Numerical Analysis of Thermoelastic Friction Clutch

Lukáš Koudela, Václav Kotlan

Faculty of Electrical Engineering, University of West Bohemia, Univerzitn 26, Pilsen, Czech Republic, e-mail: koudela@kte.zcu.cz

Abstract **A thermoelastic friction clutch for transferring mechanical torque is proposed and modeled in this paper. The friction force between the driving and driven parts of the system is produced by mechanical stress of thermoelastic origin. The computations of the typical illustrative example consist of three coupled fields (magnetic field, temperature field and field of thermoelastic displacements) are carried out by own code Agros based on a fully adaptive higher-order finite element method and some results are verified by professional code COMSOL Multiphysics.**

Keywords **Friction Clutch, Thermoelasticity, Numerical Analysis, Finite Element Method, Agros2D**

I. Introduction

Friction clutches [1], [2] are elements widely used in numerous industrial, transport, and other applications for transferring mechanical torque. The authors present an initial design of a novel friction clutch based on the thermoelastic principle and investigate its operation behaviour. The schematic arrangement of the proposed friction clutch is depicted in Figure 1.

The driving part starts rotating between two sets of segmental permanent magnets arranged in the internal and external rings producing static magnetic field. The left end of the driving part is heated by eddy currents induced in it by its rotation in the static magnetic field and its external diameter increases. This growth of dimensions gradually brings a pressure on the internal surface of the external driven part that begins to rotate together with the driving part.

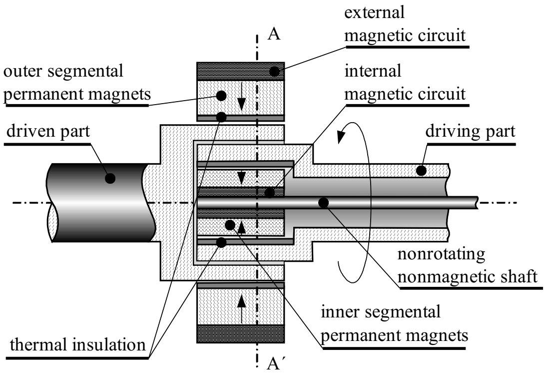

Fig. 1. Principial arrangement of the thermoelastic clutch.

II. Illustrative example

The system of the clutch is composed of two magnetic circuits (internal and external) including 8 permanent magnets of type VMM10 (FeNdB) in both cases. The mechanical part of clutch (only driving part) is made from the steel 4130, the driven part is considered from non-magnetic austenitic steel. Magnetic parts (internal and external magnetic circuit) are considered of steel 12040.

The Figure 2 displays the time evolution of the displacement on the outer diameter of the rotated part of the clutch for several revolutions of moving part.

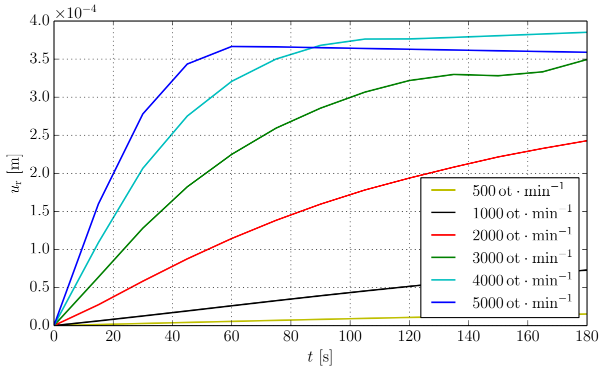

Fig. 2. Dependence of the displacement on the velocity in the point on the outer radios of the rotetion part of the clutch.

III. Conclusion

We proposed and modeled a new type of thermoelastic friction clutch. The presented results in this paper show that the device is realistic and could work appropriately. On the other hand, the development of the device is not yet finished. From the results can be seen the potential for the clutch functionality, this study was the first step of the development of this device. First, very important will be choice of materials (with higher dilatability) and optimization of its structural parts. As for another development of the modeling technique, the algorithm of computation must be supplemented with appropriate procedures for the optimization.

IV. Acknowledgements

This work was supported by the European Regional Development Fund and Ministry of Education, Youth and Sports of the Czech Republic (project No. CZ.1.05/2.1.00/03.0094: Regional Innovation Centre for Electrical Engineering RICE) and by the University of West Bohemia under project SGS-2015-035.

References

[1] Gopinath, K.; Mayuram, M. M.: Machine Design II Clutch. Květen 20 2011.
URL <http://nptel.iitm.ac.in/courses/IIT-MADRAS/Machine_Design_II/pdf3_5.pdf>

[2] Orthwein, W. C.: *Clutches and Brakes: Design and Selection*. Dekker Mechanical Engineering, 2 edition, CRC Press, 2004.