Thermal Analysis and Design of ACOP for PDR

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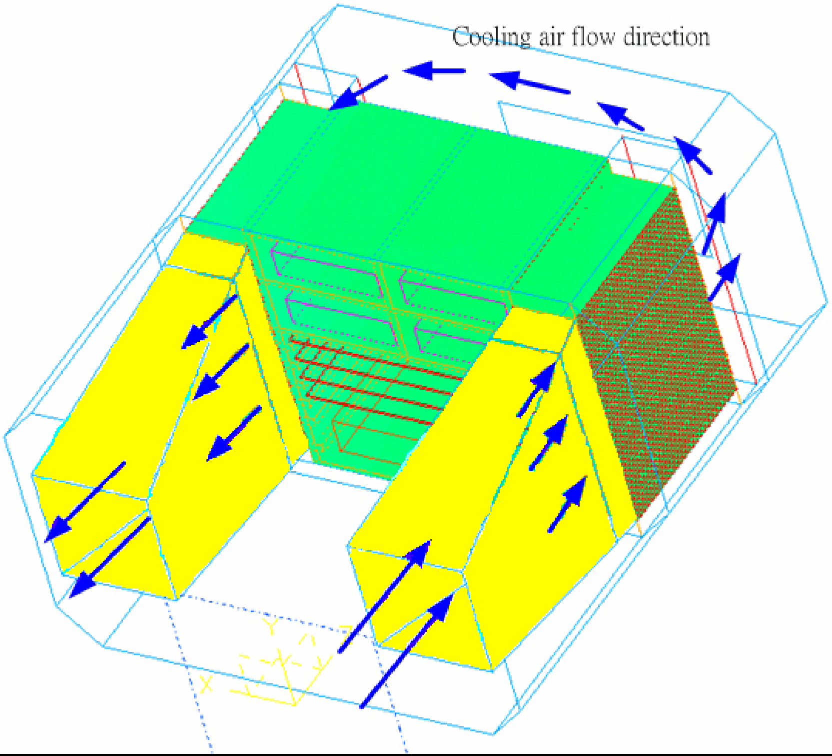
Outline

1. Introduction

The cooling air comes into the inlet duct, through the cold fin channels, and comes out to cool the LCD panel, and then goes through the hot fin channels, by the outlet duct and finally to the Rack locker.



2. System Description

- A minimum flow rate, 12cfm, of the cooling air with a pressure of 10.2psia is compressed into ACOP.
- 56 fins are extruded from the ACOP chassis at each side to be heat sinks.
- Chassis and fin channels are made of 7075-T7351

Geometry of the fin channels of ACOP

Fin gap	Thickness	Height	Length
2.5mm	1.5 mm	60 mm	162 mm

3. Thermal Control Concept and Thermal Design Description

- Power dissipation of components conducts to the board edge via copper layers, and to the chassis and fins, and transfers to the cooling air.
- A spacer is utilized to conduct the heat.
- The hard disk driver(HDD) uses a heat sink to conduct the heat to the HDD edge.

4. Thermal Requirements

- The temperature requirement for the ACOP chassis is less than 50 ℃, following the AMS-02 worst case crate temperature.

5. Boundary Conditions

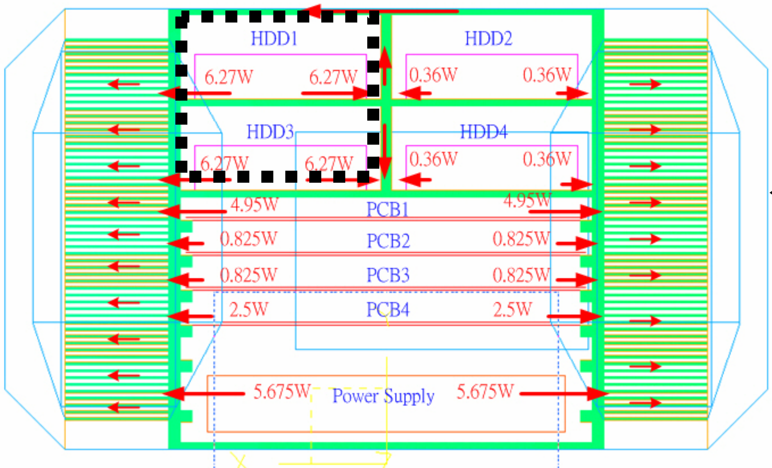
- Cooling air temperature: 30 ℃, referred to the document SSP 52000-IDD-ERP.
- The enclosure of ACOP is insulated from the environment, except for the front panel.
- The natural heat transfer coefficient h between the front panel and the cabin is ~1 W/m^2 ℃.

