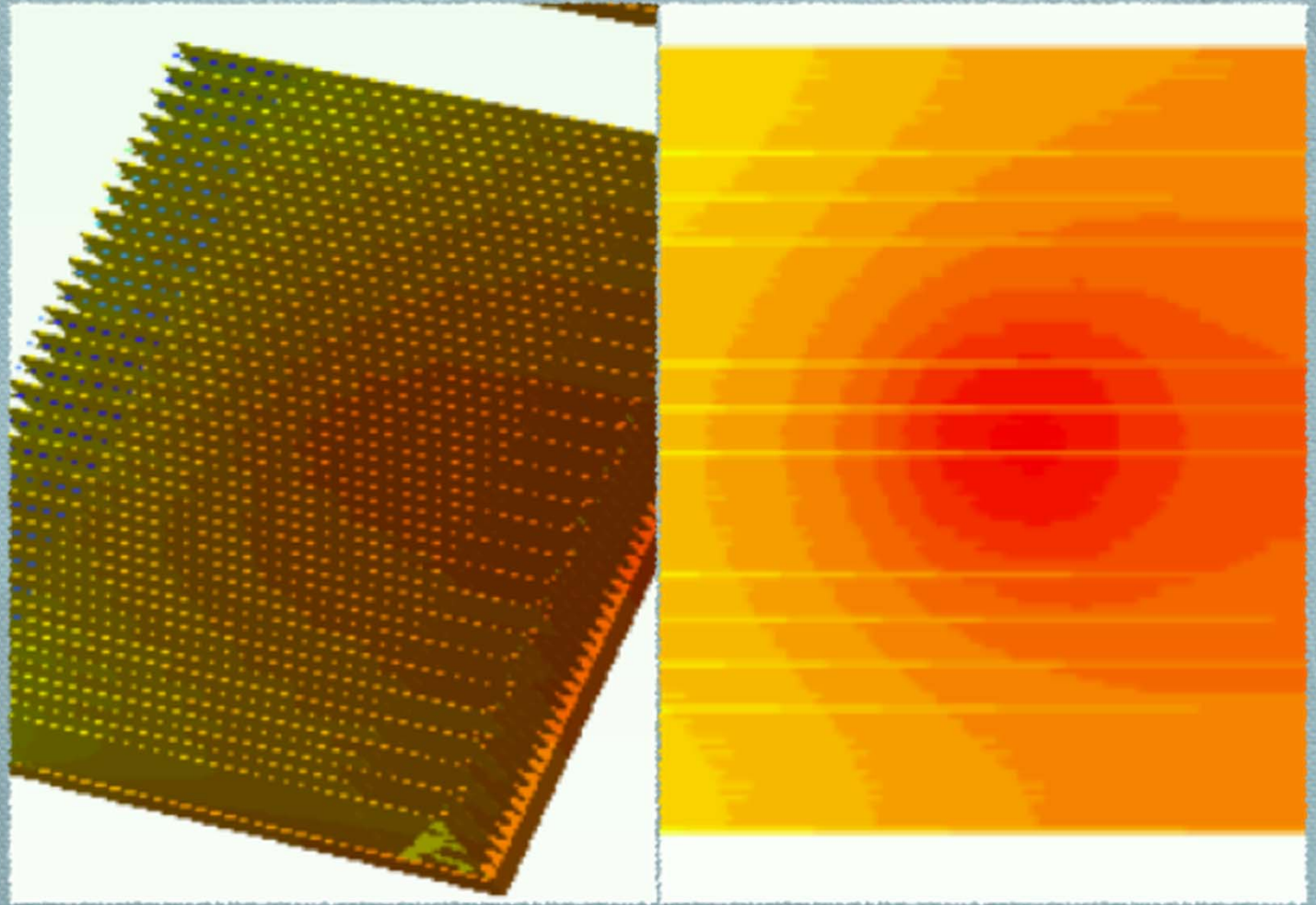




The Optimization of Server Cooler

Homeming Technology Co., 泓銘科技公司

總經理 陳恆隆 11/13/2013

Content

- ◆ Project Motivation
- ◆ Model Correlation of Flotherm and Theoretical Result
- ◆ Boundary Layer Effect on Fin surface
- ◆ Effect of Velocity Profile on Single Fin
- ◆ Mathematical Thermal Analysis on Fin with Variable Velocity
- ◆ Optimization of Interleaved Cut on Fin
- ◆ Conclusion

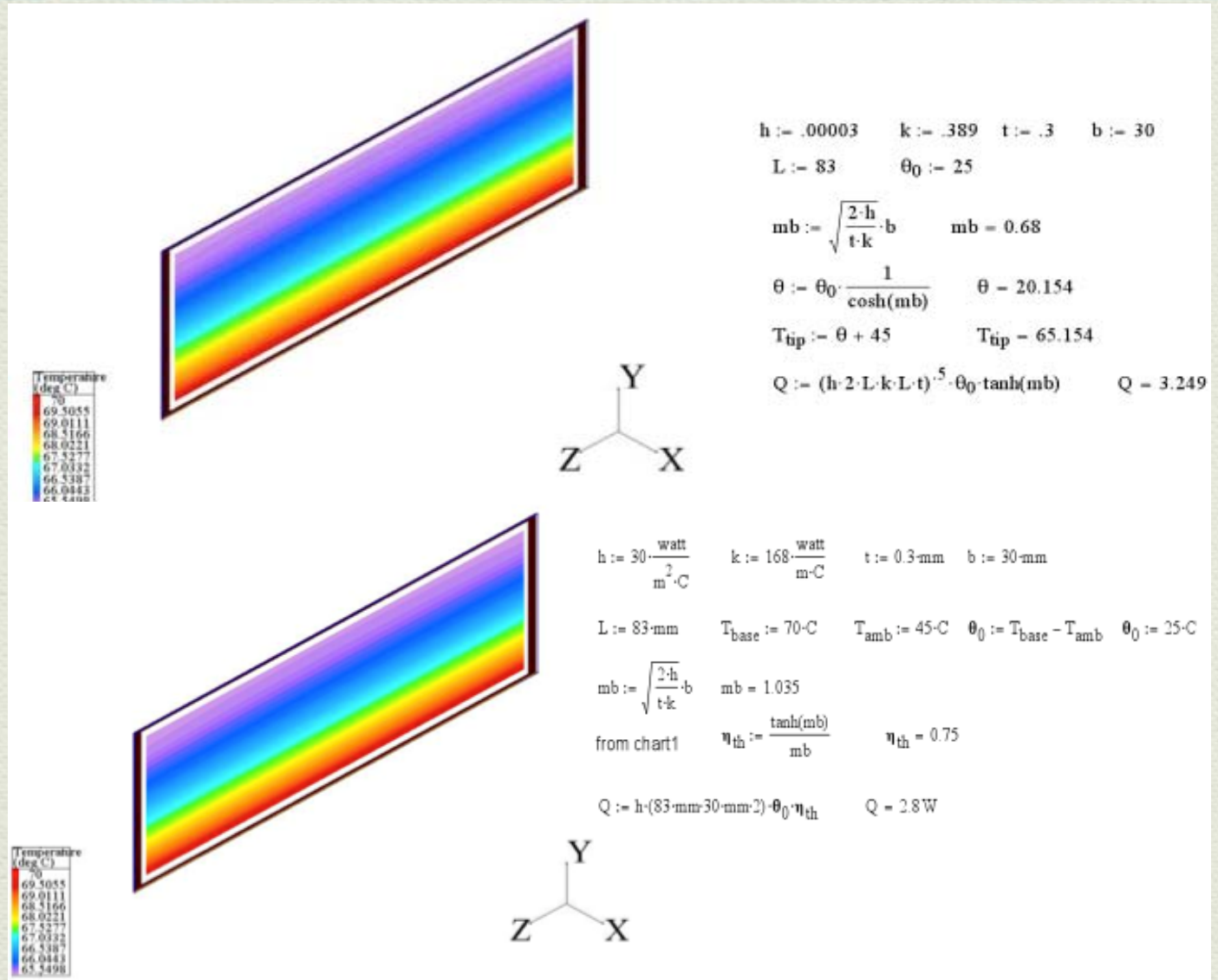
Project Motivation

- ◆ PC market is eroded by tablets by 20-30% in 2013
 - ◆ Result - margin is leaner & leaner!
- ◆ Server demand is booming due to cloud application
 - ◆ Result - PC suppliers shift to server side, more competition, leaner profit !
- ◆ Conclusion: Heat sink suppliers try to down the weight to reduce the material cost or recover margin from scraps.

