FEM Analysis on Locomotive Train Brake for Improved Efficiency by using CATIA and ANSYS-Workbench

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Abstract: *- The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc (or rotor), usually made of cast iron or ceramic composites (including carbon, Kevlar and silica), is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads (mounted on a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert friction to heat, but if the brakes get too hot, they will cease to work because they cannot dissipate enough heat. This condition of failure is known as brake fade. Train brakes are exposed to large thermal stresses during routine braking and extraordinary thermal stresses during hard braking. The aim of the project is to model a Train brake used in Locomotives. Structural, and Thermal Analysis is done on the Train brake. By varying composite materials such as Cast Iron, Carbon steel and Aluminium Metal Matric Composite. Modeling is done in CATIA and analysis is done in Ansys-Workbench.*

Keywords: *ANSYS-WORKBENCH, Cast Iron, Carbon steel& Locomotive Trainbrake*

1. INTRODUCTION

A Brake is a mechanical device which inhibits motion, slowing or stopping a moving object or preventing its motion. Most commonly brakes use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed.

2. PRINCIPLES OF BRAKING SYSTEM

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Different types of shoe brakes and their operating principles
Design procedure of different shoe brakes

2.1 Types of Brakes

Brakes are devices that dissipate kinetic energy of the moving parts of a machine. In mechanical brakes the dissipation is achieved through sliding friction between a stationary object and a rotating part. Depending upon the direction of application of braking force, the mechanical brakes are primarily of three types

- Shoe or block brakes – braking force applied radially
- Band brakes – braking force applied tangentially.
- Disc brake – braking force applied axially.

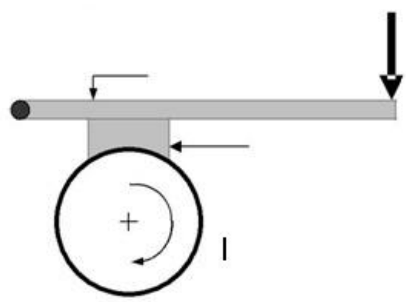


Figure 1 Single Shoe Brake

3. LITERATURE REVIEW

- . Dr. D.S. Deshmukh & Jha Shankar Madanmohan [1], "Design Evaluation and Material Optimization of a Train Brake " stated that, 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 vast 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".
- Vempada Vasudeva Rao & P. Jagan Mohan Rao [2] "Design, Static Analysis and Comparison of Materials on Train Brake Pad" Stated that ,Train is one of the major transportation which makes the things easier at low cost. This train moves by fossil fuel and the consumption of the fuel is depends up on the engine performance and braking system, as the kinetic energy of the train is to be reduced by breaking and electric system. This kinetic energy is to be converted into heat by contact material to the rotating wheels or discs which are attached to the axels.
- Ramana Chary & MD Ezaz Kha [3] "Design and analysis of train brake system" Stated that ,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.

4. COMPUTATIONAL DESIGN

4.1 Calculations

Table 1. Result for Dynamic Analysis

S.NO	Paramaters	Ranges
1	Unit Pressure	750 KN/m^2
2	Maximum rubbing speed	44 m/sec
3	Maximum temperature	350°C
4	film co-efficient	0.5807w/mm^2°C
5	Maximum axle load (Tonne)	25
6	No. of wheels per wagon	08
7	Wheel dia (mm) New Condemning	1000 mm
8	No. of brake block per wheel	01
9	Brake block force (Kg) / block	2370
10	Max. speed (kmph)	100
11	Type of brake system	Air Brake

