Thermal Simulation Report of Bonded Fin Heat Sink

Custom Thermal Solutions - Quick Ramp Manufacturing - Lowest Landed Cost

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- *Specification*
- Thermal Analysis Condition
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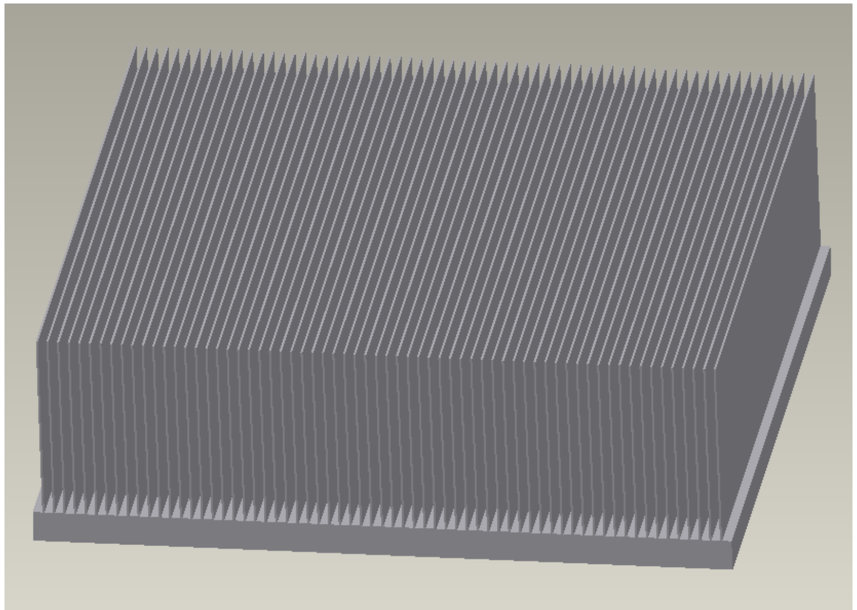
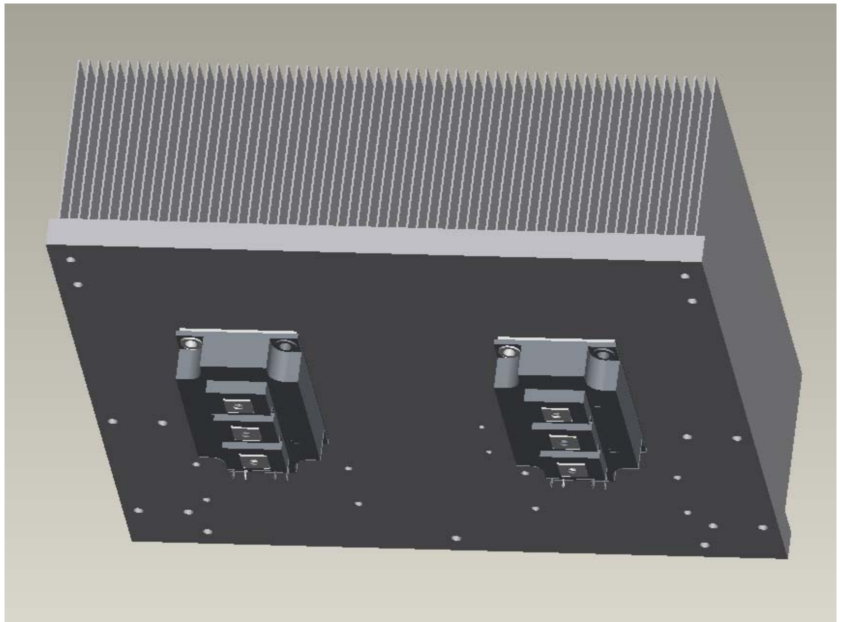
Fundamental Specification

- Ambient temperture: 35 ℃
- Devices: 2 IGBTs
  Total Power = 1500W , 1750W , 2000W
- Air flow: Provided by two Suntronix SJ1751HA2 (172 x 150 x 57mm)
  - Maximum air flow = 240CFM (at 3400RPM)
  - Maximum static pressure = 0.72inH_2O (at 3400RPM)
- Heat sink material:
  - Base: Al6063T5
  - Fin: Al1100

Fundamental Specification

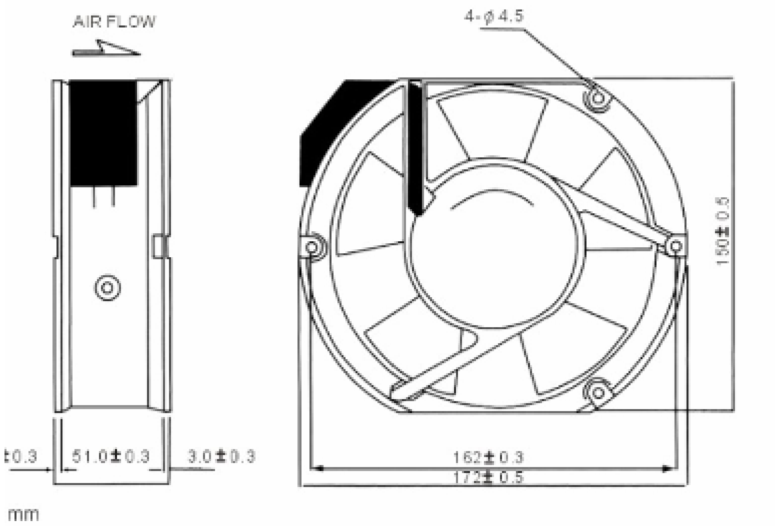
❖ System layout

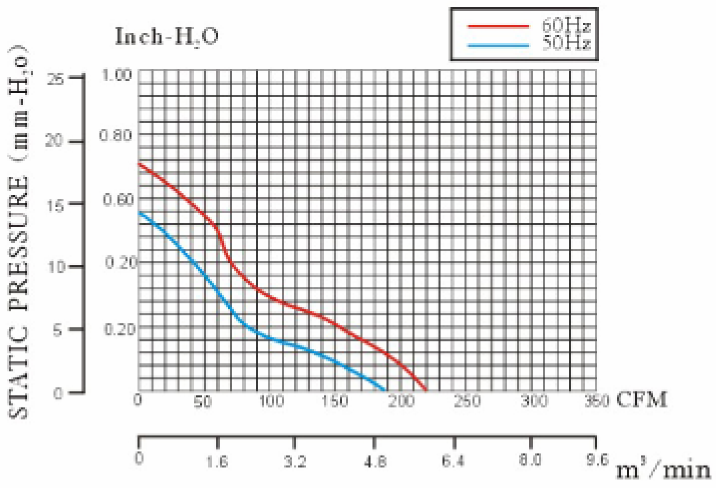




Fundamental Specification

❖ Fan specification





Model (型號)	Part Number Terminal Leadwire (端子/出線)	Bearing System (培林)	Rated Voltage (V) (電壓)	Freq. (Hz) (頻率)	Current (A) (電流)	Input Power (W) (功率)	Speed (RPM) (轉速)	Air Flow (CFM) (風量)	Static Pressure (Inch-H2O) (靜壓)	Noise Level (dB-A) (噪音值)	Weight (g) (重量)
SJ1751HA1	1751HA1BAT(L)	Ball	110/120	50/60	0.20/0.25	22/30	2850/3400	210/240	0.57/0.72	50/57	920
SJ1751HA2	1751HA2BAT(L)	Ball	220/240	50/60	0.10/0.13	22/30	2850/3400	210/240	0.57/0.72	50/57	920

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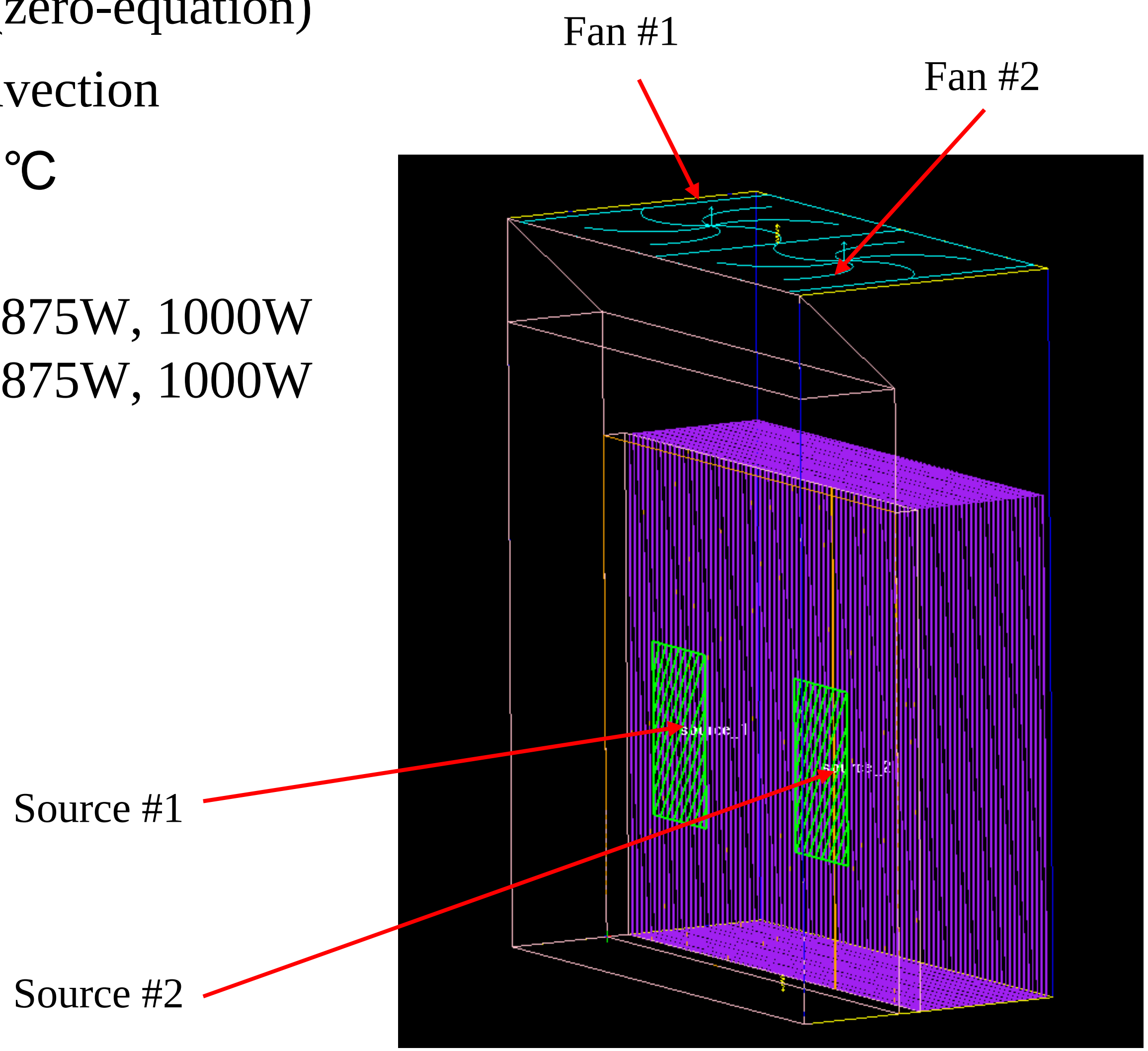
Thermal Analysis Condition

