Fatigue Analysis on Boeing 737 Wing

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***Abstract*- The fatigue life is essential for every aircraft to rectify several damages occurred on it. In this project we have done fatigue analysis of the aircraft wing Boeing 737 series wing. The detailed modeling of aircraft wing structure made by using the software CREO parametric 2.0. The stress analysis of the wing structure is carried out. The stresses are estimated by using the finite element approach with the help of NX-NASTRON to find out the fatigue life and safety factor of the structure. This Project describes about the finite element analysis of spar, ribs of a wing. The objective of this study is to reduce the weight to the maximum possible extent. The response of the wing structure will be evaluated. In this study prediction of fatigue life, safety factor, strength safety factor will be carried out.**

Keywords-Fatigue analysis, Boeing 737 series wing, CREO parametric2.0, NX-NASTRON

1. INTRODUCTION

Fatigue is a phenomenon associated with variable loading or more precisely to cyclic stressing or straining of a material. Just as we human beings get fatigue when a specific task is repeatedly performed, in a similar manner metallic components subjected to variable loading get fatigue, which leads to their premature failure under specific conditions.

In materials science, fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading. The nominal maximum stress values are less than the ultimate tensile stress limit, and may be below the yield stress limit of the material.

2. DESIGN CALCULATION

In this project we estimated the load acting on the wing using the flow analysis in Ansys 12.The below figure 2.1 shows how the flow passes on 2D airfoil. From this analysis we come to know the total pressure acting on the wing. The maximum pressure acting on the airfoil is found to be 2.05Mpa. The total pressure acting on the wing is scaled according to the scale ratio of wing. Thus the pressure acting on the wing is considered to be as 4.1e5 pa.

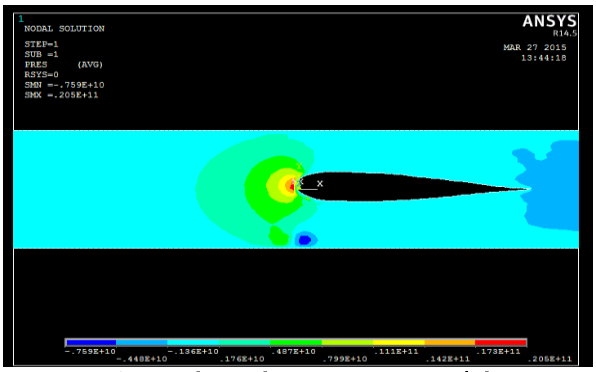

Fig 2.1: Flow analysis on Boeing 737 airfoil

2.2 Meshing

In the FEM analysis of wing components, meshing is the initial step that is to be followed after the model is being imported for the purpose of analysis. Meshing is the process that divides the model into finite number of elements for the analysis. The mesh used here is the 3D tetrahedral mesh is shown in fig 2.2.

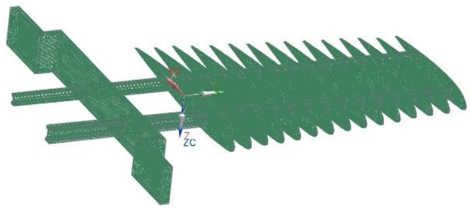

Fig 2.2: Meshed model of the Wing Structure

2.3 Loading and Boundary Conditions

After meshing the structural part of the wing, the wing is fixed at one end and other end is free. The Pressure 0.41 Mpa is applied on the top layer of the wing, loading over the wing is shown in below fig 2.3.

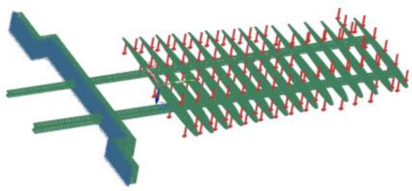

Fig 2.3: Loading and Boundary Conditions of the wing.

3. RESULT

The aircraft wing section carrying the different types of loads. In this we are considering the pressureload. We are applying the pressure load 0.41Mpa to Aluminum 2014. Then that loading results are taken and it is discussed.

3.1 Result Analysis

In this project we are analyzing the three solutions for the aircraft wing section by applying pressure load. These following analyses are carried for fatigue load. The name of the analyses is given below

- Displacement
- Elemental stress
- Fatigue safety factor
- Strength safety factor

ANALYSIS ON 50mm RIB

3.1 Displacement for Applied Pressure

S.No	Load (Mpa)	Equivalent displacement(mm)	
		Minimum	Maximum
1.	0.41	0	1330.33

Table 3.1: Displacement for applied pressure

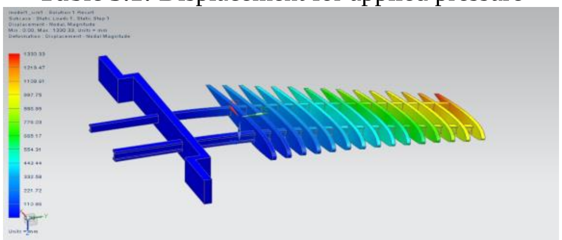

Fig 3.1: Displacement for Applied Pressure

3.2 Elemental Stress for Applied Pressure

S.No	Load (Mpa)	Equivalent elemental stress (Mpa)	
		Minimum	Maximum
1.	0.41	0	96.97

