

Brake actuator optimization of the brake test stand as a tool for improvement railway safety

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Abstract. In recent years have been the speed, comfort and safety of rail transport significantly increased. This asks for higher demands on reliability and safety of rail vehicles parts meeting. The important is research the properties of brake pair, therefore build specialized test equipment, where it is possible to programmatically load wheels, wheelset, bogie or complete vehicles. Tests on the friction test stand brake represent a special group, which replace the expensive tests of complete vehicles, that are more costly. The test stand brake allows the implementation of experimental tests of the actual brake units and components under simulated conditions.

1 Braking of rail vehicles

Braking is an important phase of the drive rail vehicle, which change the kinetic and potential energy obtained by driving to another kind energy. Brakes rail vehicles are the most important safety device.

Braking is almost always the increasing of level road resistance in order to keep required speed, stopping on a certain place or to ensure vehicle against spontaneous drive-away on downhill grade. Every powered vehicle with any kind of train has to stop in specified braking distance to avoid threatening the safety of rail traffic.

2 Properties affecting the braking of rail vehicles

2.1 Thermal stress of the braked railway wheel

Property monitored in detail in railway vehicles braking is the heat generated by friction of brake block on the wheel.

A part of frictional heat comes from friction of individual surfaces of wheels and a part of frictional heat is from brake block. Temperature reached by the steel wheel friction and non-metallic block is as high, however, due to the lower thermal conductivity of the block the bigger strain is put on wheel.

The Fig. 1 shows the progress of non-stationary temperature fields in braked railway wheel. When braking, the most heated surface is the wheel track. Temperature distribution along wheel cross section depends on:

- size of the contact force,
- speed and braking time,

- type of braking block,
- wheel material.

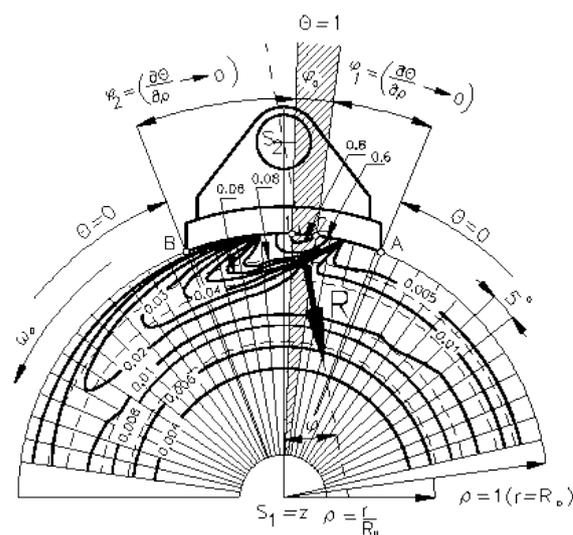


Fig. 1. The process of non-stationary temperature fields in braked railway wheel.

Fact that can be considered is that during braking 66% of created heat passes to the wheel for cast iron blocks and up to 90% to non-metallic blocks.

Another factor that significantly affects the thermal stress is placing of the brake shoe on the wheel. The worst option is overhanging brake block over flange of the wheel. Very unfavourable position is also overlapping of brake block on the outside of the wheel, where the brake block can even rub the external body rim. In both cases there is high heat flux, stress, and thus increases the possibility of damage to the wheel.

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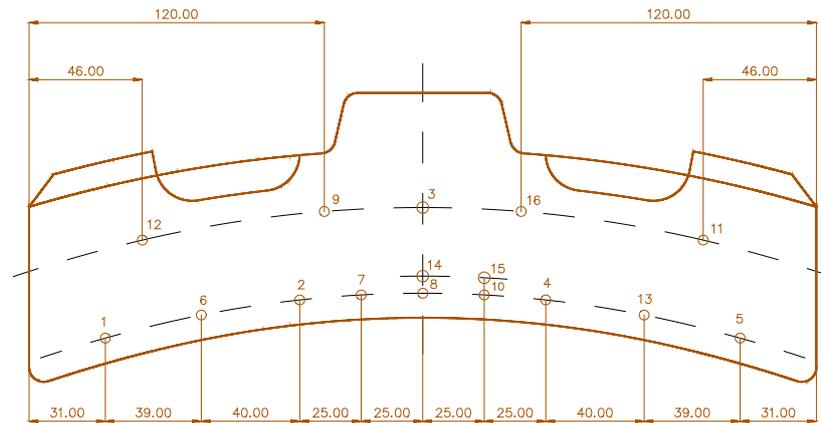


