Review of Vacuum Braking system

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Abstract - The vacuum brake is a braking system employed on trains and introduced in the mid-1860s. A variant, the automatic vacuum brake system, became almost universal in British train equipment and in countries influenced by British practice. Vacuum brakes also enjoyed a brief period of adoption in the United States, primarily on narrow-gauge railroads. Its limitations caused it to be progressively superseded by compressed air systems starting in the United Kingdom from the 1970s onward. The vacuum brake system is now obsolete; it is not in large-scale usage anywhere in the world, other than in South Africa, largely supplanted by air brakes.

The early 1870s, the same time as the air brake. Similar to the air brake, the vacuum brake system is controlled or operated through a brake pipe. But the brake pipe connecting a brake valve in the driver's cab with braking equipment on every vehicle. The operation of the brake equipment on each vehicle depends on the condition of a vacuum created in the pipe by an ejector or exhauster. The ejector, using steam on a steam locomotive, or an exhauster, using electric power on other types of train, removes atmospheric pressure from the brake pipe to create the vacuum. When a full vacuum in the brake pipe, the brake is released & when no vacuum, i.e. normal atmospheric pressure in the brake pipe, that time the brake is fully applied.

Key Words: vacuum brake, vacuum reservoirs, Driver's brake valves

1. INTRODUCTION

A moving train contains kinetic energy, which needs to be removed from the train for stopping the train. The best way of doing this is to convert the energy into heat. The conversion of kinetic energy into heat is usually done by adding a contact material in between the rotating wheels or to discs which is attached to the axles. The material which is added creates friction and converts the kinetic energy into heat. The speed is slow down and the train stops. For the braking the material used is pad or blocks. In the world's many trains are equipped with braking systems which use compressed air as the force for pushing the blocks on wheels. Such type of braking system known as "air brakes" or "pneumatic brakes". In these braking system the compressed air is transmitted along the train through a device known as a brake pipe. Different level of air pressure in the pipe causes a change in the magnitude of the brake on each vehicle. This can apply the brake, release it or hold it "on" after a partial application. This system is in limited use all over the world. There is alternative braking system to the air brake, known as the vacuum brake [VB], which was introduced around is measured as 30 inches of mercury, written as 30 Hg. Each 2 inches of vacuum therefore represents square about 1 lb. per inch of atmospheric pressure. In the UK, vacuum brakes operated with the brake pipe at 21 Hg, except on the Great Western Railway which operated at 25 Hg. In the brake pipe the vacuum is created and maintained by a motor-driven exhauster. The exhauster has two types of speeds, high speed and low speed. The high speed is switched in to create a vacuum and therefore release the brakes. The slow speed is used to keep the vacuum at the required level to maintain brake release. It maintains the vacuum for preventing small leaks in the brake pipe. The vacuum in the brake pipe is prevented from exceeding its nominated level (normally 21 Hg) by a relief valve, which opens at the setting and lets air into the brake pipe to prevent further increase. The momentum of a moving body increases with weight and speed of the body as these factors increase improvements in the brake become so important. The adhesion of the wheels and speed of the train are the main factors that determines the total retarding power. The maximum retarding force applied by the brake blocks at wheels depends upon the coefficient of friction between the wheels and the rail and the component of the weight of the wagon on the wheels. Mathematically the retarding force F can be expressed as $F = \mu * W$

Where μ = the coefficient of friction

W = component of weight of wagon on the wheels

If the coefficient of friction becomes equal to unity then the retarding force will be equal to the weight of the wagon. Also the deceleration equals the acceleration due to gravity. Then the braking efficiency is 100%. This is the theoretical limit for braking efficiency. Highly efficient brakes giving a large deceleration might injure the passengers due to sudden stopping of the train .More over this will cause the brake shoes to wear rapidly and there is always the risk of derailment. The braking efficiencies usually vary from 50% to 80%, which enables the train to stop safely within a reasonable distance. The equations used for the calculations of acceleration can also be used for calculating the braking distance except to the accelerating force becomes the braking force F_b

The brake force $F_b = p^* \eta * \mu$ Where p = brake shoe pressure

μ = co-efficient of fricton between brake shoe and wheel

η efficiency of braking

2. PARTS OF VACCUME BRAKING SYSTEM:

Driver's Brake Valve

The driver brake valve used to control & monitor the brakes. The brake valve will have the following positions: Release, Running, Lap and Brake On. There may also be a Neutral or Shut Down position, which locks the valve out of use. In the release position, the exhauster connects to the brake pipe and switches the exhauster to full speed. This causes rise in the vacuum in the brake pipe as fastly as possible to get a release.

Brake Cylinder

Every vehicles has atleast one cylinder but sometimes two or three cylinders are also there. Inside the cylinder piston is moves which operates the brakes through links called "rigging". The links which is known as rigging applies the blocks to the wheels. The piston in the brake cylinder moves with respect to the vacuum in the brake pipe. Loss of vacuum applies the brakes, whereas restoration of the vacuum releases the brakes.

Vacuum Reservoir

The operation of the vacuum brake depends on the difference in pressure between one side of the brake cylinder piston and the other. Vacuum reservoir is provided to ensure that there is always availability of source of vacuum for operates the brakes. Which is connected to upper side of piston. In the simplest type of the brake cylinder is integral with the vacuum reservoir. Some vehicles has the brake have a separate reservoir and a piped connection to the upper side of the piston.

