MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

Wind Tunnel Test Analysis to Determine Pantograph Noise Sources

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ABSTRACT
As the speed of a high-speed train increases, high aero-acoustic noise is generated around it, and its pantograph is one of the major sources of this noise. Because the pantograph is connected to the catenary, where high voltage is generated, it is difficult to measure and analyze the aero-acoustic noise generated by the pantograph during train operation. In this study, we investigated the characteristics and the influence of the aero-acoustic noise generated from a pantograph using various experimental approaches. Through this study, we have investigated the aero-acoustic noise contribution of the major components of a pantograph.

Keywords: High-speed train, Pantograph, Aerodynamic noise, Wind tunnel test, Contribution analysis
I-INCE Classification of Subject Number: 14

1. INTRODUCTION

The noise generated from high-speed trains is a major cause of discomfort and fatigue for passengers and bystanders. Aero-acoustic noise is particularly troublesome because it increases exponentially when the train speed increases, as opposed to noises caused by rolling and traction [1]. The main sources of aero-acoustic noise in high-speed trains include the front of the train, the inter-coach spacing, and the pantograph [2-3]. Of these sources, the pantograph is the only source projected outside of the train and in contact with high-voltage electric cables, which transmit electrical power to the train. In this sense, it is difficult to distinguish the characteristics of the noise generated in the pantograph from the noise emitted by each major element by attaching a noise sensor to the pantograph. In this study, we investigated the characteristics and the influence of the aero-acoustic noise generated from a pantograph using various experimental approaches.

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2. Noise source identification of the pantograph

2.1 Pantograph model

The most important function of a pantograph in a high-speed train is to supply electric power to the traction motors through contact with a high-voltage (20,000+ V) catenary. Pantographs consist of a combination of mechanical and electrical devices to receive effective power during operation. A pantograph can be divided into panhead, joint, and base sections, and each component is connected by rods, as shown in Figure 1.

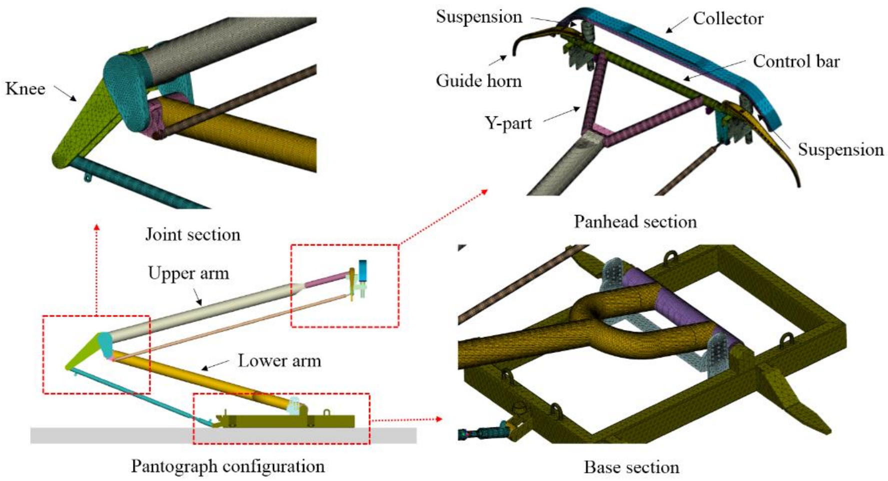

Figure 1. Detailed pantograph model

2.2 Experiment equipment

The Korea Aerospace Research Institute wind tunnel was used in this study and is presented in Figure 2. Wind tunnel tests were carried out in a closed section in order to stably implement a high-speed flow environment. The cross-sectional area of the closed test section was 4 m × 3 m and the maximum flow rate was 120 m/s. The turbulence intensity inside the closed space was less than 0.13% and the flow angle was less than 0.1°.

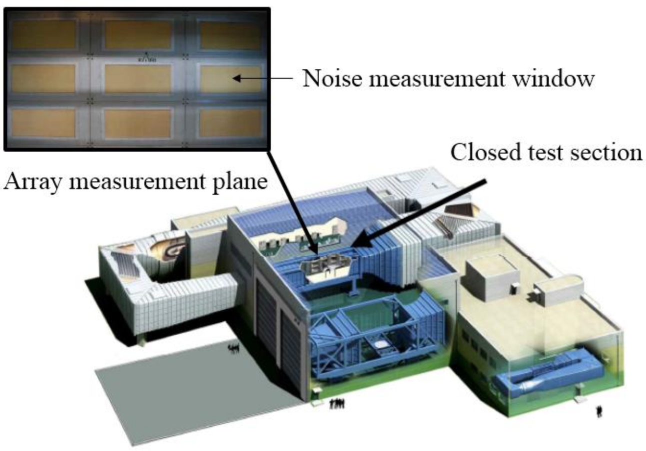

Figure 2. Closed section in wind tunnel test

2.3 Pantograph noise measurement

The noise generated in the pantograph when traveling in the forward direction is shown in Figure 3, and was confirmed to be 99.3 dB (A) in the overall frequency ranges. The highest pantograph noise level was measured at 82.1 dB (A), at a frequency of 672 Hz, and at a flow speed of 83 m/s. It was confirmed that high noises over 80 dB(A) were generated in the 384–752 Hz. It was also confirmed that the highest noise was generated at the 496 Hz frequency at a wind flow speed of 69 m/s.

