Material Optimization of Train Brake Pads

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Abstract

A moving train contains 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 majority of the world's trains are equipped with braking systems which use compressed air as the force to push blocks on to wheels or pads on to discs. These systems are known as "air brakes" or "pneumatic brakes". The existing air brake system of Railway coach has the following drawbacks due to excessive brake force on the brake blocks - thermal cracks on wheel tread, brake binding and reduced life of brake block. The aim of the project is to overcome the above said drawbacks by reducing the effective brake force on the brake blocks without affecting the existing designed (Braking Function) requirements. To validate the strength of train brake, Structural and Modal analysis are to be done on the train brake. In structural analysis, ultimate stress limit for the design is found and in modal analysis, mode shapes of the train brake for number of modes can be analyzed. The analysis is done by applying different materials Cast Iron and High Carbon Steel for train brake.

Keywords: Stress analysis, model analysis, train brake, cast iron, high carbon steel

1. INTRODUCTION

The majority of the world's trains are equipped with braking systems which use compressed air as the force 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. In the air brake's simplest form, called the straight air system, compressed air pushes on a piston in a cylinder. The piston is connected through mechanical linkage to brake shoes that can rub on the train wheels, using the resulting friction to slow the train. The mechanical linkage can become quite elaborate, as it evenly distributes force from one pressurized air cylinder to 8 or 12 wheels. The pressurized air comes from an air compressor in the locomotive and is sent from car to car by a train line made up of pipes beneath each car and hoses between cars. The principal problem with the straight air braking system is that any separation between hoses and pipes causes loss of air pressure and hence the loss of the force applying the brakes. This deficiency could easily cause a runaway train. Straight air brakes are still used on locomotives, although as a dual circuit system, usually with each bogie (truck) having its own circuit. In order to design a system without the shortcomings of the straight air system, Westinghouse invented a system wherein each piece of railroad rolling stock was equipped with reservoir and a triple valve, also known as a control valve.

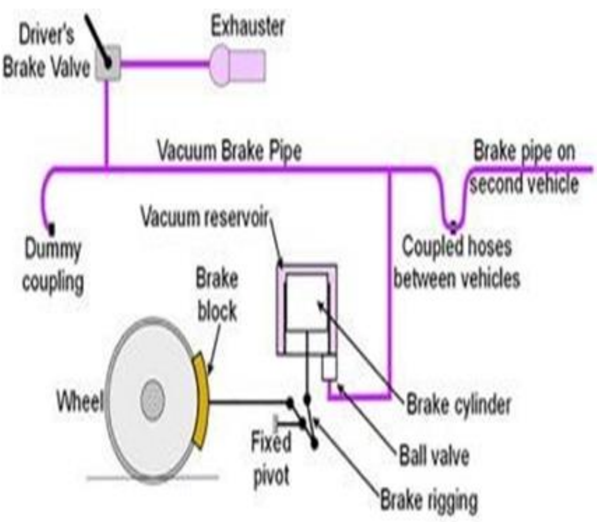

Fig 1 Pneumatic Braking System

2. MATERIAL PROPERTIES

3. Cast Iron :

It is an alloy of iron and carbon. The properties of cast iron which makes it a valuable material like low cost, good casting characteristics, high compressive strength.

4. Low Carbon Steel :

It has low ratio carbon to iron and has less than or up to 0.30% of carbon. It is low cost and effectiveness for other applications.

5. High Carbon Steel :

It has highest ratio of carbon to iron. It consists of more than 0.60% to 2.00% carbon. It is therefore stronger and harder but less ductile compared to low carbon steel. It is resistance to wear and moderate ductility, a measure of a materials ability to tolerate being deformed.

Material Properties	High carbon steel	Low carbon steel	Cast iron
Density (kg/m^3)	7870	7850	7200
Modulus of elasticity (M Pa)	210000	205000	110000
Poisson ratio	0.3	0.29	0.28
Yield strength (M Pa)	490	370	320

Table 1.1 : Material properties of High Carbon steel, Low Carbon steel, Cast Iron,

The properties of High Carbon steel, Low Carbon steel, Cast Iron are shown in table 1.1.

