International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 08 | Nov-2015 www.irjet.net p-ISSN: 2395-0072

Design and Analysis of Control Bay Used in Guided Missile

Ragam Prashanth[1], D.Muppala[2], Nirmith Mishra[3]

[1]PG Student, Department of Aerospace, MLR Inst of Tech and Management, Hyderabad, Telangana, India
[2]Associate Professor, Department of Mechanical, MLR Inst of Tech and Management, Hyderabad, Telangana, India
[3]Assistant Professor, Department of Aerospace, MLR Inst of Tech and Management, Hyderabad, Telangana, India

---***---

Abstract - ***Aerodynamic control is the connecting link between the guidance system and the flight path of the missile. Effective control of the flight path requires smooth and exact operation of the control surfaces of the missile. They must have the best possible design configuration for the intended speed of the missile. The control surfaces must move with enough force to produce the necessary change of direction. The adjustments they make must maintain the balance and center of gravity of the missile. The control surfaces must also be positioned to meet variations in lift and drag at different flight speeds. All these actions contribute to the in-flight stability of the missile. Missile control bays have been, and are arguably still, the most efficient means of controlling a missile and guiding it to a target. They can efficiently generate the required maneuvering force by a direct action near the center of gravity. Affecting all of these aerodynamically controlled configurations are the sizing and power requirements of the control surfaces.***

The paper presents a finite element model for strength analysis of a missile's control bay under different conditions like Pitch, Yaw and Roll moments. Characteristics of stress distribution and high stress locations are determined according to the model.

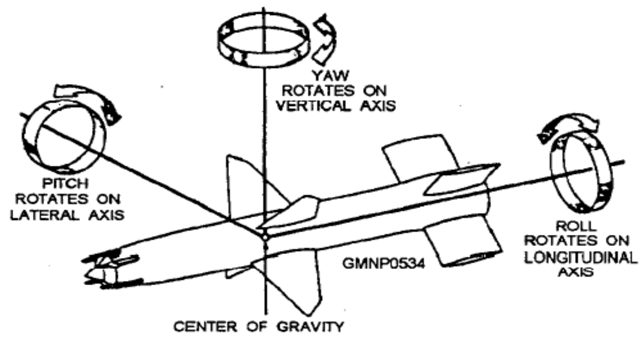
Key Words: *Control bay, Aerodynamic forces, Guided missile, Deflection, Vonmise Stress, Modulus of Rigidity*.

1. INTRODUCTION

a guided missile executes two basic types of motion-rotation and translation. In pure rotation, all parts of the missile pivot around the center of gravity. In movements of translation, or linear motions, the center of gravity moves along a line.Missiles, like other aircraft, have six degrees or dimensions of freedom (movement). To describe these motions, we use a reference system of lines or axes. These axes intersect at the missile's center of gravity.A missile can make three kinds of rotary movement—pitch, roll, and yaw (fig. below). Pitch, or turning up and down, is rotation about the lateral axis. The lateral axis is the reference line in the horizontal plane and is perpendicular to the line of flight. The missile rolls, or twists, about the longitudinal axis. This axis is the reference line running through the nose and tail. The missile yaws, or turns left and right, about the vertical axis.

A missile can make three kinds of translation or linear movements. For example, a sudden gust of wind or an air pocket could throw the missile a considerable distance from its desired trajectory. This displacement could happen without causing any significant rotary or angular movements. Any linear movement can be resolved into three components-lateral, vertical, and along the direction of thrust.

The missile must sense and correct for each degree of movement to maintain an accurate and stable flight path. This stable flight path is often called "attitude "and refers to the position of the missile relative to a known (horizontal or vertical) plane. The control system contains various components used to maintain a proper flight attitude.



2. EQUATIONS USED

Factor of safety : $\frac{\sigma\, yield}{\sigma\, max}$

Moment : $\tau = F * d$

3. MODEL DESIGN AND MESH

UNIGRAPHICS software shall be used for 3D modeling of the control bay model and Ansys software shall be used to perform the structural analysis of the control bay to find out the Characteristics of stress distribution and high stress locations are determined according to the model.

