Application of the Control Technology of the Noise Reduction along High-speed Railway

Gu Xiaoan Li Yaozeng Liu Lanhua Wu Xiangyang
(China Academy of Railway Science, Energy Saving & Environmental Protection & Occupational Safety and Health Research Institute, Beijing, 100081)

Summary
This paper summarizes and analyzes the details of the control technology of the noise of High-speed Railway and the effects of its application, The situation data of the environmental noise of Beijing-Shanghai High-speed Railway is obtained by field monitoring. The results show that during the stage of trial run of Beijing-Shanghai High-speed Railway, under the condition of the normal traffic flow and the speed at 300km/h and the noise barrier being set，both the railway boundary noise and the noise on the sensitive point located at the region in IV category could reach the requirements of the standard in Railway Boundary Noise Limit (GB12525-90) and Acoustic Environment Quality Standard (GB30 96-2008).

1. Introduction[1]

Since 1990, The Railway Ministry of China has launched the program on the control technology of noise and vibration along High-speed Railway in step with the pre-feasibility research stage of the project. Before the starting of the project construction in the year of 2006, the Railway Ministry had already scheduled projects and carried out 13 scientific research subjects, concerning on high-speed railways environmental noise and vibration proposed standards, environmental noise and vibration source strength, environment impact evaluation and noise and vibration control technology. These research results were directly applied to the design and construction of High-speed Railway.
High-speed Railway Noise Source Control Technology mainly contains the noise source control technology of both high-speed train-sets and engineering structures. Based on the diverse application effect of various noise source control technology, combined with the field monitoring results on environment protection during the check acceptance of Beijing-Shanghai High-speed Railway construction, this paper gives the environment noise influence conditions of High-speed Railway, it might provide reference data for the railway noise source control technology in the future.

2. High-speed train-sets noise source control technology and its noise reduction effect [1]

The engineering noise source control technology of High-speed Railway mainly contains: the optimization design of train-sets streamline heads, the smoothing and light weight of vehicle bodies in order to reduce the aerodynamic noise of the high-speed trains operation; the improvement of pantograph fairing and air conditioning unit pod in order to better improving the noise in the current collector system area; to

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research and develop the vehicle body with well gas impermeability and the application of sound insulation and absorption material in order to lower the level of the noise inside the vehicle.

2.1 Streamline design of vehicle heads

The new generation high-speed train-set named “Harmony” CRH380 is serving on high-speed railway. CRH380 train-set adopted the vehicle head with low resistance streamline, increased the slenderness ratio that the length of the vehicle head is 2.6m longer than that of the normal, adjusted the change rate of cross section, smoothed the modelling head, increased the head sideward fillet radius of the vehicle head fracture surface. Making vehicle head aerodynamic drag reducing by 15.4%, the aerodynamic noise reducing by 7%. The outside skin streamlined structure of the CRH380 head car driver forms a unified whole car compartment, the "groove" shape structure at the lateral side from the front to the backward extended throughout the whole vehicle, it reduces the running air resistance by 10%.

2.2 Bogie optimization design

The design parameters of the high-speed train-sets bogie was optimized. CRH380 train-sets adopted no pillow bogie, increased the anti-roll torsion bar and resist sinusoidal shock absorber, strengthened secondary suspension air spring flexibility, relative to the bogie system before optimization, at the location of locomotive bogie, the aerodynamic noise was reduced by 2.1 dB.

2.3 Pantograph mask optimization design

CRH380 train-sets used high-speed pantograph DSA350 type, active control of low airflow disturbance and double bow current technique, used baffle on both sides of the pantograph, improved the pantograph dome, air conditioning dome and etc, and the dome shape looks like a streamlined box, in front and rear side of the dome at the windward side is roughly ellipsoid. In compare with the pantograph before improvement, the aerodynamic noise of pantograph at bow can reduce 2.4 dB.

2.4 The train-set interior noise control technology

The train-sets interior noise control adopted sound insulation, sound absorption and damping measures, in the different parts of train-set, different floor acoustic damping structure was adopted. The interior noise of the CRH380 in the operation of 350 km/h, is less than 70 dB (A). Its sound level is equal to the interior noise level of early 160 km/h speed ordinary train, lower than that of civil aviation passenger plane flying in the noise and the speed of 120 km/h the car interior noise.

