ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Design and Analysis of Train Brake

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ABSTRACT:

Brakes are used on the cars of railway trains to enable deceleration, control acceleration (downhill) or to keep them standing when parked. While the basic principle is familiar from road vehicle usage, operational features are more complex because of the need to control multiple linked carriages and to be effective on vehicles left without a prime mover. Clasp brakes are one type of brakes historically used on trains. The present work is directed towards the modeling of Train brake pad in 3D CAD software called SOLIDWORKS. According to the existing air brake system of Railway coach the brake force applied per one brake block is 2, 2.5 & 3TON. The drawbacks due to existing brake force on the brake blocks are thermal cracks on wheel tread, brake binding and reduced life of brake block. Analysis is done in Solidworks simulation. By comparing the results for three materials before optimization, stress obtained is less for Titanium alloy when compared with Structural steel and grey cast iron. But structural steel has yielded less deformation compared to other materials. Therefore, from the present research it can be concluded that using Titanium alloy is best for train brake.

I. INTRODUCTION:

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction.

Most brakes commonly 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. For example, braking converts much of the energy to electrical energy, which may be stored for later use. Other methods convert energy into potential energy in such stored forms as pressurized air or pressurized oil. Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel. 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 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. Since kinetic energy increases quadratically with velocity ($K = mv^2/2$), an object moving at 10 m/s has 100 times as much energy as one of the same mass moving at 1 m/s, and consequently the theoretical braking distance, when braking at the traction limit, is 100 times as long. In practice, fast vehicles usually have significant air drag, and energy lost to air drag rises quickly with speed. Almost all wheeled vehicles have a brake of some sort. Even baggage carts and shopping carts may have them for use on a moving ramp.

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Most fixed-wing aircraft are fitted with wheel brakes on the undercarriage. Some aircraft also feature air brakes designed to reduce their speed in flight. Notable examples include gliders and some World War II-era aircraft, primarily some fighter aircraft and many dive bombers of the era. These allow the aircraft to maintain a safe speed in a steep descent. The Saab B 17 dive bomber and Vought F4U Corsair fighter used the deployed undercarriage as an air brake. Friction brakes on automobiles store beaking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake.

II. LITERATURE REVIEW

DAMPING OF POWER SWINGS BY CONTROL OF BRAKING RESISTORS[2001]

Abstract: In this paper an analysis of the stability enhancement and improved damping of power swings in a multi-machine power system by means of thyristor-controlled braking resistor installed in the network has been presented. The control law has been derived using direct Lyapunov method and non-linear multi-machine system model. It is optimal in the sense that it causes the quickest dissipation of the power system energy released by a disturbance. Simple implementation of this control using only locally available signal has been also demonstrated. A computer simulation of a multi-machine power system model has verified the effectiveness of the proposed algorithm

IMPROVEMENT OF POWER SYSTEM TRANSIENT STABILITY BY COORDINATED OPERATION OF FAST VALVING AND BRAKING RESISTOR[2003]

Abstract: Fast valving and braking resistors. individually, are an effective means of improving the stability of a power system under large and sudden disturbances. The fast valving schemes, like other methods, are not always suitable for all power systems for enhancing the transient stability. Minor variations in the switching parameters of the fast valving scheme drastically affect the stability of the system. Moreover, there are some other associated problems such as risk of safety valve operation owing to increased boiler pressure, the problem of second swing instability etc. Similarly the dynamic braking resistor has its own limitations such as excessive heat loss and the resultant temperature rise of the resistor. Therefore, coordinated fast valving and braking resistor control is proposed. The coordinated control scheme is very effective in reducing the mismatch between the mechanical input power and electrical power output of the generator, thereby reducing the generator accelerating power during the fault period. Ths dual control from load side and generation side substantially improves the transient stability perf@miance of the system. Various schemes of fast valving control and coordinated control operation were tested on a single machine infinite bus system and the results are compared.

III. DESIGNING OF TRAIN BRAKE

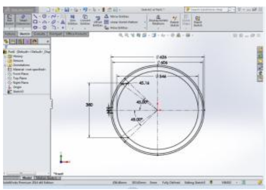
According to RDSO (Research and Development Standards Organization), Lucknow, the following are standard designed values for Railway air brake system.

