DESIGN FEASIBILITY AND STRUCTURAL INTEGRITY OF PAN DOWN COMPOSITE STRUCTURE

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Abstract - *Study of the design the feasibility and structural analysis of stuffed hat pandown sandwich composite panel of pan down stuffed hat stiffened panel to optimize for weight further from the existing stepped sandwich core model. These designs have more benefits compare to conventional stiffened panel made of Aluminium. The proposed design leads to minimization of fasteners, secondary bonding and assembly operation due to single piece stiffened panel construction, hence lesser weight, cost, fuel consumption etc.*

Today aircraft structures made of sandwich composites consist of constant core between the two face sheets which has very high strength/wt, stiffness/wt, and most commonly used in aircraft structure due to less weight. There is still an opportunity to save the weight by providing it as a pan down approach (stuffed hat model). Study is been done for the main landing gear door panel of A320 and carried out feasibility for MLGD. The project outcomes show that stuffed hat model shows better results as compared to full sandwiched core model, it means still there are chances to save the weight for any panel of aircraft and if that can be done for max number of panels in the aircraft, one will be able to save much of weight in the aircraft so that we can provide number of advantages.

Key Words: *MLGD, Laminates, Stress, F.I, Buckling Factor.*

1. INTRODUCTION

The aircraft has the following fuselage doors like Passenger door, main gear door panel, nose gear door panel, cargo door, fuselage door etc. so if we able to save some kg's of wait for one door panel and if apply the same for all the panels of aircraft, it means we will be able to save a lot of weight which always used to be the major issue for any aircraft. We are carrying out the feasibility and structural integrity of main landing gear door panel. As we know composite materials has got many benefits as compared to metals in terms of weight, stiffness, strength etc. and here minimizing fasteners, secondary bonding and assembling operation by doing it as a single piece carbon fiber composite means we are avoiding the complexity to model the panel.

Structures made of sandwich composites consist of two face sheets and a core between the two skins which has very high stiffness/wt and strength/wt ratio and is commonly used in aircraft due to its less weight. We still have the opportunity to save the weight by providing it as a pan down approach (stuffed hat model), where core will act as a hat stiffener.

Fig -1: Main landing gear door panel of A320

2. Statement of the problem

In this paper study is done by taking main landing gear door panel and performing the linear static analysis, buckling analysis, and non-linear analysis to calculate the stresses, strains and failure index in the model. Two cases has been analyzed and compared:

1. To perform the stress analysis of full sandwich core for MLGD.
2. To perform stress analysis of pandown structure for MLGD.
3. Comparison between full sandwich core and Pandown structure in terms of weight, strength.

3. Finite element analysis

3.1 Cad model of main landing gear door panel

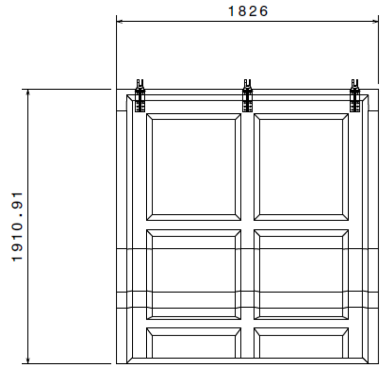


Fig- 2. Front view of main landing gear door

The material used is T700-12K-50C#2510 Plane weave fabric.

Table 1: allowable for T700-12K-50C

Toray -700-12K-50C#2510 plane weave fabric	
Young's modulus, E_{11}	56003.4mpa
Young's modulus, E_{22}	54448.8mpa
Poisson ratio, μ_{12}	0.0420
In plane shear modulus, G_{12}	4212.23mpa
Density, ρ	1800kg/m³
Allowable stress in tension in X direction, X_t	853.2mpa
Allowable compressive stress in X direction, X_c	605.3mpa
Allowable tensile stress in Y direction, Y_t	677.2mpa
Allowable compressive stress Y direction, Y_c	629.1mpa
In plane shear strength, S	124.6mpa

Source : T700S Datasheet

The core materials used are HRH-10

Table 2: Allowable for HRH-10

HRH-10(Honeycomb core)	
Transverse shear modulus, G_{1z}	930.792mpa
Transverse shear modulus, G_{2z}	372.3mpa
Poisson ratio, $\mu 12$	0.3
Density, ρ	130 kg/m3

Source : Hex Web Honeycomb attributes

The materials used for solid laminate is T700-12K-50C composite which is plane weave fabric and that for core is HRH-10. The source is been the Toray composite datasheet for solid laminate and that for core is Hex web Honeycomb attributes.

