

Modeling of the Magnetic Field around a Ferrite-Cored Generator in a Proximity Detection System

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Abstract— A three-dimensional (3-D) distribution model of the magnetic field flux density around a ferrite-cored generator in a proximity detection system is presented, and the accuracy of the model has been experimentally verified. Our data collection setup and data processing method to produce the model are also presented in the paper.

I. BACKGROUND INFORMATION

Recently, magnetic proximity detection systems have been developed for use on mining vehicles and machinery to detect workers and to issue warnings or disable machine functions when workers are dangerously close to the equipment. Ferrite-cored magnetic field generators are often used in these systems to establish AC magnetic fields around the vehicle or machine. A magnetic sensor worn by a worker senses the magnetic field and determines the distance to the machine based on the magnetic flux density as shown in Figure 1. These systems currently in use can only provide an estimate of the distance to a machine but cannot indicate the location of a worker relative to the machine. The best protection for the worker from machine hazards would require an exact location of the worker relative to specific parts of the machine. Knowing the relationship between magnetic flux density and distance to the generator lays the foundation for being able to determine an exact location of a worker relative to the machine. The accuracy of this relationship would largely determine the accuracy of the proximity detection system which, in turn, might determine whether a worker is injured or killed. To establish an accurate relationship between magnetic flux density and distance, we present a model we have created and verified to characterize the distribution of vector-sum magnetic flux density in the 3-D space near a generator.

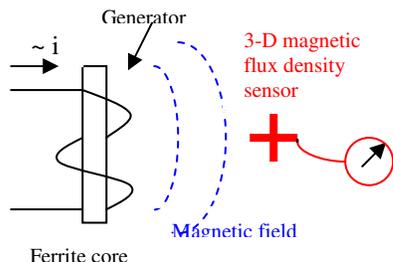


Fig. 1. Operating principle of a magnetic proximity detection system

II. THE MAGNETIC FIELD MODEL

The model includes three functions, a magnetic shell function, a shell shape function and a shell size function. The shell function can be used to find the locations of all points

with an equal magnetic flux density. The shell shape function and the shell size function quantitatively define the shell shapes and sizes, respectively, in terms of the vector-sum magnetic flux density. The accuracy of these models has been experimentally verified. The data show that the relationship between magnetic flux density and distance is highly nonlinear and that the shapes and the sizes of the magnetic shells vary continuously with the magnetic flux density. An example of the continuous changes of the shells is illustrated in Figure 2 which was produced by simulation of the model. All of these characteristics of the magnetic field are captured in our model. Our data collection setup and the method for data process to obtain the model will be described in the paper.

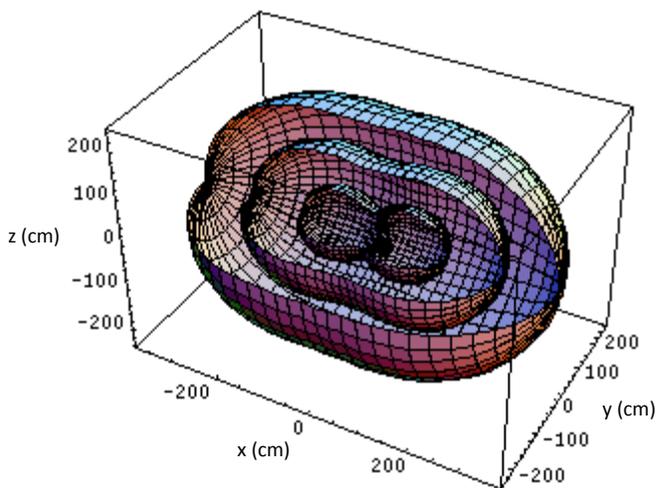


Fig. 2. The changes of magnetic shell size and shape

III. APPLICATIONS OF THE MODEL

To determine an exact and specific location of a magnetic sensor relative to a machine, we have set up a system with two generators on a plane to generate two alternately pulsed magnetic fields. Using this system, we have been able to consistently obtain the exact location of the sensor to an accuracy within millimeters as the intersection of the two shells using the field models. The model will be a useful tool for magnetic proximity system design, development, simulation and verification. The model can also be a useful tool in the near-field study of ferrite rod magnetic radiators.

IV. REFERENCES

- [1] E. C. Snelling, *Soft Ferrites, Properties and Applications*, Iliffe Books Ltd, London, 1969, pp. 327-358.