Thermal analysis of a rack mountable unit to study conjugate heat transfer using Solid Works

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Abstract — When an electronic component is powered, heat will be developed which will in turn increases the component temperature. For safe functioning of these components manufacturer specifies allowable temperature. If the component temperature exceeds these limits component fails. To get rid of this situation heat dissipation mechanism must be effective. Thermal design of an enclosure for PCBs of a rack mountable unit is taken up in this work. The primary objective is to enhance the heat dissipation rate with the proposed enclosure in free and forced convection environment. Selection of fan and estimation of cooling rate is also done. As part of the work junction temperature is estimated using commercial SOLID WORKS software package. After validation process maximum component temperature is obtained in order to ascertain the cooling effectiveness of the proposed thermal design by ensuring that maximum temperature is within the prescribed limits. The selection of a cabinet, enclosure or other packaging for an electronic product presents the designer or system integrator with a variety of choices, in addition to certain criteria that will be dictated by the nature of the application.

1 INTRODUCTION

The effect of the heat developed is, raising the temperature of the component mounted on PCB. Each component will have allowable temperature specified by the manufacturer crossing which will result into either malfunctioning of the component or permanent failure of the component. As the total reliability of the electronic enclosure is highly dictated by the component, a cooling mechanism is essentially required for an electronic enclosure. Compared to other modes of heat transfer, forced convection means will provide faster cooling rates. This work deals with designing a cooling scheme for an electronic enclosure of a Rack Mountable Unit in free convection environment as well as in forced convection environment. In the whole exercise estimation of junction temperature is a tedious task as standard literature mentions about standard geometries like plate, cylinder etc., but not for this kind of complex geometries like enclosures with PCBs. An analytical method is established during this work in which an expression for junction temperature is used. This expression will be validated with that of evaluated using commercial SOLID WORKS software package. The outcome of this work would be the correct form of cooling system to be employed in order to maintain safe working of the electronic device and also the better material to be used in order to increase the cooling efficiency. The solid model of the electronic enclosure in assembled configuration is shown in Fig. 1.

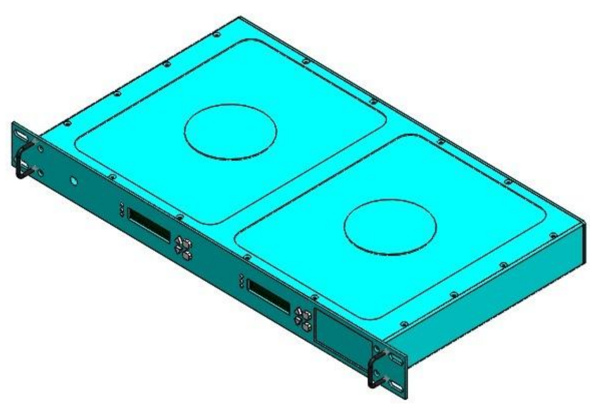

Fig.1.Closed Enclosure

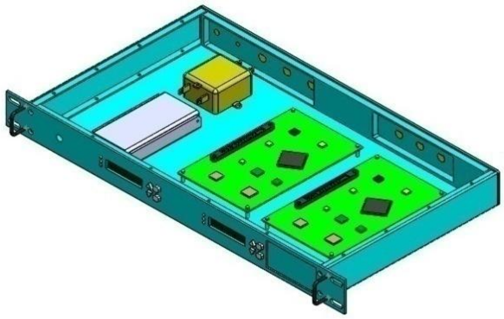

Fig.2. Open view of the components

2. Design Inputs

- Number pf PCB's = 2
- Air Inlet Temperature = Ambient Temperature
- Heat Load

ELEMENT	LOAD/HEAT(watts)
TSSOP	2
BGA 11,BGA 13	5
QFN	0.5
BGA 27	10
SOP	0.5
TQFP	1.5

3. Constraints

- Analysis Type – Internal
- Gravity – Along Z direction (-9.81 m/s^2)
- Project Fluid – Air (Gases)
- Flow Type – Laminar and Turbulent
- Project Solid – Aluminium 6061
- Wall Condition – Adiabatic Wall
- Pressure – 101325 Pa
- Velocity – 0 m/s (all the directions)
- Initial Solid Temperature – 30^{0}C
- Relative Humidity - 40%
- Reference Temperature – 30^{0}C

4. Thermal Analysis of Electronic Enclosure

For appropriate analysis the given model cannot be used for flow analysis, in order to perform the analysis, the given model needs to be an enclosed one. Hence the model is optimized.

The enclosure consists of four panels. Front, Rear, Left and Right. The front panel is inserted with vent holes and the rear panel is inserted with an exhaust fan and is optimized as said before and is shown in fig.3.

