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DESIGN AND FEA ANALYSIS OF VEHICLE LIFTING HYDRAULIC CYLINDER – APPROACH USING CAD AND CAE

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Abstract:-*Many machines and machine mechanisms run under dynamic working conditions. The vibrations produced under dynamic conditions affect many important design parameters such as strength, production costs, productivity. Fatigue life also plays a vital role in design of any part. For analysis of fatigue life in a high-cyclic range ANSYS is used. This paper focuses on the review of various papers based on the CAD and CAE FEM techniques used by various authors to eliminate or minimize the errors/ failures during the working of hydraulic cylinder.*

This paper explains the study of the literature, it is considered that the moving load acts on to the beam periodically and dynamic results of these periodical loading are analyzed. According to this analysis, under the longer periodical loading conditions, the dynamic magnification becomes larger.

M/s.Vaidharbhi Motors, Morshi Road, Amravati is a small scale automotive service point working from last 10 years in this area, where approximately 25-30 numbers of vehicles daily visited for service and repair purpose. Hydraulic cylinder with ELGI Hydraulic Two Post Lift with Single Cylinder is used by the organization for lifting the vehicle. They want to improve the performance of the available hydraulic cylinder by CAE analysis and want a new improved material suggestion.

Keywords: *Dynamic analysis, hydraulic cylinder, finite element method, ANSYS, dynamic magnification factor*

1.0 INTRODUCTION

A hydraulic cylinder also called a linear hydraulic motor is a mechanical actuator that is used to give a unidirectional force through a unidirectional stroke. It has many applications, notably in construction equipment (engineering vehicles), manufacturing machinery, vehicle lifting and civil engineering.

An actuation device that makes use of a pressurized hydraulic fluid is known as a hydraulic pump. This mechanism is used for producing linear motion and force in applications that transfer power. In other words, a hydraulic cylinder converts the energy stored in the hydraulic fluid into a force used to move the cylinder in a linear direction.

1.1 INDUSTRY DETAILS

Vaidarbhi Service Centre (Car Repair & Services) is retailer cum service provider; it is in the business of automotive products as well as full-scale automotive services since 2008. This establishment offers comprehensive car and bike care across the city through its wide network, comprising of multiple stores and mobile vehicles. Find a vast range of automotive products such as tyres, batteries, alloy wheels, oil, accessories and genuine parts for cars, two-wheelers and commercial vehicles. Run by professionals in a professional manner, this dealer looks to deliver beyond expectations when providing world-class products and services to their customer's day in and day out. It employs a proficient and competent team of sales personnel and technicians, who uphold this firm's commitment towards offering impeccable services.

2.0 SIMULATION PROCEDURE STEP BY STEP

After the launch of ANSYS Workbench software, Home screen appear as shown in figure 3.1.

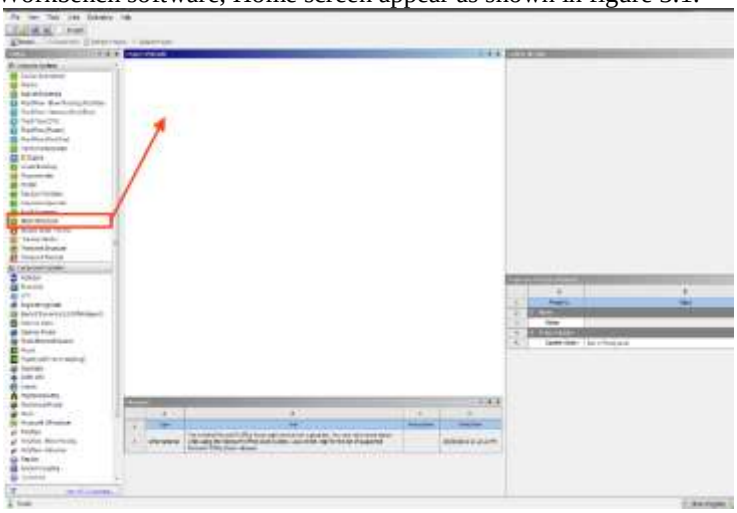


Figure 2.1 Home Screen of ANSYS Workbench Software

Now select the type of analysis and follow the steps as mentioned below

Step 1: Pre processing (Setting up the Model)

Select the Static Structural analysis. It can be found in the Toolbox on the left, and needs to be added to the Project Schematic by either double clicking it, or dragging it into the pane.