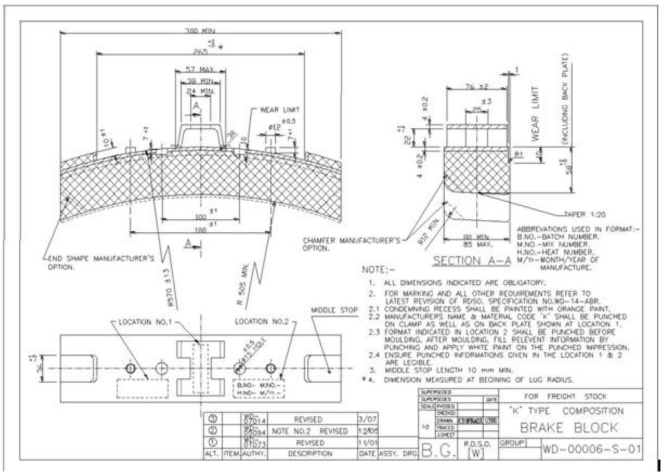


Figure 2 Production Drawing for Locomotive Shoe Brake.

4.2 Modelling of a Propeller:

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.

GROOVE-The groove tool cuts a feature by revolving a sketched section around center line.

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.

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.

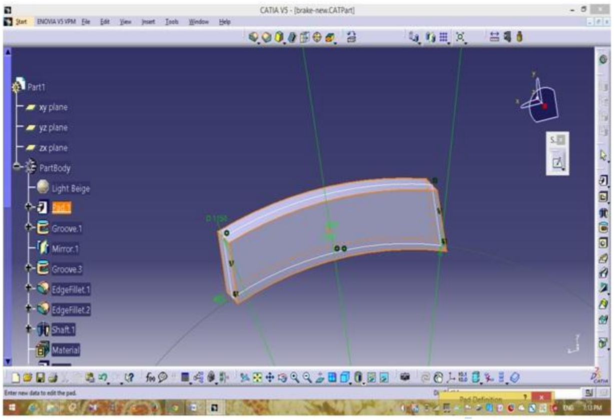


Figure 3 CATIA model of *Locomotive Train Brake.*

4.3 Fundamentals of FEA:

Finite Element Analysis is performed on Train Brake is to find the Internal stresses which are generated with in a Train brake. Finite Element Methods is the back up for FEA.

4.4 Meshing of Propeller Blade:

The solid model is transfer to the ANSYS WORK BENCH software. With the required commanding the mesh is generated for the model. Generally there two types of meshes are there they are Tetrahedral mesh

(i) Hexahedral mesh

The tetrahedral mesh is a polygon consists of four triangular faces three of them are meet at a point called as vertex. It has 6 edges and 4 vertices. In case of hexahedral mesh it has 12 edges and 8 vertices. For the accuracy of the solution hexahedral gives the exact result. In the ANSYS software the internal command setting can be available for mesh generation.

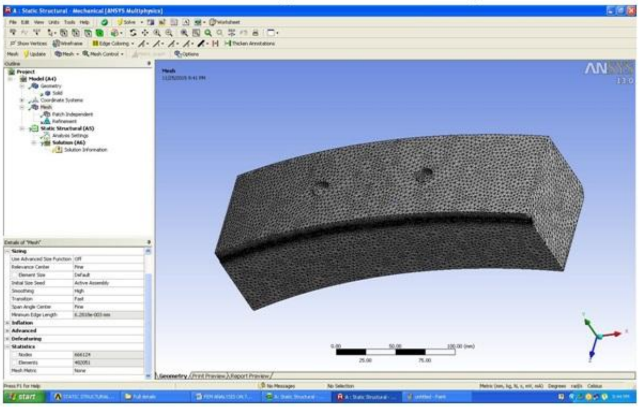


Figure 4 Fine meshed model of Train brake with nodes: 666124 numbers.

