# Finite Element Analysis of Skirt to Dished junction in a Pressure Vessel

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***ABSTRACT:*** *Pressure vessels are probably one of the most widespread equipment within the different industrial sectors. In fact, there is no industrial plant without pressure vessels, steam boilers, tanks, autoclaves, collectors, heat exchangers, pipes, etc. The traditional method of proving a pressure vessel is to carry out mechanical design calculations in accordance with established codes .While so called design by rule approach is sufficient for majority of cases there are sometimes features of design which necessitates the use of design by analysis methods.*

*Skirt to dished end junction in vertical pressure vessel is one of such critical junction which is often subjected to different loads. These loadings include internal pressure inside vessel, wind & seismic shear force and moments, operating weight of vessel& thermal stresses in the welds near the junction. This paper re-presents guidelines in structural analysis for skirt to dished end junction. Analysis is carried out in compliance with ASME Section VII Division 2. Finite elemental model of junction is prepared using UG-NX. It is then loaded in ansys 12.0 and results obtained are compared to code allowable.*

***KEYWORDS:*** *Finite element analysis, Skirt to dished end junction, Structural etc.*

## I. INTRODUCTION

Most vertical vessels are supported by skirt. Skirt assembly generally consists of skirt shell, base-ring, top-ring & gussets. These supports transfer the loads by shear action. They also transfer loads to foundation through anchor bolts & bearing plates. Support skirts are welded directly to bottom of dished ends. Skirt carries entire weight of vessel as it supports whole assembly during operating condition. It includes weights of cylindrical shell, dished ends, internal trays, liners, nozzles & liquid column. All these loads are transferred to skirt shell through skirt to dished end junction only. Apart from these loads there are also wind and seismic loads junction have to withstand with.

Chemical reactions taking place inside vessels usually occur at high temperatures. So skirt to dished end junction experiences high temperature inside dished end and atmospheric temperature outside, which causes thermal stresses across the junction. All these loads make skirt to junction design critical.

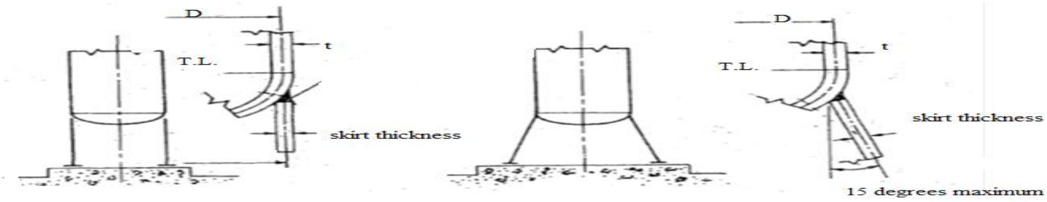


**Fig.1-Pictures showing types of skirt constructions**

UG-NX model of skirt to junction is depicted below.

**Fig.2- Assembly of skirt & dished end**

## II. DESIGN SPECIFICATIONS

### II.1 Dished END

| | |
|---|---|
| Design pressure | 16.9 |
| Design temperature | 210 °C |
| Dished end I.D | 3472 mm |
| Dished end material | SA 537 CL2 |
| Allowable stress s | 209.47 |
| Joint efficiency | 1 |
| Corrosion allowance | 0 mm |

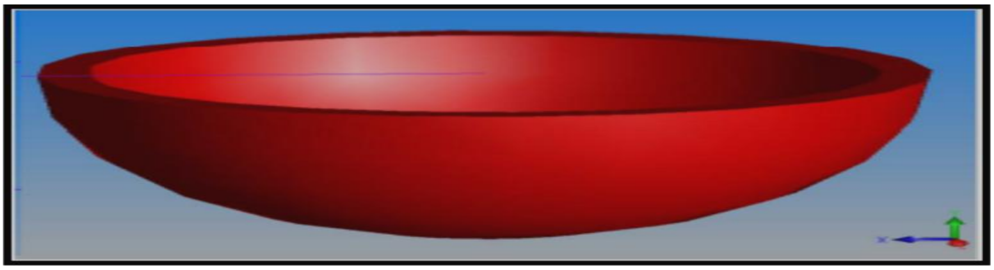

**Fig 3- Bottom hemispherical dished end**

Minimum Required Thickness as ASME SEC. VIII DIV 2 Part 4,

$$= \frac{D}{2}\left[e^{\frac{0.5P}{SE}} - 1\right]_{+} C_i + C_o$$

$$= \frac{3472}{2}\left[e^{\frac{0.5\times 16.982}{209.478\times 1}} - 1\right]_{+} 0 + 0$$

