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A Paper on Braking Systems in Railway Vehicles

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Abstract: Braking system is an essential feature for halting and stopping the railway vehicle within the minimum time. This paper offers a discussion on the various braking systems used in railroad vehicles. This paper also looks at electrodynamics and electromagnetic train braking, which is especially important in high-speed trains. A train that moves requires energy, known as kinetic energy that needs to be removed from the train to cause it to stop. The simplest way to do that is to turn the kinetic energy into heat energy. Normally the conversion is achieved by adding a contact substance on the spinning wheels or on the disks connected to the axles. The substance creates friction and the kinetic energy is converted into heat energy. The wheels slow down and the train ends up halting. The material used to brake is usually in block or pad shape. The vast majority of trains around the world are fitted with braking systems that use compressed air as the force to drive the blocks on to wheels or pads to discs.

Keywords: Vacuum brake, Air brake system, Straight air brake system, Electrodynamics braking system, Mechanical braking system, Electromagnetic braking system.

INTRODUCTION

The brakes are used on railway train coaches to allow for regulate acceleration downhill,deceleration, or to keep them standing when parked.While the basic principle of road vehicles is similar, the usage and operating characteristics are more complex due to the need to control multiple connected carriages and to be effective on vehicles left without a primary mover.The important factors affecting braking operation in any vehicle in controlling any braking system are friction, contact surface area, amount of heat generation and the braking material used[1].The basic requirements of brake areneeded to be strong enough to halt the vehicle in the shortest possible distance during an emergency for safety of human life and physical resources.Upon brake operation, there should be no skidding and the driver must have good control of the vehicle upon emergency.Brake efficiency should remain constant even when applied prolonged or when descending on a down gradient.Brake should keep the vehicle stable even when the driver is not present[2].

1. *Vacuum Brake & Its Limitations:*

The vacuum brake system derives the braking power from the atmospheric pressure acting in the vacuum brake cylinder at the lower side of the piston while a vacuum is maintained above the piston.The train pipe runs the entire length of the coach and is linked by hose coupling with consecutive trains.The vacuum is created by the ejector or exhauster installed on the locomotive in the train shaft, and the vacuum cylinder[3].

The following drawbacks apply to vacuum brake system:

a. Brake cylinder piston requires longer time to release due to single train pipe after each brake application.A considerable volume of air has to be added to the train pipe on a very long train to make a complete brake operation and to release the brake a considerable volume has to be drained.
b. To high speed trains, vacuum brakes are not appropriate the maximum pressure required brake operation is atmospheric only. For higher loads and speeds the braking power is insufficient.
c. The practical limit on the attainable degree of vacuum means that it takes a very large brake piston and cylinder to produce the necessary force on the brake blocks[4].

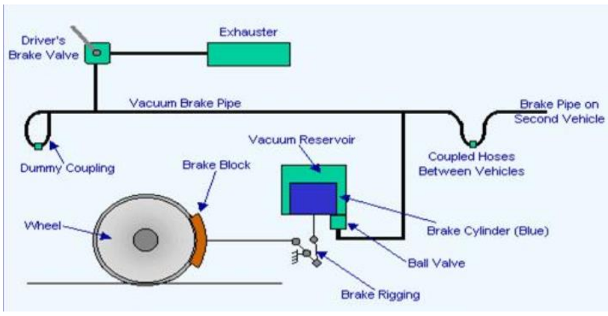

Figure 1: Vacuum Brake

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2. Air Brake Systems:

An automatic air brake system is shown in figure 2. Each two to four coaches are mounted air compressors that supply compressed air to the air brakes.The air, which is compressed to almost 8 kg/sq cm, is piped down to the main air reservoirs below the coach floors.With pressure regulator, the air pressure is lowered to 5 kg/sqcm, and air is fed to auxiliary air reservoirs via thebrake tubing, braking valve, and control valves[5].

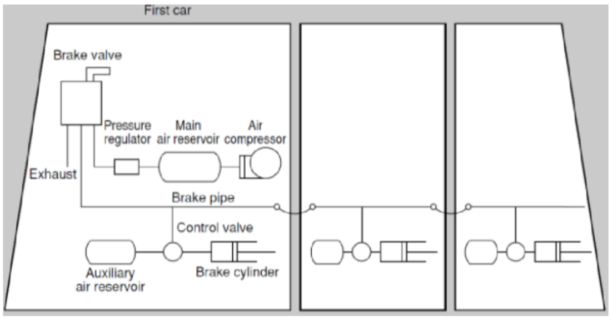

Figure 2: Principle of Automatic Air Brake System

If each coach has 5 kg/sq cm of compressed air in the brake pipes and auxiliary air reservoirs, brakes are not disabled.The triggered brake valve restricts air flow from the pressure regulator, and falls in the brake pipes with air pressure.The control valves on each coach sense the decrease in air pressure. The control valves then regulate the flow of compressed air into the brake cylinders from the auxiliary air reservoirs.The brake valves enable the basic mechanisms for braking to slow down and stop the coach. The air flow from the auxiliary air reservoirs to the brake cylinders is controlled by the control valves at a pressure proportional to the pressure drop in the brake pipes[6].