- Flow model: Turbulent (zero-equation)
- Flow regime: forced convection
- Ambient temperture: 35 ℃
- Devices:

  Source-1 = 750W, 875W, 1000W

  Source-2 = 750W, 875W, 1000W



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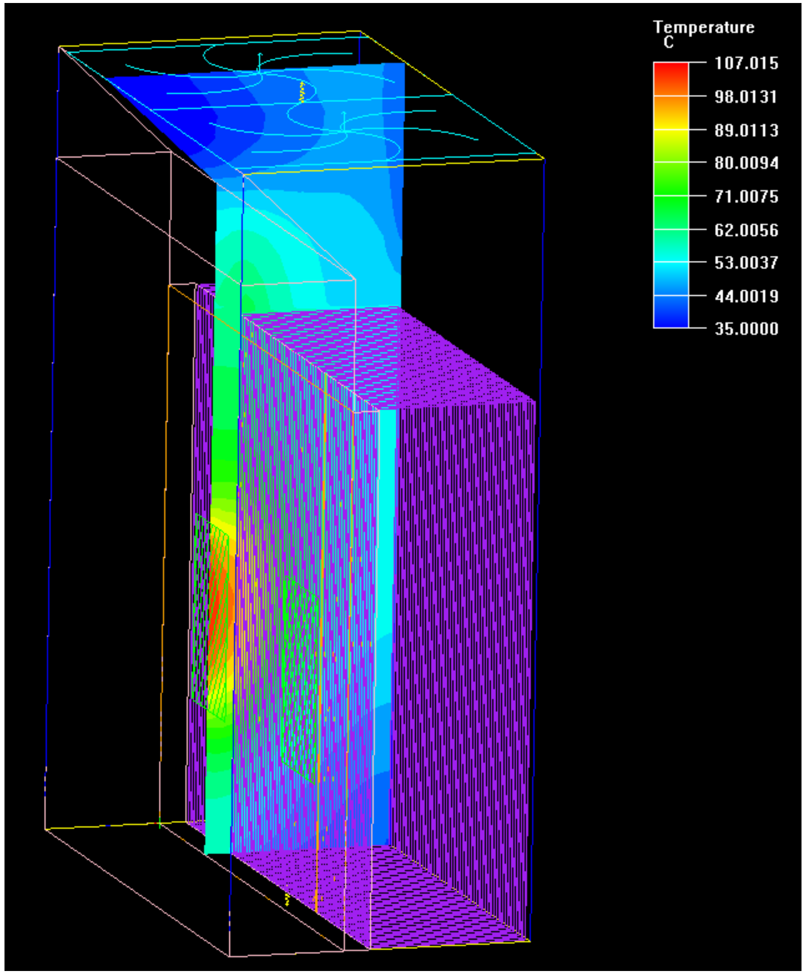
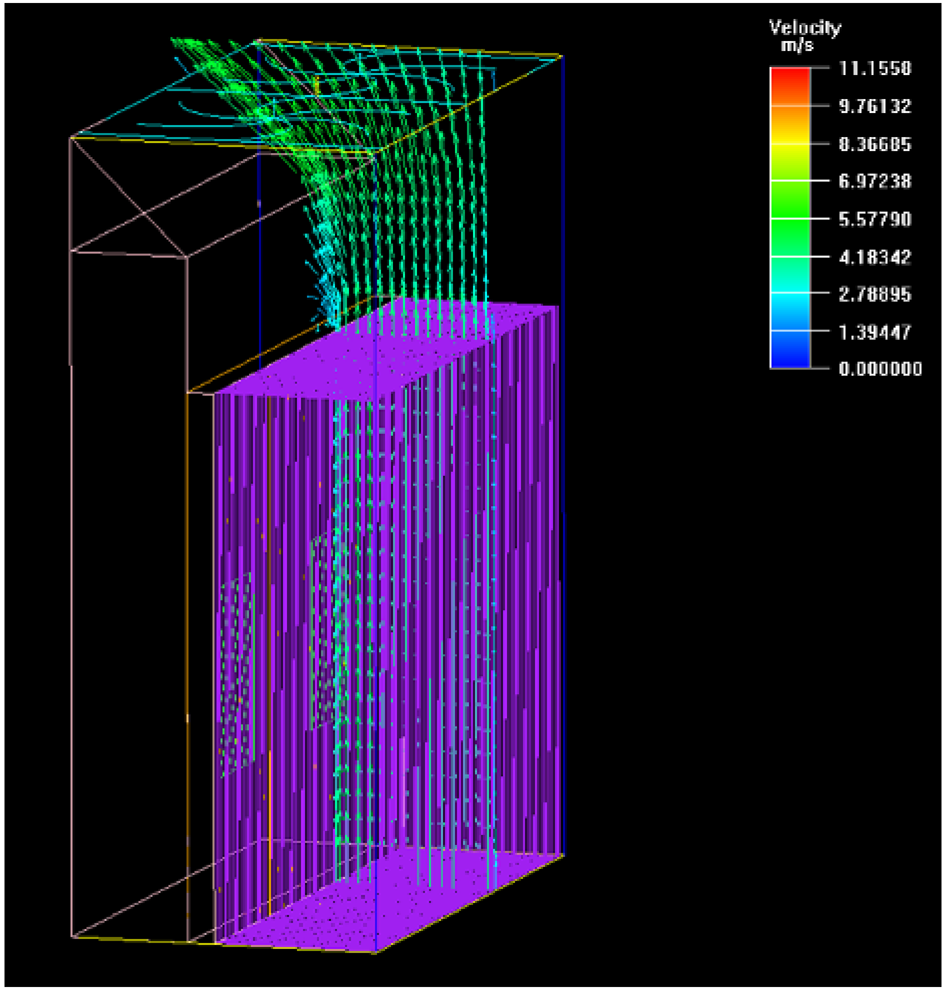
Simulation Results

