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Modelling and Analysis of Hydraulic Cylinder Using ANSYS Parametric Design Language

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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. Under this title we study, the vibration analysis of a hydraulic cylinder subjected to dynamic loads. Computer aided engineering (CAE) procedures are used to analyse the dynamic response of the cylinder walls. The finite element methods used in the analysis are applied by a computer aided design and analysis software ANSYS. The studies on the moving load are extended to the hydraulic cylinder .The finite element model of the cylinder is created. An ANSYS APDL code is developed to obtain the time-histories of the nodal excitation functions of the pressure loading created by the movement of the piston in cylinder. APDL stands for ANSYS Parametric Design Language, a scripting language that one can use to automate the common tasks or even building the model in term of parameters.

***Keywords*-: Hydraulic Cylinder, Dynamic Analysis, Finite Element Method, ANSYS Software, Dynamic Magnification Factor.**

INTRODUCTION -:

Hydraulic systems are widely used systems in industry. While they are used widely in the industry, the system components like pumps, valves, cylinders are always became investigation topics in the history. Hydraulic cylinders are one of the most common components of the hydraulic systems used in many engineering applications like; automatic manufacturing and montage lines, heavy construction equipments, control systems, sensitive measurement and test systems. They are used for producing linear motion in the hydraulic systems and they convert hydraulic energy to mechanical energy.

One of the most important factors considering at the design step of these equipment is working conditions of cylinder. Cylinders have different working frequencies according to their usage fields. While the huge sized cylinders used in system that requires higher force and power inputs, work generally in lower frequencies, the small sized cylinders used in sensitive application fields like test and measurement systems can have higher working frequencies. At the lower working frequency situations, pressure effect on the cylinder is considered as static load, and the hydraulic system equipments are designed according to this criterion. Besides this, at the design procedure of cylinders with higher working frequencies, the dynamic effect with respect to instantaneous change of pressure must be taken into consideration as well as the static analysis.

LITERATURE SURVEY-:

Tzeng & Hopkins (1996) study the dynamic response of composite cylinders subjected to a moving internal pressure. Tzeng (1998) also analyses the resonance of stress waves in the cylinder at the instant and location of the pressure front passage, when the velocity of the moving load approaches to the critical velocity. De Faria (2004) investigates the vibration of a cylinder panel with a moving force or mass by using finite element method. He analyses the effect of the panel curvature, moving load velocity and the moving mass to main structure on the dynamic response. He observes that the dynamic response of the cylinder is significantly affected by rapid traversing velocity or heavy moving masses. Beltman & shepherd (2002) suggest that the flexural waves can result in much higher strain and stress than static loading with the same loading pressure .The wave propagation in a hollow cylinder is analysed for pressure and velocity prescribed at its inner boundary (EI Rahep,2004).

The dynamic loading of cylinder can be classified as a moving load problem in which various parameters play a role. The moving load problem is studied by engineers and researchers for many years and is still an interesting engineering subject. The studies on the moving load problem are generally focused on the moving load on beams which are elastically supported or not supported.

A basic study upon the moving load problem and reference data is given by Olsson(1991).Olsson studies the dynamic of the beam subjected to a constant force moving at a constant speed and presents analytical and finite element solutions. Thambiratnam & Zhuge (1996) study the dynamic of beam on an elastic foundation and subjected to moving load by using the finite element method .they investigated the effect of the foundation stiffness, travelling speed and the spam length of the beam on the dynamic magnification factor which is define as the ratio of the maximum displacement in the time history of the mid-span to the static mid-span displacement. Recently, Gutierrez & Laura (1997) consider the beam with non- uniform cross section and present the analytical and approximate solution for different boundary conditions. Wang (1997) analyses the multi -span Timoshenko beams subjected to a concentrated moving force by using a mode superposition method and made a comparison between the Bernoulli-Euler beam and Timoshenko beam. Wu & Shih (2000) study the dynamic responses of railway and carriage under the high-speed moving loads and consider the action of the multi-roller carriage. They employ the finite element method in the solution and investigate the influence of the total number of carriage and the spacing between the rollers on the dynamic response of the railway. Rao (2000) investigates the inertial effects of the moving load by using the mode superposition method and made a comparison between the moving mass models. The experimental studies on the moving force identification are carried out by law et al. (1999), Law & Zhu (2000) and Chan et al. (2000).Recently N.Upendra (2014), P.Moulali (2014) investigates the study hydraulic and pneumatic system components are modelled with the computer aided static and modal analysis performed by using finite lement methods. These studies are addressed to the inverse problem in which the forces acting on the structure are identified by using the vibration responses without the knowledge of the vehicle characteristic.