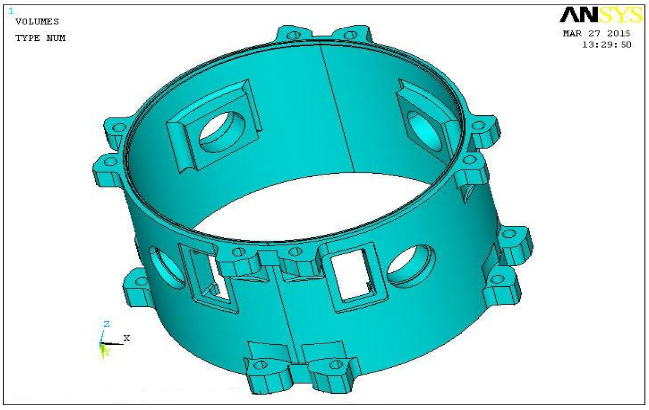


Fig: 3D model of control bay imported in to ansys

MATERIAL PROPERTIES

Material used for control bay is Aluminium Alloy 24345

Young's Modulus: 0.7e5N/mm2

Poisson's Ratio: 0.3

Density: 2700kg/m3

Yield strength: 420Mpa

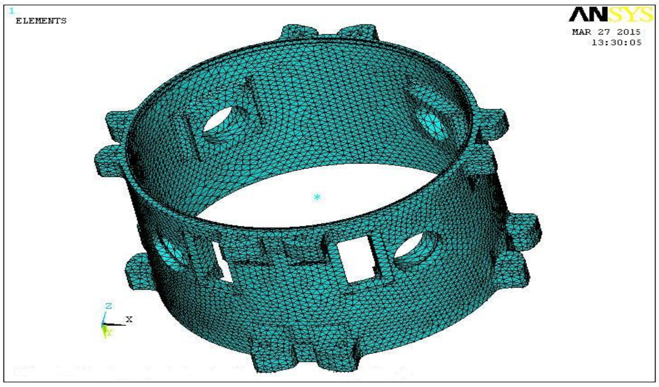


Fig: FE model of control bay

The free meshing type is used for irregular bodies. The control bay has so many holes and sub parts.so we cannot divide the controlbay in to equal parts.so I have proceeded with Free mesh for the control bay.SOLID92 element has used. It has quadratic displacement behavior and it is well suited to model irregular meshes.

BOUNDARY CONDITIONS

All Bolting locations are constrained in all DOF. Moment is applied along the Axis which is depend on the condition of moving of control surfaces.Then Moment is transferred to the control bay lugs using couple equation.

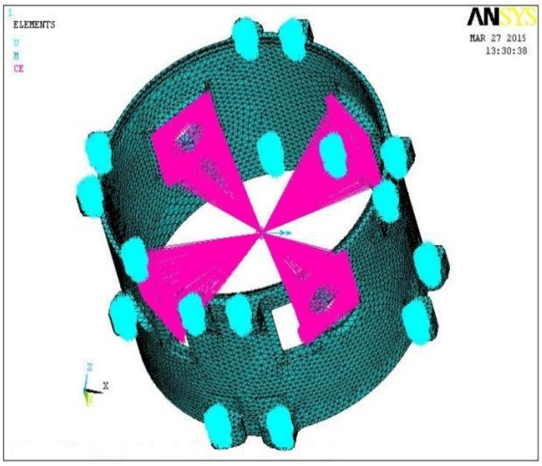


Fig: control bay after applying Boundary conditions

4. RESULTS AND DISCUSSIONS

CONDITION: YAW

The missile yaws, or turns left and right, about the vertical axis. Moments are applied at the CG of control bay along X-axis. Deflections and stresses are plotted.

