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Design and Structural Analysis of Master Cylinder for Pressure Loads

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Abstract: The demand for a reduction in failures in brake pedal and vibration movement without losing any wastage of raw material and machining cost has play major role for effective breaking system in vehicles. This opportunity occurs at accurate design and stress safe zone must consider in pressurizing the brake fluid inside of the master cylinder 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 break oil is known as hydraulic braking systems. The braking system used most frequently operates hydraulically, by pressure applied through a liquid. In this article, design of master cylinder is explained in details. After that designed master cylinder imported in Ansys software for performing analysis. The goals of the structural analysis are to visualize the stress distribution, deformation under static pressure condition. Dangerous stress distribution found on master cylinder and avoided those regions in manufacturing process. Unigraphics software is used for developing design.

Keywords: Unigraphics, Structural Analysis, Cylinder, Pressure Loads.

I. INTRODUCTION

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 braking system used most frequently 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. Hydraulics is the use of a liquid under pressure force or motion, or to increase an applied force. 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. Braking action starts at the brake pedal. When the pedal is pushed down then brake fluid is sent from the master cylinder to the wheels. At the wheels, the fluid pushes brake shoes, or pads, against revolving disks or drums. The friction between the stationary pads or shoes and the revolving drums or disks slows and stops them.

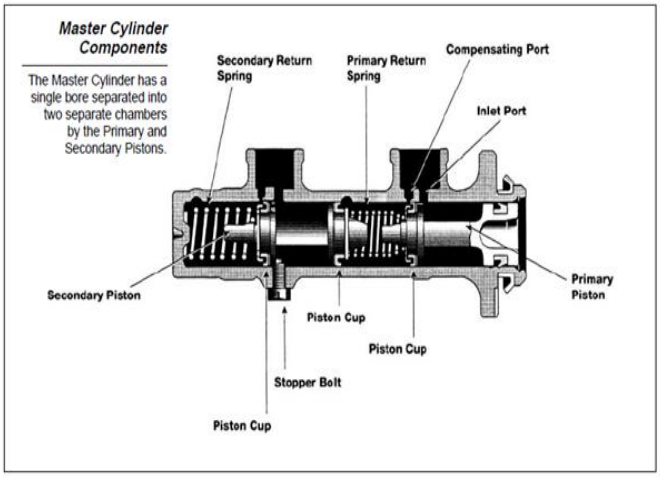

Fig.1.

When the brake pedal is released, the pistons are returned to their original position by hydraulic pressure and the force of the return springs. However, because the brake fluid does not return to the master cylinder immediately, the hydraulic pressure inside the cylinder drops momentarily. As a result, the brake fluid inside the reservoir tank flows into the cylinder via the inlet port, through small holes provided at the front of the piston, and around the piston cup. This design prevents vacuum from developing and allowing air to enter at the wheel cylinders.

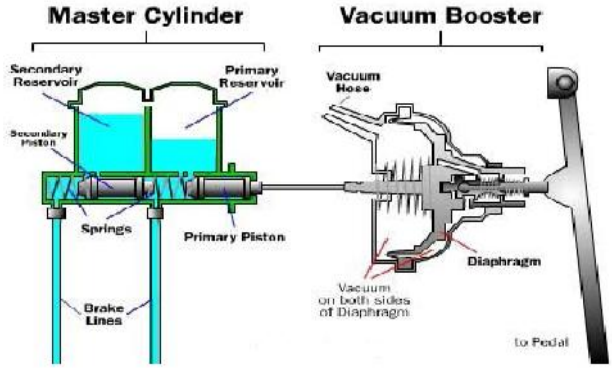

Fig.2.

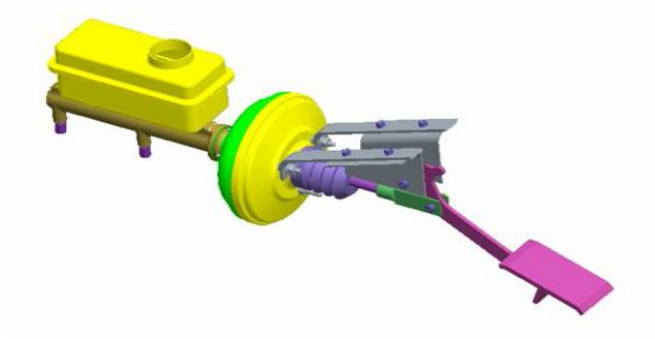

Fig.3.

