Proceedings of the 7th International Conference on Mechanics and Materials in Design,
Albufeira/Portugal 11-15 June 2017. Editors J.F. Silva Gomes and S.A. Meguid.
Publ. INEGI/FEUP (2017)

PAPER REF: 6538

INVESTIGATIONS OF THE SHRINK-FITTED JOINTS IN ASSEMBLED CRANKSHAFTS

Zbigniew Siemiątkowski[1], Mirosław Rucki[1(*)], Sergiy Lavrynenko[2]
[1]Kazimierz Pulaski University of Technology and Humanities in Radom, Poland
[2]National Technical University "Kharkov Polytechnic Institute", Ukraine
[(*)]*Email:* m.rucki@uthrad.pl

ABSTRACT

This work describes the investigations on the shrink-fitted joints. The models of the marine engine cranks and pivots were made in the scale 1:5 considering the real manufacturing conditions of the large-sized crankshafts. The results of the ultrasonic measurements of the stresses were compared to the temperature distribution during the cooling of the assembled couplings. The conclusion was that the unsteady stress distribution might be caused by the unsteady cooling process. As a consequence, more tight joints may reveal not better ability to bear a load torque.

Keywords: mechanical engineering, shrink fittings, assembled crankshafts.

INTRODUCTION

There are two main technologies for the crankshaft fabrication, the monolithic type, and the assembled type made out of the separated elements (Yamagata 2005, s. 165). In case of the large-size crankshafts manufactured for the marine engines, the monolithic technology poses many problems, so the assembled crankshafts are preferable. For example, the crankshaft 6S35MC type is of 4,700 mm long, its crank radius is 700 mm, and the weight is 11,730 kg. The crankshaft is assembled in vertical position, and all its elements are joined together in an appropriate angle position, with a shrink-fitting technology. Fig. 1 presents the elements of such a crankshaft, and the Fig. 2 illustrates how these elements are being assembled together in the factory CELSA Huta Ostrowiec (Poland).

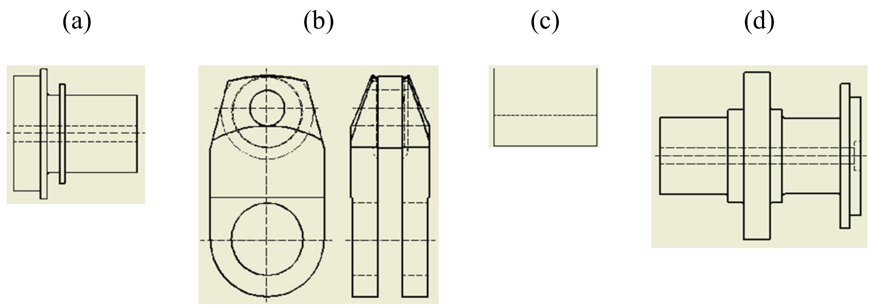

Fig. 1 - Elements of the assembled crankshaft: a) supporting journal, b) crank, c) main journal, d) journal with flange

