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Static and Thermal Analysis of Train Brake Pad and By Using Fem

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ABSTRACT:

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 to push blocks on two 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. The modeling is done using CATIA and analysis is done using ANSYS. CATIA is a 3d modeling software widely used in the design process. CATIA is used by the automotive and aerospace industries for automobile and aircraft product and tooling design.ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements.

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. Imagine a vehicle that is a mile in length. It is so long that the front of the vehicle might be climbing a grade while the back is descending, or perhaps the front and back are turning left while the middle is turning right.

This same vehicle is more than 300 times as long as it is wide. Next, imagine that it weighs more than 8 million pounds (3,700,000kg) or 4000 tons. Onboard the vehicle are televisions, foodstuffs and hazardous material. Now visualize the vehicle is traveling at 70 MPH and the operator wants to stop. This is a complex and challenging problem, but a situation that occurs thousands of times every day. The vehicle of course is a typical freight train. This short paper will introduce the reader to the principles of how train brakes accomplish this remarkable task.

Each power unit (locomotive) has an air compressor that supplies air for the entire train’s braking system. The brake pipe carries the compressed air from the control unit to the rest of the train. Unlike truck brakes (and passenger train brakes for that matter) this single source of air carries both the air that powers the brakes as well as the signal control them.

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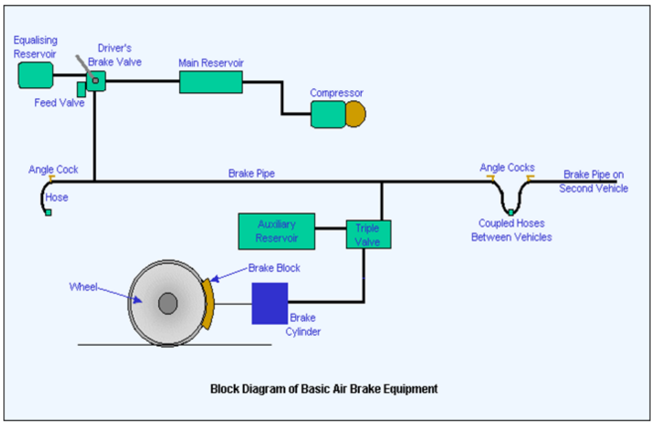
INTRODUCTION TO BRAKES:

A brake is a device that decelerates a moving object such as a machine or vehicle by converting its kinetic energy into another form of energy, or a device which prevents an object from accelerating. Most commonly brakes use friction convert kinetic energy into heat, but in regenerative braking much of the energy is converted instead into useful electrical energy or potential energy in a form such as pressurized air, oil, or a rotation flywheel.

Air Brake System:

The vast majority of the world's trains are equipped with braking systems which use compressed air as the force to push blocks onto 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.



Block Diagram of Basic Air Brake Equipment

DESIGN OF TRAIN BRAKE:

Fast expanding industrialization of country needs fast movement of higher freight and passenger. Railway traffic coupled with safety of men and material. Air brake system plays an important role in running of trains.The existing air brake system of Railway coach has the following draw backs due to excessive brake force on the brake blocks.

- Thermal Cracks on wheel tread.
- Brake binding.
- Reduce life of brake blocks.

MODIFICATION TO THE EXISTING SYSTEM

In the existing horizontal lever and bottom fulcrum bracket plate, the modifications are to be carried out.

- The bottom fulcrum bracket plate and horizontal lever assembly is to be removed from brake rigging mounted under the coach.
- The horizontal lever is to be rotated by 180 degrees so that the existing SAB
(Slack adjusting barrel) and hole will become brake cylinder end hole and the brake cylinder end hole become sab end hole for modification lever.
- The existing bottom fulcrum bracket pivot hole on the lever is to be closed suitably.
- A new hole of 55 mm diameter is to be drilled in horizontal lever at the distance of 328 mm from the centre of the sab end hole. Before drilling

