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COMPARATIVE STUDY OF DIFFERENT TYPES OF END CLOSURES USED IN HORIZONTAL PRESSURE VESSELS AND ITS EFFECT ON STRESS LEVELS IN PRESSURE VESSEL AND SADDLE SUPPORT

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ABSTRACT

Different end closures or head ends are used in pressure vessels which are subjected to different pressure conditions. Most of the pressure vessels are designed according to ASME code as per zicks theory, but this theory has used horizontal pressure vessel as simply supported beam but this assumption do not consider the effect of change in size and shape of the vessel head ends. In this work comparative study of different end closures hemispherical head, Flat head & Semi – ellipsoidal is discussed. Design by Analysis Approach using FEA software ANSYS is used to observe the level of stresses at mid span of horizontal pressure vessels & saddle support to find out the optimum pressure vessel end closure type.

KEYWORDS: Zicks Theory, FEA, Saddle, end-closure, hemispherical head, flat head, semi-ellipsoidal head.

1. INTRODUCTION

1.1. End Closures in Pressure Vessels: A pressure vessel is a closed container designed to hold gases or liquids under internal or external pressure. Pressure vessels are designed to operate safely at a specific pressure and temperature. End closures or head ends are used in pressure vessels which are subjected to different pressure conditions. Different types of head ends which are use in pressure vessels are hemispherical head, Flat head, Semi –ellipsoidal & Torispherical Heads.

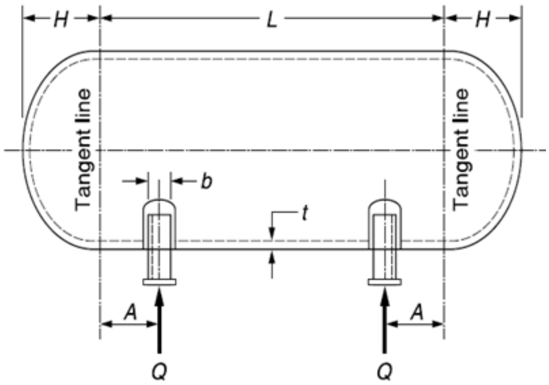

Fig. 1: Horizontal Pressure Vessel.

1.2. Types of End Closures or Head ends: Heads are one of the important parts in pressure vessels and refer to the parts of the vessel that confine the shell from below, above, and the sides. The ends of the vessels are closed by means of heads before putting them into operation. The heads are normally made from the same material as the shell and may be welded to the shell itself. They also may be integral with the shell in forged or cast construction. The head geometrical design is dependent on the geometry of the shell as well as other design parameters such as operating temperature and Pressure. The geometry of the head is selected based on the function as well as on economic considerations, and methods of forming and space requirements. The elliptical and torispherical heads are most commonly used. The carbon steel hemispherical heads are not so economical because of the high manufacturing costs associated with them. They are thinner than the cylindrical shell to which they are attached, and require a smooth transition between the two to avoid stress concentration effects. The thickness values of the elliptical and torispherical heads are typically the same as the cylindrical shell sections to which they are attached.

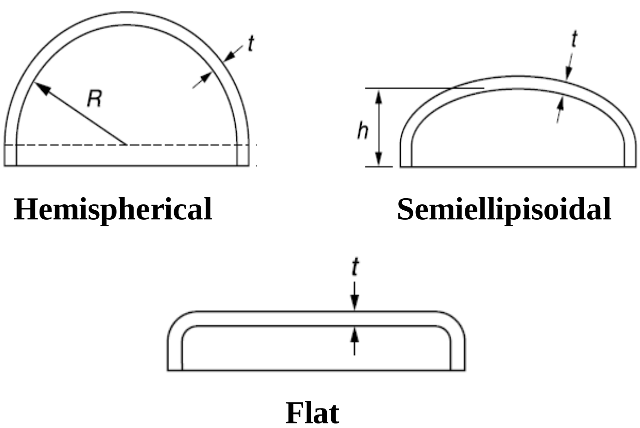

Fig. 2: Types of End Closures or Head ends.