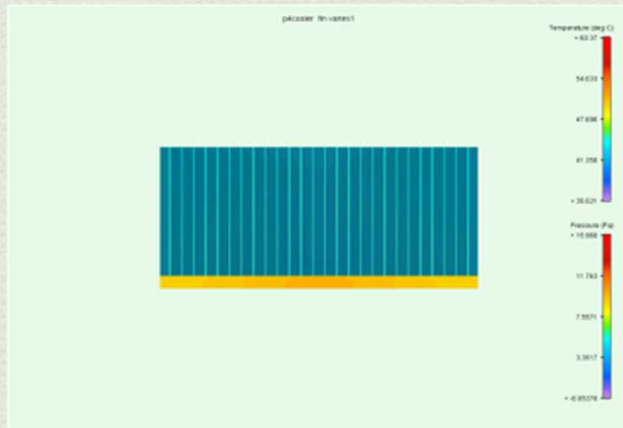
Model Correlation of Flotherm and Theoretical Result

- Fin dimension:
20H*83L*0.3t
- Base temp $T_b=70^\circ\text{C}$,
ambient $T_a=45^\circ\text{C}$
- Material : copper $k=389$
 $\text{W/m}^\circ\text{C}$

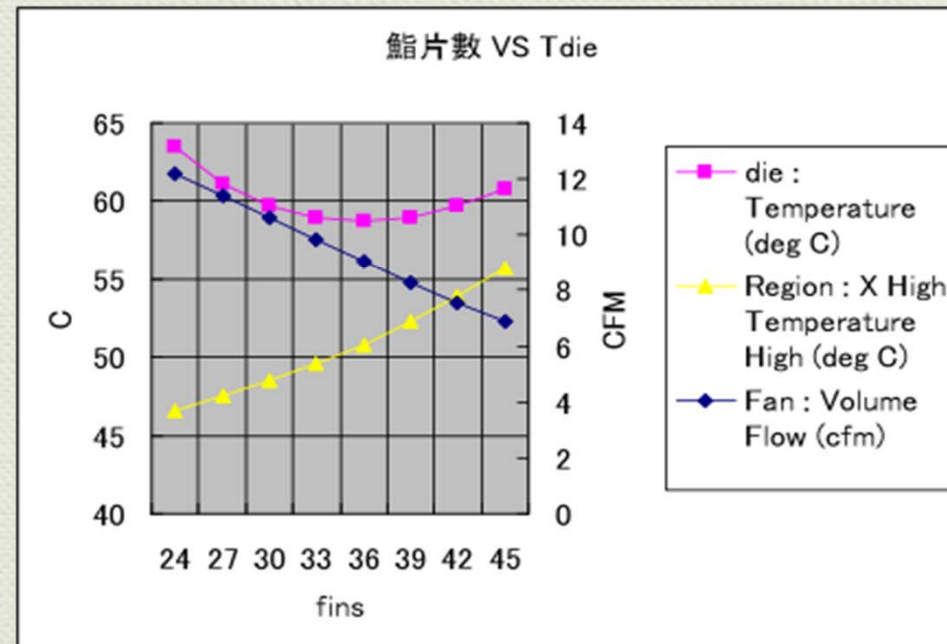
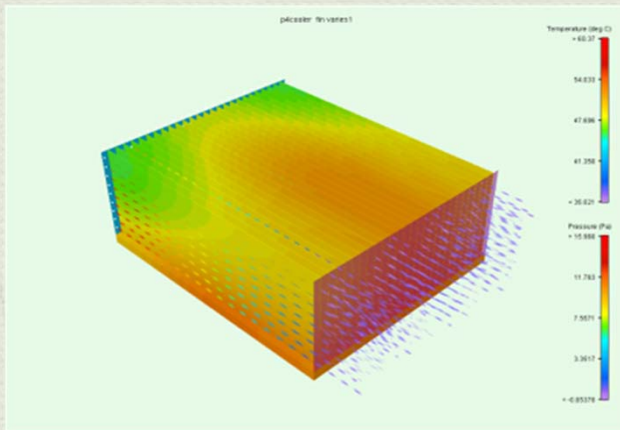
- Theoretical $T_{\text{tip}}=65.1^\circ\text{C}$
- Flotherm result 65.18°C



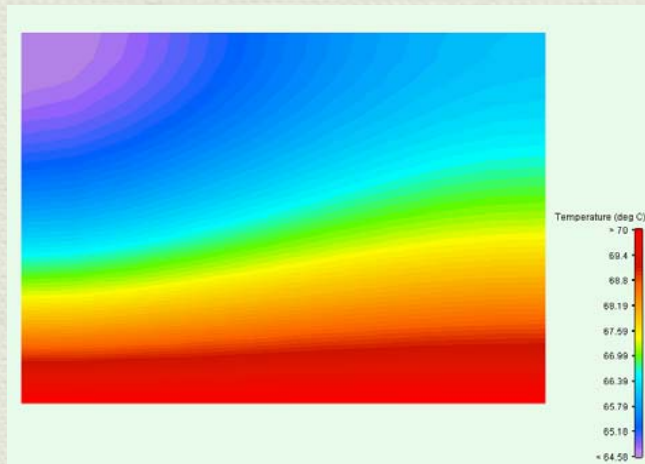
Flotherm Verification for Variable Parameters Trend Prediction



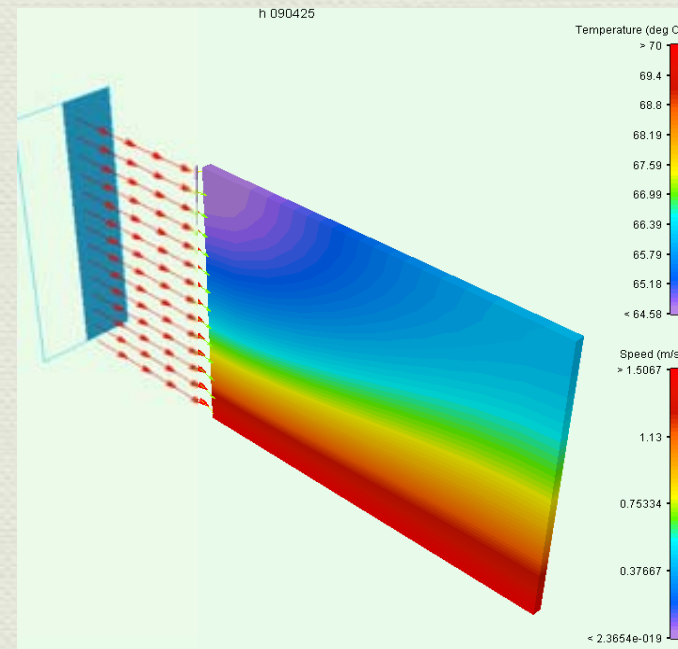
Heat Sink 1 : Number Of Internal Fins	24	27	30	33	36	39	42	45
die : Temperature (deg C)	63.46	61.15	59.7	58.92	58.71	58.98	59.68	60.78
Fan : Volume Flow (cfm)	12.21	11.4	10.6	9.808	9.027	8.268	7.543	6.855
Region : X High Temperature High (deg C)	46.61	47.51	48.47	49.55	50.81	52.25	53.88	55.72