6. Thermal Loads-Power Budget

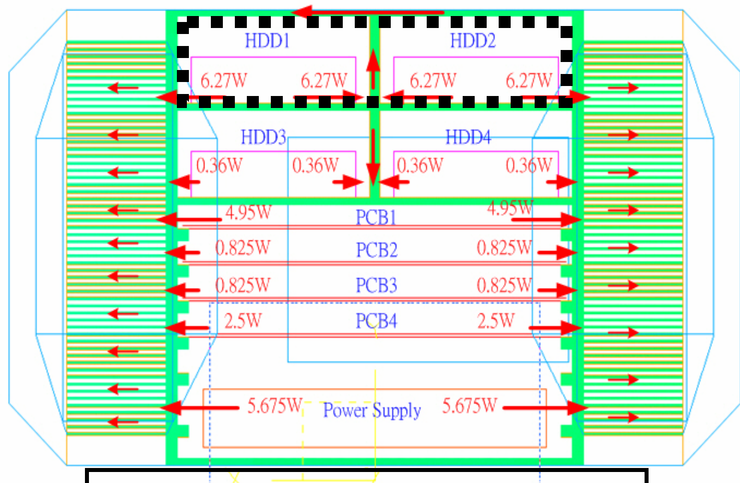
- **ACOP power dissipation of thermal dimensioning case: 62.37W**

ACOP FLIGHT MODEL: POWER BUDGET			
LOC	**Part Number**	**Description**	**Power(W)**
CompactPCI chassis			
SLOT1	**ACOP-SBC**	**Single Board Computer+DIO**	**9.90**
SLOT2	**ACOP-T103**	**CompactPCI 6U SATA and Fan Control**	**1.65**
SLOT3	**ACOP-T102**	**CompactPCI 6U Ethernat and Video**	**1.65**
SLOT4	**ACOP-T101**	**CompactPCI 6U HRDL**	**5.00**
Power	**ACOP-PS**	**Power Distribution**	**11.35**
	ACOP-LCD	**LCD Monitor**	**6.30**
HDD LOC 1	**TBD**	**Hot Plug SATA 250G HDD**	**12.54**
HDD LOC 2	**TBD**		**12.54**
HDD LOC 3	**TBD**		**0.72**
HDD LOC 4	**TBD**		**0.72**
ACOP FM Total			**62.37**

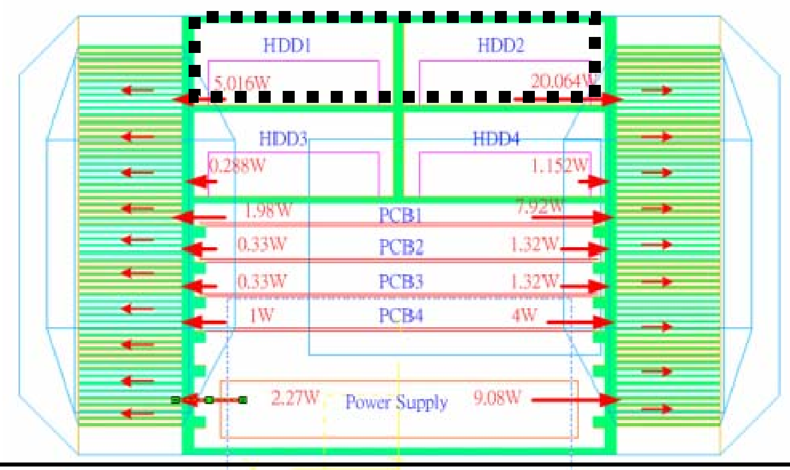
6. Thermal Loads-Allocation



Two working HDD's at the hot side and the thermal load evenly and uniformly allocated on the slots, denoted as case 1.



