Design and Dynamic Analysis of a Fuze Body Outer case used in Guided Missile

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ABSTRACT:

Fuze body is a very important component of the guided missile. So, extreme care should be taken in designing the fuze body structure for these loads. With the flexibility of CAD/CAE tools it hasbecome easy and fast for designing these components for impact loads.

In this project 3D modelling of the contact type Fuze body outer case is done and performed dynamic analysis. Characteristics of stress distribution and high stress locations are determined according to the model and design optimization had been performed based on the results obtained from the modal and Spectrum analysis. ANSYS software is used to carry out the analysis and NX-CAD is used for 3D modelling.

INTRODUCTION

The fuzing and firing system is normally located in or next to the missile's warhead section. The system consists of a fuze, a safety and arming (S&A) device, a target-detecting device (TDD), or a combination of these devices. There are generally two types of fuzes used in missiles.

1. Proximity fuzes

2. Contact fuzes.

During the missile launching, arming of fuzes will happen when the accelerating forces act. Arming willstart only if the fuze is subjected to a given level of accelerating force for a specified amount of time. In the contact fuze, thefiring switch within the fuze is closed by the impact force to complete the firing circuit, thereby detonating the warhead. The firing action is very similar to the action of proximity fuzes used with bombs and rockets for proximity fuzes.

PROBLEM DEFINITION AND METHODOLOGY

Fuze body has been designed and optimized for vibration control. Structural analysis will be done by applying the operating loads and design optimization will be done to minimize the deflection. Acceleration forces upon missile launching arm both fuzes. Arming is usually delayed until the fuze is subjected to a given level of accelerating force for a specified amount of time.

So, extreme care should be taken in designing the fuze body structure for these loads. With the flexibility of CAD/CAE tools it has become easy and fast for designing these components for impact loads.

The methodology followed in my project is as follows:

- Design of Fuze body outer case is done in NX-CAD.
- Perform Modal analysis to find natural frequencies on the original model of the Fuze body outer case.
- Perform RSA analysis to find maximum deflections and stress on fuze body outer case for dynamic conditions.
- Optimize the original model to minimize the deflections and stress distributions at high stress locations are determined according to the model.
- Perform Modal analysis on optimized model to find natural frequencies on the modified model of the Fuze bodyouter case.
- Perform RSA analysis to find maximum deflections and stress on fuze body outer case for dynamic conditions.
- .Perform PSD analysis to find maximum deflections and stress on modified fuze body outer casefor random loading conditions.

3D MODELING OF FUZE BODY OUTER CASE

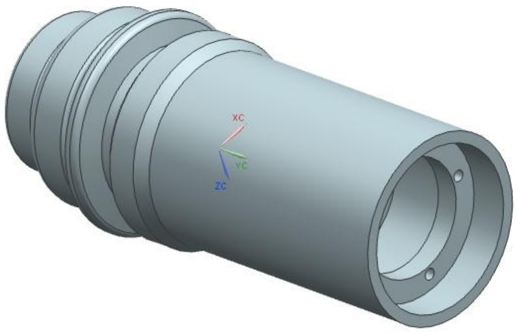

Fig. 3D model of Fuze body outer case

DYNAMIC ANALYSIS OF FUZE OUTER CASE

MODAL ANALYSIS:

The fuze outer case was studied to understand the natural frequencies in the range of 0-3000Hz. The Boundary condition used for modal analysis is shown in below figure.

Boundary conditions:

- Fuze body outer case is fixed in all Dof at one edge of fuse body which is base.

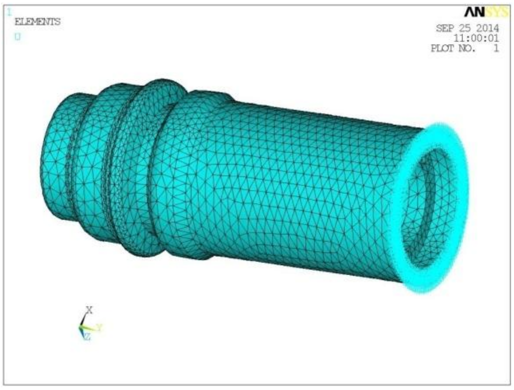

Fig. Shows Boundary conditions on the Fuze outer case

From the above modal analysis results it is observed that only 2 natural frequencies exists in the operating range of 0-3000 Hz.

From the modal analysis,

The total weight of the Fuze outer case is 1.7 kg.

- It is observed that the maximum mass participation of 0.4Kgs and 0.6Kgs observed in X-dir for the frequency of 1153Hz.
- It is observed that the maximum mass participation of 0.6Kgs and 0.4Kgs observed in Z-dir for the frequency of 1153Hz.

Spectrum analysis is carried out to check the structure behavior for random vibrations in the frequency range of 0-3000Hz.