❖ **Temperature Distribution (Z-dir.)**



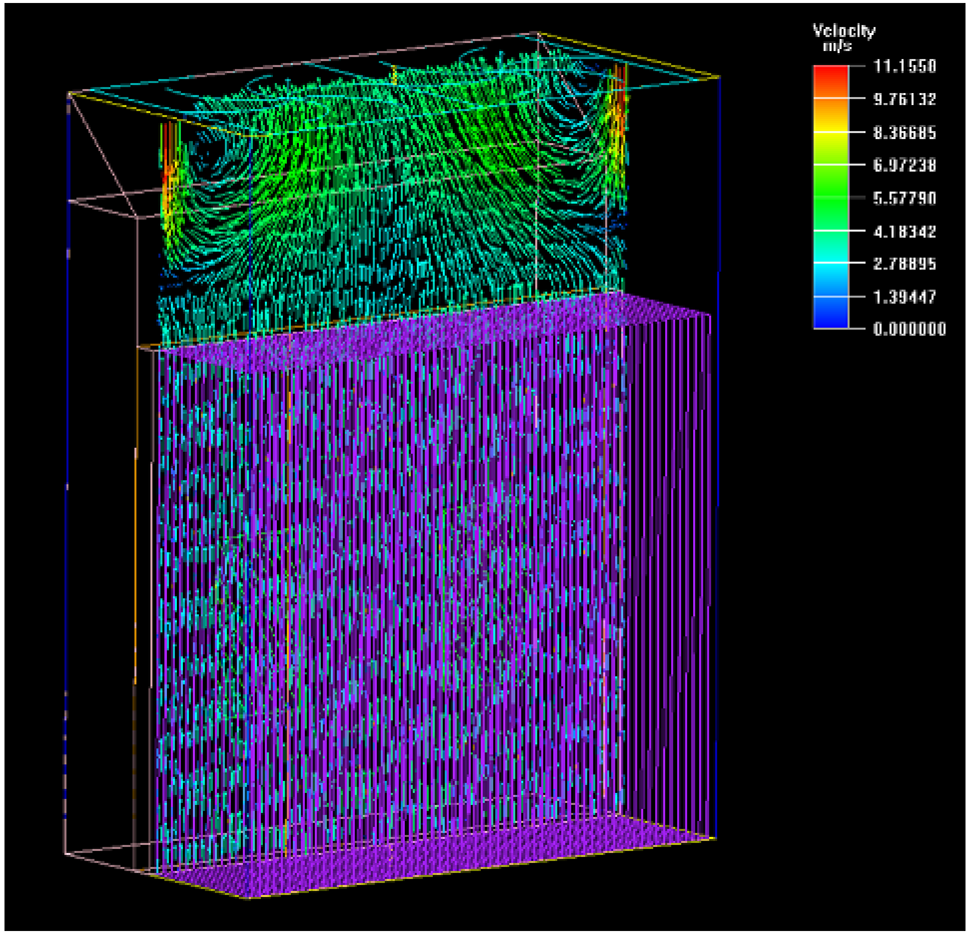
Simulation Results

❖ **Velocity Profile (Z-dir.)**



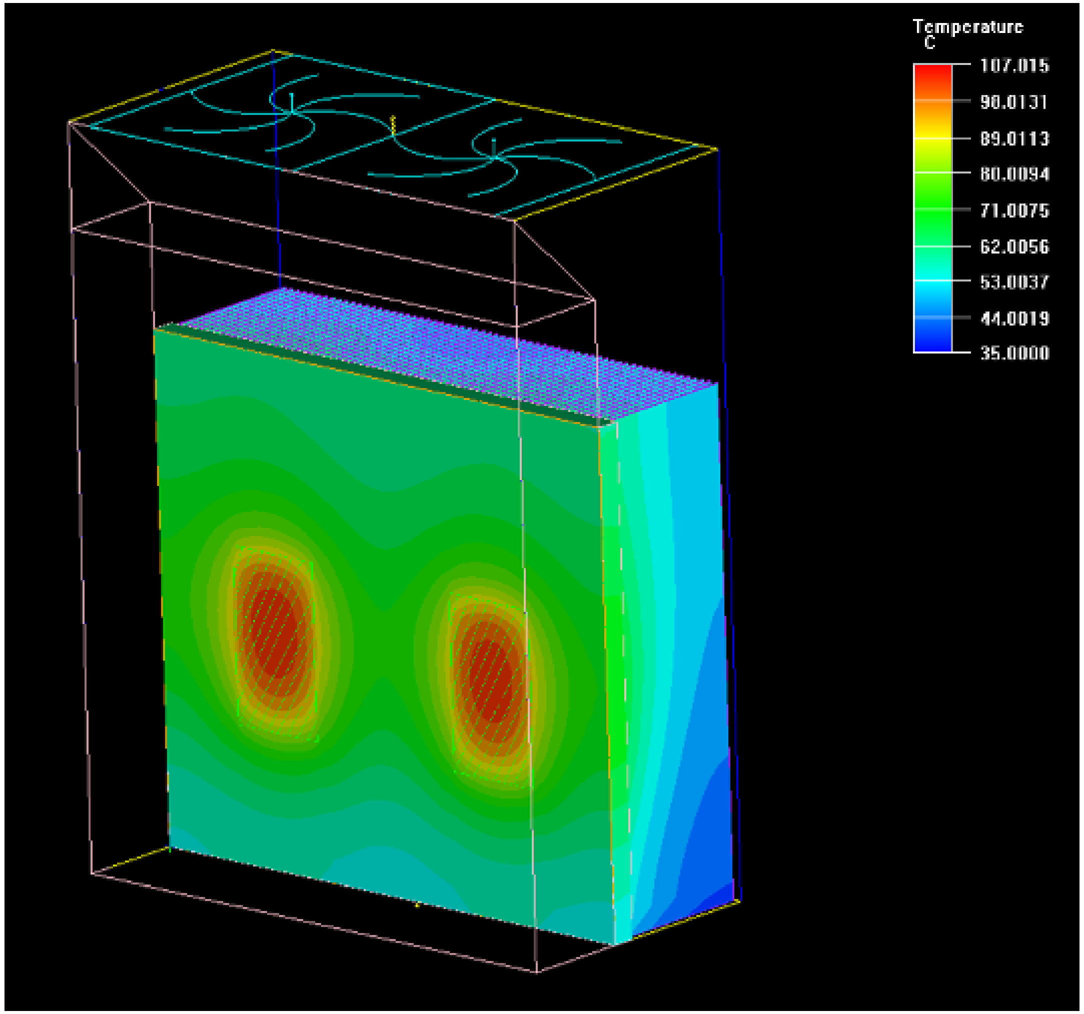
Simulation Results

❖ **Velocity Profile (X-dir.)**



Simulation Results

❖ **Temperature Distribution on Heat Sink Surface**



❖ **Summary**

Model	Source-1	Source-2	Source-1	Source-2	Source-1	Source-2
Power (W)	750	750	875	875	1000	1000
Tcase (℃)	88.87	88.24	97.61	97.13	107.2	107.3
Tamb (℃)	35.0	35.0	35.0	35.0	35.0	35.0

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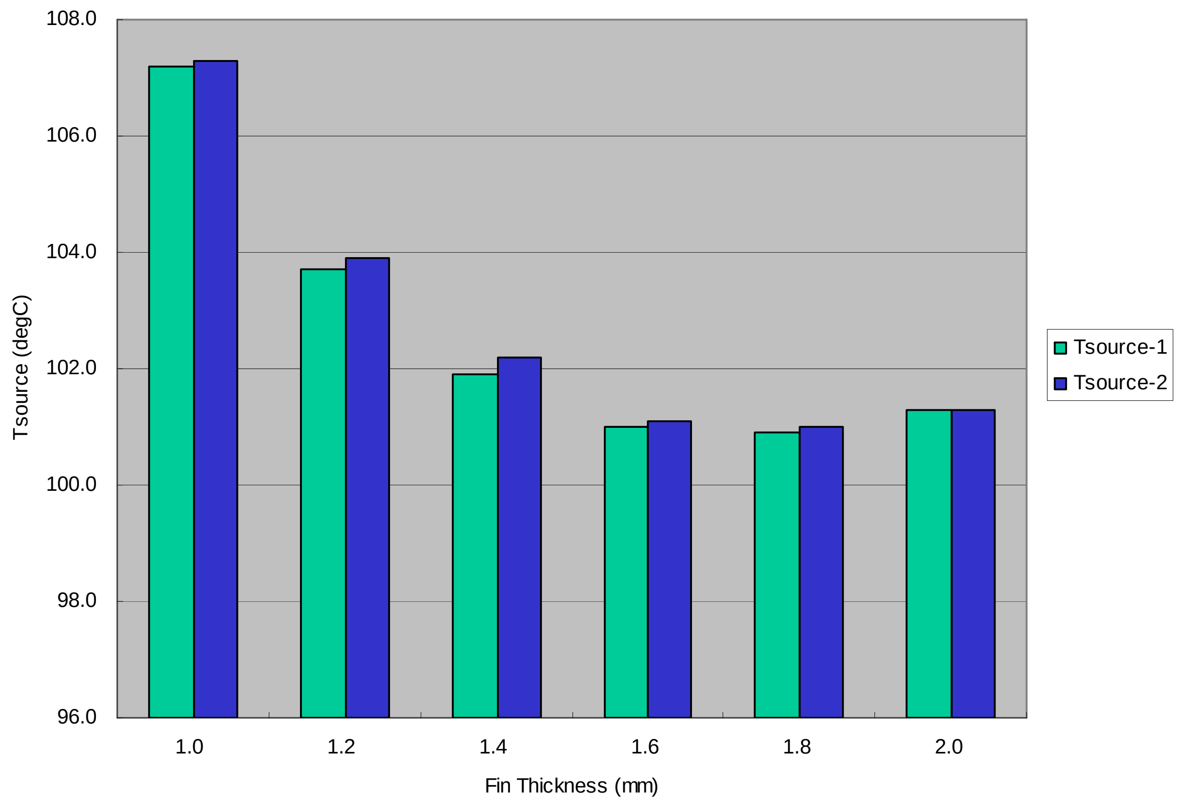
Optimization

❖ **Temperature variation with increased thickness (Power=1000W+1000W, Fin number=64)**

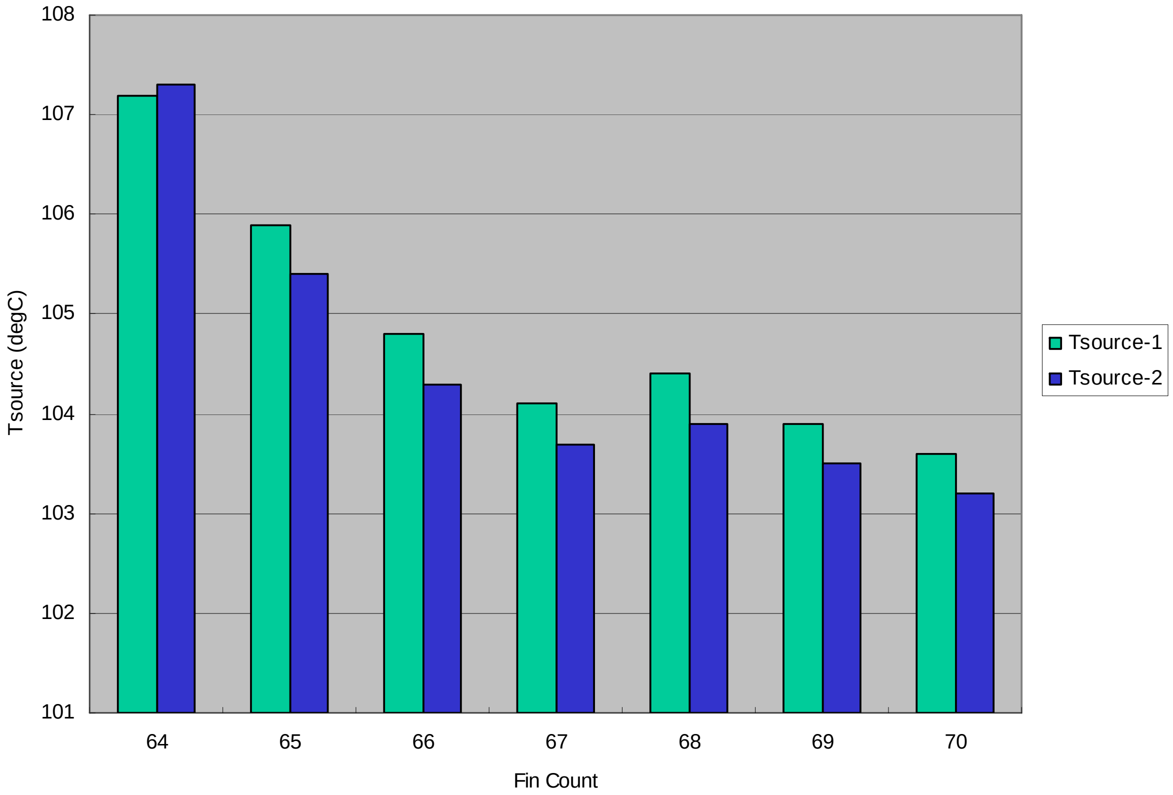
Fin Thickness (mm)	Tsource-1 (℃)	Tsource-2 (℃)
1.0	107.2	107.3
1.2	103.7	103.9
1.4	101.9	102.2
1.6	101.0	101.1
1.8	100.9	101.0
2.0	101.3	101.3