Fig. 2. Location of thermocouples in the test of cast iron.

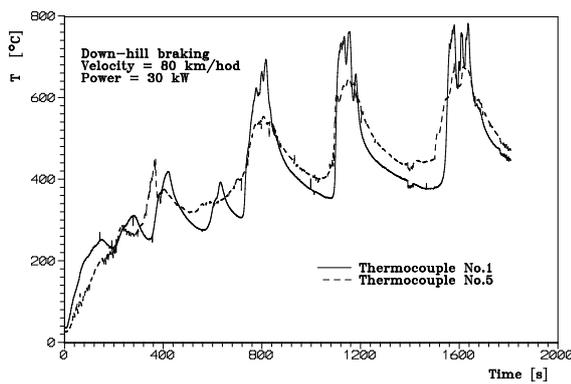


Fig. 3. Temperatures measured in a distance of 1.5 mm from the wheel tread, at a max. distance from the middleblockaxis.

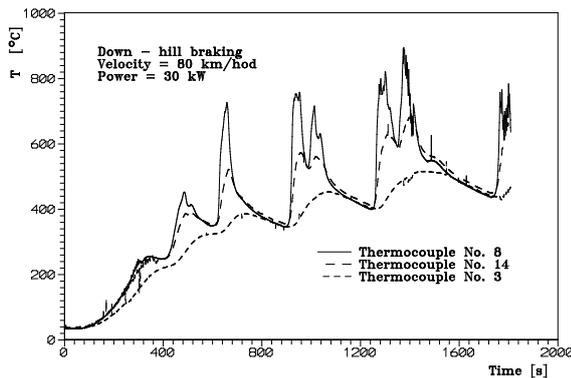


Fig. 4. Temperatures measured in a distance of 1.5, 8 and 45 mm from the wheel tread, in the middleblockaxis.

When braking on an incline at a speed of 80 km/h and braking power 30 kW on test brake bench UIC on Department of transport and handling machines was found in the research the distribution of temperatures in thermocouples. The distribution of thermocouples is shown in Fig. 3 and Fig. 4.

Coatings from rails, which are caused by heating of the wheel, may occur in traffic to tread wheels – if the adhesive forces are only slightly larger than the friction forces. Hardness of coatings is very high and in extreme cases can reach up to 11 mm thickness. Equally there may be a coating from material of the brake block, when

the wheel is braked more force and it develops the large amount of heat.

An important factor that affects the production of heat in the braking is friction coefficient between the brake block and wheel tread. Its size decreases with warming of brake block.

Further warming of brake blocks is related to braking time. The practice is known, that mild and long slopes are more dangerous than sharp and short slopes. Brake block is heated by prolonged braking and changes its shape due to temperature changes, and thus support surface is a deformed while keeping the brake force, resulting in an excessive increase in pressure and thereby decrease the friction coefficient. There will be more heat per certain time unit, how can penetrate deep into the material of the wheel and brake block and then into the air. This leads to the melting of surface layer in the contact wheel and brake blocks. Molten metal and impurities lubricate the contact surfaces and thereby reducing braking effect, that is, begins to decrease friction and temperature also. Molten material solidifies due to the reduction temperature. Dry friction between wheel and brake blocks increases and this leads again to an increase in temperature.