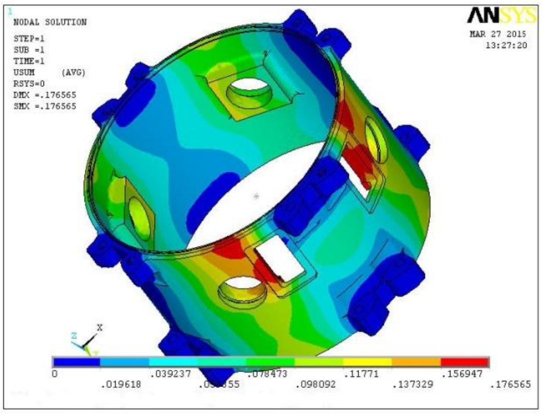


Fig Total deflection in yaw condition of Al bay

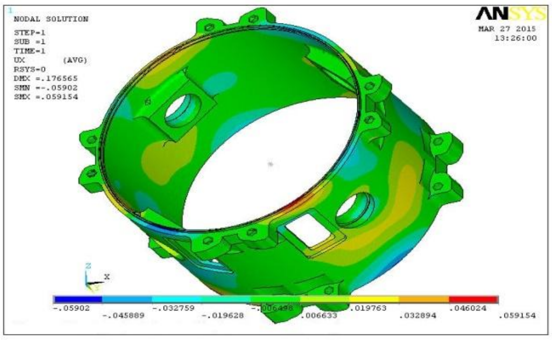


Fig deflection in X-direction in yaw condition

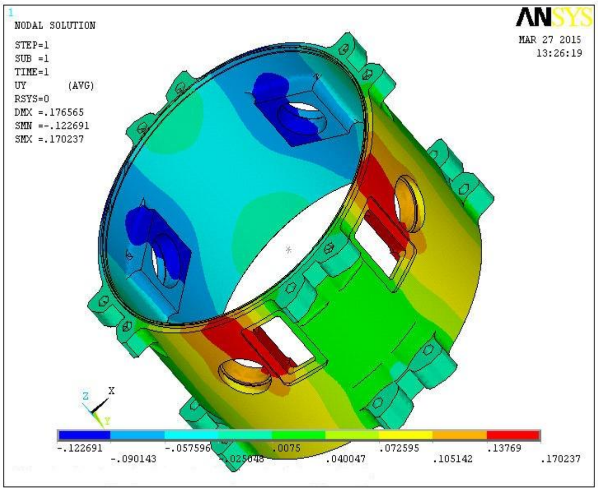


Fig: deflection in Y-direction in Yaw condition

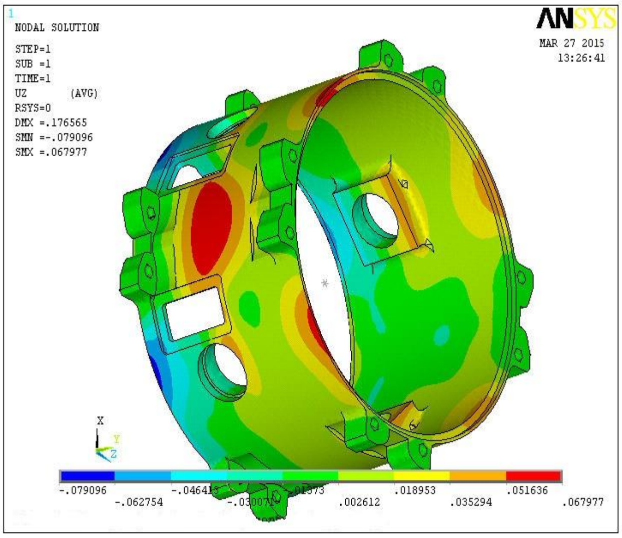


Fig: Deflection in Z-direction in Yaw condition

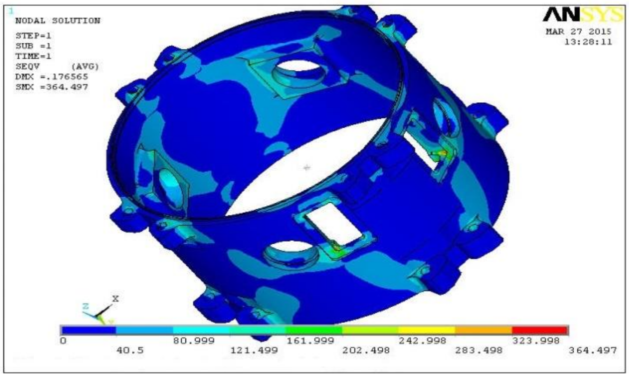


Fig: Maximum VonMises stress

S.NO	DEFLECTION	VONMISE STRESS
1	0.176mm	364Mpa

CONDITION: ROLL

The missile rolls, or twists, about the longitudinal axis. Moments are applied at the CG of control bay along Y-axis. Deflections and stresses are plotted.

