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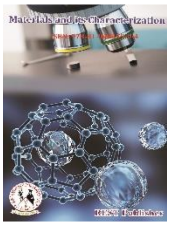

Fatigue analysis of flat plate shell and Nozzle junction

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Abstract: *In the field of pressure vessel design, much research has been done to predict the fatigue analysis of round nozzle connect to spherical and cylinder plates. This has been motivated by the fact that the majority of pressure vessels in industry have round bodies, as these are better suited to withstanding pressure. A large demand however also exists for flat plate pressure vessels with round nozzles, but there is a lack of research and guidelines that accurately predict how these structures behave. This paper investigates the categorization of the structural behavior arising from the fatigue analysis of the shell nozzle head and the convergent nozzle junctions.*

1. INTRODUCTION

Connections of nozzles in a shell is a common requirement in many industries such as boilers, reactor pressure vessel, pipe network in chemical plants, offshore oil drilling tower, etc. Here, A convergent nozzle on flat plate shell is having special nature of the structure due to which the strength of the shell and nozzle junction weakened more seriously than by a normal one. As the century progressed and the use of metals expanded with the increasing use of machines, more and more failures of components subjected to repeated loads were recorded. Today, structural fatigue has assumed an even greater importance as a result of the ever-increasing use of high strength materials and the desire for higher performance from these materials. There are four empirical curves to estimate mean stress effects on the fatigue life of a component. They are Soderberg, Goodman, Gerber and Morrow. Soderberg empirical curve is applied only for the ductile materials, Goodman empirical curve is applied for the brittle materials. The observations are most of the actual test data tends to fall in the region between Goodman and Soderbergh, in most situations small mean stress in relation to alternating stress is less than 1 and little difference between these theories, where the range is approaching to 1 theory show large differences and in this case the yield stress may set the design limits. The region outside of the ultimate stress and endurance limit triangle is unsafe and the remaining area below the infinite lifeline is safe and generally used in designing. This type of analysis will allow a shell and nozzle junction designer to understand how the nozzle head will fail and creates the opportunity to design in safety features into the nozzle head junction and its surrounding containment component.

2. SOFTWARES USED MODELLING

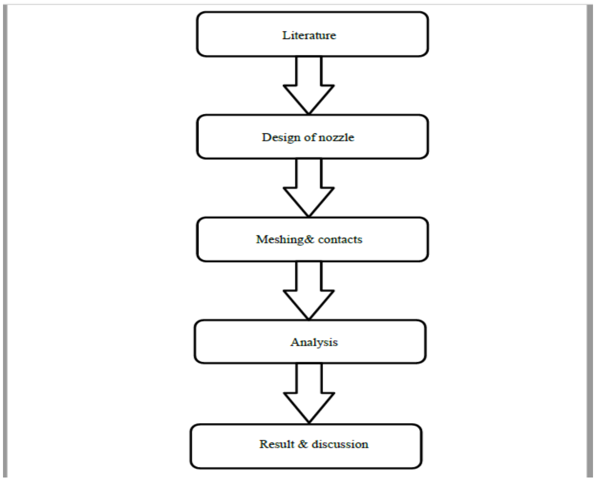
In this project ANSYS DM (3D modeling software) is used to create the model, which is like kit software to ANSYS user to perform slicing, etc. I use ANSYS DM to create the whole model of metallic expansion joints.

Analysis:

ANSYS 18.1 is used to analysis the nozzle head model. Ansyis develops and markets finite element analysis software used to simulate engineering problems. The software creates simulated computer models of structure, electronics or machine components to simulate strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow and other attributes.

FIGURE 1. ANSYS 18.1 software

3. METHODOLOGY



4. STATIC STRUCTURAL ANALYSIS

A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The results of the analysis are used to verify a structure's fitness for use, often precluding physical tests. Structural analysis is thus a key part of the engineering design of structures.

5. EQUIVALENT STRESS

It is also known as Von Mises stress. The von Mises stress is often used in determining whether an isotropic and ductile metal will yield when subjected to a complex loading condition. Maximum equivalent stress of the nozzle head model is 38.261 MPa.