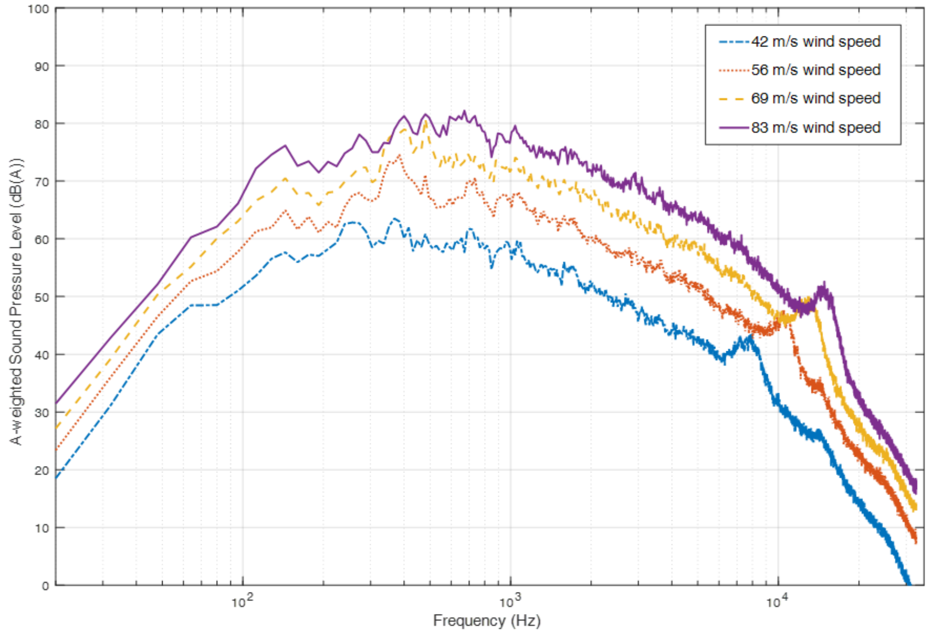

Figure 3. Pantograph noise generated in forward motion

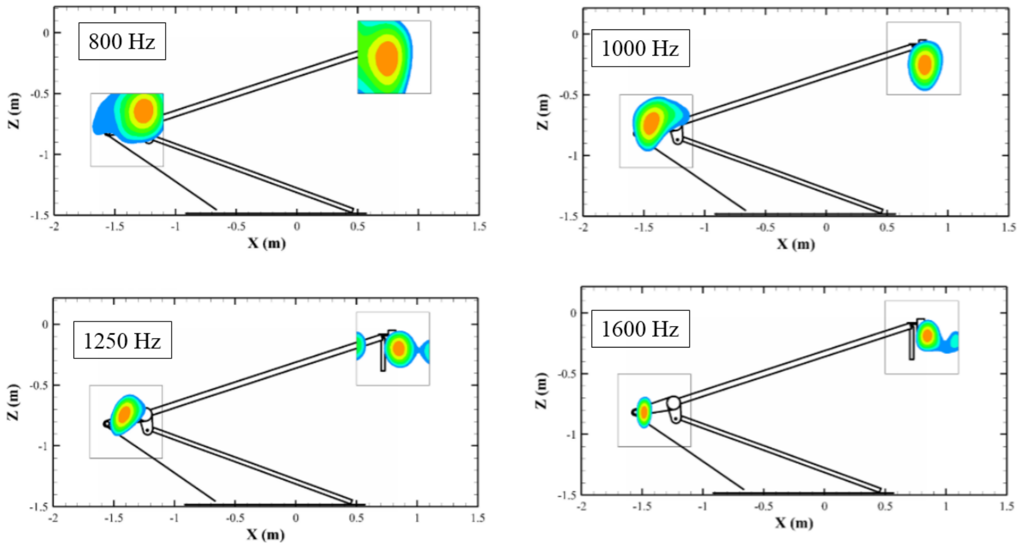

Figure 4. Pantograph noise maps for forward motion

(Beampower level -2.5 <  <0)

The sound field visualization analysis domain was selected on the area of the panhead and joint section. The main noise sources of the pantograph in the forward direction were distributed in the panhead and the joint sections, as shown in Figure 4. The panhead results showed that a high noise level at the collector was generated at a frequency of 1600 Hz, and the main noise source of the joint section was the knee device that connects the upper and lower arms.

3. CONCLUSIONS

In this study, a wind tunnel experiment was conducted to analyze the characteristics of noise generated in a pantograph and its individual components. First, the characteristics of the noise generated in the pantograph were derived. In addition, a sound field visualization was performed using a 95-channel microphone array that was placed on one side of a wind tunnel. The results showed that there were no specific noise differences when the train moves in a forward or reverse direction. Moreover, from the noise maps of the panhead and the joint section, it was confirmed that the collector in the panhead and the knee in the joint section were the main noise sources in each section.

4. ACKNOWLEDGEMENTS

This research was supported by a grant from R&D Program of the Korea Railroad Research Institute, Republic of Korea.

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