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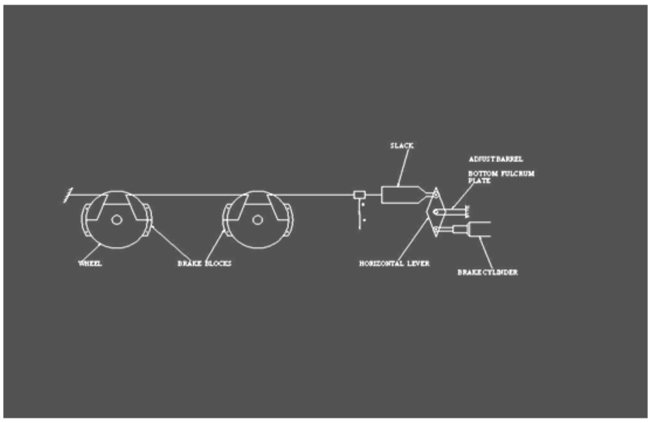
55mm diameter hole, a12mm diameter pilot hole is to be drilled.

- From the centre line of the newly provided hole (i.e. 55 mm diameter hole) a hole of 10 mm diameter is to be drilled in the horizontal lever at a distance of 150 mm to avoid the relative movement of horizontal levers so that both will act as one unit
- Nylon bushes of suitable size are to be provided in the newly drilled holes to avoid metal contact, thereby reducing wear and tear, friction and for noise control
- The modification lever assembly is to be assembled on the under frame.



BRAKE RIGGING ARRANGEMENT

Before modification, X = 420 mm, Y = 280 mm

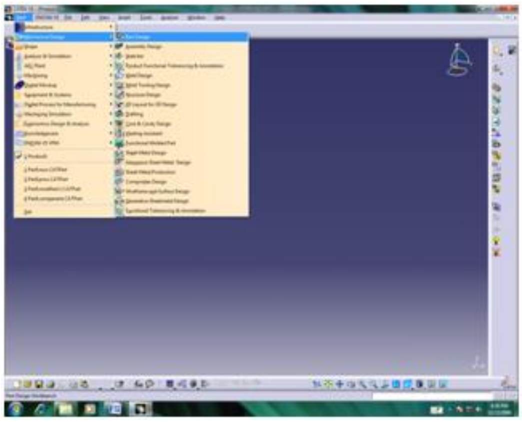
Total 700 mm

After modification, X = 372 mm, Y = 328 mm

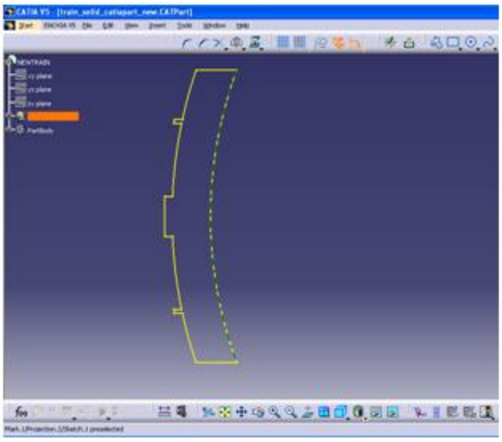
Total 700 mm

CATIA

There are different modules in CATIA using which different tasks can be performed. The main window and modules of CATIA shown in figure:



Sketch of the Model:



OPTIONS USED TO CREATE SOLIDS

Pad - Pad is a method of defining three-dimensional geometry by projecting a two-dimensional section at a specified distance normal to the sketching plane.

Pocket - Pocket is a method of extruding a profile or a surface and removing the material resulting from the extrusion

Shaft - The Shaft tool creates a feature by revolving a sketched section around a centerline.

Fillet - A fillet is a curved face of a constant or variable radius that is tangent to, and that joins, two surfaces. Together, these three surfaces form either an inside corner or an outside corner.

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Chamfer - Chamfering consists in removing or adding a flat section from a selected edge to create a beveled surface between the two original faces common to that edge.

Draft - Drafts are defined on molded parts to make them easier to remove from molds.