Two working HDD's at the top, as case 2



80% of thermal load on the cold slots and 20% on the hot slots, as case 3

7. Model Description and Thermal Analysis

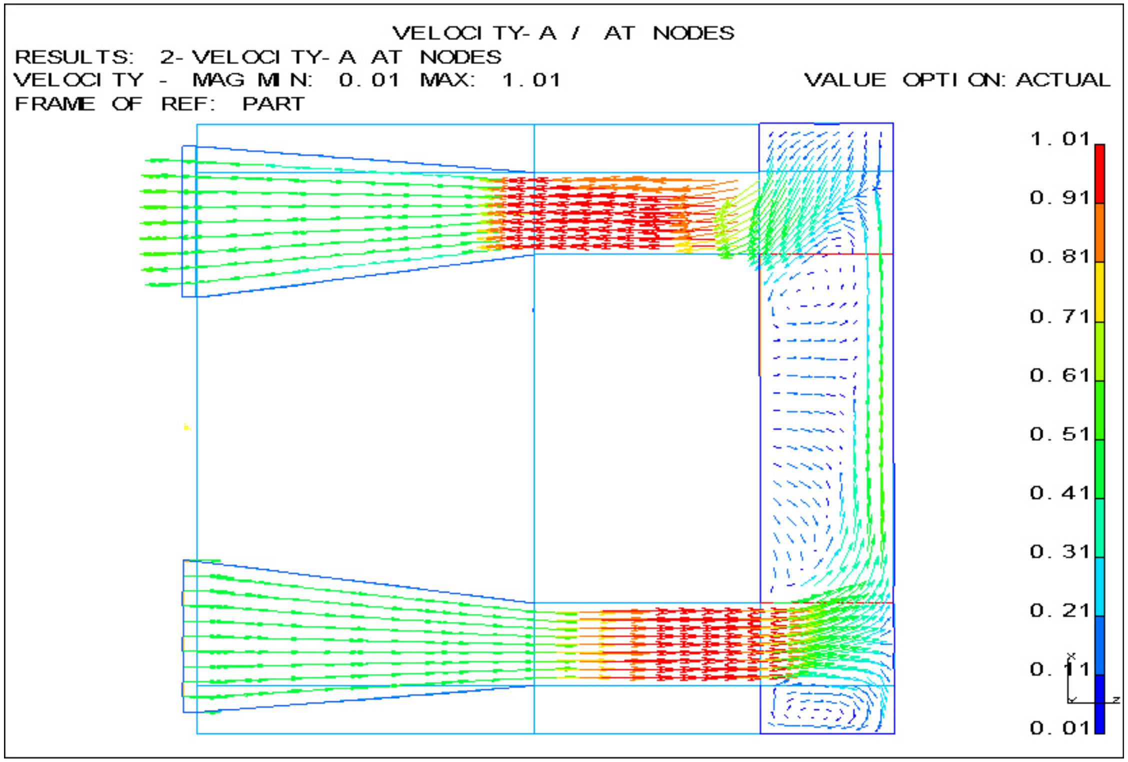
- "I-DEAS+TMG+ESC" code is applied to solve the computation task.
- For the solid and the fluid, 67,045 hexagonal elements and 157,671 trihedral elements are meshed respectively.
- System pressure loss of ACOP is calculated via semi-empirical correlations.

7. Model Description and Thermal Analysis

- Based on the electrical analogy, thermal model constructs a resistance-capacitance thermal network.
- A hybrid approach is developed in the code by utilizing the element based finite difference method to simulate conduction, and surface convection.
- The thermal code is coupled with the element based finite volume method flow solver, which models air flow, turbulence, fluid conduction, and advection.