2.2 The friction in rail vehicles

The basic element of the problem of rail vehicles during braking can be classified adhesion and friction. Adhesion is the ability to transfer tangential forces by contact area between wheel and rail. Friction has the ability to ensure the creation of tangential forces between wheel and brake blocks.

The basic consideration of effective braking based on the conditions of adhesion, which is the limiting factor for rail transport.

If frictional forces acting on the wheel will be greater than the adhesion, wheel is blocked and begins to slide, there is theoretically elliptical area with a depth into the wheel, the effect of friction wheel - rail is significantly lower than in rolling the wheel. At the same time the place area leads to high overheating and thus a change in the structure of the material. Deformed wheel loses circularity. Wheel becomes exciter dynamic oscillations

at the next ride and it deteriorates the drive properties of vehicle. When the wheel rotates during braking just a few degrees short groove will be created, which leads to influence of the structure of the material and fast damage of wheel.

Friction coefficient between the wheel tread and brake blocks mainly depends on the material of brake block. The values of the friction coefficients are high at low speeds. The friction coefficient of cast iron brake blocks is significantly lower than for non-metallic.

3 Use of composite brake blocks

Cast iron brake blocks in operation causing considerable noise, which is not invoked only by braking but rolling wheels braked of cast iron blocks on rails. These wheels have on tread the deposits of cast iron, that create inequalities causing vibrations. One of the measures to reduce railway noise has been a requirement for manufacturers of friction materials, that began to develop brake blocks of composite materials. These composite blocks that still bring the noise reduction effects, but on the other hand, it should be borne in mind that, have a lower heat dissipation and therefore own wheel more damaged, especially in the surface layers of the tread. Materials are usually made up of polymer matrix enriched with various materials such as small particles of pumice, dolomite, aluminium oxide, silicon oxide, zinc oxides, magnesium and copper, graphite powder, iron powder, powder of white cast iron, cast iron powder phosphor, barium sulfate, copper, aluminum, mild steel scrap, metal fibers of brass. Currently, are fillers asbestos-based, lead and zinc environmental reasons completely replaced by other fillers and they use mainly fast hardening powders of various alloys and ceramic particles, which are characterized by high hardness, such as corundum.

Composite brake blocks can be divided into organic and metal-ceramic. The main difference between organic and metal-ceramic brake blocks is in materials, in the production and subsequent heat treatment.

The problem in the introduction of composite brake blocks is the friction coefficient, which is much higher than cast iron block. Replacement of these blocks is not possible. Therefore come the requirement from a railway companies to produce of composite brake blocks, which should have the friction coefficient same as cast iron brake blocks and may be freely exchangeable in existing rail vehicles. These brake blocks are marked LL. Blocks, which have a slightly higher the friction coefficient are marked L and blocks with the highest friction coefficient are marked K.

The disadvantage of composite blocks is their price, which is 5 times higher than that of cast iron blocks. Various literary sources but ultimately argue that operating costs of K blocks are lower, but their life is 4-5 times higher.

4 Rail vehicles brake components test stand RAILBCOT

Purpose of test stand RAILBCOT is the analysis of changes geometry tread profiles of railway wheelset. Change is induced by simulated working load under laboratory conditions, that mimic real traffic.

Activity test bench consists of active loading the test wheelset different forces, which will be simultaneously simulated in combination with change of engine torque, engine speed, change wheel load, resizing of free channel gauge, the angle of attack wheelset change and variable braking mode, which is based on the independent activity of two and two brake units with changes in their organization, shape and material composition brake blocks.

