iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** IV **Month of publication:** April 2015

DOI:

Reverse Engineering of Motorcycle Rear Disc Brake System

V. Lakshmi Narayanan[1], Ranganath lolla[2]
[1]*PG student,* [2]*Assistant professor, Department of Mechanical Engineering, Kumaraguru College of Technology, Coimbatore*

Abstract - Generally motorcycles above 150cc have two discs in the rear, one is brake disc rotor and other is sprocket. In this concept one of the discs is removed and two of the vehicle function is achieved in one disc itself. The materials and the process for one of the discs are completely eradicated and thus the total cost is decreased. Reverse engineering is done for the disc and calliper and analysis is carried out for the disc to validate the concept.
Keywords - Sprocket, Brake Disc rotor, Reverse Engineering Design and Analysis.

I. INTRODUCTION

Motorcycle play a vital role in day to day life for transportation, the cost of the vehicle is also increasing so major steps are taken to decrease the total cost of the vehicle without decreasing the performance of the vehicle. This concept deals with the same idea of decreasing the cost of vehicle by reducing the number of parts. If a part is totally eradicated means the material, process and labour cost etc will be eradicated from the total cost so that ultimately the total cost of the will be reduced. This concept is implemented for the two wheelers which has disc brake system at rear. This concept can be applied for all other bikes which have rear disc brake just changing few parameters.

A. Reverse Engineering

Reverse engineering is altering the existing component with new idea so that the overall efficiency of the system is improved. Many companies which refuse to invest to develop a new component adapt reverse engineering where they just implement new idea in existing component and save huge capital. Reverse engineering will be good to certain extent and after that extent; new component design will be the key to success.

B. Sprocket

Sprocket is used in the final drive of the drive train of motorcycle. It is the component which is connected to the wheels and the rotational motion from the gear box is transmitted to wheels via sprocket. The final reduction is also achieved in the sprocket. Sprocket had teeth at the outer region in which the chain slides and rotational motion is achieved. Sprocket is bolted to the wheel and bolts are the connecting members of the sprocket and wheel. Sprocket has relief holes and thus weight is decreased but within safer limit, excess of material removal will decrease the overall strength of the material and so optimal design is done within the safer condition. In general Mild Steels (MS) [1] are used as the sprocket material in motorcycle because of its easy availability, easy machinability, low cost etc. Various series of Mild Steel are used based on the requirements like strength, cost etc.

Fig. 1 Example of motorcycle sprocket

Fig 1 shows the sprocket used in the motorcycle to transmit the torque to wheel. Relief holes in the sprocket are for weight reduction.

C. Disc Brake System

International Journal for Research in Applied Science & Engineering
Technology (IJRASET)

Disc brake is more efficient than drum brake because of its good heat transfer rate. The components used in disc brake system are Master cylinder, Break lever, Brake line (rubber hose), Calliper and Disc rotor

While breaking the brake lever is pushed and the fluid in the master cylinder is pushed to the brake calliper via brake line. The pressure developed in the master cylinder reaches the calliper piston and it pushes the calliper piston outwards and thus the brake pad within the calliper hits the disc rotor and braking is achieved. Generally vented disc are used for better heat transfer since enormous heat is generated. The material generally used for the disc rotor is cast iron like grey cast iron [2], alloy etc.

Fig. 2 Rear disc brake system of pulsar 200NS

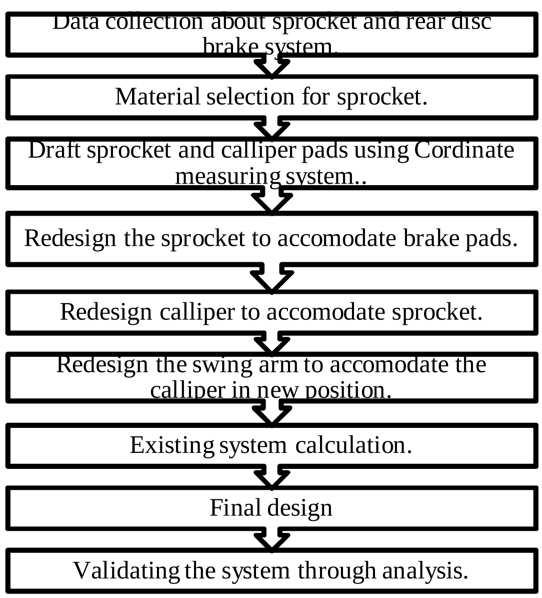
From Fig 2.