3. Straight Air Brake System:

A straight air brake system is shown in figure 3. In each coach, the straight air brake system has no control valve or auxiliary air reservoir, as in the automatic air brake system. Compressed air from straight air pipe brake cylinders is triggered by brake valve powers, triggering the basic braking mechanism. The straight air pipes do not contain compressed air under normal running conditions; if coaches are uncoupled the brakes will fail. The straight air brake system in combination with the automatic air brake system may be used to avoid this. It may also be stopped by using another pipe from the first to the last bus, called a main air reservoir pipe.Air pressure in main air reservoir pipe acts like compressed air in the brake pipes of the automatic air brake system.When compressed air falls in this main air reservoir pipe, or if it spills in between coaches from air pipes or air hoses, etc., pressure drop is detected and brakes are automatically applied[7].

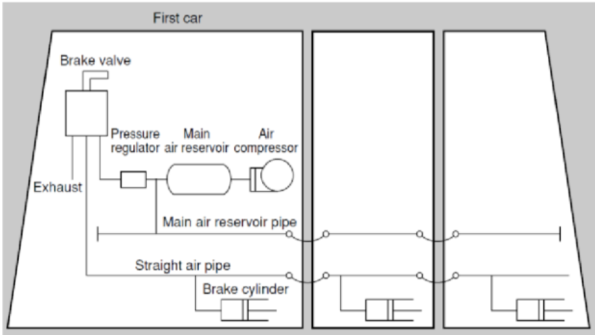

Figure 3: Principle of Straight Air Brake System

4. Electrodynamics Braking System:

An electrodynamics braking system is a system which converts the motor into a braking generator which dissipates the kinetic energy in the form of heat.Regenerative braking uses the electricity generated instead of dissipating it as heat, and is becoming more common because of its energy-saving capability[8]. The electrodynamics traction principles, dynamic braking and regenerative braking systems are shown in figure 4.

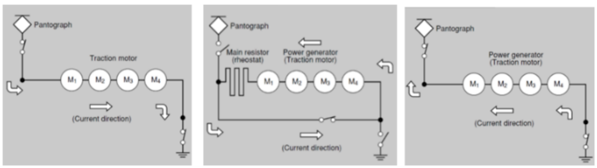

Figure 4: Principle of Electrodynamics Traction

At braking, the traction motor slows and accelerates the train, and instead serves as an electric generator, forming part of a circuit consisting of a rheostat, armatures and a field network. The key resistor absorbs electricity, which transforms the train's kinetic energy into heat, which serves as a brake. Regenerative braking uses the same circuit type; but rheostat does not absorb the electricity generated by braking. The connection is to the overhead

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cable. Under the pantograph a controller controls the flow of this electricity, which opens and closes within a fraction of the time. Electrodynamics brake systems are inexpensive to use because, as with mechanical brake systems, they do have friction components. Even more efficient is the regenerative braking system because the electricity regenerated from the kinetic energy of the train is transferred to the overhead wire and becomes usable to power other rolling stock. Electrodynamics braking systems however sometimes fail because they have complex circuits. Consequently they cannot be used as emergency brakes. In an electrodynamics braking system the traction motor's braking force is transmitted via gears to the wheels[9].

