© August 2018 | IJIRT | Volume 5 Issue 3 | ISSN: 2349-6002

Design and Analysis of Brake master cylinder for an ATV

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Abstract- **Braking system is a means of converting momentum into heat energy by creating friction in the wheel brakes. The braking system which works with the help of hydraulic principles is known as hydraulic braking systems. The most frequently used system operates hydraulically, by pressure applied through a liquid. These are the foot operated brakes that the driver normally uses to slow or stop the car. Our special interest in hydraulics is related to the actions in automotive systems that result from pressure applied to a liquid. This is called hydraulic pressure. Since liquid is not compressible, it can transmit motion. A typical braking system includes two basic parts. These are the master cylinder with brake pedal and the wheel brake mechanism. The other parts are the connecting tubing, or brake lines, and the supporting arrangements. The present paper is about designing of Twin master cylinder system for and all-terrain vehicle and doing a feasibility study of its strength using ANSYS. Our work is focused on reducing weight which is one of the factors to increase the efficiency. Reduction in weight and space, due to its compactness. The twin Master cylinder system is a great advancement in braking system for an ATV. 3-D CAD modelling is done using SOLIDWORKS 2017, whereas the analysis of its strength is done using ANSYS.**

Index Terms- **Hydraulic system, brake, master cylinder, analysis, design, twin master cylinder**

1. INTRODUCTION

Twin master cylinder set-up:

It consists of two master cylinders each having separate hydraulic circuits in Front rear split. One master cylinder provides hydraulic pressure for the front brakes while the other provides pressure for the rear. Master cylinders are actuated by bias bar through pedals. The force provided by the driver is divided according to the necessity required to satisfy the torque required at each wheels.

II. WORKING

In the initial position when the brake pedal is not pressed, the position of piston can be seen as follows: The ports of the master cylinder are open in the initial position.

When the pedal is pressed, the piston moves forward against the spring force. The piston cup seals the compensating port. This prevents the entry of more fluid into the front section. Thus pressure starts to build up. This pressure is carried by the fluid lines to the brake caliper. When the pedal is released again, the piston returns to its original position. However, the fluid does not return to its original position at the same time. Thus, a low pressure region is developed. This is the reason why small holes are provided in the piston seat and also conical nature of piston cup. Fluid from the reservoirs enters through the inlet ports. It flows through the holes on the piston side to the low pressure area.

When the pressure becomes equal, the excess fluid is returned back to the reservoir via the compensating port.

III. CALCULATIONS

Important Parameters:

Pedal Force applied by driver (FP) = 250 N

Pedal Leverage = 4.5

Wheel Torque (Tc) = 161 Nm

Brake caliper piston diameter (Dc) = 32 mm

Maximum piston travel of caliper (Lc) = 1.5mm

Radius of disc (R) = 190 mm

Assumptions:

Deceleration = 0.8g

Coefficient of friction between tire and ground = 0.78

Coefficient of friction between pads and disc = 0.35

Dynamic weight transfer = 75.66 kg

Piston Diameter Calculations:

F_M = Force on master cylinder

$$F_M = F_P \times l$$

F_C = Force on caliper

$$F_C = \frac{T_C}{R}$$

A_C = Area of caliper piston

$$A = \left(\frac{\pi}{4}\right) \times {D_C}^2$$

P = Pressure in the system

$$P = \frac{F_C}{A_C}$$

A_M = Area of Piston

$$A_M = \frac{F_M}{P}$$

M = Master cylinder bore diameter

$$D_M = \sqrt{A_M \times \frac{4}{\pi}}$$

Stroke Length Calculations:

V = Volume displaced by caliper piston

$$V = \frac{\pi \times {D_C}^2 \times L_C}{4}$$

L_M = Stroke length of master cylinder

$$L_M = \frac{4 \times V}{\pi \times {D_M}^2}$$

IV. CAD MODELLING

3-D CAD modelling is done in SOLIDWORKS 2017 software. Topological optimization was done by making several iterations of components by comparing its strength, weight and feasibility. Final design of components are shown below:

Casing:

This part houses the piston, piston cups, washer and spring. It is designed so as to bear the pressure generated by the piston arrangement.

Material: Aluminium 7075-T6

Fig.1: Casing

Piston:

This part slides in the casing to produce the pressure.