RSA analysis:

From the RSA spectrum analysis in X - Dir,

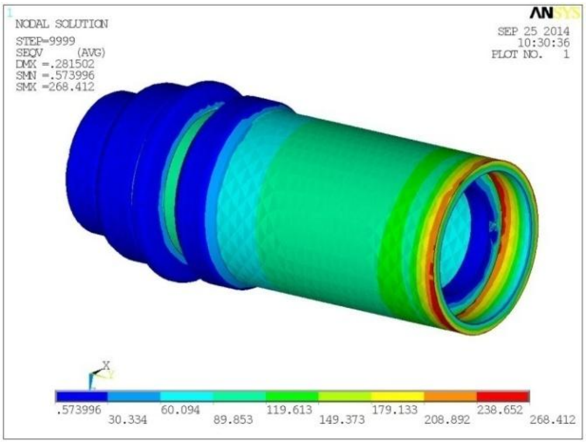

Fig. VonMises Stress of fuze outer case for RSA analysis in X-Dir

Table. Shows the deflection and stress of Fuze for RSA analysis in X-Dir

S.NO.	DEFLECTION (mm)	VONMISES STRESS (MPa)
1	0.281	268

From the RSA spectrum analysis in Y - Dir,

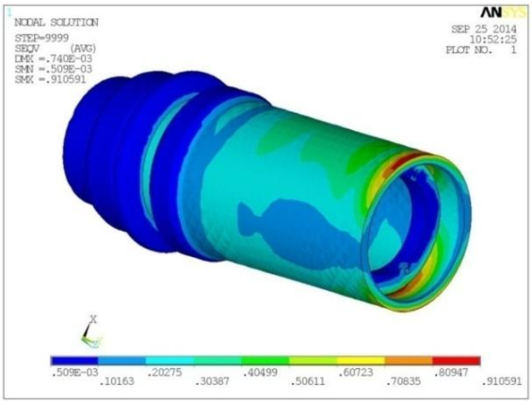

Fig. VonMises Stress of fuze outer case for RSA analysis in Y-Dir

Table. Shows the deflection and stress of Fuze for RSA analysis in Y-Dir

S. no.	DEFLECTION (mm)	VONMISES STRESS (MPa)
1	0.00074	0.9

From the RSA spectrum analysis in Z - Dir,

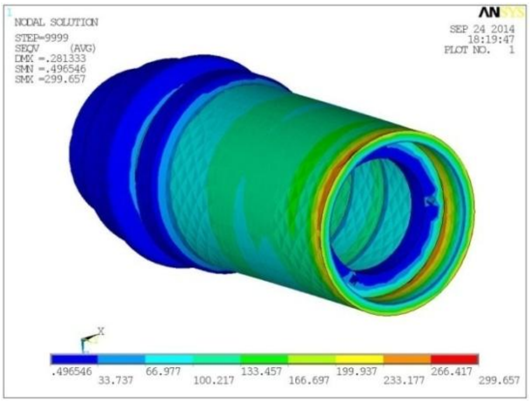

Fig. VonMises Stress of fuze outer case for RSA analysis in Z-Dir

Table. Shows the deflection and stress of Fuze for RSA analysis in Z-Dir

S.NO.	DEFLECTION (mm)	VONMISES STRESS (MPa)
1	0.2813	299

From the above RSA analysisresults VonMises stress of 268MPa, 0.9MPa and 299 MPaare observed in X, Y, and Z directions respectively. The yield strength of the material used for Fuse body outer case is 250MPa. According to the VonMises Stress Theory, the VonMises stress of Fuse body outer caseis morethan the yield strength of the material. Hence modifications are required.

The modifications are made on the Fuse body outer case by increasing wall thickness at the high stress locations.

MODAL ANALYSIS:

Modal analysis was carried out on Modified Fuze outer case to determine the natural frequencies and mode shapes of a structure in the frequency range of 0 -3000Hz.

From the modal analysis,

The total weight of the Fuze outer case is 1.8 kg

- It is observed that the maximum mass participation of 1Kgs observed in X-dir for the frequency of 987Hz.
- It is observed that the maximum mass participation of 1Kgs observed in Z-dir for the frequency of 2956Hz.

Spectrum analysis is carried out to check the structure behavior for random vibrations in the frequency range of 0-3000Hz.