= 71.8173 + 0.000 + 0.000
= 71.8173 mm

Finished thickness = 78 mm

### *2.2 Skirt specifications:*

| | |
|---|---|
| Skirt material | SA 516 GR.70 |
| Skirt thickness | 45 mm |
| Corrosion allowance | 0 mm |

## III. ANALYSIS DETAILS

The 180 ° sector 3D finite element model for head to skirt junction was prepared in Uni-graphics (UG). In order to reduce the overall size of FE model only half portion of the skirt to dished end assembly was considered. Meshing of model is carried out by using UG. This FEA analysis is carried out in order to know the stress distribution near head to skirt junction due to internal pressure, discontinuities, operating weight and seismic loads. ANSYS 11.0 was used for pre-processing, solution and post-processing of this finite element analysis. Stress classification lines were plotted to know distribution of stresses at critical junction. Finally, resulting von-misses stresses were compared to code allowable.

| | |
|---|---|
| Component | Skirt to dished head junction |
| Software | ANSYS 12.0 |
| Analysis type | Structural linear static |
| Element | Solid 45 |

### III.1 Design data

| | |
|---|---|
| Design code | ASME SEC VIII Div. 2 |
| Design pressure | 16.982 Mpa |
| Design temperature | 210 ° C |

### III.2 Material data

| Component | Material | Design temperature | Allowable stress S |
|---|---|---|---|
| skirt | SA516GR70 | 210 °C | 138 MPa |
| Bottom dished end | SA 537CL2 | 210 °C | 134 MPa |

Allowable stresses for skirt & dished end material are obtained from table 5A,of ASME SEC. VIII Div.2,Ed 2010

### III.3 Meshed model:

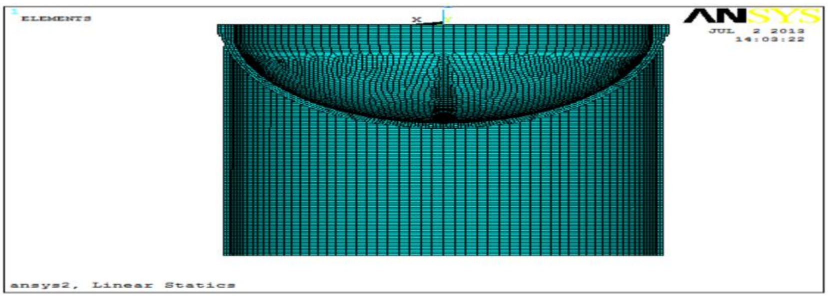


**Fig 4- finite elemental model of skirt to dished junction**

Stress classification lines (SCL) were plotted near junction and intensity of von misses stresses is observed across these junctions.

