Analysis of Influencing Factors on Magnetic Flux Density in Wire Ropes

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***Abstract*—Magneto-inductive rope-testers using NdFeB-permanent magnets are a common way for breakage and failure measurements of wire ropes. These measuring instruments are often used in safety relevant areas, e.g. cable cars and suspension bridges. Therefore, absolute reliability on the measuring principle is required. The magnetic flux density in the wire rope is the most important parameter for detecting wire breaks. This project intents to analyze the influence of different magnet arrangements and iron counterplates on the magnetic flux density in the wire rope as well as the utilizability of NdFeB- and SmCo-magnets.**

I. Introduction

If the magnetic flux exits at the wire break point, a large volume of air is required to flow into the adjacent piece of wire due to the low permeability of air. The flux leakage exits almost vertically from the wire surface at a failure point and can thus be used for wire break detection by means of radial coils. A simplified mathematical model of the measurement system was developed to obtain influencing factors on the magnetic flux density in the rope as for example the axial distance between the magnets. These factors, for the variation of the magnet arrangement, were implemented in the measuring system as well as in the EMS-simulation and compared with the goal of determining the minimum flux density required to detect a wire break. In addition, the applicability of SmCo-magnets was investigated which, due to their lower corrosion tendency, represent an advantage in terms of a lower effort in production compared to the NdFeB-materials previously used.

II. Details about the model structure

The CAD model used for the permanent magnetic simulation is a simplified reproduction of the current generation of the Stuttgart Magnetic Rope Tester (SMRT). Due to the two-week test license, the model for the EMS-simulation was broken down to the basic components which are the focus of the analysis. The influence of different magnet arrangements as well as different magnet materials can thus be calculated by neglecting disturbance variables of adjacent components.

The CAD model in Fig. 1 shows the tangential arrangement of 12 magnets around the wire rope.

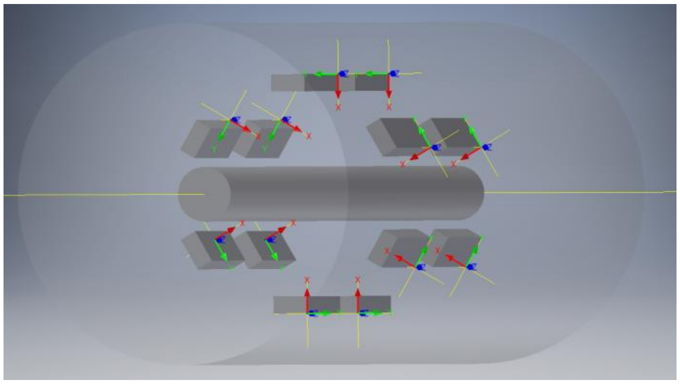

Figure 1. Autodesk Inventor model of permanent magnets surrounding the wire rope

The minimum flux density for detecting wire breaks was determined on the real measuring device. By variation of the magnet arrangement in the EMS-tool, both with and without iron counterplates, an optimal positioning of the magnets for generating the maximum flux density at the coil position should be found.

Subsequently, individual magnet arrangements were analyzed with the magnetic material SmCo and compared with the results of NdFeB-material. This should show whether, despite the lower energy product of SmCo and the larger geometric dimensions associated with it compared to NdFeB-magnets, the permissible installation space in the real measuring system can be adhered to and thus a potential application is given.

III. Simulation results

The following figures and descriptions show an excerpt of the results from the variation of the axial distance of the magnets to each other. Materials used in this analysis are shown in Table 1.

	Conductivity [Mho/m]	Permeability	Coercivity [A/m]	Remanence [T]
Typical Steel	1	-		
NdFeB N42	0	1,20536	891268	1,35
Air	0	1	-	-

Table 1.: Material properties

Fig. 2 shows the measured and with EMS calculated magnetic flux density at the coil position (x=0,15 m) as a function of the axial distance between the magnets.

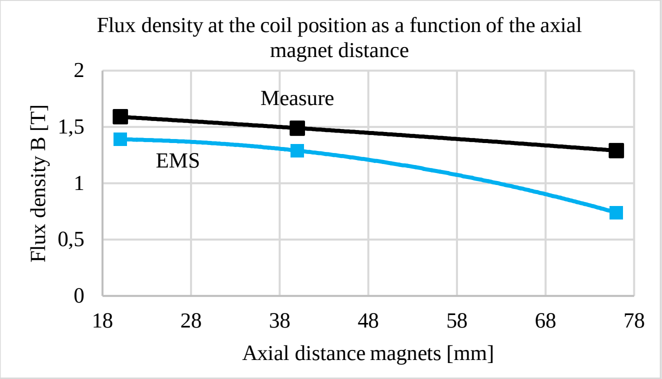

Figure 2: Flux density at the coil position as a function of the axial magnet distance

The magnetic flux density in Fig. 2 shows a decrease with increasing axial distance of the magnets to each other.