CALCULATION BY FLOTHERM SIMULATION FOR NON-UNIFORM dT in dY DIRECTION

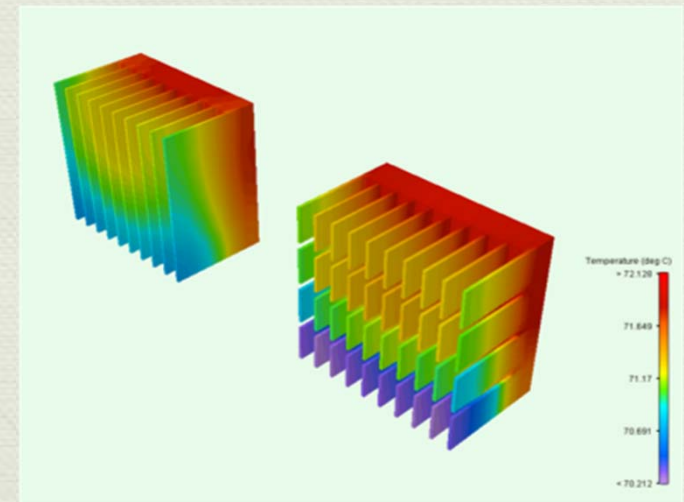
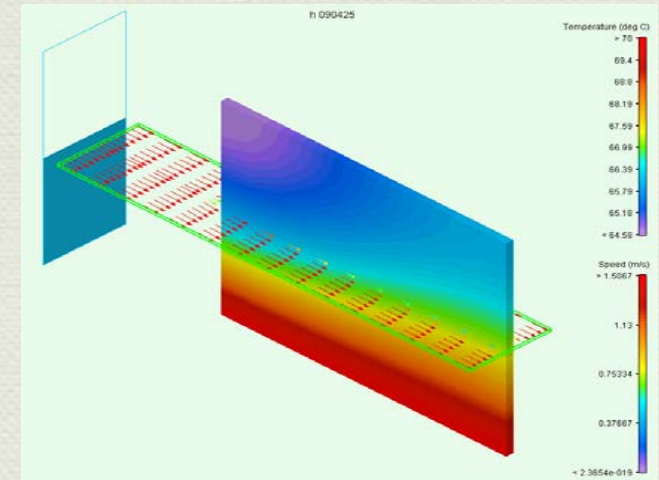
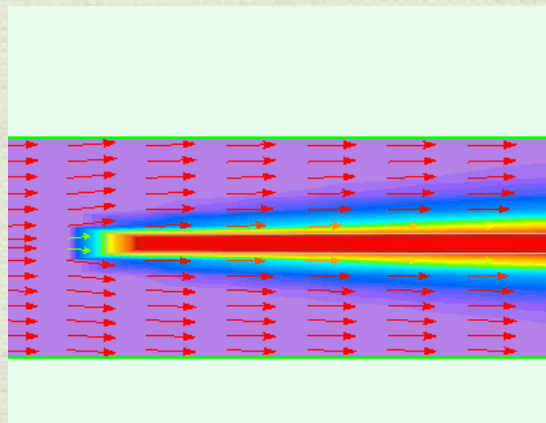
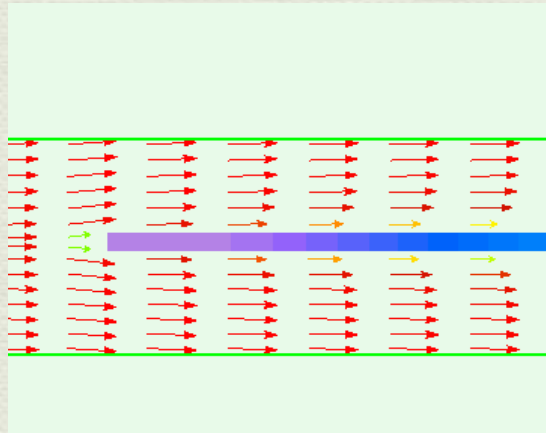


Conv Heat Net (W)	Conv Heat Transfer Coefficient (W/(m ² K))
-0.012947	13.7271
-1.2125	31.5351
-1.2172	31.6574
-2.44265	

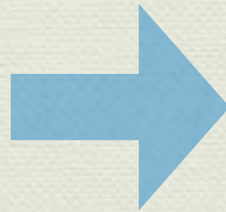


Boundary Layer on Fin Surface

- ❖ Flotherm is a good tool for boundary analysis
- ❖ Layer is thicker towards the end of fin
- ❖ Break boundary layer for h enhancement



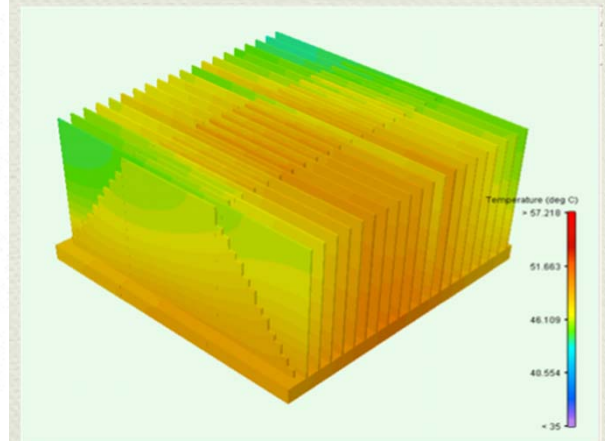
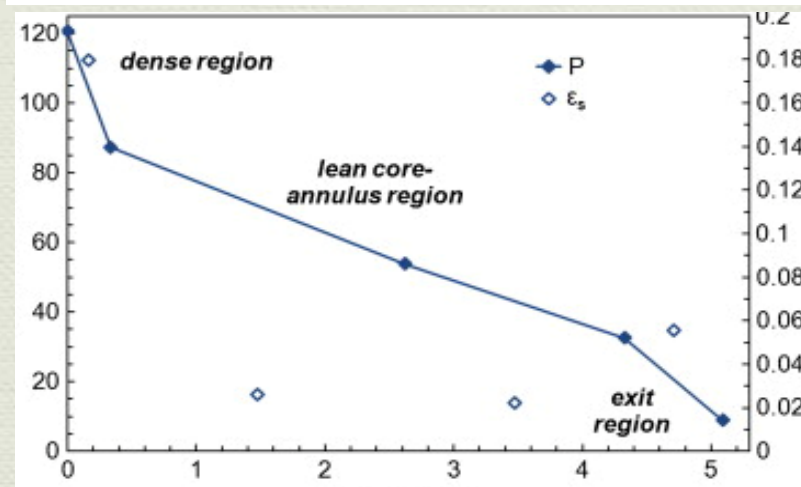
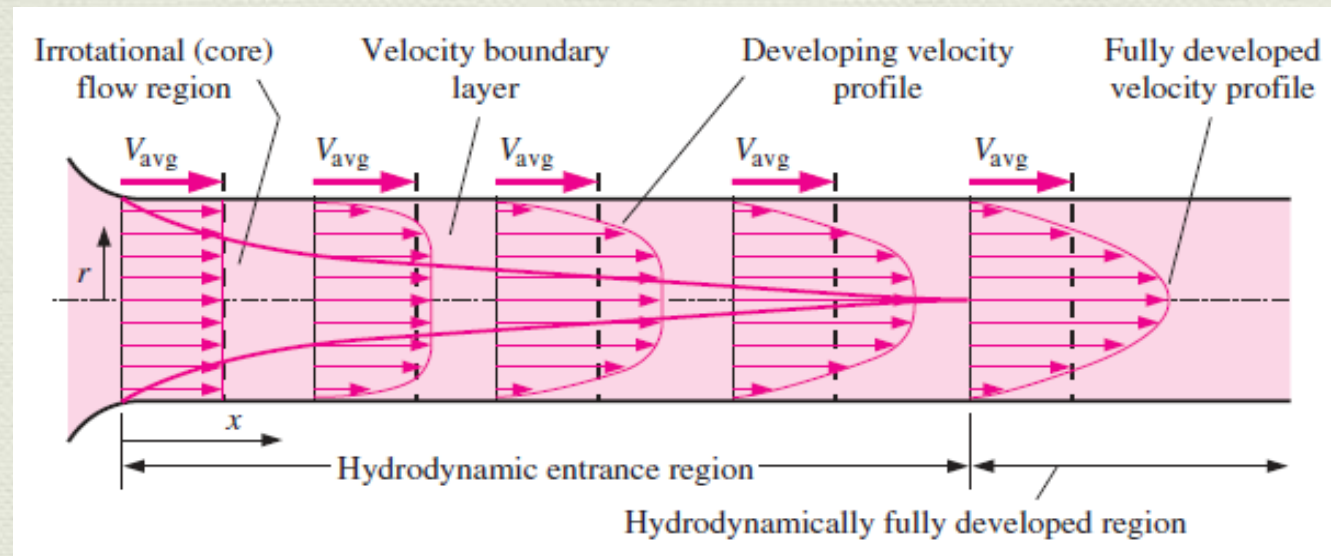
Break Boundary for h Enhancement Applying in CPU Cooler



