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Performance Evaluation and Analysis of Cooling System Used in Digital Machine Control

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ABSTRACT

The DMU (Digital Machine Control UNIT) houses the processers of the control systems. The integrated circuits in the processers produce large amount of heat due to the large amount of data processed during operations. If this waste heat generation goes unchecked the PCB may temporarily malfunction or permanently fail. Due to this it affects the performance and speed of the DMU. This might lead to catastrophic disaster during operations. During operations there might be change in temperature from 55 °C to -20 °C. Hence the designed DMU should be able to control the temperature of the PCB's such that it should not affect the performance. The target temperature under which ATR work is 80 °C, for analyzing and achieving this target temperature thermal management system is analyzed using a commercial CFD software package (STAR CCM+).Considering as an Conjugate Heat Transfer Analysis and Optimization of the DMU was also done by changing the position of Fan and also increasing number of fans.

Keywords - *Computational Fluid Dynamics, conjugate heat transfer, cooling, thermal management*.

1. INTRODUCTION

Digital Machine Control Unit plays a very important role in many fields such as Aerospace, Automobiles, Electronic Enclosures, CPU's and etc. Due to the large amount of data processed during operations there will be discharge of large amount of heat from PCB's due to this the system may temporarily malfunction and also it might fail permanently, Hence thermal management plays an very important role in cooling of DMU.

This paper describes an effort to investigate the capabilities of a modern CFD solver in predicting the design and performance of DMU. The use of commercially available CFD software tools for these kind problems lead to a better understanding of the flow phenomenon. Furthermore, better designs that enhance design operation and improve the performance could result in gaining confidence to apply CFD analysis tools to the design process. The results will validate the use of commercially available CFD software tools for these problems and lead to a better understanding thermal management which includes different types of cooling system such as Conduction, Free and Forced Convection and Radiation [14].

2. MODEL CONSTRUCTION AND FORMULATION

In this, the model is constructed in such a way that, there is presence of stagnant air near PCB's, due to this the heat produced by PCB's will be distributed by free convection and intern this is closed in all the sides with plates and with presence of fins where conduction takes places, these fins are closed using plates and fans are installed at exit due to the suction of air from fans will induce the air to force out from inlet to outlet through the fins which will lead to the forced convection. The entire model is shown in the figure 1. This was been designed by using a CAD software Unigraphics and Meshed by using Hypermesh and Star CCM was used to solve the problem.