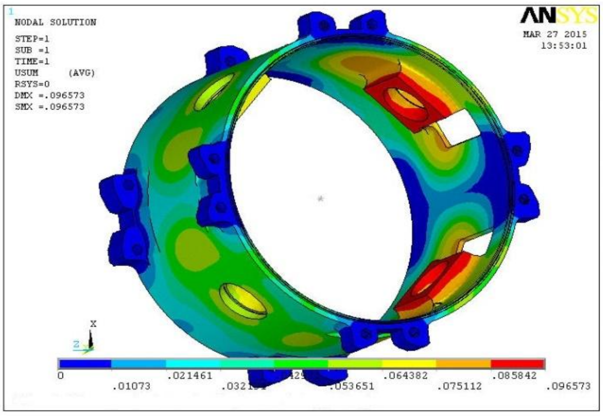


Fig: Total Deflection in Roll condition

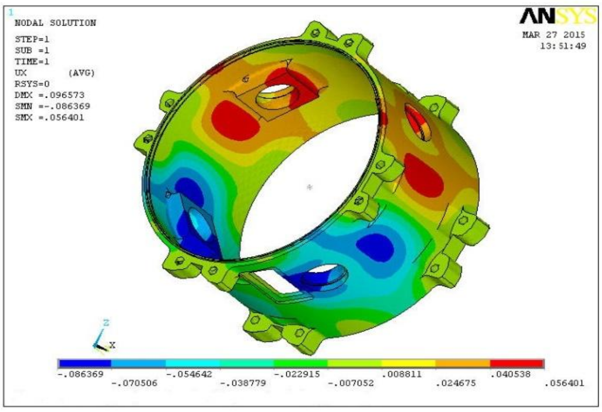


Fig: Deflection in X-direction

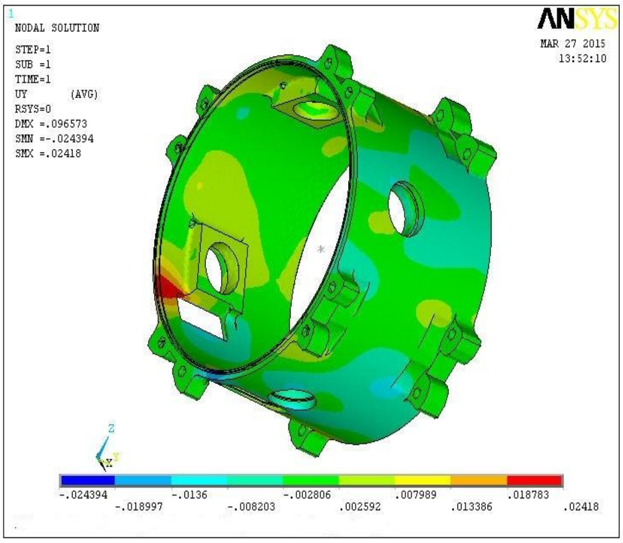


Fig: Deflection in Y-Direction

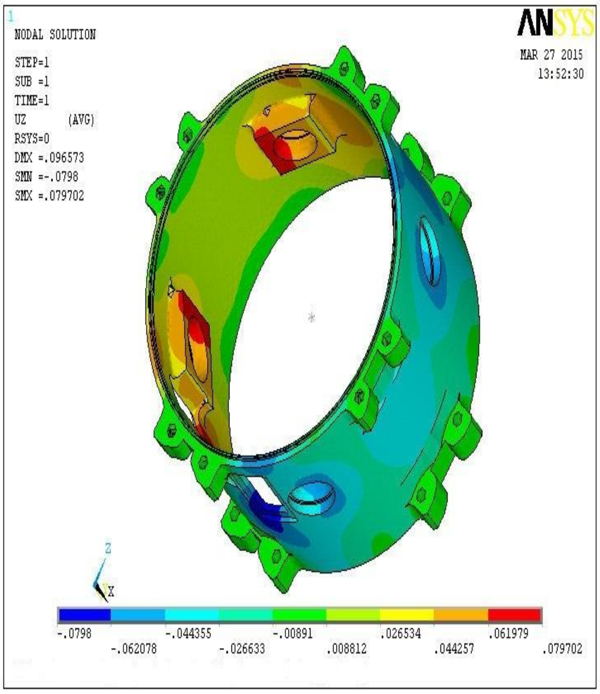


Fig: Deflection in Z-Direction

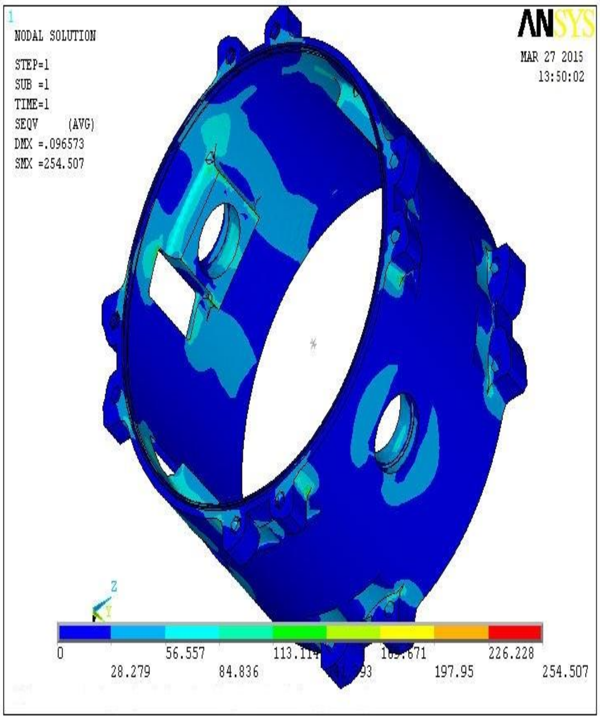


Fig: Maximum Vonmises stress

S.no	Deflection	Vonmises stres
1	0.0966mm	254Mpa

CONDITION: PITCH

Pitch, or turning up and down, is rotation about the lateral axis. The lateral axis is the reference line in the horizontal plane and is perpendicular to the line of flight. Moments are applied at the CG of control bay along Z-axis. Deflections and stresses are plotted.