RSA analysis:

From the RSA analysis in X - Dir,

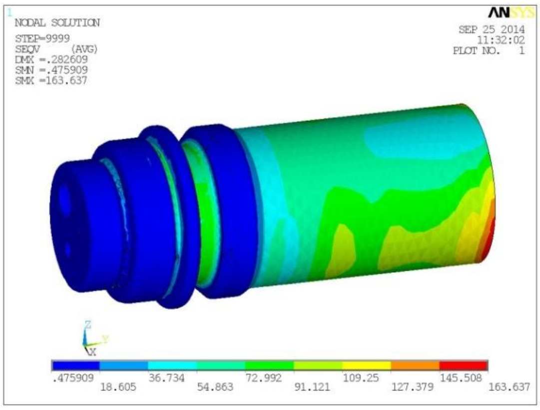

Fig. shows VonMises Stress of Modified Fuze outer case for RSA analysis in X-Dir

From the RSA analysis in Y - Dir,

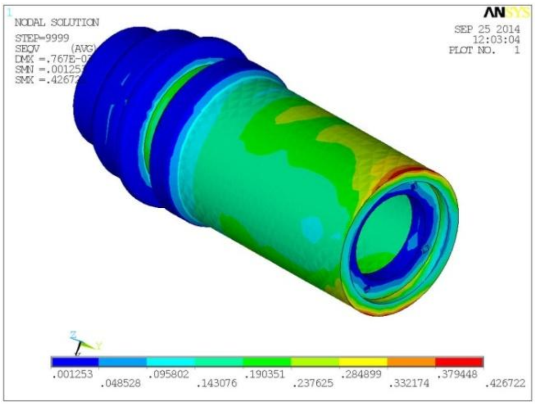

Fig. VonMises Stress of Modified Fuze outer case for RSA analysis in Y-Dir

From the RSA analysis in Z - Dir,

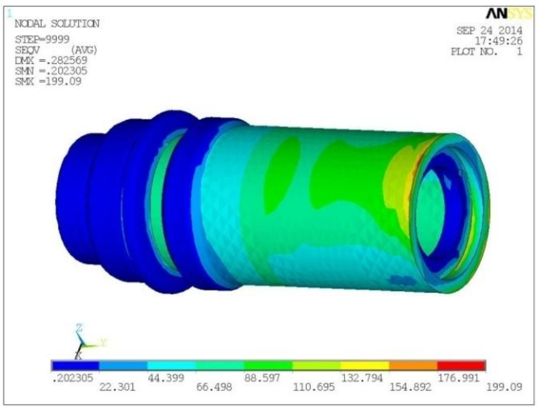

Fig. VonMises Stress of Modified Fuze outer case for RSA analysis in Z-Dir

Table. Deflection and stress of Modified Fuze for RSA analysis in X, Y and Z-Dir

S. NO.	DEFLECTION (mm)			VONMISES STRESS (MPa)		
	X	Y	Z	X	Y	Z
1	0.27	0.0007	0.28	163	0.4	199

From the aboveRSA analysis results VonMises stress of 163MPa, 0.4MPa and 199 MPaare observed in X, Y, and Z directions respectively. The yield strength of the material used for Fuse body outer case is 250MPa.

According to the VonMises Stress Theory, the VonMises stress of Modified Fuse body outer caseis less than the yield strength of the material.

However PSD analysis has been carried out to check the structure behavior for random vibrations in the frequency range of 0-10000Hz.

PSD analysis:

From the PSD spectrum analysis in X-Dir,

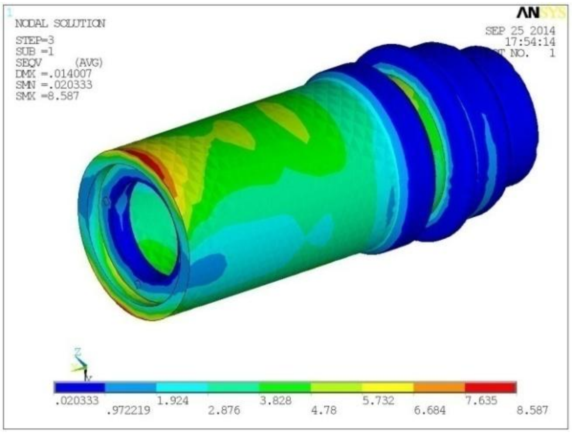

Fig. VonMises stress of Modified Fuze outer case for PSD response in X – Dir

- 1 sigma Stress = 8N/mm2
- 3 sigma Stress =24/mm2

This implies that only 0.3% of the time the board deflection reaches 24 N/mm2.

From the PSD analysis in Y-Dir,

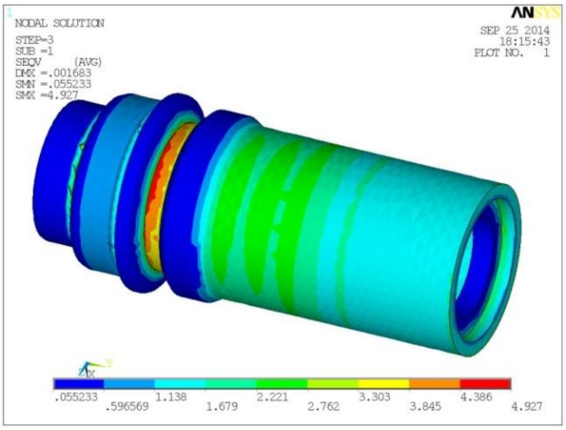

Fig. VonMises stress of Modified Fuze outer case for PSD response in Y – Dir

- 1 sigma Stress = 4N/mm2
- 3 sigma Stress = 16N/mm2

This implies that only 0.3% of the time the board deflection reaches 16 N/mm2.

