INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 6.078
(Volume 6, Issue 3)
Available online at: www.ijariit.com

Modelling and structural analysis of double bubble fuselage for optimal payload capacity

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ABSTRACT

This paper describes the model III Modelling and Analysis of the Double Bubble (DB) fuselage at different pressure loads condition. The computer analysis includes the computation of circumferential stress, total deformation, maximum stresses. The advantage of DB fuselage is to increase the payload carrying capacity and contributes towards the increase of lift. The modelling of the fuselage has been carried out with different configurations so as to minimize the total deformation. There is the research compulsion to modify the existing fuselage geometry to accommodate a greater number of passengers with less cost. This project optimizes the design using SOLIDWORKS latest version. The in-depth analysis have been carried using ANSYS R18.1 version. Three models have been created and compared for optimized characteristic parameters. This project fulfills the gap between the passenger's comfort and airlines economy. The computations of three models give a converging result. Model III has almost elliptical geometry which obtained by the DB concept and it has the least computational result values. The model III provides more seating space for the passengers.

Keywords— *Double Bubble Fuselage; Blend Wing Body; Semi-Monocoque; Stressed Skin; Structural analysis; Optimization; Simulation*

1. INTRODUCTION

The fuselage is that the structure, or body, of the aircraft's which offers space for personnel, cargo, controls systems, and most of the accessories. And attachments of the fuselage are power plant, wings, stabilizers, and landing gear. Basically the fuselage construction are two types —welded steel truss and monocoque design. In the welded steel truss design is constructed with the truss members joined to form a rectangular hollow section which is termed as fuselage, and the structural members used in the rigid construction are bars, structs, and beams. The monocoque design is mostly depends on the strength of the skin, is used to cover and to carry various loads. The monocoque design is classified into three classes—monocoque, semi-monocoque, and reinforced shell.

The monocoque construction is designed by using formers, frame assemblies, and bulkheads to give shape to the fuselage, the skin carries the major stresses. Since there are no bracing members, the skin must be strong and heavier enough to remain the fuselage rigid. Semi-monocoque design overcomes with the strength-to-weight problem of monocoque construction. In the semi monocoque construction has the skin reinforced with the longitudinal members and the remaining are same as monocoque construction, like formers, frames, and bulkheads. For the reinforced shell the skin is completely reinforced with framework of structural members. Different portions of some fuselage may belong to any one of the three classes. The most considerable construction is semi monocoque-type construction.

2. METHODOLOGY

The modeling is done by the comparative data collected from the existing fuselage design models. The suitable cabin pressure is taken for the analysis of model. And the loads on cabin floor are estimated from the conceptual design data. In designing of the model, the structural members like bulkheads, frames, formers, stringers, longerons are done by using SOLIDWORKS. From consolidation of data the height and width of fuselage is evolved, which is suitably selected for construction.

The material selection is done to give as an input for ANSYS, most of the fuselage are constructed using Aluminium alloy. Then the designed model is imported form SOLIDWORKS. The analysis of the model is by FEM procedure,in pre-processing the model is discretized and mesh with triangular and quad elements. In the solution procedure different types of boundary conditions are applied, and result is evolved in the post processing.

3. MODELLING

3.1 Model I

This is the primary design which has designed by using the SOLIDWORKS software. For the development of this design is used from the output data of the data collection table, which has made by using different wide body aircraft by using those dimensions design model is developed. This design is developed by using the combination of two circles intersected with the angle of 120 degrees.In this design it has developed using I section vertical beams in-between the intersection of the circles. This wall will take the maximum loads and stresses acting on the skin. To make this design elliptical from outside, a additional small platting at the top and bottom of the circle intersections. Finally, the outer skin for the entire fuselage is given by extruding the curve.

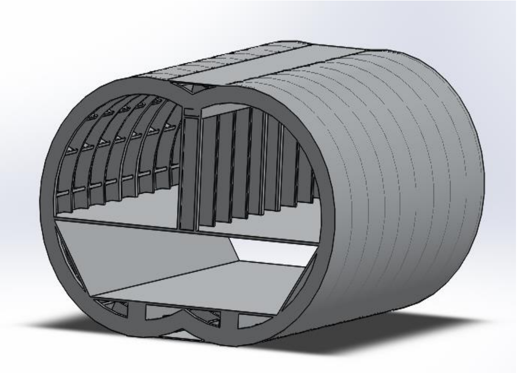

Fig. 1: Designed model I

The outer skin for the entire fuselage. In the figure 1 model I able to show the design which has developed in solid works. In this design 14-Z section longerons,12-I sections beams, 4-bulkheads, 6-frames are developed. Using the rectangular shape supports at the bottom at the cargo section.