In this study, a brief summary is given about the theory of dynamic analysis used in the CAE program ANSYS. Then, the moving load problem on beams is analysed which forms the basis of the hydraulic cylinder dynamic analysis. The vibration response of a simple supported beam with and without elastic foundation to a moving single point load is analysed performing the finite element vibration analysis. The dynamic magnification value versus the load travelling speed obtained and compared with the results of the similar studies in the literature. Finally, the dynamic model of the hydraulic cylinder is created. The geometry and the finite element model of the cylinder are given. The method for generating the nodal excitation functions is described. The finite element vibration analysis and selection of the time step is described. Dynamic magnification values obtained under the action of pressure loading are presented for the hydraulic cylinder.

The studies on the moving load are then extended to the hydraulic cylinder. The finite element model of the cylinder is created. An ANSYS APDL code is developed to obtain the time- histories of the nodal excitation functions of the pressure loading created by the movement of the piston in the cylinder. APDL stands for ANSYS Parametric Design Language, a scripting language that one can use to automate the common tasks or even building the model in term of parameters. The working pressure and the piston velocity are considered in defining the loading functions. The vibration analysis of the hydraulic cylinder is performed by using ANSYS after creating nodal excitation functions. The dynamic magnification values are calculated for various piston velocities. It is observed that the dynamic magnification value is dependent to piston velocity. Furthermore, the effects of damping in the dynamic analysis are investigated. As a result, it is observed that the finite element programs like ANSYS can be used to create the dynamic loading models of the hydraulic or pneumatic cylinders.

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WORKING METHODOLOGY-:

1. Design is carried out by modeling the cylinder in terms of beam.
2. Analysis of beam is carried out using ANSYS with applicable pressure.
3. Modeling of cylinder with APDL language.
4. Analysis of cylinder with APDL language

The dynamic analysis involve the transient dynamic analysis:-Transient dynamic analysis (sometimes called time-history analysis) is a technique used to determine the dynamic response of a structure under the action of any general time-dependent loads. This type of analysis can be used to determine the time- varying displacements, strains, stresses, and forces in a structure as it responds to any combination of static, transient, and harmonic loads. The time scale of the loading is such that the inertia or damping effects are considered to be important. If the inertia and damping effects are not important, it might be able to use a static analysis instead.

The transient analysis solution method used depends on the DOFs involved. Structural, acoustic, and other second order systems (that is, the systems are second order in time) are solved using one method and the thermal, magnetic, electrical and other first order systems are solved using another. Each method is described subsequently. If the analysis contains both first and second order DOFs (e.g. structural and magnetic), then each DOF is solved using the appropriate method.

The transient analysis of the hydraulic cylinder is performed in the solution task of the CAE program ANSYS. The set of equations for the forced and undammed vibration of a system by using the finite element methods is formed as follows:

[M]{&u&}+ [K] {u} = {f (t)}

Where;

[M] Is the mass matrix?

{&u&} is the acceleration vector,

{U} is the displacement vector

And {f (t)} is the time-dependent force vector defined to pressure loading. For the nodes subjected

Both the full solution method and the mode-superposition method are used in the transient analysis. Although, set of desired mode-shapes can be considered in the mode-superposition method, all extracted mode shapes are taken into consideration in the solution of the system. By considering all extracted modes in the mode superposition method, a similar solution to the full solution is done and also more shorter run-times are obtained with respect to full solution method.

