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STRAIN-STRESS ANALYSIS OF GEAR COUPLING

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Abstract: *This paper deals with the contact analysis study of crown gear couplings during the simulation of its working conditions. The toothed couplings are often used to transmit high torque in case when the input and output shafts are misaligned. With increasing transmitted torque and value of misalignment it is necessary to design the gear shape very carefully. It is not possible to completely reduce uneven running, even with knowledge of the latest trends in the field of gear development. Inefficient and costly experiments are often used to determine the correct shape of gear teeth. For this purpose, a computational approach to describe a contact pressure on the teeth of couplings at different misalignment and loads is proposed. The model helps to understand the composition of the contact pressure during the working mode of misalignment and its behavior within the rotation of the gear coupling.*

Keywords: Crown gear coupling, Tooth contact analysis, Misalignment, Load distribution, Strain – stress analysis, Finite element method.

1. 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 operations life and non-problematic operating parameters. The gear coupling conditions of misalignment are able to be categorized into parallel, angular and combination misalignment. The angular misalignment can be handled coupling with half gear, but for transmission with a combination misalignment it is necessary to use full gear coupling.

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 0. From that facts it is important to study the contact pressure and load distribution on the gear coupling teeth during its torque transmition with non-perfect alignment.

If the pressure distribution is not known on all coupling teeth, then it is only partially possible understanding of the gear couplings working life in case of misalignment, thus the tooth geometry can not be designed properly. Design of correct crowning or barreling of the teeth is also reflected by frequent problems, experiments and mistakes 0. 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. Existing studies are focused on description of the contact pressure distribution and increase understanding of its behaviour during ring tilting and rotation of rings coupling. 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. Analytical approach is used in article 0, where theoretical model of meshing force of gear coupling in misalignment was used to calculate the meshing force and its variation with the amount of misalignment. In the theoretically all teethes transmitted the same amount of torque and there is no difference in meshing

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force for each tooth. In other article 0 is analytical approach used, where mathematic models of the surfaces of crown gear and internal gear were established. The equation of internal gear surface was given. The equation of conjugate surface of crown gear is solved according to the principle of gearing. And the equation of non-conjugate crown gear was derived with crown curve of a circular arc.

The numerical approach used in article 0, where three generating principles were proposed for hub tooth of crown gear coupling and these three finite element mesh models are built. 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 program Ansys Workbench was used to deeply understand the behaviour of gear coupling at different operation conditions.

2. 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.

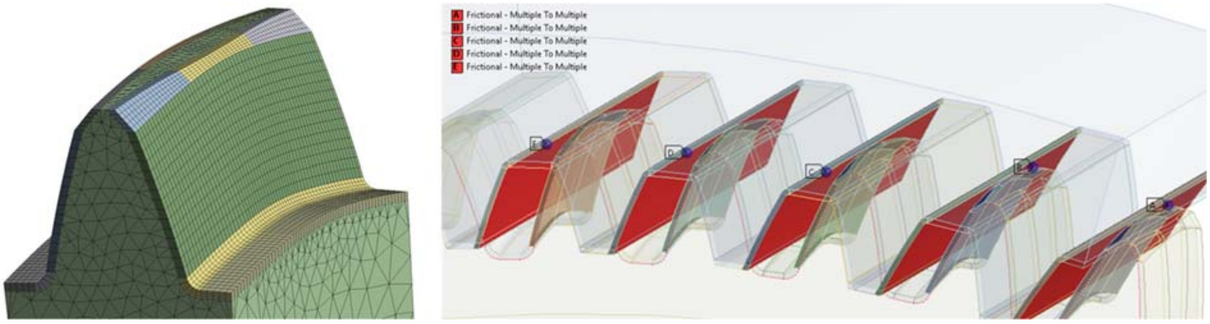

Fig. 1: Reference tooth of the hub (left) and contact settings (right).

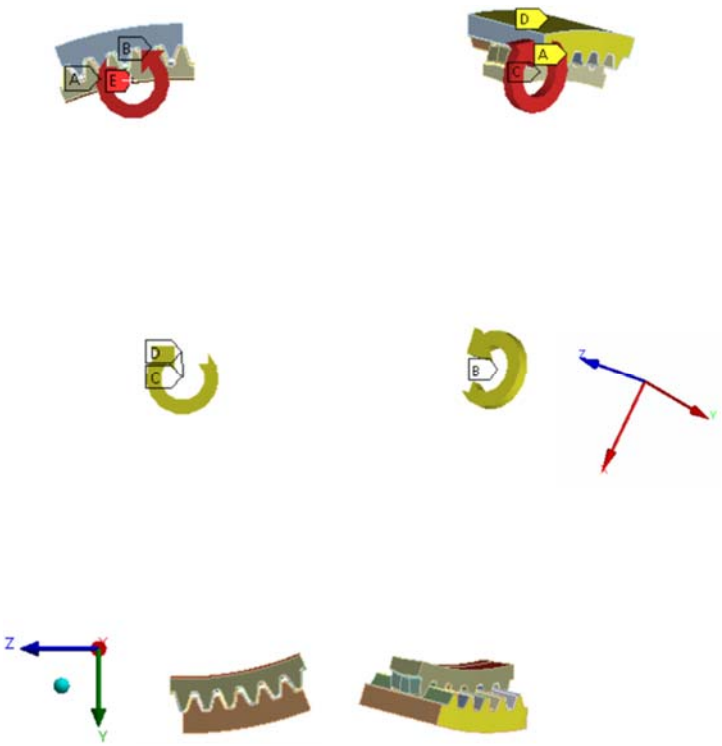

Fig. 2: Boundary conditions of alignment state (left) and misalignment state (right).

