	10
5	1.33	10
6	0.53	1.12
7	0.48	1.02

The results of the tests show that mechanical surface hardening can be used to improve the fatigue strength of the screws. For screws which did not withstand the 10^7 number of cycles, fatigue failure occurred at the fillet under the screw head. Figure 4 shows some typical fatigue failures of the tested screws, and Figure 5 shows the flows at the cross-section A-A under the screw head.

CONCLUSION

On the basis of the given analysis we can conclude that it is possible to achieve significant improvement of screw fatigue strength with mechanical surface hardening at the points of considerable stress concentration.

REFERENCES

(1) Plavšić,N., "Dinamika loma zategnutih štapova sa kružnim zarezom", Ph.D. Thesis, Faculty of Mechanical Engineering, Belgrade, 1979.

(2) Rašeta,Z., "Problem daljeg povišenja mehaničkih svojstava vijaka proizvedenih hladnim postupkom u velikoserijskoj proizvodnji", Ph.D. Thesis, Faculty of Mechanical Engineering, Belgrade, 1965.

(3) Plavšić,N., Mitrović,R., Tanasković,R., Report of screw fatigue strength testing, No 13.03-1/90, Faculty of Mechanical Engineering, Belgrade, 1990.

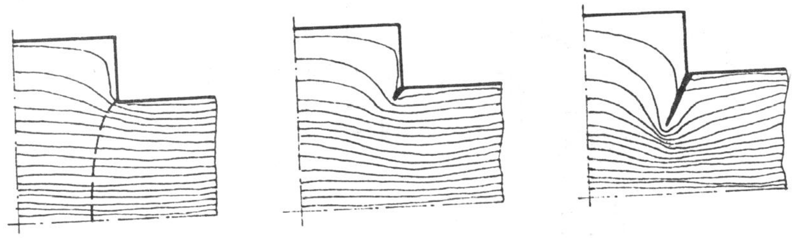

Figure 1 Crack development process.

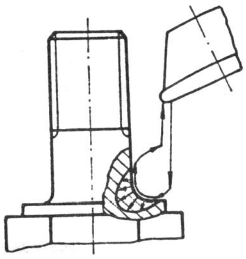

Figure 2 Mechanical surface hardening of the fillet under the screw head.

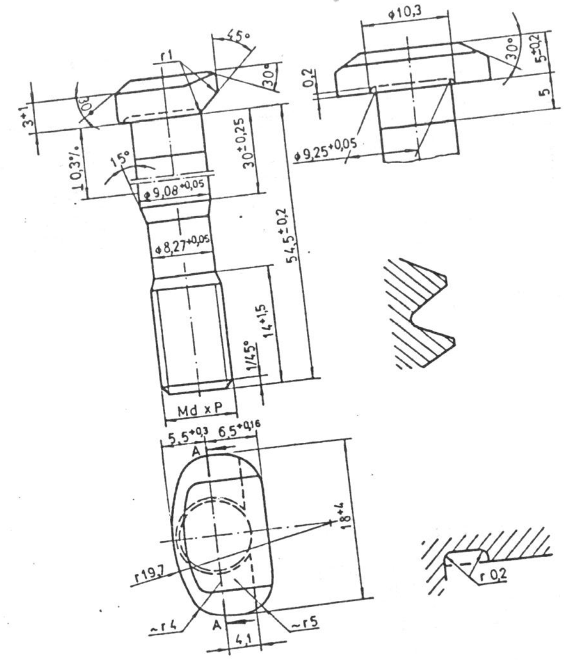

Figure 3 Test screw

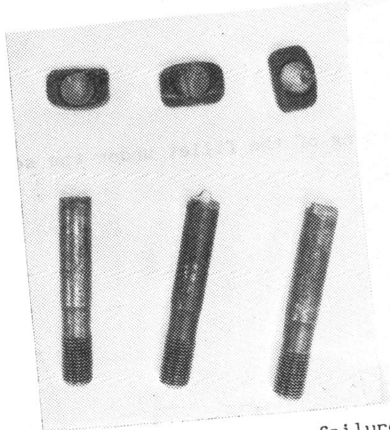

Figure 4 Screw fatigue failures

Figure 5 Cross-section flows