3.2 MODEL II

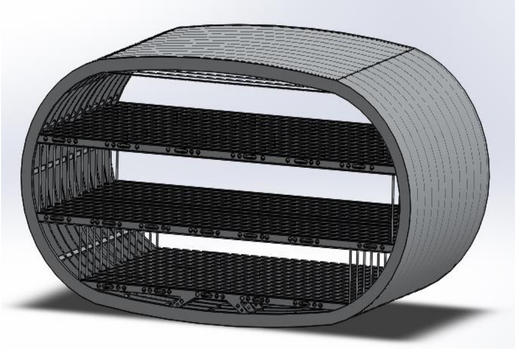

Fig. 2: Designed model II

At the bottom is designed by giving the cross angled supports which will act as a support to the cargo flooring and takes the load acting on it. Finally, The outer skin is extruded for the entire fuselage. In the fig 5.3 model II able to provide the designed model which have developed in solid works. In this design 18-Z section longerons,12-hat section stringers,4-bulkheads,6-frames are developed.

3.3 MODEL III

Fig. 3: Designed model III

The outer skin for the entire fuselage is designed to cover the entire structure. In the fig 5.4 model III able to provide the designed model which have developed in solid works. In this design 6-Z section longerons, 12-hat section stringers,2-bulkheads,10-frames is developed.

4. RESULTS AND DISCUSSIONS

4.1 ANSYS Static Structural Analysis

The static structural analysis it is mechanical structural analysis, In which the application of inertial loads, supports, pressures, and moments and real physical manner. Behalf of that it can also applicable for thermal loads. For this project it uses supports, inertial loads, and pressure load. As the inputs are given form standard atmospheric pressure table.

4.1.1 Model I: As the total deformation in the model I the deformation floor is because there no support below the cabin floor. The connecting upper and lower surface have high deformation, the triangular gap is designed to the direct air ventilation in the emergency prospect. This model is adopted for the previous research journal. The pressure values at 30000 ft altitude is 30089.59 Pa on the outer skin and on the inner side is given at sea level pressure is 101325 Pa.

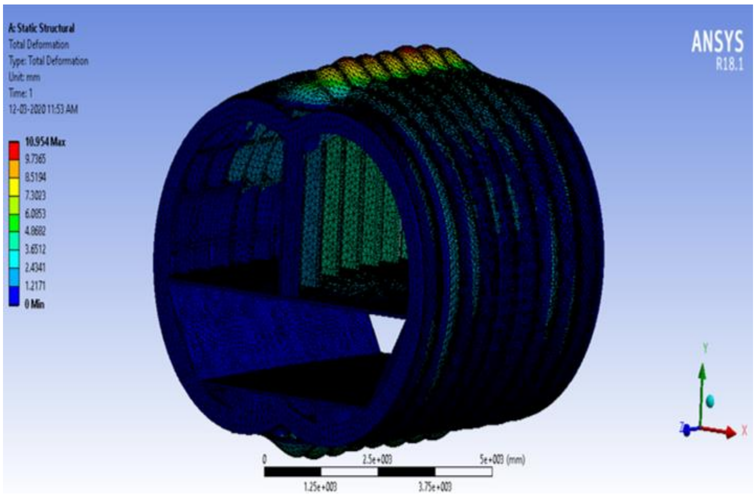

Fig. 4: Total deformation of model I

Table 1: Results for Model I

Outputs	Minimum	Maximum
Total deformation (mm)	0	10.954
Equivalent stress (MPa)	$1.3693*10^{-3}$	123.91
Maximum principal stress (MPa)	-50.994	236.64
Equivalent elastic strain (mm/mm)	$3.8378*10^{-8}$	$4.2486*10^{-3}$
Maximum principal elastic strain (mm/mm)	$-8.8405*10^{-5}$	$2.0775*10^{-3}$