4.5 FEM Analysis of Propeller Blade:

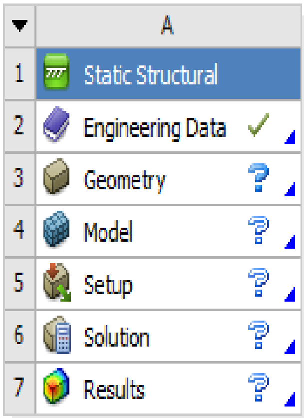


Figure 5 *Step by step procedure of Train Brake Analysis in ANSYS.*

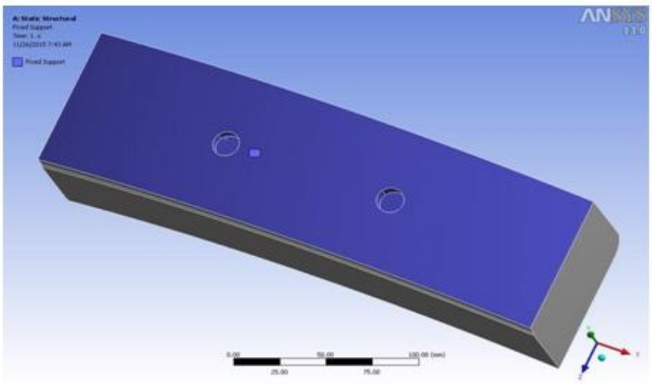


Figure 6 Boundary conditions applied to the marine propeller blade in ANSYS.

Applied Pressure:0.75Mpa.

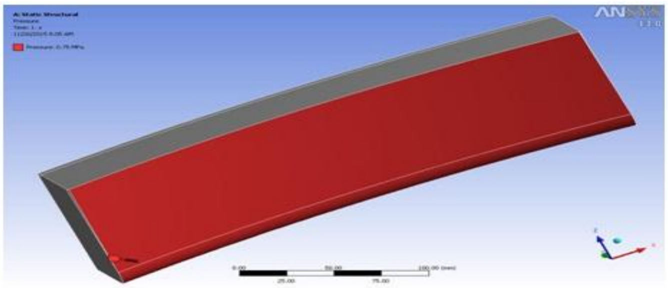


Figure 7 *Loads are applied to the Locomotive Train Brake in ANSYS*

4.6 Structural Analysis:

Structural Analysis is performed on Train Brake to find its Strength.Vonmises-stress (Equivalent stress) is very important stress in design this stress tells us wether the design is safe or not.If the vonmises stress is with in the Ultimate strength of the material then the design is safe.

4.6.1 CAST IRON Material Properties

Young's Modulus : 1.29e5MPa

Poisson's Ratio : 0.29

Density : 6800 kg/m^3

Thermal conductivity: 56000 W/m ^{0}C

Thermal expansion: 1.06e-0051/^{0}C

Specific heat: 0.46 J/kg ^{0}C

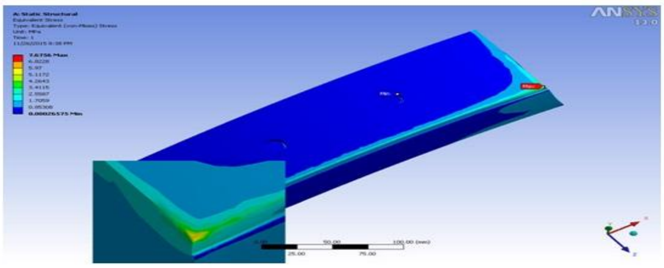


Figure 8 Vonmises-Stress distribution of CAST IRON Locomotive Train Brake in ANSYS

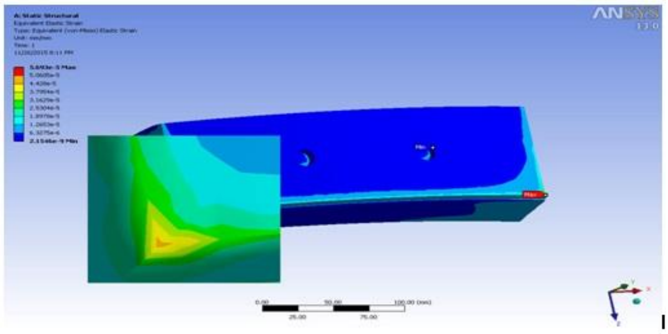


Figure 9 Vonmises-Stain distribution of Cast Iron Locomotive Train Brake in ANSYS.

