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Magnetic field in the core of a magnetic fluid seal taking magnetic structural elements into account

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Introduction

Usually, analyze the magnetic flux of the magnetic system, breaking it into two main components: the working magnetic flux and the scattering flux. However, a common consideration for all these models is the consideration of MFS without taking into account the fact that MFS is only a common element of a complex technical system containing structural magnetic elements. This can lead to serious errors in solving an important design problem - the choice of a rational scheme for connecting MFS to technological equipment.

The experience in introducing MFS, accumulated in LLC Ferrohydrodynamica, shows that most often seals are designed to protect against contamination of bearing assemblies.

The bearing housing and the bearing shield are made of magnetic steel, which can significantly increase the magnetic fluxes of scattering in the MFS and weaken the magnitude of the magnetic induction in its working gap. The aim of this work is the numerical calculation by the finite element method of the magnetic field in the MFS core, taking into account the presence of structural ferromagnetic elements (bearing shield and bearing) taking into account their nonlinear magnetic properties, and studying the influence of these elements on the level of the magnetic field in its working gap.

Mathematical model

The studied MFS, the design of which is shown in Fig. 1a, is intended to protect the bearing assembly from the effects of an external aggressive environment. Its design has axial symmetry; hence the field problem of calculating the magnetic field can be solved in a two-dimensional formulation in a cylindrical coordinate system in the plane . The calculated region for magnetic field analysis is shown in Fig. 1b and contains areas with different magnetic materials: a permanent magnet 1, magnetized in the axial direction, ferromagnetic material of the poles of the magnetic system 2 with the gear zone 3, the rotating shaft 4 and magnetic fluid 5, which is in the gap between the poles and the shaft and is held there by magnetic forces.