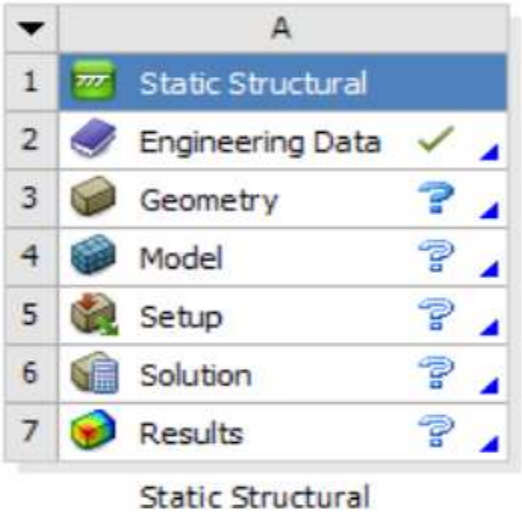


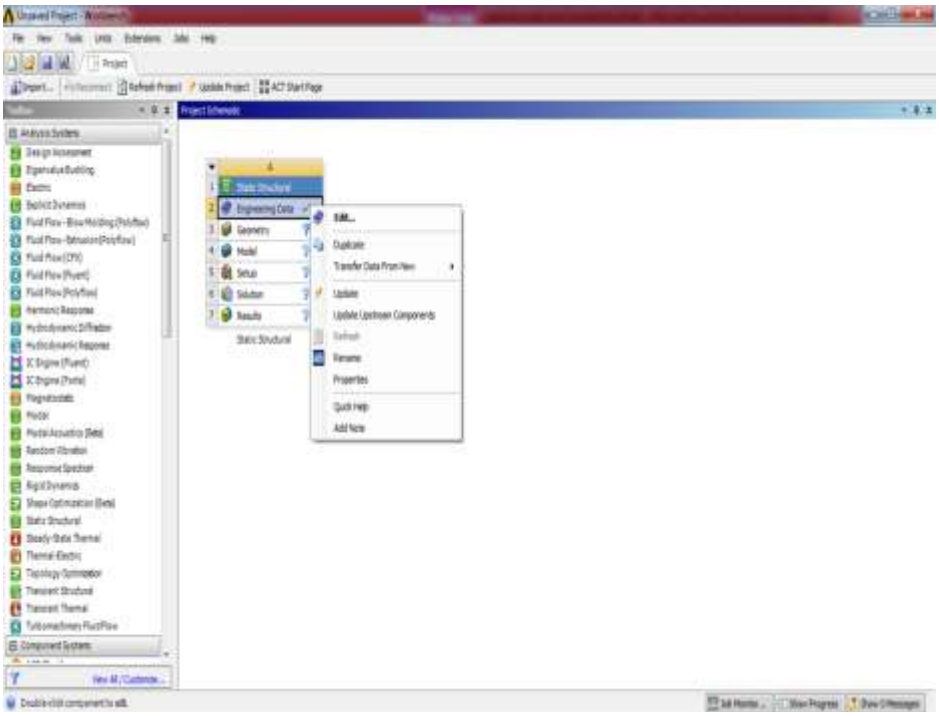
Figure 2.2 Static Structural Analysis Details

Engineering Data module is used to define the material properties. Geometry module opens the Design Modeler application, which can be used to import CAD models from other software like PROE or to sketch a new 2D or 3D geometry.