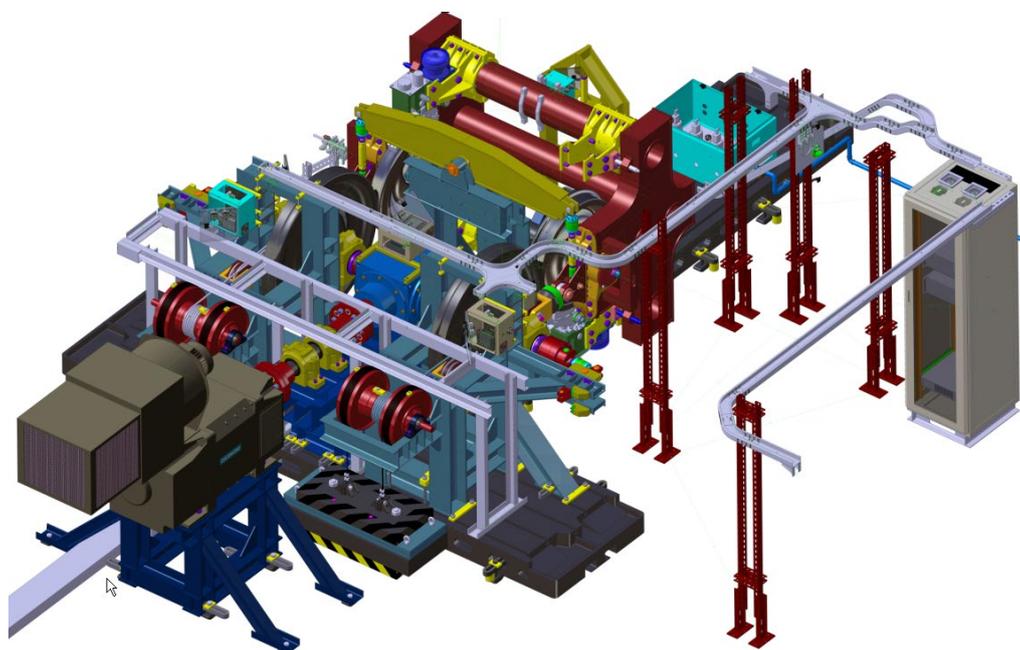


Fig. 5. Model of the test stand RAILBCOT.

4.1 Description of the test stand RAILBCOT

Test stand RAILBCOT (Fig. 5) is built at the Department of Transport and Handling Machines. Will be used to detect changes of profiles of wheels and rails, and hence changes in running properties wheelset. The test consists of two processes. The first is rolling the wheel on the rotating rail. The second is the process of braking wheelset with integrated brake units. Each wheelset is braked by two brake units. Each unit has a separate brake control pressure in the cylinder and it is possible to simulate the bilateral and unilateral action of brake blocks.

The principle of making the wheel forces and braking forces are shown in (Fig. 6). The wheelset (3) is pressed to powered rotating rail (4) by mechanism (5). This mechanism consists of a set of pulleys and size of the workforce is set by the appropriate number of segments weights. On the test bench can simulate wheel loads up to 25 tons per axle. Braking force is inferring with the brake unit (2), which is attached in the bracket on the frame. Brake unit is controlled with compressed air, which is supplied by flexible hose (1).

