Structural Analysis of LRU box for a typical fighter aircraft

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***Abstract*: Design and analysis of 8 channel LRU box for typical fighter aircraft is conducted which is made of composite (CFRP) and Rohacell foam which is sandwiched construction, The LRU box is modeled in hyper mesh software of different thickness each thickness having different ply orientation. Material property is assigned. Shock loading analysis and arrestor landing analysis which is sinusoidal loading is done for different acceleration versus time profile and stress and displacement is found out for different time instant. Both simulated results and hand calculated results are calculated and are closely same.**

***Keywords*: vibration, Nastran, Shock loading, Arrestor loading, Fourier series, Normal modes**

1) Introduction:- LRU is abbreviation of line-replaceable unit , which is mainly rectangular in shape is a component of an airplane An LRU is usually sealed unit . Mostly LRU are made up of Aluminum and Steel. LRU consists of aircraft controls system like miniature super computer control units or flight data recorder, voice recorder, temperature controller and some critical components. Typically it is made of steel this has more mass than compared to composite. Reduction of weight is most important factor in aircraft industry which in turn reduce the drag

2) Materials and Procedures

The composites are light in weight when compared to aluminum and steel. After modeling the LRU box in steel and composites weight has been drastically reduced from 1 kg to 150 grams. The overall stress and displacements also reduce due to reduction in weight The LRU has been modeled in various thickness each thickness is having different ply orientation

3) Figure And Modeling

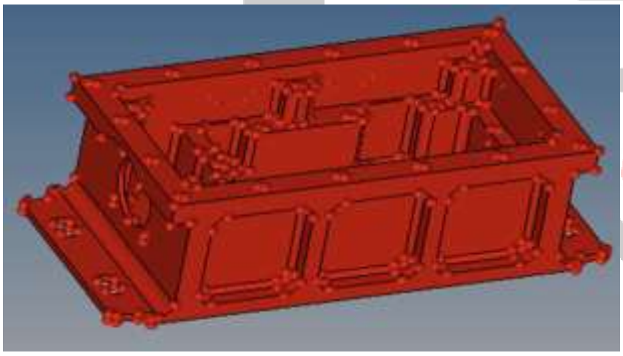


Figure 3.1 LRU box in original IGES file

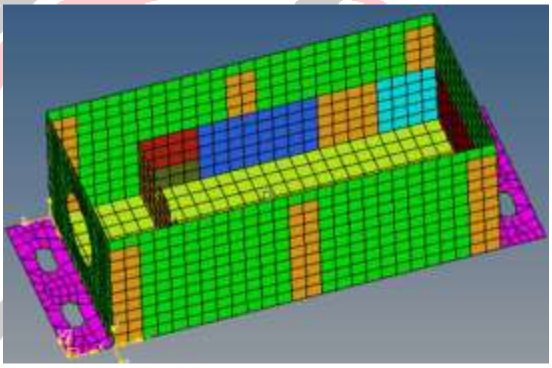


Figure 3.2 LRU box modeled in hyper mesh

4) Objective Of The Project:

Our objective is to analyze and design typical LRU for a typical fighter aircraft taking into consideration thermal heat dissipation and mechanical shock

Shock landing: Where the LRU is subjected from 0 to 15G (gravity force) amplitude with half sine profile having time period of 0 to 11 millisecond
Arrestor landing: Where the LRU is subjected from 0 to 30G(gravity force) amplitude with half sine profile having time period of 0 to 30 millisecond

5) Results and discussion:

4.1 Shock Landing: Where the LRU is subjected from 0 to 15G amplitude with half sine profile having time period of 11 millisecond. The equation can be represented as follows

$$f(t) = \frac{2a}{\pi} - \frac{4a}{\pi} \sum_{n=1}^{n=\infty} \frac{\cos n\omega t}{4n^2-1}$$

A=15g = 15x9.81m/s^2= 147.15 m/s^2

Time period, t=11ms

ω=2*π/t = 360/11(in degrees per second)

n=1 to infinity

$$f(t) = 98 - 187 \sum_{n=1}^{n=100} \frac{\cos 32.72nt}{4n^2 - 1}$$

For this equation profile the Acceleration versus time is found out and tabulated in the table and written in hyper mesh fo6 file . to find stress and displacement The table is as follows