Optimization

❖ **Temperature variation with increased fin count (Power=1000W+1000W, Fin thickness=1.0mm)**

Fin Count	Tsource-1 (℃)	Tsource-2 (℃)
64	107.2	107.3
65	105.9	105.4
66	104.8	104.3
67	104.1	103.7
68	104.4	103.9
69	103.9	103.5
70	103.6	103.2



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Conclusion

Based on the simulation results, the thermal performance of current design can be improved by increasing the fin thickness from 1.0mm to 1.6mm. On the other hand, a minor improvement is also observed when the fin count is increased from the original 64 to 67.

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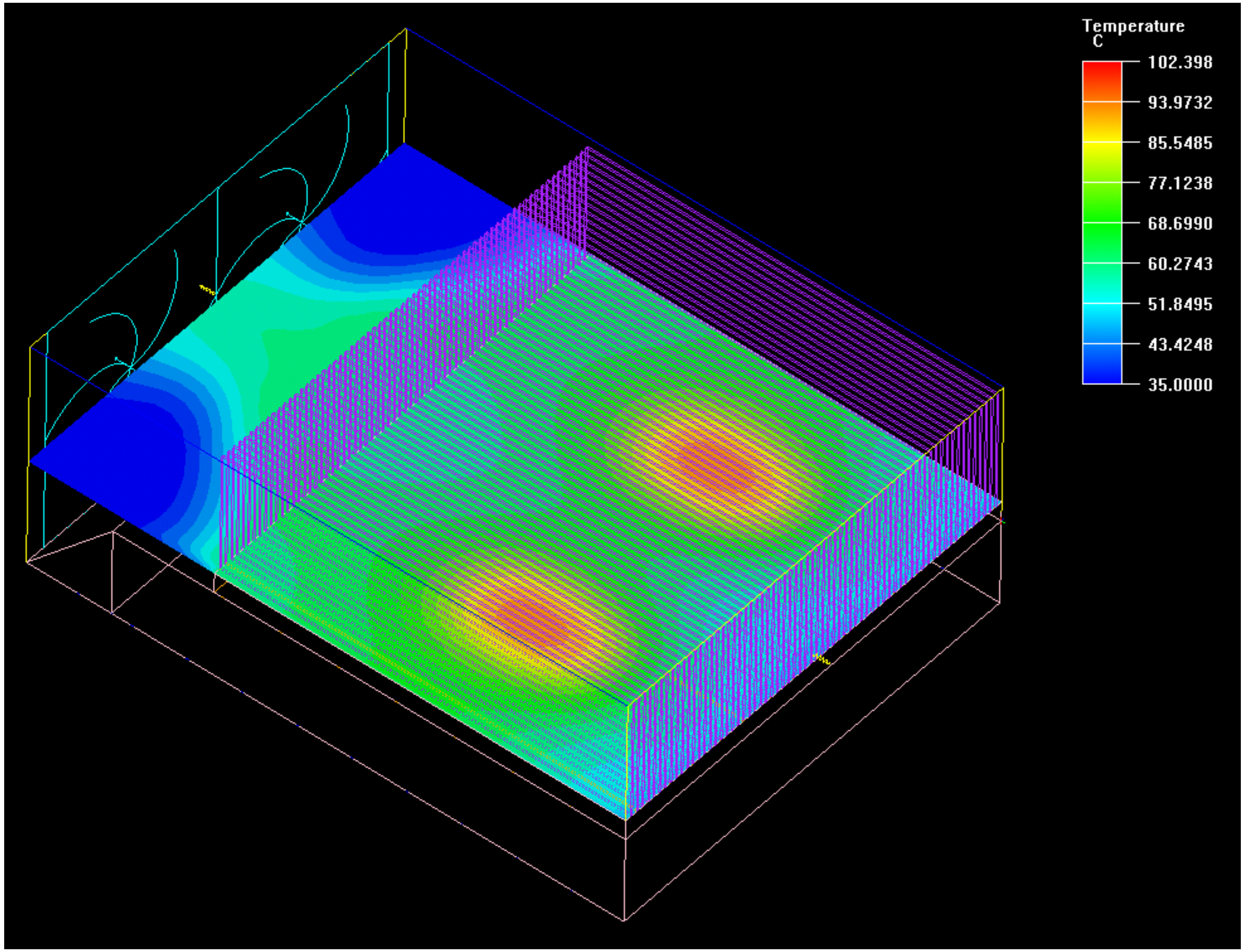
❖ **Temperature Distribution on a plane cut (X=15mm, Fin bottom)**



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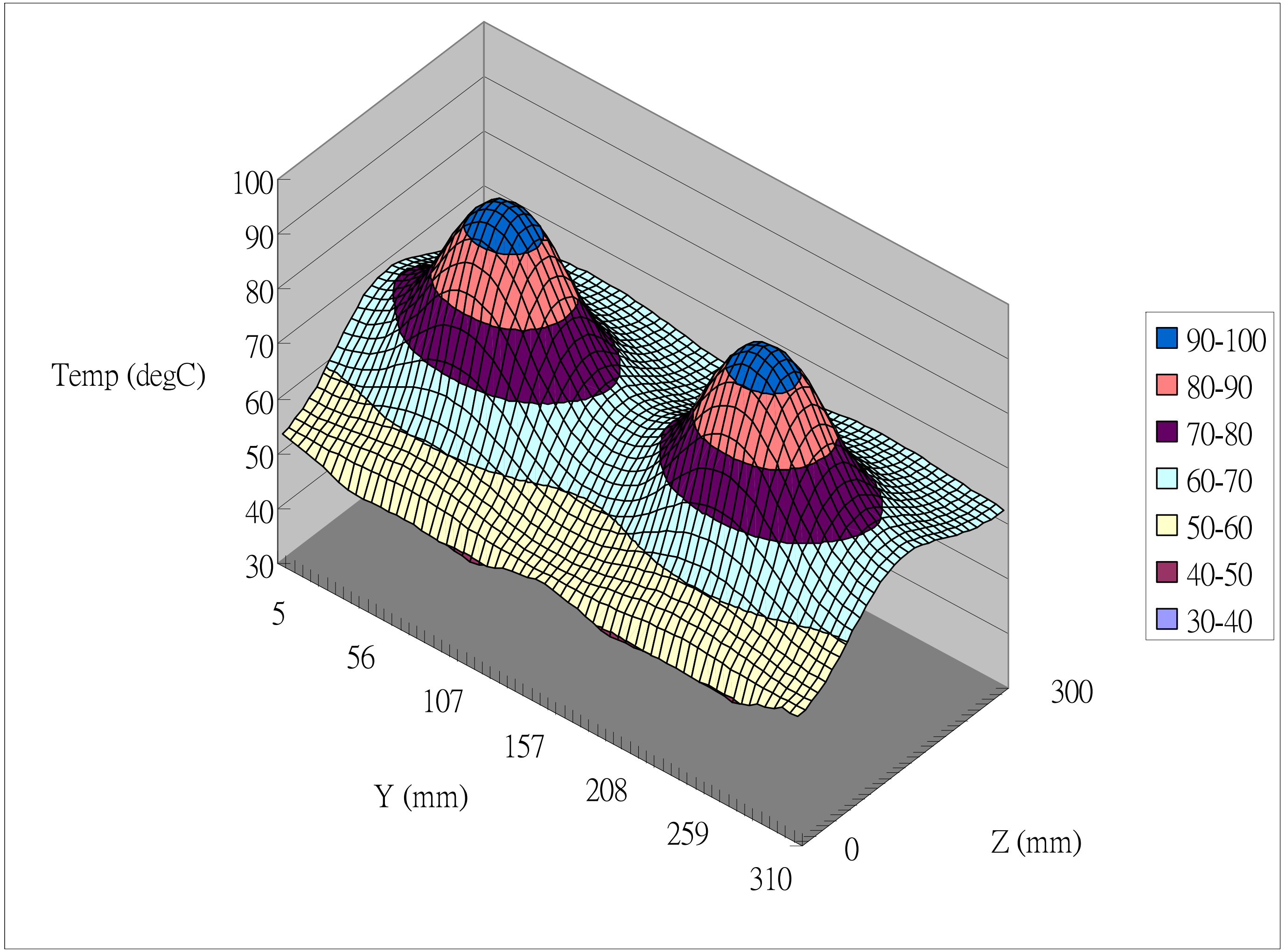
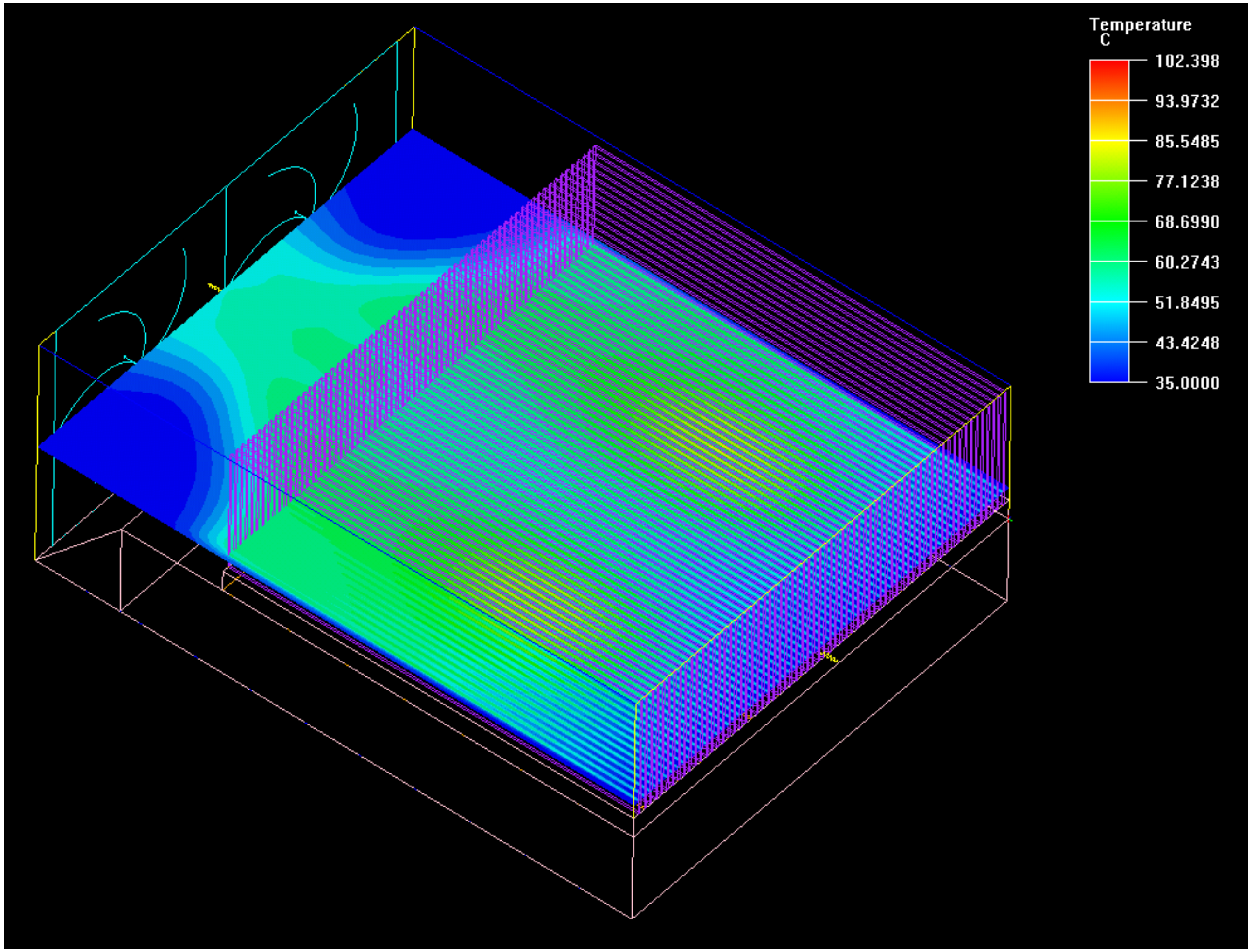
❖ **Temperature Distribution on a plane cut (X=15mm, Fin bottom)**