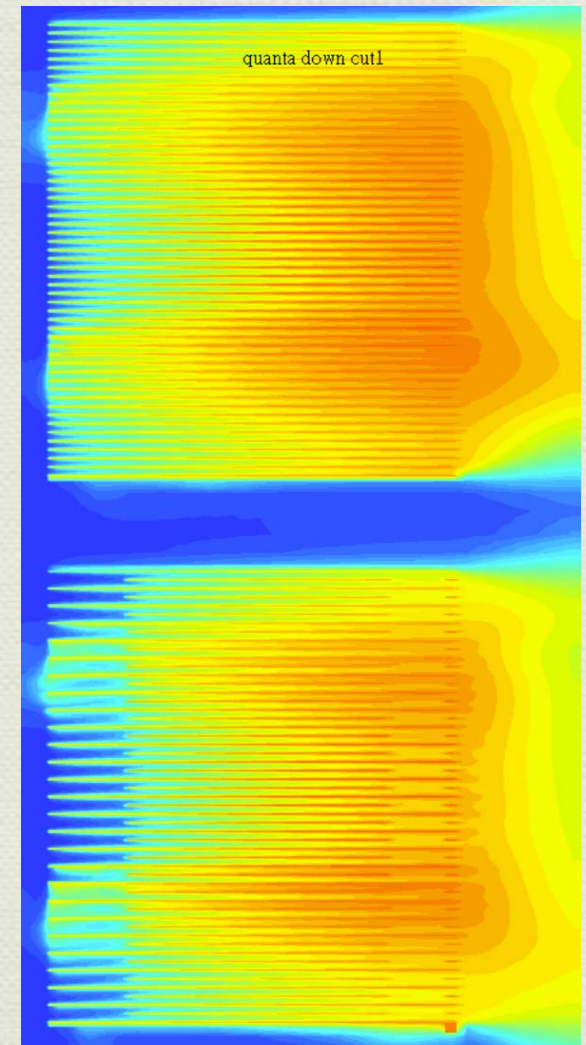
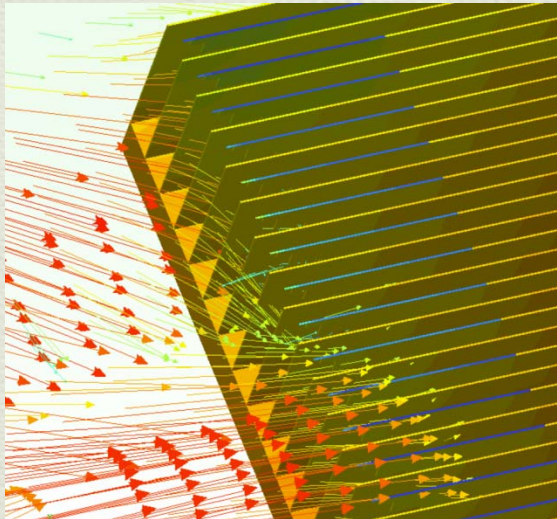
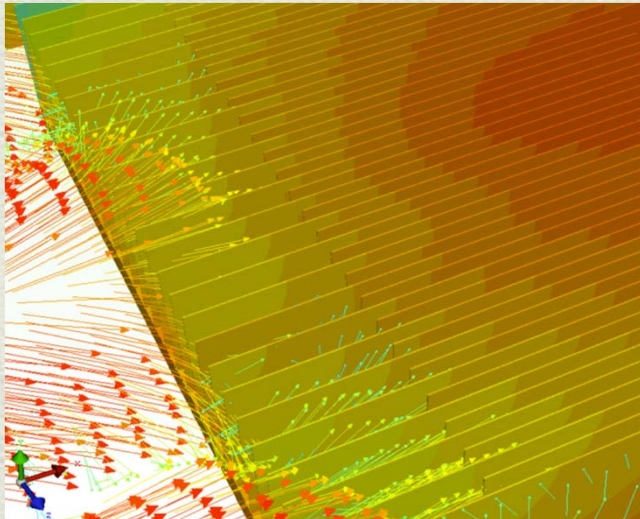
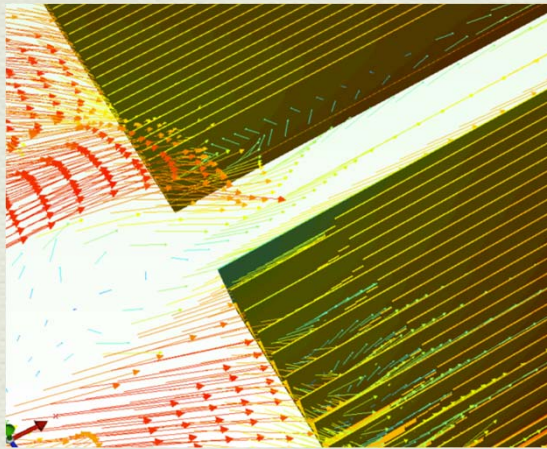
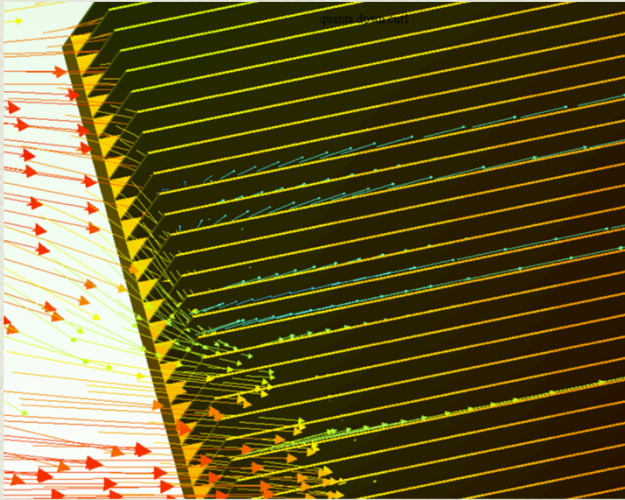
15%

Pressure Drop in Channel Flow

- ◆ Pressure loss the most in fin module entrance due to flow duct contraction
- ◆ If flow is from axial fan, the entrance loss is worsen due to swirling effect of rotating fan blades
- ◆ Interleaved trapezoidal fin module design is adopted for entrance pressure loss reduction