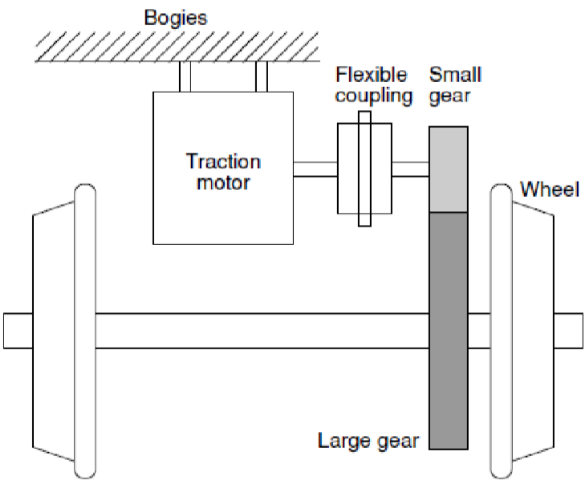

Figure 5: Transmission of Breaking Force from Traction Motors to Wheels

5. *Mechanical Braking System:*

Mechanical braking systems use basic braking devices such as wheel tread brakes, axle-mounted disk brakes, and wheel-mounted disk brakes. These brake systems use a brake shoe where friction force is applied to the disc. To control the braking force the applied pressure is set. The brake shoe applies friction force to the tire tread in wheel-tread brake, which produces a sliding effect. This type of brake can't be used by high-speed trains, because doing so can damage the wheel tread. They use disk brakes mounted on an axle or wheel. For this reason, axle-mounted disk brakes require enough space to accommodate used in trailer bogies. Wheel mounted disk brakes are used on motor bogies as they only need to accommodate the traction motor and lack room for an axle-mounted brake. Compressed air or oil is applied to a brake cylinder on both systems which pushes the brake lining against the disk. Brake disks are dead weight which is only useful when braking, so operators can install lighter disks. Multidisc of carbon/carbon composite and composite disks of aluminium gives lighter weights and is commonly used. The multidisc carbon / carbon-composite have alternate carbon-fibre rotor and stator parts. They rub against each other during braking to generate a frictional force slowing down the wheel or axle. The disk weights less than traditional materials and has excellent heat-resistant characteristics. It is possible to make aluminium composite brake disks much lighter than forged steel and cast-iron brake disks today. In fact, their structure is specific to both axle- or wheel-mounted disks, producing a much smaller, undersigned disc[10].

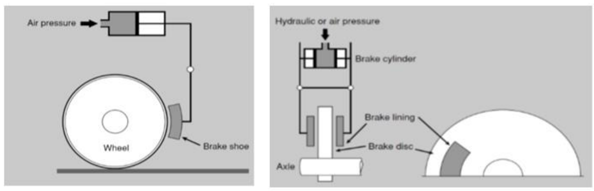

Figure 6: Principle of Wheel Tread and Axle-Mounted Disc Brakes

6. *Electromagnetic Braking System:*

Conventional train braking systems are heavily dependent upon adhesion between the tread and the rail. In the case of high-speed trains, adhesion decreases with increasing speeds, making it necessary for the train to minimize braking force in order to stop slipping of the axle. Longer braking distances are this consequence. An electromagnetic brake device that does not rely on adhesion has been established to overcome this problem. By using magnetic repulsion obtained from eddy currents produced on the top surface of the rails it produces a braking force. It had not been used earlier because of the fact that the eddy currents heat small sections of the rail to such a degree that the rail would bend sideways. This is overcome by the invention of an electromagnetic brake that uses frictional force and eddy currents. The electromagnetic brake is connected to batteries that create alternating north and south poles that form magnetic fields between the poles. The magnetic fields produce eddy currents in the top surface of the rails, generating a force that works in the opposite direction to the train's motion that is to say a braking force[11].

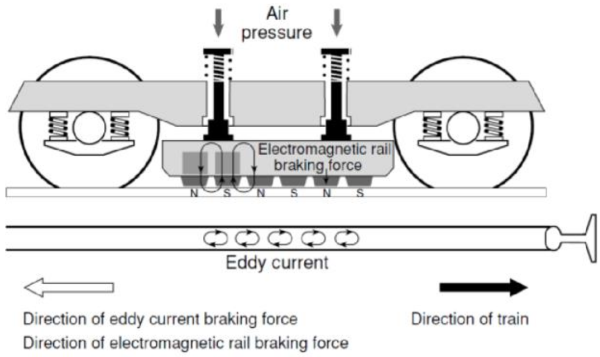

Figure 7: Principle of Electromagnetic Brake

CONCLUSION

The formulation uses a three-dimensional model of touch with complete parameterisation of the two interacting body are surfaces. The benefit of the formulation is the ability to evaluate the roll of the components of the wagon, which most regular consumer products cannot identify. Vacuum brakes have extremely limited uses because they are slower to operate and are impractical for high speed trains. Air brakes are efficient compared to vacuum brakes; thus, they do not need to be used for emergency braking, but they require considerable stopping distance. Mechanical brakes should be kept in reserve parallel to another breaking strategy, and should be used to stop the engine at low speed absolutely. The braking forces required can be obtained in a wide range, with regeneration braking being used in a high-speed range, and low-speed rheostat braking .Electrodynamics brake systems often fail due to complex circuits. Consequently they cannot be used as emergency brakes. For high-speed train electromagnetic braking is an efficient method of separation.

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