Model, Setup, Solution, and Results modules opens the Mechanical application, which can be used to set up and solve the simulation (includes meshing, load and boundary condition applications, solving, and results

Step 2: Engineering Data

Double click Engineering Data. Here a new material can be added by defining a new material entry. Load all the material properties for Brass CuZn Ally, steel alloy with Cu, Mn alloy with Cu one by one. Important properties are Young's Modulus, Poisson Ratio, and Density etc



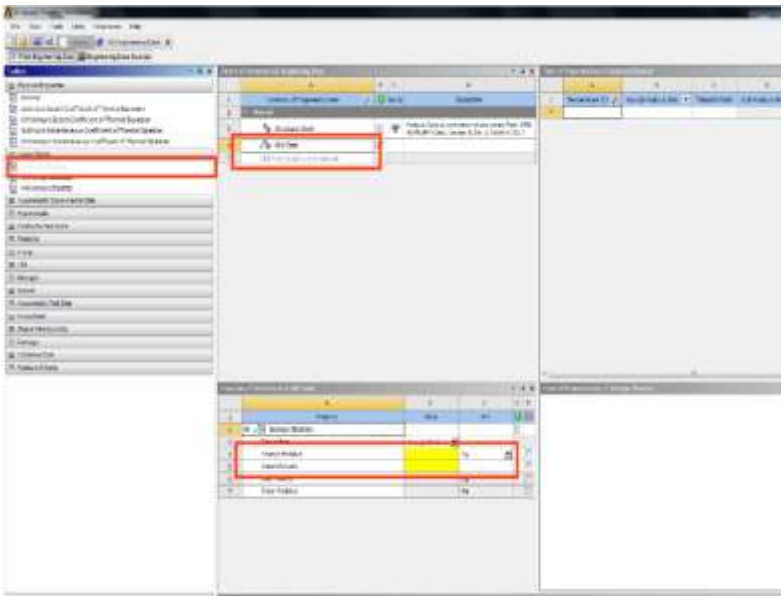


Figure 2.3 Material Data Loading

Step 3: Model for Analysis

Ansys Workbench can use already created model or can allow user to create the model in its Design Modeler directly. Here in this project the CAD model created already in ProE is used for more accuracy. The IGES file is then imported to Design Modeler.

IGES - Initial Graphics Exchange Specification is a neutral file format designed to transfer 2D and 3D drawing data between dissimilar CAD systems like ProE to Ansys. The IGES standard defines two file formats: fixed-length ASCII, which stores information in 80-character records, and compressed ASCII.