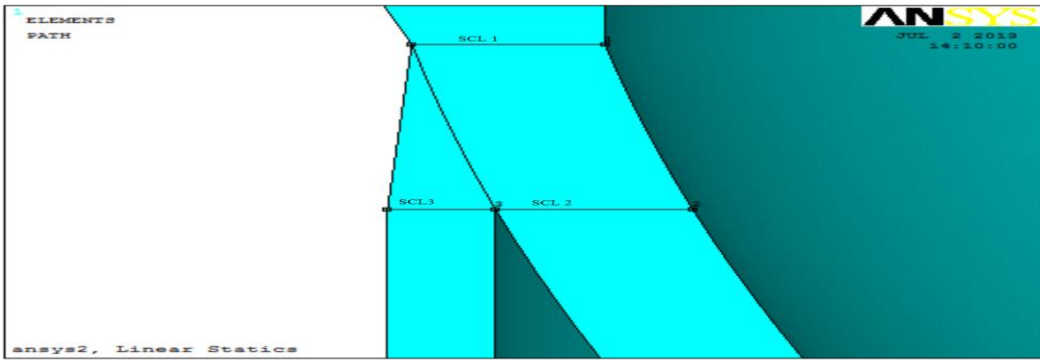


**Fig 5- location of stress classification lines in the junction**

## IV. STRUCTURAL BOUNDARY CONDITIONS

1. Internal pressure has been applied on inside surface of dished end. P = 16.98 MPa
2. Operating weight of vessel including liquid and internals have been applied through center of gravity of vessel with the help of rigid elements.
3. W= 4208861 N
4. Horizontal Seismic shear force = 2212515 N
5. Seismic base moment = 28 .827 $\times 10^9$ N-mm
6. Seismic moment acting at C.G
7. = Seismic base moment – Seismic shear force distance from base model to top
8. = $28.827 \times 10^9 - 2212515 \times 11870$
   = $2.564 \times 10^9$ N-mm
9. Axial thrust on dished end thickness
10. Longitudinal stress due to internal pressure = $\frac{PD}{4t}$
    = $\frac{16.982 \times 3414}{4 \times 135}$ = 107.36 MPa Stress due to operating weight = $\frac{4208861}{\frac{\pi}{4}(3684^2 - 3414^2)}$
    a. = 2.7962 MP
11. So, resulting axial thrust on dished end thickness = 107.36 – 2.7962 = 104.5638 MPa
12. Base of the skirt is constrained in all directions.

### IV.1 Loads and boundary conditions:

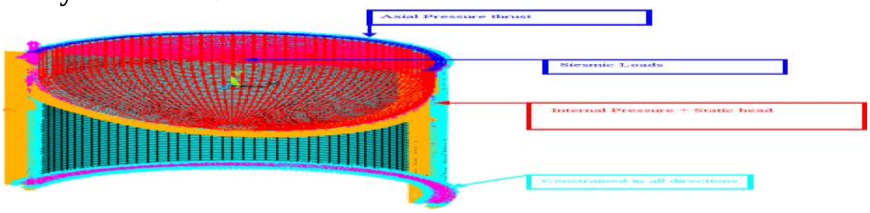

**Fig 6- Boundary conditions**

## V. RESULTS & DISCUSSIONS

Model is solved for above mentioned loadings in ansys 12.0 deformation plot and von misses stress plot are obtained. Maximum primary stress, bending stress across stress classification lines in the junction are summarized in the table.