From the PSD analysis in Z-Dir,

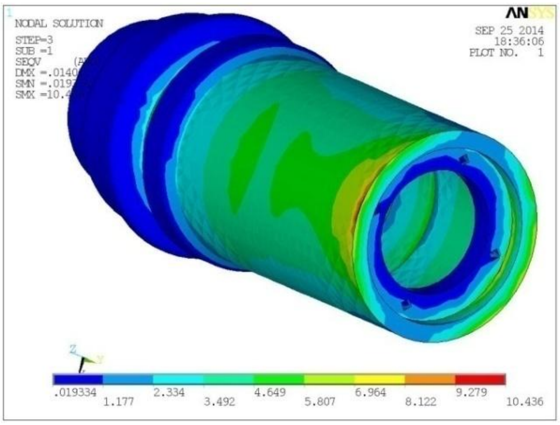

Fig. VonMises stress of Modified Fuze outer case for PSD response in Z - Dir

- 1 sigma Stress = 10N/mm2
- 3 sigma Stress = 30N/mm2

This implies that only 0.3% of the time the board deflection reaches 30 N/mm2.

Table.Deflection and stress of Fuze for PSD analysis in X, Y and Z-Dir

S. NO.	DEFLECTION (mm)			VONMISES STRESS (MPa)		
	X	Y	Z	X	Y	Z
1	0.041	0.002	0.042	24	16	30

From the above PSD results the VonMises stress of 24MPa, 16MPa and 30MPa are observed in X,Y and Z directions respectively which are less than the yield strength of material used Modified

Fuze body. The yield strength of the material used for Modified Fuze body is 250 MPa.

According to the VonMises Stress Theory, the VonMises stress of Modified Fuze body is less than the yield strength of the material.

Hence the design of Modified Fuze body is safe for the above dynamic loading conditions.

CONCLUSION

In the present project the Fuze outer casehas been studied for Dynamic behaviour of well designed model.

The Fuze outer case was studied for 3 different cases:

- Modal analysis
- Spectrum Analysis
  - RSA analysis
  - PSD analysis

From the above analysis it is concluded that that the modified Fuze outer casehas stresses and deflections within the design limits of the material used. The deflections and stresses obtained in the spectrum analysis are also under the design limits of the material.

Therefore it concluded that the Modified Fuze outer caseis safe under the above loading conditions.

REFERENCES

1. Redundancy and Reliability of Air to Air Missile Fuze Electronics by Ali Peiravi ,
2. Adaption of the plastic compression ignition fuze to an 81 mm practice and training cartridge by Craig A. Lester,
3. The optimization design of circular aperture horn antenna with hollow conical beam by using body of revolution method of moments by Wen – Ming Yu,
4. Structural design and analysis of an existing aerodynamically optimised mortar shell by Yohannes Asfaw,
5. Design and Analysis of a Fuze-Configurable Range Correction Device for an Artillery Projectile by Michael S.L. Hollis, Fred J. Brandon,
6. Y. S. Dai, G. Levitin, Optimal resource allocation formaximizing performance and reliability in tree-structured grid services, IEEE Trans. on Reliability, Vol. 56, No. 3, pp.444-453, (Sept. 2007).
7. Rinker RA, "Understanding firearm ballistics" ; Mulberry House publishing, Croydon, Indiana 47112, U.S.A.; 2nd revised edition 1998.
8. Karl G. sellier, Beat P. Kneubuehl, "Wound ballistics and the scientific background", Elsevier science B.V. 1194.
9. Moss GM, Leeming DW, Farrar CL (1995), "Military Ballistics – A basic manual,
Brassey's", London 1995.
10. Beat vogelsanger, "Chemical stability, compatibility and shelf life of explosives", chimia 58 (2004) 401-408.
11. J. Davidson, The reliability of mechanical systems, Wiley,1999.
12. N. Friedman, The Naval Institute Guide to World Naval Weapon Systems, Fifth Edition, 2006.
13. D. L. Overholts, J. E. Bell, M. A. Arostegui, A location analysis approach for military maintenance scheduling with geographically dispersed service areas, Omega, Vo. 37, No. 4, pp. 838-852, (August 2009).
14. Ponder Timothy C. et.al., "Cylindrical warhead design optimization", Final rept. Jun- Aug 1971, Air Force Armament Lab. EGLIN AFB FL.