An Electromagnetic Vibration Exciter for Rapping System of Collecting Plate in Electrostatic Precipitator

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Abstract — This research on electrostatic precipitator in urban railroad equipment technology is under an active study. More and more, its miniaturization is becoming a key element to the success of an efficient precipitator due to the limited space allowed to install electrostatic precipitator in subway tunnel. Therefore, there is an increasing need for replacing dry rapping system used with a hammer, which is the most pervasive method to clean electrostatic precipitators. However, the size of rapping system used with a hammer is large. Accordingly, this research proposes a compact size of rapping system in electrostatic precipitator using an electromagnetic vibration exciter. Collected dust can be removed by vibration exciter from collecting plates not by imposing direct impacts to the dust collecting plates.

I. INTRODUCTION

As a subway became the key public transportation in modern times, fresh indoor air quality maintenance has developed into an important issue. In order to reduce air pollutants created in the tunnel, research on air quality improving methods using dry electrostatic precipitator is in progress.

In this research, we suggest an electromagnetic vibration exciter to reduce collected dust in a dry electrostatic precipitator. Also, we propose three rapping methods according to an installing position and an excitation direction of an electromagnetic vibration exciter.

Fig. 1 shows schematic diagram of three rapping methods according to an installing position and an excitation direction.

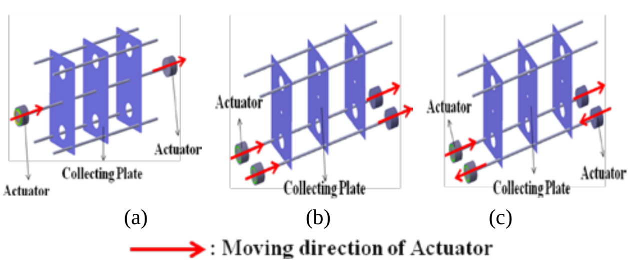


Fig. 1. Schematic diagram of rapping methods (a) 1st method (b) 2nd method (c) 3rd method

Therefore, in this paper, we performed modal analysis of collecting plate using, ANSYS and analyzed the dynamic performance of an electromagnetic vibration exciter using a commercial electromagnetic analysis software program, MAXWELL.

II. MODAL ANALYSIS OF COLLECTING PLATE

To analyze vibration characteristics of collecting plate, modal analysis is performed using, ANSYS.

Fig. 2 shows collecting plate shape and dimension. The width, height and thickness of collecting plate are 250 mm, 400 mm and 0.5 mm. The collecting plate is a steel plate.

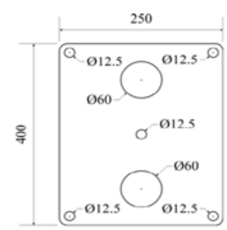


Fig. 2. Shape and dimension of collection plate

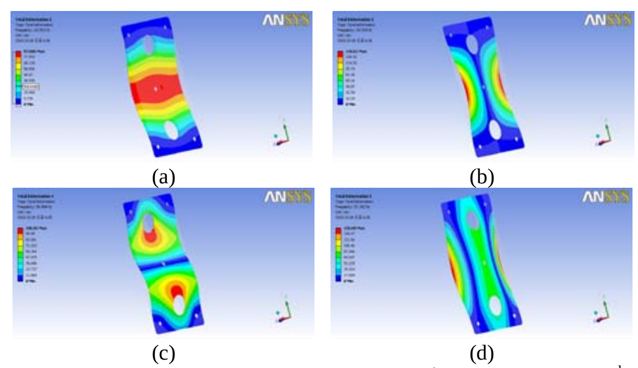


Fig. 3. Modal analysis of collecting plate (a) 1st mode (21 Hz) (b) 2nd mode (31 Hz) (c) 3rd mode (55 Hz) (d) 4th mode (57 Hz)

The first method is to set both holes on the top and bottom edges as fixed boundary condition and analyzed each mode shape and natural frequency for four modes. Fig. 3 shows the results of modal analysis of collecting plate.

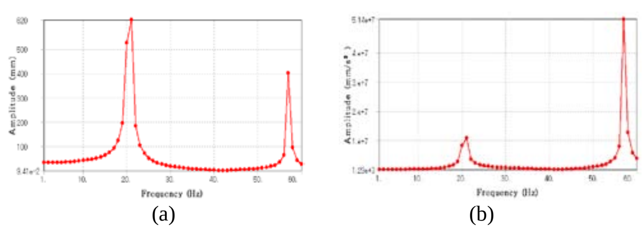


Fig. 4. Vibration characteristics as the excitation frequency changed (a) displacement (b) acceleration

Fig. 4 shows vibration characteristics of the first method as the excitation frequency changed.

The second and third methods are to set both holes on the top edges as fixed boundary condition. Fig. 5 shows the results of modal analysis of collecting plate.

