SYSTEMATIZATION OF PREVENTIVE MAINTENANCE PROCEDURES OF BRAKING SYSTEMS FOR RAIL VEHICLES AND CRITERIA FOR BRAKE INSERTS REPLACEMENT

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Abstract: Braking systems used in the Serbian Railways have a significant impact on the safety of railway transportation. Therefore, preventive maintenance procedures and criteria for the timely replacement of consumable elements of braking system are extremely important to the security of railway transport. This paper presents a systematization of preventive maintenance procedures and criteria for the replacement of consumable elements of braking system.

Key words: braking systems, pedal brakes, disc brakes, brake inserts

1. INTRODUCTION

Using rail vehicles presents a clear need for controlling the movement of a single composition or a single rail vehicle. The increase in speed of a rail vehicle is achieved through towing engine of the vehicle i.e. the locomotive, while brake systems, located in each vehicle, are used to slow down the vehicle. Brake systems may be used to reduce the speed and for the full stop of the composition.

Brake includes the system of assemblies and devices that are organized into one unit on the rail vehicle. Control of this assembly is done from the locomotive. The principle of the present braking procedure is turning of the kinetic energy of rail vehicle into heat by work of the friction force. Depending on which type of brakes are applied a different form of friction is achieved.

2. BASIC TYPES AND DIVISION OF BRAKE SYSTEMS

Development of towing and towed vehicles, and the entire railway infrastructure, is followed by ongoing development of appropriate brake systems and brakes. Braking systems are complex systems that include a wide range of components that are physically found from the cabin to the wheels themselves [1]. Brakes represent very important devices built on the rail vehicles. Their importance is reflected in the safety of rail transport, as it is very often more important to stop than to move the rail vehicle. Brakes on rail vehicles can be divided as shown in Figure 1, according to the braking performance. At railway vehicles in the Republic of Serbia, the most represented brakes are pedal brakes and disc brakes. These two types of brakes are a group with a friction braking.

![Fig. 1. Brake types](image-url)
Brakes with pedals work on the principle of transferring of pressure force from the brake cylinder through the lever system or brake block to the pedals. This type of brake is very common in many countries. Consumable parts of brakes are brake pedals, in contrast to the holder, which is not replaceable. Characteristics of brake inserts, as well as their dimensions are prescribed by international regulations UIC 541-1 [2]. Quality of brake inserts must be enough to withstand high mechanical and thermal stresses without harming the surface of the wheel.

Inserts of pedal brakes [3] (Figure 2) are made of various kinds of cast iron and composite material. Freight trains and locomotives are using pedal brakes in almost hundred percent of cases. Serbian Railways use 80% of brake inserts is made from cast iron, and the rest form the composite materials. The most common type of cast iron that is used in the Republic of Serbia for the development of brake inserts is the SL25.

Fig. 2. View of brake pedals position

Some of the disadvantages of brake inserts SL25 are [4]:

- Short lifetime,
- Sparking during the braking process,
- Laborious and time-consuming brake replacement of inserts due to their weight and
- The coefficient of friction is a variable function that depends on many factors, particularly the speed.

With the increase of speed brakes with brake inserts made of cast iron reduce the coefficient of friction. This led to the development of brake implants of composite materials having a constant coefficient of friction, regardless of the change of speed. Brake pedal inserts, which are made of composite materials, were made to remove the shortcomings of brake inserts made of cast iron. Brake inserts of composite materials are produced from various fibers, metal, mineral and organic inclusions. Because of its components braking inserts made from composite materials are depleted 20% -50% less than the brake pads made of cast iron. Lack of brake inserts of composite materials is the depleting of wheel material. Exploitation of this type of brake inserts leads to appearance of small surface cracks in places where the insert contacts the wheel, because the poor thermal conductivity of this material.

Disc brakes, Figure 3, are used as the primary brake for railway vehicles with speed up to 200 km/h, but the possibility of their use for larger velocities is researched.

The disc consists of two circular plates that are tightly linked with ribs. Ribs that connect panels allow better cooling. Brake inserts for disc brakes are made entirely of composite materials. Characteristics of the brake inserts are defined by international UIC 541-3. Application of disc brakes is very expensive because they require installation of counter-sliding devices.

The advantages of disc brakes over the pedal brakes are:

- More effective brake operation,
- High braking effect,
- No erosion of rolling wheels
- Longer lifetime of rolling wheels versus brake pedals,
- No metal dust.
- Nearly constant coefficient of friction in terms of speed, which allows smoother deceleration and
- Braking is silent.

Fig. 3 Disc brakes with brake disc mounted on the shaft

3. FACTORS THAT AFFECT THE WEAR OF MECHANICAL PARTS IN BRAKE SYSTEMS

In exploitation of both types of brake systems and brakes, inserts wear of during the time. Vehicles with disc brakes are checked on the channels. During the inspection the occurrences that are not allowed are determined [5]:

- The appearance of the whole crack,
- The appearance of small cracks,
- More than one crack at each frictional area,
- Cracks on both friction surfaces, in line with the same cooling channel ,
- Any cracks in the hub,
- More than four cracks in the cooling ribs,
- Damage, looseness, traces of rust on the brake ring,
- Absence of the circular edge channel of the disc and
- Brake-offs on the peripheral zones of the friction surfaces, if they are bigger than 5 cm².