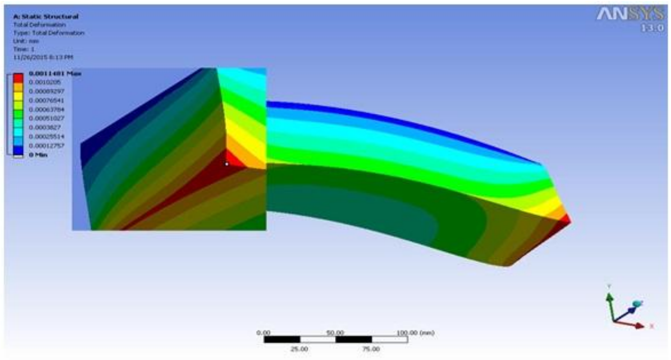


Figure 10 Total deformation of Cast Iron Train Brake in ANSYS.

4.6.2Carbon steel Material Properties

Young's Modulus : 2.0e+05 MPa

Poisson's Ratio : 0.295

Density : 7872 kg/m^3

Thermal conductivity: 54000 W/m ^{0}C

Thermal expansion: 1.17e-005 1/^{0}C

Specific heat: 0.49 J/kg ^{0}C

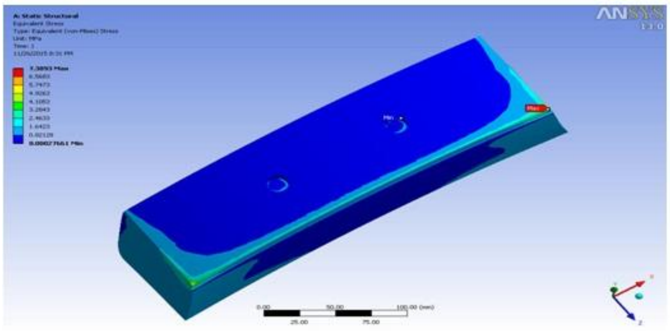


Figure 11 Vonmises-Stress distribution of Carbon steel Locomotive Train Brake in ANSYS.

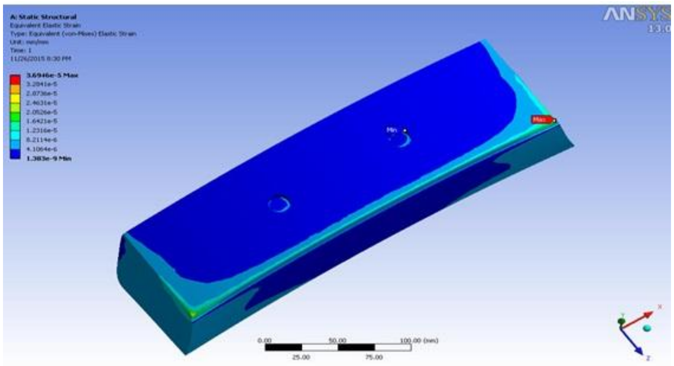


Figure 12 Vonmises-Strain distribution of Carbon steel Train Brake in ANSYS.

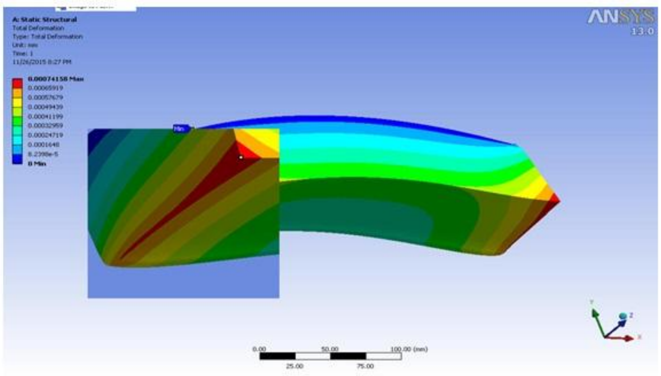


Figure 13 Total deformation over Carbon steel blade in ANSYS.