Appendix

❖ **Temperature Distribution on a plane cut (X=25mm)**



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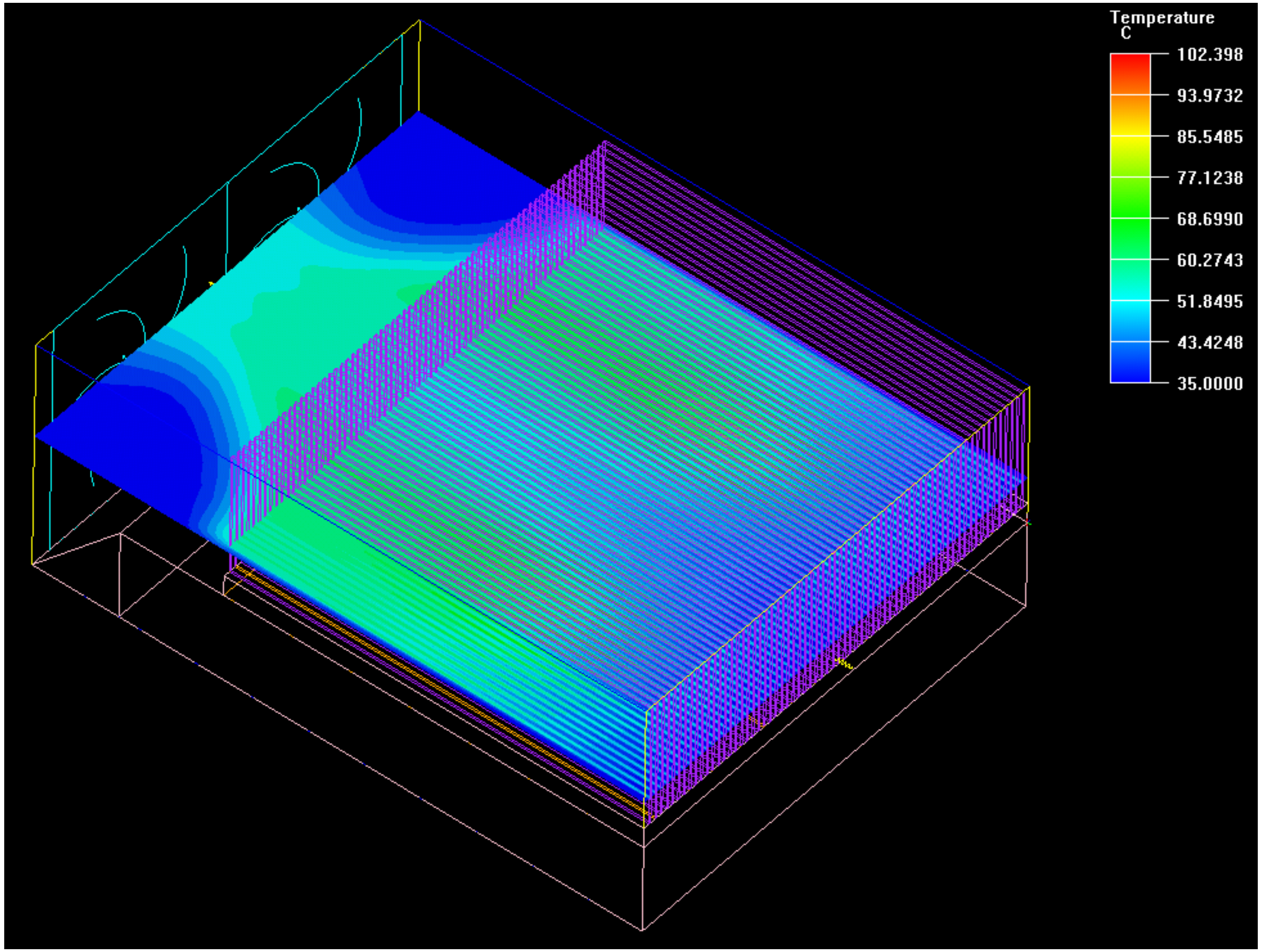
❖ **Temperature Distribution on a plane cut (X=35mm)**