•Brake cylinder diameter: 355.6 mm (14 inches).
•Effective piston force of brake cylinder: 3.6 tons.
•Number of brake cylinders per coach: 2
•Number of brake bogie levers per coach: 4
•Mechanical efficiency of brake rigging: 0.9.
•Brake rigging ratio: 0.9.
•Number of brake blocks per one coach: 16

Mechanical advantage of bogie Bogie leverage ratio X no. of bogie levers

Mechanical advantage of complete brake system

Mechanical advantage of bogie X Horizontal leverage ratio



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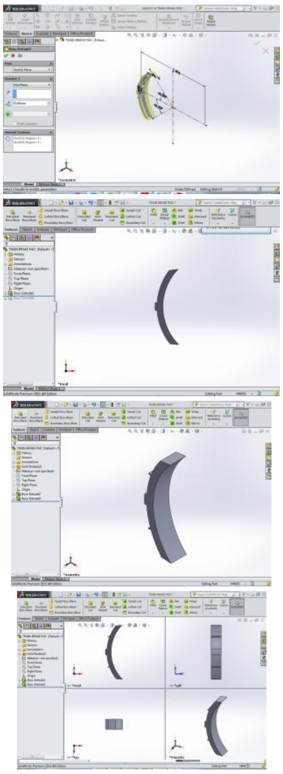


STATIC ANALYSIS OF TRAIN BRAKE PAD

Static analysis of Train brake is done by applying three different materials namely structural steel, Grey cast iron and titanium alloy .2Ton, 2.5Ton &3Ton braking forces are applied to each of the material.

IV. STATIC ANALYSIS OF TRAIN BRAKE PAD USING STRUCTURAL STEEL BY APPLYING 2TON BRAKING FORCE

Model name: TRAIN BRAKE PAD

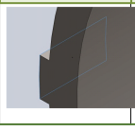
MASS PROPERTIES

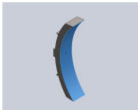
<L_Mdinf_SldBd_Nm/>	Treated As	Volumetric Properties	Document Path/Date Modified
Boss-Extrude3[1] 	Solid Body	Mass:7.05788 kg Volume:0.000899093 m^3 Density:7850 kg/m^3 Weight:69.1672 N	D:\desktop\train brake pad_files\TRAIN BRAKE PAD.SLDPRT Nov 17 00:55:30 2016

Study Properties

Study name	Static STRUCTURAL STEEL
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from Solid Works Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	Solid Works document (D:\desktop\train brake pad_files)

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		Entities: 1 face(s) Type: Fixed Geometry

Load name	Load Image	Load Details
Force-1		Entities: 1 face(s) Type: Apply normal force Value: 19613 N Phase Angle: 0 Units: Deg

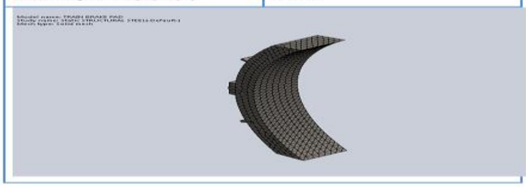
Material Properties

Model Reference	Properties
	Name: ASTM A36 Steel Model type: Linear Elastic Isotropic Default failure criterion: Max von Mises Stress Yield strength: 2.5e+008 N/m^2 Tensile strength: 4e+008 N/m^2 Elastic modulus: 2e+011 N/m^2 Poisson's ratio: 0.26 Mass density: 7850 kg/m^3 Shear modulus: 7.93e+010 N/m^2

Mesh Information

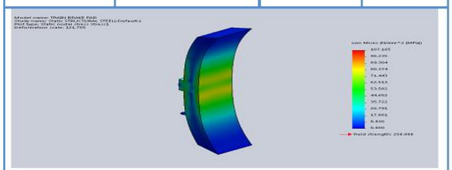
Mesh Information - Details

Total Nodes	11001
Total Elements	6610
Maximum Aspect Ratio	6.5789
% of elements with Aspect Ratio < 3	99
% of elements with Aspect Ratio > 10	0
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:03

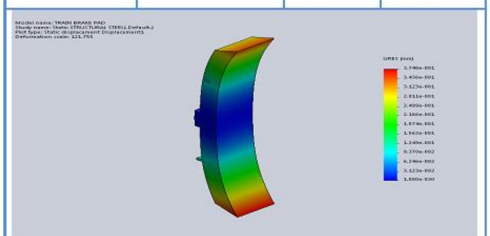


Study Results

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 10778	107.165 N/mm^2 (MPa) Node: 6903



Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 648	0.374784 mm Node: 8938



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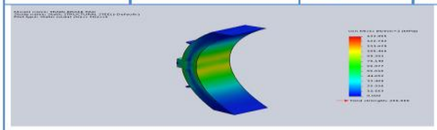
STATIC ANALYSIS OF TRAIN BRAKE PAD USING STRUCTURAL STEEL BY APPLYING 2.5TON BRAKING FORCE