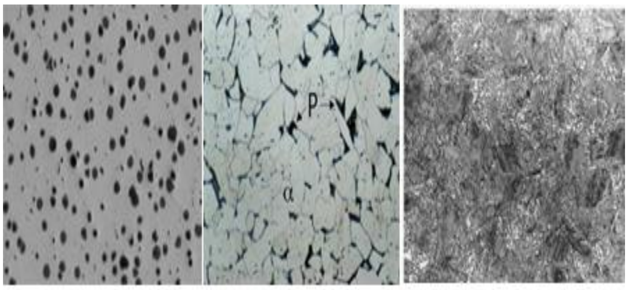

Fig 2 Micro Structure of Cast iron, Low carbon and High carbon steels

The micro Structures of Cast iron, Low carbon and High carbon steels are shown in Fig. 1.10.

3. OBJECTIVES

A modification is made in this project work to overcome the above said troubles by reducing the minimum effective brake force on the brake blocks without affecting- the existing designed(braking function) requirements The suggested modification is to change the horizontal leverage ratio in the horizontal lever. The horizontal lever transfers braking force from brake cylinder to the brake rigging arrangement of Air brake system. By changing the horizontal leverage ratio, the mechanical advantage of the brake system can be reduced which in turn reduces the minimum effective brake force on the brake blocks. The procedure of implementation of modification and brake force calculation are discussed in this research Air Brake System.

4. METHODOLOGY

- By considering the train brake pads, 3D brake pad is modelling using CATIA V5 software.
- After modelling is done, the file is extracted into ANSYS 15.0, subsequent material is added to the component and structural and model analysis is performed.
- Then we can analyse the internal stresses, dynamic characteristic (damping) and displacement that occurred during the working conditions.
- After computing the material with suitable analysis, we can consider the optimum material
- (as it is efficient to work in working conditions).