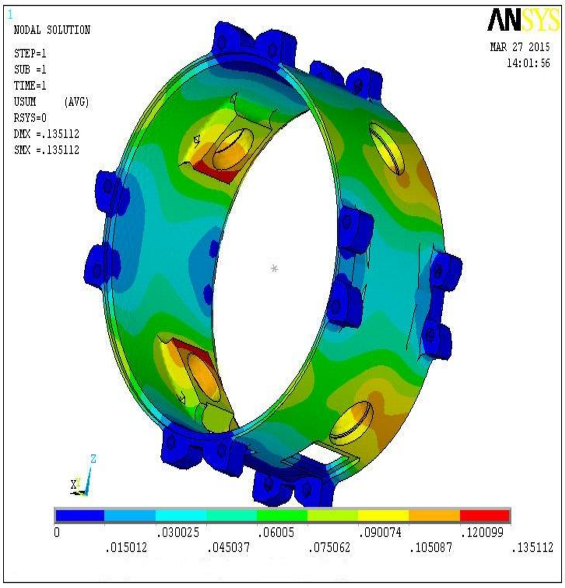


Fig: Total Deflection in pitch codition

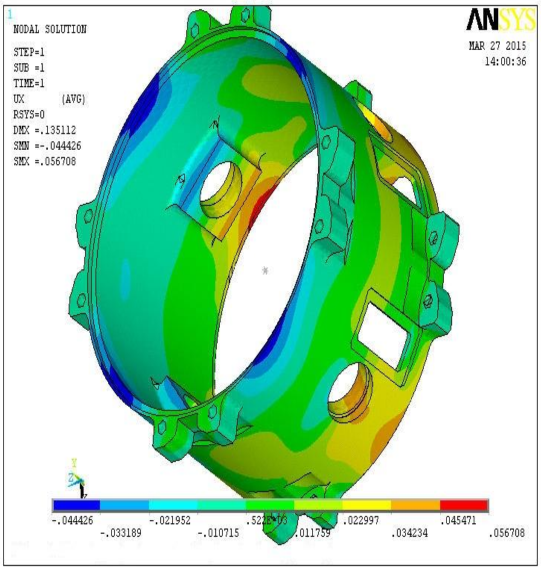


Fig: Deflection in X-Direction

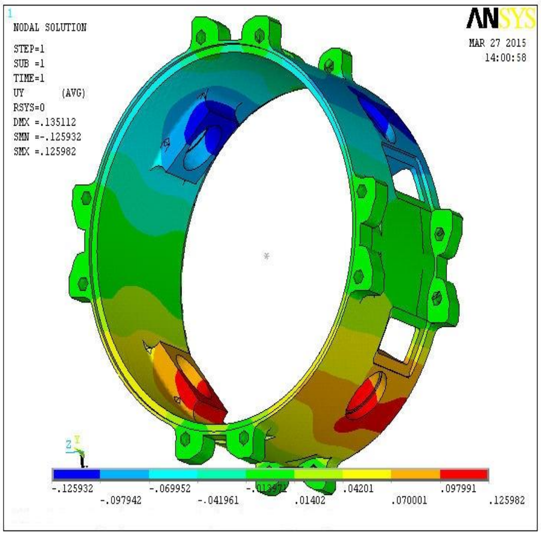


Fig: Deflection in Y-Direction

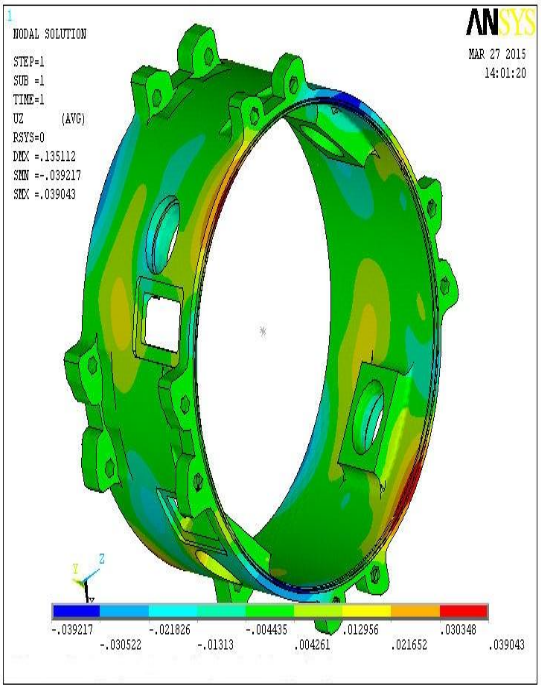


Fig: Deflection in z-direction

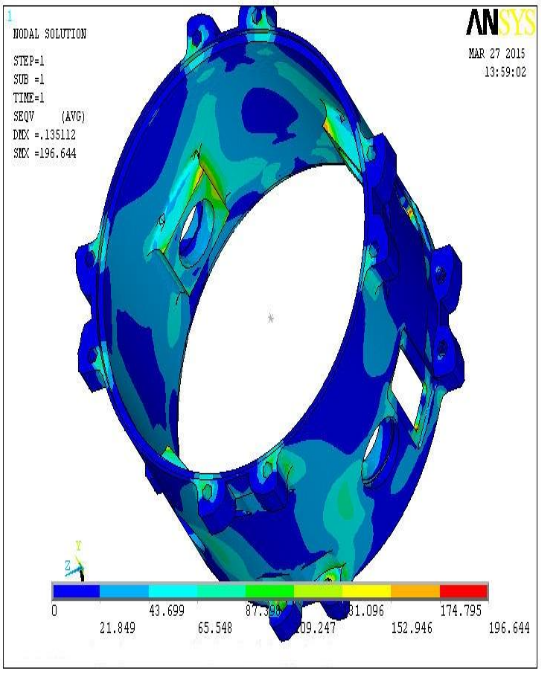


Fig: Maximum vonmises stress in pitch condition

S.NO	DEFLECTION	VONMISESSTRES
1	0.135	196Mpa

ANALYSIS OF Mg CONTROL BAY

MATERIAL PROPERTIES:

Young's Modulus: 0.4e5N/mm2

Poisson's Ratio: 0.3

Density: 1800kg/m3

Yield strength: 220Mpa

CONDITION: YAW

The missile yaws, or turns left and right, about the vertical axis. Moments are applied at the CG of control bay along X-axis. Deflections and stresses are plotted.