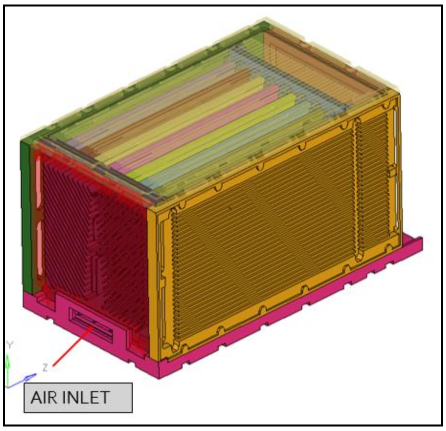

Fig 1: Geometry Of The Model

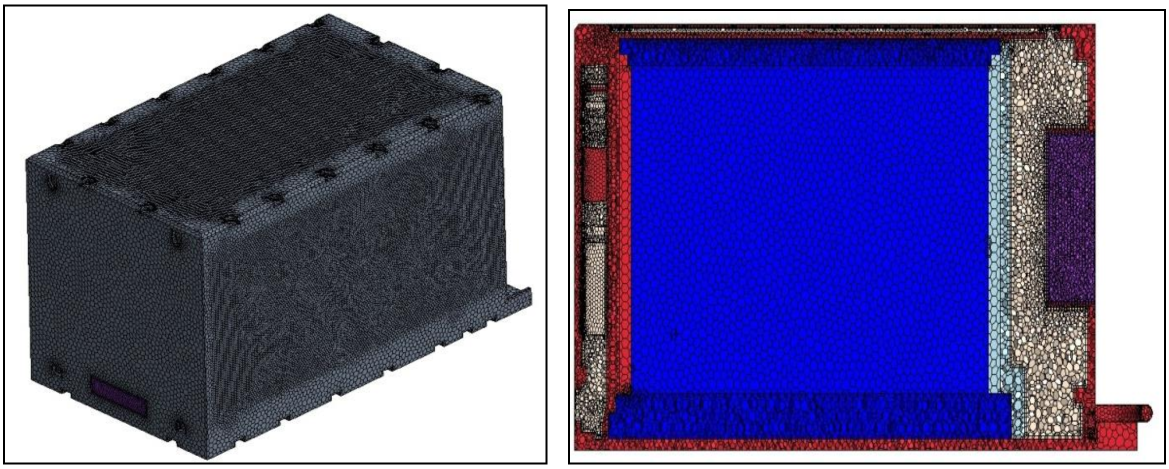

Fig 2: CFD Mesh Model

3. BOUNDARY CONDITIONS

i. Operating temperature: -20 ±3 °C to +55 ±3 °C.
ii. The unit is sealed and conduction cooled.
iii. No air is allowed (natural free convection) inside the card cage and forced convection is achieved through external airflow over fins.
iv. Total heat generated is 330W, out of which 250 W is distributed between the 8 cards and power supply is about 80 W.

FAN	Operating Speed (RPM)	Airflow (CFM)	Operating Temperature (Min/Max °C)	Voltage (V)	Noise (dB)	Input power (Watts)
Optifan-70	22000	100	-55°C / +85°C	28	77	40
Optifan-45	22000	53	-45°C / +85°C	28	85	42

Table 1: Specifications of Fan

4. RESULTS AND DISCUSSION

4.1 Case 1: Optifan 70

Fan Curve & Model

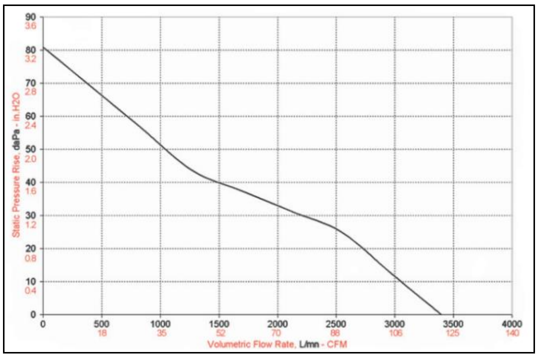

Fig 3: Optifan 70 fan curve [10]

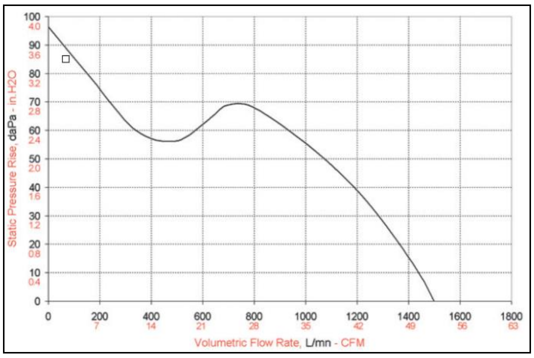

Fig 4: Optifan 45 fan curve [10]