4. Fem Description

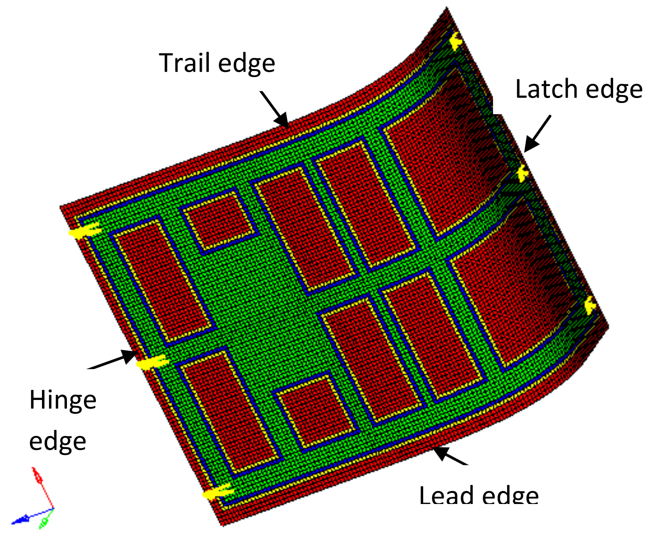


Figure 3. Fem description of main landing gear door panel

- The FE model of the above configuration is built as shown in figure.
- FE modelling is done by using 2D quad elements of element size 20mm.
- Number of RBE2 = 6 (3 for hinges and 3 for latches).
- The composite laminate were represented by PCOMP'S ply layups as shown in table
- Slant region of the core is been represented as stepped core.

5. Ply layup definition

Ply orientation plays a key role as where we need extra stiffness we tailor the plies more over that region.

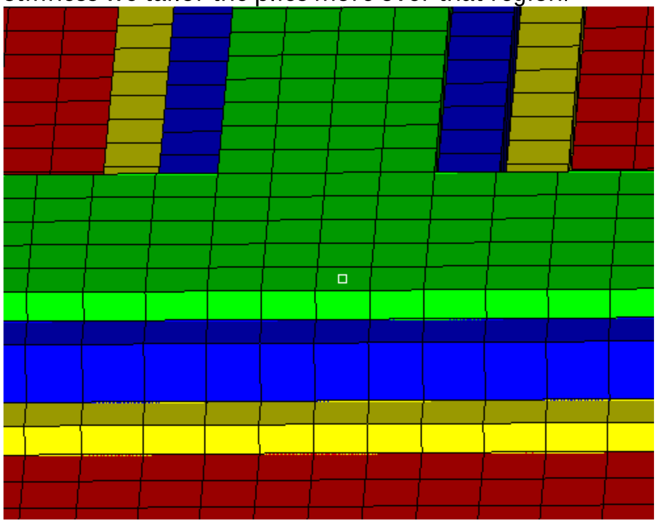


Fig -4: Stack ups for panel and core

There is solid laminate and a core which has different ply orientation which is described in the below table:

Table 3: Ply stacks

Serial no.	Stack A Solid laminate t= 0.218mm n= 12	Stack B, Full core t = 0.218mm 7th **ply 't' = 40mm** n = 13	Stack C, Step core 1 t = 0.218mm 7th **ply 't' = 30mm** n = 13	Stack D, Step core 2 t = 0.218mm 7th **ply 't' = 10mm** n = 13
1.	+45	+45	+45	+45
2.	0	0	0	0
3.	0	0	0	0
4.	-45	-45	-45	-45
5.	0	0	0	0
6.	90	90	90	90
7.	90	0	0	0
8.	0	90	90	90
9.	-45	0	0	0
10.	0	-45	-45	-45
11.	0	0	0	0
12.	+45	0	0	0
13.		+45	+45	+45

6. Pressure conditions

There are two pressure condition has been analysed which industry generally follow to model any panel of an aircraft, those are:

A. Bursting pressure : The pressure is acting from inside of the cabin to the outside free air is called bursting pressure

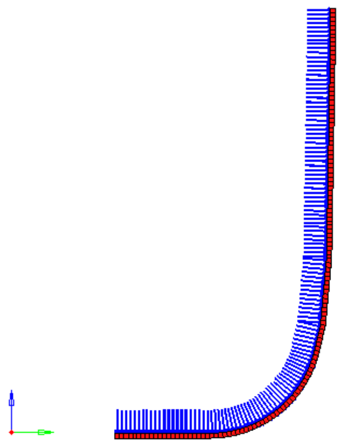


Figure 6. Bursting pressure on main landing gear door

B. Crushing pressure: The pressure is acting from outside free air to the inside of the cabin is known as crushing pressure.