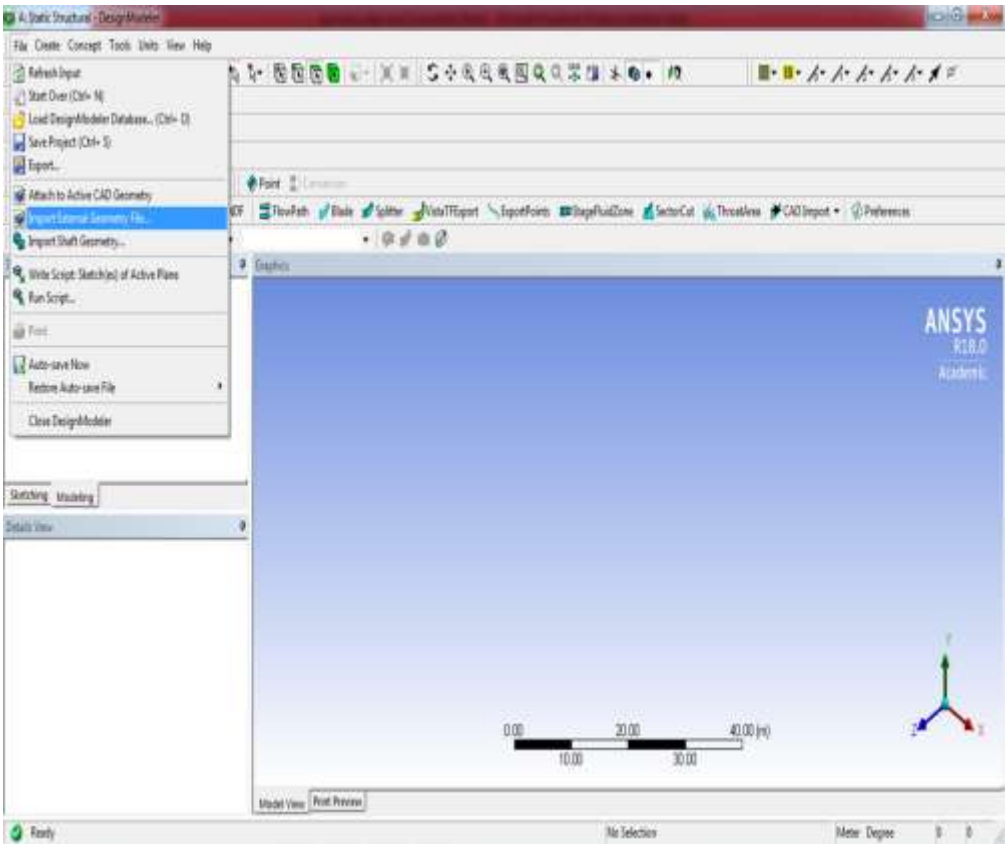


Figure 2.4 Import of External Geometry File

Step 4: Do the initial settings of Mesh

Step 5: Give all boundary conditions and Inputs for analysis

Step 6: Take all output results required

Step 7: Do Analysis Settings

This is very important step which depends on the type of geometry, loading condition, linear non linear behavior of load, meshing styles, material properties etc. Generally these settings takes more time in analysis part and if not properly done then the results are not proper.

After the analysis is done with supplied materials having fixed boundary conditions results obtained are as shown in table 3.1

3.0 SIMULATION RESULT AND COST ANALYSIS

Table 3.1: Results obtained for all Material

Input Conditions	**Plunger is Made up of High Grade Steel**				
	Up to 1mm coating we can do (As per Industry Data)				
	Fine size with **tetrahedron type of mesh**				
	Ambient Temperature **350C**				
	Pressure applied is **1.1768 Mpa (design Pressure)**				
	Force 40000N Downward (Capacity)				
Results					
	Original Without Coat	**With 0.5 mm Coat**		**With 1 mm Coat**	
ANSYS Results Comparison					
Material Used	High Grade Steel	Vanadium	Chrome	Vanadium	Chrome
Total Deformation Value	**2.499 mm**	2.0029 mm	2.4907 mm	1.7325 mm	2.0054 mm
Equip. Stress	**97.114 Mpa**	86.713 Mpa	53.133 Mpa	54.779 Mpa	50.499 Mpa
Shear Stress	**9.9057 Mpa**	9.6836 Mpa	7.4175 Mpa	7.2535 Mpa	6.6832 Mpa
Normal Stress	**36.762 Mpa**	28.499 Mpa	34.207 Mpa	23.1 Mpa	28.427 Mpa
Safety Factor	**1.5736**	0.95418	1.6223	0.85199	1.6385

Table 3.2: Cost analysis

Cost Comparison					
Area of Base of coating material		4.2 cm2		8.5094 cm2	
Volume		640.5 cm3		1297. 69 cm3	
Density of material		6.7 gm/cm 3	7.15 g/cm3	6.7 gm/cm 3	7.15 g/cm3
Weight of coating Required		4291.3 5 gm	4579.5 75 gm	8694.5 23 gm	9278.4535 gm
		4.3 Kg	4.6 Kg	8.7 Kg	9.3 Kg
Cost Per KG		1930.5	182	1930.5	182
Total Cost of Coating		8301.1 5	837.2	16795. 35	1692.6