Brake Block

Brake block is the friction material which is pressed against the piston of brake cylinder. The brake block made of cast iron or some composition material, brake blocks are the main source of wear in the brake system. This brake block require regular inspection to see that they work effectively or not.

Brake Rigging

Brake rigging is the system in which the movement of the piston in the brake cylinder transmits pressure to the brake blocks on each wheel. Rigging can rarely be complex, generally under a passenger car with two blocks to each wheel, making a total of sixteen. The careful adjustment is needed by rigging to ensure that all blocks should be operated from same cylinder which provides the even rate of application on each wheel. When we change one block, that time we have to check and adjust all the blocks on that same axle.

Exhauster

A two-speed rotary machine fitted to a train to deplete the atmospheric pressure from the brake pipe, reservoirs and brake cylinders to release the brakes. This is usually controlled from the driver's brake valve, in which switched in at full speed brake is release or at slow speed to maintain the vacuum at its release level while the train is running. Exhausters can be run directly from a diesel engine.

Brake Pipe

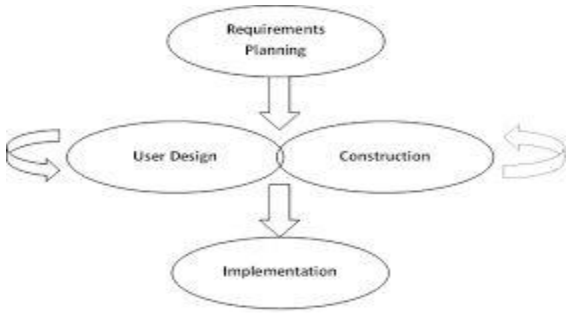
The vacuum-carrying pipe transmits the pressure difference required to control the brake throughout its length. By flexible hoses the brake pipes connected between the vehicles, which can be uncoupled to allow vehicles to be separated. The use of the vacuum system makes the brake safe and prevents from failing of brakes, i.e. the loss of vacuum in the brake pipe will cause the brake to apply.

Dummy Coupling

A dummy coupling point is provided at the ends of each vehicle to allow the ends of the brake pipe hoses to be sealed when the vehicle is uncoupled. The sealed dummy couplings avoids lost from the brake pipe.

3. METHODOLOGY

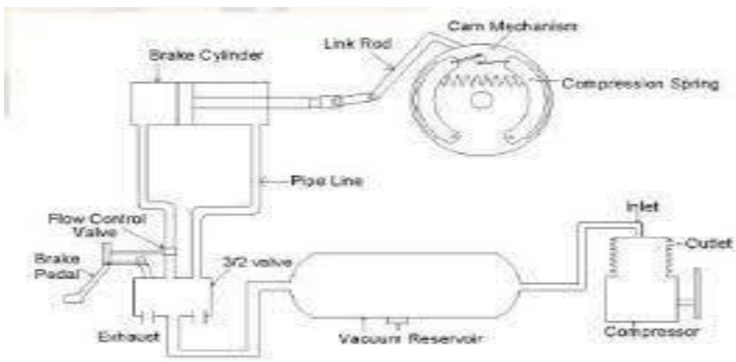
The methodology for the Vacuum Braking System as shown in below. The methodology is the systematic way to perform a specific task



(Flow diagram)

CONSTRUCTION OF VACUUM BRAKING SYSTEM

Vacuum braking system as shown in fig. consists of brake cylinder, compressor, vacuum reservoir, direction control valve, flow control valve, brake hoses, brake linkages, drum brake and foot brake pedal.



Vacuum breaking system

DESIGN OF COMPRESSION SPRING

Spring was designed using standard formulae as listed in the given table.

Table: Specification of spring parameter

Spring parameters	Values
Safe pressure(p)	0.2 N/mm^2
Spring index(C)	4
Wahl's stress factor, K_s	1.40325
Stress (${}_y$)	570 N/mm^2
Standard size of wire diameter(d)	9 mm
Mean coil diameter(D)	36 mm
Deflection(y)	20 mm
Stiffness(q)	164.4 N/mm
Number of active turns(n)	8
Total number of turns(N)	10
Solid length(L_s)	90 mm
Free length(L_f)	110 mm
Pitch(p)	12.22 mm

Compression spring

ADVANTAGES:

1. Simple in design.
2. Without any additional equipment ability to get partial release.
3. Greater amount of safety because the vacuum loss age results in the braking of the vehicle.
4. In case of rail wagons, highly reliable.
5. It permits the automatic application of brakes down the entire length of the train from the simple control in the driver's hand.

DISADVANTAGES:

1. On none ejector a vacuum pump is required.
2. Low pressure means relatively large brake cylinder are required which may be awkward to site.
3. Leaks can be difficult to find.
4. High initial cost.

4. CONCLUSION

The vacuum break was preferential to the air break in railroad applications largely because it was cheaper to install on a locomotive. Air break required a steam powered compressor bulky ,nosily and using a lot of power, while the vacuum ejector used to generate vacuum was much simpler in device.it has the advantage of being simple in design and have ability to get a partial release ,something the air could not do without additional equipment.

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