There are three methods available for Transient dynamic analysis:-

1. The Full Method
2. The Reduced Method
3. The Mode Superposition Method.

The all three methods are good but for this project we prefer the mode superposition method which gives the better result for mode analysis.

The mode superposition method sums factored mode shapes (eigenvectors) from modal analysis to calculated the structure's response. This is the only method available in the ANSYS / Linear plus program.

Its advantages are:

- It is faster and less expensive than the reduced or the full method for many problems.
- Element loads applied in the preceding modal analysis can be applied in the transient dynamic analysis.
- It accepts modal damping.

The mode superposition method uses the natural frequencies and mode shapes of a linear structure to predict the response to transient forcing function. This solution method imposes the following additional assumption and restrictions:

- Constant [K] and Matrices [M]. This implies no large deflection or change of stress stiffening, as well as no plasticity, creep, or swelling.
- Constant time step size.
- There are no element damping matrices, however various types of system damping are available.
- Time varying imposed displacement is not allowed.

APDL language of the ANSYS software is used for creating the model and performing the analysis of this study. APDL stands for ANSYS Parametric Design Language, a scripting language that one can use to automate the common tasks or 38 even building the model in term of parameters. APDL also includes a wide range of other features such as repeating a command, macros, if-then-else, do- loop cycles, and scalar, vector or matrix operations. Every important modeling and analysis parameter used in these codes is parameterized. This makes it possible to analyze many different situations.

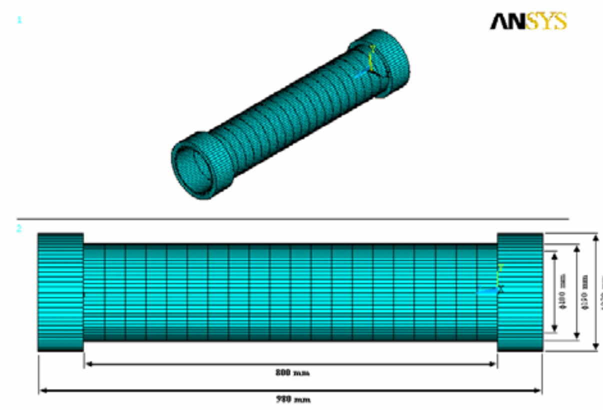

Fig. 1.1 **:- Model of Double Acting Hydraulic Cylinder**

A double-acting hydraulic cylinder is used in the analysis. The model is created as finite elements to ensure the variation of parameters easily when is needed instead of using any solid model software. Nodes are created by do-loop and if-then cycles and the elements are created from nodes in the APDL codes in the preparation of the model. Hydraulic cylinder, modeled as finite element, is made of steel.

The properties of steel are given at Table (a):-

Material properties of cylinder	
Material properties of cylinder	E 203 GPa
Poisson Ratio	*n* 0.3
Density	7869 Kg / m3

In the analysis, two different boundary conditions are considered for the hydraulic cylinder. It is assumed that, the cylinder is directly installed to the other components or to the body in two different mounting types and the static and dynamic analyses is made for these two mounting types.

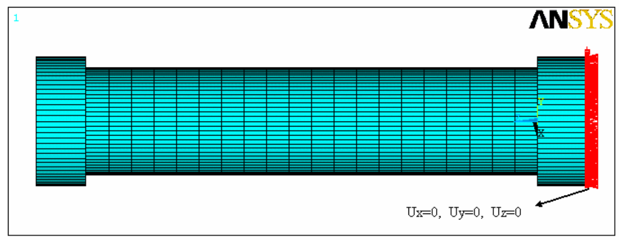

***Fig. 1.2*:- Boundary condition a) Bc-type 1**

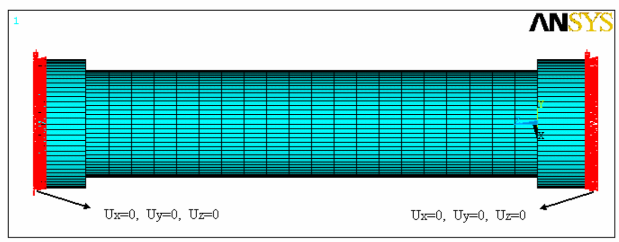

***Fig. 1.3*:- Boundary condition b) Bc-type 2**

Working pressure of cylinder is taken as 250 bars and the pressure load is applied statically to the inner surface of cylinder. The region that pressure applied is considered as stroke region of the piston.