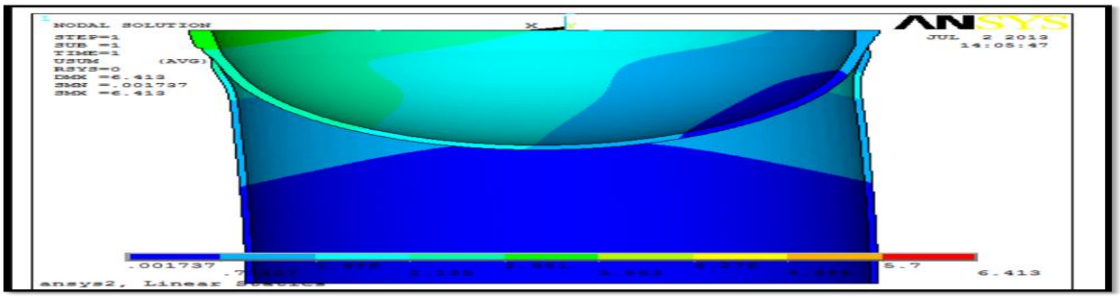


**Fig 7- figure showing deformation in the junction**

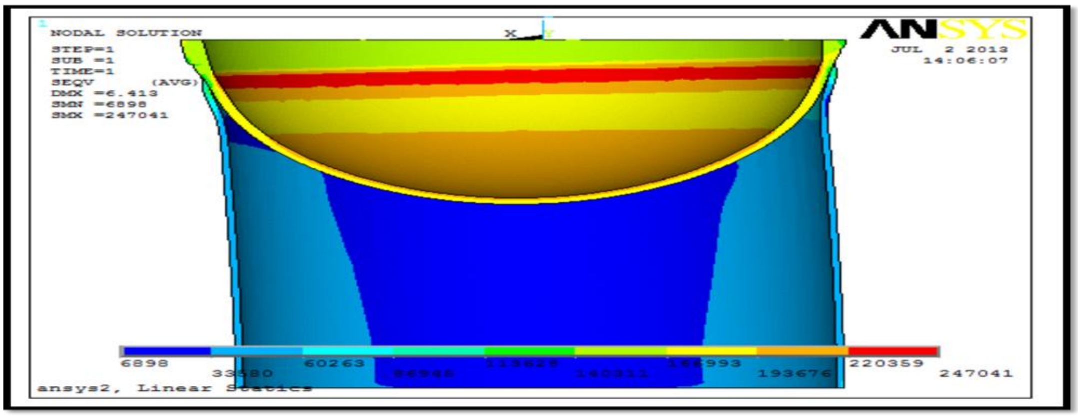


**Fig 8 - Von misses stress plot**

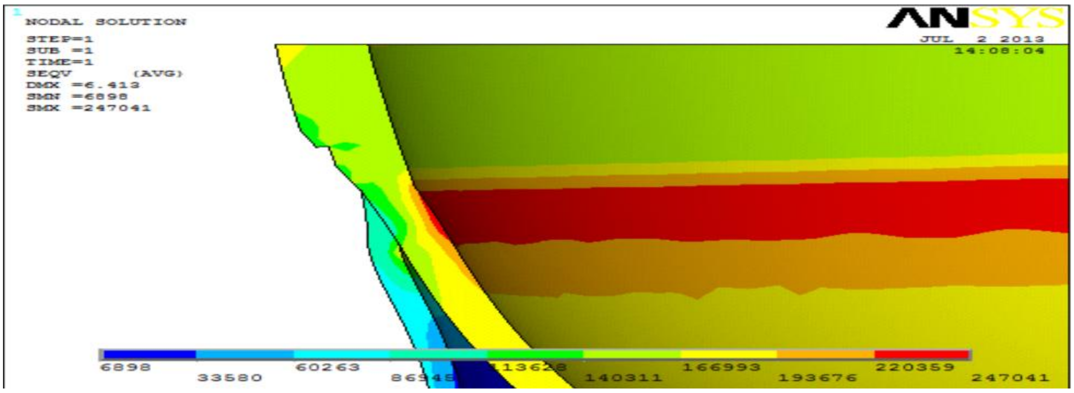


**Fig 9-Von misses stress plot acros stress classificatio lines (SCL)**

## V.1 RESULTS TABLE

| Stress Classification Line (SCL) (2) | Type of stress | Max Induced Von Misses stress (MPa) | Allowable Design stress (MPa) (1) |
|---|---|---|---|
| SCL 1: In Shell at Shell to Skirt Joint | Pl | 154.4 | 1.5 S = 201 |
| | Pl + Pb + Q | 50.81 | 3 S = 402 |
| SCL 2 : In Dish End at Shell to Skirt Joint | Pl | 168.4 | 1.5 S = 201 |
| | Pl + Pb + Q | 74.04 | 3 S = 402 |
| SCL 3: In Skirt at Shell to Skirt Joint | Pl | 94.65 | 1.5 S = 207 |
| | Pl + Pb + Q | 36.06 | 3 S = 414 |

Primary & secondary stresses induced in the junction across stress classification lines are compared to code allowable & are found within allowable limit which justifies structural stability of the junction.

## VI. CONCLUSION

a. This analysis throws light on various stresses encountered in the skirt to dished junction which makes its design critical.

b. After this analysis optimum parameters should be considered which can minimize stresses in junction. This can increase life of pressure vessel & reduce its cost.

c. It can be concluded that stress and other parameters are also decreased by changing weld size of skirt to dished end junction.

## VII. ACKNOLEDGEMENT

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## REFERANCES

❖ **Books**

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