The lifetime of the brake inserts is affected by:

- The quality of brake pad material,
- Train speed at which the brake is applied,
- Weight of the composition of the train,
- Railway inclination, etc..
If material, and the relation of substances in the material is not suitable, brake pad lifetime will be shorter. The choice of material for making brake inserts can have a direct impact on the wear of disk or wheel, which are much harder to replace. The choice of material should meet the quality criteria to be met by manufactured brake inserts. Material for the production of brake inserts must not contain lead, heavy metals, solvents, rubber, etc. Great impact on the quality of the brake inserts has the production process itself.

Brake inserts wear most when composition brakes. Mass of composition is also a factor that affects the wear of brake inserts. The bigger composition mass, and the inclination of the railway both affect the wear of brake inserts. Stopping of the train on the railway with rise affects the brake inserts considerably.

4. BASIC PHASES OF PREVENTIVE MAINTENANCE OF BRAKE SYSTEMS

Due to safety of railway traffic the inspection of brake systems on all rail vehicles is conducted. Inspection of air brakes is divided into four types: Type A includes a complete test of brakes, while braking and release the brakes is examined for all vehicles in the composition. Type B means the testing of brakes, with brake and release examined in all additional vehicles in one composition. Type C is the test that inspects the braking and release of the first braking vehicle located behind the split point. Type D test involves the examination of the main line, while braking and release of the braking vehicle at the end of the composition is checked.

The shorter testing of brakes means testing by type B, C or D.

Brake test is performed by the locomotive driver and review employee. The pressure in the main line should be at 5 bar. The time to charge up the air brakes working pressure of 5 bar code is:

- Completely empty individual car without air, 2 to 4 minutes
- Freight train of 60 to 80 axles, 6 to 8 minutes
- Freight train of 120 axles, 10 to 12 minutes
- Passenger train of 60 axles, 3 to 6 minutes.

Review workers check both sides of the train to find:

- Are all vehicles properly included in the main line,
- Are all distributors connected,
- Are all vehicles cocked,
- Are the hand brakes all cocked,
- Does the gearshifts of brakes and braking force on the correct position,
- With hearing sense reveal unsealed spots,
- Are the brake inserts of prescribed thickness,
- Is there mechanical damage affecting the proper operation of the brake and
- Is involved rapid discharges of the main line turned on.

After these inspections, the train driver checks the connection of main line with the main tank checking if it is sealed properly. If not satisfactorily-sealed, disputed cars of the compositions are excluded. Thereafter, the train driver puts down the to 4.5 bar, and review employee evaluates if inserts are resting properly. This inspection is done according to the following procedure:

- For inserts made of cast iron by hammering,
- For composite inserts pushing pedals with a hammer
- For disc brakes reviewing whether inserts fit and whether the control pointing devices shows blocked.

If inserts are resting properly train driver cocks of the composition. Train driver places the handle in the position of fast breaking, and then into the driving position. Review worker checks if the brakes are cocked, i.e. is the gap on the entire range of pedals from 5 to 10 mm. If some inserts are not detached the detaching device is used.

Shortened brake preventive tests are carried out in stations while composing the towing and towed vehicles, if the test of type A and test of type D were made in less than 24 hours. In the event of a merger of two trains which were previously inspected in less than 24 hours with brake test type A test, the test of the main line - type D should be made. After the inclusion of one or more cars in one or more spots on the train, it is necessary to do:

- Individual brake test of type B
- Examination of the main line type D.

If we have to uncouple one or more cars from any part of the train, it is necessary to pass the test of the main line of type D. If after completion of the train ride or after dissolve in a passing station train continues moving in the same composition, it is necessary to pass the test of the main line of type D, provided that in the last 24 hours train had complete type A brake test.

The time required for testing of brakes with type A test:

- For a freight train of 100 axle, one employee ant the driver, 40 minutes or
- Two operators and a driver, 20 minutes or
- One worker and fixed installations, 50 minutes
- The passenger train from 40 axles, 20 minutes.

Mentioned time is calculated after the merger of towing vehicle (or stable plant) and charging brakes of all vehicles on the train up to work pressure.

Shortened the time required for the test of type B, C or D:

- The freight train of 100 axle, 15 minutes
- Passenger train of 40 axles, 7 minutes.
5. CRITERIA FOR REPLACEMENT OF BRAKE INSERTS

For reliable movement of trains it is very important to check the validity of the brake system of composition.

Figure 4 shows the process of brake inspection and brake criteria for inserts replacement.

When the brake pedal is checked, the insert thickness, clearance and regularity of seating is inspected. If the thickness of the pad is less than 10 mm the replacement should be done. The clearance between pedals and the wheel should be in the range of 5-10 mm. Checking the proper insertion of the pedal made of cast iron is done by hammering, and inserts from composite material are checked by pushing of pedals.

In disc brakes the thickness of inserts, the clearance between the insert and the disc and the proper fit is checked. If the thickness of the pedal is less than 5 mm it must be replaced. The clearance between the rotor and the pad should be 1-2 mm. Proper fit tests is done visually or using a pointing device.

![Checking procedure of the brake correctness](image)

6. CONCLUSIONS

Procedures for preventive maintenance of brake systems on the railways of Serbia have a significant impact on increasing of the safety of railway transportation.

Criteria for replacement of consumable elements of brake systems, as well as inspection of clearance and proper overlap of brake inserts on the wheels or discs, which are defined by the Directive on the braking of trains, set the main phase of work in the maintenance of brake systems, and also make a significant contribution to the safety of the railway transport.

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