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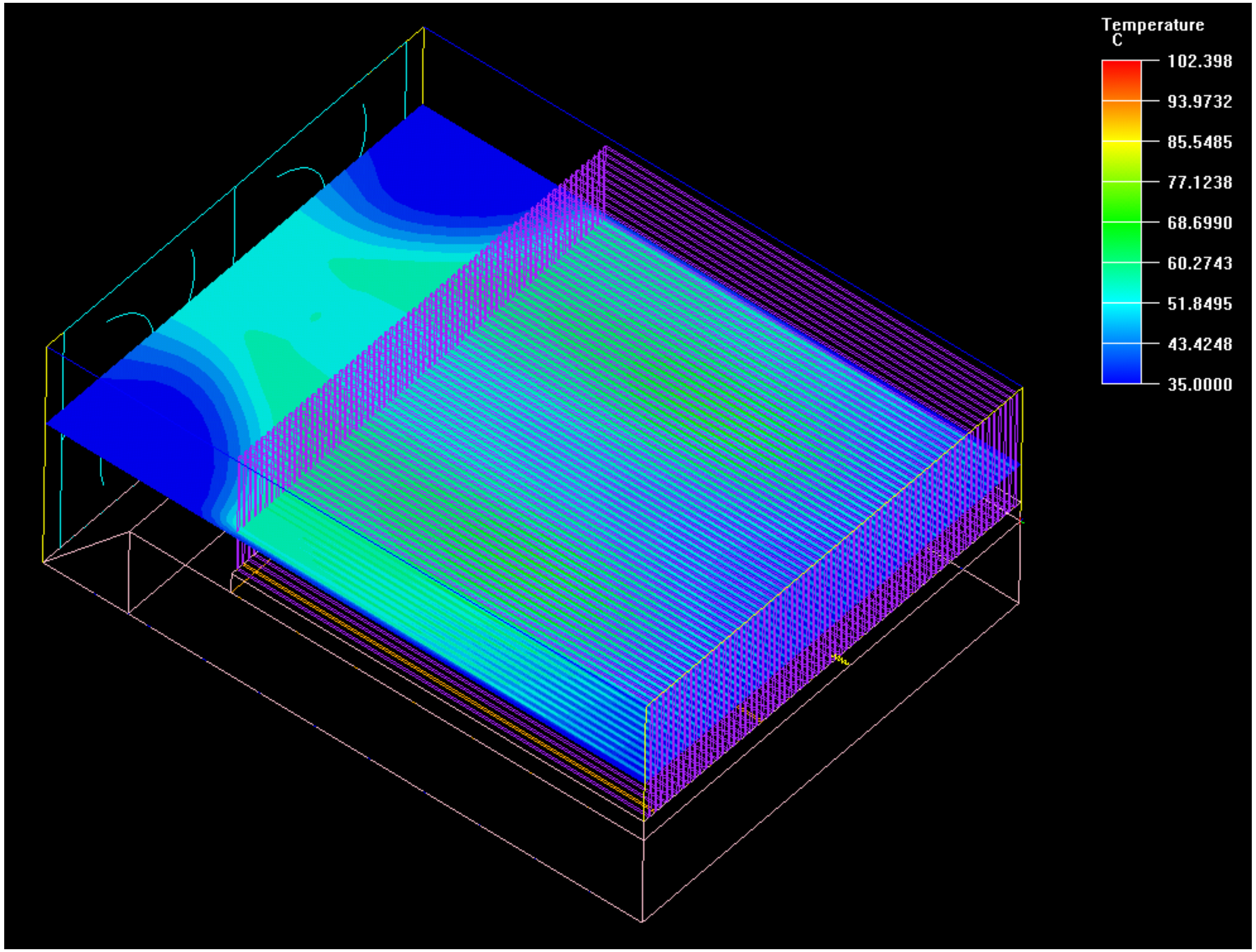
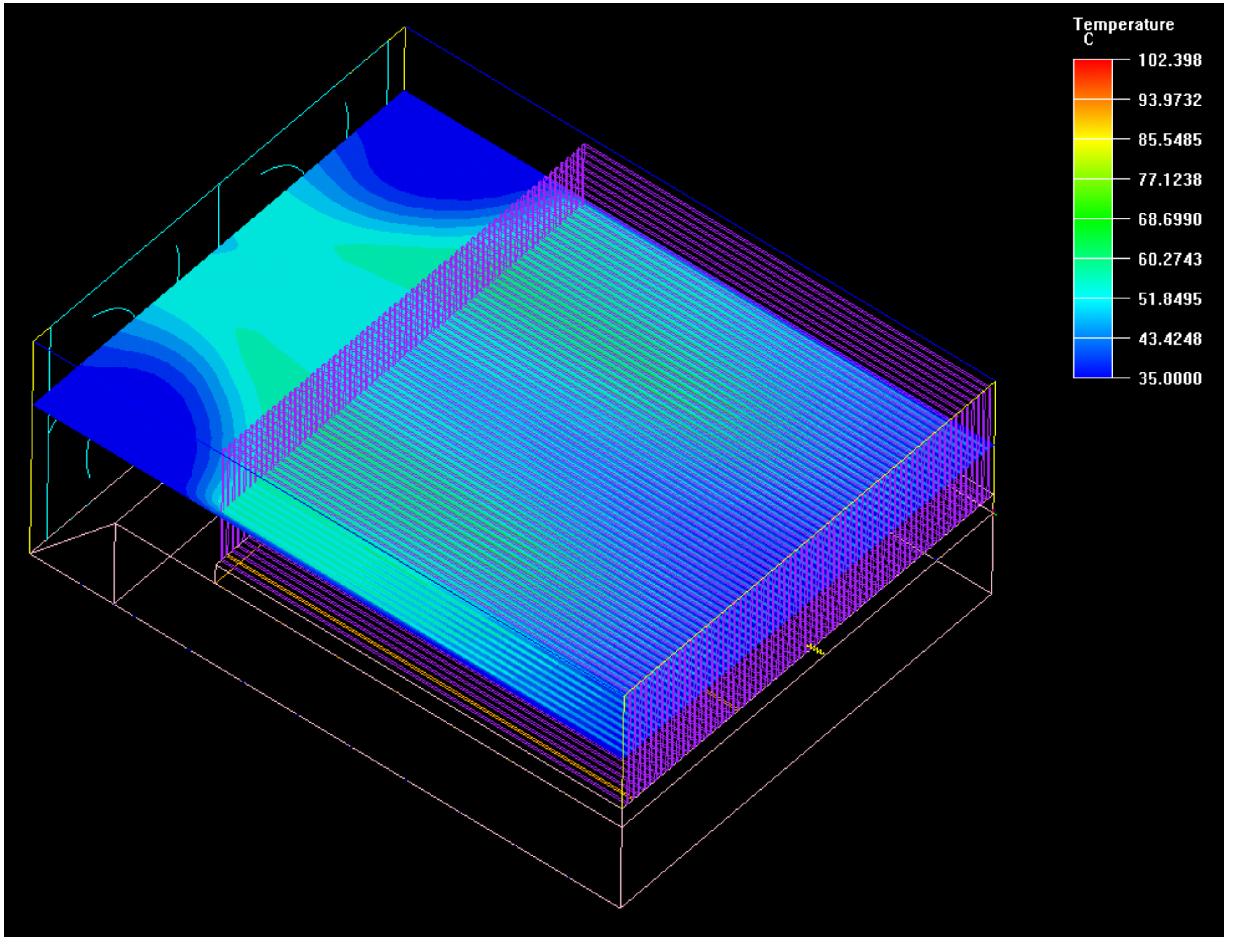
❖ **Temperature Distribution on a plane cut (X=45mm)**