4.1.2 Model II

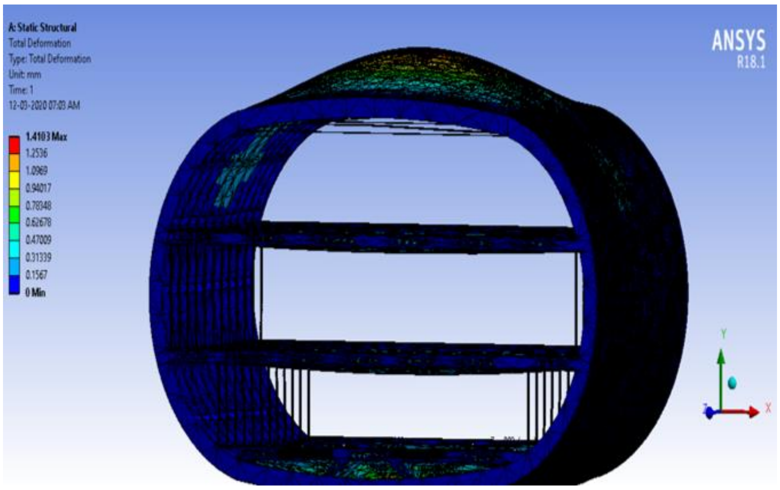

Figure 5 Total deformation of model II

Table 2: Results for Model II

Outputs	Minimum	Maximum
Total deformation (mm)	0	1.4103
Equivalent stress (MPa)	$2.8688*10^{-11}$	37.739
Maximum principal stress (MPa)	-18.758	39.091
Equivalent elastic strain (mm/mm)	$1.2085*10^{-15}$	$3.5746*10^{-4}$
Maximum principal elastic strain (mm/mm)	$-1.2927*10^{-5}$	$1.7167*10^{-4}$

4.1.3 Model III

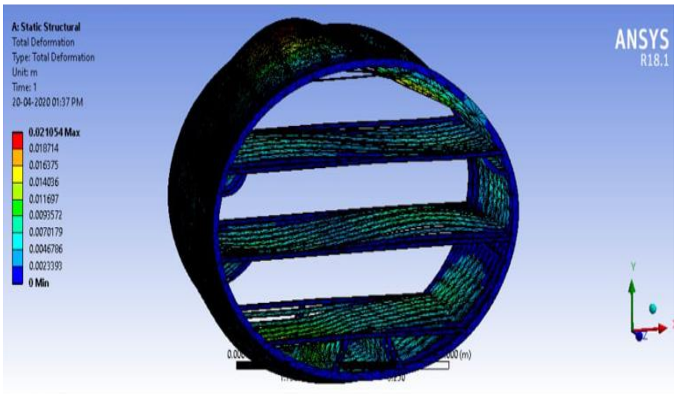

Fig. 6: Total deformation of model III

Table 3: Results for model III

Outputs	**Minimum**	**Maximum**
Total deformation (mm)	0	$2.1141*10^{-2}$
Equivalent stress (MPa)	$7.3433*10^{-2}$	6.0907
Maximum principal stress (MPa)	-2.2377	4.2863
Equivalent elastic strain (mm/mm)	$3.1915*10^{-18}$	$9.3891*10^{-9}$
Maximum principal elastic strain (mm/mm)	$-7.1328*10^{-11}$	$6.1445*10^{-9}$

5. ANALYSIS BY APPLYING LOADS

As the selected model III and estimated loads on the cabin floors are import for analysis, same procedure follow that discussed in model III analysis, in additional this load is implemented which acting downwards on floor.

5.1 Case I

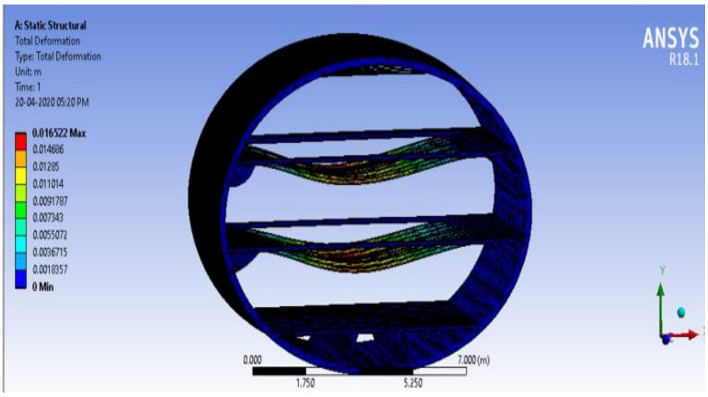

Fig. 7: Deformation of model III (case 1)

