Non-contact Gripping of Thin Steel Plate by Magnetic Field from Horizontal Direction: Improvement of Levitating Performance by Tilted Electromagnet

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Abstract

Generally, steel plates are conveyed by rollers. There is a possibility that conveyance by rollers deteriorates the surface quality of steel plates. As a solution, a technology for non-contact gripping and conveyance using electromagnetic force has been proposed. In this study, we proposed a magnetic levitation system using tilted electromagnets to improve levitation stability. Moreover, the magnet field characteristics of the system were investigated.

1 Introduction

Thin steel plates are widely used in various products. However, there is a problem where deterioration of surface quality occurred by transporting. As a solution, a non-contact transport of steel plates using electromagnetic force has been proposed [1]. Based on previous studies, the magnetic levitation system for small steel plate was proposed [2]. However, a large steady current is required to obtain a support force that is balanced by the weight of the steel plate. In large steady current condition, power consumption and heat generated by the coils affect the stability. In this study, we proposed a magnetic levitation system in which the levitation position and tension force can be freely designed by tilting electromagnets. Moreover, the levitating characteristics of the system were investigated using electromagnetic field analysis.

2 Analysis Conditions and Results

In this study, we proposed a model in which the surface of the electromagnet is tilted with
Figure 1: Placement of electromagnets and thin steel plate

Figure 2: Horizontal magnetic flux density

respect to the steel plates, as shown in Fig. 1, to freely design suspension and tension forces. In addition, this model can change the surfacing position and tension force to suit the material and shape of the steel plates. During levitation, the attractive force $F_0$ pulls the steel plate toward the center of the electromagnet, which can be decomposed into two components: a tension force $F_X$ and a suspension force $F_Z$. Stable levitation becomes possible when tension force $F_X$ is applied to thin steel plates, deflection is suppressed. The thin steel plate can levitate when its own weight and the suspension force $F_Z$ are balanced. In this section, the characteristics of the attractive force of the electromagnet of this system were investigated using magnetic field analysis. In this analysis, the flexible steel plate was SS400, and the electromagnet core was ferrite with reference to an actual magnetic levitation system. The tilted angle of electromagnet $\theta$ was 0 and 40 degrees, and the steady current was 0.1 A.

As analytical results, Fig. 2(a) shows the horizontal magnetic flux density, where the electromagnets are placed perpendicular to the steel plate, and Fig. 2(b) shows the magnetic flux density in the inclined direction. By tilting the electromagnet, the horizontal flux density is reduced.

3 Conclusion

In this study, as a consideration of electromagnet units in magnetic levitation systems, the levitating characteristics of the system were investigated using electromagnetic field analysis. The electromagnetic field analysis reveals the effect of the attractive force of tilting electromagnets.

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References