a = Brake lever
b = Master cylinder
c = Trail arm
d = Disc rotor
e = Calliper

II. GENERAL PROCEDURE

A. Concept methodology

Methodology is developed and system is developed accordingly. Step by step each of the stages are completed and at last a reliable system is developed.



B. Material Selection Consideration for Sprocket

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

The parameters to be considered in the selection of materials for sprocket are as follows,

1) *Optimal strength* – Since both power transmission and also braking is achieved on sprocket excess of shear force act over the sprocket and so the material should have more strength (yield).
2) *Good wear resistance* – Generally friction exists between chain and sprocket and additionally braking is also achieved at sprocket so more wear will occur between brake pad and sprocket.
3) *Low coefficient of thermal expansion* – Due to high friction between brake pads and sprocket excess of heat is generated in sprocket which will lead to expansion of sprocket. So to prevent it thermal expansion should be low for sprocket material.
4) *Abundant available of material* – If the material is abundant then the cost of the component can be decreased.
5) *Good machinability* – Sprockets cannot be fabricated in single stage, it will undergo secondary machining process and so the material for the sprocket should have good machinability characteristic.
6) *High melting point* – Since excess of heat is generated on the sprocket, the melting point of the material should be high.
7) *Anti-corrosive* – Sprocket is exposed to open environment which will lead to corrosion of the material so anti corrosive materials or anti-corrosion coating has to be given.

Since MILD STEEL is been used in most of the automobile spares, those category of steels are analysed. En series of steel play a vital role in the automobile transmission system because of its high strength, availability etc. On referring En series, mostly En19 and En24 are used in the transmission systems. Their property is listed below,

TABLE 1
CANDIDATE MATERIAL PROPERTIES

Materials	Ultimate strength MPa	Yield strength MPa	Hardness HB
En 19	700-1225	495-950	201-375
En 24	860-1980	740 - 1860	250-520

On comparing the two materials, both has good strength, hardness etc since both torque transmission and braking are achieved in sprocket itself, high strength material selection is the wise decision and so En24 is selected as the material for the sprocket. **Highly hardened En 24 is selected.**

D. Major Design Consideration

1) Diameter and thickness of the sprocket are maintained the same to maintain same speed and torque characteristic.
2) Brake torque is maintained the same in new system for effective braking.
3) Brake pads geometry are maintained the same.
4) Calliper has to be positioned at the non contact chain region of sprocket. The region where chain never contacts the sprocket is the non contact chain region.
5) For safer condition, braking on teeth of the sprocket can be avoided, so brake pads have to be placed accordingly.

D. Reverse engineering of sprocket, calliper and trail arm

The drafted sprocket and calliper are now redesigned in any of the modelling software like CATIA, SOLID WORKS and Pro E etc. Design has to be adapted on considering space for brake pad, relief holes (for optimal weight reduction and for better convection). The thickness of the sprocket and brake pad are maintained the same as it is in existing system. Since the thickness of the sprocket is more than the Disc rotor, the conventional spacing to accommodate the sprocket in the calliper is altered. The gap between the brake pads is increased in the calliper to accommodate the sprocket. More wear occur in between sprocket and pad so some materials will be removed after long use, since chain is also sliding on the teeth, excess of wear will occur. For safer conditions braking on the teeth of the sprocket can be avoided and brake pads have to be placed accordingly.