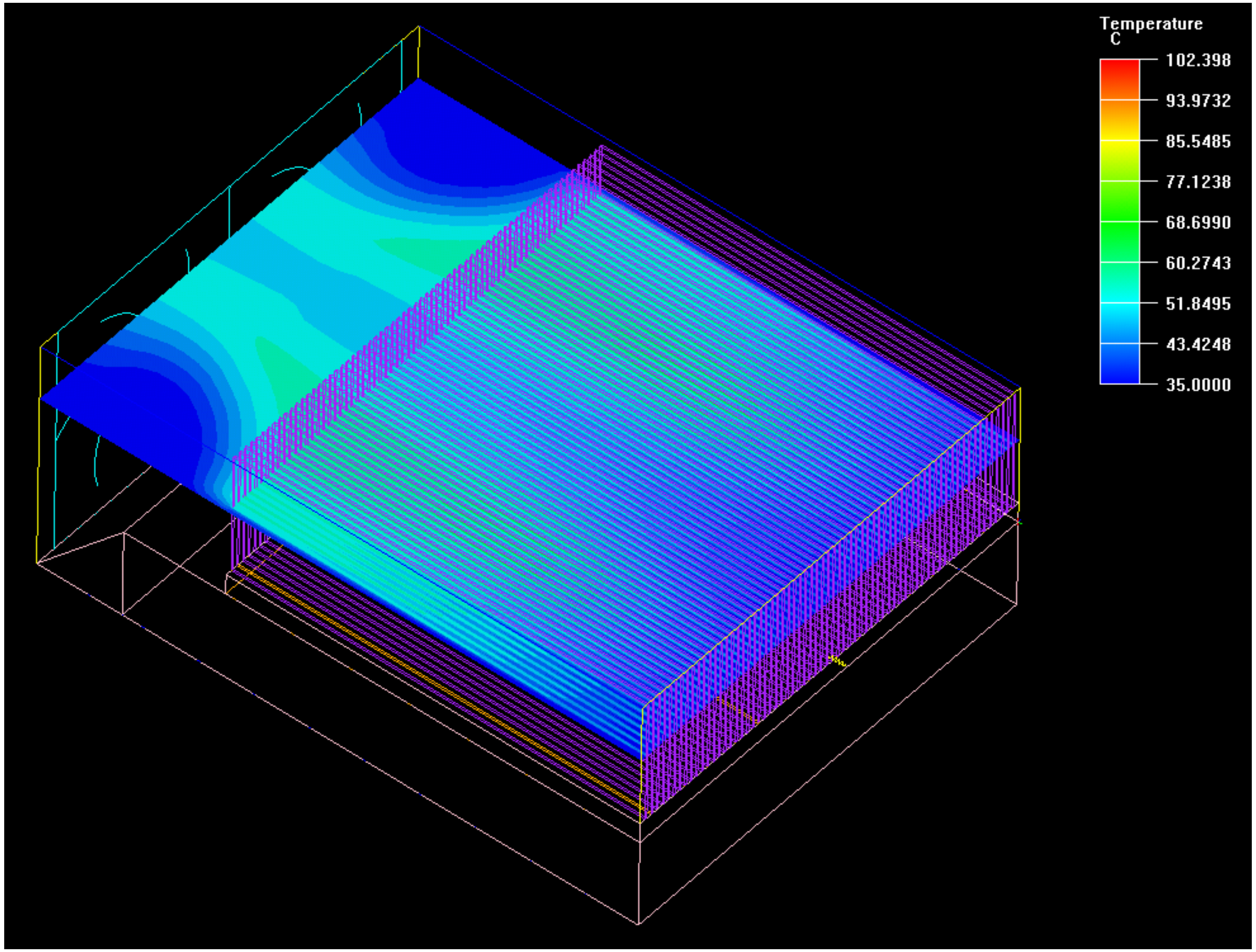
Appendix

❖ **Temperature Distribution on a plane cut (X=55mm)**



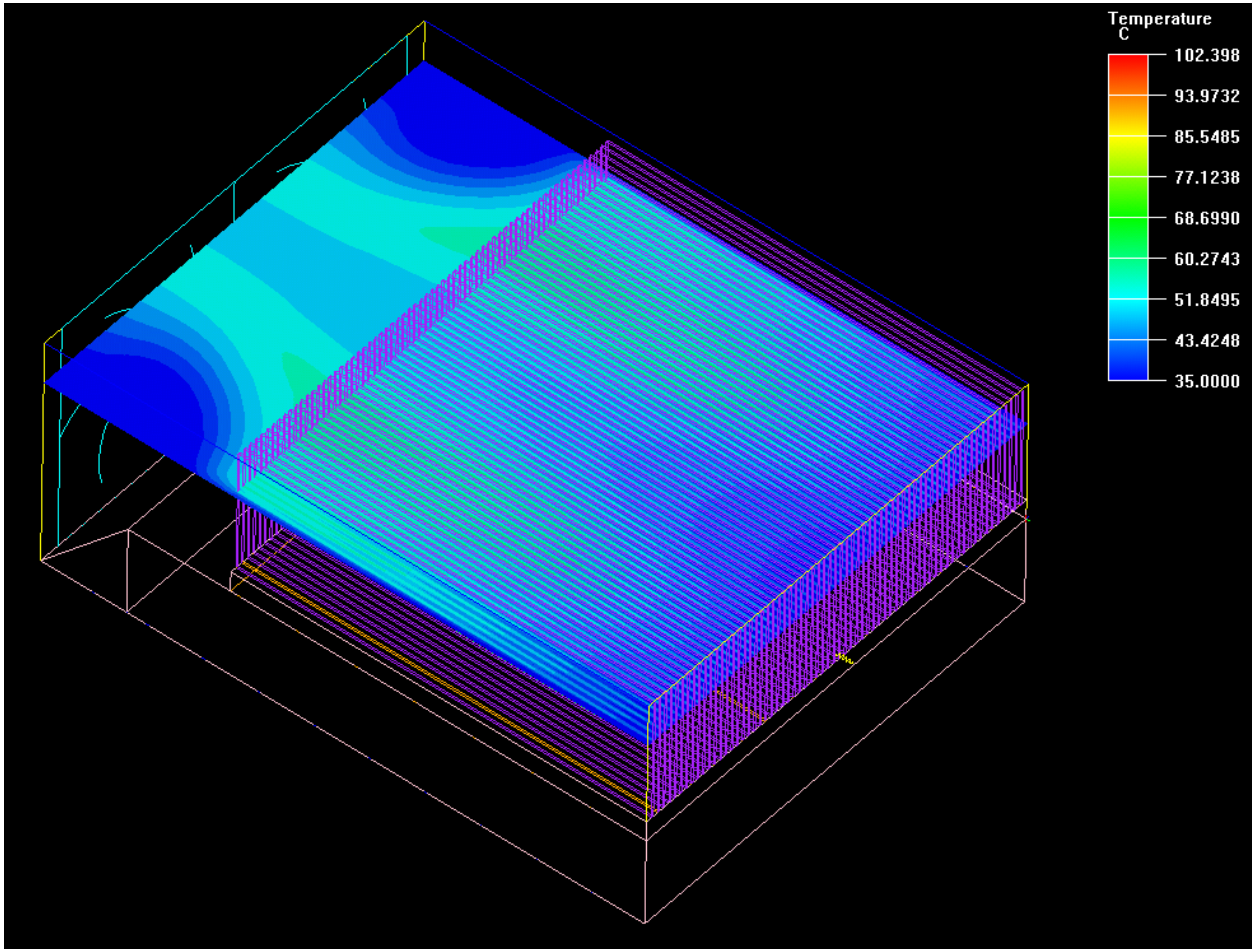
Appendix

❖ **Temperature Distribution on a plane cut (X=65mm)**



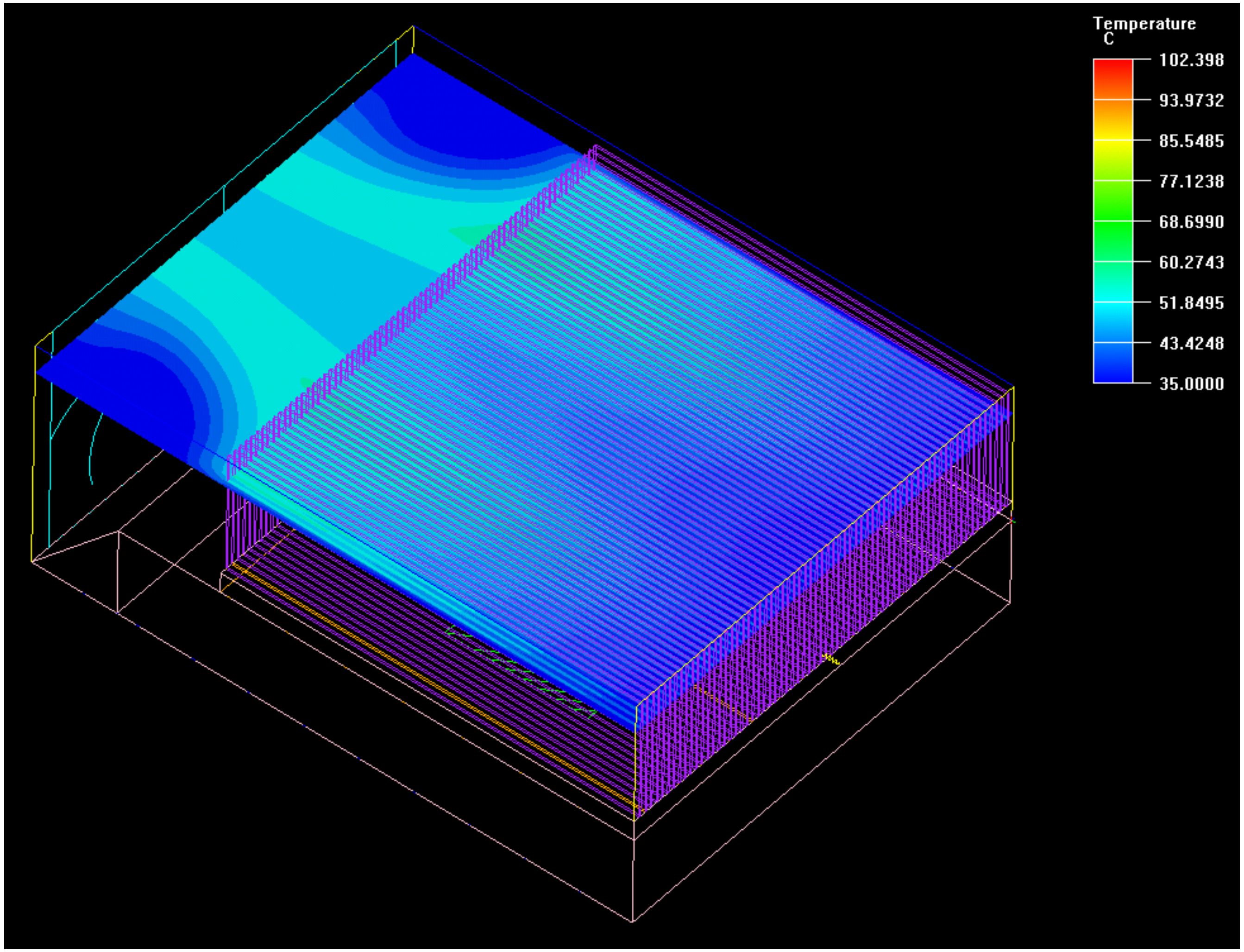
Appendix

❖ **Temperature Distribution on a plane cut (X=75mm)**



Appendix

❖ **Temperature Distribution on a plane cut (X=85mm)**



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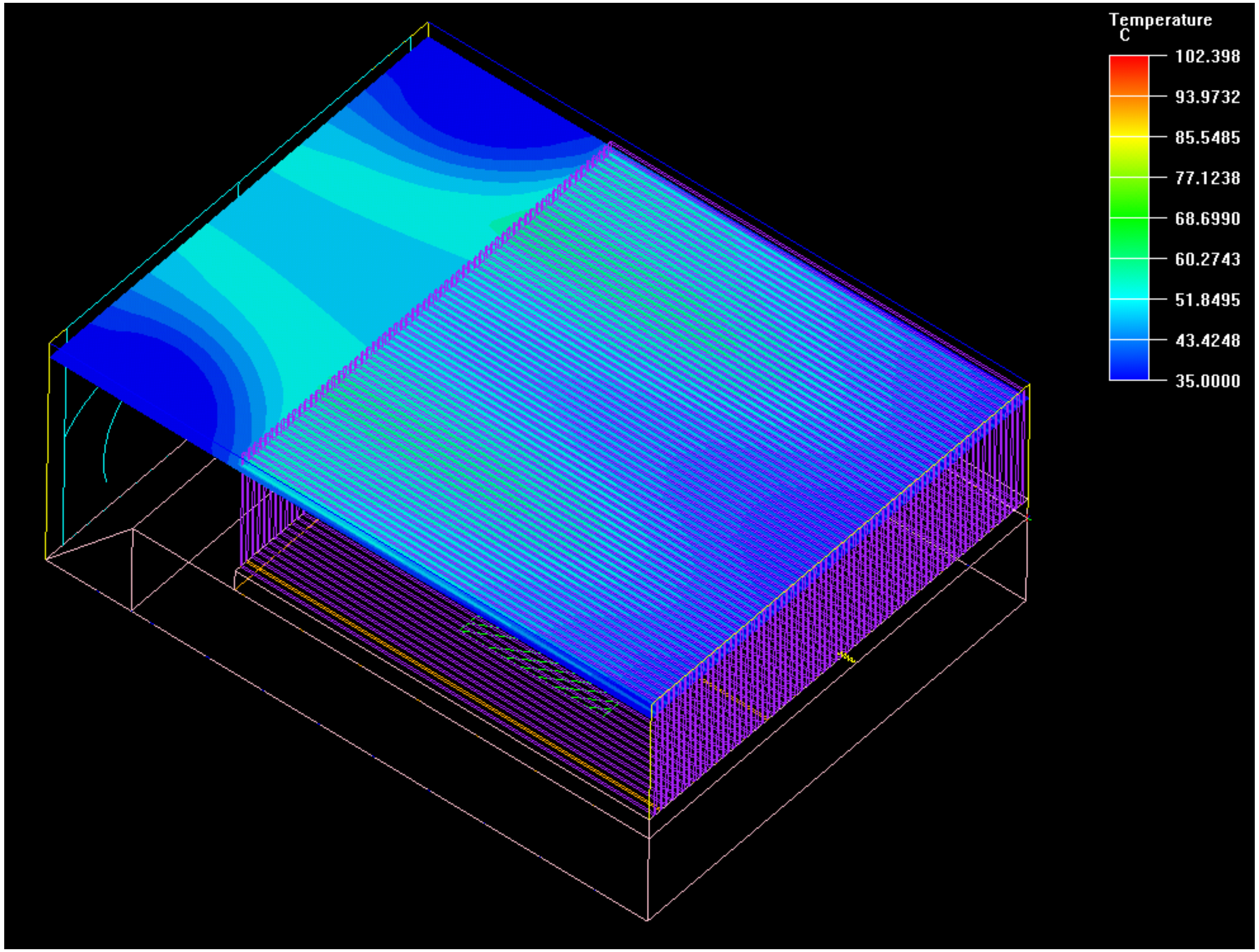
❖ **Temperature Distribution on a plane cut (X=95mm)**



