International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-7, Issue-6, March 2019

Analysis of Buckling Strength in The Case of Axial Load of Various Composite Cylinder Shells

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Abstract*: Critical load of any component is necessary to know now days. From this we can know maximum amount of load it can withstand. As well as there is a huge demand in composite materials. Using this, various machinery components and aero components can be fabricated. This paper deals to analyze the critical load of composite cylinders with different cut outs. Initially, all geometry models are created in modeling package CATIA, after that analysis is performed by using ANSYS. Different analysis has been performed using cut out shapes, height and diameter of the vessels. The improvement of critical load is very important, so that optimization is also selected in this present work. Using design of experimental data TAGUCHI technique as well as grey relation analysis is used and the result has been found.

Keywords: Critical load, vessels with cutouts and optimization.

I. INTRODUCTION

Hollow cylindrical shapes are mostly used piping industries and pressure vessel industries. To check the flow pressure and flow velocity, gauges and transducer are used. To places these, cut shape and sizes are important. Weight and cost also plays a key role in manufacture of the components. To overcome these, industries uses composite materials to fabricate. Different types of composite materials are available. In this glass E fiber materials are available more and these are low cost. Using this we can produce required shape of the geometries.

To create a component physically, we can find some defects and errors in that component. So that, many industries depends on computer aided design software. In that CATIA is a one of the user friendly components. In short time we can create a required model with this software. Such geometry is cut in to small strips and depending on the degree of freedom, using finite elements we can find the structural behavior of the component. ANSYS is one of the simulation software which is very useful to find out the structural and thermal behavior of the components using finite element methods [1].

Cylindrical shapes are used in high pressure piping systems. As well as in this piping system, stress concentrations are the main observable parameters to find out the crack initiation. Different cut out sizes and location of the cut out is important to know to avoid the crack initiation [2]. In 1980's many authors has done analysis on critical load analysis using uni-axial and biaxial loadings. Improvement and decrement of the critical load is depending upon accept ratio of rectangular plate [3]. Object with cut out sizes and location of cut out and cut out shapes has huge changes can be observed. If we decrease the cutout size, the critical load will improve [4]. In building, industrial structures or in some components, vertical members are mainly subjected to compressive loadings, these loading are called axial loading. From this we can observe the failures. This failure at that time is called bucking. It is mainly depending upon the types of support [5]. Fine matt type glass fiber and epoxy resin is collected from local industries. 70, 80, 90 and 100mm diameter wooden cylinders with 100, 150, 200 and 250mm height are prepared as wooden patterns. Initially, suitable hardener and epoxy resins are mixed in a bowl. 50% of epoxy resin and 50% of matt glass fiber are used to prepare the hollow cylinders. Orientation angles of glass fiber matt is 0/90 s. The required size of wooden pattern is taken and a cling wrap is wrapped around the wooden cylinder. The cling wrap is used to prevent the sticking of the epoxy resin to the cylinder. Once the wrapping is done, the hardener and resin mixing is applied around the plastic wrap. Once the epoxy mixture is applied, the matt glass fiber is surrounded around the cylinder and the fiber is cut. Again the epoxy mixture is applied around it matt glass fiber and it cut and the same procedure is repeated till the layer is reached to 5mm thickness. After these specimens are made, different shapes of cut outs are placed in the center of the height as shown in image 1. Circular, rectangular, elliptical and reversed elliptical shapes are considered by maintaining the constant area of the cut out. Prepared cylinder with circular cut outs are shown below.

Revised Manuscript Received on 30 March 2019.

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Fig 1: Elliptical cutout in cylinder.

To find out the critical load of each specimen, compressive testing machine is used as shown in image 2. At first, the work piece to be tested is placed on clean lower platen. And some space is left between upper platen and top of the specimen. After that, the pressure release wall is closed and dial gauge is set to the value of zero. Later the display unit is turned on. Gradually, the axial load is slowly compressed till the specimen is crushed and the moment when the specimen crushed is noted. And that will be the critical load of the specimen.

Fig 2: compressive testing on CTM.

Finite element method is one of the alternative sources to find out the different types of analysis and to avoid the method of work which is done above. As well as, it is an alternative source to compare the experimental results. So many FEM related softwares are available in the market but ANSYS is of the best software. After creating all the models in the modeling package, individual models are imported in to analysis software. In this ANSYS there is eign buckling method is available, using this we can find out the buckling factor. Initially, static structural analysis is performed and the same data has been transferred to Eigen buckling. Initially, 1000 N axial load is applied to the top of the cylinder image:3 and the bottom edges are fully constrained without moving alone 3directionly. In Eigen buckling software has given the buckling multiplier factor. Using this we can find out, how much of critical load which can withstand the cylinder.

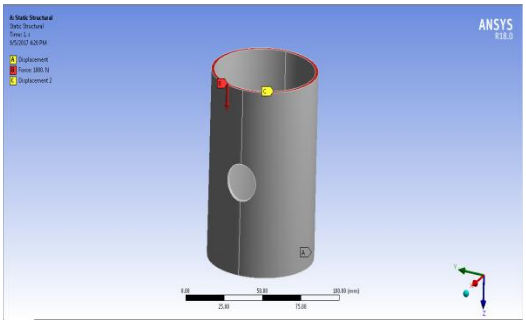


Fig 3: load Appling on cylinder.

To perform this analysis, 8Gb ram, i3 speed processor hardwares and ANSYS 18.0 software is used. Because of the cut out between the cylinders, it is said to be irregular geometry. Tetra hedron machine is used in this project. In this model, 2215 elements and 16670 nodes are present.