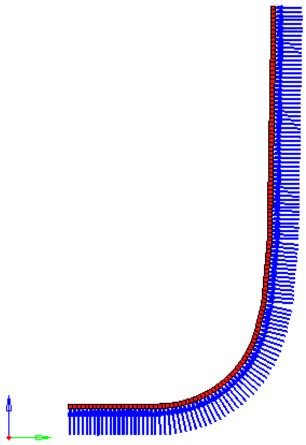


Figure 6. Crushing pressure on main landing gear door

7. Results and discussion

Case 1: For Bursting pressure of 0.2068mpa (3psi)

1(a) Stress plot for pandown model is

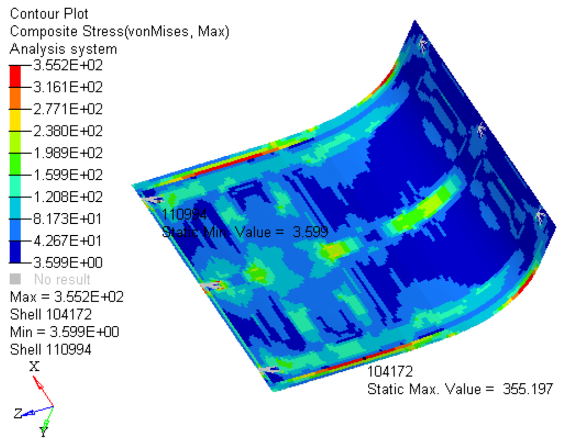


Figure 7. Stress region for stuffed hat model

1(b) Stress plot for full sandwich core is

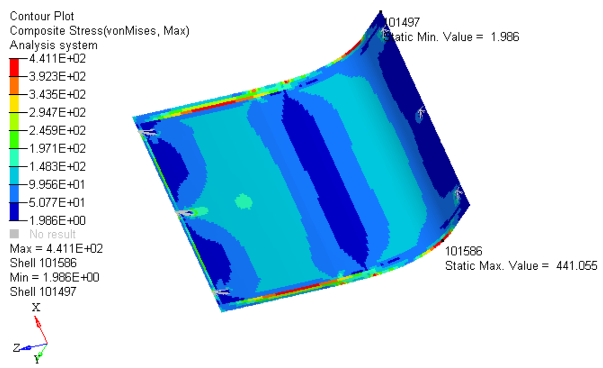


Figure 8. Stress region for full sandwich core model

Max stress observed is 355.2mpa for stuffed hat model for burst pressure and for full sandwich core model it is 441.1mpa for the same burst pressure. Maximum stress regions are represented by the red lines in the plot.

2(a) Deformation plot for pandown model is

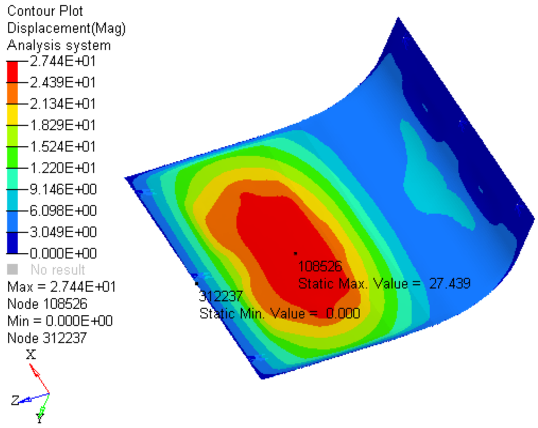


Figure 9. Deformation region for stuffed hat model

2(b) Deformation plot for full sandwich core model is

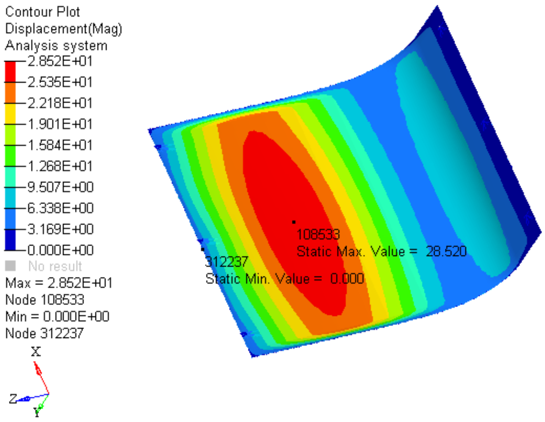


Figure 10. Deformation region for full sandwich core

Maximum deformation observed for stuffed hat model is 27.44mm and for full sandwich core model is 28.52mm. Deformation is more in full sandwich core model as compared stuffed hat model of MLGD.