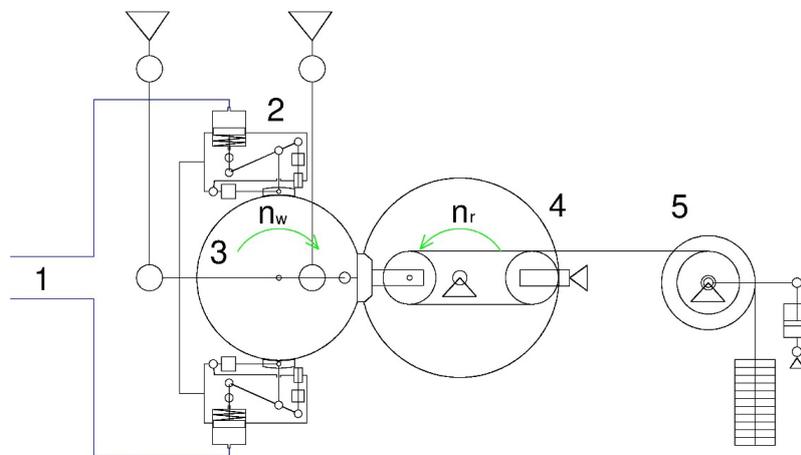


Fig. 6. Scheme arrangement of the test stand RAILBCOT

Production of compressed air and regulating pressure provides air distribution (Fig. 7). Compressed air at a pressure of 1 MPa is formed by compressor 3DSK 75 (1), which is powered by engine 1A9 130 2LA (3). Power transfer is secured by belt drive. Compressed air is stored in the primary reservoir (4). Air passes through a pressure valve (5) to the secondary reservoir (6). The pressure in the primary reservoir is in the range 0,8-1 MPa (depending on emptying the primary reservoir) and in the secondary reservoir is 0,8 MPa. This arrangement was chosen in terms of smaller impacts in the pneumatic system when refilling pressure air by compressor (1) to the pneumatic system and therefore provides constant pressure 0,8 MPa at the input of the proportional pressure valve MPPE3 126010 B2 (7). Compressed air is supplied by input branch (a) to the valve, where it is on the principle of abandoning air pressure in the flow line (b) into a waste branch (c). The pressure is set by the pre-stress membrane valve, which is controlled electronically.

In order to record the course of braking power when braking process, it was necessary to make adjustments on the used locomotive brake unit.

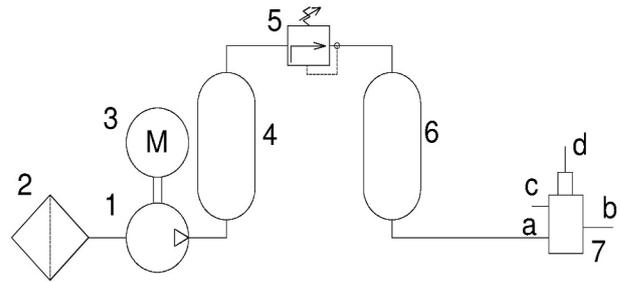


Fig. 7. Air-conditioning distribution system scheme

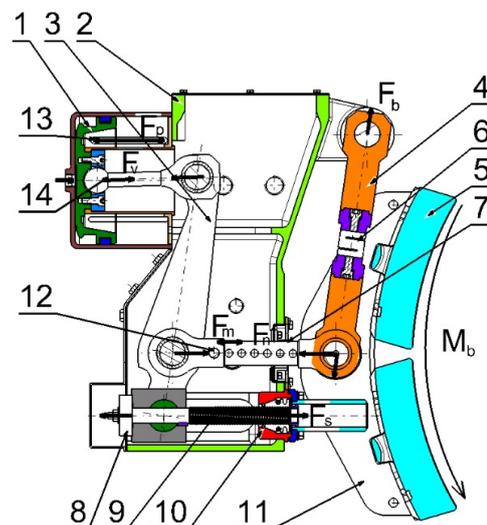


Fig. 8. Forces in the brake unit during braking

In Fig. 8 shows a function diagram of a modified brake unit: (1) brake cylinder, (2) frame of brake unit, (3) brake handle transmission lever, (4) suspensions for transmitting tangential forces, (5) brake block, (6) tangential force sensor, (7) rod for inferring normal force, (8) normal force sensor, (9) screw of slack adjuster, (10) frame of slack adjuster, (11) holder of brake blocks, (13) spring of brake cylinder, (14) connecting rod of piston. Force is transmitted through the connecting rod (14) on the brake rigging (3). Through the transfer lever leads to an increase value of braking force, but reduce the distance made by brake blocks. The unit is equipped with one-sided slack adjuster (10, 11). This ensures a constant remoteness between wheel and brake release blocks in the un-braked state.