5. EXPERIENTIAL RESULTS

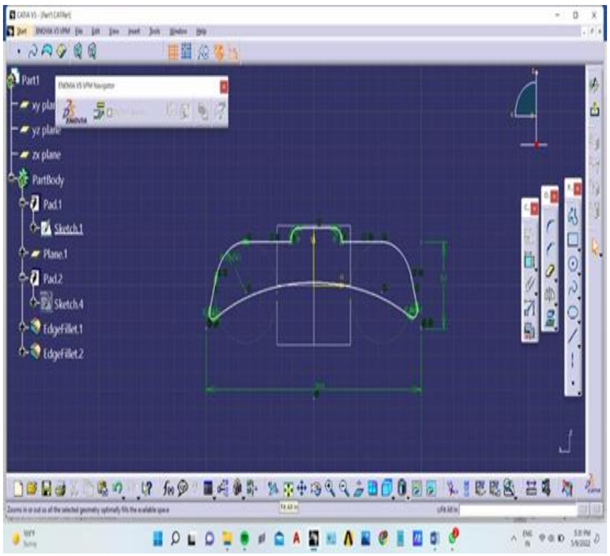

Fig 3 Base frame of CATIA V5

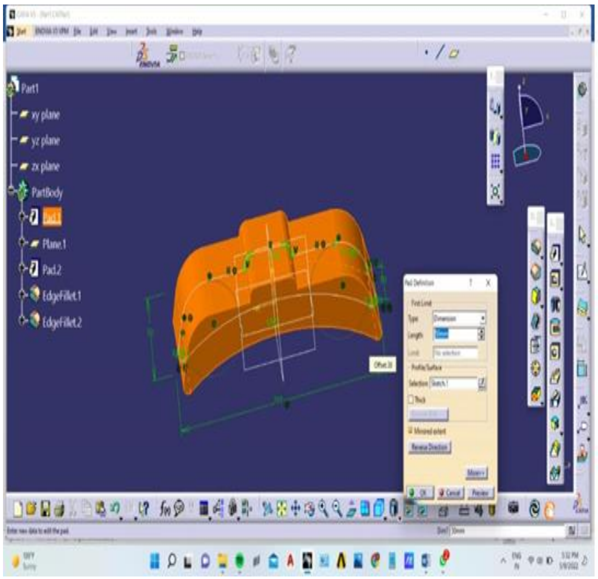

Fig 4 Modelling and creating the object

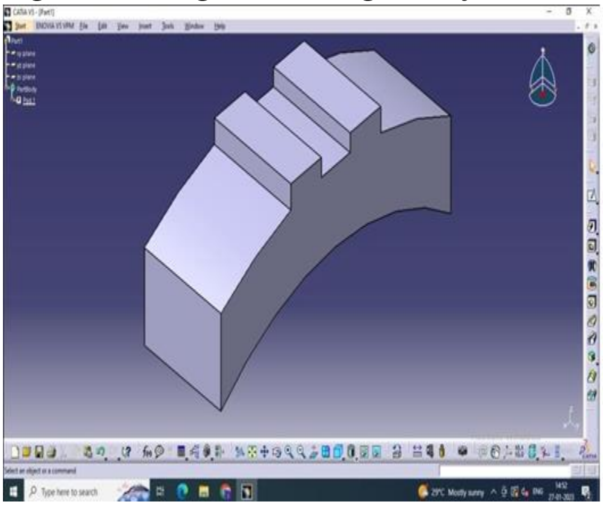

Fig 5 Part module

6. FLOW DIAGRAM

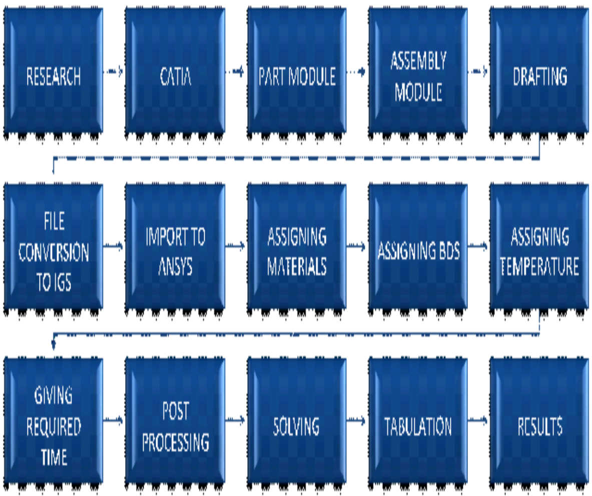

Fig. 6 Flow Diagram of ANSYS

7. EXPERIMENTATION

- The total deformation. Equivalent stress and Equivalent strain are the output parameters and the outputs obtained by using ANSYS workbench software.
- The models of brake pads first designed and constructed by using CATIA V5 software.
- Modal analysis and sketcher module I done using CATIA V5 software.

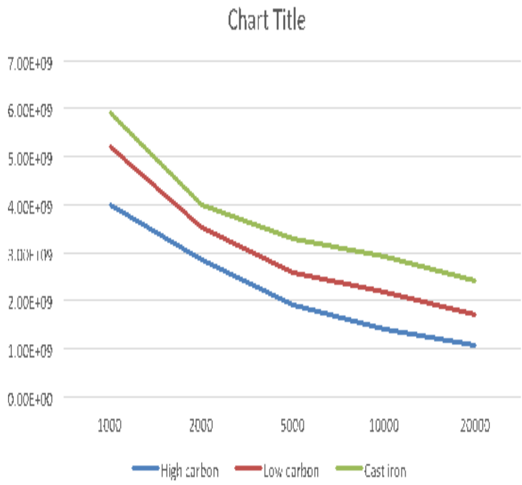

Fig. 7 Alternate stress vs No. of cycles

8. RESULTS AND DISCUSSION

Result 1: DEFORMATION

- The following image shows the total deformation on brake block using static structural steel.
- The maximum deformation obtained is 1.3306e-7 and the minimum deformation is 0