1.3. Design by Analysis (DBA) Methodology using ANSYS

Parameters

- Design pressure P= 200psi
- Saddle width b= 12in
- Load per saddle Q=300,000lb
- Saddle angle of contact θ=120°
- Outside radius of shell R=6in
- Shell thickness t_s=1in
- Length of vessel of tangent to tangent line L=60in
- Depth of dish of head H=6in
- Distance from tangent line of head to centre of saddle A=2.5inch

2. METHODOLOGY

The entire CAD model of the pressure vessel with saddle support is modeled in FEA software ANSYS as shown in below Fig 4. The CAD model prepared in ANSYS is meshed by using SHELL 63 as shown in below Fig 5. SHELL63 as shown in Fig 3 has both bending and membrane capabilities. Both in-plane and normal loads are permitted. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z-axes. Stress stiffening and large deflection capabilities are included. A consistent tangent stiffness matrix option is available for use in large deflection (finite rotation) analyses.

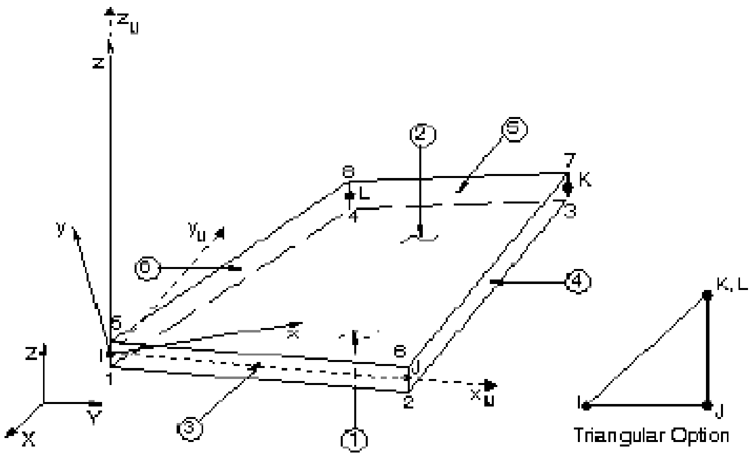

Fig. 3: Shell 63 Element.

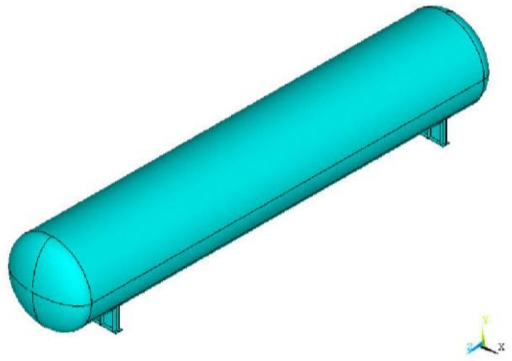

Fig. 4: CAD model.

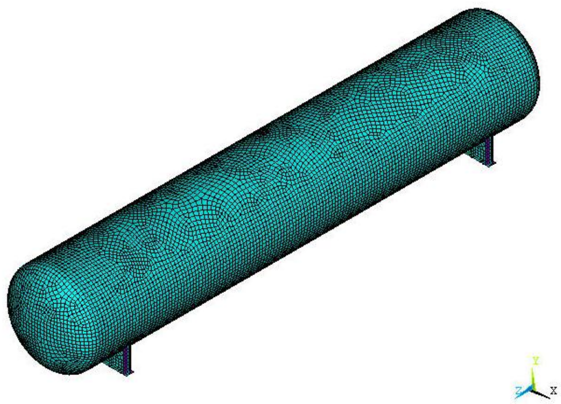

Fig. 5: Meshed model using shell 63.

3.2. Boundry Conditions and application of load

The boundary conditions applied are both saddles were made fixed and internal pressure was apllied to the vessel and the analysis was performed to see the stresses in saddle and in the vessel. For meshing the model we have used mesh size that is element size as 5.

3. RESULTS AND DISCUSSION

3.1. Case I:- hemispherical end

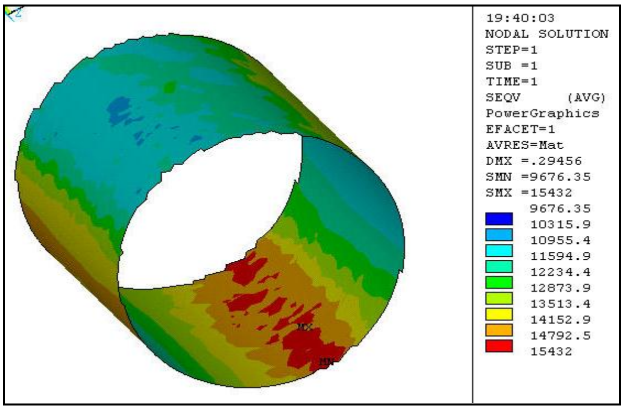

Fig. 6: Equivalent stress in vessel for hemispherical end.

