ISSN No - 2394-3696

DESIGN OPTIMIZATION OF HUB-CUM-BRAKE DRUM FOR WEIGHT REDUCTION

Arvind P Jinturkar
Department of Mechanical Engineering, Savitribai Phule Pune University,ACT's Alard College of Engineering & Management, Pune, India.

ABSTRACT

Baking system is necessary in an automobile for stopping the vehicle. Brakes are applied on the wheels to stop or to slow down the vehicle. Brake system Performs two basic functions i.e. to slow down or stop the vehicle in the shortest possible time & to control the speed of vehicle at turns and also at the time of driving down on a hill slope The objective of this study is to define parameters which contribute for the automotive brake system design & those break characteristics, within the space bounded by the relationships between brake pedal force and Vehicle deceleration, which lead to acceptable driver - vehicle performance.
Also this study aimed at focusing on the working of major brake system components in details. Brake wear life & its performance during working play a vital role in safe braking of the vehicles which ultimately depends on the serviceability & proper maintenance of the Brake system. Considering this fact the Serviceability guide lines are also covered under this study.

INTRODUCTION

The safe reliability of the vehicles is attracting more and more attentions with the sharp Increase in the vehicles. It is fact that owing to recent improvement in the braking mechanism may be chiefly attributed the increased speeds of the modern cars on the road. Brake system is the most significant safety aspect of an automobile. It must be slow the vehicle quickly and reliably under varying conditions. Braking is a complex energy conversion process whereby the kinetic energy of the vehicle is dissipated in the form of heat energy due to friction between moving parts i.e. wheel drum and stationary parts of vehicle ie brake shoes. During the braking process, the pedal force acts through a mechanical-hydraulic system to apply retarding torque to each of the four wheels of the vehicle. The braking torque is opposed by the inertia of the wheel and the frictional force between the tire and the road, with the net result being the deceleration of the vehicle.

Brake drum is specialized brake that uses the concept of friction to decelerate the vehicle speed. The deceleration is achieved by the assistance of the friction generated by a set of brake shoes or pad. The material generally preferred for making the brake drum is grey cast iron or vermicular cast iron. During the operation of drum brake excessive heating of brake drum may occur. This excessive heating occurs due to repeated or frequent contact of the brake shoes against the drum. This causes the drum to crack, oversize, extreme wear, out of round drums and also leads to vibration which while braking will leads to reduced brake drum life and braking efficiency. The Un-laden weight of the vehicle will result in increased fuel consumption, reduced payload and ride handling characteristics. During the retardation of the vehicle by transforming the kinetic energy of the vehicle into heat by the process of friction result in to heat generation which must be effectively and efficiently dissipating to the surroundings by the brake components. There are many types of brake systems that have been used since the inception of the motor car, but in principle they are all similar.

A drum brake is a brake in which brake shoes with Brake lining attached to them are pushed by hydraulic pistons against the inner surface of a drum rotating together with the axle. This generates friction, which converts kinetic energy into heat and slows or stops the drum and the attached wheel. There are many studies investigated experimentally the performance of the brake systems, as well as studying the braking process behaviour. Since the improvement of the brake design and manufacturing is of great significance in ensuring the brake quality & thus the vehicle's safe running, the brake parameter optimization design which is a key part in the whole brake design procedure is becoming increasingly important. Therefore, the research in this field is becoming a hot topic.

Fig.1 Typical Automobile Brake Cast Iron Drum

In general, in the brake parameters optimizing procedure, the first step is to set up parameter optimization model and the next step is to validate its performance with the desired vehicle performance. A lot of researches have been done in this field, most of which are carried out to in the field of Design & weight optimization. The objective of this project is to optimize the Brake drum design with negligible or less modification with minor cost impact.