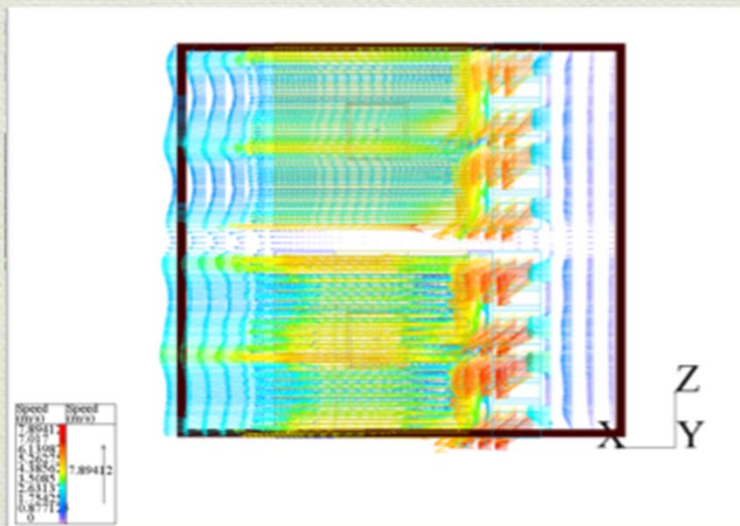
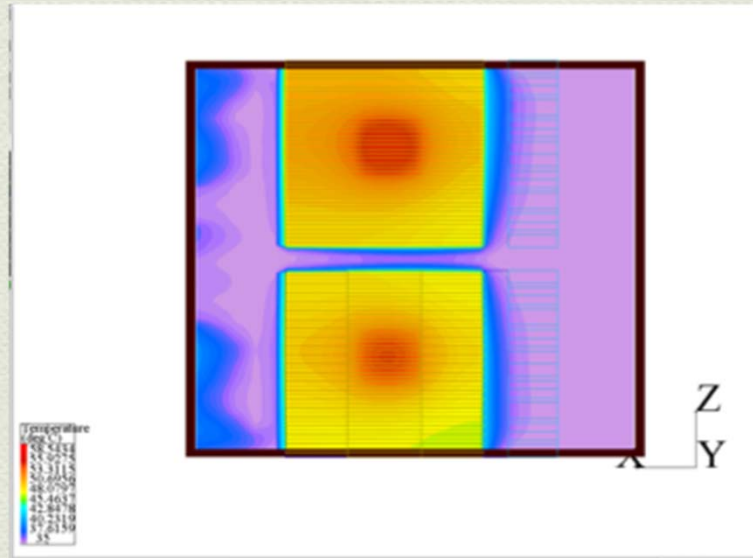
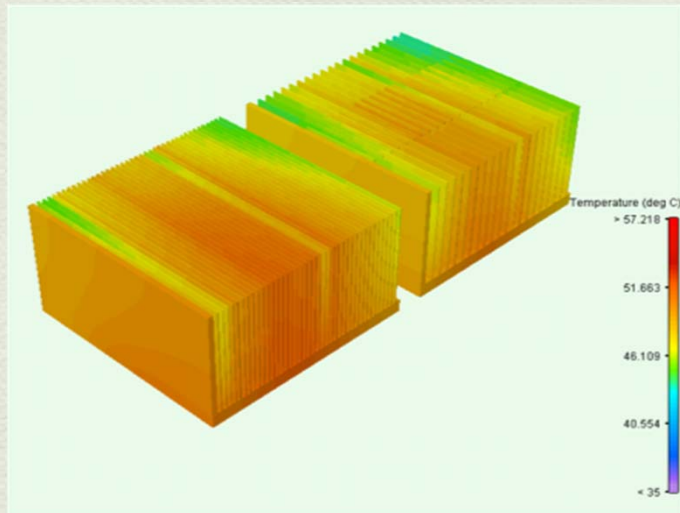


Huge Entrance Pressure in Fan Swirling



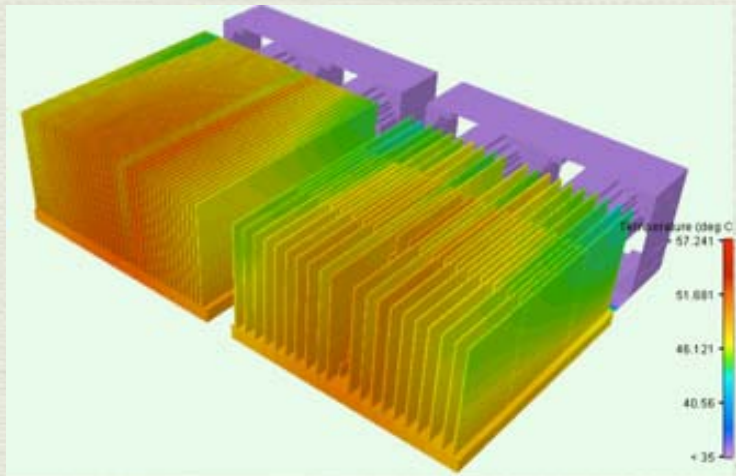
Interleaved Trapezoidal Fin Module

Simulation Result

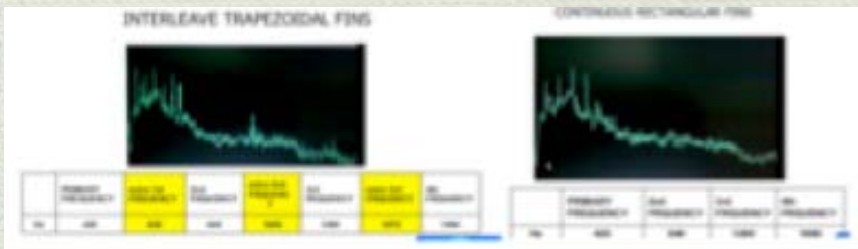


	die temp(C)	airflow	Pressure loss (pa)
RECTANGULAR FINS	58.62	9.8	29.1
INTERLEAVE TRAPEZODIAL FINS	57.65	11.2	23.18

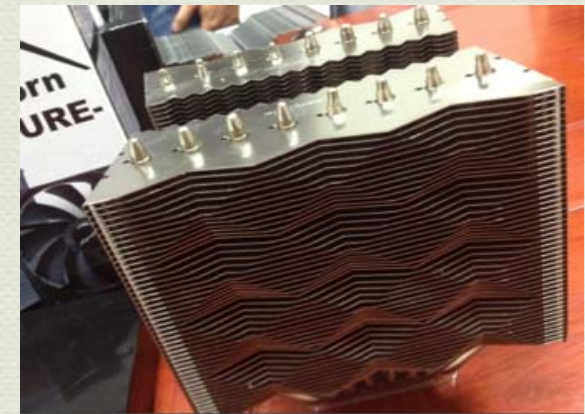
ITFM Technology on Desktop Cooler



- Performance UP : **2%**
- Weight DOWN : **12%**
- Noise down : 2dB

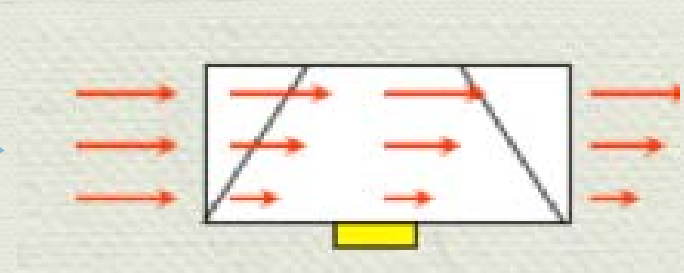
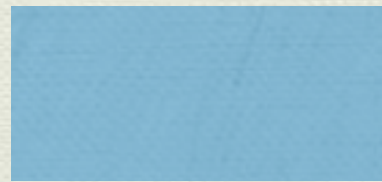


Interleaved Trapezoidal Applied in CPU Cooler



Variations of Entrance Cut & Exit Cut

- Entrance trig-cut reduces pressure drop, increase CFM



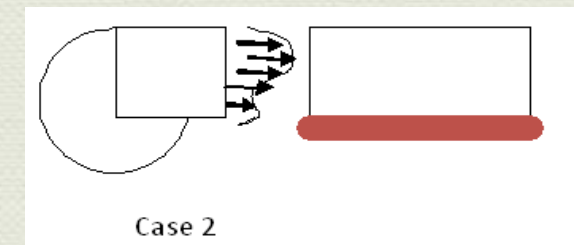
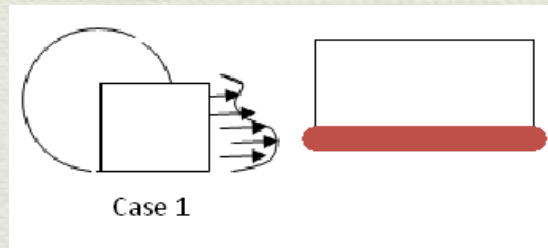
- What if inverse the front trig-cut & exit trig-cut for case 1 & 2?