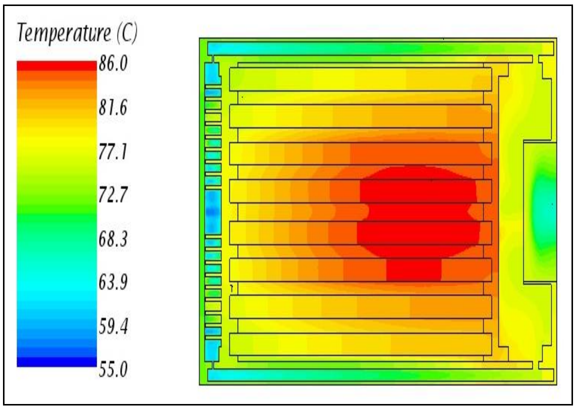

Fig 5: Contour Temperature on cards

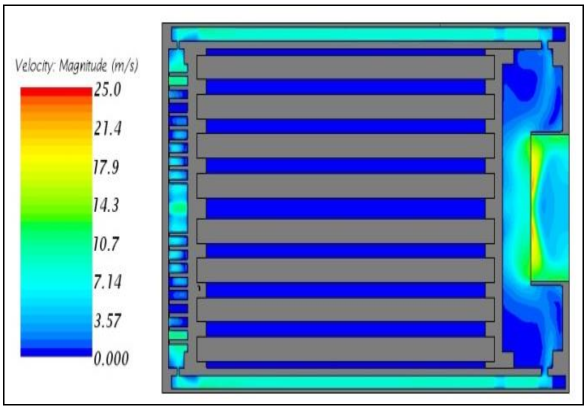

Fig 6: Velocity plot

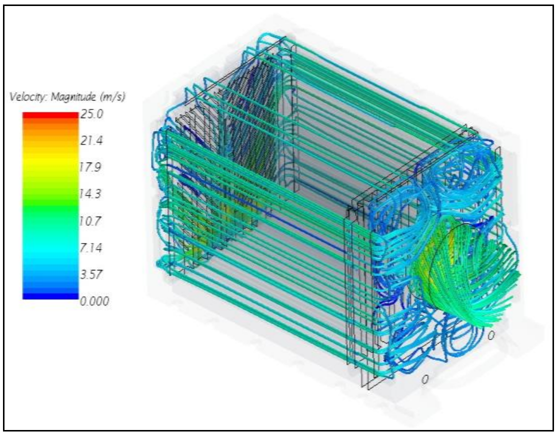

Fig 7: Streamlines - velocity

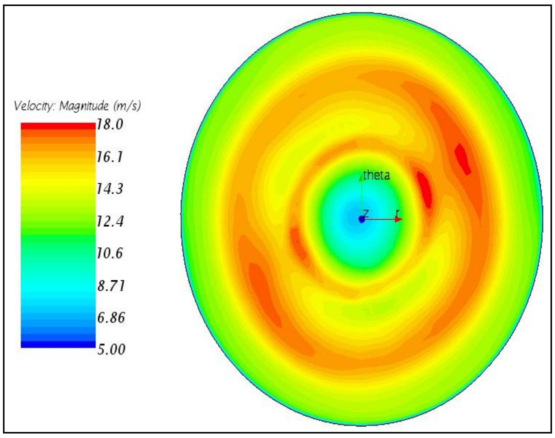

Fig 8: Contour plot on fan velocity

4.2 Case 2: Optifan 45

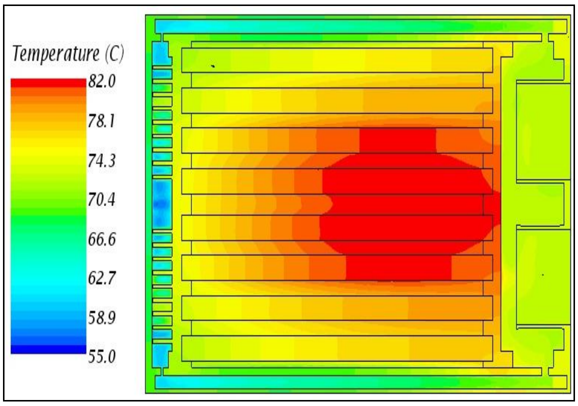