Trail arm has to be altered since the calliper has been repositioned. Same method and provisions for the calliper are provided in the new position and so the system is not affected. Hard rubber bedding is provided to calliper to protect it from chain sliding on calliper under any circumstances. **Here only reverse engineering for the sprocket is going to be carred out.**

E. Modelling the system

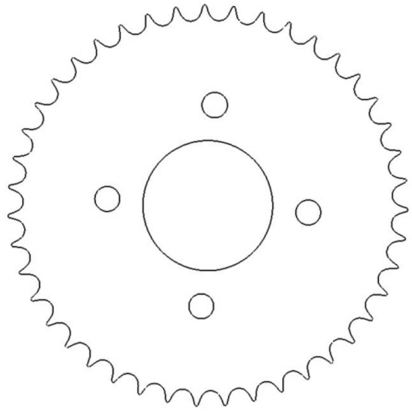


Fig. 3 Drafted sprocket

As shown in the fig 3 the existing sprocket is drafted using CMM and the relief holes are not included since that region is where the brake pads are about to be placed, for effective braking area relief holes are not considered from existing design.

Fig. 4 Drafted Brake pad

The brake pads are drafted using CMM. The surface area is calculated for the brake system calculation. The geometry of the pad is maintained the same and position of the pads are unaltered in the calliper.

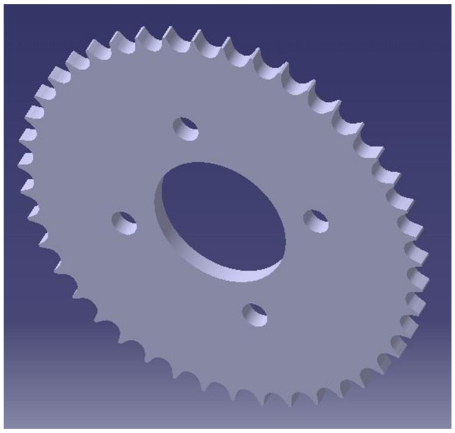


Fig. 5 3D model of sprocket

The drafted components have to be developed into 3D model using CATIA V5 R20 modelling software's and that design has to be altered to accommodate the new system. Space for the brake pad has to be provided below the addendum circle and then relief holes have to be provided for weight reduction. Convection holes are also provided to increase convection rate so that excess heat doesn't affect the system. The thickness of the sprocket is maintained the same so that the drive train is unaffected.

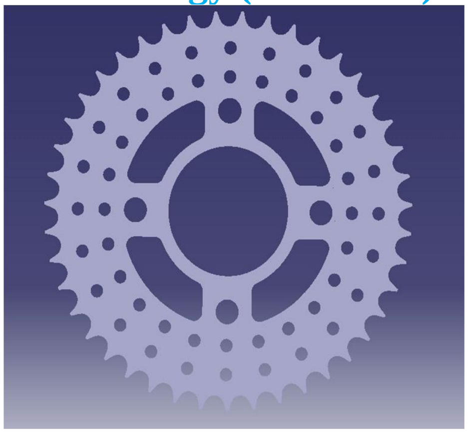


Fig. 6 Redesigned sprocket

The fig 6 shows the redesigned sprocket provided with spacing for brake pads and also relief holes are provided to optimize the design. Relief holes and convection holes are designed based on the consideration of convection and also strength. If more material s removed means the strength of the sprocket will become less and so optimal design is done to the sprocket as shown.

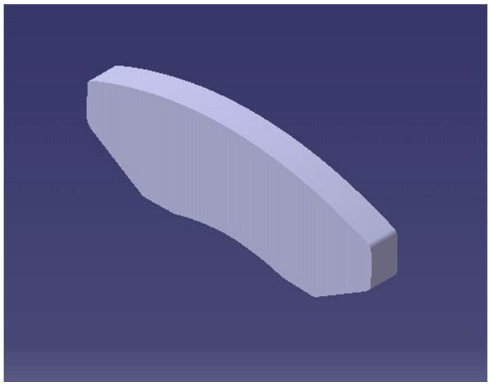


Fig. 7 Brake pad

Fig. 8 System design

The system with sprocket and brake pad position is shown in the fig 8. The brake pads are positioned as per the design considerations.

F. Existing Brake System Calculation

The existing system brake calculation has to be carried out and the same characteristic function has to be adapted in the new system. Initially the developed system pressure is calculated by considering few parameters as follows

1) Human effort on brake lever,
2) Leverage ratio,
3) Master cylinder piston diameter,
4) Calliper piston diameter and
5) Effective diameter of rotor disc.

