NEW SOLUTIONS IN CHOICE OF MATERIAL AND DESIGN OF BRAKE SHOES REQUIRED BY RAILROAD APPLICATIONS

L.A. Vukolov  
All-Russian Railway Research Institute, Moscow, Russia, e-mail: Gerasimova@fritex.ru

A.I. Voronchikhin  
Stock Company FRITEX, Yaroslavl, Russia, e-mail: petrova@fritex.ru

ABSTRACT

The results of interaction of cast iron and composite brake shoes against wheel treads on dynamometer during carry out certificate tests of brake shoes are examined. It has been established that cast iron brake shoes are more aggressive against the wheel running surface. They have inclination to emerge of transverse cracks in tread. On the contrary the composite brake shoes and sintered materials too did not cause the formation of the thermal cracks in the wheel tread owing to more low temperatures rise in friction contact layers. Like this use of composite and sintered material brake shoes in field service on Railway Rolling Stock is more preferable.

INTRODUCTION

The rise of freight and passenger train speeds requires necessity to provide for enough brake ratio of the vehicles. Amongst different possible brake shoe materials have involved cast iron, compositions and sintered metals which meet safety requirements as either an UIC Standards or as Specifications of Association of American Railroads.

Defective wheels have been a cost drain on railroads. For instance Association of American Railroads estimates that wheel shelling and spalling, slid flats, thermal cracks and other wheel defects in 1999 cost railroads about $111 million. Shelling, caused by thermal stress from constant braking on heavily loaded wheels and spalling, caused by wheel sliding in association with resulting friction are the most common problems, accounting for two-thirds of the wheel-defect costs [1,2]. True thermal cracking is a serious defect and in any stage of development it is cause for the immediate removal of the wheel from service. Otherwise it is possible for instance destruction of the dynamometer wheel.

NOMENCLATURE

Key words: cast iron, composite, sintered material brake shoes, wheel tread, friction wear, transverse thermal cracks, dynamometer, braking stops.

TEST ARRANGEMENT

The dynamometer tests of the full size brake shoes manufactured by different factories are fulfilled by Air Brake Division of All-Russian Railway Research Institute and Stock Co FRITEX in accordance with certificate and set norm. On dynamometer with six mechanical inertia flywheels for test of brake shoes and brake pads of the disc brakes are used two car wheels of 950 mm diameter and one brake steel disc of 620 mm diameter arranged between wheels (Fig.1). Maximum initial speed is equal 300 km/h and imitated load on axle is equal 245 kN. Cast iron brake shoes, gray or phosphorous (P=3%) types for cars and locomotives are tested in pair with one wheel and composite brake shoes – with other wheel solely. Because of the influence of metallic or composite brake shoes on wheel treads can be estimate enough exactly indeed. [3].

The wheels of the freight and passenger cars had made on obsolete standard 10791-89 from one mark of steel with contents of carbon 0,520,63%.

The steel of wheel shall conform to the following chemical requirements: C = 0.52 -0.63, Si = 0.40-0.60, Mn = 0.80-1.20, P≤ 0,035, S ≤ 0,040%.The rim of the wheel must be heat-treated after lathe machined. The Brinell hardness of the rim of heat treated wheels shall be not less than 248.BHN.

RESULTS AND DISCUSSION

In period from April 3, 2001 to July 148 full service reductions have been fulfilled at initial speeds 50-140 km/h, applied forces 20 and 30 kN on each cast iron brake shoe manufactured by different Russian factories: Peskov, Sibirtsev (Far East), Yekaterinburg, Nizhnetagil and Yaroslavl. First seven transversal thermal cracks in wheel tread have formed in July 10, 2002. Dimensions of thermal cracks: 30, 40, 25, 30, 55, 70 and 20 mm. The wheel with thermal cracks was rejected. It was changed. Summary brake distances have been 165 km 036 m. The new wheel of dynamometer has interacted against cast iron brake shoes produced by different manufacturers in Gomel (Belarus), Balakovo, Bryansk etc. After fulfilled 90 full service braking at initial speeds 50 to 140 km/h and applied forces on each brake shoe 20 and 30 kN has formed one transverse thermal crack in wheel tread 23 mm length with
continue on front face of rim 5x45°.(Fig.2) Summary brake distances have been 84 km 834 m. The contact surfaces of friction partners: cast iron brake shoes and wheel tread in braking process from high speeds over than 120 km/h is heating to dark-red light. Therefore wheel tread is received periodic impulse thermal load of temperature 800ºC and over.

The second dynamometer car wheel is interacted against composite brake shoes. It was interacted against composite brake shoes of serial standard types TIIR-300, TIIR303 and asbestos-free friction materials 2110, TIIR-308, Fritex-950 in period time from July to November 2003. It was carry out 648 full service reductions from various initial speeds 50 to 160 km/h in dry and wet conditions. Braking in wet conditions with a water volume of 14 l/h for V <120 km/h and 22 l/h for V >120km/h. Brake application force on shoe from 10 to 20 kN, inertia axle load 146,5 kN. Drag braking tests have been performed on a wheel of 950 mm diameter with single brake shoe of non-inertia rig. Maximum speed 100 km/h, applied pressure force per brake shoe from 7,9 to 13,6 kN. It have been performed friction in dry and wet conditions, wear rate, heat resistant, tendency to the formation of metallic inclusions especially in wet conditions [3,4,5].

During full service braking to stop from initial speed 160 km/h the friction layers on distance of 5 mm of composite brake shoes have heated to maximum temperatures of 285, 272 and 138ºC in brake shoes TIIR-303, TIIR-308 and TIIR-300 accordingly [3,4]. That is why considerable change of temperatures in wheel tread during braking by composite brake shoes did not obtained. The same results were reached at investigation of brake shoes F-970 with copper powder introduced into asbestos-free formulation F-950. Also satisfactory results have received under dynamometer tests of the metal-ceramic brake shoes (Fig. 2). Sintered materials are heat in hot braking, while keeping their original properties. Reducing noise and weight, gentle to the wheel. The same results have been received in field experiments and services on real locomotive, passenger and freight cars of Russian Railroads [4,5,6,7].

CONCLUSIONS AND FUTURE WORK

1. Results of dynamometer comparative tests of cast iron and composite brake shoes are showed increasing temperature influence into wheel tread by cast iron shoes. Friction contacts have heated to melted temperature, microstructure of wheel steel is changed and make brittle (martensitic transformation) owing to quick heating when temperature fast increase to critical values and hard of cooling. Then thin thermal cracks can create in wheel tread.

2. The composite brake shoes are heated wheel tread on braking to temperature not over of friction material self-inflamed with melting point 505ºC. Therefore the steel microstructure of wheel tread do not changes and thermal cracks do not forms.

3. For decreasing of wheel inclination to emerge of thermal cracks it is recommended to use composite brake shoes on Railway Rolling Stock in service.

REFERENCES

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FIGURES

Fig.1 - The scheme of the Russian dynamometer for test of brake shoes (1-swing frame, 2-bearings, 3-main shaft, 4-inertia disc, 5-ul size wheels, 6-adjust bolts, 7-brake cylinders, 8-gear, 9-dc, electric motor, 10-disc brake.)

Fig.2 – Diagram dependence of friction coefficient versus speed for asbestos-free brake shoes Fritex-950 (1,2) and sintered metal brake shoes (3,4). Simulate interia load on axle is 245 kN. Applied shoe forces: K=10 kN (1,3), K=20 kN (2,4). Dry friction.