Steady state thermal analysis of 8 channel LRU box for a typical fighter aircraft

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***Abstract*: Analysis of 8 channel LRU box for typical fighter aircraft is conducted which is made of composite (CFRP) and Rohacell foam, The LRU box is modeled in ICEM CFD software and boundary are assigned for the domain wall, heat source, and the LRU walls, The modeled in imported in Ansys and material property is assigned. Steady state analysis is done keeping heat source at the middle assuming heat source to be 4watts Temperature distribution is found out for walls and inside the LRU box.**

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 Aluminium 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

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 heat transfer analysis is done using Ansys fluent and temperature distribution is calculated

Figure 1.1 The figure is modeled and meshed in ICEM CFD

2) Steps Involved In Analysis

1) The geometry of the LRU box is created using data supplied by NAL
2) The inner wall is named as LRU inner wall and outer wall is named as LRU outside wall with 2mm thickness
3) Domain is created 10 times larger than the model and meshed
4) The domain acts as ambient atmosphere 5)The heat source (electronic components) is modeled with volume which is 1/4th of the LRU box and 4W of heat dissipation
6) Fine meshing is done at the boundary layer and coarse meshing at the domain
7) The meshed file is imported in fluent for processing
8) After checking the mesh quality the model is scaled to mm
9) Default pressure based solver is selected and steady state with gravity due to natural convection is selected and g value is entered as 9.8m/s2
10) In model option energy equation is switched on and laminar flow is selected 11)Air is selected as fluid material In the domain and also inside the box
11) For box CFRP material is assigned and boundary condition of heat source of 140 w/m2 and thermal conductivity of

0.67w/mk, heat transfer coefficient of 15w/m2 are given

After all this 2000 iterations are provided convergence of energy equation is selected to 10-9 and results are obtained and tabulate

3) Result and Discussion

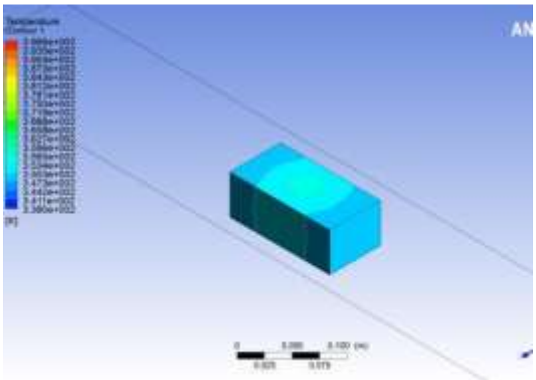


Figure 4.1 Outer wall temperature of LRU box

Shows the temperature profile on the outside wall of CFRP LRU box. The temperature on the outside wall shows variation from point to point. The average temperature is around 79 degree

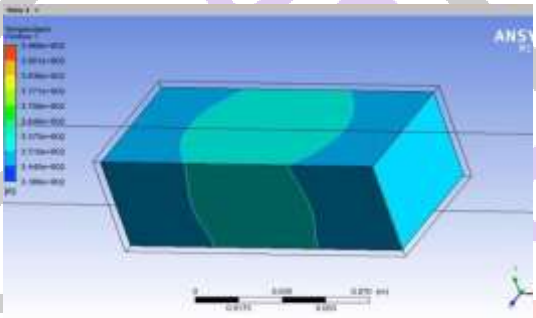
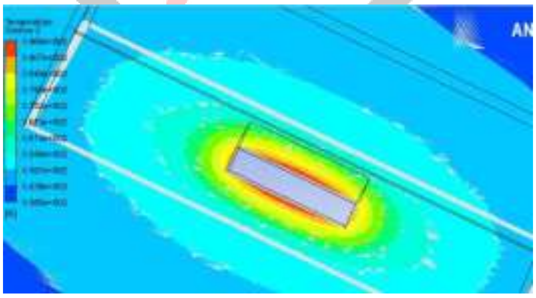


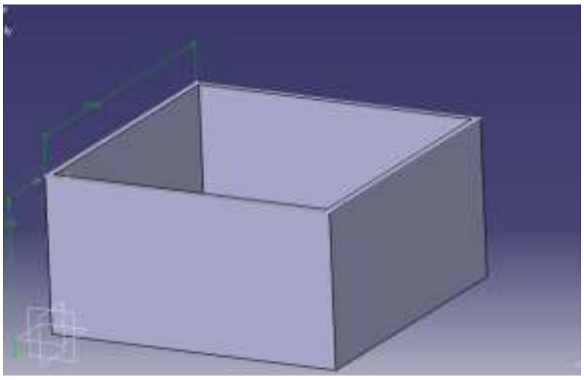
Figure 4.2 Inner wall temperature of LRU box

The temperature on the inside wall shows variation from point to point.. The average temperature is around 80 degree



The figure4.3 shows the temperature distribution of air inside the LRU box. As seen the temperature of air is maximum near the heat source to minimum near the inside wall of the LRU. The maximum temperature of air is around106 degree and minimum temperature of air is around 76 degree The temperature of air with increasing distance from heat source for 4 different points are shown in table. The average temperature of air is around 90 degree

Analytical calculation of heat transfer in box with heat generation



Typical representation of a LRU box

The LRU box with the CFRP material and 2mm outer wall thickness is first assigned for heat dissipation. The box is assumed to house electronic component which generates heat at a rate of 4-5 w the ambient air temperature is assumed to be 65degree

Heat source is assumed at the middle of the box
T∞=outside temperature of the air which should not exceed 65 degree
All thickness are 2mm
Total surface area = $0.035mm^2$
Thermal conductivity of the CFRP box in the direction normal to the fibre is 0.67w/mk Fibre weight fraction wf=0.6
Matrix weight fraction wm=0.4 Fibre density =1800kg/m2 Matrix density =1100kg/m3 effective laminate density
T ∞= Ambient air temperature =65 egree
T air= Air temp inside the box
T wallout= outside wall temp of the CFRP box

T wallin= inside wall temp of the CFRP box h = convective heat transfer coefficient of air

It is assumed to be in steady state heat conduction

Dissipated power Q=5W
Uniform heat flux q=Q/A =140 W/m2

Step 1
Considering convection heat transfer happening from the exterior of the box to the ambient air the heat transfer equation is h(Twallout-T∞)=q
15(Twallout-65)=140 Tout=74.5 degree

Step 2
Considering the conductive heat transfer from inside of the wall and to outside assuming 2mm thickness
k/t(Twallin-Twallout)=q 0.67/0.002(Tin-74.5)=140

Tin=75 degree

Step 3
Considering convection heat transfer happening from the interior of the box to air inside the heat transfer equation h(Tair-Twallin)=q
15(Tair-74.5)=140 Tair=84.5 degree

Results and conclusion

The Results of temperature obtained by hand calculation is of 1 dimensional heat conduction so there some small variation with the actual results. Actual results represent the 3D heat conduction But results are well accurate of not more than 10% variation in each case

REFERENCES

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