8. Analysis Results-Air Velocity

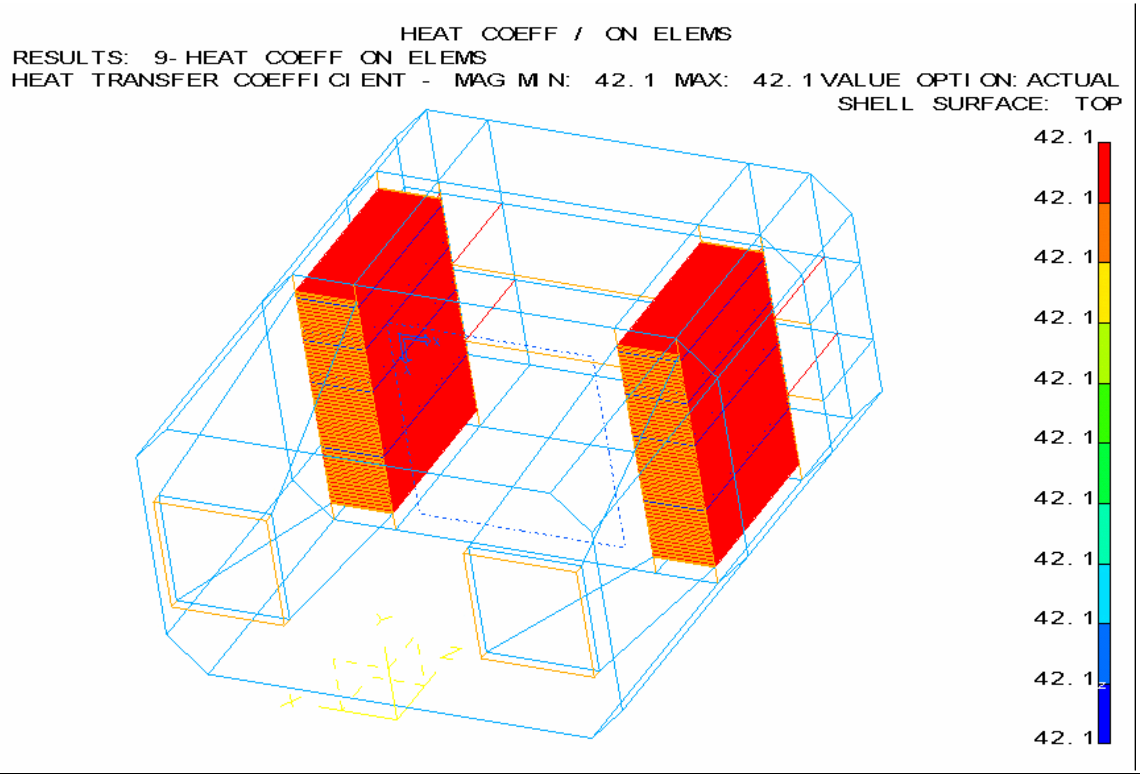
- The cooling air velocity field.



- The predicted maximum velocity is 1.01m/sec.
- A low Reynolds number produces a laminar flow.

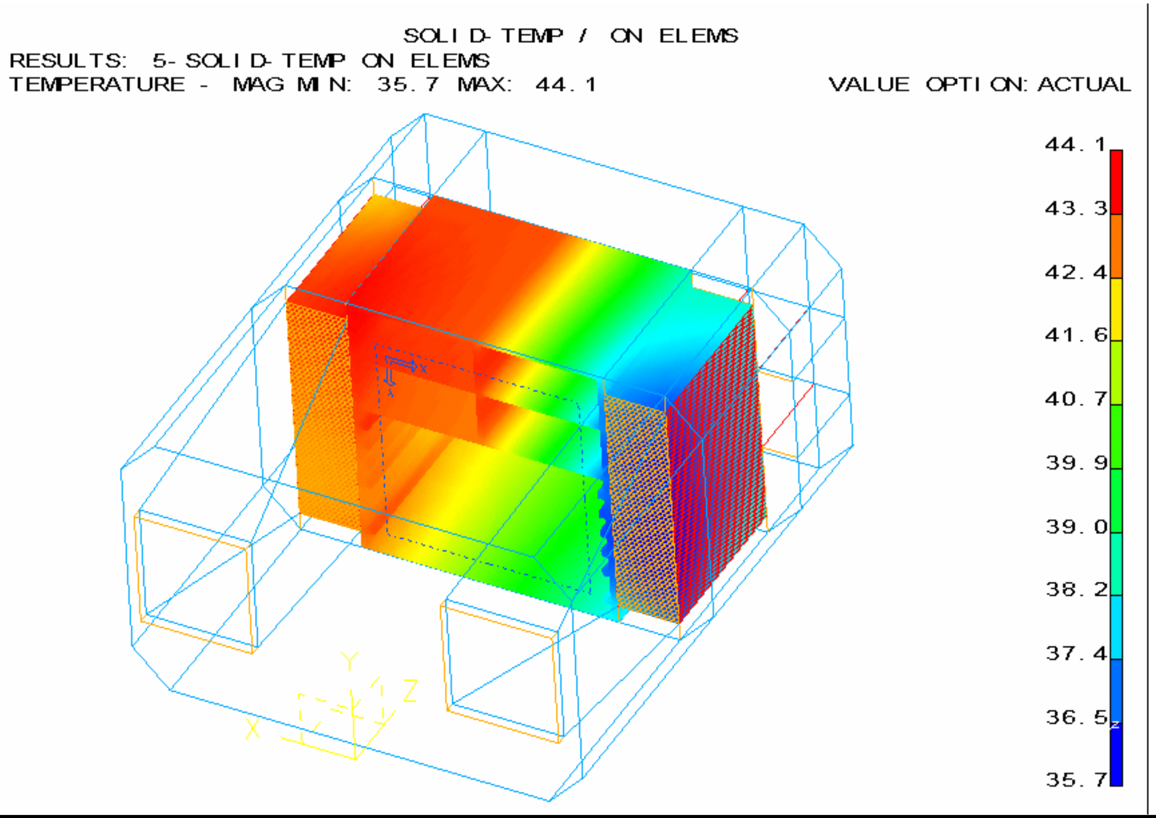
8. Analysis Results-Heat Transfer Coefficient