A. Overview Of CAD

In the mid-1970s, as computer aided design systems began to provide more capability than just an ability to reproduce manual drafting with electronic drafting, the cost benefit for companies to switch to CAD became apparent. The benefit of CAD systems over manual drafting are the capabilities one often takes for granted from computer systems today; automated generation of Bill of Material, auto layout in integrated circuits, interference checking, and many others. Eventually CAD provided the designer with the ability to perform engineering calculations. During this transition, calculations were still performed either by hand or by those individuals who could run computer programs. CAD was a revolutionary change in the engineering industry, where draftsmen, designers and engineering roles begin to merge. It did not eliminate departments, as much as it merged departments and empowered draftsman, designers and engineers. CAD is just another example of the pervasive effect computers were beginning to have on industry. Current computer-aided design software packages range from 2D vector-based drafting systems to 3D solid and surface modelers. Modern CAD packages can also frequently allow rotations in three dimensions, allowing viewing of a designed object from any desired angle, even from the inside looking out. Some CAD software is capable of dynamic mathematical modeling, in which case it may be marketed as CAD.

II. SCOPE OF WORK

A. Scope Of The Project

In this article, the master cylinder of an automotive vacuum – suspended power brake is analyzed using advance software Ansys. The goals of the structural analysis is to visualize the stress distribution, deformation under static loads. Dangerous stress distribution found on master cylinder and avoided those regions in manufacturing process. Unigraphics software is used for developing design.

Objective of the Project: The objective of my project is to do design of master cylinder is explained in details. After that designed master cylinder imported in Ansys software for performing analysis. The goals of the structural analysis are to visualize the stress distribution, deformation under static pressure condition.

Limitations: In this work, static analysis of master cylinder is done by using light weight material like Aluminium. The performance of the component under maximum hydraulic pressure conditions.

III. 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 polytetrafluor ethylene. 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.

IV. METHODOLOGY

A. The methodology followed in the project is as follows

- Initially, Literature survey is done on the project by downloading international journals.
- 3D modeling of the master cylinder is done using UNIGRAPHICS.
- Boundary conditions and loading are evaluated and applied on the model.
- Static analysis is done using Ansys software.
- Deflections and stress are calculated from the analysis.
- Results are plotted and documented
- Conclusions are made from the results

V. INTRODUCTION TO UNIGRAPHICS SOFTWARE

A. Unigraphics Introduction

NX is one of the world's most advanced and tightly integrated CAD/CAM/CAE product development solutions. Spanning the entire range of product development, NX

delivers immense value to enterprises of all sizes. It simplifies complex product designs, thus speeding up the process of introducing products to the market. The NX software integrates knowledge-based principles, industrial design, geometric modeling, advanced analysis, graphic simulation, and concurrent engineering. The software has powerful hybrid modeling capabilities by integrating constraint-based feature modeling and explicit geometric modeling. In addition to modeling standard geometry parts, it allows the user to design complex free-form shapes such as airfoils and manifolds. It also merges solid and surface modeling techniques into one powerful tool set. Our previous efforts to prepare the NX self-guiding tutorial were funded by the National Science Foundation's Advanced Technological Education Program and by the Partners of the Advancement of Collaborative Engineering Education (PACE) program. NX is a premier 3D computer aided design suite. It allows you to model solid components and assemblies, to perform engineering analyses such as mechanism simulation and stress analysis, to create tool paths for computer-based manufacturing processes and to perform numerous other engineering design activities in a single software environment. Software suites like NX are referred to as product lifecycle management (PLM).

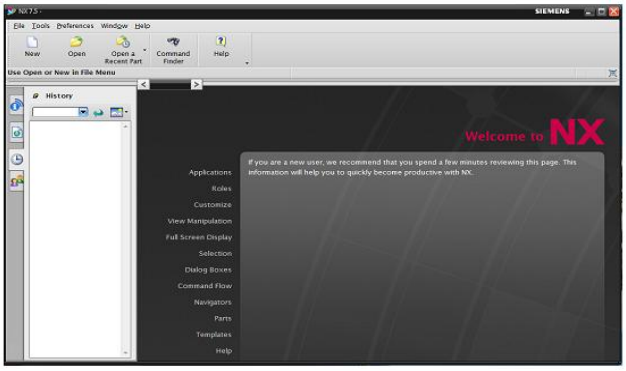

Fig.4.