Table 4 Results for case I

Outputs	**Minimum**	**Maximum**
Total deformation (mm)	0	$1.6522*10^{-2}$
Equivalent stress (Pa)	377.72	1.9676
Maximum principal stress (MPa)	-2.2774	1.3268
Equivalent elastic strain (mm/mm)	$1.0024*10^{-14}$	$2.8652*10^{-9}$
Maximum principal elastic strain (mm/mm)	$-6.8758*10^{-11}$	$2.2407*10^{-9}$

CASE 2

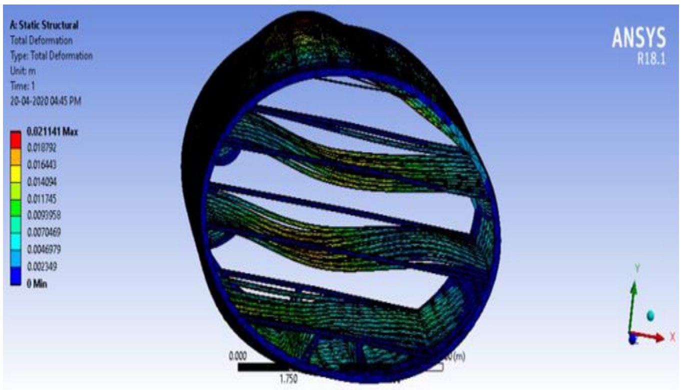

Fig. 9: Deformation for model III (case 2)

The results for the analysis are tabulated below, the load estimation is carried out to give input loads on the cabin floors and cargo, and the estimated values on cargo floor is 4500 kg, on first floor is 6053 kg and on second floor is 4454 kg. The cargo floor there is no deformation because it is arrested by the supports. The deformation in the fuselage due to the weight on cabin floor, is high.

Table 5: Results for case II

Outputs	Minimum	Maximum
Total deformation (mm)	0	$2.1141*10^{-2}$
Equivalent stress (MPa)	732.52	6.0907
Maximum principal stress (MPa)	-2.2377	4.2863
Equivalent elastic strain (mm/mm)	$2.92*10^{-14}$	$9.3541*10^{-9}$
Maximum principal elastic strain (mm/mm)	$-7.8581*10^{-11}$	$6.1592*10^{-9}$

6. COMPARISON OF GRAPHS

i) Total deformation

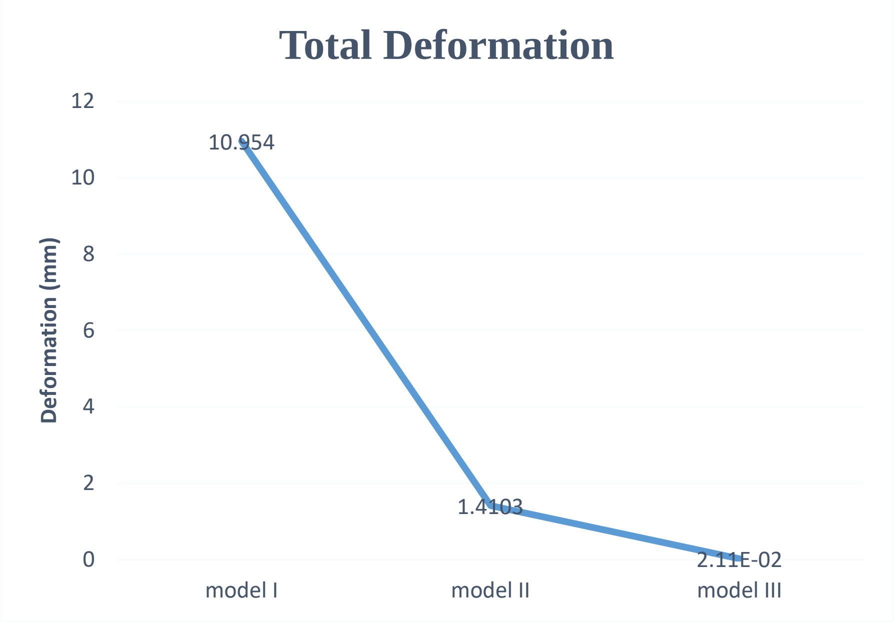

Fig. 10: Total deformation

The comparison of the total deformation figure 10 which plotted the graph using maximum values. For the model I has the total deformation value is 10.95 mm, and the model II has 1.46 mm, for the model III the small deflection 0.029 mm.