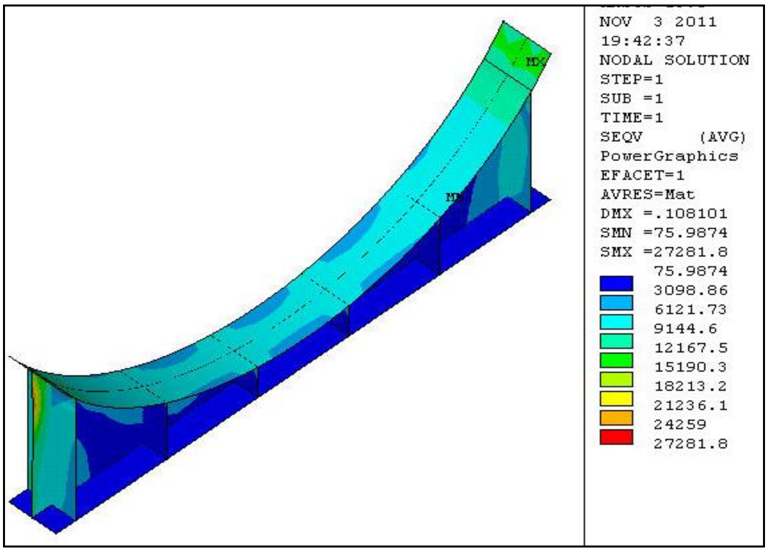

Fig. 7: Equivalent stress in saddle for hemispherical end.

3.2. Case II:- Semiellipisoidal end

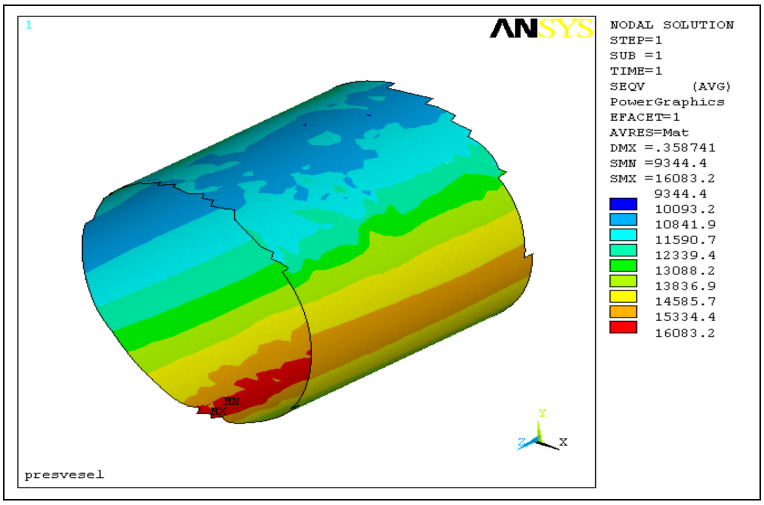

Fig. 8: Equivalent stress in vessel for semiellipisoidal end.

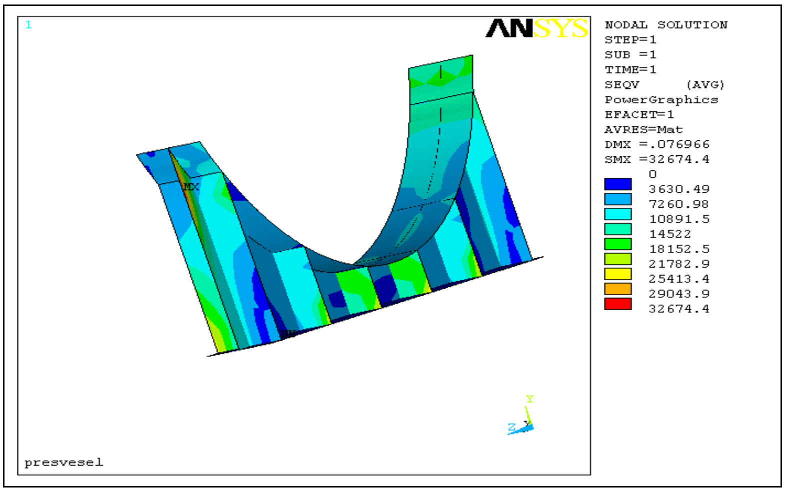

Fig. 9: Equivalent stress in saddle for semiellipisoidal end.