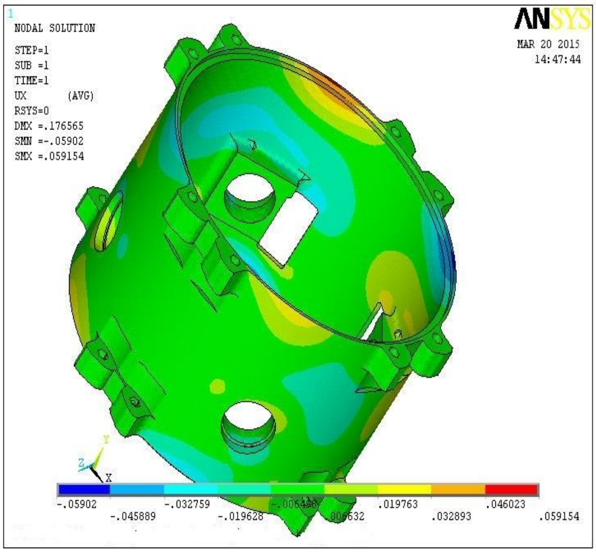


Fig: Deflection in X-Direction

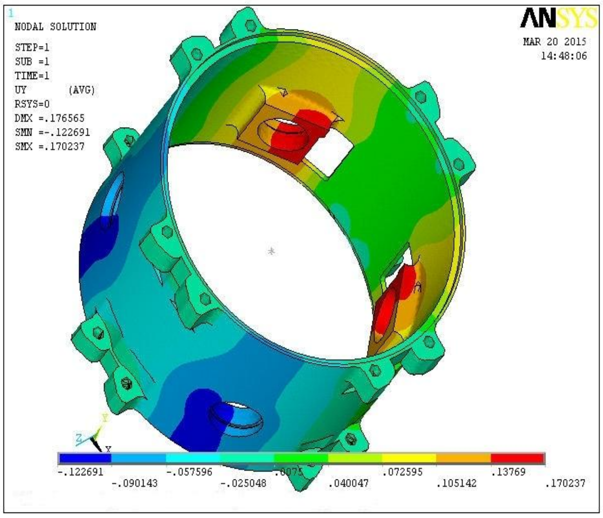


Fig: Deflection in Y-Direction

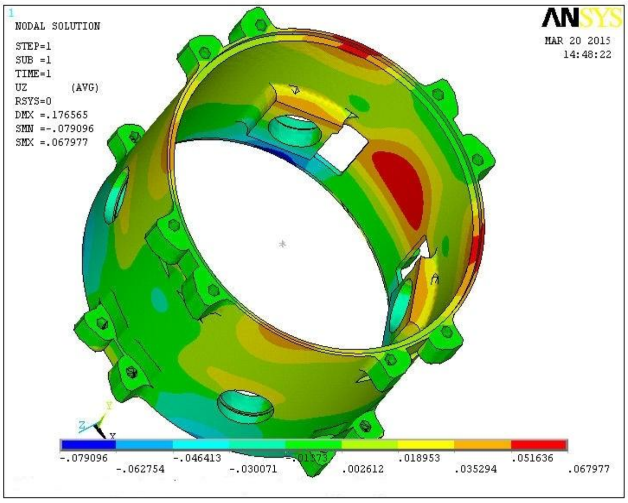


Fig: total Deflection in Yaw condition

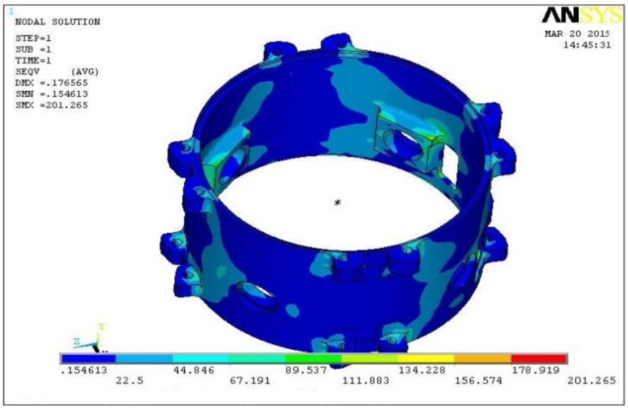


Fig: Vonmise stress in Yaw condition

S.NO	DEFLECTION	VONMISE STRESS
1	0.176mm	201Mpa

CONDITION: ROLL

The missile rolls, or twists, about the longitudinal axis. Moments are applied at the CG of control bay along Y-axis. Deflections and stresses are plotted.