- The calculated heat transfer coefficient h at the fin channels.
- h=42.1 W/m^2 ℃
- Via the semi-empirical equation, the h value is calculated to be 40. W/ m^2 ℃.



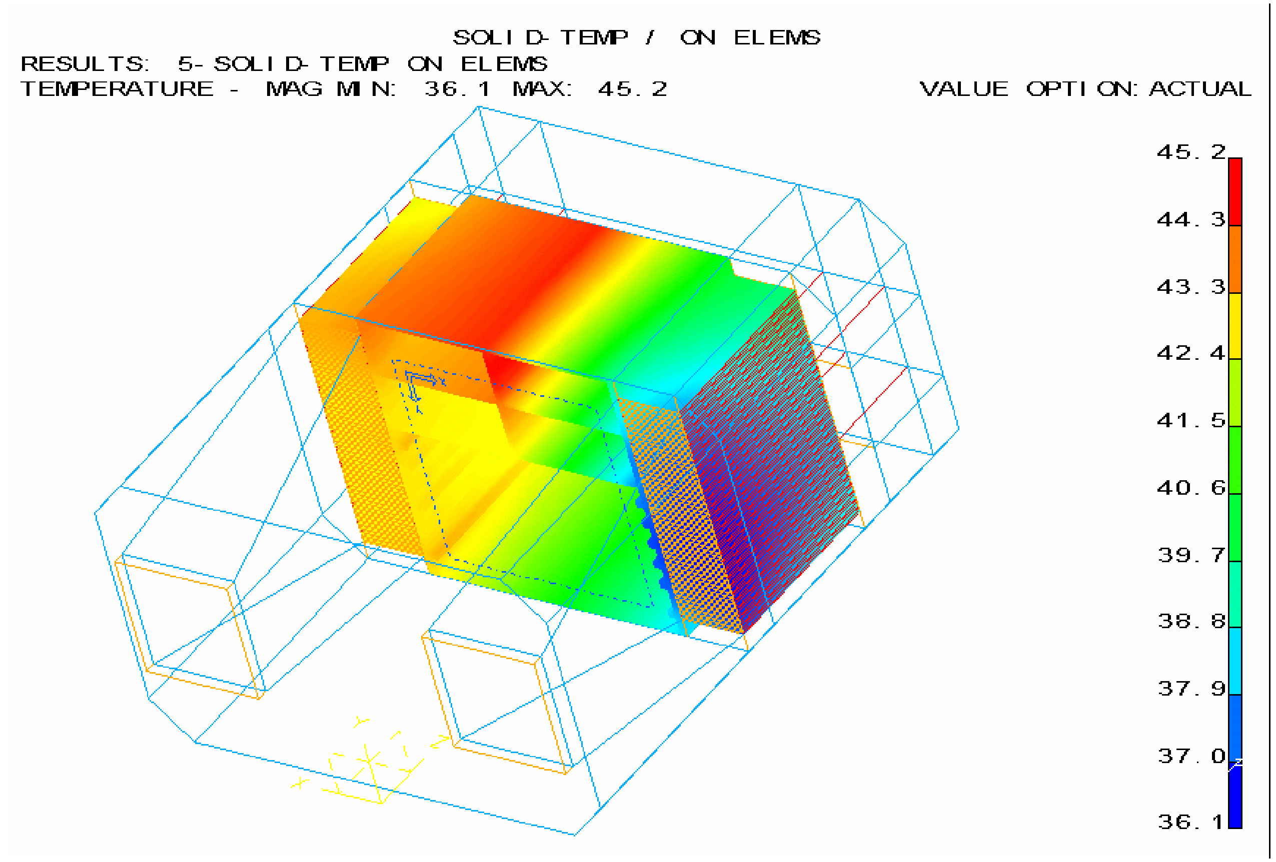
8. Analysis Results- Case 1 Chassis Temperature