LITERATURE REVIEW

1. Research Article on Study on Parameter Optimization Design of Drum Brake Based on Hybrid Cellular Multi objective Genetic Algorithm.	Yi Zhang, Hu Zhang, and Chao Lu presented a Multi objective optimization design model of drum brake with the goals of maximizing the efficiency factor of braking, minimizing the volume of drum brake, and minimizing the temperature rise of brake, in order to better meet the requirements of Engineering practice. They have presented a differential evolution cellularmultion objective genetic algorithm DE Cell by introducing differential evolution strategy into the canonical cellular genetic algorithm. Its conclusion shows that are an effective algorithm that can be applied to solve the drum brake parameters optimization.
2. Weight reduction of a standard brake drum A design approach.	D Rambabu,R Gopinath,U Senthil rajan,G B Bhaskar, presents Finite Element model of Brake drum has been developed to evaluate the drum behaviour with respect to temperature, pressure and displacement parameters. Analysis is carried out with different proposals in brake drum construction. Fins are placed to reduce over-heating and improves brake drum life Based on the proposals carried out for brake drum, iteration-10 is yielding optimized results for the required displacement and stress values. I.e., the iteration with rib thickness 75 mm, star shaped removal and wall thickness 17 mm. 1.8Kg of weight is being reduced from the brake drum including fins. This is leads fuel efficiency and longer life. Further study can be done for fatigue and fracture toughness study with different materials like aluminium, steel alloys etc, without compensating the base performance.
3 Experimental investigation of drum Brake performance for passenger car.	Nouby M Ghazaly South Valley & Mostafa Makrahy Minia University presented a paper which aims to establish a brake test rig capable of measuring the performance of a drum brake at different operational and environmental conditions. The effects of dry and humid environment are considered under different applied forces and vehicle sliding speed. The experimental results showed a slight increase in the friction coefficients between drum and brake lining with increasing pressure or speed at dry and wet conditions.

ISSN No - 2394-3696

PROBLEM DEFINITION

3.1 PROBLEM STATEMENT

Drum brakes, like most other brakes, convert kinetic energy into heat by friction. This heat should dissipate into the surrounding air. Brake drums must be large to cope with the massive forces involved, and must be able to absorb and dissipate a lot of heat. Heat transfer to air can be aided by incorporating cooling fins onto the drum but which may contributes for the weight addition. However, excessive heating can occur due to heavy or repeated braking, which can cause the drum to distort, leading to vibration under braking. The other consequence of overheating is fade. This is due to one of several processes or more usually an accumulation of all of them. When the drums are heated by hard braking, the diameter of the drum increases slightly due to thermal expansion, so the shoes must move farther and the driver must press the brake pedal farther.
Traditional Brake Drum facing below major difficulties while performing on fields.

1. Excessive brake drum heating can cause the brake fluid to vaporize, which reduces the hydraulic pressure applied to the brake shoes. Therefore, the brakes provide less deceleration for a given amount of pressure on the pedal.
2. The properties of the friction material can change if heated, resulting in less friction. This can be a much larger problem with drum brakes than disc brakes, since the shoes are inside the drum and not exposed to cooling ambient air. The loss of friction is usually only temporary and the material regains its efficiency when cooled, but if the surface overheats to the point where it becomes glazed the reduction in braking efficiency is more permanent. Surface glazing can be worn away with further use of the brakes, but that takes time.
3. Brake fade is not always due to overheating. All friction braking systems have a maximum theoretical rate of energy conversion. Once that rate is reached, applying greater pedal pressure doesn't change it.
4. Also today world is growing for day by day with the new technologies with are manufacturing the high speed automobiles.

To overcome the above problems of brake durm & sustain the competitor market the potential a real where we can work includes.

1. To Development of complete new design of Brake durm which will able to minimize the problem. This will involve reconsidering the vehicle parameters once again from Stretch.

2 To develop Alternate material which will perform well to sustain extreme conditions, but this may involve huge development & validation cost.

3 .To development the Brake drum with a minor or less modification in the existing design with the shape optimization.

4. Optimization of weight can be possible with less modification in the peripheral area as in the central hub Bearing is press fitted which is a standard part. Also design of the hub is based on the suspension parameters. For the initial development the option of the shape change at the periphery is suitable as it involves also minor changes to optimize the weight

3.2 OBJECTIVES OF THE STUDY

1. To Optimize the Existing Cast Iron Hub cum Brake drum for Weight reduction.
2. To achieve the weight reduction without compromising on the stiffness of the Existing Cast Iron Hub cum Brake drum.
3. To determine the proposed Cast Iron Hub cum Brake drum deflection in comparison with Existing Brake drum Design.
4. To validate the performance of the proposed brake drum with physical validation & test cycles.
5. Stress Analysis comparison of Existing design & proposed design with the aid of Computer aided Engineering CAE.

3.3 SCOPE

By doing this we can propose a new Brake drum with minor modifications in the existing brake drum to achieve the weight optimization which is in turns achieve the cost benefits. The major challenge to achieve the set target without compromising the performance characteristics of the drum. For doing so following practices are to be adopted:

1. To study the effect outer peripheral form of Brake drum on the deflection.
2. To study the effect of Stress distribution across the zones of the brake drum.
3. To study the alternative design way forward options in order to optimize the existing break drum in terms of weight & cost.
4. To prove the design aspects of proposed design as a record for future studies.
5. To optimize & finalizing the solution.