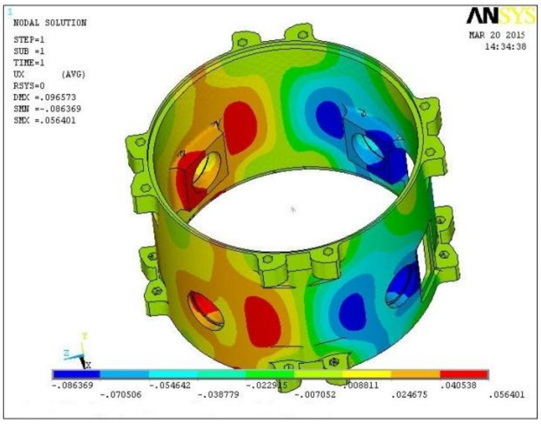


Fig: Deflection in X-Direction

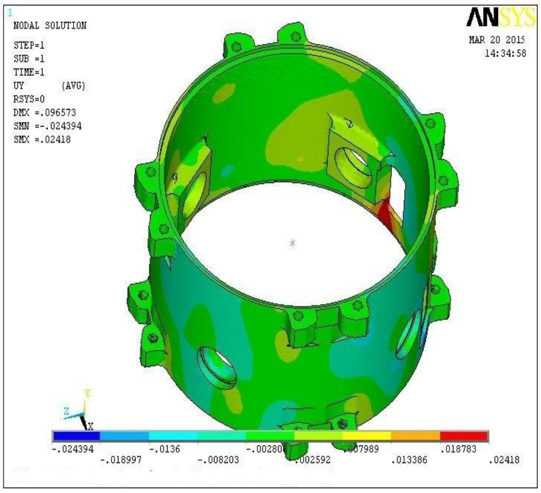


Fig: Deflection in Y-Direction

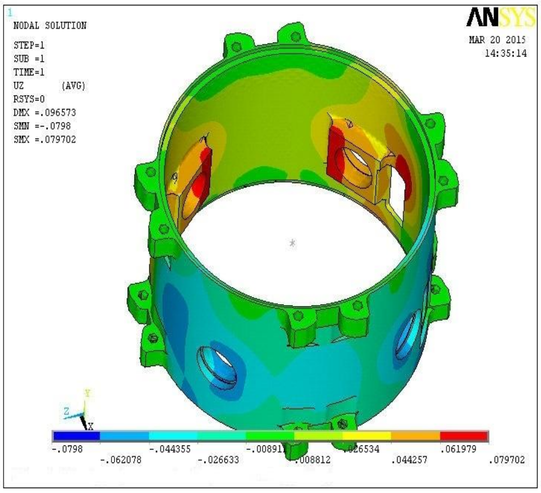


Fig: Deflection in Z-Direction

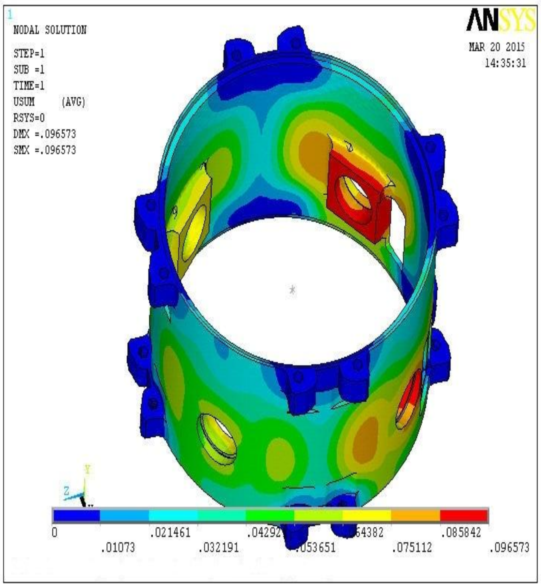


Fig: Total Deflection in Roll condition

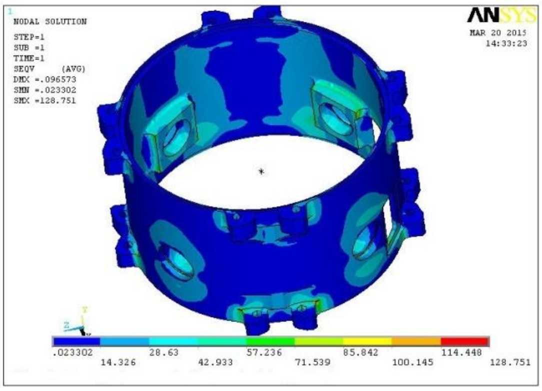


Fig: Maximum Vonmise stress in Roll condition

S.NO	DEFLECTION	VONMISE STRES
1	0.096mm	128Mpa

CONDITION: PITCH

Pitch, or turning up and down, is rotation about the lateral axis. The lateral axis is the reference line in the horizontal plane and is perpendicular to the line of flight. Moments are applied at the CG of control bay along Z-axis. Deflections and stresses are plotted.