- Predicted temperature of ACOP chassis and fins for case 1.
- The maximum temperature at the central chassis, 44.1 ℃.



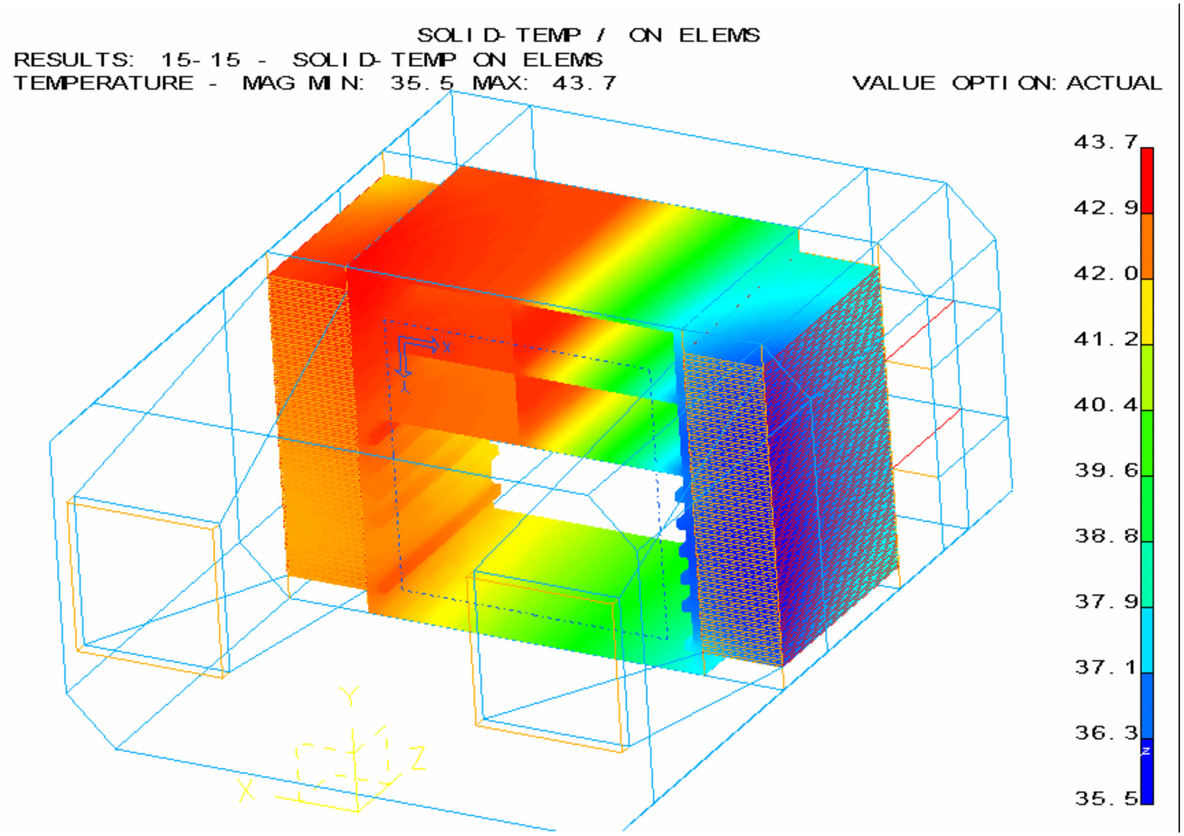
8. Analysis Results- Case 2 Chassis Temperature

- The maximum temperature at the central chassis, 45.2℃.



