Noise Testing Methods and Indicators for Transport Equipment

Zengqing Wang[1,2] and Zengyu Xie[1,2,3,4](✉)

[1] School of Traffic and Transportation, Beijing Jiaotong University, Beijing 100044, China
xiezhengyu@bjtu.edu.cn
[2] State Key Laboratory of Advanced Rail Autonomous Operation State, Beijing Jiaotong University, Beijing 100044, China
[3] Key Lab of Proactive Safety and Risk Control in Railway Operation, Beijing 100044, China
[4] Beijing Research Center of Urban Traffic Information Sensing and Service Technologies, Beijing 100044, China

Abstract. With the development of transportation technology for carrying equipment, the noise during the operation of carrying equipment has become a key concern with increasing speed. In response to the above requirements and in order to better test noise indicators and ensure that the development of transportation equipment meets national standards, this article studies the methods and indicators of noise testing in recent years, and explores the construction of a noise testing indicator system, providing strong theoretical knowledge for the development of transportation equipment.

Keywords: Carrier equipment · Noise test · Noise index · Noise index system

1 Preface

For transportation equipment, when the operating speed of the equipment reaches a certain level, the noise mainly falls into three categories–traction noise, wheel rail noise, and aerodynamic noise. Other noises (such as system noise and contact noise of the pantograph and power grid) are relatively smaller in this process compared to the above three categories. Traction noise refers to the noise generated by the operation of traction motors, cooling fans, air conditioners, gears, etc. during the operation of carrying equipment; Wheel rail noise refers to the noise generated by the friction between the wheels and the track of the transport equipment during operation; Aerodynamic noise is the noise generated by air friction during the operation of transport equipment. All three have a certain relationship with speed, which is reflected in: traction noise: proportional to speed; Wheel rail noise: proportional to the third power of speed; Aerodynamic noise: proportional to the sixth power of velocity. In recent years, with the development of transportation equipment, research on noise has become increasingly in-depth in various countries, but there is no systematic testing system. In this article, the testing methods, indicators, and tools for the above three types of noise have been mainly studied, providing a theoretical basis for transportation equipment testing.

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2 Overview of Research Methods at Home and Abroad

2.1 Traction Noise

In terms of traction noise, a large number of mathematicians and scholars at home and abroad have conducted relevant research. In 1994, Wei Pinxian proposed a method and test program for testing the noise of traction motors; In the past 20 years, Song Zhongming and others analyzed the research methods of noise in Japanese railways, explored on-site experiments, laboratory experiments, digital simulations, and other methods of suppressing noise by Japanese scholars, and conducted relevant experimental research. In the 21st year, Zhou Ande and others studied the working principles of traction transformers, four quadrant pulse rectifiers, and the generation mechanism of electromagnetic noise in traction transformers. In 2022, Cheng Xiong and others analyzed the noise order and structural mode of traction motors, explained the reasons for the frequency of traction motor noise (the test points are shown below), and proposed optimization and improvement measures and suggestions. In 23 years, He Yuyao carried out research on noise prediction and predestined noise reduction algorithm based on neural network, designed MRA-2LFNN model to predict noise, designed C-FNN active noise reduction algorithm based on prediction results to estimate vehicle noise, and established Transitive relation between noise elements at different positions of Railroad speeder and noise at target points through convolution to verify correlation, and then realized stepless noise reduction through fuzzy layer (Fig. 1).