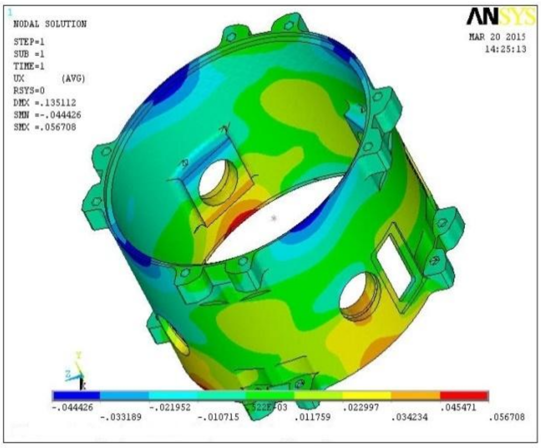


Fig: Deflection in X-Direction

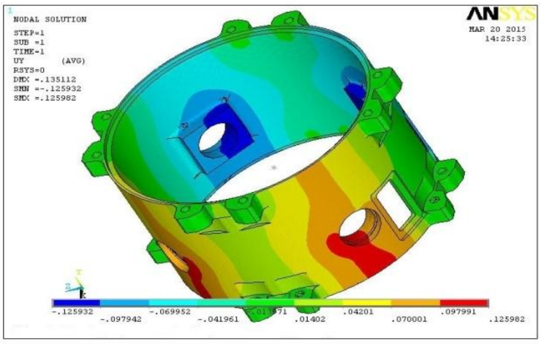


Fig: Deflection in Y-Direction

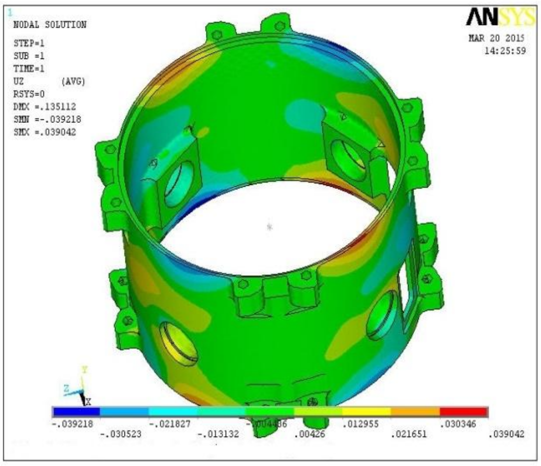


Fig: Deflection in z-Direction

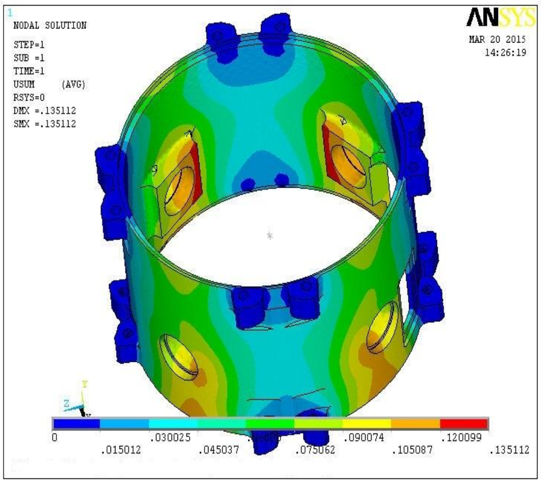


Fig: Total Deflection in pitch condition

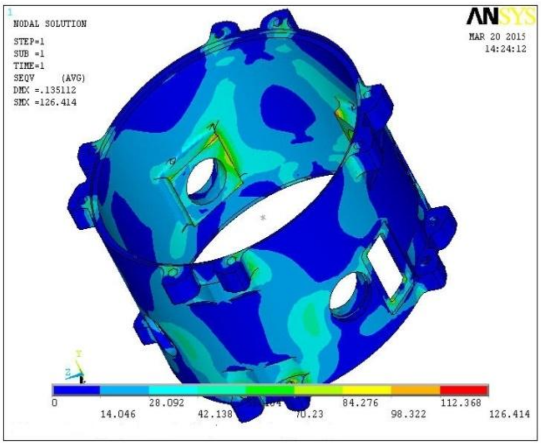


Fig: Vonmise stress in pitch condition

S.NO	DEFLECTION	VONMISE STRESS
1	0.135mm	126Mpa

COMPARISON OF AL AND MG RESULTS:

	AL BAY	MG BAY
MAX DEFORMATION	0.176 for yaw	0.172 for yaw
MAX VONMISE STRESS	364Mpa for yaw	201Mpa for yaw
YAW-FOS	1.15	1.1
ROLL-FOS	1.65	1.7
PITCH-FOS	2.14	1.75

4. CONCLUSIONS

3d model of the control bay is created using UNIGRAPHICS software. Static Stress analysis of the control bay was carried out for Yaw, Roll and Pitch conditions and moments are applied. From The analysis it is observed that the maximum Vonmises stress induced in the master cylinder is 364Mpa for Yaw condition. From The analysis it is observed that the maximum deformation of the control bay is 0.176 for Yaw condition. The factor of safety is 1.15, 1.65 and 2.14 for Yaw, Roll and Pitch respectively.
From the analysis it is concluded that the design of control bay is safe under the given operating conditions.

ACKNOWLEDGEMENT

The authors would like to graciously thank K.V.Reddy, Principal and D.Muppala, Head of the Department MLRIT&M, Hyderabad, for their extended support in project. Finally I would like to thank D.Muppala, Associate professor, MLRIT&M Hyderabad, who has provided me with the best knowledge about the project.

5. REFERENCES

[1] Hobbs, M., Fundamentals of Rockets, Missiles and Spacecraft, John F. Rider Publications, 1962.

[2] Merrill, G , Principles of Guided Missile Design, D Van Nostrand Company, Inc., New York.1959

[3] Koelle, H. H., Handbook of Aeronautical Engineering, McGraw-Hill Book Company, Inc.,New York, 1961

[4] Hobbs, M., Fundamentals of Rockets, Missiles and Spacecraft, John F. Rider Publications,1962

[5] Missile Design, Ballistic Systems Division, Exhibit 64-10, November 1964

[6] Herrick, J.W., Rocket Encyclopedia, Illustrated, Aerospace Publications, 1959

[7] . Heaslet, Max A., and John R. Spreiter: Recipro'city Relations in Aerodynamics, NACA Tech. Repts. 1119, 1953

[8] Nielsen, Jack N.: Quasi-cylindrical Theory of Interference at Supersonic Speeds and Comparison with Experiment, NACA Tech. Repts. 1252, 1955

[9] Journal of the operations research society of America from 1952 to 1957 under ISSN 0096-3984.

[10] Technical rept. Jun-Jul 66, Accession number: AD0812373 experimental stress analysis of over pressure facility for project hest, Minuteman missile site D-1.