- What if entrance flow is asymmetrical instead of uniform ?

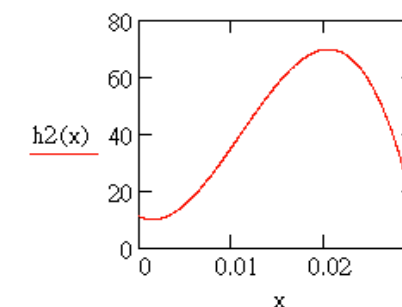
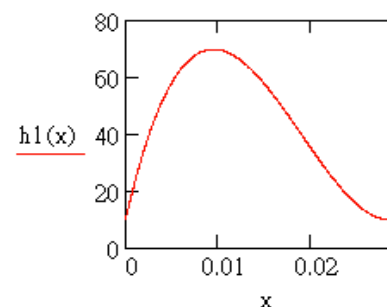
When Velocity Profile is Not Uniform?

- Blower fan's velocity profiles is asymmetrical from one end to the other
- Axial fan's velocity profile is diagonally symmetrical
- h is function of velocity $h=h(v)$ which can be experimentally measured or obtained from Flotherm from data base
- Same blower with different orientation on an vertical fin, Q difference can be theoretically analyzed



$$h1(x) := 1.415 \times 10^4 \cdot x - 9.921 \times 10^5 \cdot x^2 + 1.739 \times 10^7 \cdot x^3 + 10.145$$

$$h2(x) := 1.415 \times 10^4 \cdot (b - x) - 9.921 \times 10^5 \cdot (b - x)^2 + 1.739 \times 10^7 \cdot (b - x)^3 + 10.145$$



Theoretical Calculation for Model Correlation

Conclusion :

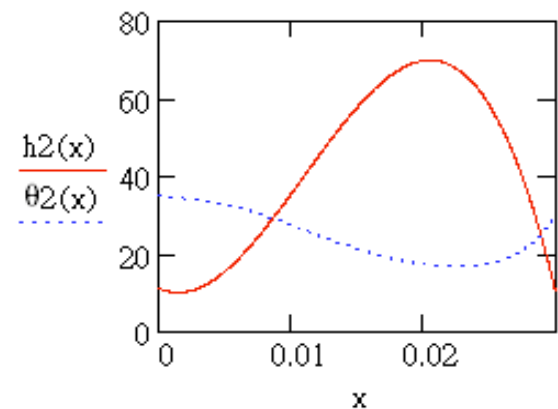
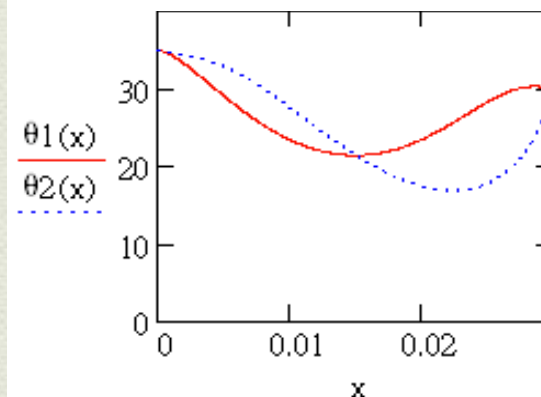
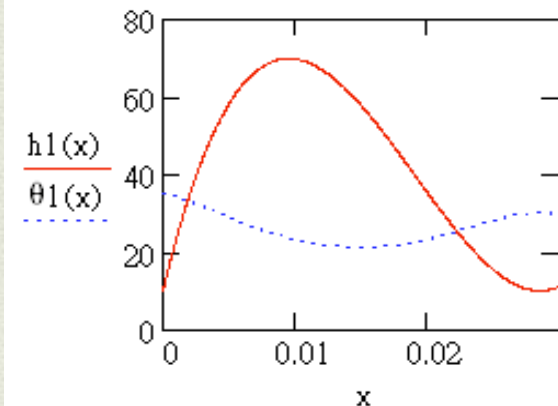
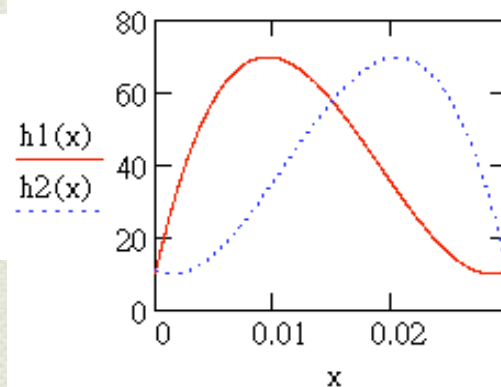
Case 1 is better in heat dissipation
with $Q_2 = 2.55W$, $Q_1 = 2.18W$, about
17% improvement!

$$Q = h A dT$$

When Q is 3W, what is the T_b ?

$$\theta_{01} := \frac{Q}{\int_0^b h_1(x) \cdot 2L \cdot \left[\frac{\cosh[m_1(x) \cdot (b-x)]}{\cosh(m_1(x) \cdot b)} \right] dx} + T_a = 76.136$$

$$\theta_{02} := \frac{Q}{\int_0^b h_2(x) \cdot 2L \cdot \left[\frac{\cosh[m_2(x) \cdot (b-x)]}{\cosh(m_2(x) \cdot b)} \right] dx} + T_a = 83.158$$



$$\theta_1(x) := \theta_0 \cdot \frac{\cosh[m_1(x) \cdot (b-x)]}{\cosh(m_1(x) \cdot b)} \quad \theta_2(x) := \theta_0 \cdot \frac{\cosh[m_2(x) \cdot (b-x)]}{\cosh(m_2(x) \cdot b)}$$

$$Q_1 := \int_0^b h_1(x) \cdot 2L \cdot \theta_1(x) dx = 2.553 \quad Q_2 := \int_0^b h_2(x) \cdot 2L \cdot \theta_2(x) dx = 2.18$$

