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STRAIN-STRESS ANALYSIS OF GEAR COUPLING

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INTRODUCTION

In several engineering applications, it is necessary to connect two shafts, where has to be enabled slightly movement between them. For this application there can be used several kinds of couplings, which are very significantly affected by installation dimensions, transmitted torque, rotation speed and operating environment. With considering all these requirements, it is necessary to develop connecting components with a stable engagement, long operation life and non-problematic operating parameters. The gear coupling conditions of misalignment are able to be categorized into parallel, angular and combination misalignment. One of the possibilities for these operation conditions are used crown gear couplings, which can transmit high torque at large misalignment. On the other hand, there is about 20 % of known gear coupling failures, due to misalignment conditions (Locke 2013). From that reason, it is important to study the contact pressure and load distribution.

If the pressure distribution is not known on all coupling teeth, then it is only partially possible to understand of the gear couplings working life in case of misalignment. Design of correct crowning or barreling of the teeth is reflected by frequent problems, experiments and mistakes. (Guan 2019) The responsible design of the gear coupling with barell teeth will increase the service life and reduce the cost of spare parts and as well protection of operating personal. There are also three main approaches that can be used to describe problem: analytical, experimental and computational. Because of the time and cost consumption of experimental development, the analytical and numerical approach is getting used and only final design is tested.

The tooth contact analysis of crown gear coupling with misalignment was developed and used for comparison of contact pressure distribution of different models to study the effect of misalignment on contact. It was discussing about maximum interference and contact pressure distribution along the circumference. In this study the computation approach in FEM software Ansys Workbench was used to deeply understand the behaviour of gear coupling at different operation conditions. (Hu 2017, Yi 2005, Guan 2019)

METHODS

Because this study is focused on contact area, it is necessary to have a full control of mesh on the teeth. For this reason, the body was divided into internal and surface parts, where the mesh density can be set identical for all modifications, thus the results can be compared, see Fig. 1. It was necessary to apply separate tooth contact to each pair of contact and target body of model to have full control on the whole state of each contact, see Fig. 1.

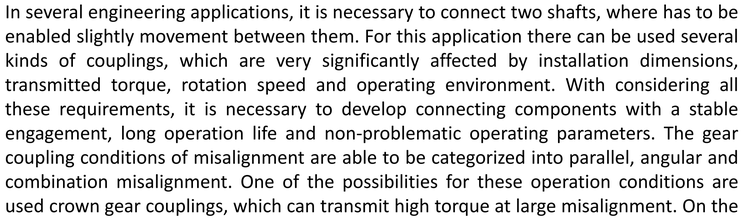

Fig. 1 Reference tooth of the hub (left) and contact settings (right).

Whole tooth rings contain 88 teeth on each of them. The hub teeth of gear coupling is presented tip crowning, flank crowning and crowned chamfers. Due to large number of teeth, the initial study was performed on small part of whole coupling, which is consist of two parts lying opposite each other. This simplified computational model includes 12 teeth of the hub and 10 teeth of the sleeve ring of gear coupling. It was used for optimizing contact settings and load distribution. Boundary conditions of alignment state were applicated only for plane YZ with constant torque 600 Nm.

The misalignment case was obtained by tilting part of hub ring by 5 degrees around the axis Z, under the same value of torque, see Fig. 2. For a complete description of the problem, it is necessary to monitor all the teeth around the circumference of the gear coupling.

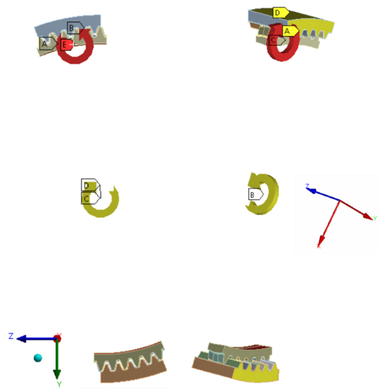

Fig. 2 Boundary conditions of alignment state (left) and misalignment state (right).

RESULTS

Fig. 3 shows the distribution of contact pressure on all teeth of the model for initial study without any tilting. Based on the distribution, it is noticeable that the ring of gear coupling was perfectly aligned. In the Fig. 4 the distribution of contact pressure is shown, where the ring of gear coupling was misaligned by 5 degrees. The contact pressure moves along the side of the teeth and its trajectory is changing tooth by tooth.