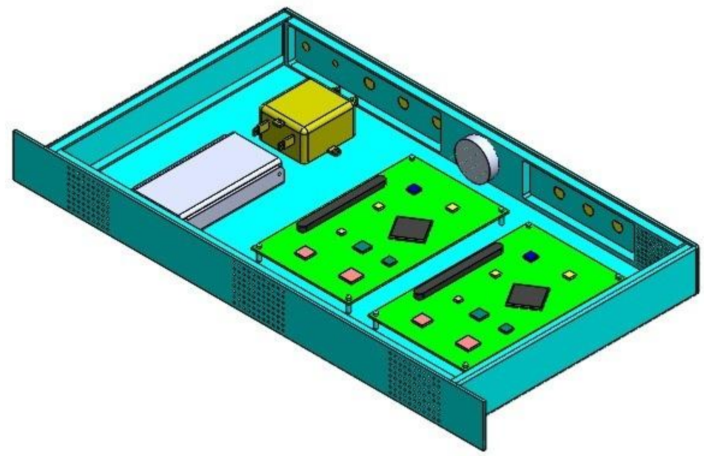

Fig.3. Enclosure with vent holes and exhaust fan

The properties of the exhaust fan used is mentioned below

Property	Value
Name	PMD1238PKBX-A (2) (Pre-defined)
Fan type	Axial
Reference density	1.2 kg/m^3
Mass/Volume flow rate	Volume flow rate
Rotor speed	1570.7964 rad/s
Outer diameter	0.037999 m
Direction of rotation	Clockwise

Further in order to specify the external conditions or the environment it is placed in, the enclosure is kept in a fluid sub-domain with the specified constraints. Fig.4 shows the enclosure inside the fluid sub-domain.

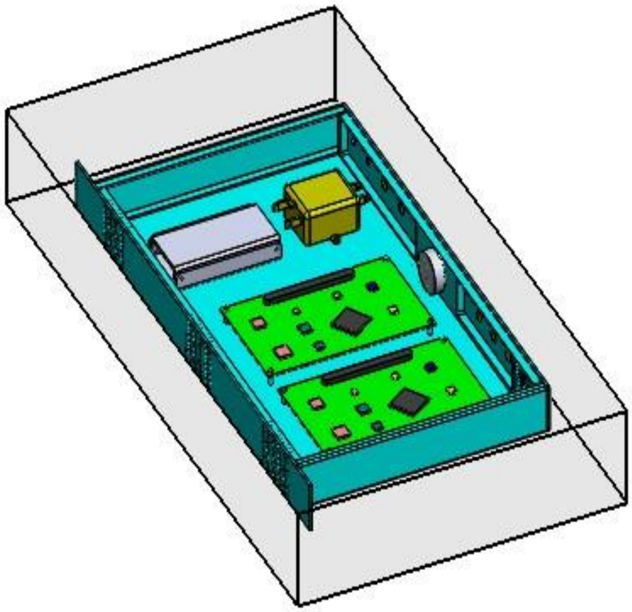

Fig.4.Enclosure inside the fluid sub-domain

The next part of the analysis is to mesh the model. Finite Element Method reduces the degrees of freedom from infinite to finite with the help of discretization or meshing (nodes and elements). One of the purposes of meshing is to actually make the problem solvable using Finite Element.

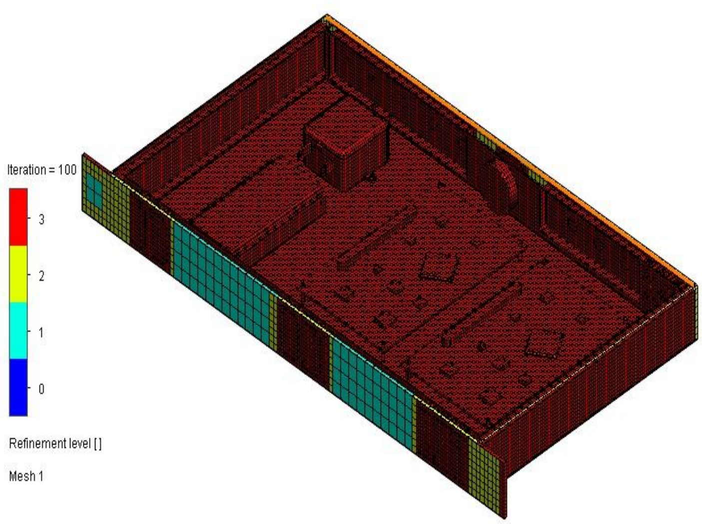

Fig.5.Meshed Model

The meshed model is then run through the analysis with the required constraints and the surface plot is obtained with the amount of heat dissipated from the individual components in the unit.

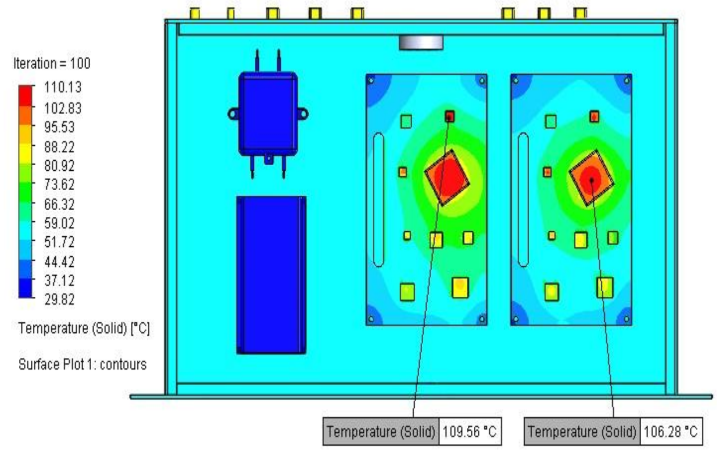

Fig.6.Surface Plot

Figure.7. represents the floe trajectory of air flowing through the unit and also the heat carried by it.