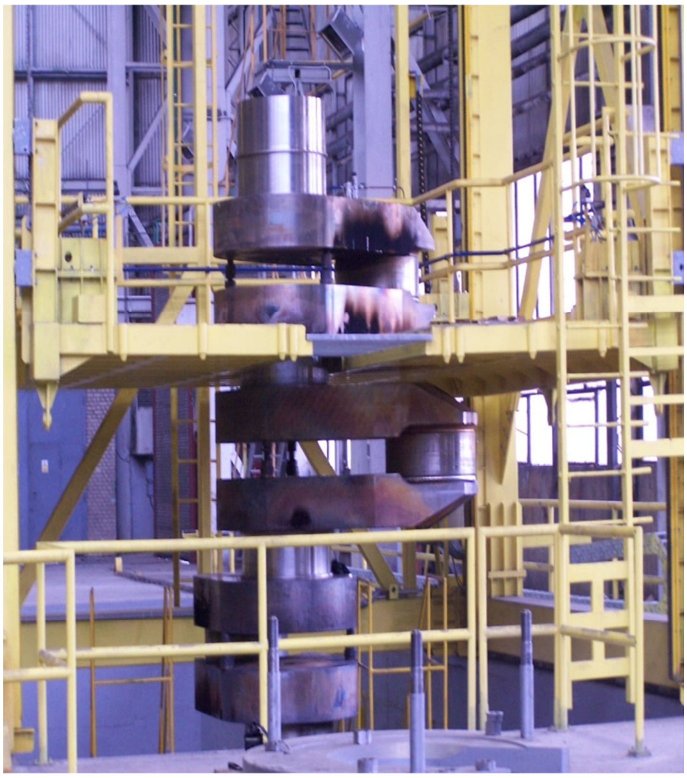

Fig. 2 - Partially assembled crankshaft of 6S35MC type in the factory CELSA Huta Ostrowiec

Crankshaft is a very responsible element of the marine engine, because its failure, especially during the operation in the storm, may lead to the life threat of the shipboard personnel and passengers. It is known that fractures in crankshafts can occur by bending fatigue, by torsional fatigue or a combination of both (Jadhav & al., 2013). Moreover, in the assembled crankshafts, the hub must be axially positioned on the shaft and resist the moments and forces generated by misalingments (Mancuso, 1999). And finally, the joints must be able to bear the increased load.

THE EXPERIMENTAL RESEARCH

There are many methods of the shrink fit couplings analysis in different applications (Wang 2016), but in case of such a large-sized elements empirical investigation and measurement is extremely difficult and expensive. Thus, the models in scale 1:5 were fabricated, so the laboratory measurement became possible. The shrink fitted couplings were made considering the real technical conditions. The roughness and form deviations were measured in order to keep the appropriate relative tightness of the couplings in the range between 2.0 and 2.5‰. Roughness of the surfaces was kept between Ra = 0.32 and 0.40 μm. The example of the examined model of the crank and the roundness measurement is shown in the Fig. 3. The surfaces designed to get in contact were dried and degreased before the operation, but no substances increasing friction were applied. To complete shrink-fitted joints, each crank was heated in the area around its orifice up to the temperature 350°C, and pivot was left in the room temperature. After the pivot was inserted into the crank, the coupling was left to cool down in the air.

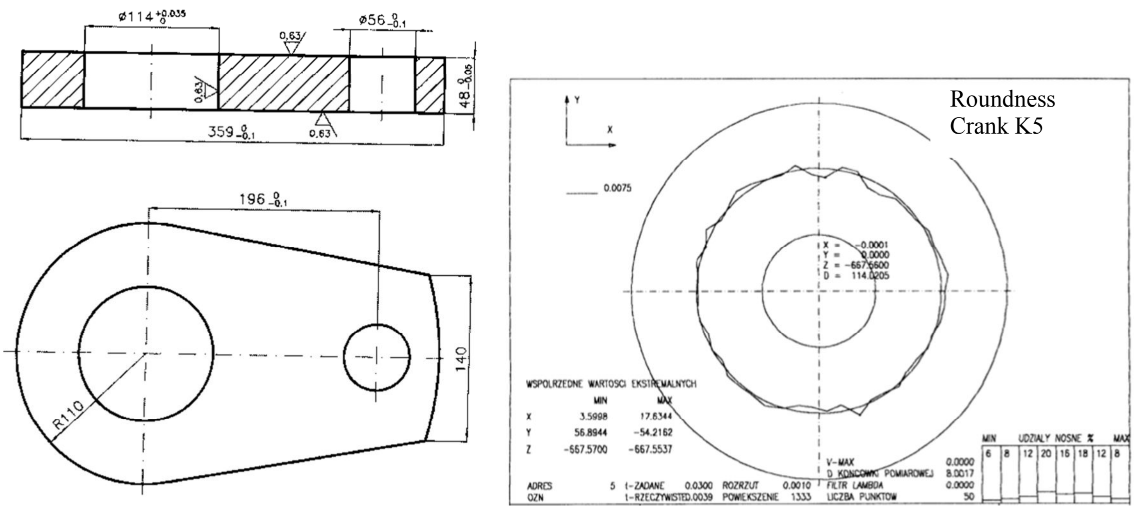

Fig. 3 - Example of the nvestigated model of the crank (left) and the out-of-roundness of its orifice (right)

