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Design and Optimization of Disc Brake Master Cylinder Piston by Using Various Materials

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ABSTRACT

Most of the two wheeler vehicles have disc brakes to their front wheel. The disc brake consists of master cylinder which is housing for a plunger which acts as a piston to create and push the pressurized oil into the oil hose of the front disc brake system. This piston is made of aluminum which is heavy in weight as compare to plastic. In this project we are focusing on to change the material of the piston from aluminum to plastic. We will study advantages of using plastic material in piston.Through CAE, stresses in Aluminum and Plastic will be compared. Design for manufacturability will also be checked. The advantages of the changed material piston are the low cost and superior material properties.Through experimental setup, Plastic & Aluminum Piston wear and failure modes will be validated. In Experimental setup, force on the lever will be applied through manually or though actuator. Piston will be pushed linearly and with Pascal's Law pressure will be generated. This pressurized oil will apply force on the Brake Disc through Caliper pistons.With above experiment we will get reduction in design cost and productivity improvement due to material change of the piston from metal to plastic

***Keywords*— design optimization, disc brake, experimental setup, master cylinder piston, material change.**

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I. INTRODUCTION

The piston pump according to the invention is provided in particular as a pump in a brake system of a vehicle and is used to control the pressure in wheel brake cylinders [1]. The disc brake of two wheeler consists of master cylinder which is housing for a plunger which acts as a piston to create and push the pressurized oil into the oil hose of the front disc brake system.

A. *Problem Statement*

This master cylinder piston is made up of aluminium which is heavy in weight as compare to plastic. The pistons for use in hydraulic wheel cylinders and hydraulic master cylinders of the common hydraulic brake systems are formed of aluminium and the forming process consists in die casting the metal to give it the desired shape and then grinding the outer surface of the piston to obtain a piston diameter which will conform closely to the inner diameter of the cylinder in which the piston is to be used [7]. While metals such as aluminium are satisfactory, proper combinations of non-metallic materials including some ceramics and filled hard plastic such as high glass content nylon are useful in some instances [4] . The advantages of the changed material piston are the low cost and superior material properties.

I. LITERATURE REVIEW

Schuller W., Eckstein U.,[1] had invented a piston made of plastic, which is manufactured by means of injection molding. The advantages of the plastic piston are positive sliding properties of the piston in the pump housing. In order to improve the sliding properties and to reduce wear, the plastic of the piston can have TEFLON components added to it. The piston pump, in which the piston is polytetrafluorethylene.
Hauser M., Alaze N., et al. [2] to make a piston of the piston pump easy and inexpensive to manufacture, the invention proposes that the piston be comprised of a sleeve like shaped part and a valve seat part that is made of plastic and is press fitted into the shaped part. The invention permits a small and

compact design of the piston pump. Other advantages are the fact that it is manufactured from simple and inexpensively producible components and is comprised of a small number of components. The piston is optimized with regard to its manufacture while simultaneously retaining its full functionality.

Nakamura K., [3] invented the piston and the body are made of resinous material and are molded as a single body thereby reduce the resultant weight and the cost. It is an object of the invention to provide a new and improved piston for a cylinder device.

Schardt M. M. [4] says each of the pistons has a metallic, ceramic or high glass nylon plastic core insert with glass filled nylon plastic molded around it to form the finished piston. The invention relates to master cylinder pistons which are constructed in composite form and more particularly to such pistons having a metallic, ceramic or high glass-filled nylon plastic core covered with an envelope of a suitable material such as glass filled nylon plastic molded around it to form the finished piston.

Genz O. F., Park E., et al [6] the main objective of the invention to provide a piston for a cylinder whereby a condition incident to the operation of the cylinder is turned to advantage causing the bearing and wear absorbing functions to be performed and coaxiality of the piston and cylinder is maintained.

III. PROJECT OVERVIEW

In this project, I have focused on to change the material of the piston from aluminum to plastic. The material itself may be selected from the group or groups including the nylon type of plastic or substantial equivalent [6]. Preferably the piston is made of a thermoplastic polyamide plastic such as the polyamide resins made by polymerization of a hexamethylene diamine salt of adipic acid and generally termed nylon or of polymerized tetrafluoroethylene commonly called Teflon [5]. A Piston can be made from steel stampings, although brass or other metal may be utilized. The plastic materials such as Nylon, PPS and other plastic materials are to be checked for its functionality and design for manufacturability.

IV. SCHEME OF IMPLEMENTATION

The conventional aluminum piston of the master cylinder is manufactured by the process of casting, considering the Factor of Safety (FOS) more than 2. To fulfill this requirement, the plastic piston is to be processed as follows,

1) The plastic piston is to be designed analytically by considering the Factor of Safety more than 2.
2) These dimensions are then use to draft a 3D model by using Creo CAD software.
3) This 3D model is used for analysis in Hypermesh.
4) The outcome of the Hypermesh software is to be validated with analytical results.
5) If, there is significant differences in both results then the procedures will be repeated till the results match.
6) Through CAE, the stresses in Aluminum and Plastic will be compared.
7) The design is to be checked for manufacturability.
8) This new design is to be optimized for its design.
9) The plastic piston is manufactured through machine route.
10) This manufactured piston is then to be tested for wear and tear and to be checked whether it sustains to create sufficient oil pressure.

V. LAYOUT OF SETUP

The testing rig is to be setup for experimental setup. In this testing rig the wear and tear of the piston is to be checked and validated. In this setup, force on the lever will be applied through manually or through actuator. Piston will be pushed linearly and with Pascal's Law pressure will be generated. This pressurized oil will apply force on the brake disc through caliper pistons.

The testing rig is to be set up as follows,

1) The testing rig is to be designed and fabricated.
2) On one end the two wheeler handle is joined with the disc brake assembly and brake lever.
3) At the other end of the testing rig, the actuator is positioned and bolted to apply the forces on lever.
4) This operates the lever and hence the braking assembly.
5) By using this set up, we can get the testing of piston is done for the wear and failure mode in operating condition.
6) This result is to be validated with the results of aluminum results.

VI. REMARKS

With above procedure, we will get reduction in design cost and productivity improvement due to material change of the piston from metal to plastic. We will study the advantages of using plastic material in piston. One of the advantages of the changed material piston are the low cost and superior material properties.

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It gives me great pleasure to present a paper on 'DESIGN AND OPTIMIZATION OF DISC BRAKE MASTER CYLINDER PISTON BY USING VARIOUS MATERIALS'. In preparing this paper, number of hands helped me directly and indirectly. Therefore it becomes my duty to express my gratitude towards them.

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