For a more detailed view, the flux density curve along the rope axis was plotted.
With increasing axial distance of the magnets, initially a plateau of constant flux density (Fig. 3) spreads at the position of the coil (x=0,15 m).

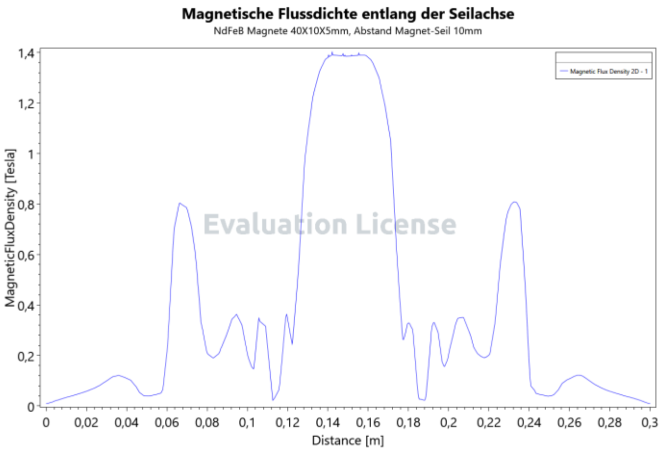

Figure 3: Plateau of constant flux density

As the axial distance between the magnets continues to increase, this decreases to a local minimum that increases in magnitude. Fig. 4 illustrate this. Thus, there is an optimal axial distance between the magnets, so that there is a constant flux density in the area of the coil (Fig. 5).

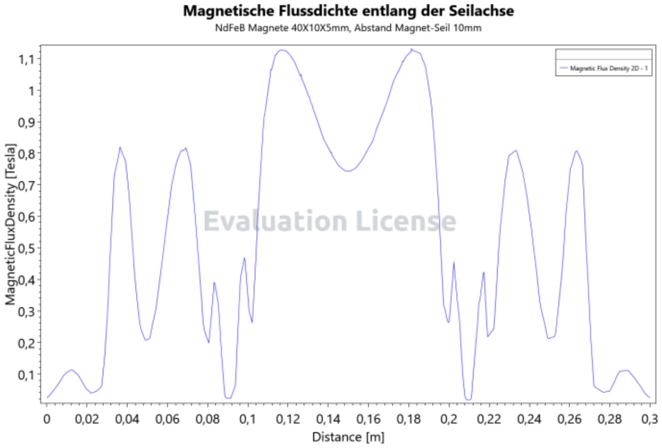

Figure 4:Magnetic flux density drops at the coil position

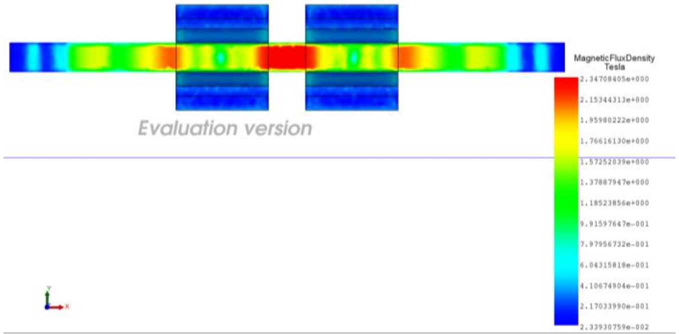

Figure 5: Maximum flux at the coil position

IV. CONCLUSION

The integration of the CAD model of the measuring device into the EMS-tool allows a simple and fast adaptation of the model structure and geometry. This enables to collect a lot of helpful information for the described project. This includes among others:

-The influence of the axil distance of the magnets and thus the optimization of the maximum flux density in the area of the coil position
-The influence of the radial distance of the magnets o the wire rope
The influence of the iron counterplate on the flux density
-A direct comparison of NdFeB and SmCo magnetic material

The results of the EMS-tool showed a similar behavior as the measurement results, even if the concrete numbers of the results differ. This difference is amplified by the highly abstracted CAD model compared to the real measuring device. The CAD model of the real measuring device must be networked and calculated in order to use the tool in the future and to ensure that simulation and measurement results are more consistent. The EMS-tool is a very helpful way to quickly calculate various models and arrangements and thus reduce the number of experiments on the test bench.