3. Engineering structures noise reducing control technology and its effect [2]

High-speed rail lines used ±1 mm gauge deviation allowing , <2 mm rail height deviation allowing and rail track laying precision control, cross-regional seamless rail, CRTS Ⅱ slab non-ballast track structure and elastic fasteners, as well as the operation of rail grinding maintenance, These technologies realize high smooth-going characteristic of the track; used large amount of concrete box girder and bridge pier; Roadbed, bridge and tunnel structure transition section stiffness transition measures were taken; Increase tunnel effective clearance area, at the inlet and exit of the tunnel, different form of buffer structure was adopted according to different tunnel length in order to reduce the micro pressure wave of tunnel portal surrounding environment.

3.1 high smooth-going track design

Rubber plate is set in the CRTS II type slab non-ballast track fastener system between rail and rail plate, 30 cm thick cement bearing layer was deposited directly onto the surface layer of road bed of regional road bed. In the track plate at the regional bridge section, mortar filling layer was adhesive to the base plate, the base plate was separated by so called "two cloth one film" technique from beam surface. Through technologies mentioned above, the rail vibration to the roadbed and bridge surface

vibration reduced effectively, vibration power attenuation reached more than 99.7%. At the same time, the rail grinding measures were adopted in the operation of Beijing-Shanghai High-speed Railway in order to reduce the roughness of surface of rail and wheel. After polishing the track, the corresponding dynamics indicators, such as the train derailment coefficient, wheel weight ratio of load, transverse stability, vertical stability of the High-speed Railway were decreased to some extent, trains running stability is also improved. After the rail grinding, it can reduce the noise 3~6 dB (A).

3.2 Use large quantity of concrete box bridge structure

High-speed Railway used 32m simply supported box girder beam span simply supported beam, it has enough lateral and vertical stiffness and good dynamic performance; Bridge pier adopted different forms such as : circular pier end entities, double line single cylinder of bridge pier, hollow block, rectangular type double column pier. Bridge foundation pile foundation adopted surface-dig or well-dig according to the geological conditions along the High-speed Railway. Bridge transverse vibration are mainly pier beam of transverse vibration, bridge pier transverse amplitude is less than 0.1 mm. It avoids the secondary noise of bridge structure effectively.

3.3 Enlarge the effective clearance area of tunnel

The effective clearance of tunnel in High-speed Railway adopted no less than 100 m² of tunnel cross section, compare with early Japanese High-speed Railway Shinkansen's nearly 70 m² of tunnel cross section, the micro pressure wave can reduce the ambient noise influence on tunnel is about 1.5 dB. After setting buffer hole along the tunnel structure, slow down the micro pressure wave effect is about 10% ~ 40%.

4. Beijing-Shanghai High-speed Railway environment noise influence conditions [3]

According to "Newly Constructed Beijing-Shanghai High-speed Railway Engineering Completion Environmental Protection Acceptance Research Report", there settled 630 noise monitoring spots, monitored 350 monitoring fracture surface, the results show that on the whole line of Beijing-Shanghai High-speed Railway, Beijing-Shanghai High-speed Railway flow 63 ~ 81 pairs/ day during trial operation stage for each section. Table 1 below shows the environmental noise impact conditions after road noise barrier being set :

Table 1. Environmental noise standard distance after noise barrier being set in operation stage

Functional areas and noise control standard		Corresponding traffic（63 pairs/day）		Corresponding traffic（81pairs/day）	
		Bridge	Roadbed	Bridge	Roadbed
Railway Boundary	Day 70dB(A)	<30	<30	<30	<30
	Night 70dB(A)	<30	<30	<30	<30
IV category region	Day 70dB(A)	<30	<30	<30	<30
	Night 55dB(A)	<30	41～82	<30	52～97
II category region	Day 60dB(A)	<30	30～51	30	37～74
	Night 50dB(A)	36～73	121～179	54～121	153～213

P.S. ①bridge height is 10m, roadbed height is 4m. ② uplink and downlink traffic on average allocation. ③calculate in accordance with 8h equivalent at night.

5. Conclusion

After using several noise control technology to the high-speed train-sets and the engineering structures construction, the engineering of Beijing-Shanghai High-speed Railway has gained satisfied application effect. The field monitoring results of Beijing-Shanghai High-speed Railway construction completion environmental protection acceptance illustrated that either railway boundary noise or the noise of sensitive spot located on IV category region could reach the IV category standard requirement in the railway boundary noise limit (GB 12525-90) and acoustical environment quality standard (GB 3096-2008).

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Reference:

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