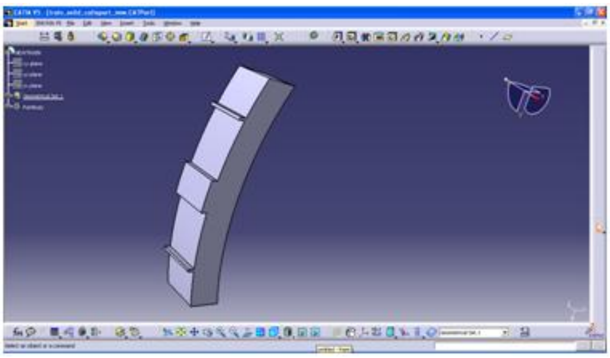
Thickness – Adds or removes to the faces.

Translation – Moving a body.

Mirror - Mirroring a body or a list of features consists in duplicating these elements using symmetry by selecting a face or plane as reference.

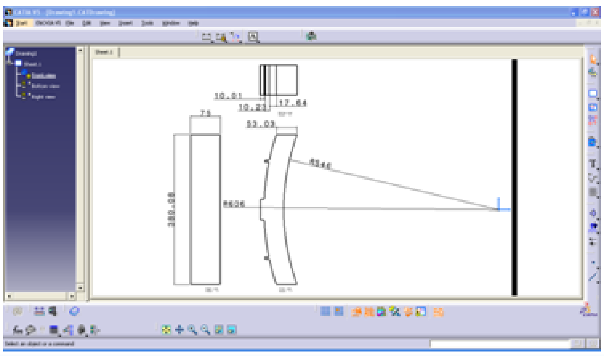
Pattern - To duplicate the whole geometry of one or more features and to position this geometry on a part.

4.4 Model of the Train Brake



GENERATIVE DRAFTING

VIEWS OF THE Train Brake



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STRUCTURAL ANALYSIS OF TRAIN BRAKE

- **Material Data**
  - AISI 1018 mild(Low carbon steel)

FIGURE 2 Model (A4) > Static Structural (A5) > Pressure > Figure

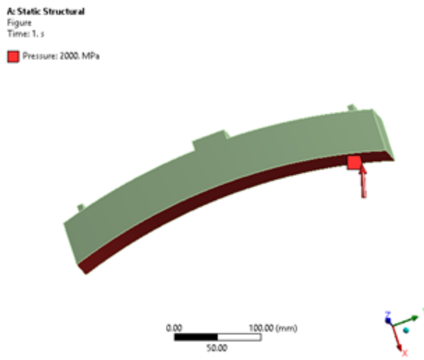

FIGURE 4 Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation > Figure

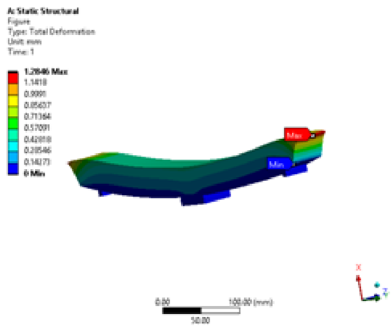

FIGURE 5 Model (A4) > Static Structural (A5) > Solution (A6) > Maximum Principal Elastic Strain > Figure

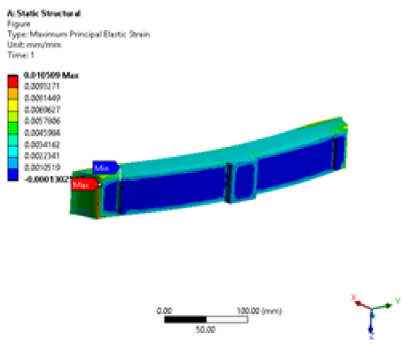

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FIGURE 6 Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress > Figure

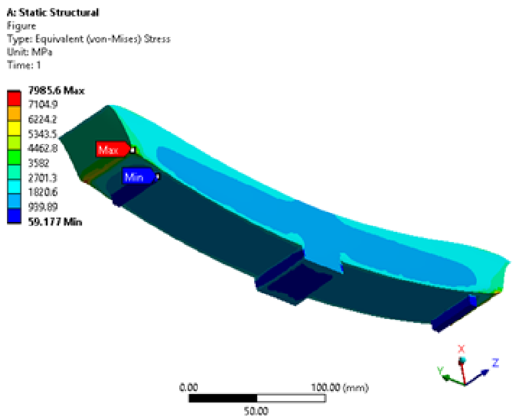
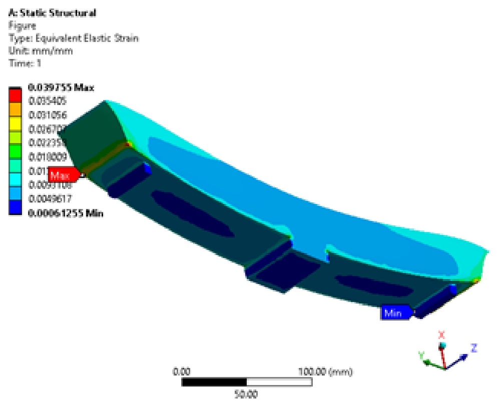