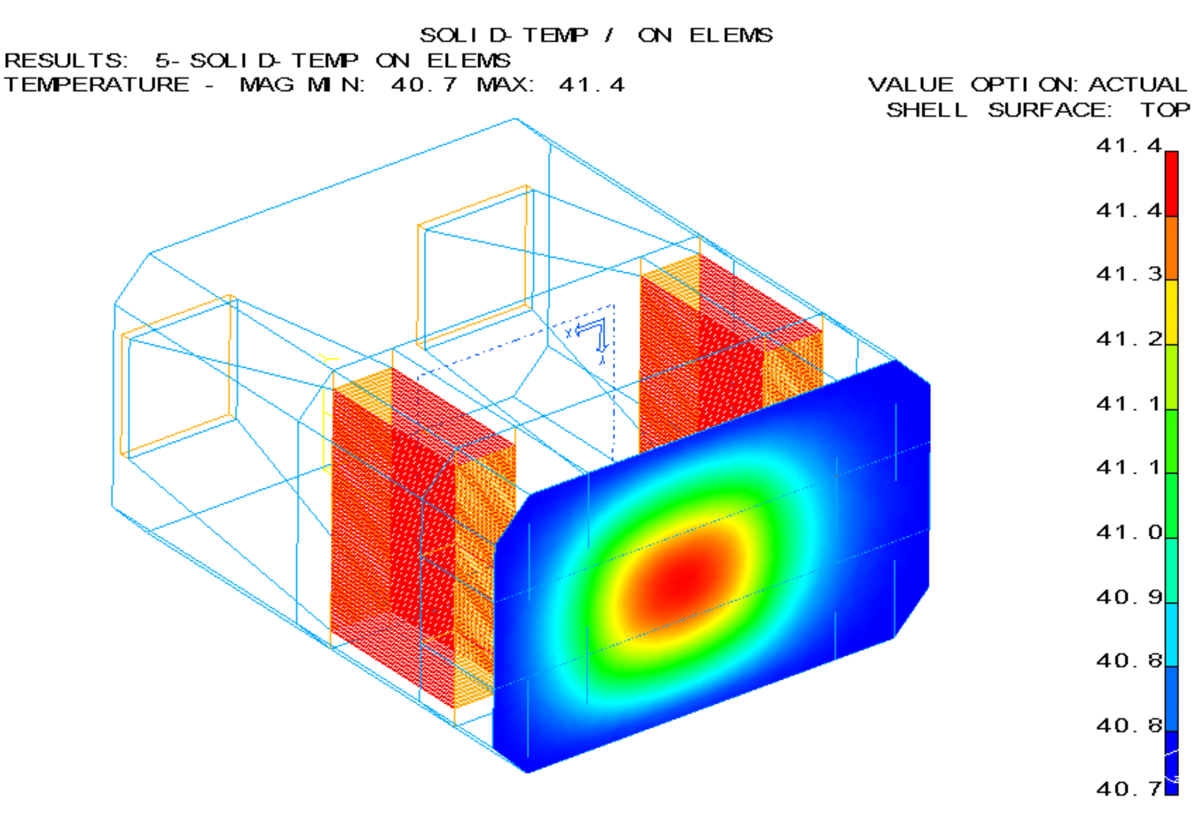
8. Analysis Results- Case 3 Chassis Temperature

- The maximum temperature at the central chassis, 43.7 ℃.