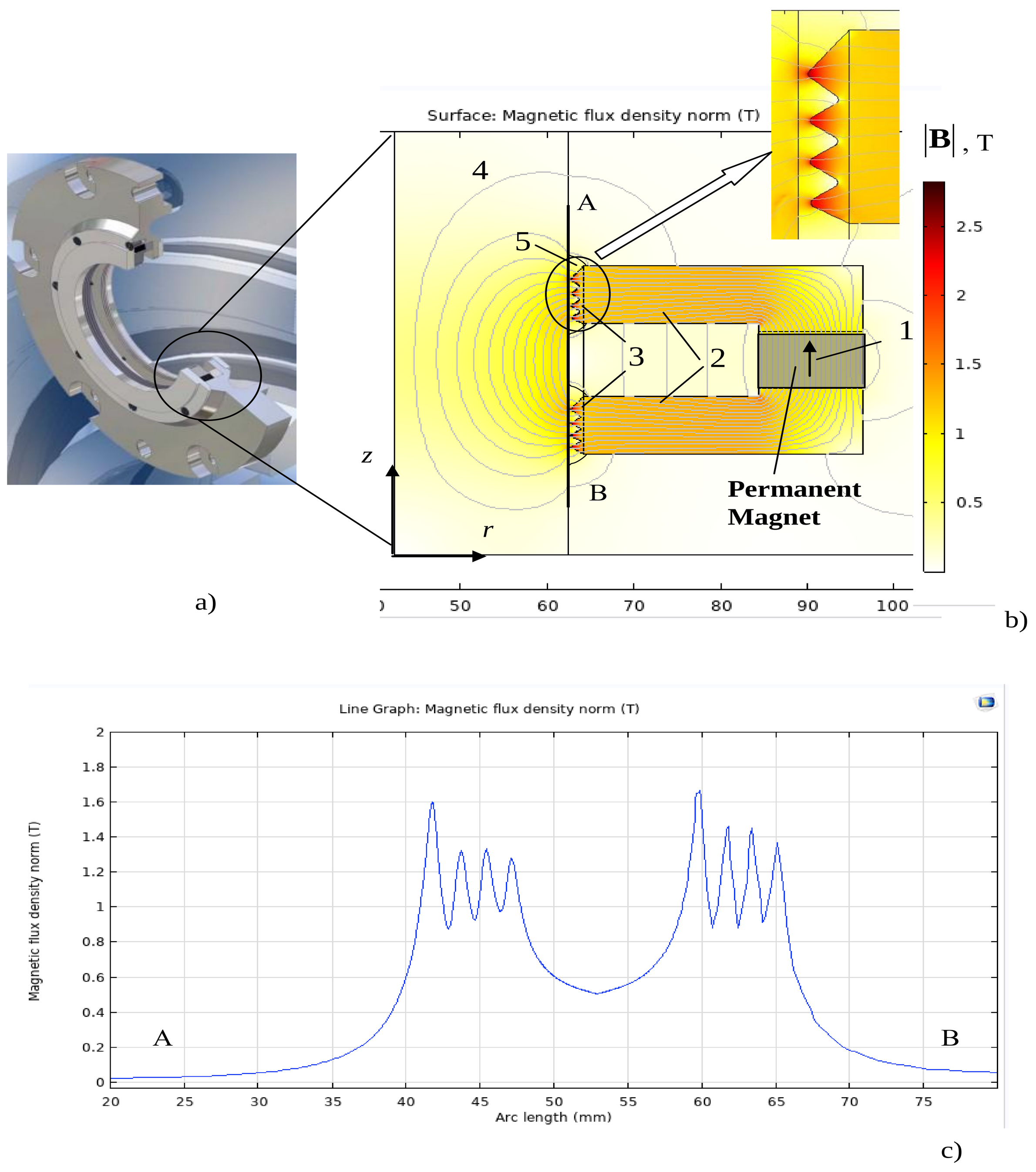

Fig. 1. General view of a typical MZHG design a) the distribution of the magnetic field in the active zone of the seal b) and the distribution of magnetic induction |B| on the shaft surface along straight line A-B c) when it is located far from the bearing shield. The inset above shows the distribution of magnetic induction in the tooth zone on an enlarged scale.

Aim

The aim of this work is the numerical calculation by the finite element method of the magnetic field in the MFS core, taking into account the presence of structural ferromagnetic elements (bearing shield and bearing) taking into account their nonlinear magnetic properties, and studying the influence of these elements on the level of the magnetic field in its working gap.

Analysis of results and conclusions

- According to the results of finite element analysis of the magnetic field of a liquid metal seal designed to protect the bearing assembly from external aggressive influences, it is shown that its mounting directly on the bearing shield having magnetic properties leads to an increase in magnetic fluxes of scattering and, as a result, to a decrease peak value of magnetic induction in the working gap from 1, 6 T to 1.1 T, i.e. to a decrease of 31%.
- The use of a non-magnetic insert between the seal and the bearing assembly allows this induction to be increased. The dependence of this induction on the thickness of the insert is given, which makes it possible to choose its rational value when installing the seal.
- It is shown that the use of a small additional volume cylindrical permanent magnet located in the insertion region allows increasing the peak value of magnetic induction in the working gap from 1.3 T to 1.75 T and, as a result, improving working seal characteristics.

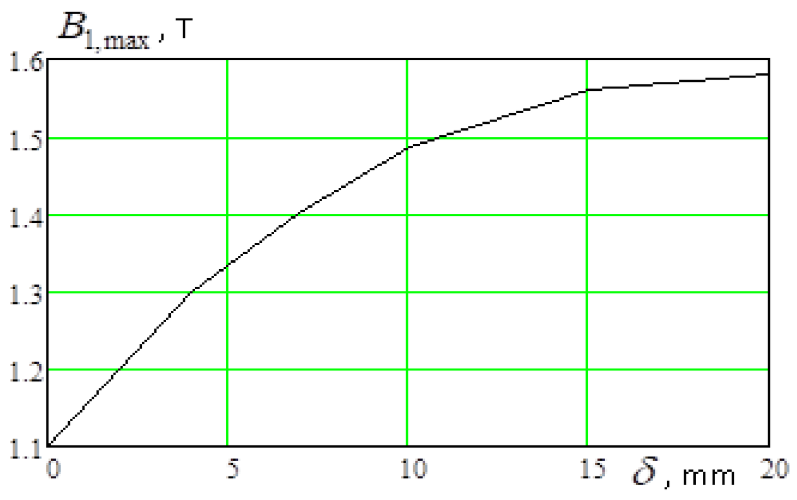

Fig. 5. The dependence of the peak value of magnetic induction in the working gap MFS from the thickness of the non-magnetic δ