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 applicate only for plane YZ with constant torque 600 N·m. 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.

3. 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.

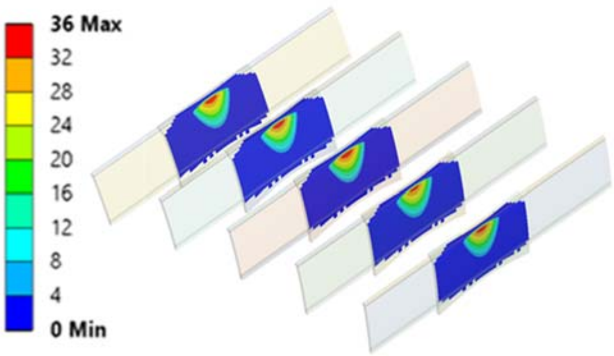

Fig. 3: Contact pressure at alignment state.

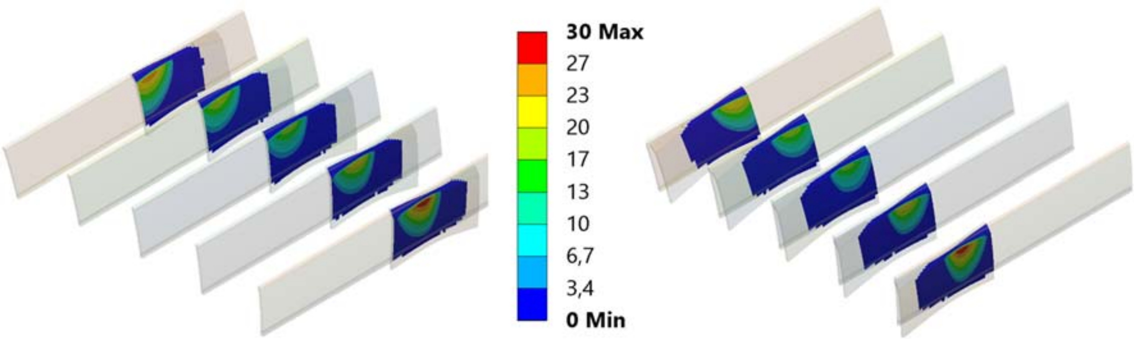

Fig. 4: Contact pressure at misalignment state.

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.

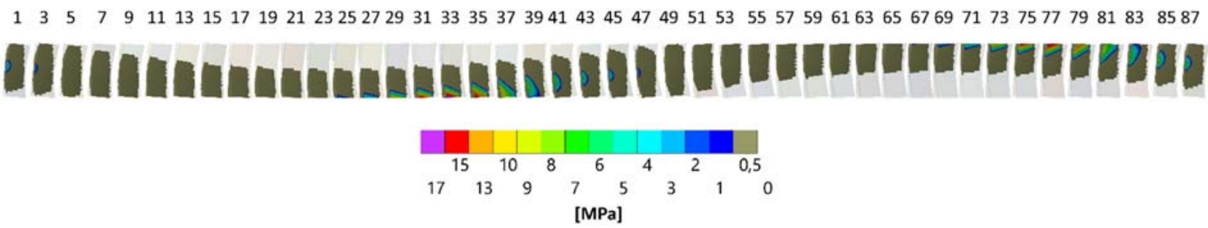

Fig. 5: Contact pressure at misalignment state of every other tooth on the hub.

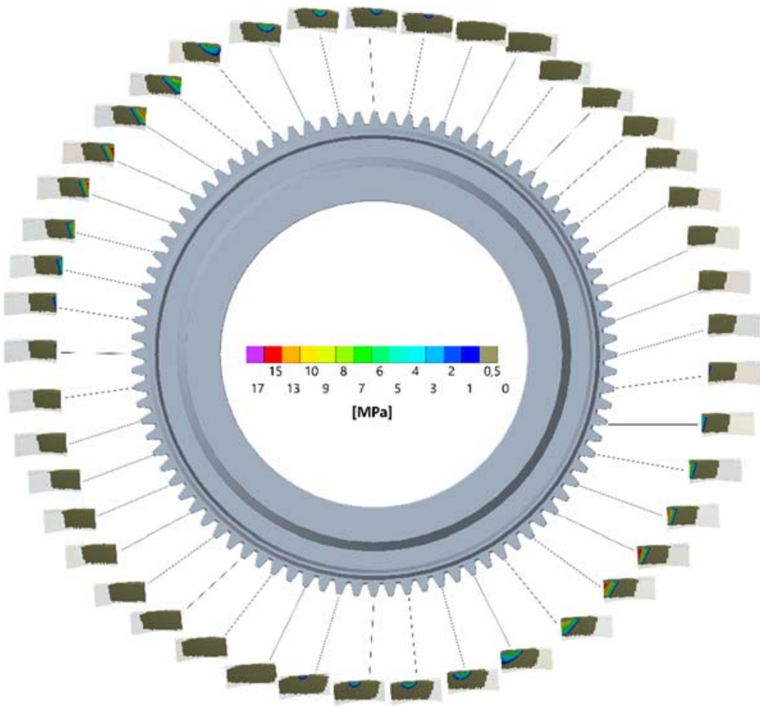

Fig. 6: Contact pressure at misalignment state of whole ring hub.

In Fig. 6, the contact pressure can be seen at 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. 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.

4. Conclusion

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 future to design and test the protorype 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.

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