INTRODUCTION

A moving train contains energy, known as kinetic energy, which needs to be removed from the train in order to cause it to stop. The simplest way of doing this is to convert the energy into heat. The conversion is usually done by applying a contact material to the rotating wheels or to discs attached to the axles. The material creates friction and converts the kinetic energy into heat. The wheels slow down and eventually the train stops. The material used for braking is normally in the form of a block or pad.

The vast majority of the world's trains are equipped with braking systems which use compressed air as the force used to push blocks on to wheels or pads on to discs. These systems are known as "air brakes" or "pneumatic brakes". The compressed air is transmitted along the train through a "brake pipe". Changing the level of air pressure in the pipe causes a change in the state of the brake on each vehicle. It can apply the brake, release it or hold it "on" after a partial application. The system is in widespread use throughout the world.

An alternative to the air brake, known as the vacuum brake, was introduced around the early 1870s, the same time as the air brake. Like the air brake, the vacuum brake system is controlled through a 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. With a full vacuum, the brake is released. With no vacuum, i.e. normal atmospheric pressure in the brake pipe, the brake is fully applied.

The pressure in the atmosphere is defined as 1 bar or about 14.5 lbs. per square inch. Reducing atmospheric pressure to 0 lbs. per square inch, creates a near perfect vacuum which is measured as 30 inches of mercury, written as 30 Hg. Each 2 inches of vacuum therefore represents about 1 lb. per square 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. The vacuum in the brake pipe is created and maintained by a motor-driven exhauster. The exhauster has two speeds, high speed and low speed. The high speed is switched in to create a vacuum and thus release the brakes. The slow speed is used to keep the vacuum at the required level to maintain brake release. It maintains the vacuum against 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

\[ F = \mu \times W \]

Where \( \mu \) = 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. Moreover 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 with in 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 \( F_b = p \times ? \times \eta \)

Where \( p \) = brake shoe pressure

\(?\) = co-efficient of friction between brake shoe and wheel

\( \eta \) = efficiency of braking

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