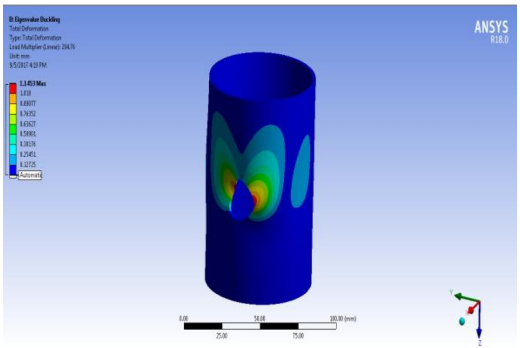
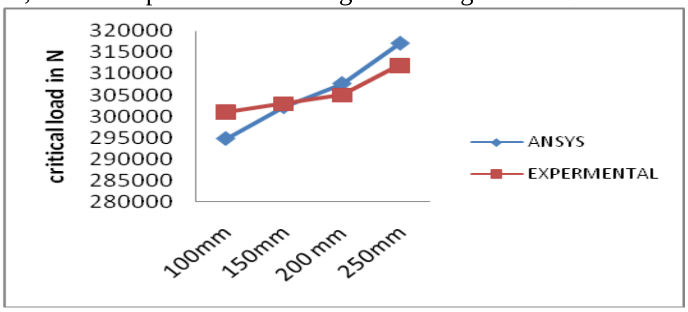
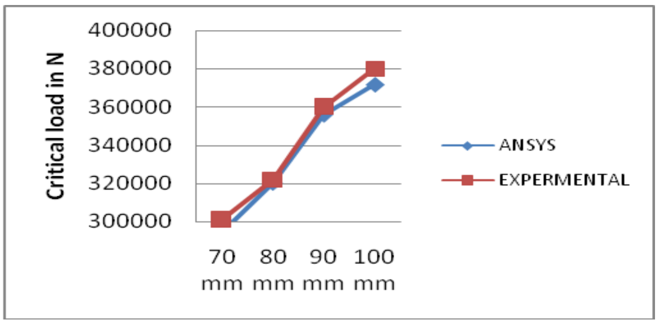


Fig 4: Buckling mode of cylinder with cutout.

The above image 4, the place where the crushing occurs is clearly seen in the image and it's shown in red colour. As well as, load multiplier value is also gained using ANSYS.



Graph 1: Critical load results with different height of shell.



Graph 2: Critical load results with different Diameter of shell.

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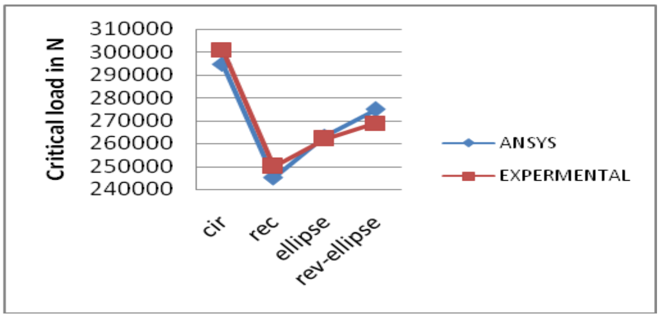

Graph 3: Critical load results with different shapes of cutouts.

Taguchi optimization technique is one of the alternative methods to identify the optimum shape, height and diameter of the hollow cylinder. Experimental and analytical results are taken as the input to the taguchi technique. L16 array model is prepared by three factors and four levels of hollow cylinders. Cut out hole shape, height and diameter of the cylinder are taken as factors. Circular, rectangular, ellipse and reverse ellipse are levels of cut out hole shape. 100, 150, 200 and 250mm heights are taken as levels of cylinder height. 70, 80, 90 and 100mm are levels of cylinder diameters. Using these designs of experimental data, optimum parameters are identified as circular, 250mm height and 100mm diameter which is clearly shown below mini tab results. Grey relation analysis is also used and maintained L16 model are used is specified above. These two optimization techniques results has good agreement.

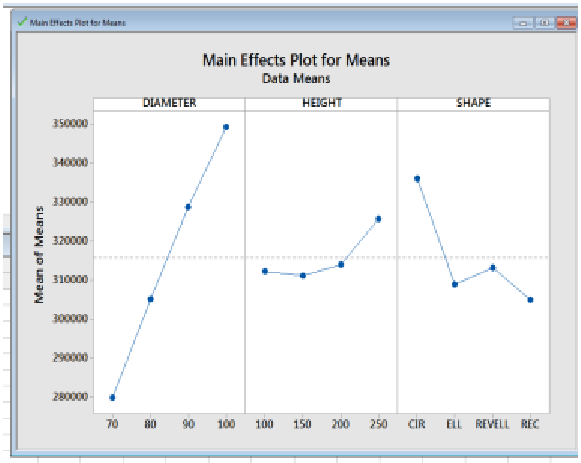

Fig 5: Taguchi optimization technique results.

II. CONCLUSION

In cylinders cut out shapes is needed thing. With this, axial critical load has more effects. Cut out shapes which has circular shape object has maximum axial critical load when compared to rectangular and elliptical shapes. The height of the cylinders also has effect on the critical load. Maximum height of the cylinders is preferred to improve the axial critical load. Using maximum diameters of the cylinder, we can improve the critical load. Experimental method, computer aided engineering methods are used to analyze the critical load. In computer aided engineering software, analysis is performed as well as after identifying the optimum parameter of the object we can reduce unnecessary wastage of material during fabrication

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