FIGURE 7 Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Elastic Strain > Figure



- **Model (B4)**
  - Geometry
    - Part 1
  - Coordinate Systems
  - Mesh
    - Patch Conforming Method
  - **Steady-State Thermal (B5)**
    - Initial Temperature
    - Analysis Settings
    - Loads
    - Solution (B6)
    - Solution Information
    - Results

- **Material Data**
  - AISI 1018 mild(Low carbon steel)

FIGURE 3 Model (B4) > Steady-State Thermal (B5) > Solution (B6) > Temperature > Figure

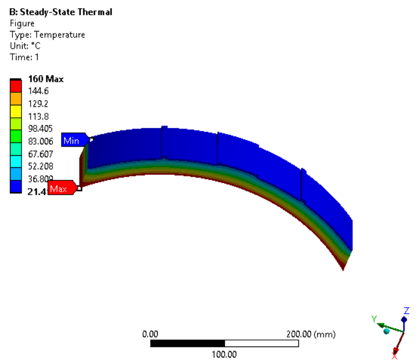


FIGURE 4 Model (B4) > Steady-State Thermal (B5) > Solution (B6) > Total Heat Flux > Figure

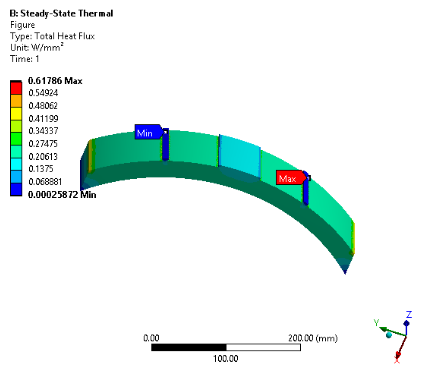
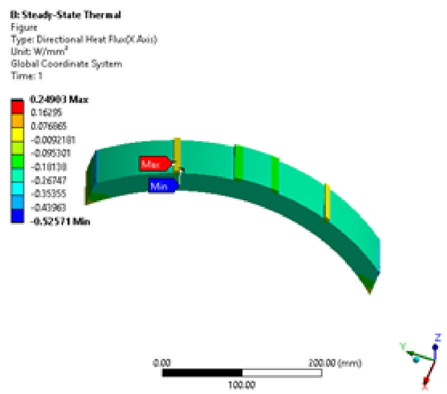


FIGURE 5 Model (B4) > Steady-State Thermal (B5) > Solution (B6) > Directional Heat Flux > Figure



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Static Structural

1	TOTAL DEFORMATION	1.2846
2	MAX PRINCIPAL ELASTIC STRAIN	0.010509
3	VON-MISES STRESS	7985.6

THERMAL

1	Temperature	160
2	Total heat flux	0.61786
3	Directional heat flux	0.24903

CONCLUSION:

- According to the existing air brake system of Railway coach the brake force applied per one brake block is 2.187 ton.
- The following drawbacks due to existing brake force on the brake blocks - thermal cracks on wheel tread, brake binding and reduced life of brake block.
- A modification is done in the project to overcome the above said troubles by reducing the minimum effective brake force without affecting the existing designed requirements.
- After modification, the brake force applied per one brake block is 1.653 ton.
- The maximum compressive stress induced in the brake block by the application of modified brake force (1.653 ton) is 19.9Mpa which is less as compared with stress induced in the brake block by the existing brake force (2.187 ton) is 26.4Mpa.
- 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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