Fig 9: Contour Temperature on cards

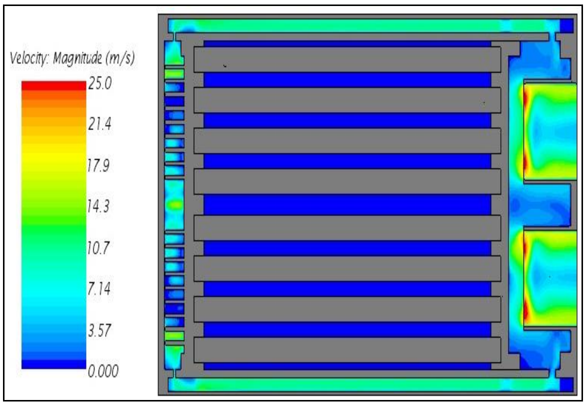

Fig 10: Velocity plot

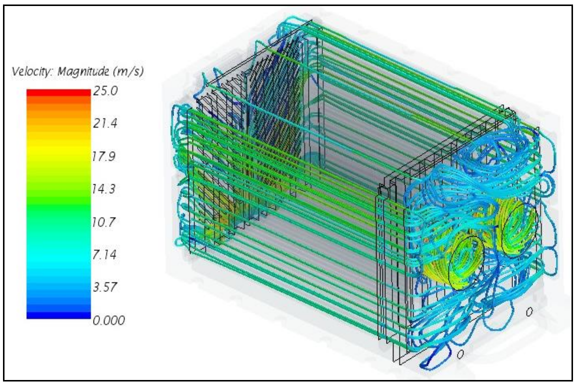

Fig 11: Streamlines – velocity

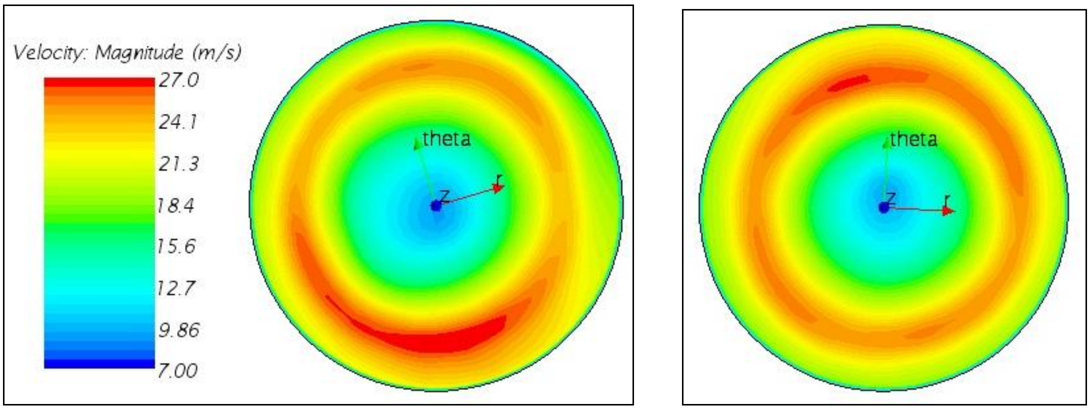

Fig 12:- Contour plot on fan velocity

4.3 Case 3: Optifan 45 – Optimization of Fins

Fan details will be same as in CASE 2. The fins added are as shown below.