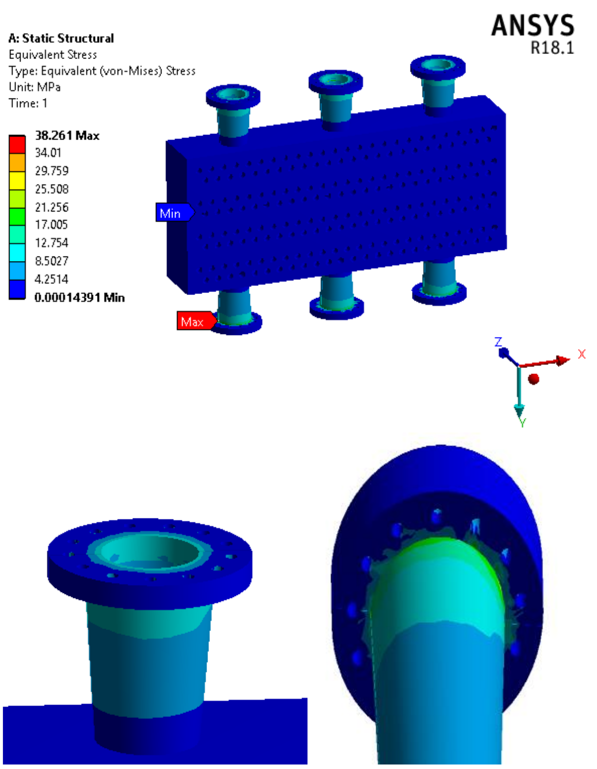


FIGURE 2. Equivalent stress

6. TOTAL DEFORMATION

It is used to obtain displacements from stresses. The main difference is the directional deformation calculates for the deformations in X, Y, and Z planes for a given system. Maximum deformation of the nozzle head model is 0.009211 mm.

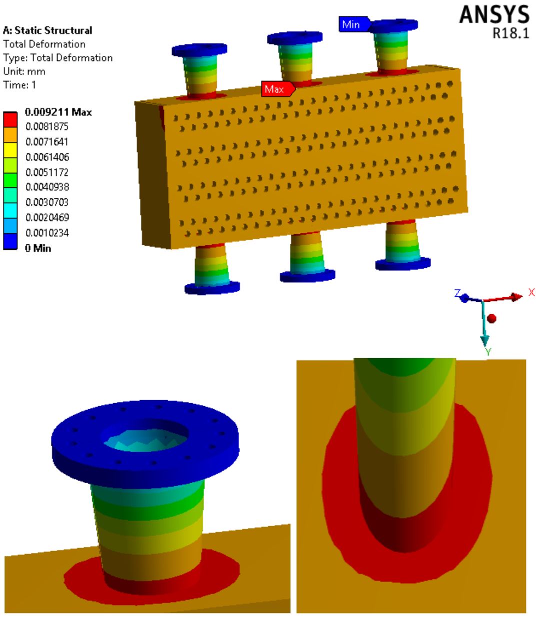


FIGURE 3. Total deformation

7. FATIGUE STRESS LIFE ANALYSIS

Goodman Theory:

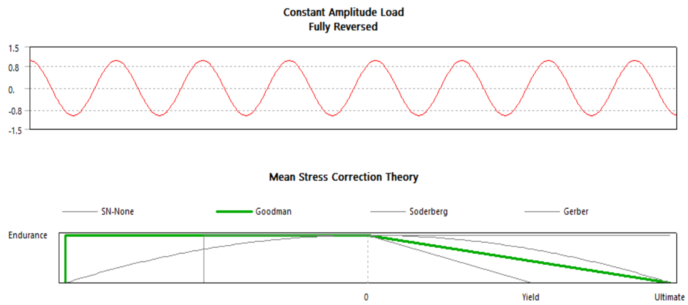


FIGURE 4. Goodman theory graphical results

Life:

Generally, allowable and safe life of the material between 104 to 109 cycles. Here, the Nozzle head model's life is 2×106 cycles. So, this model is safe.

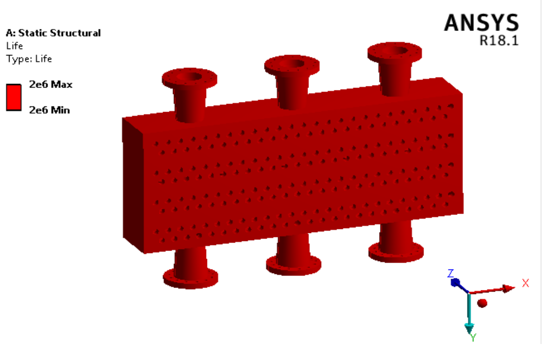


FIGURE 5. Goodman theory life

Damage:
Minimum damage level of the machine elements in industries is 200. In our Nozzle head model, damage value is 500. So, this Nozzle head model is safe and allowable.