3.4 MOTIVATION

Automotive light weighing component is one of the major goals for original equipment manufacturers (OEM's) globally. Significant advances are being made in developing light-weight high performance components. In order to achieve weight savings in vehicles. In a quick changing Automotive industrial scenario, Domestic as well as foreign market demands efficient, versatile, and value for money automobiles with best performance in terms of ride handling & safety. As far as safety is concerns it has same importance to stop the vehicle in the stipulated time as to accelerate it in time of seconds Typically modern vehicle weight around 1.5 ton has a 305 Lit Engine and accelerates from 0 to 100 Kmph in approximately 10 Sec. to this it has sophisticated engine, drive lines & powerful engine these systems made up of thousands of mechanical components & contribute about half of the vehicle weight in contract the braking system consists of less than 200 parts & contribute for less that 40 kg of vehicle weight. & this system able to stop the vehicle from 100kmph to 0 speed only in 0-3 Sec ,it means the Braking of the vehicle is most important aspect in the design of vehicle. Hence optimizing the brake for weight, cost & performance is required today to chase the competitor market. Weight optimization of of brake drum is one of main aspect for the achieving the above target.

PARAMETER SELECTION
DRUM ANALYSIS IN PRO-E MECHANICA.
LOAD CASE:-

Diameter of Wheel Cylinder =19.5 MM

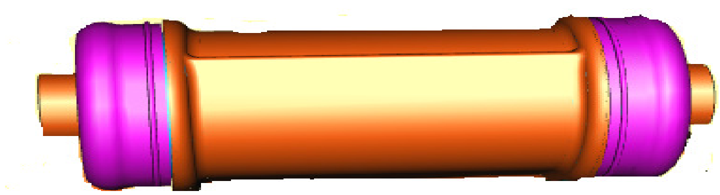


Fig.Wheel Cylinder.

STEPS INVOLVED:-

1. Force on Shoe Pressure P Bar = (π*D2)/4= F Kg. -------------------------P Should be above 50 Bar.

2. Pressure to be applied on Drum-Liner contact surface in Pro-Mechanica= (F/Liner Area*100) Kpa.

3. Apply Cast Iron (Density =7200 Kg/m3) properties to drum material.

This Drum is fixed on four mounting Bolts.ie Δx=Δy=Δz at mounting Locations.
By applying above load case find out the Max.Drum Deflection (x) using single pass adaptive run.
Drum Stiffness (KN/mm) = (F*9.81/1000)/X

The minimum Stiffness to be achieved =57.6 KN/mm.

MATHEMATICAL WORKOUT

1) Wheel Cylinder Dia (dw) =19.05 mm=0.01905 m
Area of Wheel Cylinder (Aw) = (π x d2)/4
Aw= 2.850229 x e-4 m2
2) Now, Let's Consider the Pressure applier by Piston of Wheel Cylinder =100 bar ie 100 x e5 pa
We Know, Pw=Fw/Aw
Therefore Fw=pw x Aw=100 x E5 x 2.850229 x e-4
Fw=2850.229N=2.850229KN
3) Now Linear Area of drum Ad= Arc Length of the drum which is in contact with Brake liner. x width of liner
Arc length =189.833 mm =0189833 m
Width of shoe =30mm=0.03m
Area Ad=5.694e-3 m2
4) Now pressure applier on drum Pd=Fw/Ad= 2.8502/5.694e-3 m2=500.561 KN/m2
5) The deflection obtained from Pro-Mechanica for existing brake drum =0.03433mm
6) Stiffness of the Existing Brake drum Ke=2.8502/0.03433=83.02 KN/mm.
7) The deflection obtained from Pro-Mechanica for Praposed brake drum =0.03315mm
8) Stiffness of the Praposed brake drum Kp=2.8502/0.03315=85.97 KN/mm.

From Eq 6 & 8 we can see here we can obtain the stiffness benefit with the Praposed brake drum design.
Existing Hub cum Brake Drum Constrain & Loading Details. (wt. 5.90Kg)

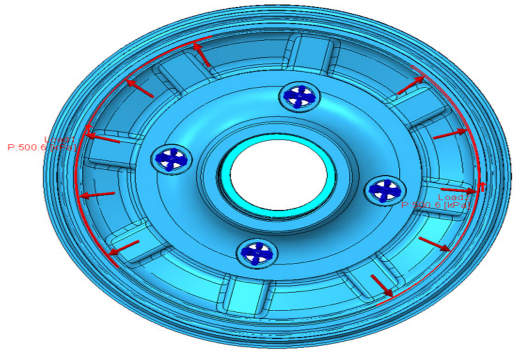


Fig. Existing Base Hub cum Brake Drum Constrain & Loading Details.

DEFLECTION ANALYSIS OF BASE HUB CUM BRAKE DRUM. (WT. 5.90KG)

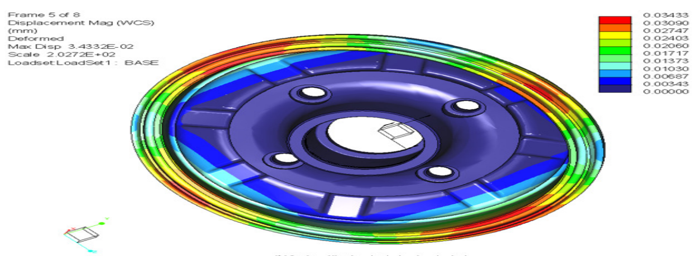
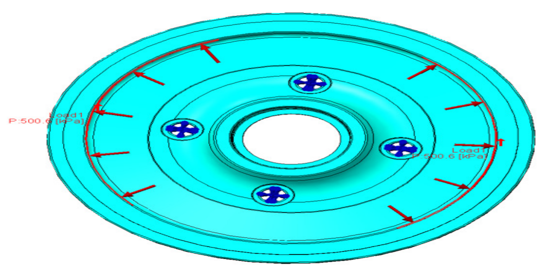


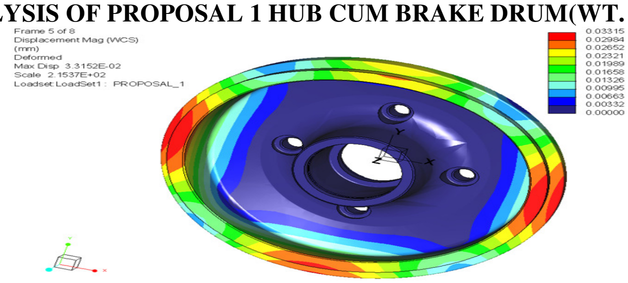
Fig.Deflection Analysis of Base Hub cum Brake Drum

PROPOSAL 1 HUB CUM BRAKE DRUM CONSTRAIN & LOADING DETAILS. (WT. 5.62KG)



Proposal 1 Hub cum Brake Drum Constrain & Loading Details.

DEFLECTION ANALYSIS OF PROPOSAL 1 HUB CUM BRAKE DRUM(WT. 5.62KG)



Deflection Analysis of Proposal 1 Hub cum Brake Drum

PROJECT DESIGN

5.1 FUNCTIONAL REQUIREMENT

i. Software requirements

Pro-E Cero 2.0, CAE work Station hyper mesh, ANSYS, MS-Excel.

ii. Hardware requirements

Weighing machine, Inspection lab, and Materialgical lab.

5.2 NONFUNCTIONAL REQUIREMENT

i) Software requirements, Electrical sensors, probe & Data Acquisition system.

ii) Test rig fixture,

RESULT AND DISCUSSION

We have studied from above workout that the minor modification in the existing Cast iron brake drum along the peripheral region we can achieve the potential weight saving of 0.28 kg per Brake drum. & which will be 0.56 kg (0.28x2= 0.56) kg per vehicle. Also from the Deflection analysis we come to know that there is no adverse effect on the performance stiffness criteria with the Praposed design. Instead we get the increase in the stiffness from 83.02 KN/mm to 85.97 KN/mm.

FUTURE WORK

From the above result & discussion we can give the actual part development kick-off for the physical validation of the Praposed design.

CONCLUSION

Brake drum along the peripheral region potential weight saving of 0.56 kg per vehicle can be achieved & we get the increase in the stiffness from 83.02 KN/mm to 85.97 KN/mm.

REFERENCES

[1] D. Rambabu *1, R. Gopinath*2, U. Senthil rajan*1, G.B. Bhaskar1"Weight reduction of a standard brake drum: A design approach", *(1)Department of Mechanical Engineering, Tagore Engineering College, Chennai – 127,*(2) Department of Mechanical Engineering, Bharath University, Chennai – 73, International Journal of Engineering & Technology, 3 (2) (2014) 201-207.

[2] Nouby M. Ghazaly*1,Mostafa m. Makrahy*2," experimental investigation of drum brake performance for passenger car", 1Mechanical Eng. Dept., Faculty of Engineering, South Valley University, Qena-83523, Egypt, 2Automotive and Tractor Eng. Dept., Faculty of Engineering, Minia University, El-Minia, Egypt

[3] Nouby M. Ghazaly*1,Mostafa m. Makrahy*2," experimental investigation of drum brake performance for passenger car", 1Mechanical Eng. Dept., Faculty of Engineering, South Valley University, Qena-83523, Egypt, 2Automotive and Tractor Eng. Dept., Faculty of Engineering, Minia University, El-Minia, Egypt