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DIFFERENTIAL INDUCTION SENSOR WITH EXTREME GEOMETRICAL WIDTH OF SCANNING

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The paper presents basic information about special induction sensors for heavy industrial conditions, namely a strong electromagnetic disturbance. As the major parameters are the extreme geometrical width of sensing and precise measurement of the time moment for transition of magnetic markers. For this sensor the gradient differential concept with a core manifesting strong shape anisotropy was selected. The developed sensor is used in practice with great success.

Keywords: differential magnetic induction sensor, magnetic core with shape anisotropy, conveyor belts diagnostics

1 INTRODUCTION

The design a differential induction sensor with extreme geometrical width of sensing is based on the need for a reliable and most precise measurement of the moment of transition of magnetic markers at the beginnings and ends of the conveyor belt joints already during the development of the KDP Systems (Systems of Complex Diagnostics of the Belt). It is capable of generating an overall picture of the conveyor belt, keeping eye on the number of the joints and the distances between them, evaluating the status of each of them. Furthermore, the KDP System is able to stop the belt at any determined point and at any arbitrary place along the conveyor. The principle of using magnetic markers, as it, is covered by a Czech patent.

2 CONCEPT OF THE SENSOR

The induction sensor of the KDP System sensing the transition of magnetic marking must remain fully functional also at side-ways motions within the limits of ± 20 cm deviating from the standard, operational position of the belt while considered as an extreme geometrical width of scanning. At the same time, the sensor must be able to, most efficiently, suppress signals arriving from relatively distant sources of magnetic fields, *eg* fields of interference generated by the electric machines of the conveyor drive.

The submitted contribution is providing a solution of an induction sensor of the gradient concept with a magnetic circuit featuring an I-shaped core. Located in its upper- and lower parts are double-windings connected in opposition. The closely situated source - a small-size magnet of the marker- enables application of a substantial dispersion of its magnetic flow in the core profile. As a consequence, the signal of closer winding is substantially stronger than that of the differentially connected farther winding. For signals from interference sources located farther, the dispersion of their magnetic flow in the I-shaped core is not applied, and thus, the signal of the couple of sensor windings is compensated for with success.

Fig. 1. (a) - Conveyor excavator, (b)- measuring roller with gravity positioning beneath the conveyor belt, (c) - roller and induction sensor

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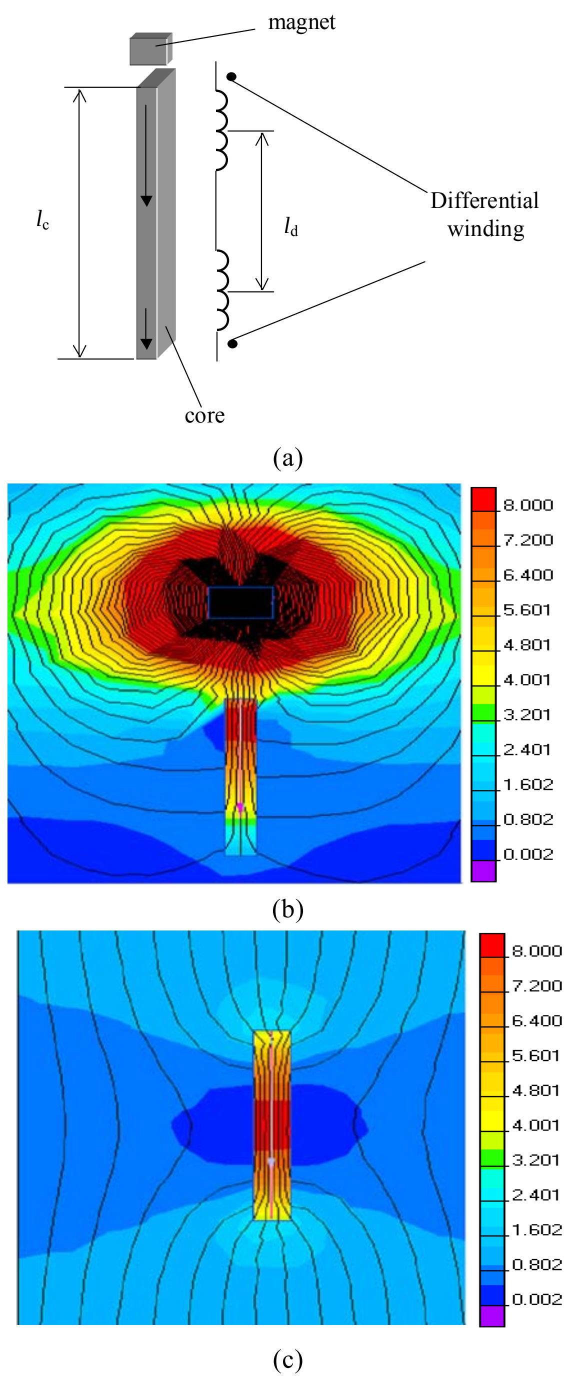