3(a) Failure index plot for pandown model is

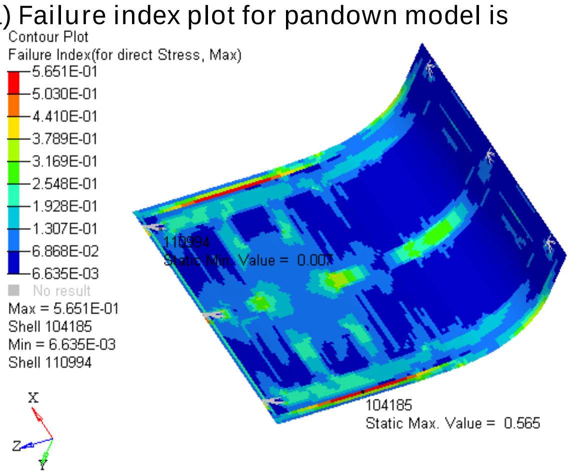


Figure 11. Failure index region for stuffed hat model

Failure index is defined by applied maximum strain to the allowable maximum strain which should be less than to one for the safe design.

3(b) Failure index plot for full sandwich core model is

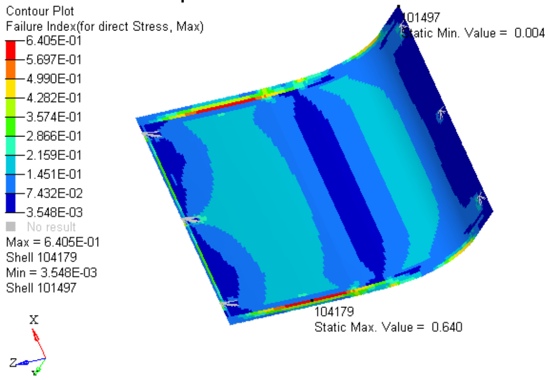


Figure 12. Failure index for full sandwich core model.

Maximum Failure index for stuffed hat model is 0.565 and for full sandwich core is 0.640. stuffed hat model has got least failure index as compared to full sandwich core model which is very positive sign for this approach of optimizing the weight for MLGD of an Aircraft.

Case 2. For Crushing pressure of 0.00689mpa (1psi)

2(a) Stress plot for stuffed hat model is

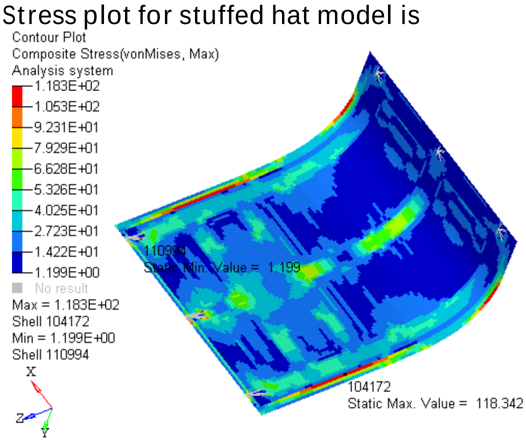


Figure 13. stress region for stuffed hat model

2(b) Stress plot full sandwich core model is

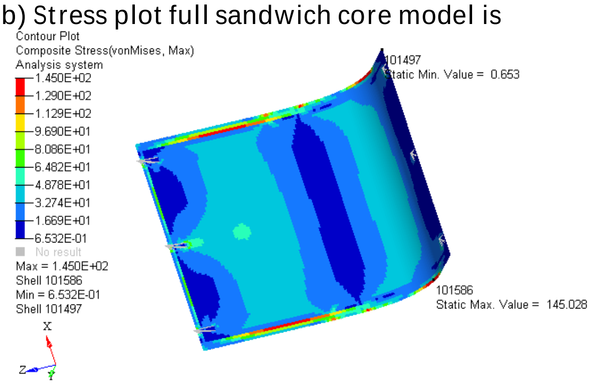


Figure 14. stress region for full sandwich core model

Max stress observed is 118.342mpa for bursting pressure 145.028mpa for bursting pressure which is represented by the red lines. As in case of bursting stuffed hat model shows lesser stress for the same MLGD for the crushing pressure also which shows one can go for this approach for any panel of Aircraft to have advantages of weight which provides many more benefits.