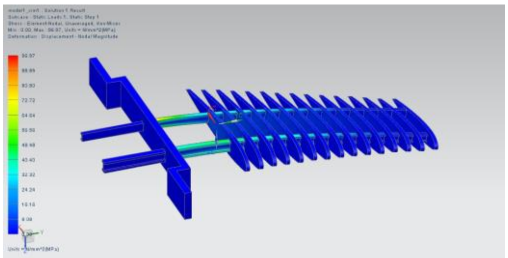

Fig 3.2: Elemental Stress for Applied Pressure

3.3 Fatigue Life for Applied Pressure

In this fatigue analysis, we obtain the result of fatigue life, strength safety factor and fatigue safety factor of the wing at definite load.

S.No	Cycle	Fatigue life (Duty cycles)	
		Minimum	Maximum
1.	10000	7.30e4	1e36

Table 3.3: Fatigue life for applied pressure

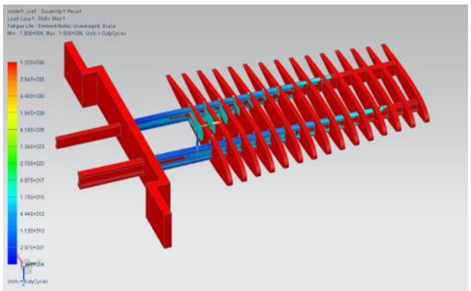

Fig 3.3: Fatigue life for applied pressure

3.4 Strength Safety Factor for Applied Pressure

S.No	Cycle	Strength safety factor	
		Minimum	Maximum
1.	10000	4.55	6.18e23

Table 3.4: Strength Safety Factor for Applied Pressure

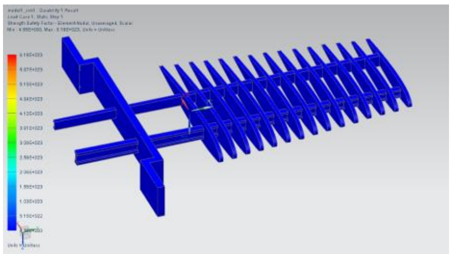

Fig 3.4: Strength Safety Factor for Applied Pressure

3.5 Fatigue Safety Factor for Applied Pressure

S.No	Cycle	Fatigue safety factor	
		Minimum	Maximum
1.	10000	0.058	2.18e12

Table 3.5: Fatigue Safety Factor for Applied Pressure

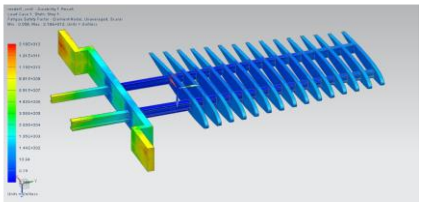

Fig 3.5: Fatigue Safety Factor for Applied Pressure

ANALYSIS ON 20mm RIB

3.6 Displacement for Applied Pressure

S.No	Load (Mpa)	Equivalent displacement(mm)	
		Minimum	Maximum
1.	0.41	0	857.49

Table3.6: Displacement for applied pressure

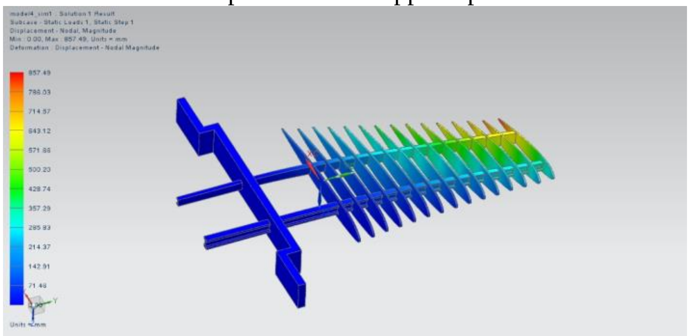

Fig 3.6: Displacement for Applied Pressure

3.7 Elemental Stress for Applied Pressure

S.No	Load (Mpa)	Equivalent elemental stress (Mpa)	
		Minimum	Maximum
1.	0.41	0	51.06

Table 3.7: Elemental Stress for Applied Pressure

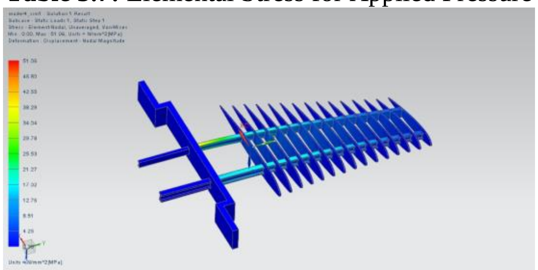

Fig 3.7: Elemental Stress for Applied Pressure

3.8 Fatigue Life for Applied Pressure

In this fatigue analysis, we obtain the result of fatigue life, strength safety factor and fatigue safety factor of the wing at definite load.