The shrink-fitted elements generate internal stresses, which was measured using the ultrasonic measurement device Debro in the laboratory of the Institute of Fundamental Technological Research (Polish Academy of Sciences). For each couple crank-pivot and ring-pivot, the measurement was made before they were joined together and afterwards. The measurement results should be treated as the stresses averaged along the material thickness. In case they were performed close to the border between the details, they meant average along the joint. The digital simulation confirmed the unsteady stress distribution.

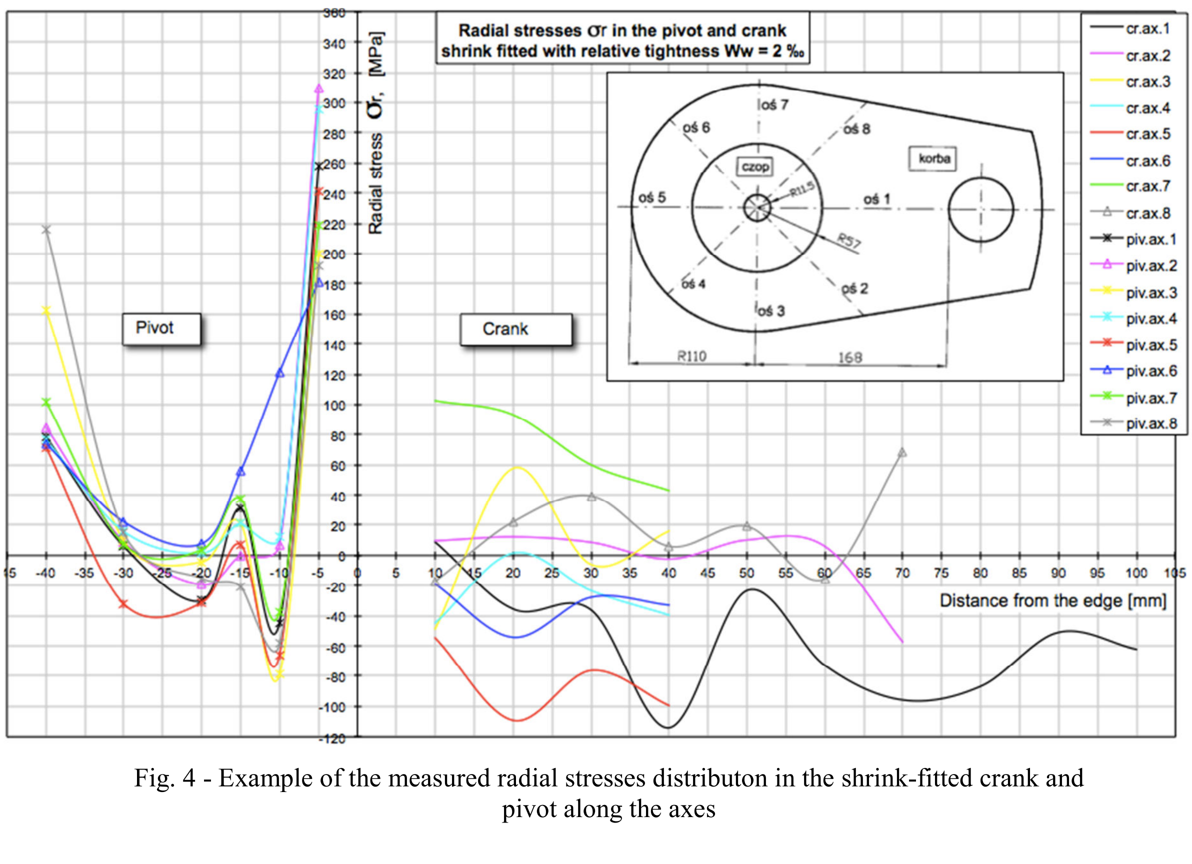

Fig. 4 - Example of the measured radial stresses distributon in the shrink-fitted crank and pivot along the axes

