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CANISTER TESTING CHAMBER DESIGN & ANALYSIS USING FEM

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ABSTRACT

Canister is used for carrying, storing and launching of missile. During this process, it is subjected to an internal pressure of 45 kg/cm² and external pressure of 9 kg/cm². A canister testing chamber is used to test the canister for both internal and external pressures. This testing chamber is one of the most critical components in defence organisations. For testing the canister its both ends shall be closed by dummy dished ends. Testing chamber is tested for any leakages through the hinged dished end. Analysis of contact gap between this dished end and the shell of the chamber is carried using finite element method in ANSYS.

Key words: Canister, Canister testing chamber, contact gap analysis, von Misses stress

INTRODUCTION

Canister is a cylindrical container for holding, carrying, storing and launching missile. Canister testing chamber is used for testing the canister which can withstand an internal pressure of 45 bar and external pressure of 9 bar. The following components are used in canister.

- 1.Canister chamber shell
- 2.dished ends
- 3.support legs
- 4.Bolts
- 5.pressure legs

The shell of the testing chamber is made from IS: 2062 steel plates whose carbon % is 0.23 with UTS 410 MPa and yield strength of 250 MPa. These plates are welded to get 11 meters length and diameter of 1.5 meters. One end of the test setup will have dished end welded

integrally to the shell. The other end of the shell will be a hinged door which is bolted to the shell with proper sealing between the contact gap to prevent the leakage. On the side of the dished end a screw rod is provided to press the dished end for leak proof joint which shall withstand the internal pressure during testing. The screw is actuated by a hand wheel provided through nut. The nut is fixed in a welded housing on the dished end.

The screw front portion will have good surface finish with proper sealing arrangement to withstand 45 bar pressure without any leak. This screw is used to press the dummy dish end of the canister. Rubber gasket is provided between the mating faces to avoid any leak of water during pressure testing. The chamber have inlet, outlet and air removal ports with suitable ball valves and pressure indicators. A storage tank and pumping system is provided for pressurisation of the chamber.

In the present study, the analysis of the contact gap between the hinged dished end and shell of the testing chamber used for canister testing is performed. The factors that are studied are stress distribution, deformation and selection of appropriate bolt size.

METHODOLOGY

The methodology adopted in the present study is given below

1. Based on the canister dimensions and loads, canister testing chamber dimensions are calculated
2. A 3-D model of the chamber is developed in Pro-E as shown in figure 1
3. The model is imported to ANSYS and finite element analysis is carried out for internal pressure, deflection and stress on the chamber
4. The best bolt size is selected based on the results of the FEM analysis

Fig.1 model of canister testing chamber assembly

ANALYSIS OF TESTING CHAMBER

The canister testing chamber is meshed with shell 181 element which is quad4 node element. Thickness is given as the real constant. Following boundary conditions are applied:

1. Base plates are constrained in all degrees of freedom
2. Head closure is bolted to chamber using constraint equations-Simulating bolts
3. Internal pressure of 9 bar is applied
4. Gravity-9810 mm/sec² is applied to simulate self weight.

CONTACT GAP ANALYSIS

Contact gap analysis is carried out at the bolting locations of the chamber to check for the leakage of the pressure to the atmosphere. Contact problems are highly nonlinear and difficulties in the study are:

1. The regions of contact are not known until the problem is run. Depending on the loads, material, boundary conditions, and other factors, surfaces can come into and go out of contact with each other in a largely unpredictable and abrupt manner.
2. Most contact problems need to account for friction. There are several friction laws and models to choose from, and all are nonlinear. Frictional response can be chaotic, making solution convergence difficult.

Fig.2 Model of contact created between the mating surfaces near bolted region

BOLT CALCULATIONS

Model of contact created between the mating surfaces near bolted region is shown in figure 2. Bolt preload or prestress comes from the installation torque T applied while installing the bolt.

Bolt preload is computed as follows:

$$P_i = T / (K \cdot D)$$

Where P_i = Bolt preload

T = Bolt installation torque = 10858 N-mm

K = Torque coefficient = 0.2 (which is a function of thread geometry, thread coefficient of friction and collar coefficient of friction)

D = Bolt nominal diameter

$$\delta \text{ (delta)} = \text{measured bolt elongation} = PL / (EA)$$

where P = Bolt preload = 4524 N

L = Bolt length = 50 mm

E = Modulus of Elasticity of bolt = 2×10^5 N/mm²

$$A = \text{Bolt cross-sectional area} = (\pi/4) \cdot D^2$$

Initial strain or delta values (δ) for M22, and M36 are 0.001 mm and 0.00037 mm respectively.

The calculated delta value for M36 bolts 0.00037 mm is applied as initial strain for the bolts modeled as beams.

Maximum total deflection of 3.2 mm is observed from on the canister testing chamber deflection analysis as shown in figure 3.

Maximum stress of 58 N/mm² is observed from on the canister testing chamber stress analysis as shown in figure 4.

With M22 bolts, it is observed that VonMises stress is 24 N/mm² which is within the limit at bolt region but there is an opening of 0.0034 mm at the bolt locations. Hence it is recommended to check for higher bolt diameter. With M36 bolts, Vonmises stress is 6 N/mm² which is within the limit at bolt region and there is no opening at the bolt locations as shown in figure 5. Hence M36 bolts are best suitable to prevent the leakage of pressure to the atmosphere.

Fig.3 Total deflection of testing chamber

Fig.4 Von Mises stress of testing chamber

Fig.5 Contact gap for M36 bolts

CONCLUSIONS

- 1.The maximum VonMises stress with M36 bolts, observed on the canister testing chamber is 58 MPa
- 2.The maximum deflection observed with M36 bolts on the canister testing chamber is 3.2 mm
- 3.With M36 bolts, gap opening observed is 0 mm.
- 4.Contact gap analysis suggests to use M36 bolts for canister testing chamber to avoid the pressure leakage to atmosphere.

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