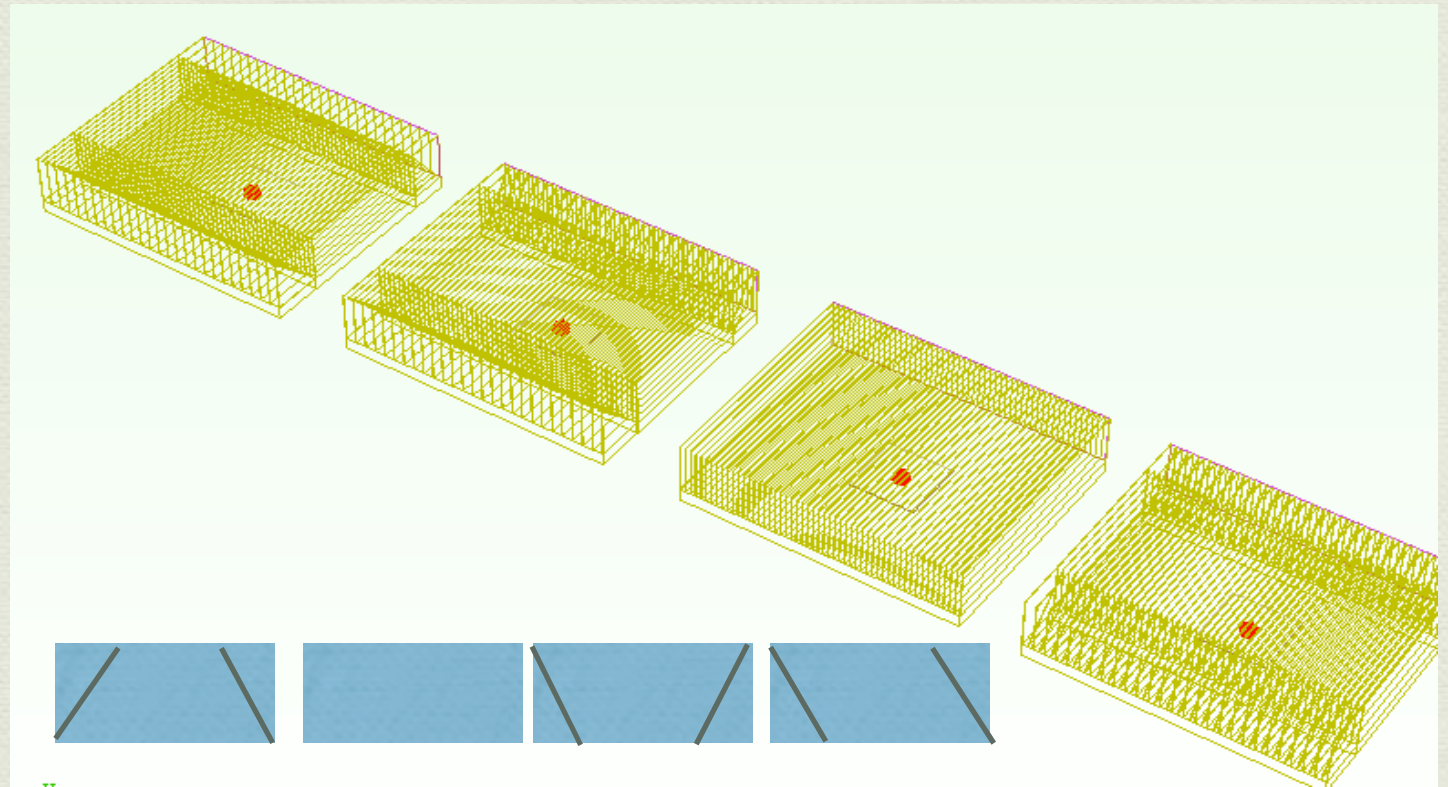
Server Original Samples

- ◆ dimension: 107Wx91Lx25H
- ◆ base thickness : 5MM
- ◆ base material: AL + Heatpipe
- ◆ FIN:91x20Hx0.2Tx53F
- ◆ fin material: AL



SIMULATION MODEL

- ◆ dimension: 107Wx91Lx25H
- ◆ base thickness : 5MM
- ◆ base material: CU
- ◆ FIN:91x20Hx0.2Tx53F
- ◆ fin material: AL
- ◆ DIE size: 25X25MM
- ◆ power: 100W
- ◆ Fan: 40X40, 30CFM/45Pa



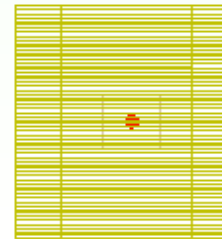
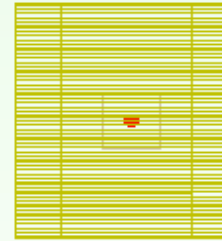
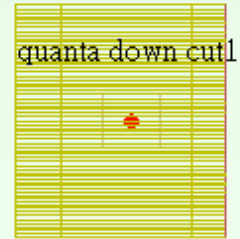
Simulation Models

◆ #1 Front down-cut 45 degree / Back up-cut 30 degree

◆ #2 Front down-cut 45 degree / Back down-cut 30 degree

◆ #3 Prototype no cut

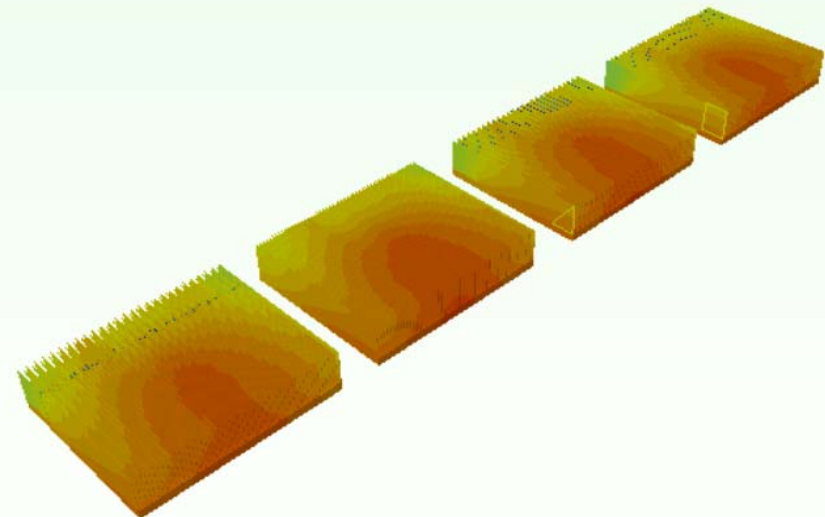
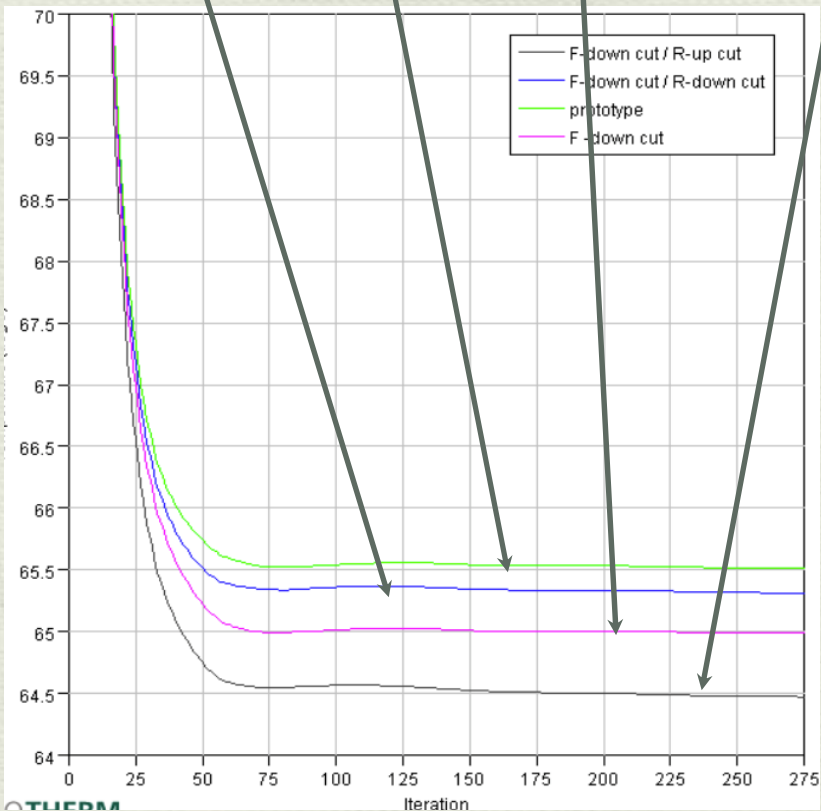
◆ #4 Front up-cut 45 degree / Back up-cut 30 degree