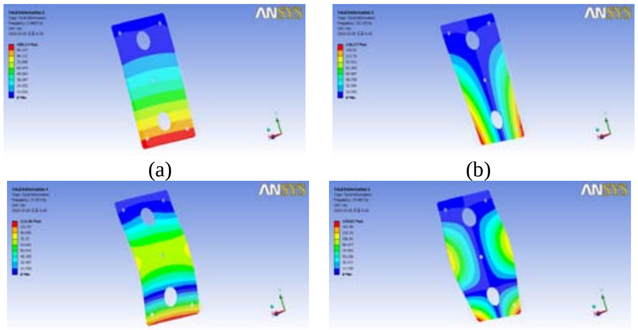

(a) (b) (c) (d)

Fig. 5. Modal analysis of collecting plate (a) 1st mode (3 Hz) (b) 2nd mode (10 Hz) (c) 3rd mode (18 Hz) (d) 4th mode (33 Hz)

Fig. 6 and 7 show vibration characteristics of the second and third methods as the excitation frequency changed.

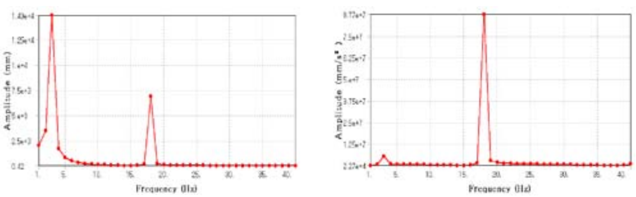

(a) (b)

Fig. 6. Vibration characteristics as the excitation frequency changed (a) displacement (b) acceleration

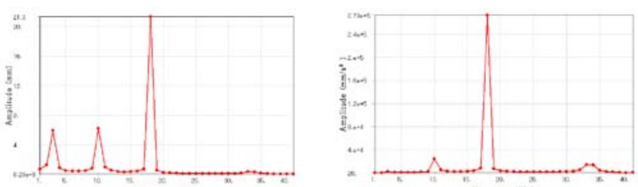
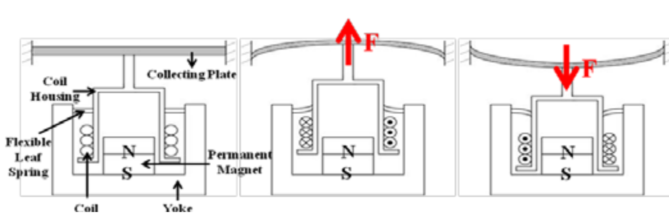

(a) (b)

Fig. 7. Vibration characteristics as the excitation frequency changed (a) displacement (b) acceleration

III. SIMULATION OF ELECTROMAGNETIC VIBRATION EXCITER

To analyze the dynamic performance of the electromagnetic vibration exciter, the simulation is performed by a commercial electromagnetic analysis software program, MAXWELL.



(a) (b) (c)

Fig. 8. Schematic diagram of electromagnetic vibration exciter (a) at initial position (b) at upper position (c) at lower position

Fig. 8 shows schematic diagram of electromagnetic vibration exciter. It consists of two steel yoke parts, a permanent magnet, a coil and coil housing. The vibration exciter is moved by Lorentz force, which is the relationship between the flux generated by permanent magnet and the current applied to the coil. The Lorentz force is given by equation (1).

$$F_{Lorentz} = nB_g il_{eff} \tag{1}$$

The sine wave current is applied to the coil. The applied current is given by equation (2).

$$i = i_0 \sin(2 \cdot \pi \cdot f \cdot t) \tag{2}$$

Fig. 9 shows displacement of electromagnetic vibration exciter as the input frequency changed.

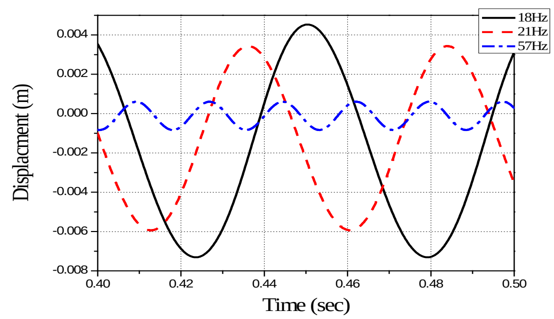


Fig. 9. Displacement of electromagnetic vibration exciter

Fig. 10 shows the excitation force of electromagnetic vibration exciter.

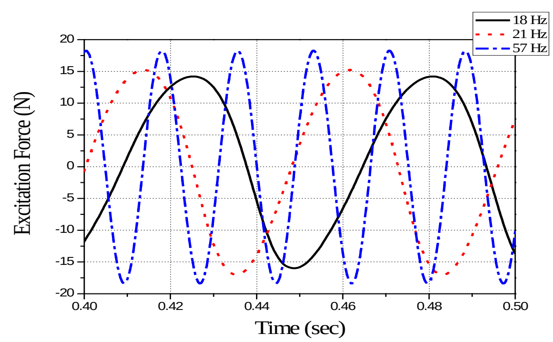


Fig. 10. Excitation force of electromagnetic vibration exciter

IV. REFERENCES

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