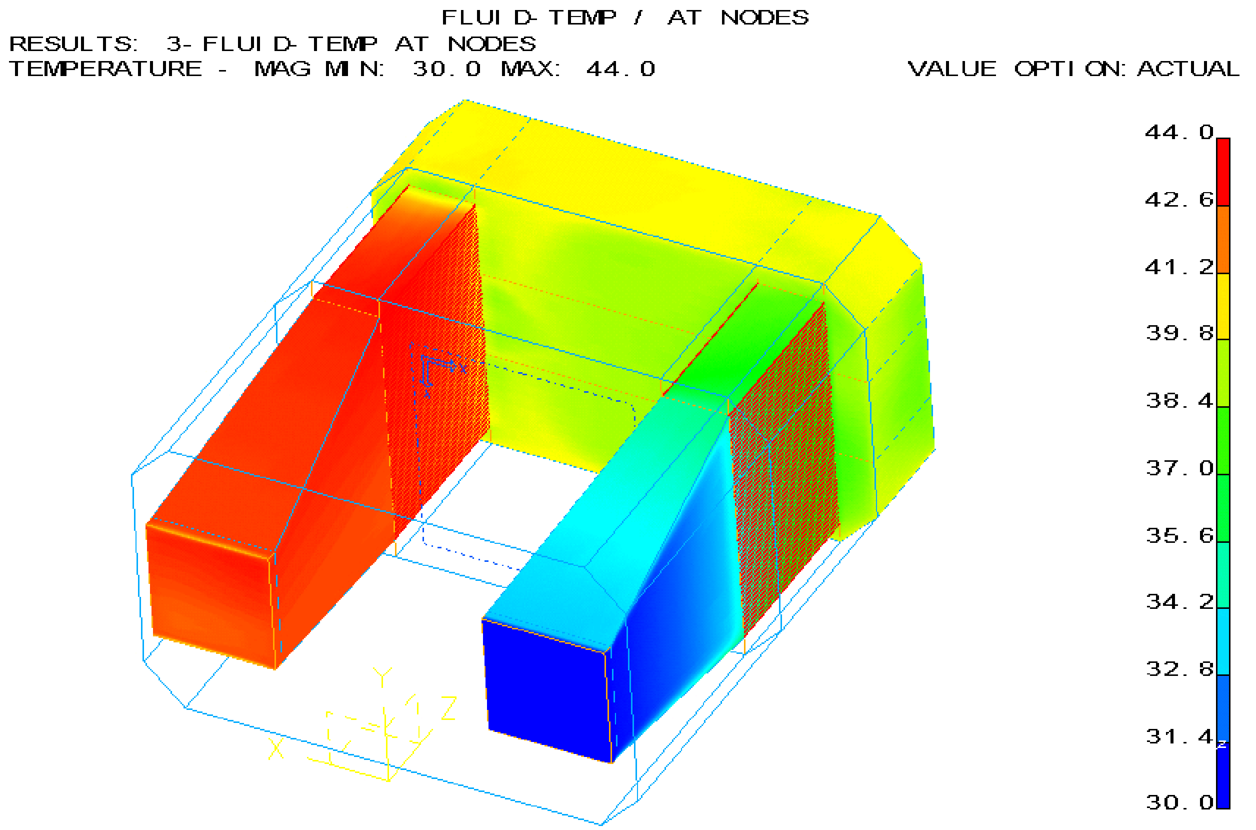
8. Analysis Results- LCD Panel Temperature

- The predicted temperature of the front panel for case 1.
- Predicted maximum temperature:41.4 ℃



8. Analysis Results- Air Temperature

- The predicted temperature of the cooling air for case 1.
- The predicted maximum temperature:44 ℃



8. Analysis Results- System Pressure Loss

•System total pressure loss: 10.86 (20.61) Pa
for the flow rate 12.00 (18.00) cfm.

Fin channel pressure loss of one side via the semi-empirical correlations

Pressure / Flow rate	10.2psi		15.2psi	
	V_m (m/s)	ΔP (Pa)	V_m (m/s)	ΔP (Pa)
12cfm	0.686	4.28	0.686	4.35
15cfm	0.857	5.4	0.857	5.5
18cfm	1.029	6.53	1.029	6.67

9. Conclusions

- The fin channel design makes the thermal resistance between the cooling air and ACOP low, leading to an increase temperature by 15 ℃.

Predicted maximum temperature for three cases

	Thermal Load	Hottest Location	Max. Temp. (℃)
Case 1	**Work HDD's at hot side Even and uniform**	**Top centre of chassis**	**44.1**
Case 2	**Work HDD's at top Even and uniform**	**Top centre of chassis**	**45.2**
Case 3	**80% at cold side 20% at hot side**	**Top centre of chassis**	**43.7**

9. Conclusions

- The predicted maximum temperature of ACOP chassis 45.2℃ is below the requirement, 50℃.
- Among these cases, the maximum temperature difference is predicted 1.5℃, much less than ACOP chassis working temperature 45.2℃.
- The thermal management design is appropriate for ACOP and needs a maximum pressure loss around 20.61Pa for the flow rate 18cfm.

10. Further Task

- The cooling air doesn’t enter into ACOP directly.
- Thus, two fans will be implemented in the inlet and outlet respectively to blow in and to exhaust out the cooling air.
- Model of the Fan: UTEC HDF-8025-12MB,

Size: 80x80x25mm , Max. flow rate: 29cfm, Noise: 32dBA at 1m, Power rate: 1.26W, Weight: 100g