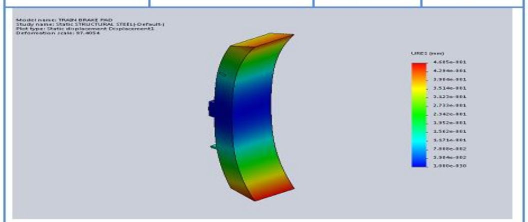
By applying 2.5 brake force with same boundary conditions results are as follows:

Study Results

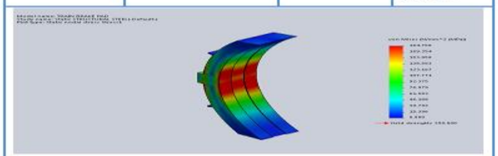
Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 10778	133.955 N/mm^2 (MPa) Node: 6903



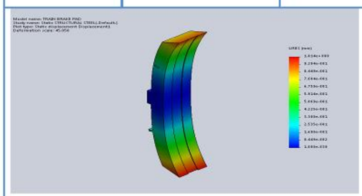
Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 648	0.468475 mm Node: 8938



Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 1	184.75 N/mm^2 (MPa) Node: 9772

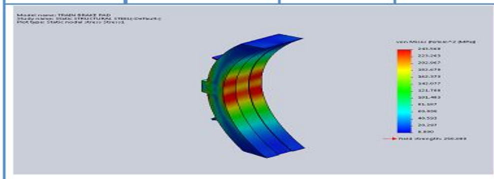


Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	1.0139 mm Node: 408

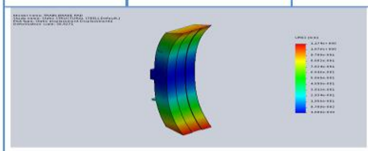


STATIC ANALYSIS OF OPTIMISED TRAIN BRAKE PAD USING STRUCTURAL BY APPLYING 3TON BRAKING FORCE

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 1	243.560 N/mm^2 (MPa) Node: 9772

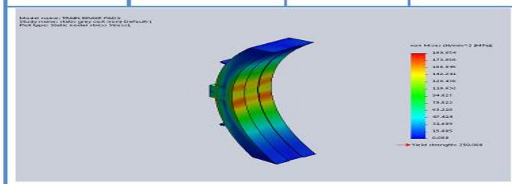


Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	1.17358 mm Node: 408

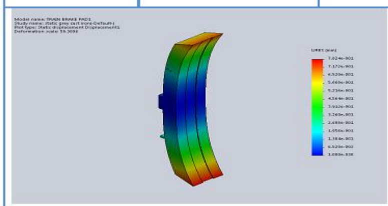


STATIC ANALYSIS OF OPTIMISED TRAIN BRAKE PAD USING GREY CAST IRON BY APPLYING 2TON BRAKING FORCE

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 1	189.654 N/mm^2 (MPa) Node: 9772



Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	0.9645 mm Node: 408



ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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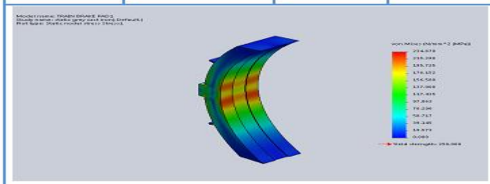
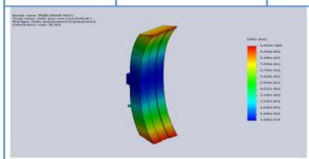
STATIC ANALYSIS OF OPTIMISED TRAIN BRAKE PAD USING GREY CAST IRON BY APPLYING 2.5TON BRAKING FORCE

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 1	234.879 N/mm^2 (MPa) Node: 9772

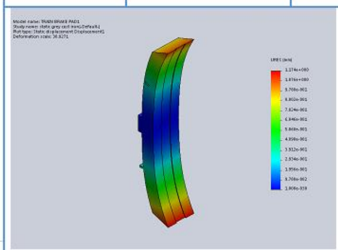


Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	1.245 mm Node: 408



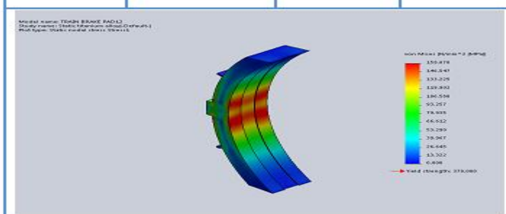
STATIC ANALYSIS OF OPTIMISED TRAIN BRAKE PAD USING GREY CAST IRON BY APPLYING 3TON BRAKING FORCE