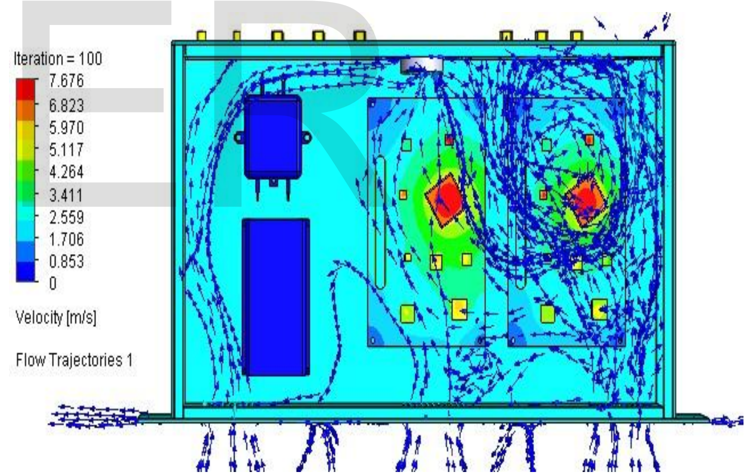

Fig.7.Flow Trajectory

After analysis we found out the maximum temperature is 110.13℃ as shown in the above figure. This also shows the heat dissipation throughout the PCB

Further the two graphs indicate the maximum amount of heat carried out by the solid and fluid after certain number of iterations and hence gave an idea to enhance or further modify the model.

Fig.8.Maximum Temperature (fluid)

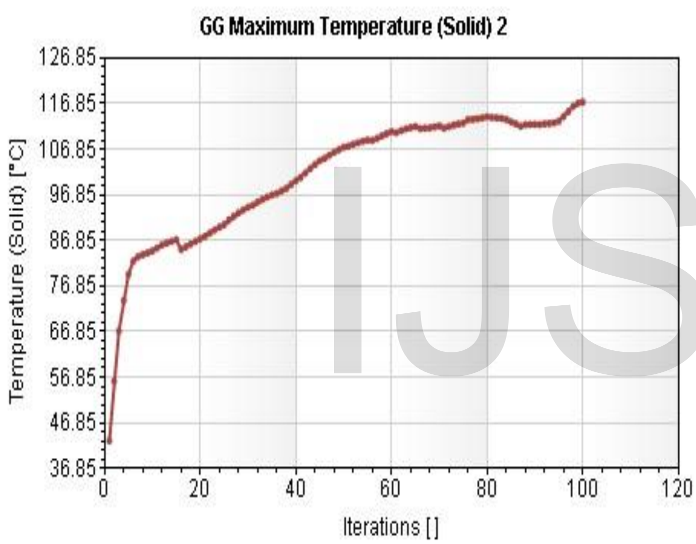

Fig.9.Maximum Temperature (solid)

RESULTS AND SUMMARY

Maximum solid temperature in degree Celsius (℃) for the entire different configurations with both Aluminium enclosure and Magnesium enclosure is as following

Configuration Properties	Aluminium	Magnesium
Closed enclosure	131.68	131.21
Enclosure with vent holes	118.62	118.96
Enclosure with exhaust fan	110.13	111.03
Enclosure with heat sink	89.09	84.09

CONCLUSION

As mentioned earlier the specified maximum temperature for the safe functioning of the rack mountable unit is 120°C.From the analysis we can see that the maximum amount of heat is dissipated by using heat sink i.e., the thermal pad along with vent holes and exhaust fan. But practically it is not possible due to the increase in power consumption and also makes the model more complicated. Hence we conclude that it is best suited to use the enclosure with vent holes as it ensures the required amount of heat dissipation to keep the unit safe.

From the analysis on using alternative material that is magnesium we find that there is a bit more heat lost but not much difference when compared with aluminium. When the two materials are compared with respect to other properties aluminium has better heat conductivity and better machinability and has a thermal conductivity of 205 W/mK whereas magnesium has lower weight density and is brittle in nature with a thermal conductivity of 156 W/mK. Hence we conclude that Aluminium is best suited for the manufacturing of the RACK MOUNTABLE UNIT.

REFERENCE

1.P Rada, P bowler et al. Proceedings of the ASME 2011 Pacific Rim Technical Conference & Exposition on Packaging and Integration of Electronic and Photonic Systems InterPACK2011 July 6-8, 2011, Portland, USA.

2. KunLi, Lianfa Yang et al. Advanced Materials Research Online: 2012-06-14

3. B.Raja et al. Int. Journal of Engineering Research and ApplicationsNovember 2015.

4. Anjaiah Madarapu, Murali Mohan Raju.T et al. IOSR Journal of Mechanical and Civil Engineering (2012)