Electromagnetic Guideway for Seamless Ultra-thin Steel Plate (Experimental Consideration of Damping Effect from Electromagnet Position)

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Abstract

A continuous steel plate production line in steelworks is several kilometers long; over this distance, steel plates suffer from problems such as vibration, friction, distortion, and surface quality degradation, which are caused by contact with rollers. To solve this problem, our research group investigates noncontact guidance control that suppresses the vibration of continuous steel plates by applying an electromagnetic force near the edge of the plates. We analyze and experience the vibration characteristics of steel plates by changing the positions of the electromagnets used in the magnetic guideway for the plates, which are stationary.

1 Introduction

Galvanized steel plates are currently used for a lot of products such as automobiles and buildings. In steel plate production lines, long continuous steel plates are transported while being supported by numerous rolls. However, the steel plates are transported vertically for 20-50 m during the drying process after plating; this is problematic because of the deterioration of surface quality attributed to plating peeling and contact with the rolls. To solve this problem, we have been studying the non-contact guideway of steel plates by applying an electromagnet force near the edge of a continuous steel plate running in a straight line [1]. In addition, we focused on multibody dynamics (MBD) to obtain a steel plate shape in the loop-shaped section is at rest and confirmed that the experimental and analytical results matched the same. The transient dynamic behavior of steel plates when the electromagnetic guideway was installed has also been calculated using MBD [2], but the behavior of steel plates when the electromagnet placement position is changed has not been considered yet.

In this study, the behavior of the steel plate in a stationary state was experienced by changing the electromagnet placement position for the magnetic guideway.

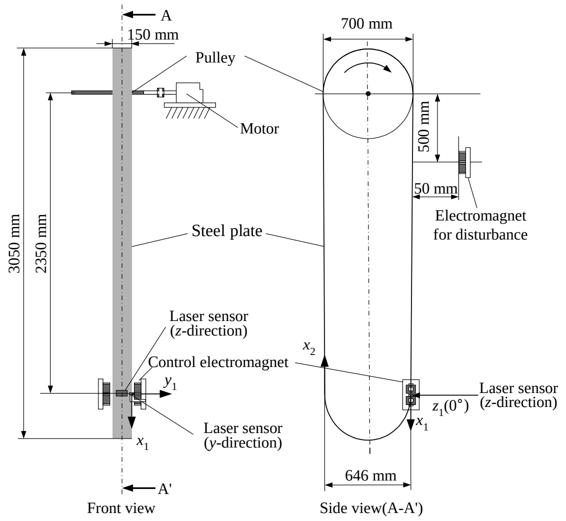

Figure 1: Schematic of experimental apparatus and measurement position.

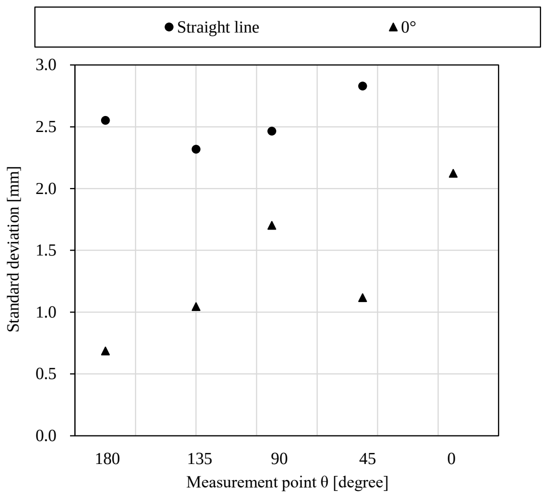

Figure 2: Experimental results of changing position of electromagnet.

2 Magnetic Guideway System

The experimental equipment used in the study is shown in Fig. 1. A continuous steel plate 6894 mm long, 150 mm wide, and 0.3 mm thick, welded into a belt shape, was suspended from a pulley 700 mm in diameter and 154 mm wide. The in-plane running direction of the steel plate is defined as the x-direction; the direction perpendicular to the plate running direction is in the y-direction; and the direction perpendicular to the steel plate plane is in the z-direction. The control electromagnets are composed of two electromagnets, which were installed facing each other at the edge of the continuous steel plate.

The control electromagnets were installed in the running-direction-changing section which is 2350 mm below the center of the pulley, and the straight section which is 1000 mm below the center of the pulley, respectively. As shown in Fig. 1, an electromagnet for disturbance input was installed 500 mm below the center of the pulley is energized to attract the continuous steel plate; the continuous steel plate was displaced 50 mm in the z-direction. The experiment was done by removing the force of the electromagnet for disturbance input in order to cause vibration and measure it at that time. In this study, the steady-state current of the control electromagnet was set to 0.5 A, and the measurement point were set to 0, 45, 90, 135, and 180 degrees at the bottom of the continuous steel plate, where is making a semicircle by changing the running direction.

3 Conclusion

The standard deviation of the displacement which was obtained by the experiment is shown in Fig. 2. The experimental results indicated that a higher vibration suppression effect was obtained when the control electromagnets were installed in the direction-changing section than straight section.

References

[1] K. Kashiwabara et al., Noncontact guide for a traveling elastic steel plate using magnetic force, *The Jpn. Soc. Appl. Electromagn.* Mech., 11 (2003), 235-241.

[2] R. Nakasuga et al., “Narita and H. Kato,” Dev. Electromagn. Guideway Seamless Ultra-Thin Steel Plate (Consideration on Effect of Vibration Suppression against Input Vibration Disturbance by Multi Body Dynamics), *Journal of the Magnetics Society of Japan (Special Issues)*, 5 (2021), 37-43.