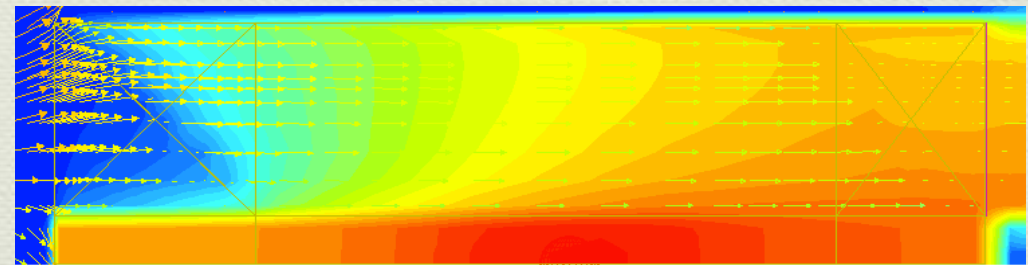
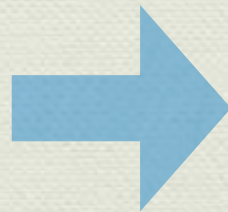
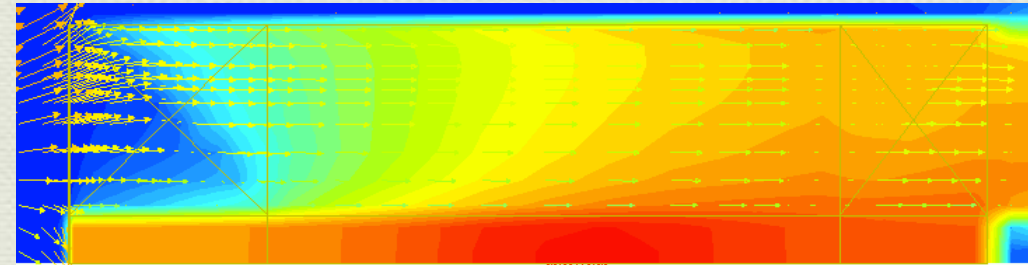
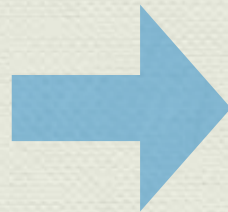
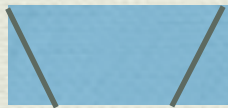
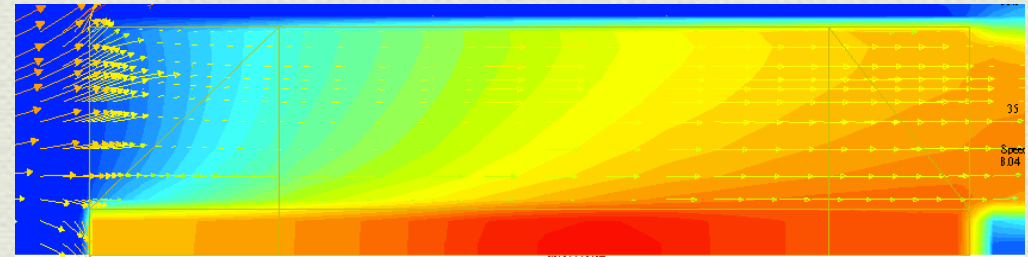
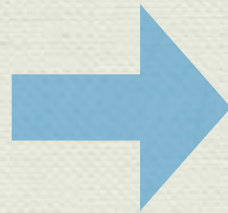
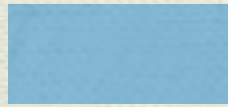
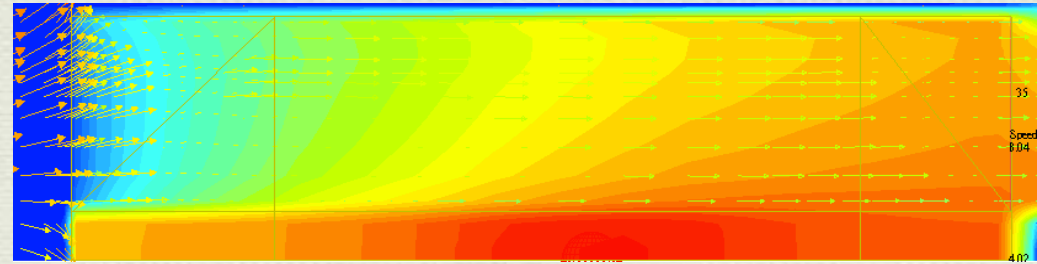
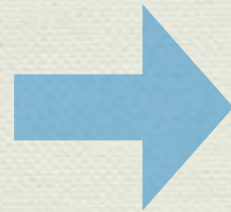
Result Analysis



Volume Flow High (cfm)	Mass Flow High (kg/s)	Heat Flow High (W)	Temperature High (deg C)
9.52733	0.0052221	277.53	52.868
8.89739	0.0048768	264.64	53.985
9.64641	0.0052874	280.26	52.733
9.85724	0.005403	284.47	52.383

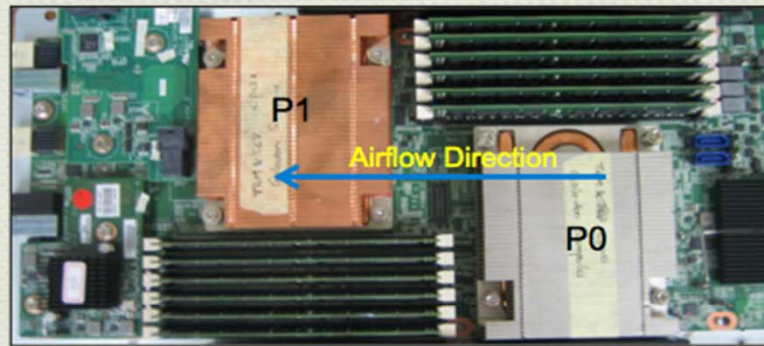


Flow Field & Temperature Field Analysis



Real Test Platform

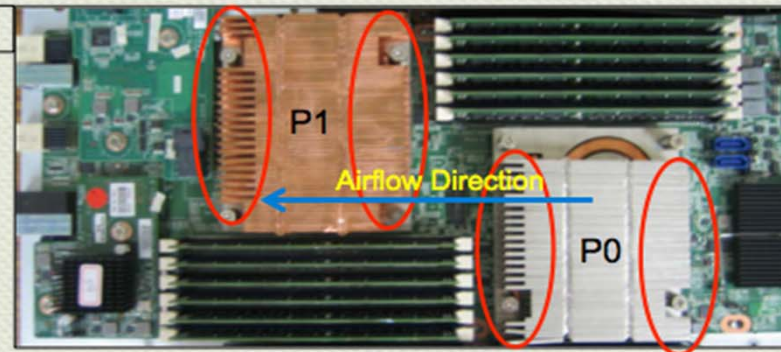
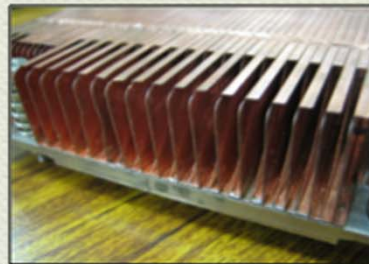
Test Setup



Heat Sink with Conventional Fin Design



Heat Sink with Modified Fin Design



Case	Case1	Case2	
Ambient	25		
P0 Dts	68	67	
P1 Dts	68	67	

END

- ◆ Thank you for your attention and time!
- ◆ Feel free to contact me if any questions!
- ◆ 陳恆隆 hong@homeming.com.tw
- ◆ [CELL:09788876902](tel:09788876902)