4.6.3 ALMMC Material Properties

Young's Modulus : 690e5 Mpa

Poisson's Ratio : 0.333

Density : 2765 kg/m3

Thermal conductivity: 49590 W/m 0C

Thermal expansion: 4.7775e-3/°C

Specific heat: 228446.4°C

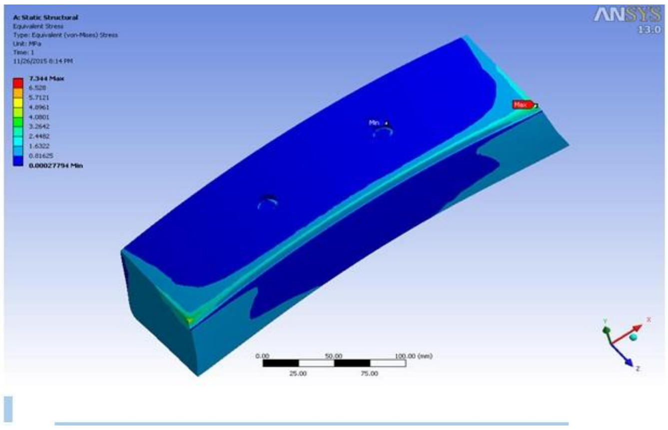


Figure 14 Vonmises-Stress distribution of ALMMC Locomotive Train Brake in ANSYS.

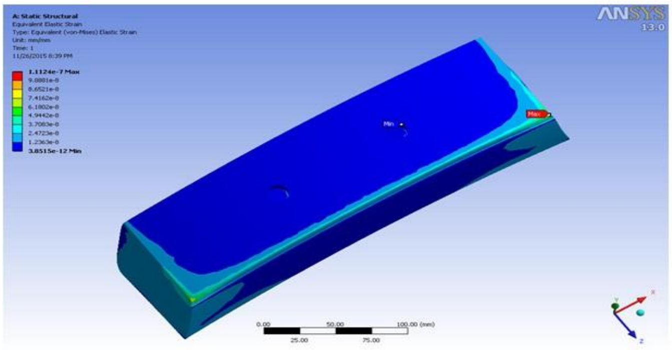


Figure 15 Vonmises-Strain distribution of Carbon steel Train Brake in ANSYS.

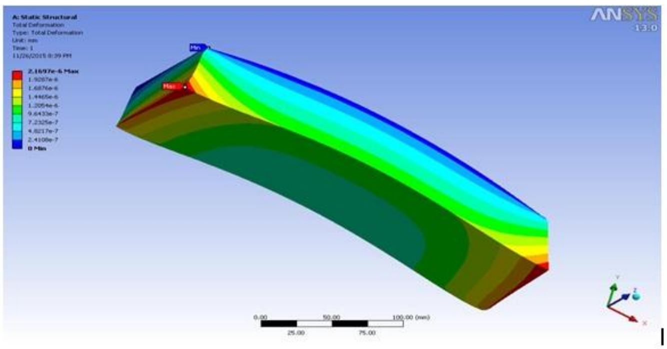
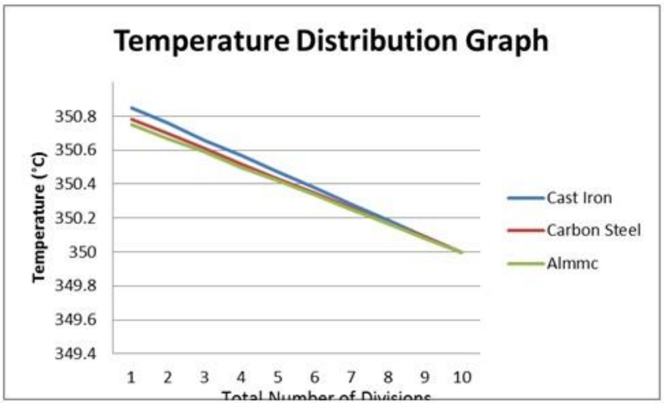


Figure 16 Total deformation over Carbon steel blade in ANSYS

4.7 Thermal Analysis:

Thermal Analysis is performed to find the Temperature distribution and Heat flux over the Surface of Train Brake. Thermal analysis is a measurement and interpretation of the relationship between the physical/chemical properties of sample and temperature. Temperature of sample is controlled in a predetermined way-either by continuously increasing or decreasing the temperature at constant rate (linear heating or cooling) or by carrying out a series of determinations at different temperatures (Isothermal measurements).