VI. 3D MODELING OF MASTER CYLINDER

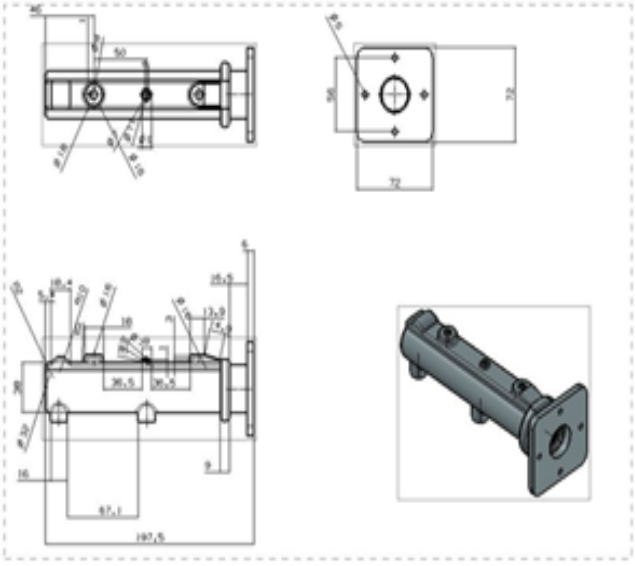

Fig.5. 2D sketch of the master cylinder.

Isometric view:

Fig.6.Isometric view of master cylinder.

VII. FINITE ELEMENT METHOD

Considered as an assemblage of these elements connected at a finite number of joints called "Nodes" or "Nodal Points". Simplefunctions are chosen to approximate the displacements over each finite element. Such assumed functions are called "shape functions". This will represent the displacement within the element in terms of the displacement at the nodes of the element. The Finite Element Method is a mathematical tool for solving ordinary and partial differential equations. Because it is a numerical tool, it has the ability to solve the complex problems that can be represented in differential equations form. The applications of FEM are limitless as regards the solution of practical design problems. Due to high cost of computing power of years gone by, FEA has a history of being used to solve complex and cost critical problems. Classical methods alone usually cannot provide adequate information to determine the safe working limits of a major civil engineering construction or an automobile or an aircraft. In the recent years, FEA has been universally used to solve structural engineering problems. The departments, which are heavily relied on this technology, are the automotive and aerospace industry. Due to the need to meet the extreme demands for faster, stronger, efficient and lightweight automobiles and aircraft, manufacturers have to rely on this technique to stay competitive.

Organization of the Ansys Program: The Ansys program is organized into two basic levels:

- Begin level
- Processor (or Routine) level

The begin level acts as a gateway in to and out of the ANSYS program. It is also used for certain global program controls such as changing the job name, clearing (zeroing out) the database, and copying binary files. When we first enter the program, we are at the begin level. At the processor level, several processors are available; each processor is a set

of functions that perform a specific analysis task. For example, the general preprocessor (PREP7) is where we build the model, the solution processor(SOLUTION)is where we apply loads and obtain the solution, and the general postprocessor(POST1) is where we evaluate the results and obtain the solution. An additional postprocessor (POST26), enables we to evaluate solution results at specific points in the model as a function Of Time.

Performing A Typical ANSYS Analysis: The ANSYS program has many finite element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. The analysis guide manuals in the ANSYS documentation set describe specific procedures for performing analysis for different engineering disciplines.

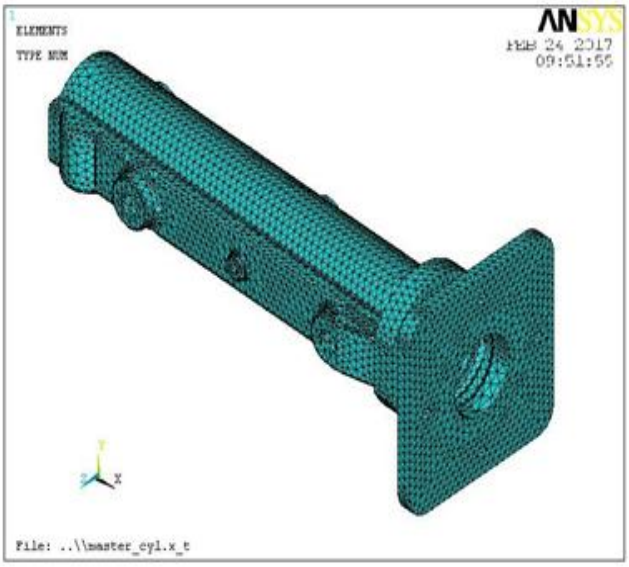

Fig.7.