4.0 CHROME RESULTS FOR 0.5 MM COAT AND 1 MM COAT

4.1 Total Deformation Results

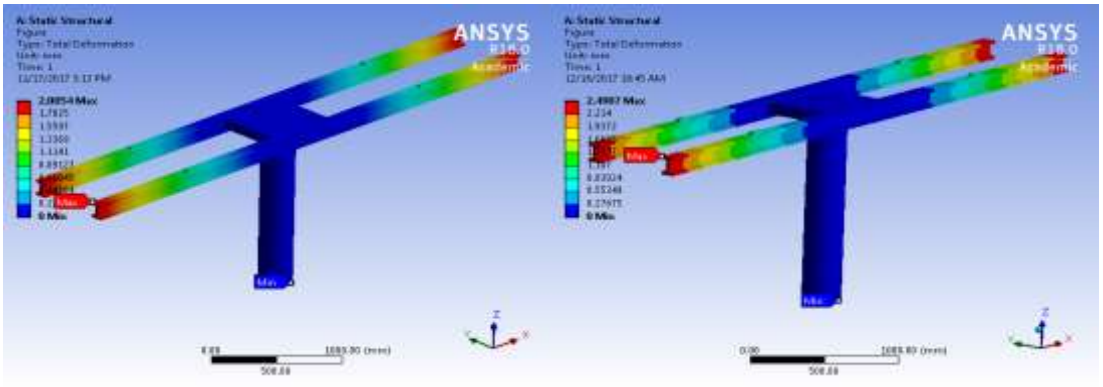
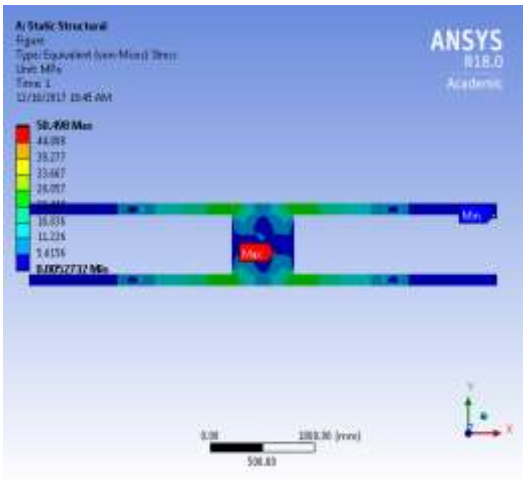


Figure 4.1 Total Deformation Results 0.5 mm and 1 mm

4.2 Equivalent Stress Results



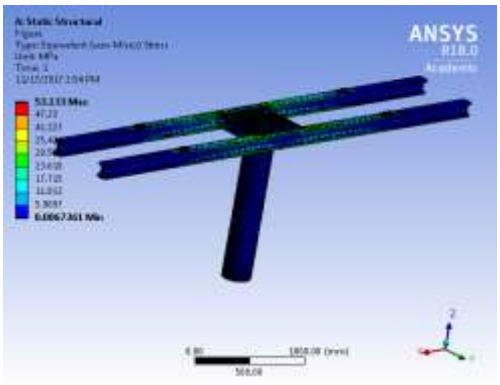


Figure 4.2 Equivalent Von Mises Stress Results0.5 mm and 1 mm

4.3 Shear Stress Results

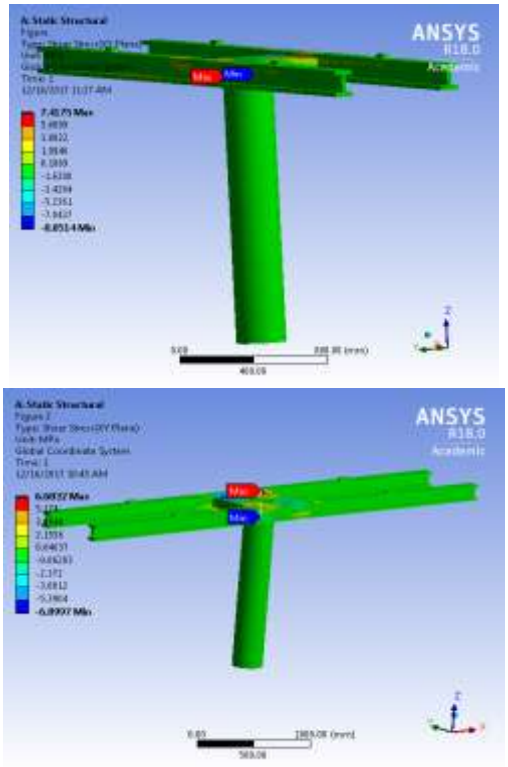
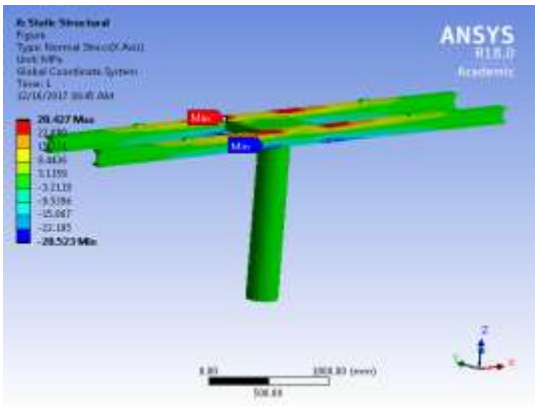