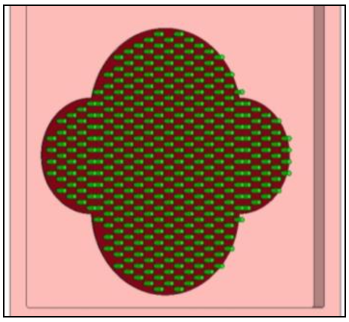

Fig 13: Optimization of Fins

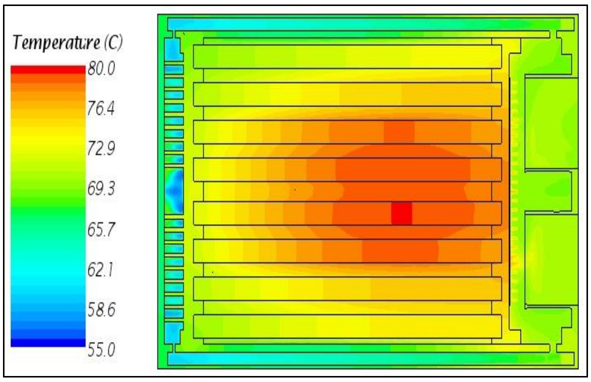

Fig 14: Contour Temperature on cards

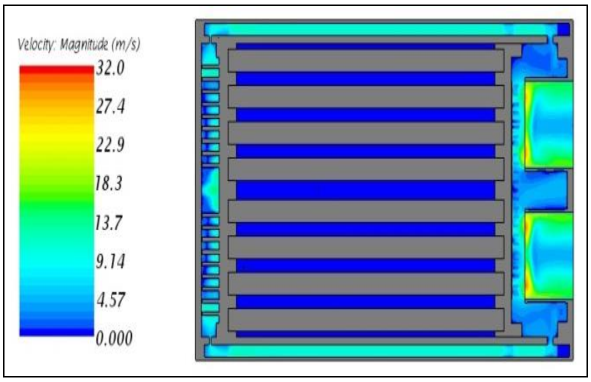

Fig 15: Velocity plot

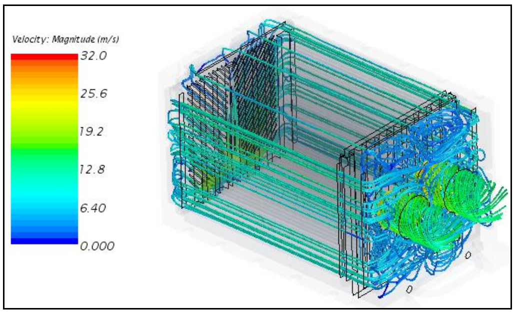

Fig 16: Streamlines - velocity

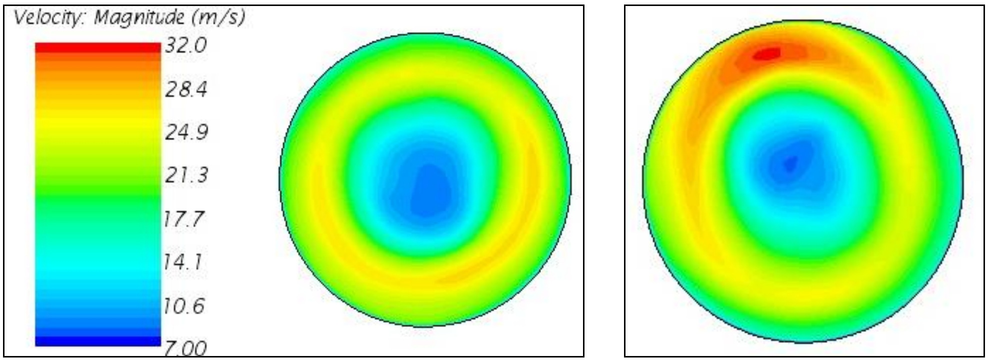

Fig 16: Contour plot on fan velocity

5. CONCLUSION

Summary of Results

Fan Selection Details	**OPTIFAN - 70**	**OPTIFAN - 45**	**OPTIFAN – 45 -Optimized**
Max. Temperature (°C)	85.82	82.21	79.24
Max. Velocity (m/s)	25	32	32

Table 2**:** Results Comparison Table

The cooling of cards is established by forced convection of air over the fins. The force will be created by an exhaust fan by sucking the air. So the objective was to find a suitable fan which can produce a forced convection of air in order to keep the maximum temperature within the system to not more than 80^{o}C.

Initially a single fan of Optifan-70 has been used. It resulted in a maximum temperature of 85.82^{o}C which was far above the target. Next a double fan of Optifan-45 is used. This resulted in a maximum temperature of 82.21^{o}C. Finally, fins are added for the Optfan-45 model and the analysis was done which resulted in maximum temperature of 79.24^{o}C. It is concluded that the final design named Optifan-45-optimized has satisfied the objective and will be considered for manufacturing.

REFERENCES

1. Guenin, B., "*Packaging: Designing for Thermal Performance",* Electronics Cooling, Vol. 3, No. 2, May 1997.
2. Mulgaonker, S., Chambers, B., and Mahalingam, M., "*An Assessment of the Thermal Performance of the PBGA Family*," IEEE Trans. Comp., Packaging, Manuf. Technol. A, Vol. 18 Dec. 1995, pp. 739-748.
3. Yovanovich, M., "*Four Decades of Research on Thermal Contact, Gap, and Joint Resistance in Microelectronics*," IEEE CPT Trans., Vol. 28, 2005, pp. 182-206, 2005.
4. Blazej, D., "*Thermal Interface Materials",* Electronics Cooling, Vol. 9, No. 4, November 2003.
5. Viswanath, R., Wakharkar, V., Watwe, A., Lebonheur, V., "*Thermal Performance Challenges from Silicon to Systems*," Intel Technology Journal, Volume 4, Number 3, 2000.
6. Vogel, M., Xu, G., "*Low Profile Heat Sink Cooling Technologies for Next Generation CPU Thermal Designs*," Electronics Cooling, Vol. 11, No. 1, February, 2005, pp. 20 – 26.
7. Soule, C., "*Future Trends in Heat Sink Design*," Electronics Cooling, Vol. 7, No. 1, February, 2001, pp. 18 – 27.
8. Kim, S., Claassen, A., "*How to Evaluate Fan Life*," Electronics Cooling, Vol. 2, No. 2, May 1996.
9. Wirtz, R.A., "*Quick and Easy Fan/Sink Characterization*," Electronics Cooling, Vol. 8, No. 3, August 2002.
10. Angelis, W., "*General Aspects on Fan Selection and Layout*," Electronics Cooling, Vol. 7, No. 2, May 2001.
11. Turner, M., "*All You Need to Know about Fans*," Electronics Cooling, Vol. 2, No. 2, May 1996.
12. Guenin, B. "*Component thermal characterization*," Electronics Cooling, Vol. 7, No. 1, February, 2001.
13. Lasance, C., "*CFD Simulations in Electronic Systems: A Lot of Pitfalls and a Few Remedies*," Electronics Cooling, Vol. 11, No. 2, February, 2005.
14. Soule, C., "*Future Trends in Heat Sink Design",* Electronics Cooling, Vol. 7, No. 1, February, 2001, pp. 18 – 27.