Thermo Structural Analyses of Vertical Pressure Vessel

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Abstract— Pressure vessel is the closed sealed cylinder shaped vessel for storage gaseous, liquid or solid products for the period of interval between production. Common welded junctions are found in vessel are the dished end to nozzle, shell to nozzle, and the skirt to the dished end. Skirt to dished end junction is very critical because it takes all dead weights and moment acting on the pressure vessel. There is two way to join the skirt to dished end either by centre to centre matching or outer diameter to outer diameter matching skirt to shell. During the cyclic heating or cooling there is a possibility of expansion of vessel wall which cause the crack at the skirt to dished end junction. Due to temperature, also temperature gradient will increase. And due to which high structural and thermal stress are develop at the junction of the skirt to dish end joint. So motive of this paper is to refer research paper on skirt to dished end finding different causes and the parameter on crack generation.

Key words: Pressure Vessel, Coke drum, FEA, ansys, wind load Stress, temperature

I. INTRODUCTION

Pressure vessels are closed containers designed to hold gases or liquids at a pressure substantially different from the ambient pressure. Its also capable of various other loading. They have a variety of applications in industry, including in oil refineries, nuclear reactors, vehicle airbrake reservoirs, and more. It have mainly two types such as vertical pressure vessel and the horizontal pressure vessel.it have the four main components e.g shell, head , nozzle , support. Support of the pressure vessel can be of saddle, leg, lug , skirt. The cylindrical vessel is closed at both ends by means of dished end, which may be hemispherical, ellipsoidal and tori spherical [1] skirt support is one of best way to support the pressure vessel. Skirt may be shaped of the cylindrical or conical shell. skirt can be either lap, fillet, or butt welded directly to the head or shell. This is the attractive point for the designer because with the proper use of the skirt leads to the reduction of the high structural and the thermal stresses developed at the skirt to head joint. Moreover stress can be distributed equally to all circumference [2]

II. LITERATURE REVIEW

Coke drums are operated under severe conditions of cyclic heating and forced cooling that apply repetitive thermal stresses to the drum walls and the skirt. Since thermal cycling is most severe near the bottom of the coke drum, where temperatures can reach up to 1000°F, the skirt and other attachment welds are just as prone to cracking and premature structural failure as the vessel wall. The purpose is to determine a skirt / "Hot-box" junction geometry which will minimize thermal gradient stresses and improve fatigue life.