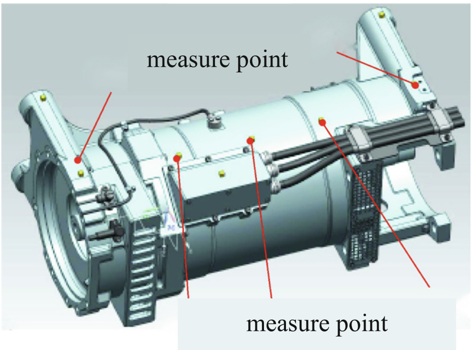

Fig. 1. Schematic diagram of engine noise measurement points

2.2 Aerodynamic Noise

Experiments show that when the running speed of the carrying equipment reaches 300km/h and above, the aerodynamic noise will become the dominant noise, and the aerodynamic noise will increase significantly with the increase of speed. Therefore, the research on aerodynamic noise at home and abroad has been carried out in detail. In the 18th year, sunzhenxu and others summarized the domestic research on aerodynamic noise in the Journal of aerodynamics in the past 10 to 18 years, and described the sound source of aerodynamic noise characteristics and optimization methods. Thompson, a foreign scholar, introduced in detail the measurement and calculation methods of aerodynamic noise of trains 10 years ago. After investigation, for aerodynamic noise, the first methods used at home and abroad are acoustic array, low noise wind tunnel and other equipment, computational fluid dynamics and component-based aerodynamic noise prediction theory. In 19, Yang Yan and others adopted the spoke acoustic array; In addition, aeroacoustic tests and tests are carried out using acoustic wind tunnels and other equipment; Then there are aerodynamic noise theory, FW-H acoustic analogy method, acoustic analogy method based on lattice Boltzmann method, vortex sound theory, acoustic boundary method, component-based aerodynamic noise model, etc. Zhujianyue et al. Reviewed the research progress of aerodynamic noise in the past 21 years, and put forward suggestions for further research on numerical simulation methods (Fig. 2).

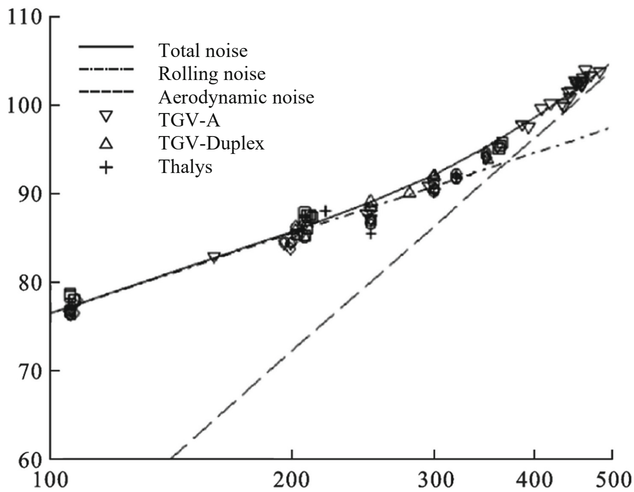

Fig. 2. Sound pressure and velocity curve

The noise distribution diagram of carrying equipment during operation is as follows (Fig. 3).

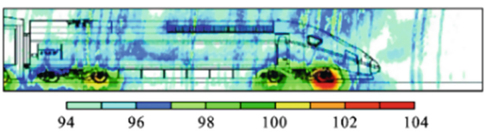

Fig. 3. Sound pressure distribution diagram

Wind tunnel test (Fig. 4).

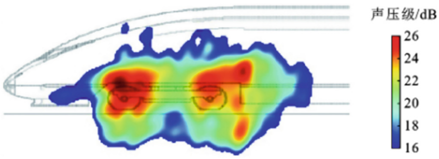

Fig. 4. Wind tunnel.

2.3 Wheel Rail Noise

The wheel rail noise is mainly caused by the friction and extrusion between the wheel and the track, which is determined by the speed of the carrying equipment and the roughness of the track. In terms of wheel/rail noise test and control, in 2001, St. Jane et al. Reviewed the research methods and progress of wheel/rail noise in Europe, and provided reference for China; Suggestions for the development of wheel rail noise research are put forward. Based on the principle of wheel rail interaction and the theory of vibration and sound radiation, Sheng Xiaozhen et al. Expounded the principle of wheel rail sound generation in the past 20 years. According to the generation mechanism of wheel rail noise, combined with the field test data and the model prediction results, they revealed the characteristics of wheel rail noise (the calculation of wheel rail noise is shown in the figure below) and put forward the control law and the problems to be further studied–the main test methods of noise sources, vibration and sound radiation. In the 21st year, Li Kefei and others carried out the application research on the active control measures of wheel rail noise in rail transit, and proposed the test methods and preventive measures of wheel rail noise.