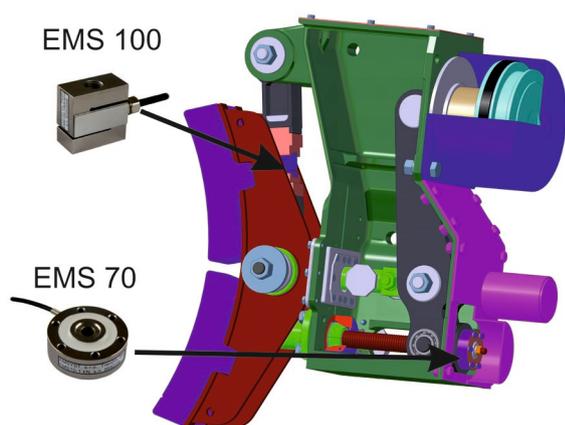


Fig. 9. Location of sensors in the brake body units.

On modified body of slack adjuster is placed force sensor. Direct measurement of the braking force was problematic because the actuator is stressed by buckling. (7). This would adversely affect the accuracy and also the additional stress.

For this reason, is the measurement point on body of slack adjuster. The body is stressed by tensile and it has a good approach when replacing the sensor, in case of its failure. Tangential force sensor (6) is placed between the two adapters (4). These adapters replace the original suspensions. Currently, the test stand RAILBCOT is ready for test operation.

5 Conclusion

For detection and deducing the normal and tangential braking force were two possible options for implementation. The first was to create a new braking system on the brake rigging used in vehicles with installed brake block. The second option is a braking system integrated into a compact unit, so use the brake unit. There was chosen the variant to use the brake unit. Unit works as a compact braking system comprising cylinder with a diameter of 8 inches, brake rigging, one-sided slack adjuster and holder of brake blocks. Brake unit is additionally equipped with force transducers for measurement.



Fig. 10. Location of brake unit in test frame

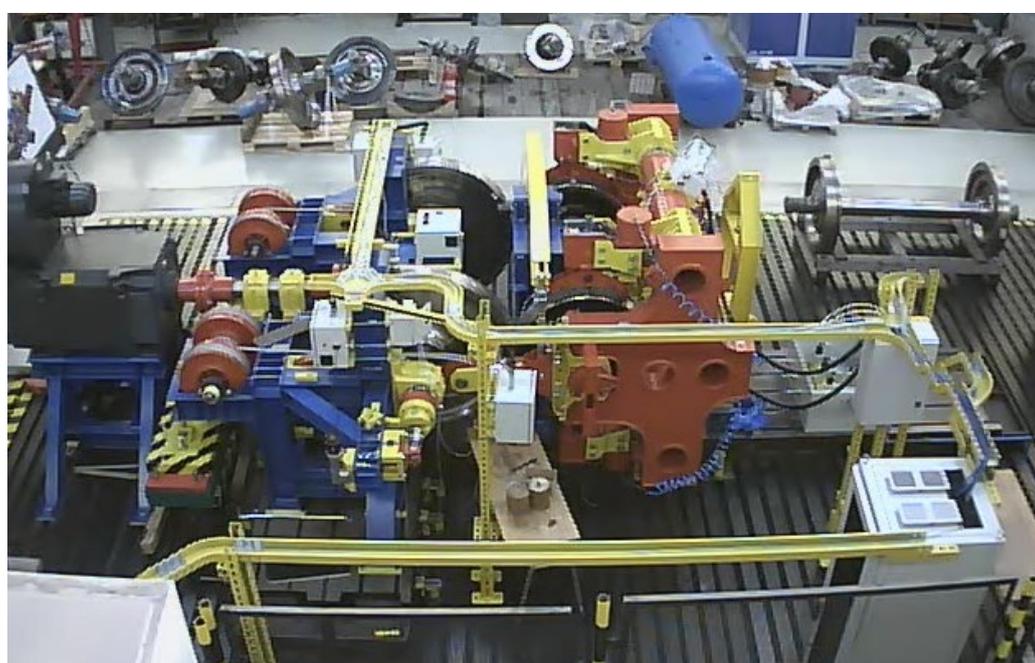


Fig. 6. Scheme arrangement of the test stand RAILBCOT

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