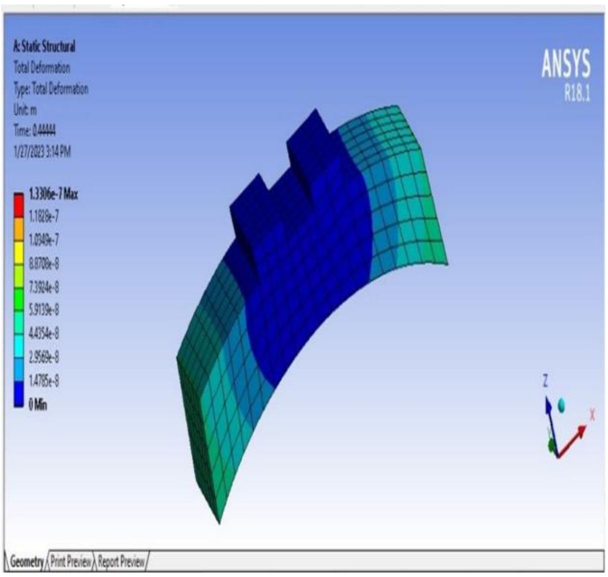

Fig 8 Total deformation on train brake block

Result 2: EQUIVALENT STRESS

- The following image shows the equivalent (von misses) stress on brake block using static structural steel.
- The maximum stress obtained is 1.0605e6 and the minimum stress is 2140.7.

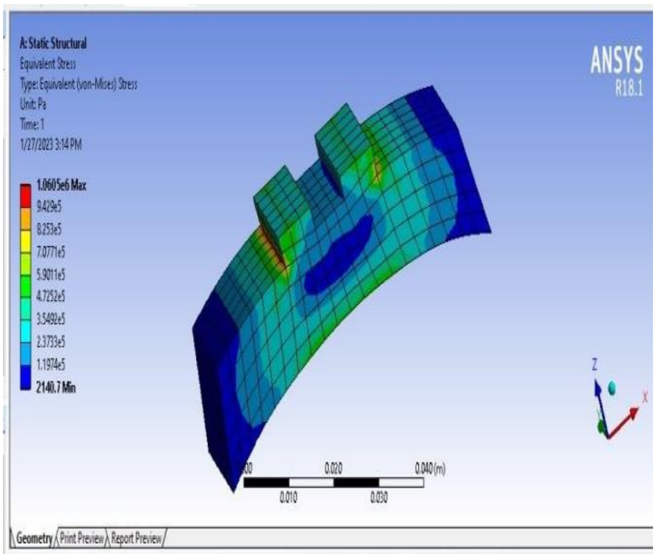

Fig 9 Equivalent stress on brake block

Result 3: EQUIVALENT STRAIN

- The following image shows the equivalent strain using static structural steel.
- The maximum strain is obtained 3.994e-6 and the minimum strain obtained is 1.7398e-6.

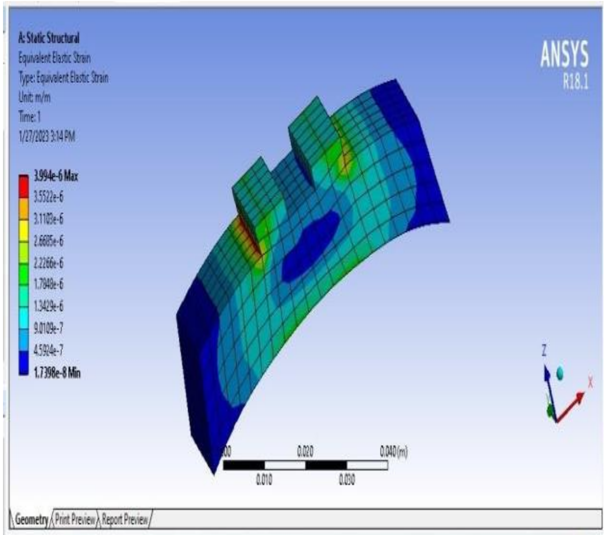

Fig 10 Equivalent strain on brake block

9. CONCLUSION

According to the results it has been concluded that among the three materials of cast iron, low carbon steel and high carbon steel, high carbon steel have low stress when compared with Cast Iron and low carbon Steel and also less deformation than cast iron & low carbon steel material, Hence it is better than cast iron &low carbon steel materials the design is safe and stresses are with in the ultimate strength of the material. With the application of modified minimum brake force, the brake block is safe. Hence the modification carried out in this project work is justified.

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