(a)

(b)

(c)

Fig. 2. *(*a) - Induction sensor of gradient concept with the I core profile,(b) - Magnetic field and its substantial dispersion in the core profile for small-size near marker magnet, (c) - Symmetrical magnetic field in the core for the far magnetic source of equal flux density

3 RESULTS FROM SENSOR MODELING AND SIMULATIONS

The proportion of core magnetization in the marker transition or equally strong electromagnetic field from distant interference sources were modeled by QuickField. See Fig.2.

For the basic cases the course of magnetization in the vertical axis of the core is shown in Figures 2(b) and 2(c).

Modelling and simulation results are consistent with the theoretical assumptions of the concept of the sensor. Excitation at a remote source is manifested by the magnetization of the core, perfectly symmetrical around the center point of the sensor, and by the induced electric voltage in the upper and lower windings is equal.

The marker at the time of its passage over the core is magnetization in the core significantly unbalanced. The upper coil sensor has a stronger field approximately by an order of magnitude than that of the lower one.

Quantitative ratios for selected cases of cores and magnetic sources are documented in Fig. 3.

In Fig. 3(a) is the situation in case of sensor with core profile 2×20×400mm. We can see flux density in the core profile for the far and near sources if their peak values are the same. The maximum of magnetization for “near” source is on the part of core from 4 to 7 mm. The maximum for the “far“ source is on the middle (10mm), but both maxima are flat. On Fig.3b) is a sensor with core profile 2×40×400mm. Maximum of flux density for the far source is again on the middle (now 20mm), maximum for near source is on 6mm from the upper end of the core. Both maxima are sharper. In both cases of core profile for symmetrically arranged differential windings, as already stated, at any distance between windings, induced voltages are compensated for the far source and do not compensated for the near source. Figure 3(c) presents the difference of magnetic flux density for the coupled windings of sensor on positions l_d/l_c[%], where l_c is the core length and l_d is the distance length of windings. Core profiles are 2×40×400, 4×40×400 and 6×40×400mm.

One can see that appropriate dimensions of the core are 2×(30–40) mm, required length of the core is defined by the geometric width of the scanning of 400 mm. The windings must be symmetrical to the center of the core in order to eliminate strong signals from remote sources. Advantageous position of winding to obtain the useful signal of magnetic markers is determined by the ratio of l_d to l_c equal 0.8 (l_d is 80% of the core height).

Reliability of the eliminate signals of strong and far sources already in the symmetrical placed sensorś windings was carefully checked for sources different directions, for example of QuickField simulation of this see Fig. 4. I shape –type magnetic core is magnetized always symmetrical from far sources.

4 CONCLUSION

The principle of the sensor of the mentioned concept was analyzed by modeling and simulation using the Quick Field program. Testing was focused on the sensor characteristics for closer, useful, and farther, interfering, sources as well as for directional characteristics.

The sensor was realized with flow-sensing, *ie* with sensing winding with a low number of windings and with a strapped output. Upon verification, the sensor was successfully employed in practical applications on several KDP Systems.