ii) Equivalent (von mises) stress

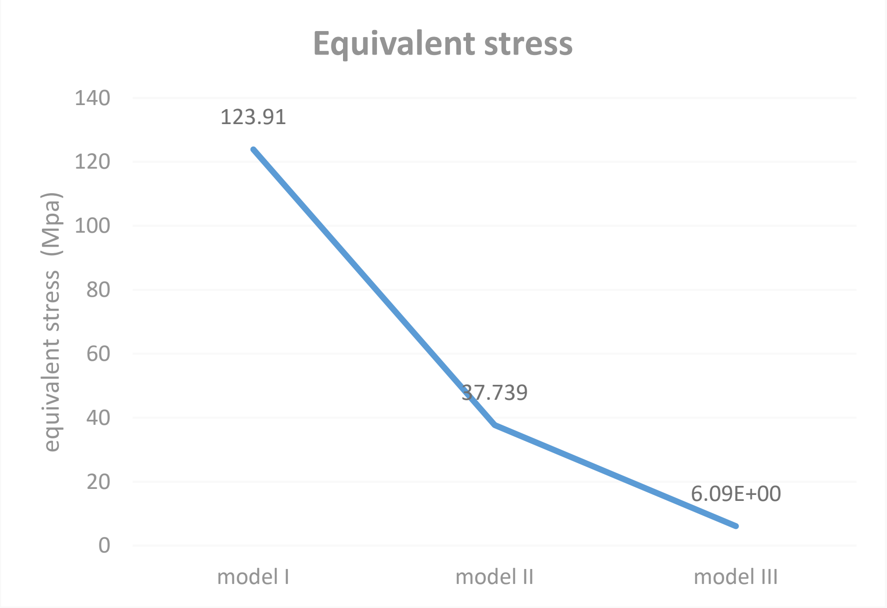

Fig. 11: Equivalent Stress

The above figure 11 will represents the equivalent stress acting on the DB fuselage design under the specified conditions.

iii) Maximum principal stress

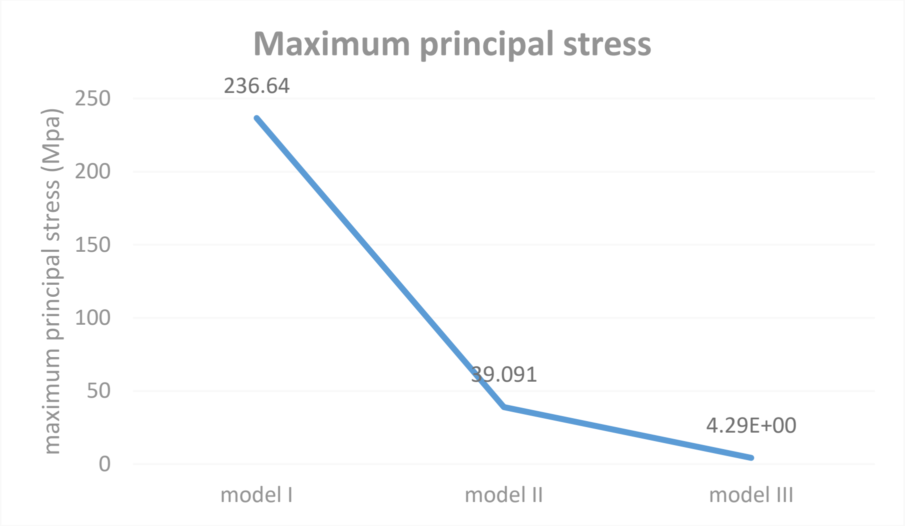

Fig. 12: Maximum principal stress

The above figure 12 will represents the maximum principal stress acting on the DB fuselage design under the specified conditions**.**