3(a)Deformation plot for stuffed hat model is

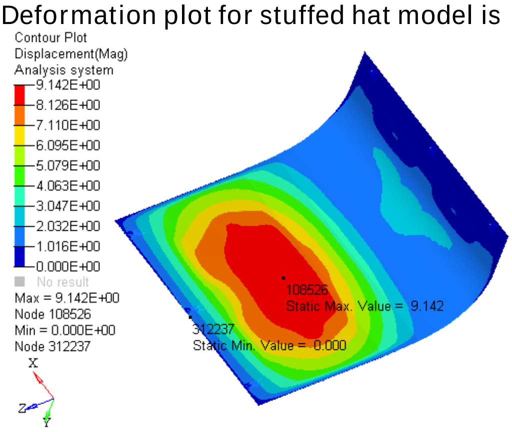


Figure 14. Deformation region for stuffed hat model

3(b) Deformation for full sandwich core model

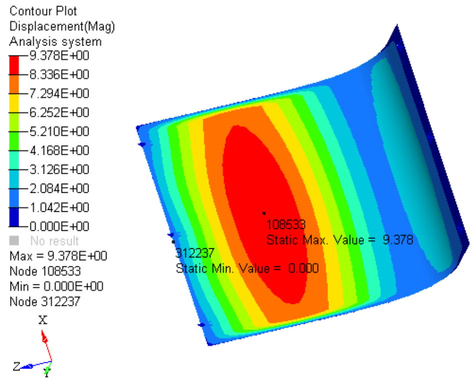


Figure 15. Deformation for full sandwich core model

Maximum deformation for stuffed hat model is 9.142 and for full sandwich core model is 9.378. Stuffed hat model has got least deformation as compared to full sandwich core model.

4(a) Failure index plot for stuffed hat model is

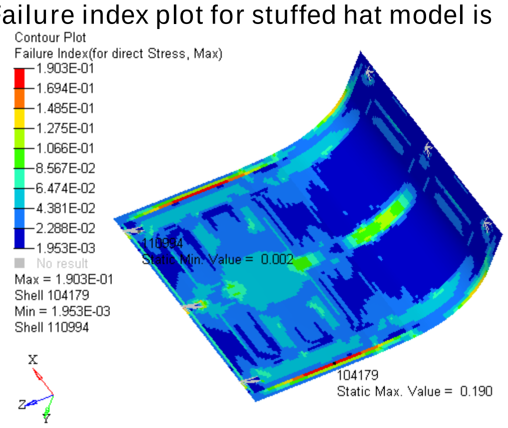
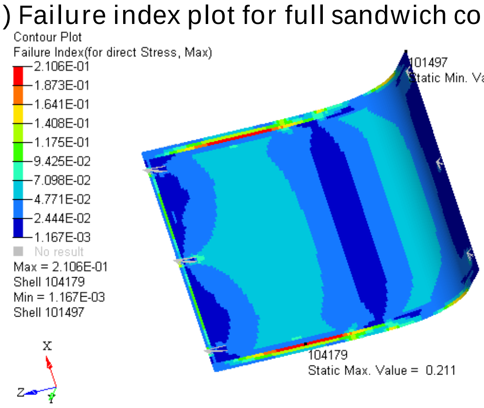


Figure 16. Failure index for stuffed hat model

Maximum Failure index for stuffed hat model is 0.190 and for full sandwich core is 0.211. Stuffed hat model has got least failure index as compared to full sandwich core model which shows the advantages of going by this approach to optimize the weight issue for any Aircraft.

4(b) Failure index plot for full sandwich core model is



Maximum Failure index for stuffed hat model is 0.190 and for full sandwich core is 0.211.

Result table

Results	Stuffed hat 2D core		Full sandwich core	
	Bursting	Crushing	Bursting	Crushing
Stress (mpa)	355.2	118.3	441.1	145.0
Displacement (mm)	27.44	9.142	28.52	9.37
Failure index	0.565	0.190	0.640	0.210
Mass(kg)	33.953		36.521	

8. CONCLUSIONS

There has been two pressure condition are analyzed which is Bursting pressure and crushing pressure for the main landing gear door panel and the results are compared with sandwiched model in terms of stress, deformation and failure index

1. From the Stuffed hat model we observe that, the max stress obtained in the model is 355.2mpa, deformation obtained in the model is 27.44mm and the failure index obtained is 0.525 and also the mass is 33.9kg
2. From the Sandwiched model we observe that, the max stress obtained in the model is 441.1mpa, deformation obtained in the model is 28.52mm and the failure index obtained is 0.640 and also the mass is 36.95kg.

From the above results we can conclude that stuffed hat model shows better results as compared to sandwiched model, it means still there are chances to save the weight for any panel of aircraft and if we able to do this analysis for max number of panel in the aircraft has to used, means we will be able save much of weight in the aircraft so that we can provide number of advantages.

The correlation process helps in refining the design and analysis procedures, identifying areas where extra care is required and provides confidence in the methodology employed.

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