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Electromagnetic and Thermal Analysis of Induction Heating System for Thin Steel Plate using 3D Finite Element Method

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This paper presents thermal characteristics according to the variables of coil dimension and a carbon percentage of steel using 3D Finite Element Method. The source of heating coil has 50[kHz] and 12.5[kA]. The thin plate which makes the changes of temperature has thickness, 2[mm], and 3% carbon. The temperature has to be maintained about 180[°C]. As holding two fields of study, electromagnetic and thermal analysis, we conduct the coupled field analysis. The process of analysis is done by ANSYS.

Induction heating is commonly used in process heating prior to metalworking, and in heat treating, welding, and melting. It offers a number of advantages over furnace techniques that make it appropriate for a variety of applications. The most significant advantages are quick heating, less scaling loss, fast startup, energy savings and higher production rates.

The system consists of coil, thin plate and shield, and the plate moves at the constant speed of 140[m/m] through the coil. Variable parts of the coil are set up and, accordingly, the temperature changes are examined. In case dimensions are fixed, we also study thermal characteristics according to the rate of carbon of the steel. Finally, two parts of characteristics are totally analyzed.

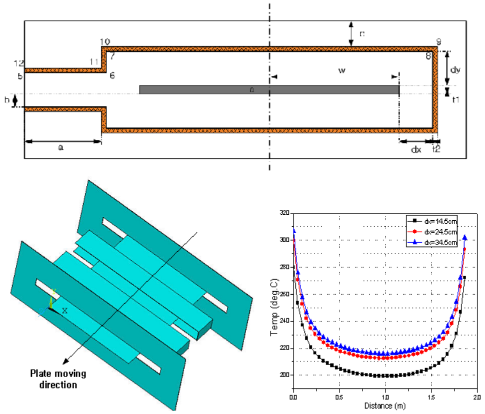

Fig. 1. (a) Variables (b) Schematic system (c) Heat distribution.

The details such as balanced temperature .etc are discussed in the full paper.

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Design and Basic Characteristics of Multi-Consequent-pole Bearingless Motor with bi-tooth main poles

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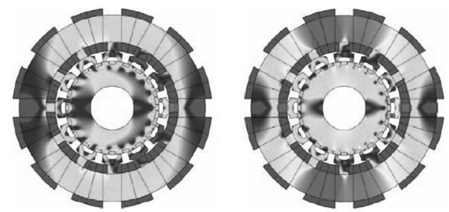
A bearingless motor has functions of a magnetic bearing and a motor. It can generate torque with a magnetically suspended rotating shaft with non-contact. Bearingless motors do not need maintenance of lubrication oil and are free from dust. A bearingless motor is expected in the applications in semiconductor manufacturing industries, cosmic space and medical devices. A bearingless motor that has a significant number of poles is expected for low speed application such as rotating and swinging stages. A flat structure is required as the stages. In the literature there are bearingless motors of two to five-axis active magnetic suspension. In two-axis control type one unit is actively controlled in only the radial directions. In two-axis active magnetic suspension the positions in the axial and tilting directions are passively regulated. A conventional 4-pole and 2-pole windings structure is employed, then the coil ends of the suspension and drive windings tend to be large compared to lamination thickness. Thus, the device can not be compact. In industry applications, a folded tooth stator with concentrated tooth winding has been used. One of other possibility is to apply toroidal coils, however, such bearingless motor developments have never reported to the author's past knowledge. Only concepts have been reported. The authors have proposed a multi-pole bearingless motor for low speed operation and swinging motion. A multi-consequent-pole bearingless motor that consists of 40-pole and 48-slot has been proposed. The bearingless motor has some advantages of low cogging torque, low torque pulsation, low suspension force pulsation and small force angular error. A double-layered structure has been proposed to enhance the axial and tilting stiffness. In those machines distributed winding is employed. Thus, the axial length of the machine is large. In this paper, toroidal coil windings are designed as the suspension winding in order to make the coil end compact. Furthermore, comparisons of radial suspension characteristics of a multi-consequent-pole bearingless motor are described. A novel structure of 12 main pole bearingless motor with supplemental magnetic poles has been proposed. The supplemental magnetic poles provide space for radial displacement sensors, thus, compact structure is realized. In addition, the main pole structure provides axial and conical stiffness in magnetic suspension. Motor windings are wound around stator main poles by compact concentrated coils. The suspension windings are in troidal coils connectec series. Three dimensional analysis is employed in design stage, then a test machine has been fabricated. Successful magnetic suspension and rotation have been realized. The design and basic characteristics of this multi-pole bearingless motor has been reported in this paper.



(a) i_x=2.00A (b) i_x=5.00A

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