iv) Equivalent elastic strain

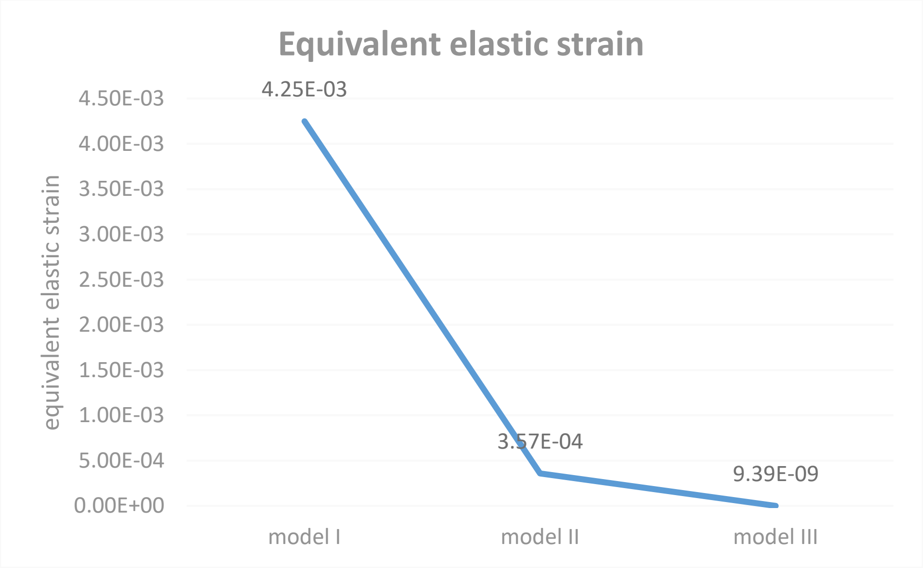

Fig. 13: Equivalent elastic strain

The above figure 13 will represents the equivalent elastic strain acting on the DB fuselage design under the specified conditions.

v) Maximum principal elastic strain

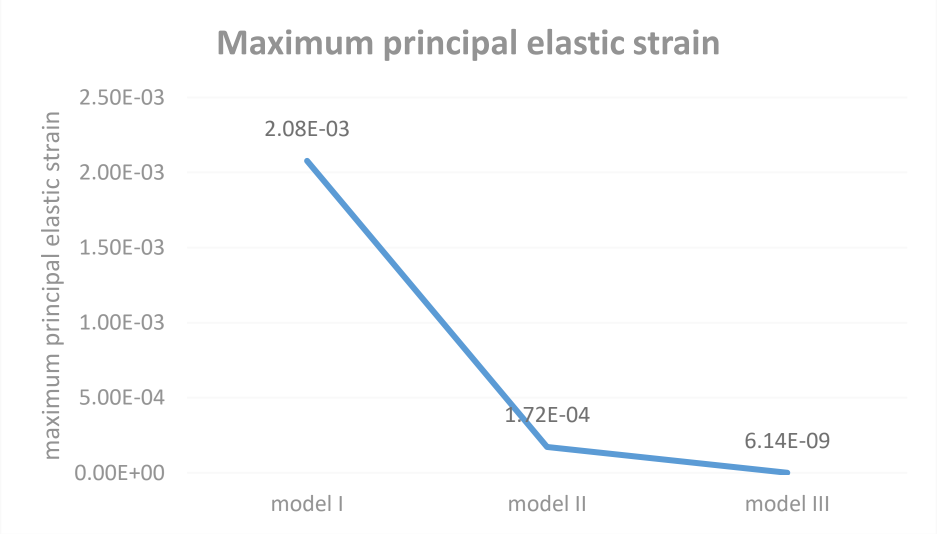

Fig. 14: Maximum principal elastic strain

Comparison of all the graphs, model III results are converging but still there is a deformation. This graph will represent the Maximum principal elastic strain acting on the DB fuselage design under the specified conditions.