3.3. Case III:- Flat end.

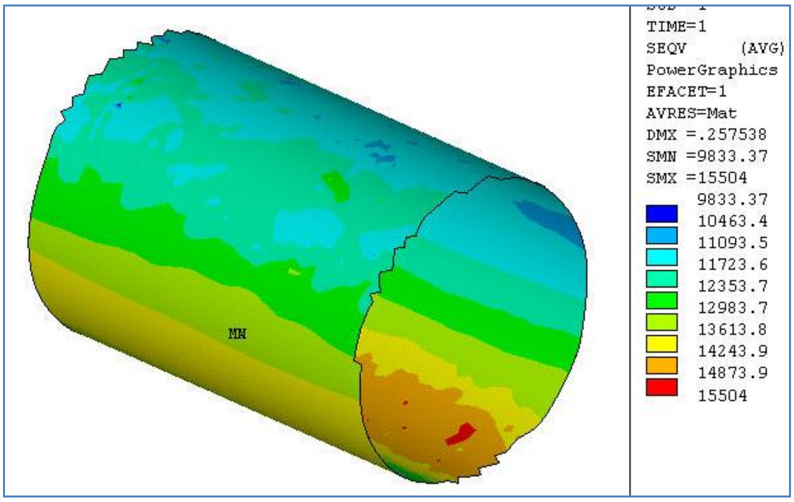

Fig. 10: Equivalent stress in vessel for flat end.

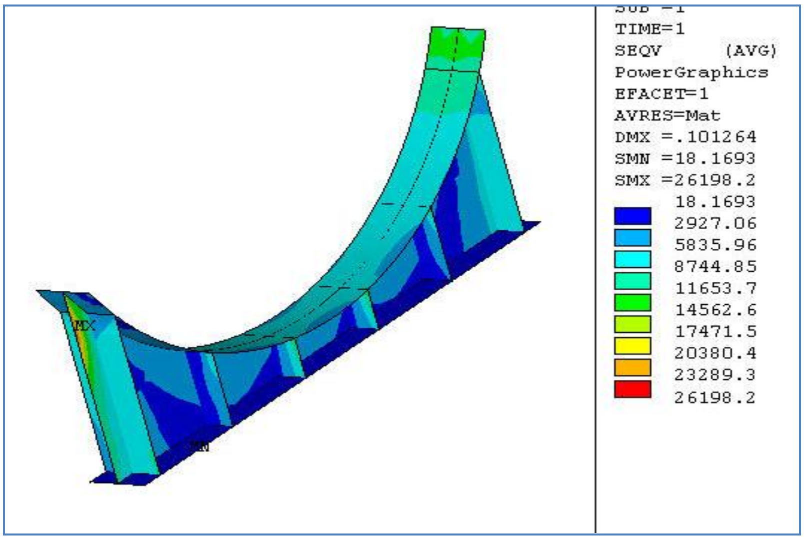

Fig. 11: Equivalent stress in saddle for flat end.

Table 1: Comparative results for stress level in vessel & saddle for hemispherical, semiellipsoidal & flat head end.

Type of end	Eqv Stress in vessel (psi)	Eqv Stress in saddle (psi)
hemispherical	15432	27281
Semiellipsoidal	16083	32674
flat	15504	26198

By design by analysis approach (DBA) also different head ends effect and their stress level effect in saddle support and pressure vessel itself is observed and it is concluded that pressure vessel having flat head ends are having minimum stresses in saddle support and in vessel itself compared to hemispherical head and semi-ellipsoidal head end.

4. CONCLUSION

Form the results of finite element analysis software ANSYS we have checked stresses in saddles for different end-closures such as hemispherical, elliptical and flat end and from the results in ANSYS the stress value are less in saddle when end closure is flat and the stress value are maximum in saddle when end –closure is hemispherical.

5. ACKNOWLEDGEMENT

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