Design and Manufacturing of Brake Shoe

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Abstract: ***The aim of this article is to design and manufacturing of Hero Honda Splendor brake shoe. Analysis is done by changing the material of the brake shoe, under different braking time and operational conditions. Brake shoe is optimized to obtain different stresses, deformation values on different braking time. Optimized results obtained are compared for Aluminium alloy and Gray cast iron material. It concludes that the aluminium alloys can be a better candidate material for the brake shoe applications of light commercial vehicles and it also increases the braking performance.***

Keywords: Brake shoe, Al alloy brake shoe, Grey cast iron brake shoe, Finite Element Analysis, and Solid works

1. Introduction

Drum brakes were the first types of brakes used on motor vehicles. Nowadays, over 100 years after the first usage, drum brakes are still used on the rear wheels of most vehicles. The drum brake is used widely as the rear brake particularly for small car and motorcycle. The leading-trailing shoe design is used extensively as rear brake on passenger cars and light weight pickup trucks. Most of the front-wheel-drive vehicles use rear leading- trailing shoe brakes. Such design provided low sensitivity to lining friction changes and has stable torque production (Limpert, 1999).[1] A brake is a mechanical device which is used to absorb the energy possessed by a moving system or mechanism by means of friction. The primary purpose of the brake is to slow down or completely stop the motion of a moving system, such as a rotating disc/drum, machine or vehicle. Many aspects of slowing and stopping a vehicle are controlled by simple physics dealing with the deceleration of a body in motion. The simplest way to stop a vehicle is to convert the kinetic energy into heat energy. The energy absorbed by brakes is dissipated in the form of heat. The heat is dissipated in surrounding, air, water etc. [2] The braking equipment of a vehicle includes all of its brake system that is all of reducing velocity of a moving vehicle, reducing its rate of acceleration, increasing its rate of deceleration, halting the acceleration, increasing its rate of deceleration, halting the vehicle and preventing the vehicle from returning movement once it is stationary. [3] A drum brake is a brake that uses friction caused by a set of shoes or pads that press against a rotating drum shaped part called a brake drum. The brake drum is generally made of cast iron that rotates with the wheel. When a driver applies the brakes, the lining pushes radially against the inner surface of the drum, and the ensuing friction slows or stops rotation of the wheel and axle, and thus the vehicle. Internal expanding shoe brakes are most commonly used in automobiles. In an automobile, the wheel is fitted on a wheel drum. The brake shoes come in contact with inner surface of this drum to apply brakes. The whole assembly consists of a pair of brake shoes along with brake linings, a retractor spring two anchor pins a cam and a brake drum. Brake linings are fitted on outer surface of each brake shoe. The brake shoes are hinged at one end by anchor pins. Other end of brake shoe is operated by a cam to expand it out against brake drum. A retracting spring brings back shoes in their original position when brakes are not applied. The brake drum Braking System closes inside it the whole mechanism to protect it from dust and first. A plate holds whole assembly and fits to car axle. It acts as a base to fasten the brake shoes and other operating mechanism. Braking power is obtained when the brake shoes are pushed against the inner surface of the drum which rotates together with the axle. Drum brakes are mainly used for the rear wheels of passenger cars and trucks while disc brakes are used exclusively for front brakes because of their greater direction stability. The backing plate is a pressed steel plate, bolted to the rear axle housing. Since the brake shoes are fitted to the backing plate, all of the braking force acts on the backing plate. A drum brake has a hollow drum that turns with the wheel. Its open back is covered by a stationary back plate on which there are two curved shoes carrying friction linings. The shoes are forced outwards byhydraulic pressure moving pistons in the brake's wheel cylinders, so pressing the linings against the inside of the drum to slow or stop it.[4] Optimal design of today's brake systems is found using additional calculations based on Finite element methods. For both types of brake systems, drum brakes and disk brakes. Results include deformation, stress distribution, contact pressure and showing which regions of the contact area are in sticking or sliding condition. [5] A parametric modeling of a drum shoe based on 3-D Finite Element Methods for non-contact analysis is presented. Many parameters are examined during this study such as the effect of shoe-lining interface stiffness, coefficient of friction, and line pressure on the interface contact. It is shown that the Unsymmetrical modal analysis is efficient enough to solve this linear problem after transforming the non-linear behavior of the contact between the drum and the lining to a linear behavior. [6] A multi objective optimization design model of drum brake with the goals of maximizing the efficiency factor of braking, and minimizing the volume of drum brake, in order to better meet the requirements of engineering practice.