Table 6: Final Results

Outputs	Model I	Model II	Model III
Total deformation (mm)	10.954	1.4103	$2.1141*10^{-2}$
Equivalent stress (MPa)	123.91	37.739	6.0907
Maximum principal stress (MPa)	236.64	39.091	4.2863
Equivalent elastic strain (mm/mm)	$4.2486*10^{-3}$	$3.5746*10^{-4}$	$9.3891*10^{-9}$
Maximum principal elastic strain (mm/mm)	$2.0775*10^{-3}$	$1.7167*10^{-4}$	$6.1445*10^{-9}$

7. CONCLUSION

This project is related to aviation industry, which has details about the DB fuselage construction and the stress analysis through the numerical methods and finite element approach. DB fuselage is developed which can able hold the pressure loading, by comparison of results in the table 6.7 which shows the converging of result to model III. Finally an elliptical profile fuselage by the DB concept and the total deformation in fig 6.6 due to internal and external pressure has less value which fulfills the aim of the project. As there is comparison of the designed models, the model III has external shell profile is in elliptical shape. As this project related to aviation industry, the aim of the project is to design development of DB fuselage, and to perform stress analysis with respect to altitude and loading conditions. By performing all the analysis that say the stress concentration on the skin is high when it compared with circular shell. But this problem can be solved by implementing the support walls.

8. FUTURE PROSPECT

The deformation in the designed models still it can minimize by re-designing the model. In chapter 6, the two cases model analysis done by applied loads on it, the internal deformation on the floors is minimize by designing support walls in between the floors. So, that the deflection is arrested. As the shell is elliptical selection FEM formulation for unsymmetrical is difficult to carried out.

9. ACKNOWLEDGEMENT

The authors would like to express their sincere thanks and show gratitude towards the Department of Aeronautical Engineering, Hindustan Institute of Science & Technology, Chennai for trusting and providing the labs facilities for this research work

10. REFERENCES

[1] Ralph D. Buehrle, Gary A. Fleming and Richard, S. pappa, “Finite Element Model Development For Aircraft Fuselage Structures”, XVIII International Model Analysis confernce, 2000, pp 1-7.

[2] V. Mukhopadhyay and J. Sobieszczanski-Sobieski, “Analysis, Design, and Optimization of Non cylindrical Fuselage for Blended-Wing-Body Vehicle”, Journal of Aircraft, 2004, vol.41, no.12, pp 925-931.

[3] Sung Hwan Cho and Cees Bil, “Columned Multi Bubble Fuselage(CMBF) for BWB”, SAE International, 2007, vol.01, 3889.

[4] F.J.J.M.M. Geuskens, S. Koussios, O.K. Bergsma, A. Beukers, “Non-Cylindrical pressure Fuselage for future aircraft”, 49th AIAA structures, structural dynamics,and materials conference, 2008, pp 1-11.

[5] F.J.J.M.M.Geuskens, O.K. Bergsma, S. Koussios, and A. Beukers, “Analysis of Conformable Pressure Vessel: Introducing the Multibubble”, AIAA Journal, 2011, vol.49, no.8, pp 1683-1692.

[6] S.Mistry, M.R. Mofakhami, J. Pinsonnault, “Evolving Fuselage design by incorporating SHM technologies”, The Aeronautical Journal, 2011, vol. 115, pp 749- 754.

[7] R.Vos, F.J.J.M.M. Geuskens, M.F.M. Hoogref, “A New Structural Design Concept for Blended Wing Body Cabins”, 53rd AIAA structures, structural dynamics and Materials confernce, 2012, pp 1-12.

[8] Vivek Mukhopadhyay, “Hybrid wing-Body (HWB) Pressurized Fuselage Modeling, Analysis, and Design for Weight Reduction”, AIAA conference, 2012, pp 1-14.

[9] M. Quatmann, N. Aswini, H.-G. Reimerdes, N.K. Gupta, “Superelements for a computationally efficient structural analysis of elliptical fuselage sections”, Aerospace Science and Technology, Elsevier, 2012, vol.27, pp 76–83 .

[10] Marampalli Shilpa, M. Venkateswar Reddy, Dr. A. Siva Kumar, “Design & Analysis of Fuselage Structure using Solidworks & ANSYS”, International Journal of Engineering Sciences & Research Technology, 2014, vol.3(9), pp 391-400.

[11] Adam Przekop,“Nonlinear finite element analysis of a composite Non-cylindrical Pressurizied structure”, 55th AIAA structures, structural dynamics, and material conference, 2014, pp 1-22.