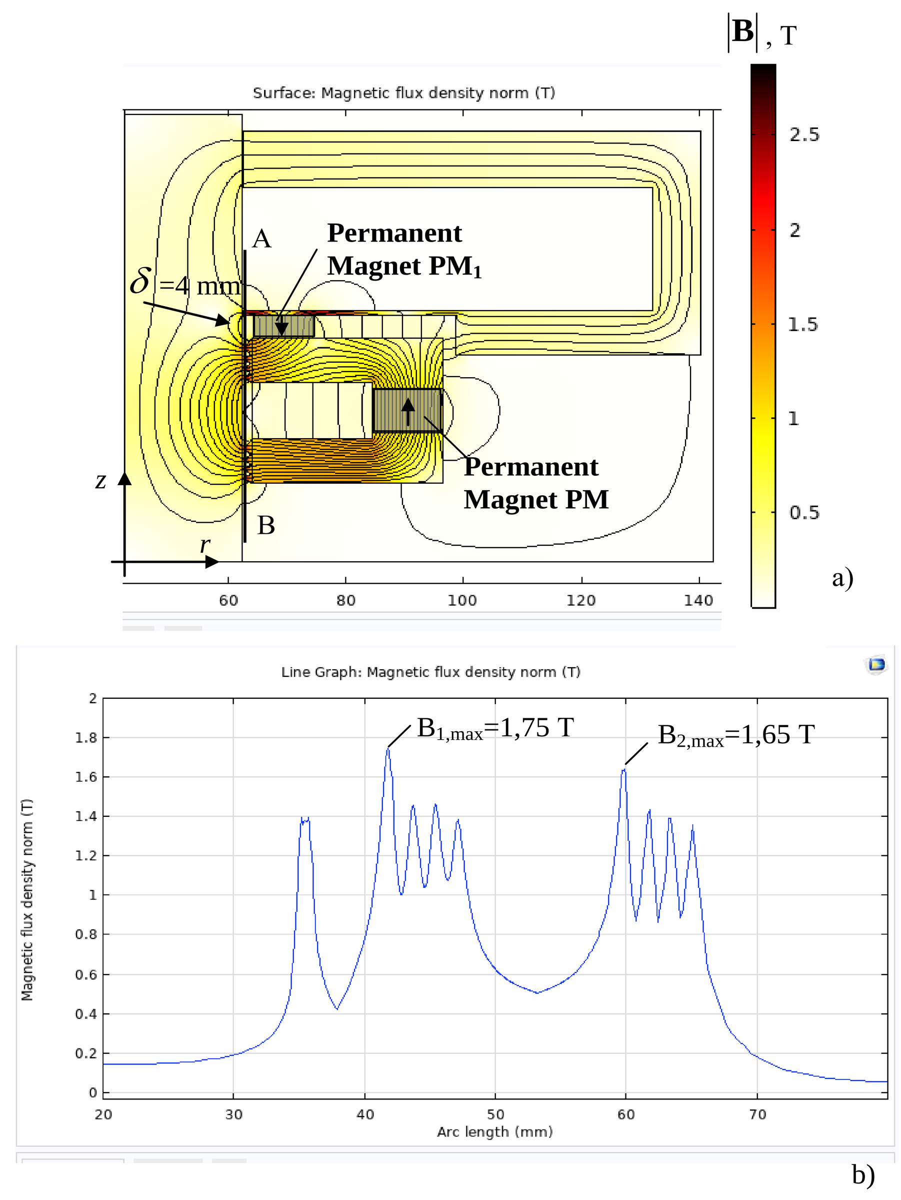

Fig. 6. The distribution of the magnetic field in the active zone of the sealant a) and the distribution of magnetic induction |B| on the shaft surface along the straight line A-B b) with a gap value of δ =4 mm and in the presence of an additional permanent magnet PM with axial magnetization in this gap

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