The pressure developed in the system is calculated using the formula,

$$P = \frac{F}{A} \text{ [3]}$$

Where,
P = System pressure,
F = Force applied (human effort) and
A = Master cylinder piston area.

As per PACALS LAW the same pressure is exerted at calliper and from the obtained pressure, the force at the calliper piston can be calculated. From the calliper force (F_c), the braking torque is calculated.

Force on disc (F_d) = F_c * μ (Coefficient of friction between pads and disc) [3]

In general the coefficient of friction (μ) between pads and disc varies from 0.3~0.5 [3].

$$T_b = F_c * r_r \text{ [3]}$$

Where,
T_b = Brake torque,
F_d = Force on the disc and
r_r = Effective disc rotor radius .

From these formulas the brake system characteristics can be calculated and the same has to be maintained for the new system. Same torque formula can be used to find the maximum force acting on the sprocket generated by the chain.

Maximum torque on sprocket (T_s) = Max engine torque (T_e)*(primary gear ratio *1stgear ratio*final ratio)......(1)

Maximum force on sprocket (F_s) = Maximum torque (T_s) / Sprocket radius (r_s)..(2)

By substituting the values on referring the desired vehicle specification, all the required values will be obtained and those values are the boundary values for the sprocket analysis. Braking torque is maintained the same in the new system and so if the effective radius of the sprocket is less than the effective radius of disc rotor then alternate solution like changing the diameter of the Master cylinder has to be done.

Steady state thermal analysis has to be carried out and formulas for those are listed below and values are substituted to get the boundary values,

Heat Flux (q) = Q/t/A (W/m²) [3]..(3)
Thermal Gradient (K) = q / k (K / m)
Heat generated Q= m*Cp*ΔT [3]..(4)

Where,
m=Mass of disc
Cp=Specific Heat Capacity of desired material
ΔT= Temperature difference
A=Area of disc

t=Braking time
k=Thermal conductivity

On considering all the parameters, final design of the sprocket has to be done. Optimal design with better convection, strength has to be carried out.

G. Validating the system

The system have to be validated by simulating the results in analysing software like ANSYS, HYPER WORKS etc,. The calculated values have to be given as the boundary condition and system is analysed.

Two modes of analysis have to be carried out and they are static structural and transient thermal analysis. For example, a vehicle is selected and for that vehicle calculation is carried out and analysis is done for the modelled system as shown in Fig 8.

TABLE 2.
KTM DUKE 200 SPECIFICATIONS

Engine displacement	200 cc
Maximum torque	19.7 Nm
Maximum engine speed	12000 rpm
Primary reduction	3.272
1^{st} gear ratio	2.833
Final ratio	3
Sprocket thickness	8mm (appx)
Rear disc rotor (Outer diameter)	230mm
External diameter of pads rubbing surface	229 mm
Internal diameter of pads rubbing surface	169mm
Overall friction length of pads	55mm
Effective braking diameter	199mm
Calliper piston diameter	32mm
Co-efficient of friction between Brake pads and Disc rotor	0.4 (appx)
Rear brake lever, Leverage ratio	4:1(appx)
Maximum speed	135 kmph
Max angular velocity of wheel	165 rad/sec

The above values are substituted and boundary parameters are obtained from equation (1), (2), (3) and (4) and those will be used in the analysis of the system.

Heat Flux (q) = Q/t/A (W/m^2)
Heat generated (Q) = m * C_p * ΔT
Mass of the disc = 0.88kg (from the new design)
Developed temperature difference = 15˚c [3]
Time = 5 sec [3]
Surface area = $0.019m^2$ (from the design)
Heat generated (Q) = 0.88 * 460 * 15= 6072 J

Heat flux (q) = 6072 / 5/ 0.019 = 63915.79 W/m^2

Similarly the maximum force on the sprocket is calculated from previous equations.