2. Literature Review

K. Radhakrishna et al (2008) - He had used aluminium with copper and fly ash as reinforcements and concluded that up to 15% the reinforcements are successfully dispersed in the matrix and hardness, wear resistance increases up to 15 wt% addition of reinforcements.[7]

K. Deepika et al (2013) - Brake lining materials generally are asbestos, metals, non -asbestos organic such as palm kernel shell (PKS), and ceramics. Asbestos during application releases the hazardous gases, which causes damage to the health. The main element is used for brake lining from palm kernel shell (PKS) which is agro-waste. The average disk temperature and average stopping time for pass is increased and it has poor dimensional stability. Hence it has lost favour and several alternative materials are being replaced these days. [8]

Pascu LV et al (2015) - For making brake shoes are used frequently gray cast iron with lamellar graphite and nodular cast iron, which have a good thermal conductivity, good mechanical properties, good wear resistance. Cast iron brake block enjoys many advantages including hardness, impact strength and so on. [9]

3. Methods and Material

To create the cad model of the brake shoe we find the existing brake shoe of Hero Honda Splendor from market for reverse engineering. We can measure all the visible dimensions manually with specified measuring instruments to create accurate and scaled model. To find out accurate feature location like holes plane angles etc.CMM is done. Using CAD software we can create CAD model of brake shoe as per measurement data we Import the CAD Model (IGES) in the Solidworks for pre-processing and then the stress and deformation analysis is done on the brake shoe. The Analysis involves the discretization called meshing, boundary conditions and loading. For analysis we take Aluminium with aluminium alloys as the material. The Aluminium has been selected based on the properties required for the existing brake shoe. The aluminium alloys has been selected as matrix for manufacturing the MMC based on the ease of manufacturing. [10]

Specifications of brake shoe

Inner diameter of drum (mm) = 110
Contact an angle per shoe = 120
Width of Shoe (mm) = 25
Thickness of lining (mm) = 4
Diameter of Anchor pin (mm) = 8.5
Thickness of Cam (mm) = 6.22
Outer diameter of hub (mm) = 46.46
No. of shoes = 2

Material properties of brake drum

Material	Density (g/cm^3)	Tensile Strength (MPa)	Young's Modulus ($x10^3$ N/mm^2)	Poisson's ratio
LM28	2.68	165	82	0.33
HT200	7.20	170	80	0.25
A6063	2.69	165	68.3	0.33

Solid Modeling: The first step was to prepare a solid model of the brake shoe. This was carried out by using Solidworks 2014 Software.

Analysis: Brake shoe finite element analysis is done through Solidworks 2014 software. Both stress analysis and deformation analysis is done under different braking time and operational conditions.

Boundary Conditions: For Stress analysis, pressure is applied on the external surface of the round face of the brake shoe.Both the ends of the shoe is fixed, as we know that, the adjuster side end of shoe is fixed but expander side of the shoe is movable due to cam, but we consider it as fixed, because when the cam is rotated, the shoe will expand to the drum and stick with the drum tightly (at full load condition), then it will be the worst condition, so at this situation we can consider that expander side as fixed.

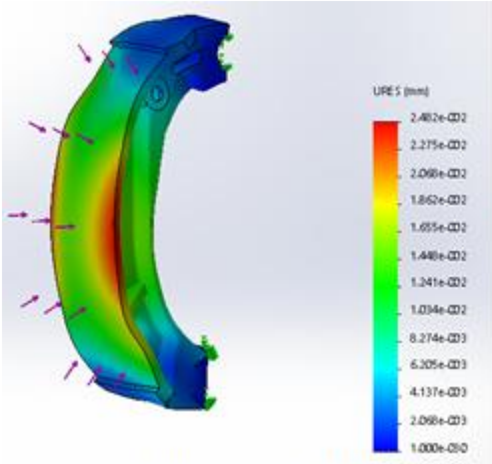
Force calculation

Force exerted on paddle will rotate the cam, that force exerts the pressure on brake shoe so brake shoe will exert same fore on drum, so that according to newton's third law the same reaction force will exert on brake shoe. For the calculation on force and pressure we have to define the loadings and other specification of brake shoe.

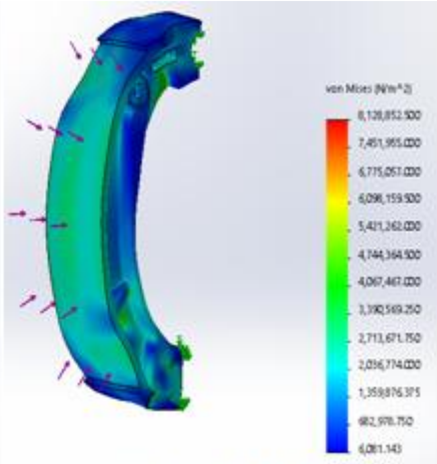
Weight of bike = 112kg
Maximum payload = 130kg
Net weight= 242kg ≃ 250kg
Maximum velocity of bike = 95km/hrs. Or 26.388m/sec.
Stopping time = 3sec
Forces on braking system = m (rω)/t = 250*26.388/3 = 2199N
Forces on each brake drum = 2199/2 = 1099.5N
According to Newton's third law,
Forces on brake drum = Forces on brake shoe
Therefore, Forces on each brake shoe = 1099.5/2 = 549.75N
Contact area of brake shoe on brake drum:-
Length of arc, L = rθ
L = 52.5*120*(π/180) = 109.9557mm
Width of shoe = 25mm
Contact area of shoe = 109.9557*25 = 2748.893572mm² = $2.74889*10^{-3}m$
Pressure on shoe = Force/Area = $549.75/2.74889*10^{-3}$
= 199989.8141N/m²= 0.119993732MPa ≃ 0.12MPa