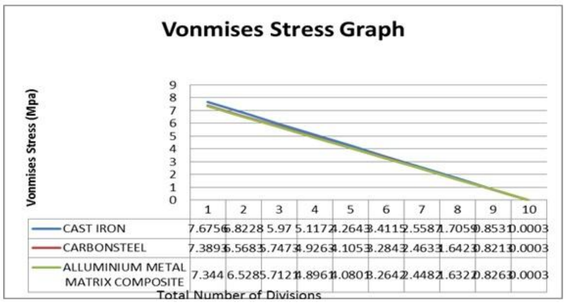


Graph 1 Temperature distribution over the surface of Train brake.

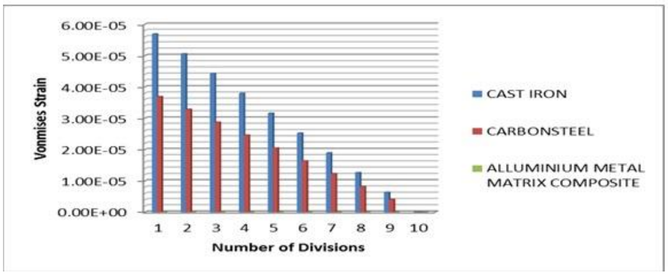
Results & Discussions:

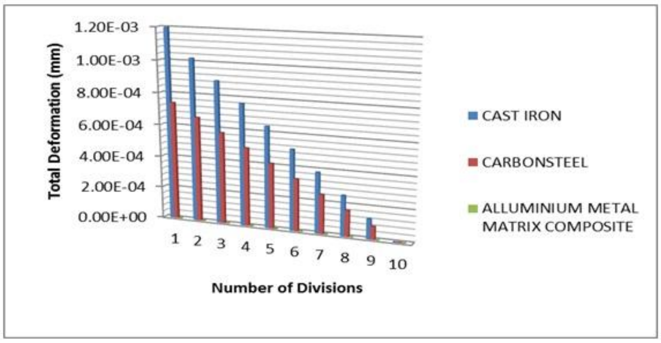
Table 1. Result for Dynamic Analysis

S.NO	Material	Vonmises-Stress (MPA)	Vonmises-Strain	Total Deformation (mm)	Temperature Distribution (°C)	Heat flux (w/mm²)
1	CAST IRON	7.6756	5.693e-5	0.0011481	350.85	2.5969
2	CARBON STEEL	7.3893	3.6946e-5	0.00074158	350.78	2.5969
3	ALMMC	7.344	1.1124e-7	2.1697e-6	350.75	2.5969



Graph 2 Vonmises Stress distribution over the surface of Train brake.





Graph 4 Total deformation distribution over the surface of Train brake.

5. CONCLUSION

FEM Analysis on Train brake is done. According to the results tabulated it has been concluded that among the Three materials of cast iron,carbon steel and ALMMC. ALMMC have low stress when compared with CastIron and Steel(7.344<7.3893<7.6756) and also less deformation than castiron & carbon steel material, Hence ALMMC is better than castiron & carbon steel materials the design is safe and vonmises stresses are with in the ultimate strength of tht material. By conducting Transient thermal Analysis Temperaure distribution and of ALMMC (350.75) is less when compared to Castiron(350.85) and Carbonsteel (350.78). In this work we suggested that by varying the train brake material to Aluminium Metal Matrix Composite the stresses induced are reduced and creep due to temperature is also reduced.Hence by this work we suggested that ALMMC is best suited composite material for train brake it increases the life period.

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