Material: Aluminium 7075-T6

Fig.2: Piston

Spring:

This part helps in retraction of piston when the pedal is released. As soon as pedal is released, the piston comes back to its original position.

Material: ASTM A 228

Fig.3: Spring

Copper Washer:

This part is placed between the piston surface and the seal. It is used for unidirectional flow of fluid during retraction.

Material: Copper

Fig.4: Copper Washer

Piston Cup:

This part provides the sealing and holds the generated pressure until the pedal is released.

Material: EPDM

Fig.5: Piston Cup

Push rod:

This part, as the name suggests, is used to push the piston when the pedal is pressed.

Material: Mild Steel

Fig.6: Push rod

Push rod adjuster:

This part connects the push rod to the pedal.

Material: Mild Steel

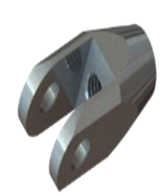


Fig.7: Push rod adjuster

Exploded view of master cylinder:

Fig.8: Master cylinder exploded view

Assembled view of master cylinder:

Fig.9: Master cylinder assembled view

V. FINITE ELEMENT ANALYSIS

Finite Element Analysis is a practical application of Finite Element Method (FEM). FEM is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It uses subdivision of a whole problem domain into simpler parts, called finite elements, and variational methods from the calculus of variations to solve the problem by minimizing an associated error function. Analogous to the idea that connecting many tiny straight lines can approximate a larger circle, FEM encompasses methods for connecting many simple element equations over many small subdomains, named finite elements, to approximate a more complex equation over a larger domain.

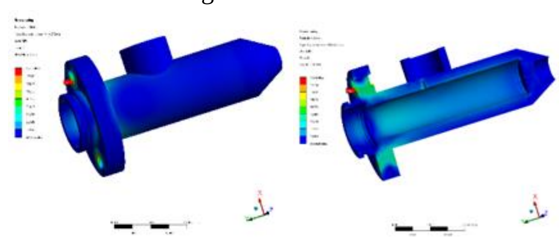
A simple structural analysis was performed as the first step to see if components were structurally strong. If a component failed with the loadings, then no need to continue stress or fatigue analysis since the component is not strong enough to be used. The analysis of the various components of the master cylinder was done in ANSYS 16.0 WORKBENCH for meshing as well as solving.

Meshing of all the parts was done in ANSYS. The mesh is generated by using tetrahedron elements of 1 mm size. Mesh quality is further improved by using proximity and curvature function. This improves mesh density where curvature is small or edges are closed in proximity.

Material used is Al 6061 with Syt=350 Mpa, Poisson's ratio=0.33 and Density=2700 kg/m3.

The boundary conditions applied are pressure generated in cylinder casing and the axial force applied through the push rod. The casing is fixed at the mounting points. For the braking system consider which is for an ATV the applied braking force is assumed to be 350 N. The force is magnify by the leverage of 4.5 provided by the pedal assembly and 1575 N force is applied by the push rod. Also the maximum pressure generated in system is applied on inner surfaces of casing.

The results of maximum stress and deformation shows that the master cylinder is safe for designed shell and mounting thickness.



(a) Casing (b) Cut section

Fig.10: FEA Model

Maximum Stress (Cylinder casing) = 177.6 Mpa

Maximum Deformation (Cylinder casing) = 0.02 mm

Maximum Stress (Piston) = 138.52 Mpa

Maximum Deformation (Piston) = 0.0108 mm

VI. CONCLUSION

The model was proposed using design oriented calculations. On the basis of study on modelling and analysis technology using ANSYS, the FEA of master cylinder was realized. The stress and deformation of the model were under control.

REFERENCES

[1] C.J.Buynacek and W.L.Winterbottom, Aluminium master cylinders.

[2] Melior, Inc., Introduction to Brake Systems – Study guide. LEXUS Technical training, Master cylinder.

[3] Thomas D. Gillespie." Fundamentals of Vehicle Dynamics."

[4] Walter W. Wright and Michael Hallden-Abberton "Polyimides" in Ullmann's Encyclopedia of Industrial Chemistry, 2002, Wiley-VCH, Weinheim.

[5] Limpert Rudolf, "Brake Design and Safety, society of automotive engineers, Warrandale, Inc, Second Edition, USA, 1992, PP 11- 157.