Table I: Force table

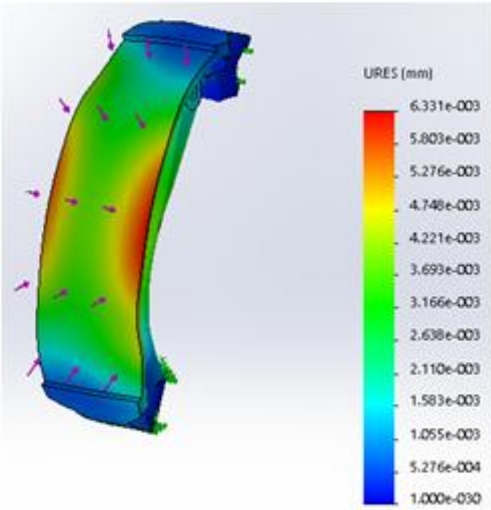
Velocity of Bike (Km/hr.)	Stopping time(sec)	Forces(N)
95	3	549.75
95	7	235.607
30	3	173.6041667
30	7	74.40178571



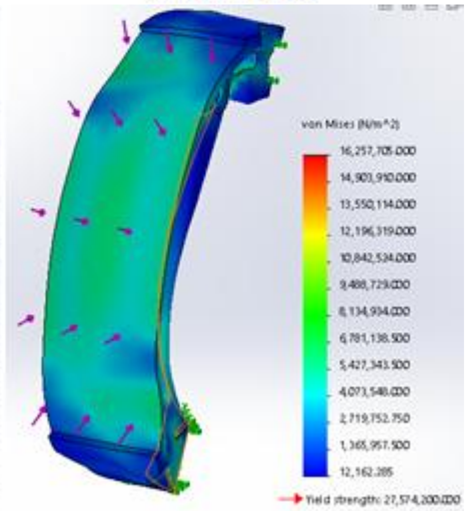
Displacement for LM28



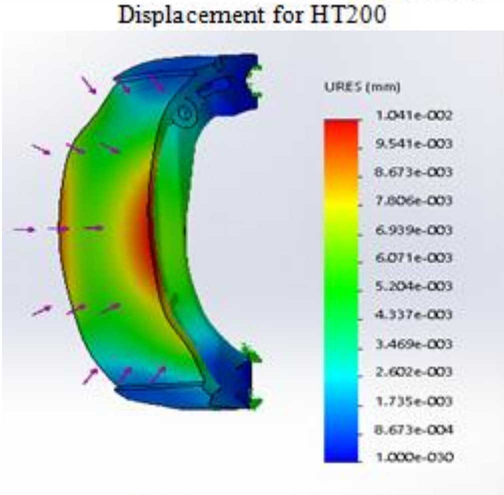
Stress for LM28



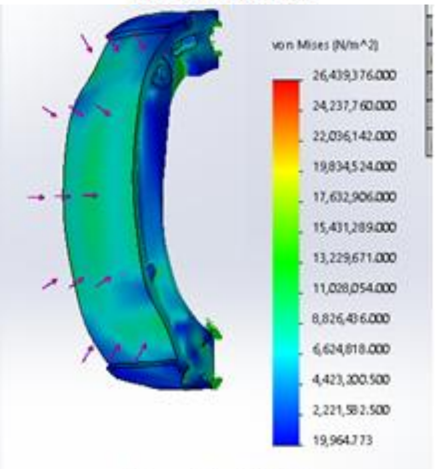
Displacement for HT200



Stress for HT200



Displacement for A6063



Stress for A6063

4. Results and discussion

Material	Displacement (mm)	Stresses (N/mm^2)
LM28	0.0248	0.021581-14.434
HT200	0.006331	0.026153-14.435
A6063	0.01041	0.019-13.229

After doing analysis on brake shoe model, we found the above result which is mentioned in tabular form. Our aim is to suddenly stop the vehicle at maximum deceleration. We took stopping time is 3 seconds as sudden stoppage, then we found different displacement and stresses on shoe after doing analysis by taking different materials. We found the displacement 0.0248, 0.006331, 0.01041 mm, and stresses 0.021581-14.434, 0.026153-14.435,0.019-13.229 N/mm^{2}on LM28, HT200 and A6063 materials respectively.

5. Conclusion

The deformation and the stress induced in the aluminium alloy and grey cast iron brake shoe during the application of brake force have been determined using finite element analysis. It is observed from the analysis that the deformation in Grey cast iron brake shoe is considerably less than the Aluminium alloy brake shoe. The stresses in the Grey cast iron and Al alloy brake shoe are found to be almost same. There is negligible variation in them. Hence, the required factor of safety is maintained in both the Grey cast iron and Al alloy brake shoe. While braking from a speed of 95km/h at sudden braking, we found that the chances of deformation in brake shoe is more on the edges of upper surface of the shoe where force is applied. The Aluminium alloys brake shoe has comparatively less weight than Grey cast iron brake shoe. From the above observations, it is concluded that the Aluminium alloy brake shoe has less weight, and easily available in the market. Hence, the aluminium alloys can be a better candidate material for the brake shoe applications of light commercial vehicles.

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