Table 4.1 Acceleration vs time for Shock loading

SL no	Time (millisecond)	Acceleration m/s^2
1	0	0
2	2.75	103
3	5.5	148
4	8.25	103
5	11	0

Arrestor landing : where the LRU is subjected from 0 to 30 G amplitude with half sine profile having time period of 30 millisecond. The equation can be represented as follows

$$f(t) = \frac{2a}{\pi} - \frac{4a}{\pi} \sum_{n=1}^{n=\infty} \frac{\cos n\omega t}{4n^2 - 1}$$

A=30g = 30x9.81m/s^2= 294.3 m/s^2

Time period, t=30ms

ω=2*π/t = 360/30 (in degrees per second)

n=1 to∞

$$f(t) = 187 - 347 \sum_{n=1}^{n=100} \frac{\cos 12nt}{4n^2 - 1}$$

For this equation profile the Acceleration versus time is found out and tabulated in the table and written in hyper mesh fo6 file .to find stress and displacement The table is as follows

SL no	Time (millisecond)	Acceleration m/s^2
1	0	0
2	2.75	103
3	5.5	148
4	8.25	103
5	11	0

5) Results and Discussion

Shock landing

Where the LRU is subjected from 0 to 15G amplitude with half sine profile having time period of 11 millisecond

Hand calculation results for stress

The dimension of the LRU box is length =128.5mm, breadth = 62mm, height = 50mm and wall thickness= 2mm.

The total cross sectional area of the four vertical walls "A" = 762mm^2.
The maximum acceleration of the LRU for shock loading is "a" = 15g = 15x9.81 = 147.15 m/s^2.
The force "F_S" due to this shock is = m x a, where "m" is the mass of the LRU box and "a" is the acceleration.
F_S = 0.125 x 147.15 = 18.4 N
The stress due to this force $\sigma_S = F_S/A$ = 18.4/762 = 0.024N/mm^2 = **0.024MPa**

Simulation in NASTRAN : Displacement of LRU box

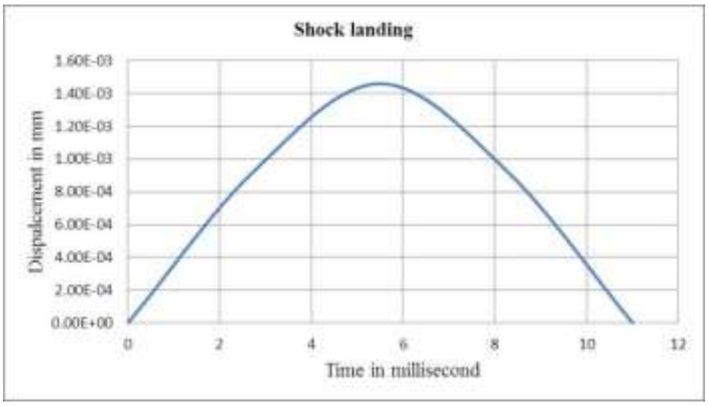
SL no	Time (millisecond)	Displacement
1	0	0
2	2.75	9.27e-04
3	5.5	1.46e-03
4	8.25	9.27e-04
5	11	0

Table 5.1 Time vs Average normal stress time

SL no	Time (millisecond)	Maximum stress
1	0	0
2	2.75	0.03
3	5.5	0.05
4	8.25	0.03
5	11	0

Conclusion For Displacement

The maximum displacement at the start (t=0) of the loading is 0 and at the end of loading is also ~0. There is a small value of maximum displacement at the end of the loading (t=11ms) This is because of the approximation of the half sine wave by it's Fourier transform. The maximum of the displacement is at t = 5.5ms and it's value is 1.46e-3mm. Acceleration is also maximum at t = 5.5ms and consequently the stress and strain will also be maximum at t = 5.5ms



Conclusion for stress

The stress is zero at the start and it varies as a sine curve and reaches and maximum at time t = 5.5 millisecond. The stress is symmetrical about time t = 5.5ms. The values of maximum displacements at time t=2.75ms and t= 8.25ms is same since the variation of displacements follows a half sine curve. This is in accordance with theoretical reasoning because stress is obtained by integrating acceleration twice. Since acceleration is a half sine wave the displacement also has to be a half sine wave

Graph 2 Stress vs time for shock loading

Results and Discussion

Arrestor loading

Where the LRU is subjected from 0 to 30G amplitude with half sine profile having time period of 30 millisecond

Hand calculation results for stress

The dimension of the LRU box is length =128.5mm, breadth = 62mm, height = 50mm and wall thickness= 2mm.