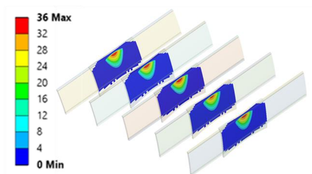

Fig. 3 Contact pressure at alignment state.

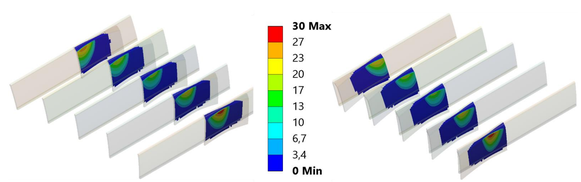

Fig. 4 Contact pressure at misalignment state.

In conditions of simplified model, it is not possible to determine place where contact line will move further yet. In case of misalignment that teeth are not evenly loaded, thus it is necessary to use the whole ring. Therefore, next results show the course of the contact pressure in the whole hub ring, see Fig. 5. The contact pressure can be seen in Fig. 6, for 5 degrees misalignment on the ring hub. In this state, contact pressure is distributed very unevenly and some teeth are loaded more then others, which corresponds to another simulations.

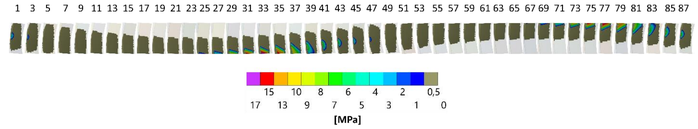

Fig. 5 Contact pressure at misalignment state of every other tooth on the hub.

Maximum value of the contact pressure is 17 MPa, which is situated at the end of face teeth. That is because the geometry was designed for misalignment up to 5 degree. On the other hand, almost half of view teeth are spent an interaction.

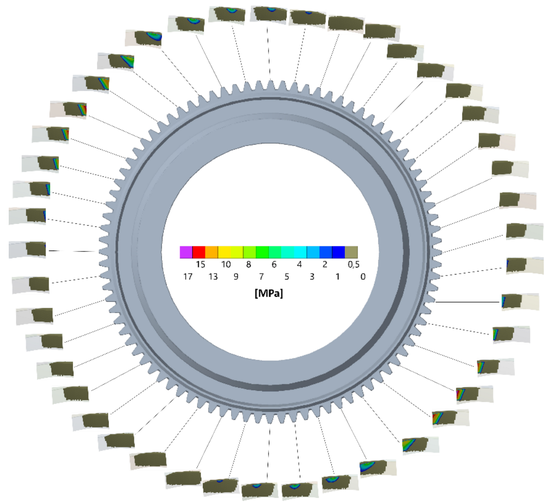

Fig. 6 Contact pressure at misalignment state of whole ring hub.

SUMMARY

The presented study provided an insight into the distribution of the contact pressure on the teeth during the misalignment of the hub ring of the gear coupling. The created FEM model can be used in the future to design and test the prototype shape of the tooth. The model offers possibility to better understand the load course and to avoid expensive experimental testing state or mistake in design. Numerical model can detection a wrong way in teeth shape design during development part of project.

ACKNOWLEDGEMENT

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REFERENCES

LOCKE, Stephen R., Joseph P. CORCORAN, Michael J. BURGESS a Thomas D. HESS. Coupling credible failure modes and owner options to intervene: Proceedings of the Forty-Second Turbomachinery Symposium, Houston, Texas, 2013

GUAN, Yabin, Zongde FANG, Xiaohui YANG a Guoding CHEN. Effects of misalignment and crowning on contact characteristics of crown gear coupling. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science. 2019, 233(12), 4397-4417, ISSN 0954-4062

HU, Yunbo, Huibin WANG, Yuanqiang TAN, Likuan JIANG a Shengqiang JIANG. Study on the meshing force of misaligned gear coupling. Proceedings of the 2016 International Forum on Mechanical, Control and Automation (IFMCA 2016). Paris, France: Atlantis Press, 2017, 113. ISBN 978-94-6252-307-4. ISSN 2352-5401.

YI, Chuan-yun. Analysis of the meshing of crown gear coupling. Journal of Shanghai University (English Edition). 2005, 9(6), 527-533.

GUAN, Yabin, Xiaohui YANG, Zongde FANG a Guoding CHEN. Comparative analysis of three geometric models for crown gear coupling. Mechanism and Machine Theory. 2019, 136, 269-283.