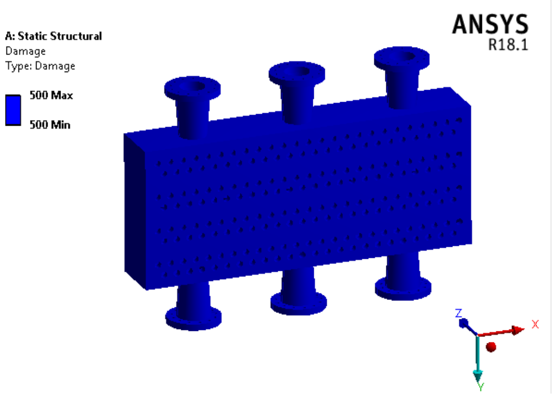


FIGURE 6. Goodman theory damage

Safety Factor:
The maximum factor of safety value of industrial machines is 15. Our Nozzle head model attained its maximum safety factor value.

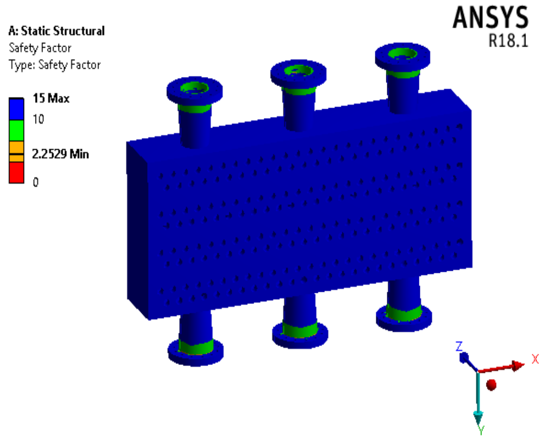


FIGURE 7. Goodman theory safety factor

Biaxiality Indication:
Maximum Biaxiality indication values are 0.99775.

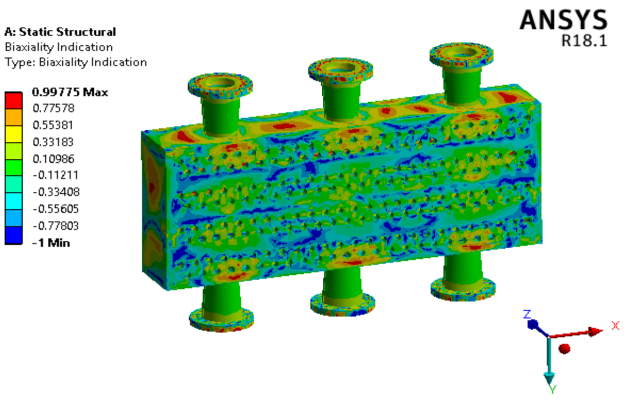


FIGURE 8. Goodman theory biaxiality Indication

8. CONCLUSION

This paper outlines the design by analysis methodologies offered in ASME Section VIII division 2 for satisfying protection against plastic collapse including elastic stress analysis. We should apply a smaller mesh element size to all shell and nozzle junction areas to capture stress concentration accurately. It found that maximum stress concentration occurs at the junction of flat plate shell and the nozzle.
Along with the modeling, analysis and verification a discussion on how to perform the code verifications are presented, shows the design is safe for design loading conditions.

From result, induced stresses are within the allowable limits (240 MPa) as summarized in the below table. Therefore, the model is safe for the given condition. The summarized stresses are considered near shell nozzle junction region only.

RESULTS:

Results		Nozzle	Flange	Plate	Nozzle head
Mean equivalent stress (Mpa)		23.371	31.5437	4.23155	38.261
Mean deformation (MPa)		0.0047044	0.00048105	0.0092055	0.0092055
Mean fatigue results	Life (Cycles)	$2\times e^6$	$2\times e^6$	$2\times e^6$	$2\times e^6$
	Damage	500	500	500	500
	Safety factor	15	15	15	15
	Biaxiality Indication	0.433365	0.98778	0.98789	0.99775
Pass or Fail		Pass	Pass	Pass	Pass

ACKNOWLEDGMENT

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REFERENCE

[1]. Surender Kumar, Experimental Analysis of Shell and Tube Heat Exchanger by using Abaqus, IJESRT, 2018.
[2]. Subin Michael, Kiran K. John and K. K. Shanid, Comparative CFD analysis of Shell and Serpentine Tube Heat Exchanger, 2017.
[3]. P. Eswar Raja Babu, Heat Transfer analysis on twisted Tube Heat Exchanger Technology, IJCET, 2015.
[4]. M. Iancu, R.G. Ripeanu and I. Tudor, Heat Exchanger Tube to Tube Sheet Joints Corrosion Behaviour, Tribology in industry, 2013.
[5]. ASME, "Rules for Construction of Pressure Vessels," in *ASME Boiler & Pressure Vesssel Code*, NewYork, The American Society of Mechanical Engineers, 2015.