3 Test Methods and Indicators

For the carrying equipment, this paper summarizes the test methods of noise related to high-speed trains, passenger trains, maglev trains, freight trains, internal combustion/electric locomotives and urban rail transit vehicles through research and experiments.

3.1 Noise Generating Parts

The main parts of noise generated by different trains in the carrying equipment are also different. The following is a finite element analysis using ANSYS simulation software to analyze the noise producing parts of four kinds of transport equipment (high-speed train, passenger train, maglev train, freight train), which provides an experimental basis for the following noise testing and test methods.

Noise distribution of the whole train (Figs. 5, 6 and 7).

3.2 High Speed Train Noise Test Method

In terms of high-speed train test methods, it mainly explores: Vehicle radiated noise test, vehicle interior noise test, dynamic noise test, etc.

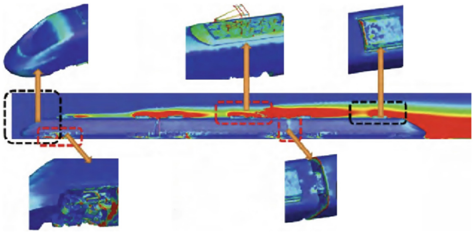

Fig. 5. Head noise simulation

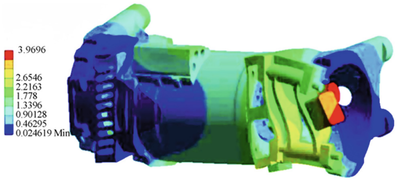

Fig. 6. Engine noise simulation

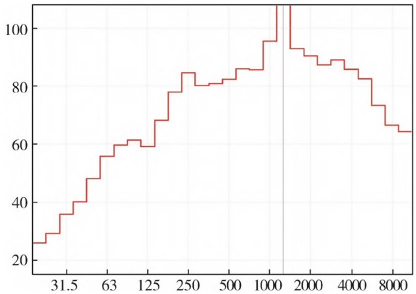

Fig. 7. Noise pressure

For the radiated noise test of high-speed train vehicles, the standards are: Code for complete vehicle test of high-speed multiple units (ty (2008) No. 28), technical conditions for high-speed multiple units with a speed of 350 km/h, IEC 61133–2006 Railway applications–railway vehicles–complete vehicle test before vehicle assembly and operation, and ISO 3095:2013 acoustic Railway applications–Measurement of emission noise of rail rolling stock; The main test equipment used include noise test equipment, multi-channel acoustic analyzer, Pak mobile Mk II, multi-channel acoustic analyzer 3660c, microphone 4189, microphone 4231.

In the vehicle radiated noise test, zjz (JP) 108 high-speed train gear transmission test bench is used for the noise test of wheels and gear boxes.

For the internal noise test of high-speed train vehicles, the standards are: Code for complete vehicle test of high-speed multiple units (ty (2008) No. 28), technical conditions of high-speed multiple units with a speed of 350 km/h, IEC 61133–2006 Railway applications–railway vehicles–complete vehicle test before vehicle assembly and operation, and ISO 3095:2013 acoustic Railway applications–Measurement of emission noise of rail rolling stock; Its main test equipment includes noise test equipment, multi-channel acoustic analyzer Pak mobile Mk II, multi-channel acoustic analyzer 3660c, microphone 4189 and microphone 4231. At the same time, the noise of traction motor and traction motor cooling fan shall be tested by noise meter, and the same method shall be used for the charging box.

