ADI Spoke Wheels

Chengqi WANG
National Innovation Center of High Speed Train, Qingdao 266111, Shandong, China
*Corresponding address: e-mail: 520053200073@crrcgc.cc

Abstract: Railway companies need quieter wheels, lighter wheels and higher wear-resistant wheels. National Innovation Center of High Speed Train is carrying out research on new ADI spoke wheels. The research optimizes the chemical composition and heat treatment process parameters of wheel ADI materials, and shows that the key properties of the stereotyped ADI materials, such as wear performance, damping performance and thermal stability, meet the requirements of railway wheel application. A new wheel with spoke structure is designed by topology optimization method, and simulation studies on static/fatigue strength, dynamics, vibration characteristics, and acoustic radiation performance are carried out. The casting process, machining and non-destructive testing methods of the new wheel were studied, and a series of bench tests were conducted.

The study shows that the strength and fatigue strength of the new ADI spoke wheels have reached the standard of rolled steel wheels, and compared with the traditional rolled steel wheels, the new wheels have a weight reduction of more than 10% and a noise reduction of more than 2dB, which is expected to improve the wheel-rail abrasion and enhance the reliability and comfort of the vehicle operation.

Keywords: ADI material; spoke wheel; casting process; performance testing; quieter, lighter, wear resistance wheel

1 Introduction

Wheel is the key component of wheelsets and bogies, plays an important role of bearing, guiding and driving, and bears complex loads. The plate rolled steel wheels are the main choice for metros and high speed train today thanks to their prices, excellent mechanical properties and easy approval processes. However, rolled steel wheels are not perfect, and their performance breakthrough is difficult to make, and a wheel with lighter quality, better vibration and noise reduction performance, and better wear resistance is needed.

In this report, through the application development of ADI materials and new topology optimized structure design, a new type of ADI spoke wheel is developed, the casting processing of the new wheel is completed, and the test verification is carried out.

2 Experimental procedure

The report researches and develops a new type of ADI spoke wheel, and the research mainly includes 4 aspects:

Research on high-performance ADI materials for wheels: In order to develop ADI materials for wheels, orthogonal tests on chemical composition and heat treatment of ADI were carried out, and the chemical composition and heat treatment process with optimal comprehensive performance were obtained, and the wear performance, damping performance, and thermal stability of ADI materials were studied.

Structural design and simulation analysis of new wheel: Based on the railway applications and boundary conditions, using topology optimization method, we carry out the optimal design of wheel structure, taking into account the strength, dynamics, acoustic radiation and other properties, as well as material properties and molding process, and carry out the static/fatigue strength, dynamics, vibration characteristics, acoustic radiation performance and other systematic simulation analysis of the designed wheel structure.

Wheel casting process: carry out new wheel casting process design, prototype trial production, non-destructive testing, machining process design, optimize the spoke wheel casting process, processing and testing methods.

Experimental procedure: The examinations were carried out with reference to UIC 510-5,13979-1 standards and other relevant standards.

3 Result and discussion

Research on high-performance ADI materials for wheels

Through the orthogonal test to explore the alloy composition content and isothermal quenching heat treatment of ADI, we got the ADI material chemical composition and heat treatment process route for the wheel . Through the damping test and friction wear test, the superiority of ADI material compared with rolled steel material in terms of noise reduction and wear resistance is verified. The feasibility of the new wheel tread braking was verified by conducting stability tests on the microstructure transformation and mechanical properties changes of ADI materials at different temperatures.

New wheel structure design and simulation analysis

The topology optimization design of wheel structure is carried out to optimize the wheel structure of multi-spoke scheme and performance simulation analysis, and the optimal structure of spoke wheel is determined. The static and fatigue strength of the new wheel is evaluated, and the vibration characteristics of the new wheel are studied. The

new wheel is better than the rolled steel wheel in terms of the vertical force of the wheel-rail, modal frequency and contact stress of the wheel-rail. The sound radiation performance and dynamic performance of the new wheel were simulated and analyzed, and they were better than the rolled steel wheel.

Wheel casting process

Multiple casting process designs and optimizations have been carried out for the new wheel. Based on the design and simulation results, the trial production of the iron mold with sand coating for the new wheel has been completed, and the prototype of the wheel has been completed The average weight of the new wheel is reduced by more than 10% compared with the weight of the rolled steel wheel, and the flaw detection shows that there are no defects on the surface of the wheel and inside the spokes.

Verification test of new wheel

The wheel axle assembly test, braking bench test, fatigue bench test and acoustic behaviour test of the new wheel have been carried out, and the performance of the wheel meets the design expectation. Rolling vibration test of the new wheel is being carried out to further study the dynamic characteristics of the new wheel, vibration and noise reduction, wear resistance and other aspects of performance.

4 Conclusion

The National Innovation Center of High Speed Train is developing a new ADI spoke-type wheel. ADI materials for the wheel was developed, and the new spoke-type structure was also developed by topology optimization method, and the casting of wheel samples was completed, as well as the verification tests. The results of the research show that the ADI spoke wheels have certain advantages in lightweight, vibration and noise reduction, wear resistance and other aspects compared with rolled steel wheels. The research of ADI spoke wheels will promote the lightweight work of trains and metros, especially in the higher requirements for vibration and noise reduction in metros. The next step will be to continue to assess the performance of the new wheel, and to promote the railway applications of the new wheel.

5 Acknowledgments (Bold, 10 pt., Arial)

This research was funded by Shandong Province Major Science and Technology lnnovation Project Funding (grant number: 2021ZDPT02)， National Key R&D Program of China (grant number: 2022YFB4300100).