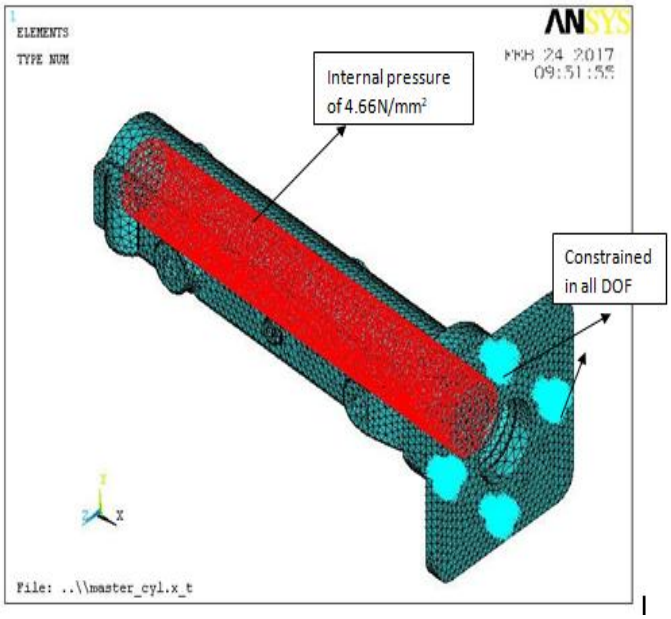

Fig.8.

VIII. RESULTS AND DISCUSSIONS

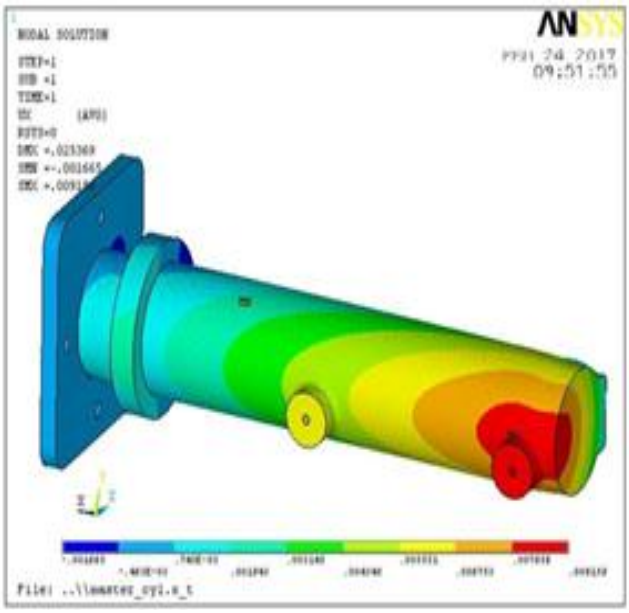

Fig.9.Displacement in X-direction.

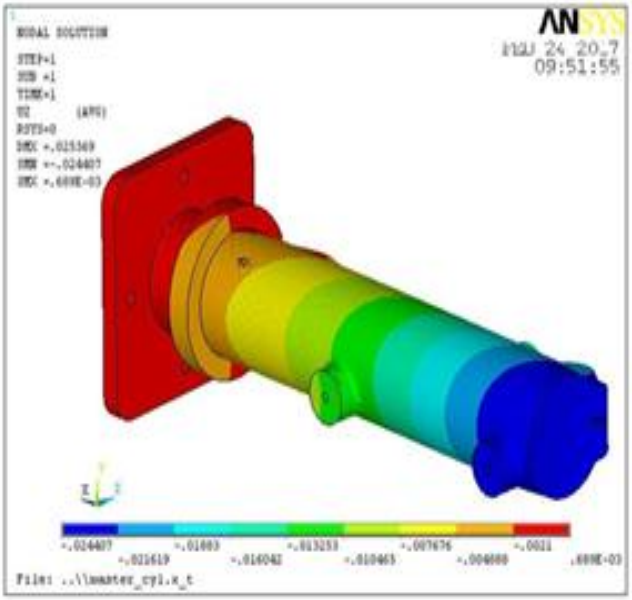

Fig.10. Displacement in Z-direction.

IX. CONCLUSION

- Static Stress analysis of the master was carried out with the internal pressure applied.
- From The analysis it is observed that the maximum VonMises stress induced in the master cylinder is 39.21 Mpa
- From The analysis it is observed that the maximum deformation of the master cylinder is 0.25mm
- As per design the working tensile strength of master cylinder is 172 N/mm2
- From the analysis it is concluded that VonMises stress is 39.218Mpa, which is below the tensile yield strength. So, the design is safe.

Future Scope: As a future work, harmonic and transient analysis of the master cylinder can be performed to find out the effect of various cyclic loading conditions along with temperature variations.

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