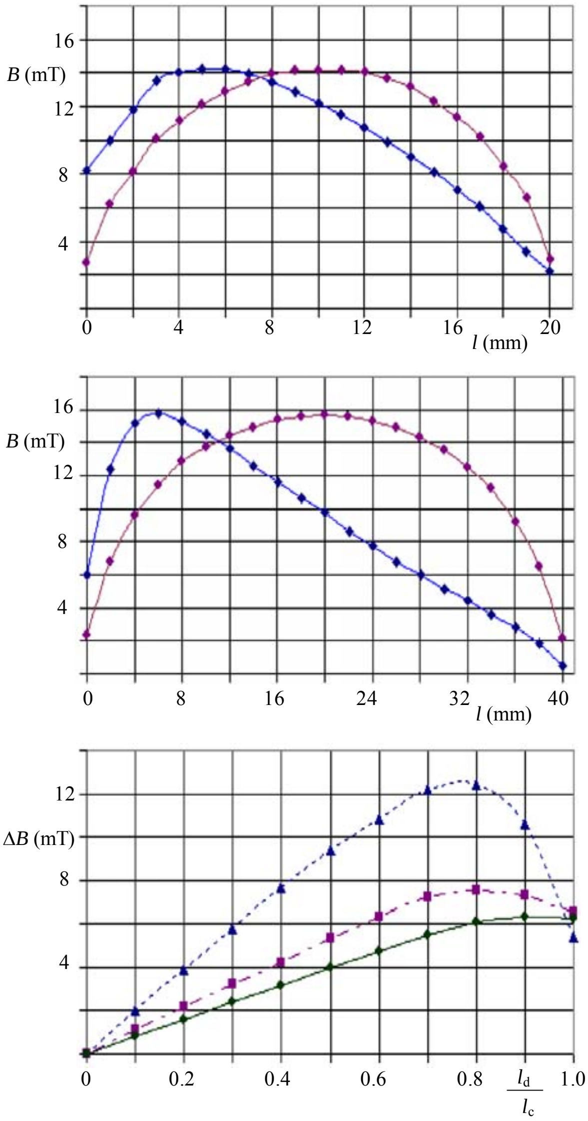

Fig. 3. (a) - Flux density in the core profile for far and near source if its values are the same. Core profile 2×20×400mm. (b) - Flux density in the core profile for far and near source. Core profile 2×40×400mm, (c) - The difference of magnetic flux density for the coupled sensor windings on positions l_d/l_c. The core profile was 2×40×400, 4×40×400 and 6×40×400mm

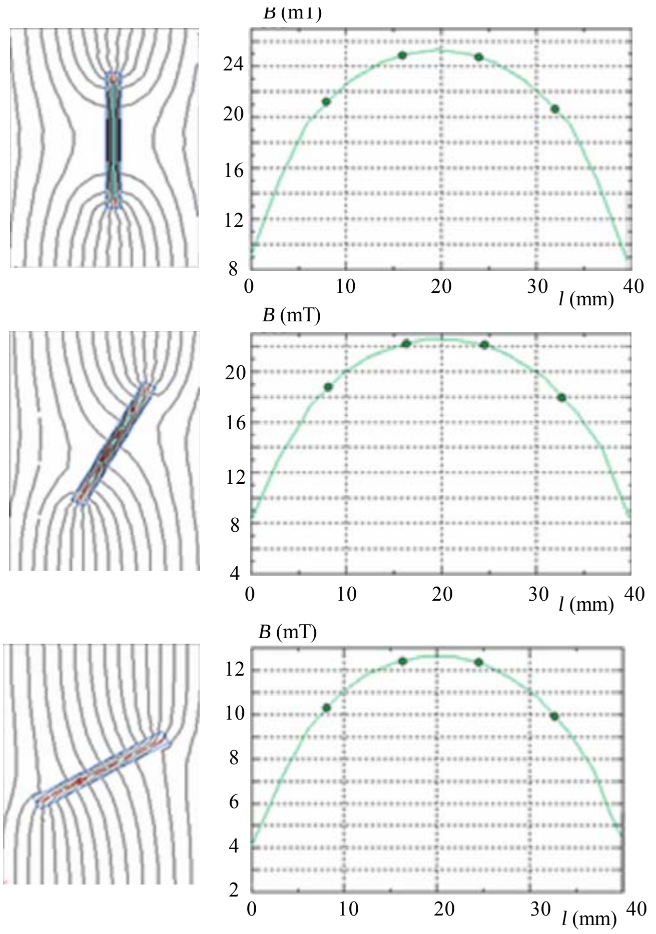

Fig. 4. The symmetric core magnetization checking in different directions of far sources

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