Apart from the stress measurements, the local temperature was measured in the area of joint between cranks and pivots or rings and pivots, respectively. The points of the temperature measurement and the graphs obtained for each sensor during the cooling are shown in the Fig. 5.

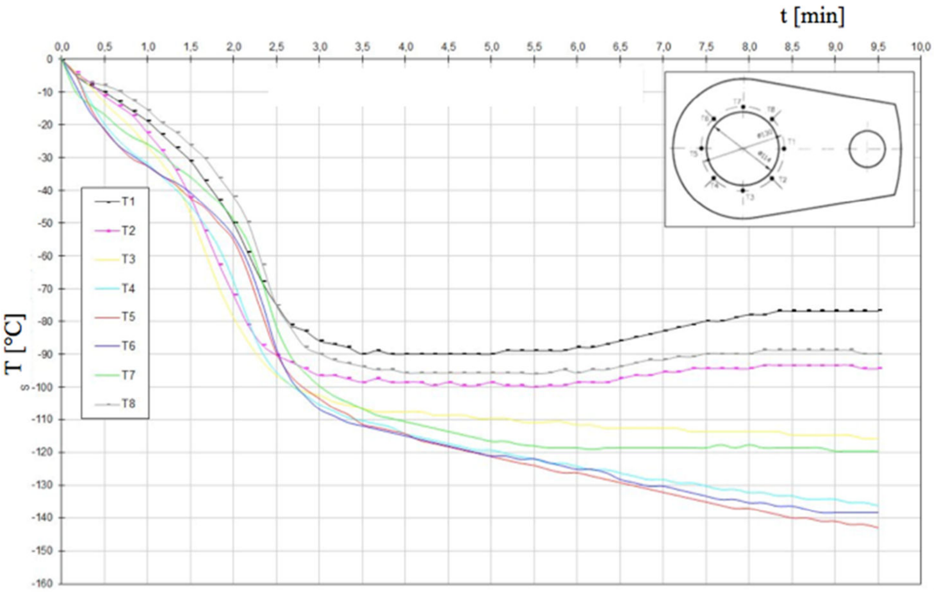

Fig. 5 - Temperature registered by the sensors during the cooling in the air

The results of the temperature measurement in the joint immediately after the assembling confirmed inevitable irregularity of the process, which leads to the weakening of the crank-pivot coupling. The irregularities of the internal stresses that have led to the non-uniformity of the adjacent surfaces contact might had been produced by the non-uniform cooling.

CONCLUSIONS

This study shows that the cooling phenomenon and the non-uniform residual stresses are the main cause of the observed phenomenon, that the increase of tightness does not improve the reliability of the shrink-fitted coupling. In the future investigations, the measurement of the maximal torque will be performed.

REFERENCES

[1]-Yamagata H. The Science and Technology of Materials in Automotive Engines. Woodhead Publishing Ltd, Cambridge, 2005, p. 165.

[2]-Wang X, Liu B, Gao K, Meng Q, Sun Y. Analysis of thermal deformation and influencing factors in shrink-fitting assembly of aluminum alloy drill pipe. Advances in Mechanical Engineering, 2016, 8(10), p. 1-15.

[3]-Jadhav A, Chalwa V, Gaikwad P. Fatigue Failure Analysis Of Marine Engine Crankshaft. International Journal of Engineering Research & Technology 2013, 2, p. 614-621.

[4]-Mancuso J R. Couplings and Joints: Design, Selection & Application. Marcel Dekker, Inc., New York - Basel, 1999, p. 179.