Figure 4.3 Shear Stress Results 0.5 mm and 1 mm

4.4 Normal Stress Results



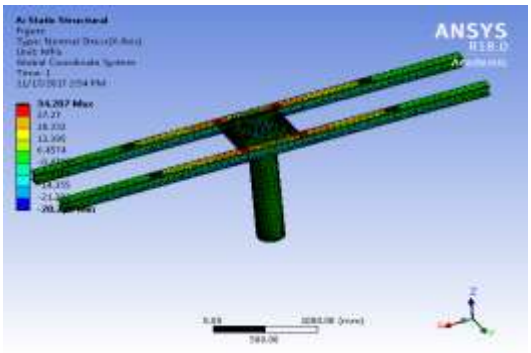


Figure 4.4 Normal Stress Results 0.5 mm and 1 mm

4.5 Safety Factor

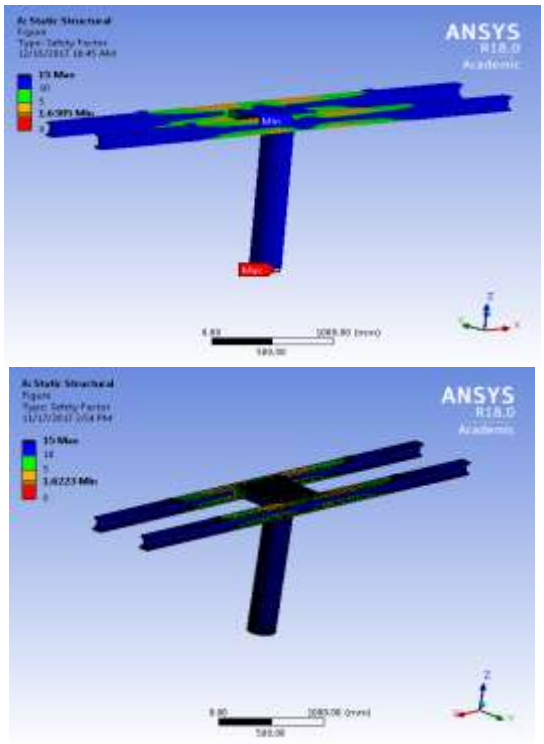


Figure 4.5 Safety Factor Results 0.5 mm and 1 mm

5.0 CONCLUSION

- The coating material for specified depth of material coat (as per company) is suggested to industry as Chromium.
- CAD model of existing and with coating material is prepared by PROE wildfire 4.0 and is tested under ANSYS workbench 18.0.
- After FEM analysis using ANSYS workbench the result for total deformation, equivalent stress, shear stress, normal stress and safety factor it is clear that existing material is having less life and can work for less period for existing pressure condition of 1.1768 Mpa.
- The two materials having nearly same material behavior are tested for two different coating thickness values i.e. 0.5 mm and 1 mm. It is found that Chrome is best suitable material as per as results of FEA.
- The cost analysis is also performed and it is found that the chromium is less expensive than vanadium for same material coat thickness.
- The optimization of the hydraulic cylinder for its coating material is carried out by means of FEM analysis using ANSYS workbench which is explained in this paper.

5.1 FUTURE SCOPE

- ➢ The flow dynamics i.e. Motion of the liquid inside the cylinder and its turbulence or pressure can be considered in CFD analysis for future study.
- ➢ Vibrational factors if any can be studied in depth, if required.
- ➢ Similar types of Hydraulic cylinder with different capacity of loading can be tested with the current results and current boundary conditions.

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