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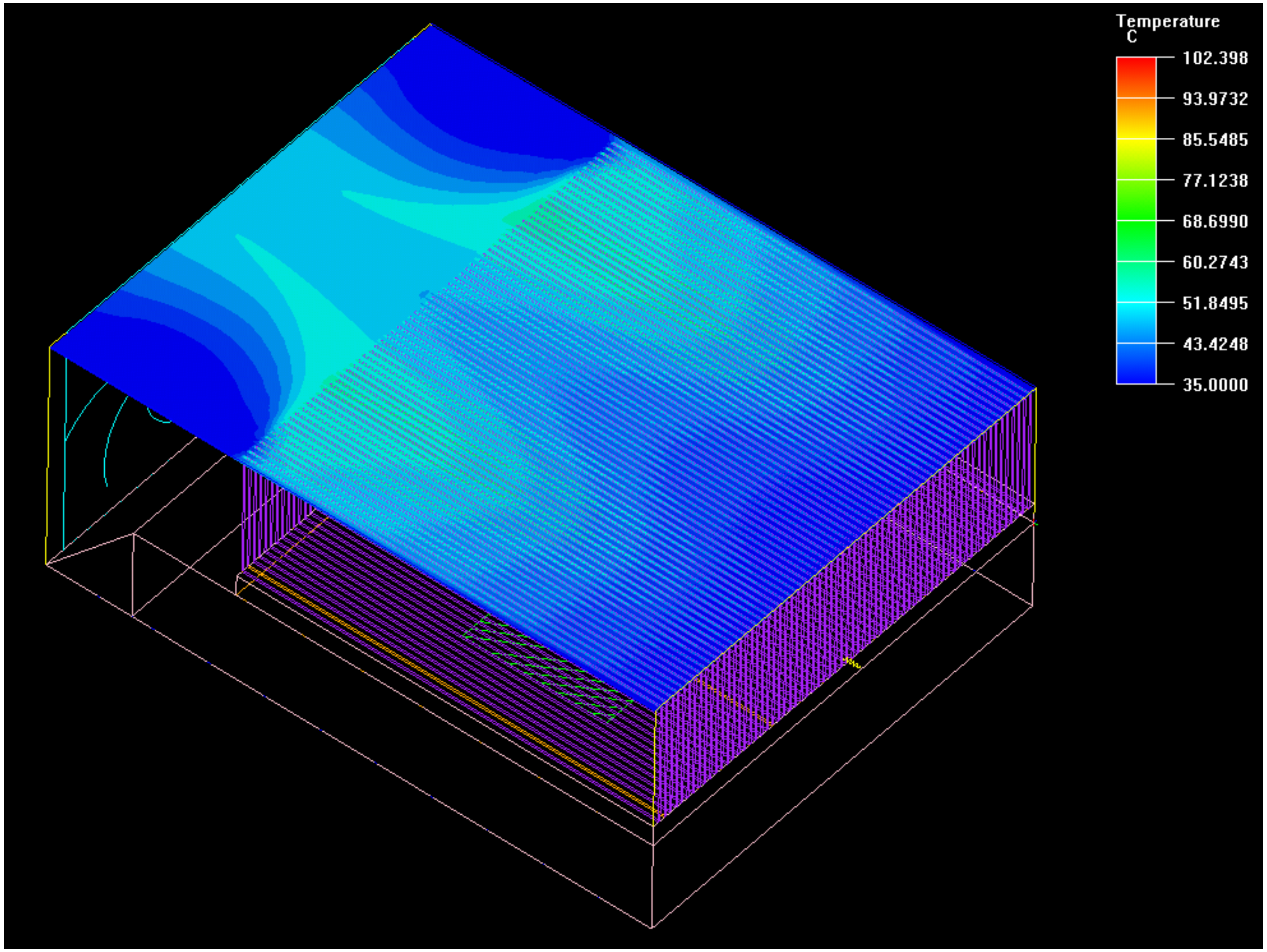
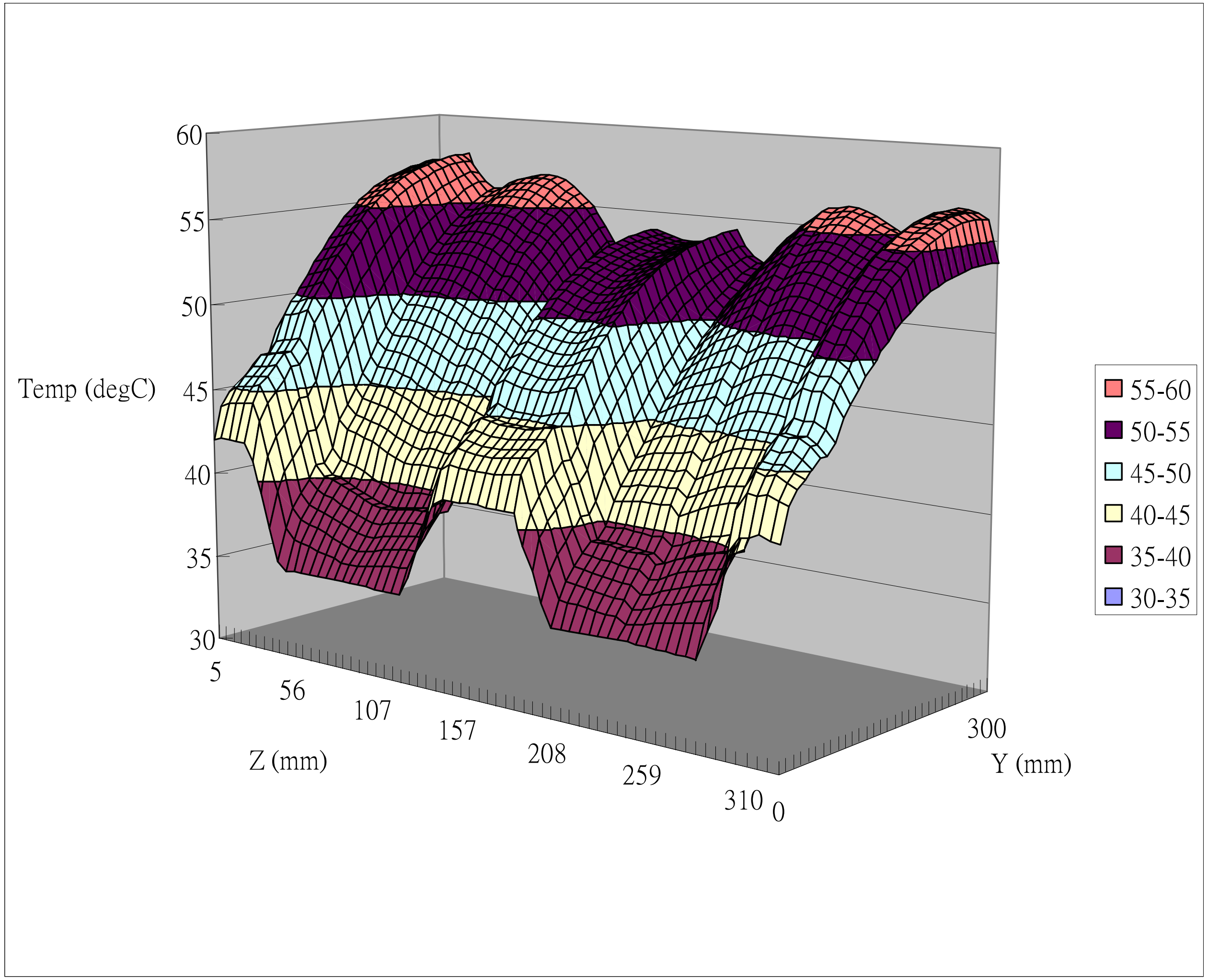
❖ **Temperature Distribution on a plane cut (X=105mm, Fin Tip)**



Appendix

❖ **Temperature Distribution on a plane cut (X=105mm, Fin Tip)**



Appendix (Discussion on fin effective height)

The temperature indeed decreases from the bottom to the tip of the fins. As can be observed from the 3D graph on P. 21, the heat sources generate two peaks on the temperature profile of the plane at X=15mm which is located at the bottom of the fins. From P. 21 to P. 30, the temperature gradually decreases toward to ambient temperature 35℃. The temperature profile of the plane at X=105mm does not show any peaks because the temperature is averaged by the lower temperature ambient flow.

By definition, the fin does not have any effect for heat transfer if the surface temperature is almost the same as the ambient temperature. Therefore, the fin is only effective only for a certain height, any height above the effective height is not helpful to the heat transfer but will increase the flow resistance.

To evaluate if the fin is over the effective height, we can simply judge from the 3D graph on P. 31. Though the temperature at the inlet (Y=0mm) is only slightly above ambient temperature 35 ℃, the temperature increases quickly as the heat conducted through the fins are absorbed by the flow passed by. At the outlet (Y=300mm), the fin tip temperature can be even as high as over 55 ℃. Therefore, we can conclude that the fins in this design is still under the effective height and all the fin area is effective for the heat convection.