Max torque = 19.7 * 3.272*2.833*3 =547.832 Nm
Where,
Radius of the sprocket = 0.086 m
So, Maximum force = 547.823 / 0.086 = 6370 N
Pressure on brake pads = 1Mpa [3]

The values obtained are applied as the boundary condition in the analysis part.

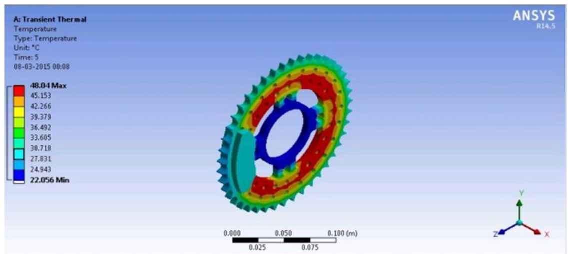


Fig. 9 Maximum temperature obtained

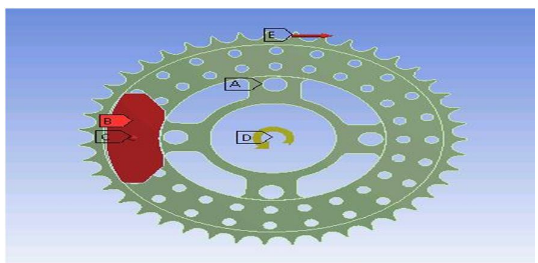


Fig. 10 Boundary condition for static structural analysis

From fig 10,

A = Fixed support, B & C= Brake pressure,
D = Angular velocity, E= Max Force on sprocket.