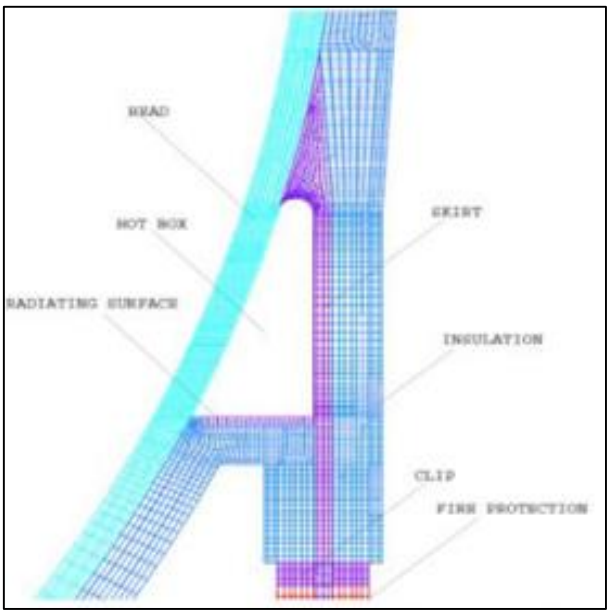

Fig. 1: FEA model for thermal analysis

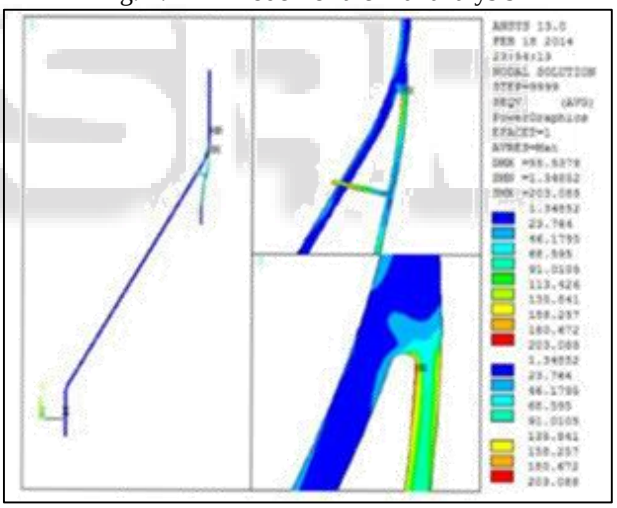

Fig. 2: differential stress for combined loading for hot and cold condition(SPS)

The process flow of coke drum along with the temperature gradient due to coking process and the effect of thermal stresses on the skirt shell junction/ hot-box using finite element model. In present project work comparative analysis of hot box is done by analytical, FEA using ANSYS 13. Study demonstrates that by modifying the dimensions of the hot box such as length, will affects the fatigue life of coke drum. This appears to be due to the longer hot-box length, which results in a more gradual thermal gradient and also moves the gradient lower on the skirt away from the welded connection. The author have done analysis is performed using "ANSYS 13.0" general purpose FEA software. Finite element analysis is used to evaluate the thermal and stress profiles for the COLD and HOT conditions. It is observed that by modifying the

dimensions of the hot box, alternating equivalent stresses decreases. Its also seen that bt Reducing the length by 190mm minimizes 28% of fatigue life.From the detail fatigue analysis, It is observed that hot box length is one of the most important factor which affects the life of coke drum[3]

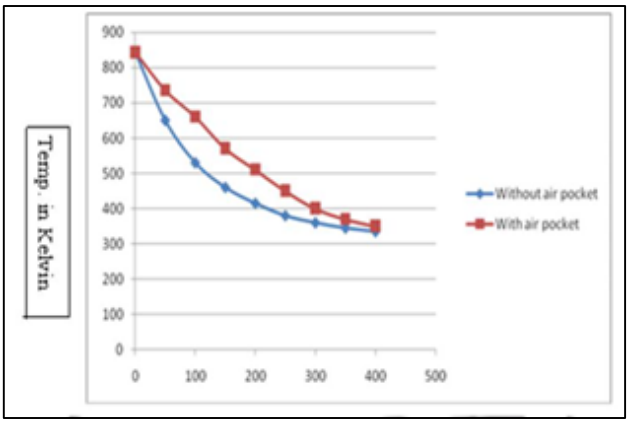

Fig. 3: distance of skirt from junction in mm

This paper demonstrated the profit of hot box over vessel without hot box according to Simulation. It has been seen that radiation has important effect on heat transfer in this triangular cavity and thereby heat conduction in the vertical wall (skirt) is the most important parameter to keep convection in steady state condition. FEA is a proven cost saving tool and can reduce design cycle time therefore it can be used as accurate tool to investigate stresses in skirt support. Moreover, the author have done the thermal analysis on pressure vessel with hot box and the without hot box. In this paper the author have shown that by providing small air pocket at the shell and skirt junction the temperature stress and overall stress concentration can reduce considerable. As per the calculation, reduction in peak stress is almost around 30% as compared to without hot box. The alternative stress becomes lower and hence fatigue life of the component increases. He have shown the graph of distance of skirt to junction to the temperature which shows that the temperature gradient is higher in without hot box compared to the pressure vessel with hot box [4] economical for the pressure vessel and it increases the life and reduces the crack possibilities.[5]

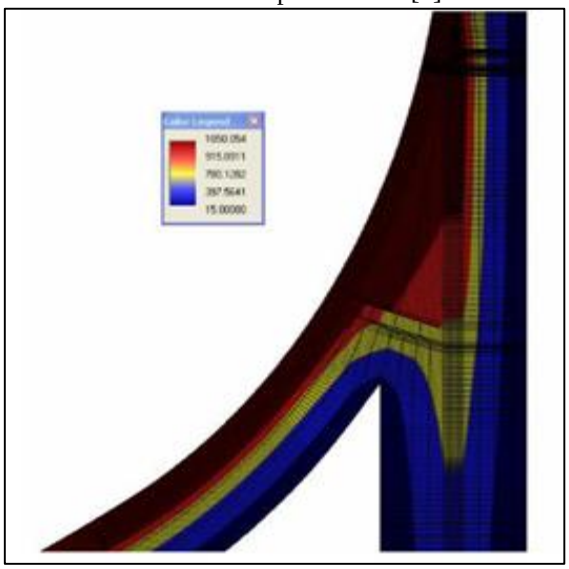

Fig. 4: hot box thermal analysis

No. of nodes	Temperature (^{0}c)
108216	327.25
100316	323.4
94993	323.86
82037	325.61
73922	328.61

Table 1: Values of Temperature Distribution using Tetrahedron Element for Without Hot Box

No. of nodes	Temperature (^{0}c)
296642	435.96
268983	323.36
245483	324.19
213607	400.22
192447	325.02

Table 2: Values of Temperature Distribution using Tetrahedron Element for With Hot Box

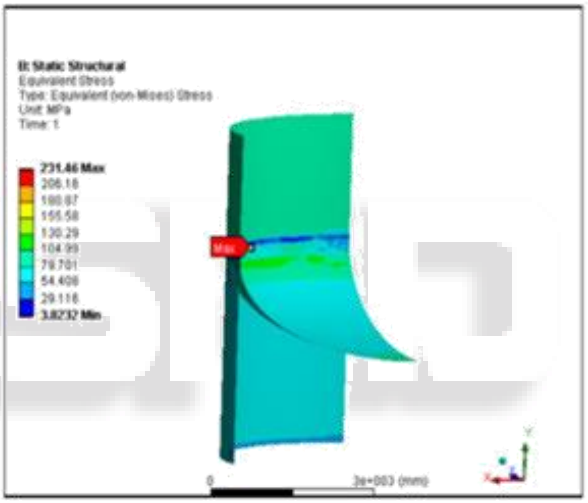

Fig. 6: maximum stress in model

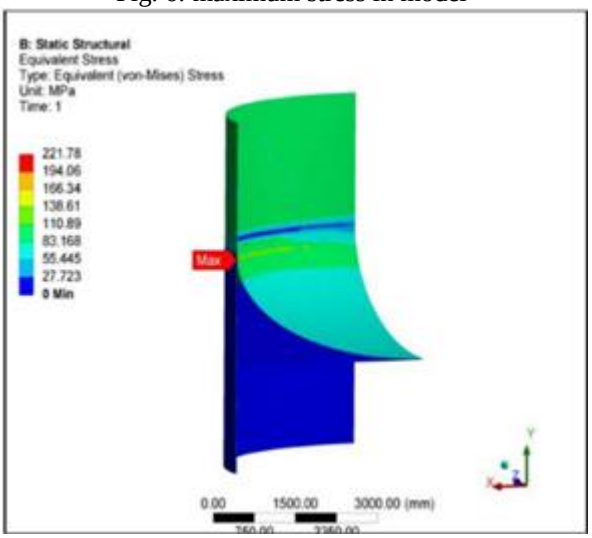

Fig. 7: maximum stress in model

the author have done the FEA analysis on pressure vessel at skirt to head junction with and without hot box considering different conditions and he found the temperature distribution by using the hexahedron and tetrahedron element. First analysis focus on various stresses

encountered in the skirt to shell joint which makes its design critical. After this analysis author come to know hot box should be considered which can minimize stresses in junction. According to result by providing hot box at the shell and skirt joint the temperature stress and overall stress concentration can reduce considerable and surely there is a reduction in peak stress as compared to without hot box. The alternative stresses become lower and hence fatigue life of the component increases & reduce its cost which is benefit for applicant. These results of analysis are also matches with experimental results performed with equipment. Hence we can conclude that model is found safe for hot box condition[6]

III. CONCLUSION

By reviewing above research paper we can conclude that by providing the hot box at the junction of the skirt to pressure vessel head leads to the reduction in the stresses and reduce the temperature and life of the pressure vessel increases and moreover conclusion can be carried out that in pressure vessel design, hot box at the junction of skirt to the pressure vessel head is safe and more economical compared to the design of the pressure vessel without hot box

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