The total cross sectional area of the four vertical walls "A" = 762mm^2.

The maximum acceleration of the LRU for shock loading is "a" = 30g = 15x9.81 = 294.3 m/s^2.

The force "F_S" due to this shock is = m x a, where "m" is the mass of the LRU box and "a" is the acceleration.

F_S = 0.125 x 294.3 = 36.8 N

The stress due to this force "σS = FS/A = 18.4/762 = 0.048 MPA

Simulation in NASTRAN : Displacement of LRU BOX

Displacement in LRU box for maximum normal stress taken into account

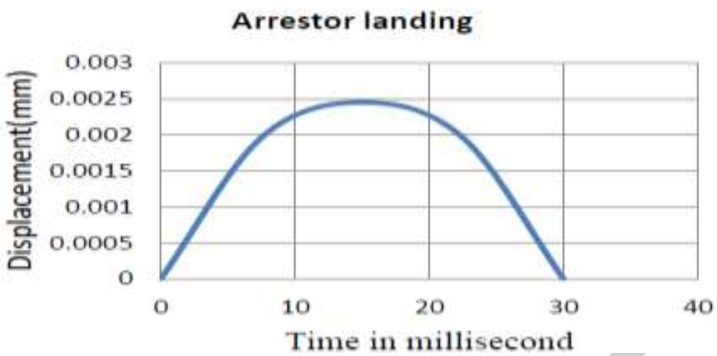
SL no	Time (millisecond)	Displacement
1	0	0
2	2.75	2e-3
3	5.5	2.45e-3
4	8.25	2e-3
5	11	0

STRESS in LRU box maximum normal stress taken into account

SL no	Time (millisecond)	Maximum stress
1	0	0
2	2.75	0.06
3	5.5	0.08
4	8.25	0.06
5	11	0

Conclusion for Displacement

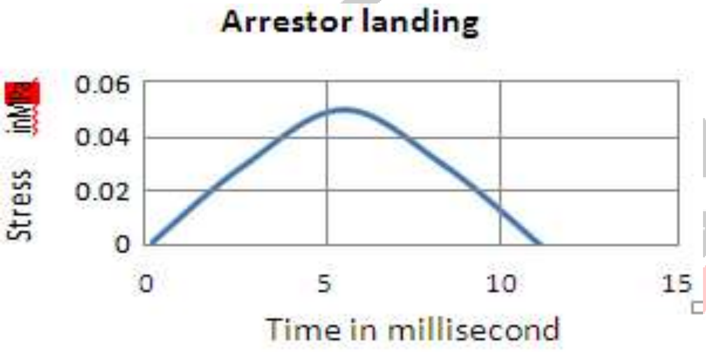
The maximum displacement at the start (t=0) of the loading is 0 and at the end of loading is also ~0. There is a small value of maximum displacement at the end of the loading (t=30ms) This is because of the approximation of the half sine wave by it's Fourier transform. The maximum of the displacement is at t = 5.5ms and it's value is 2.45e-3mm. Acceleration is also maximum at t = 5.5ms and consequently the stress and strain will also be maximum at t = 5.5ms



Graph3 displacement vs time for shock loading

Conclusion for stress

The stress is zero at the start and it varies as a sine curve and reaches and maximum at time t = 15 millisecond. The stress graph is symmetrical about time t = 7.5ms. The values of maximum displacements at time t=7.5ms and t= 22.5ms is same since the variation of displacements follows a half sine curve. This is in accordance with theoretical reasoning because stress is obtained by integrating acceleration twice. Since acceleration is a half sine wave the displacement also has to be a half sine wave



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