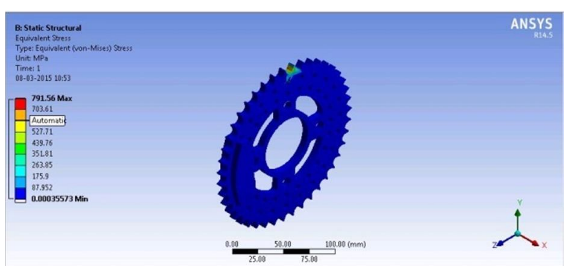


Fig. 11 Maximum stress

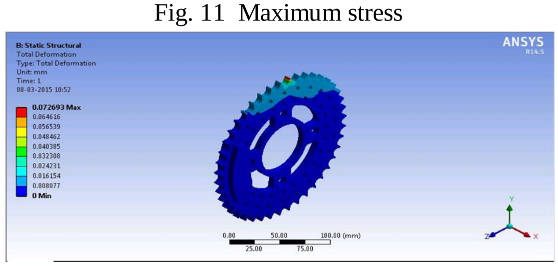


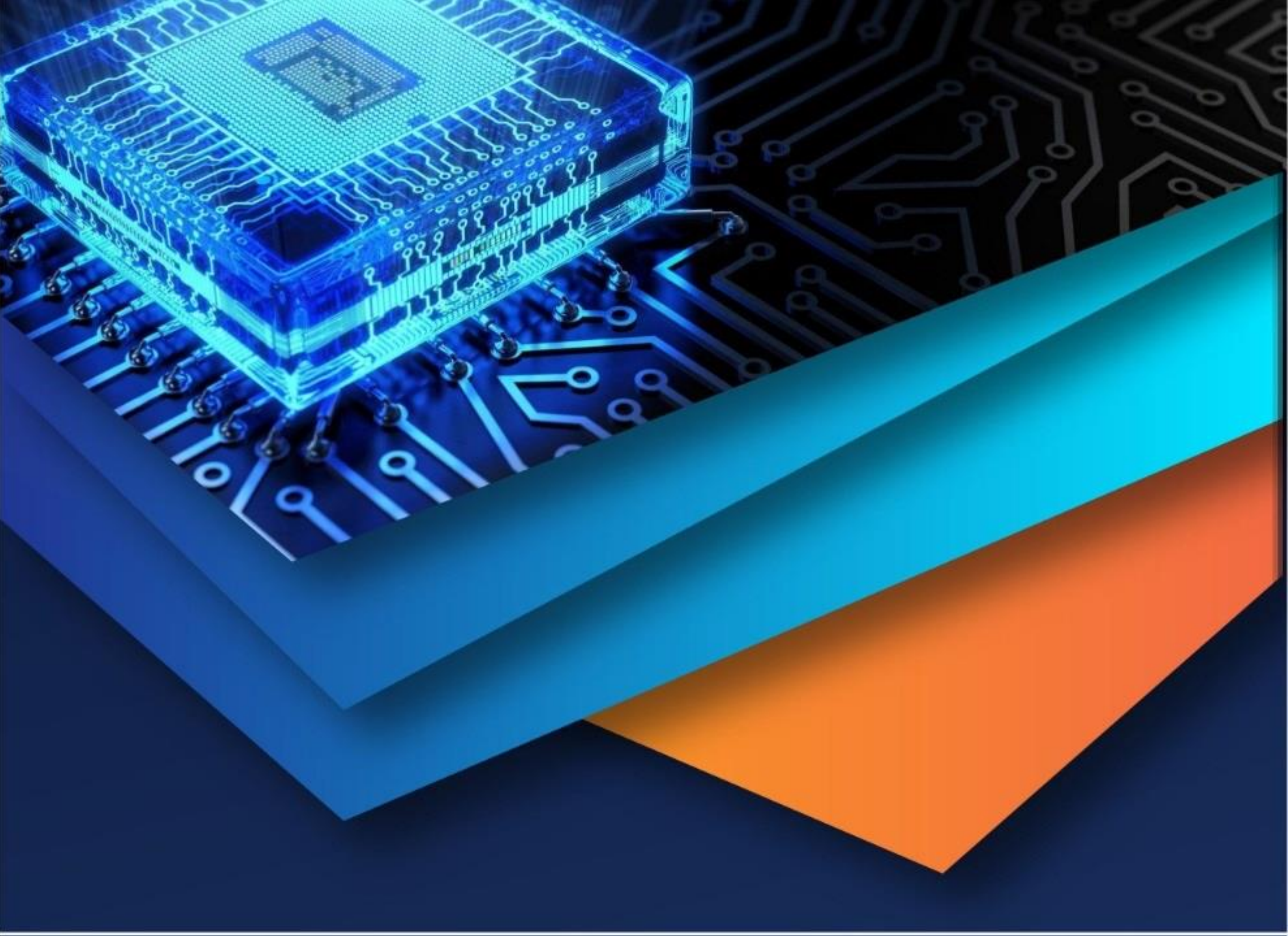
Fig. 12 Maximum deformation

III. RESULTS AND DISCUSSION

These are the general procedures to be adapted to implement braking at the sprocket. The obtained stress values are within the safer limit that defines the system is reliable to adapt. If this concept is been implemented and brake disc rotor is removed then about Rs 400 ~ 500 (approx) can be reduced from the total vehicle cost. The system can be further developed by using very low thermal expansion materials.

REFERENCES

[1] S. Thipprakmas, 'Improving wear resistance of sprocket parts using a fine-blanking process', Volume 271, Issues 9–10, Pages 2396–2401, July 2011.
[2] Ali Belhocine , Mostefa Bouchetara, 'Investigation of temperature and thermal stress in ventilated disc brake based on 3D thermo mechanical coupling model', Ain Shams Engineering Journal 4, pp 475–483. 2013
[3] Swapnil R. Abhang, D.P.Bhaskar, 'Design and Analysis of Disc Brake', International Journal of Engineering Trends and Technology (IJETT) – Volume 8-N0 4. Feb-2014.
[4] Ameer Shaik and Lakshmi Srinivas ,"Structural and Thermal Analysis of Disc Brake Without Cross-drilled Rotor Of Race Car", 'International Journal of Advanced Engineering Research and Studies', Vol. I, Issn 2249-8974, pp 39-43, 2012.
[5] V. M. Thilak , R. Krishnara Deepan & R.Palani ,"Transient Thermaland Structural Analysis of the Rotor Disc of Disc Brake ", InternationalJournal of Scientific & Engineering Research Volume 2, Issue 8, Issn 2229, 2011.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY