Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2013, 5(9):399-403

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Study on petroleum tank baffle mounted on tanker

Yonggang Zuo[1], Zhuxin Li[1], Jun Chen[1], Jing Yang[2] and Zhuwen Chu[3]

[1]*Department of Petroleum Supply Engineering, Logistic Engineering University, Chongqing, China*
[2]*Department of mechanical and electrical Engineering, Logistic Engineering University, Chongqing, China*
[3]*62217 Unit, Qinghai, China*

ABSTRACT

Baffle is an important part of petroleum tank mounted on tanker. Petroleum filled in tanker will slosh and impact tank wall when it subjects to external perturbations such as emergency brake etc, its center of gravity is changed when tanker drives on uneven road or in emergency braking. In order to reduce sloshing and impact on tank, baffles are fitted in the tank, but some unreasonable baffle structure often causes the baffle crack and even leakage of tank. This paper studies the structure design and arrangement of tank baffle which can reduce petroleum sloshing and impact on tank wall, improve stability and safety of tanker. Stress and strain of the innovated baffle and tank is analyzed on ANSYS, which verifies innovated baffle and tank is reasonable and correct.

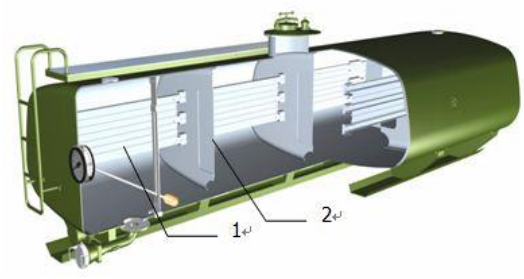
Key words: Petroleum tank, baffle, tanker, simulation

INTRODUCTION

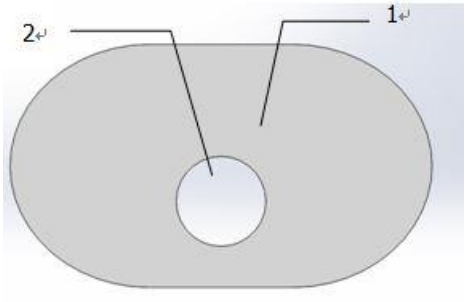
Petroleum tank is an important part of refueling tanker. Baffle is an important part of petroleum tank mounted on truck. The petroleum stored in the refueling tanker is liquid with great fluidity, so petroleum filled in refueling tanker tends to slosh when it subjects to external perturbations such as emergency brake etc. petroleum will slosh and impact tank wall, its center of gravity is changed when refueling tanker drives on uneven road or in emergency braking. For example, in recent years, earthquake often occurred in some country, a large amount of off-road equipments need to be refueled petroleum with tanker on field road during the rescue operation, the delivery of relief materials, wounded rescue etc. [1-3] In order to reduce sloshing and impact of tank, baffles are designed in the tank, There is no unified regulation on the number and structure of baffle in some country. Some unreasonable baffle structure often causes the baffle crack and even leakage of tank. It directly affects the safety and the normal use of the tanker. According to statistics on petroleum tank quality problems of 1500 tankers in 2010, the baffle quality problems accounted for 18.6% of the total test problems, mainly because of brittle fracture(as shown in figure 1) and serious deformation phenomenon of baffles. It is necessary to study on baffle of petroleum tank mounted on truck. [4]

2 STRUCTURE RESEARCH

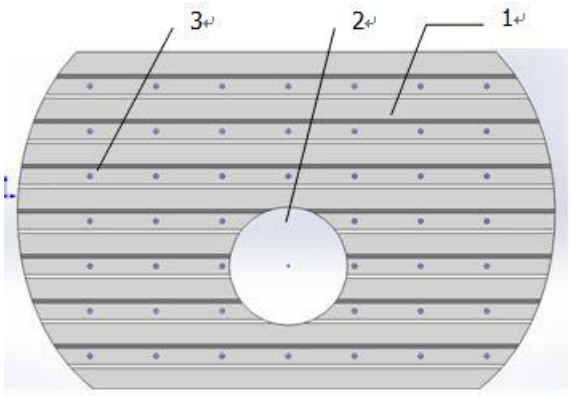
Longitudinal and transverse baffles(as shown in figure 2) in the petroleum tank of refueling tanker is designed in order to reduce the impact on the tank wall and improve stability and driving safety of refueling tanker. The longitudinal baffle is arranged along the longitudinal axis of the petroleum tank in order to reduce the sloshing of petroleum in the tank in left or right direction, the transverse baffle is arranged along the cross section of the tanker in order to reduce the sloshing of petroleum in the tank in front or behind direction. Baffle is fitted in tank wall with the connection either welded or bolted type. Bolt connection structure is welding tank wall with angle steel and connecting baffle with angle steel by bolt. Welding connection structure is welding tank wall with baffle by angle steel or flat steel.



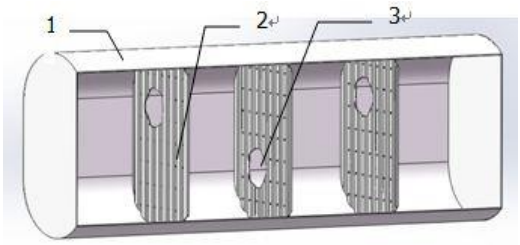
Baffle is classified into the integral plate baffle type(as shown in figure 3) and corrugated baffle(as shown in figure 4), the integral plate type baffle as a whole is installed in the tank, its shape is the same as the shape of tank section, one manhole of 500mm diameter is set in the middle of baffle. Integral baffle edge is reinforced by reinforcing ring,



Corrugated baffles can effectively reduce petroleum sloshing and impact on tank in lateral and vertical direction, but the manufacturing process is elaborate. They are often adopted the transverse installation, its folding length is often 25mm, its folding angle is often 127 °. There are holes with the diameter of 20mm in the baffle, which can reduce the baffle quality. One manhole of 500mm diameter is set in the middle of transverse baffle. The manhole edge is reinforced by reinforcing plate.



According to GB/T19905-2005, the upper arch area of baffle should be not greater than 20% of the cross-sectional area of tank, the effective area of each baffle should be larger than 40% of .the cross sectional area of tank.



Refueling tank can bear impact with 2g longitudinal and vertical acceleration and 1g lateral acceleration. Now tank volume of most petroleum tankers is 10 m^3 or so, so baffle arrangement of petroleum tank whose volume is 10m^3 is studied as below. Tank size is 4500mm ×2300mm ×1200mm，normal volume is 10m^3.

2.1 Three baffle cabin structure

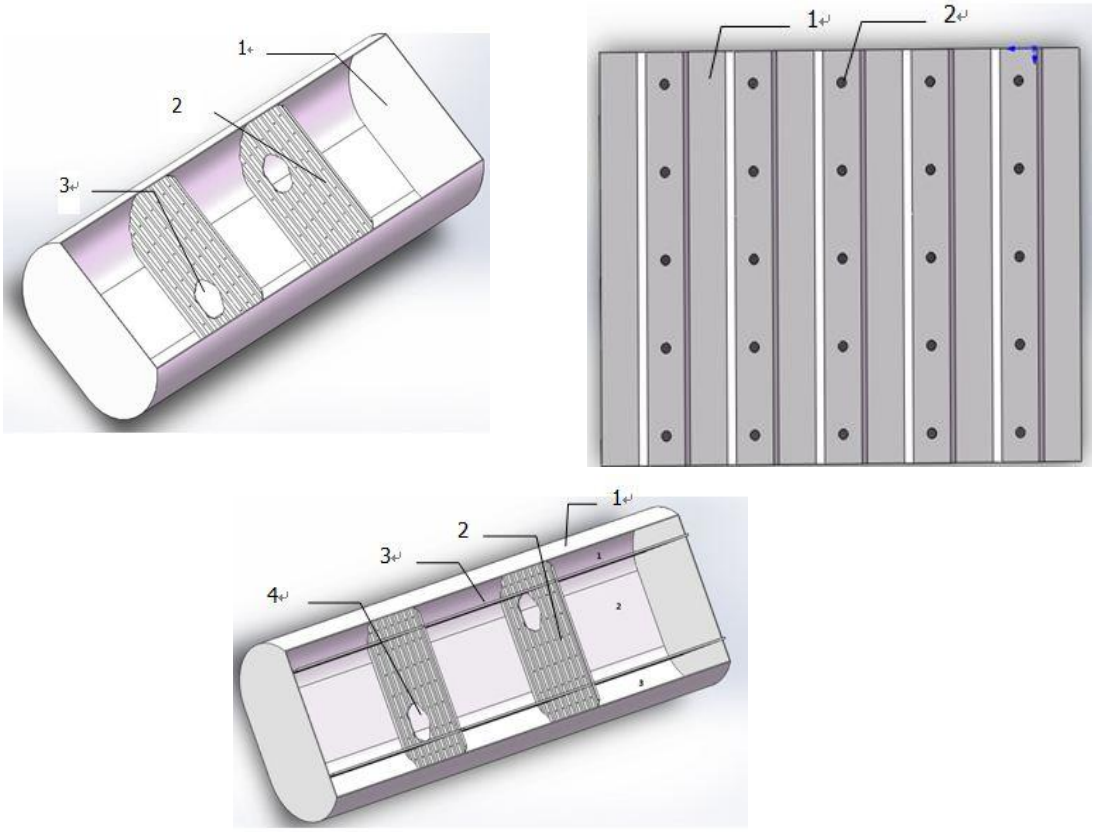
Two pieces of corrugated transverse baffles with equal distance(as shown in figure 6) are fitted in tank, the tank is divided into three baffle cabins.

2.2 Four baffle cabins structure

Four pieces of transverse corrugated baffles with equal distance(as shown in figure 7) are fitted in tank, the tank is divided into four baffle cabins.

2.3 Nine baffle cabin structure

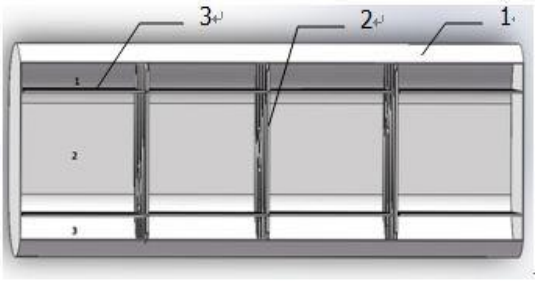
Two pieces of longitudinal corrugated baffles and two pieces of transverse corrugated baffles with equal distance(as shown in figure 8) are fitted in tank, the tank is divided into nine baffle cabins.



1 tank body 2 transverse baffle 3 manhole
Fig.7: Four baffle cabins structure

2.4 Twelve baffle cabin structure

Two pieces of longitudinal corrugated baffles and three pieces of transverse corrugated baffles with equal distance(as shown in figure 9) are fitted in tank, the tank is divided into twelve baffle cabins.



3 CALCULATION

Force acting on the tank wall and baffle is for:

$$F=Ma=KV\rho a \quad (1)$$

K—filling coefficient; V—petroleum volume, m^3; ρ—The density of petroleum, kg/m^3; a—Acceleration, m/s^2;

$$P_l=\frac{F_N}{A} \quad (2)$$

P_l—the dynamic pressure acting on the tank wall, Pa; F_N—Force acting in the tank wall, N; A—baffle area or tank wall area, m^2;

$$\delta_h=a\sqrt{\frac{KZP_c}{[\sigma]^t\phi}}+C \quad (3)$$

Z=3.4-2.4$\frac{a}{b}$, Z≤2.5; δ_h—thickness of tank head, m; P_c—petroleum pressure, Pa; $[\sigma]^t$—Allowable stress of tank material, Pa; a—length of short axis, m; b—length of long axis, m; φ—Welding coefficient; K—Structure coefficient; Z—shape coefficient ; C—Corrosion allowance, m;

Calculation thickness of tank head, tank wall and baffle with different baffle cabin is shown in table 1. Increasing the number of baffle in a certain range can decrease greatly thickness of tank head, when the number of baffle exceeds a certain value, the number of baffle has little influence on thickness of tank head and tank wall, petroleum tank whose normal volume10 m3 is suitable for nine baffle cabins structure.[5]

Table1: Calculation thickness (mm)

structure / thickness	3 baffle cabins	4 baffle cabins	9 baffle cabin	12 baffle cabin
tank head	8	7	5	4.8
tank wall	6	6	4	3.7
baffle	7	6	4	3.8

4 SIMULATION

Tank size is 4500mm × 2300mm × 1200 mm, its normal volume is 10 m3, material of tank body and baffle is Q235, yield stress is no more than 235MPa. Elastic modulus is 206000MPa, Poisson ratio is 0.3.The cross-sectional shape of tank body is rectangular cross section with round angle. Tank body and baffles are analyzed by 4-node rectangular shell element. Its finite element analysis model is shown in figure 10. Total node number is 30568.

Tanker can bear 2g longitudinal and vertical acceleration and 1g lateral acceleration according to the requirement of standard refueling tanker.[6-8] When tanker loaded 10m^3 petroleum brakes with 2g acceleration in emergency, its stress contour is shown in figure 11, the maximum stress value is 205MPa, its displace contour is shown in figure 12, the maximum displace is 0.198mm,they meet the design demand of standard refueling tanker.

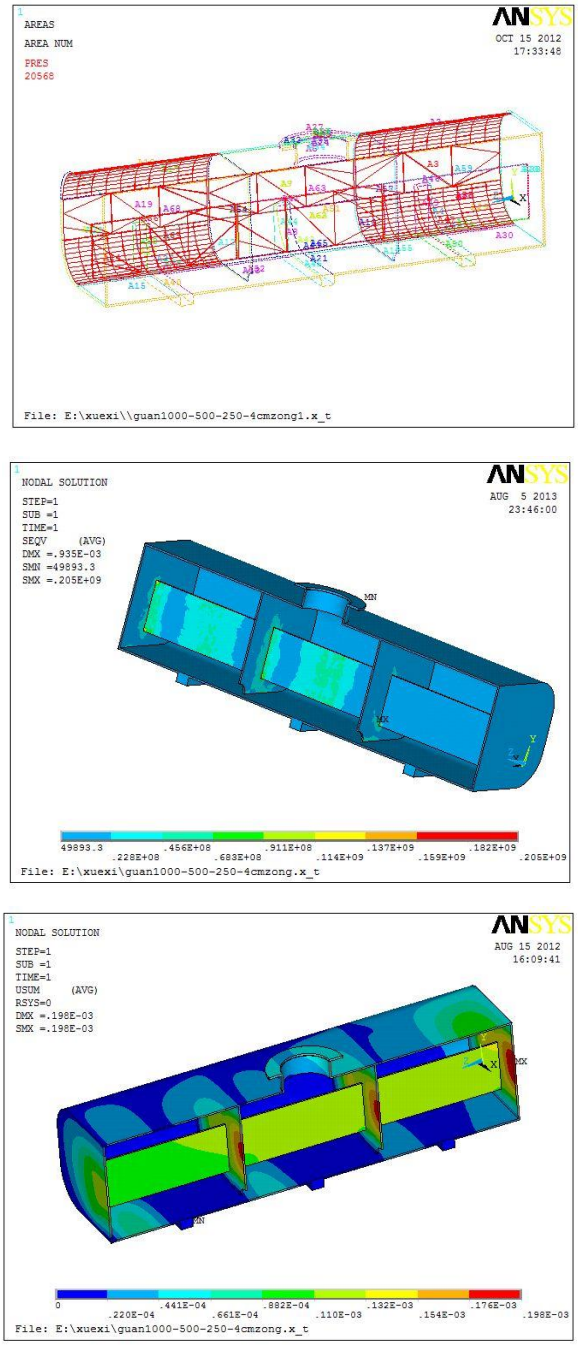


Fig.10: Finite element analysis model of tank

REFERENCES

[1] Zhenzhi Liu: military petroleum equipment, PLA Press, (**2002**)120-123.
[2] YU Qing, CAO Yuanwen: *Journal of Chongqing Jiaotong University*, Vol.22 (**2003**), p.32-34.
[3]Dong P, Hong J K. *Journal of Pressure Vessel Technology*，**2007**，129：355-362.
[4] Maleki A，Mansonr Z. *Journal of Sound and Vibration*，**2008**，311(12)：372-385.
[5] MonaghanJ J. *Journal of Computational Physics*，**1989**，82(1)：1-15.
[6] Monaghan J. *Journal of Computational Physics*，**1994**，110 (2)：399-406.
[7]Craig K J，Kingsley T C. *Structural and Multidisciplinary Optimization*，**2007**，33(1)：71-87.
[8]Gedikli A，Erguven M E. *Journal of Sound and Vibration*，**1999**，223(1)：141-155.