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	1.876 mm Node: 408

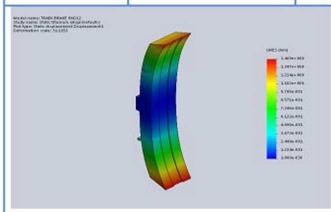


STATIC ANALYSIS OF OPTIMISED TRAIN BRAKE PAD USING TITANIUM ALLOY BY APPLYING 2TON BRAKING FORCE

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 12905	159.87 N/mm^2 (MPa) Node: 9535

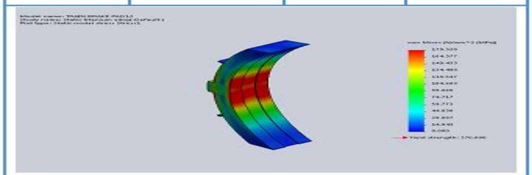


Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 573	1.46929 mm Node: 11747

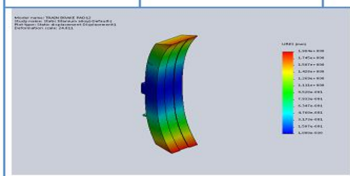


STATIC ANALYSIS OF OPTIMISED TRAIN BRAKE PAD USING TITANIUM ALLOY BY APPLYING 2.5TON BRAKING

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 12905	179.32 N/mm^2 (MPa) Node: 9535

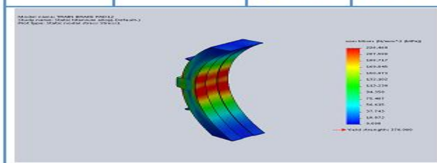


Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 573	1.90401 mm Node: 11747



STATIC ANALYSIS OF OPTIMISED TRAIN BRAKE PAD USING TITANIUM ALLOY BY APPLYING 3TON BRAKING

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 12905	226.46 N/mm^2 (MPa) Node: 9535



IV. RESULTS AND DISCUSSIONS

BEFORE OPTIMISATION

Von misses stress for three materials by applying 2,2.5 and 3TONbraking force

	structural steel	Grey cast iron	Titanium alloy
2TON	107.65	112.36	106.2
2.5TON	133.65	141.86	132.72
3TON	160.74	182	159.6

Resultant displacement for three materials by applying 2,2.5 and 3TONbraking force

	structural steel	Grey cast iron	Titanium alloy
2TON	0.374	0.958	0.74
2.5TON	0.468	1.41	0.88
3TON	0.562	1.69	1.05

V. CONCLUSIONS

- Brakes are used on the cars of railway trains to enable deceleration, control acceleration (downhill) or to keep them standing when parked. While the basic principle is familiar from road vehicle usage, operational features are more complex because of the need to control multiple linked carriages and to be effective on vehicles left without a prime mover. Clasp brakes are one type of brakes historically used on trains.

- **Continuous power dissipation** – Brakes typically get hot in use, and fail when the temperature gets too high. The greatest amount of power (energy per unit time) that can be dissipated through the brake without failure is the continuous power dissipation. Continuous power dissipation often depends on e.g., the temperature and speed of ambient cooling air. Fade – As a brake heats, it may become less effective, called brake fade. Some designs are inherently prone to fade, while other designs are relatively immune. Further, use considerations, such as cooling, often have a big effect on fade.

- **Smoothness -** A brake that is grabby, pulses, has chatter, or otherwise exerts varying brake force may lead to skids. For example, railroad wheels have little traction, and friction brakes without an anti-skid mechanism often lead to skids, which increases maintenance costs and leads to a "thump thump" feeling for riders inside.

- **Power -** Brakes are often described as "powerful" when a small human application force leads to a braking force that is higher than typical for other brakes in the same class. This notion of "powerful" does not relate to continuous power dissipation, and may be confusing in that a brake may be "powerful" and brake strongly with a gentle brake application, yet have lower (worse) peak force than a less "powerful" brake.

- The present work is directed towards the modeling of Train brake pad in a 3D CAD software called SOLIDWORKS. According to the existing air brake system of Railway coach the brake force applied per one brake block is 2.187tons.

- 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.

- Analysis is done in SOLIDOWRKS SIMULATION. By comparing the results for three materials before optimization, stress obtained is less for Titanium alloy is less when compared with Structural steel and grey cast iron. But structural steel has yielded less deformation compared to their materials.

- By comparing the results for three materials after optimization, stress obtained is less for Titanium alloy is less when compared with Structural steel and grey cast iron. Therefore, from the present research it can be concluded that using Titanium alloy is best for train brake.

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