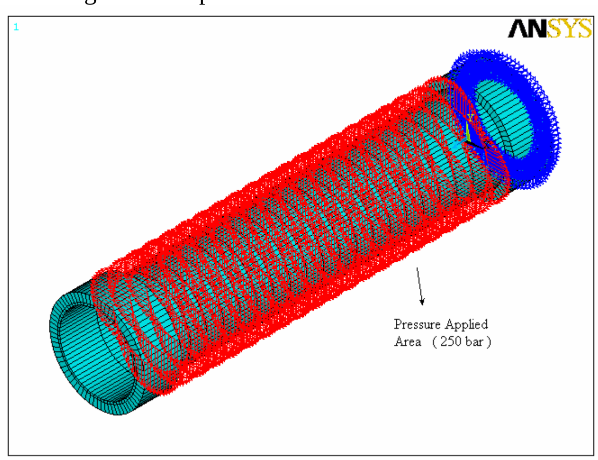

***Fig. 1.4*:- Cylinder filled with 250 bar pressure (Isometric view)**

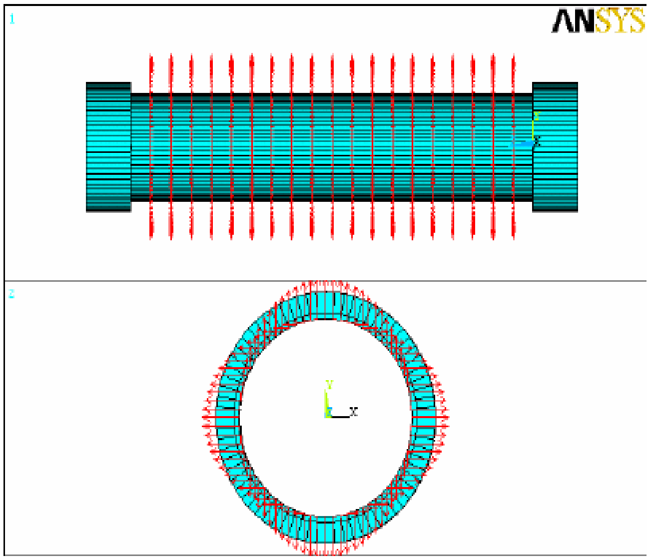

Fig. 1.5:- **Cylinder filled with 250 bar pressure (Isometric view)**

One of the most important parameters used in the transient dynamic analysis is damping parameter. To investigate the effect of damping in the dynamic analysis, eight different damping coefficient values are used at a working frequency of 550 Hz and eight different maximum displacement values are calculated for node 1522. It can be observed from below table (b) that maximum displacement values increase as the damping values becomes smaller.

Table (b):- The maximum displacement values for different damping coefficients

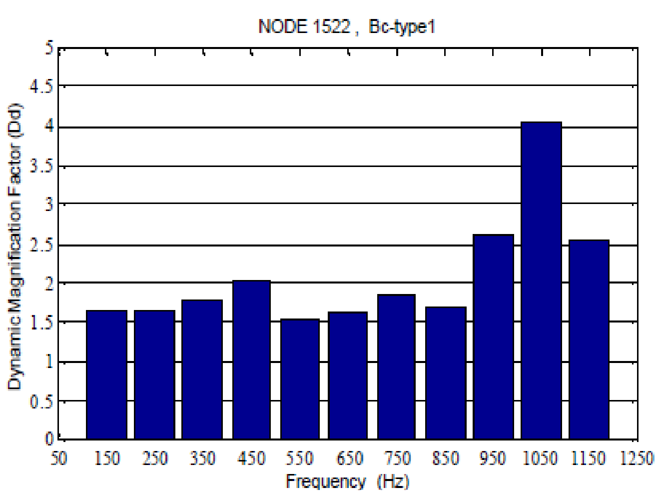

Fig. 1.6:- **Time history for normalized displacements Of node1522, Bc-type1**

Damping Coefficients Max.	Displacements (m)
0.5	0.1765E-3
0.1	0.2304E-3
0.05	0.3042E-3
0.01	0.4588E-3
0.005	0.5243E-3
0.001	0.5283E-3
0.0005	0.5283E-3
0.0001	0.5302E-3