S.No	Cycle	Fatigue life (Duty Cycles)	
		Minimum	Maximum
1.	10000	2.49e7	1e36

Table3.8: Fatigue life for applied pressure

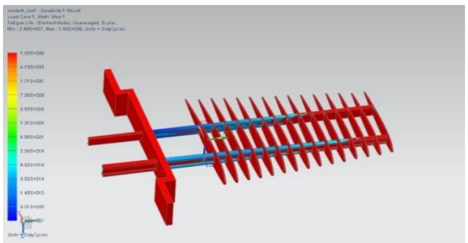

Fig 3.8: Fatigue life for applied pressure

3.9 Strength Safety Factor for Applied Pressure

S.No	Cycle	Strength safety factor	
		Minimum	Maximum
1.	10000	8.65	1.15e24

Table 6.9 Strength Safety Factor for Applied Pressure

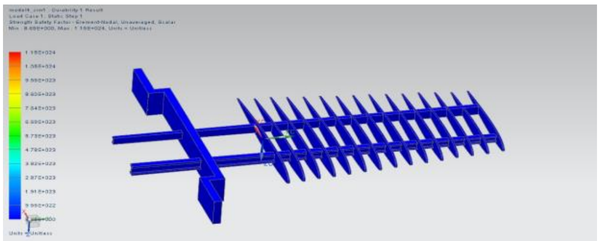

Fig 3.9: Strength Safety Factor for Applied Pressure

3.10 Fatigue Safety Factor for Applied Pressure

S.No	Cycle	Fatigue safety factor	
		Minimum	Maximum
1.	10000	0.11	6.74e12

Table 3.10: Fatigue Safety Factor for Applied Pressure

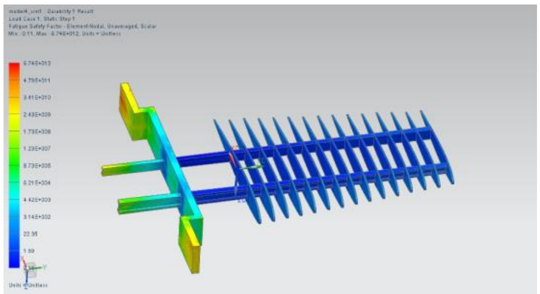

Fig 3.10: Fatigue Safety Factor for Applied Pressure

CONCLUSION

The model we designed looks very simple and easy to understand. Actually it is not conventional wing Bracket interaction .But we have used new Bracket to wing fuselage interaction. Our model is based on stress based approach which involves high cycle fatigue Thus fatigue analysis has been done at various loadings. The material properties also changed in order to get better performance; here we replaced the actual material with the aluminium 2014 and composite material. Its life and damage has been analysed. The safety factor also been analysed here and we have denied conclusion that it is essentially used for life estimation of the wing. The results obtained from different materials are compared, from this we can clearly know about the fatigue strength of different material. Finally we conclude that our wing bracket interaction is a SAFE-LIFE structure in infinite safe zone.

FUTURE WORK

In this project we have analyzed the wing for various load conditions and the results are taken. As the next step we have planned to analyses the Boeing 737 wing at different altitudes, pressure, and with different materials. we have also planned to do the analysis by changing the ribs and spar size.

REFERENCES

1. Abdullah, S.M. beden and A,KAriffin (2002), 'Fatigue Crack Growth Simulation Of Aluminium Alloy Under Cyclic Sequence Effects'.
2. Aktepe&L.Molent (1998), 'Management of Airframe Fatigue Through Individual Aircraft Loads Monitoring Programs'.
3. Ali Mate(June, 1989), ' Material Replacement For Aging Aircraft'.
4. JaapSchijve (1995), 'Fatigue Damage in Aircraft Structures'.
5. KeijoKoski, AslakSiljander, MikaBackstrom, JuhaJuntunen, JarkkoTikka and Rikulahtinen(1995), 'Fatigue Residual Strength and Non Destructive Tests of An Aging Aircraft's Wing Detail' waily, August.
6. L. Molent and B.Aktepe(1969), 'Review Of Fatigue Monitoring Of Agile Military Aircraft', Dec.
7. Marko anttial(2011),'Fatigue Life Estimation Of An Aircraft Used In Airborne Geophysical Surveying'. San Francisco, California: AIAA 2011-2231.
8. Walter Schlitz(1977), 'A History Of Fatigue' AIAA-97-3483.
9. Z. Maler, S. Slavik, T. By marczi, M. Ruzicka(1990) May-June, 'Common Mathematical Model Of Fatigue characteristicsharacteristics