For the dynamic noise test of high-speed train, the standard adopts: railway application–Railway Vehicle–railway vehicle test on completion and before use en50215, railway application–railway vehicle operation characteristic acceptance test–operation performance test and static test en14363.

3.3 Noise Test of Passenger Train

In terms of bus noise test, the whole bus test, air conditioning unit noise test and waste exhaust fan noise test were carried out (Fig. 8).

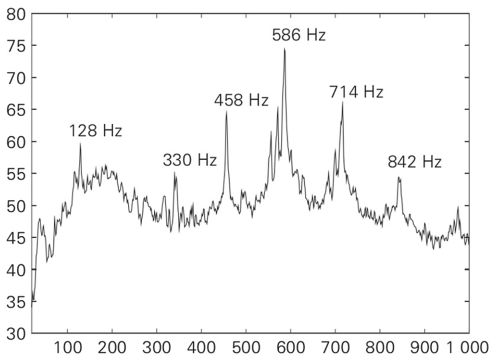

Fig. 8. Noise pressure of passenger train

For the noise test of passenger trains, the main standards adopted include gb/t12818–2004 rules for inspection and test of railway passenger cars after assembly; The test equipment includes 3660c acoustic analyzer, 4189 microphone, 4231 calibrator, smart thermometer and hygrometer, fyf-1 anemometer and bswa801 sound level meter.

In terms of noise test of passenger train air conditioning units, the main standards adopted include tb/t1804–2009 air conditioning units for railway passenger cars and tj/cl429–2014 provisional technical conditions for air conditioning units for railway passenger cars; The nl-42 sound level meter was used for noise test.

Finally, in terms of noise test of waste exhaust fans for passenger trains, according to the standard: tssc-2016–018 detailed rules for technical review of waste exhaust fans for railway passenger cars; Nl-42 sound level meter is used for the test.

3.4 Noise Test of Maglev Train and Freight Train

This section mainly deals with the internal noise test of maglev train, external noise test, internal noise test of freight train, etc.

For the internal noise test of maglev train, the main standards used include q/cybgmj011 rules for inspection and test of medium and low speed maglev vehicles after assembly, IEC 61133–2006 railway facilities–railway vehicles–vehicle test before assembly and operation, and gb/t 14894–2005 rules for inspection and test of urban rail transit vehicles after assembly; After that, equipment including multi-channel acoustic analysis instrument, microphone, calibrator, hygrometer and anemometer were used for noise test.

For the external noise test of maglev train, the standards issued by the National Bureau of standards include q/cybgmj011 rules for inspection and test of medium and low speed maglev vehicles after assembly, IEC 61133–2006 railway facilities–railway vehicles–vehicle test before assembly and operation, and gb/t 14894–2005 rules for inspection and test of urban rail transit vehicles after assembly; After that, noise equipment including multi-channel acoustic analysis instruments, microphones, calibrators, thermohygrometers and anemometers were used for noise testing.

For the test of interior noise of freight trains, the main standards issued by the National Bureau of standards include gb/t 12816–2006 limits and measurement methods for interior noise of railway passenger cars; Use the noise test equipment to test the noise of the main parts in the vehicle, including the wheel rail, traction motor, air conditioner, bogie, electric rail, pneumatic noise, etc.

4 Summary

In this paper, the noise generation and test methods of high-speed trains, passenger trains, freight trains and maglev trains in recent years are analyzed and studied. For the three main types of noise–aerodynamic noise, wheel rail noise and traction noise, the sound source can be analyzed by microphones and multi-channel acoustic sensors, and then analyzed by multi-channel acoustic analyzer. And this paper provides the methods of measuring noise in recent years—aerodynamic noise theory, FW-H acoustic analogy method, acoustic analogy method based on lattice Boltzmann method, vortex sound theory, acoustic boundary method, component-based aerodynamic noise model, etc. It provides a theoretical basis for carrying equipment noise test.

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