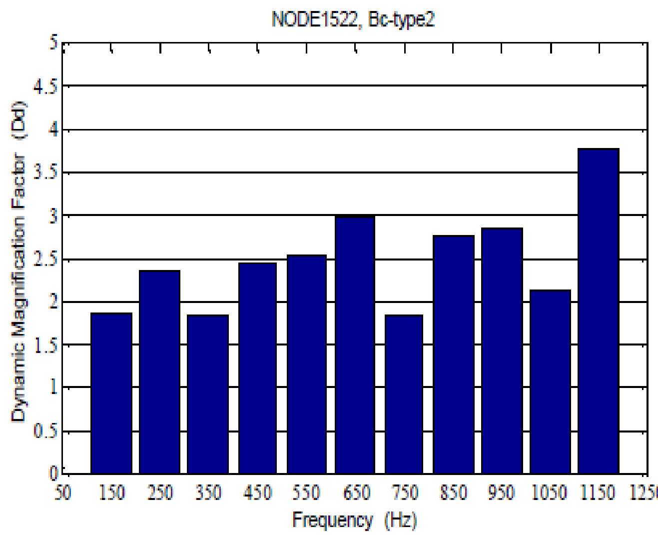

Fig. 1.7:- **Time history for normalized displacements Of node1522, Bc-type2**

CONCLUSION-:

Vibration analysis of the hydraulic system components for the different speed, size and the loading conditions can be performed by using the commercial finite element packages if the dynamic loading of the structure is properly defined. The APDL commands of the computer aided engineering program ANSYS is used to write codes for defining both the structural parameters and the dynamic loading of the hydraulic cylinder. Constructing the written code in a manner to allow any parametrical changes of the structural dimensions or the loading condition provides a significant amount of saving in time, work power and money. By this way, many different cases can be successfully applied to the analysis of the structure under investigation.

REFERENCES-:

[1] Beltman, W.M., & Shepherd, J.E. (2001). Linear elastic responses of tubes to internal detonation loading. Journal of Sound and Vibration ,252(4),617-655

[2] El-Raheb, M. (2004).wave propagation in a hollow cylinder due to prescribed velocity at the boundary. International Journal of Solids and Structures, 41, 5051-5069.

[3] Faria De, A.R. (2004).Finite element analysis of the dynamic responses of cylindrical panels under traversing loads. European Journal of Mechanics A/Solids, 23, 677-687.

[4] Gutierrez, R.H., & Laura, P.A.A. (1997). Vibration of a beam of non-uniform cross section traversed by a time varying concentrated by a time varying concentrated force. Journal and Sound and Vibration, 207, 419-425.

[5] Law, S.S., Chan, T.H.T., & Zeng, Q.H. (1999).Moving force identification a frequency and time domain analysis. Journal of Dynamic Systems, Measurement, and Control, Transactions of the ASME, 121, 394-401.

[6] Thambiratnam, D., & Zhuge, Y. (1996). Dynamic analysis of beams on elastic foundations subjected to moving loads. Journal of Sound and Vibration, 198, 149-169.

[7] Tzeng, J.A. (1998). Dynamic response and fracture of composite cylinders. Composite Science and Technology, 58, 1443-1451.

[8] Tzeng, J.A., & Hopkins, D.A. (1996). Dynamic response of composite cylinder subjected to a moving internal pressure. Journal of Reinforced Composites and Plastics, 15(11), 1088-1105.

[9] Wang, R.T. (1997). Vibration of muti-span Timoshenko beams to a moving force. Journal of Sound and Vibration, 207, 731-742.