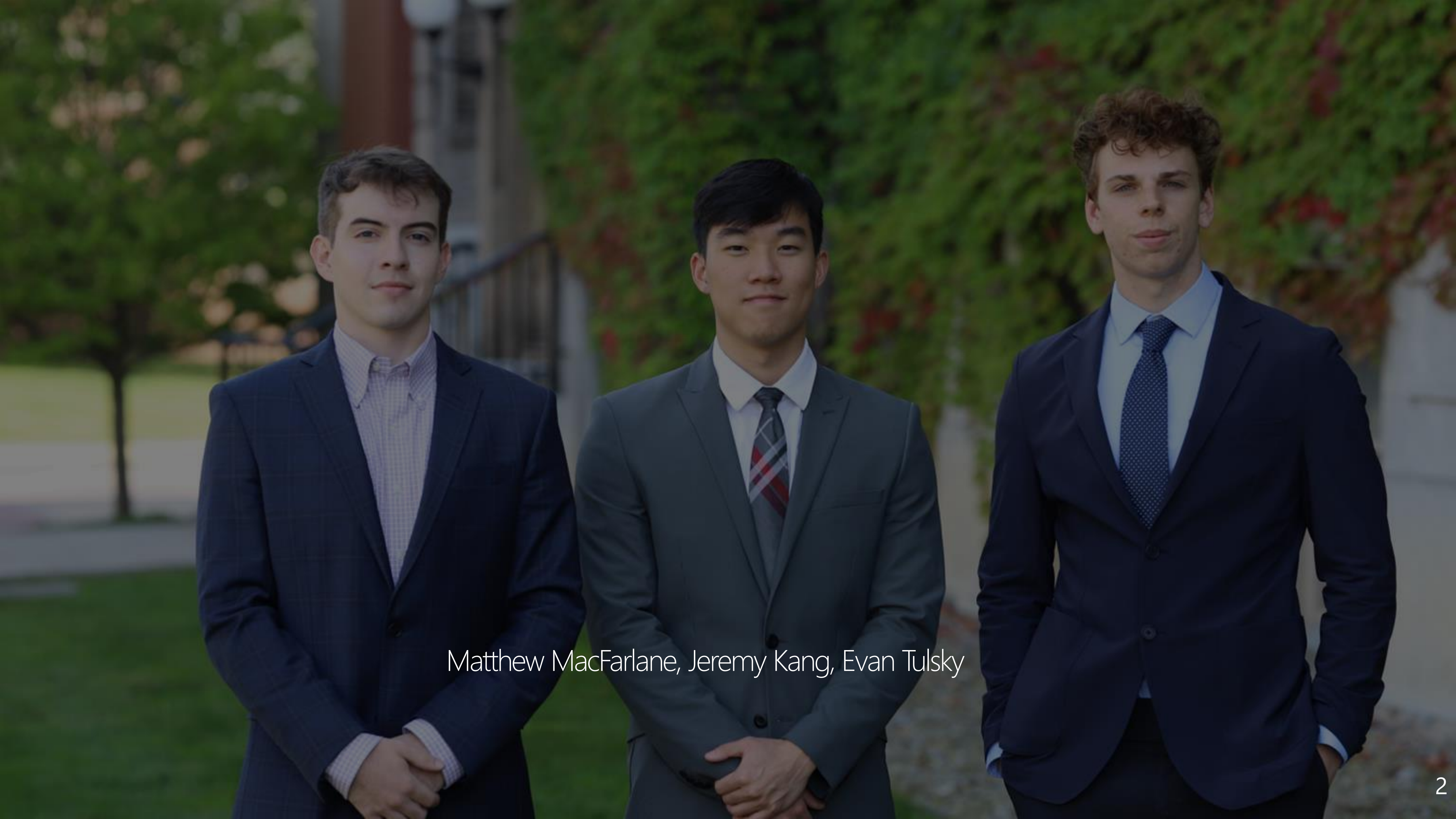
Microsoft

Bifacial Cold Plates for High Powered Servers

Syracuse University

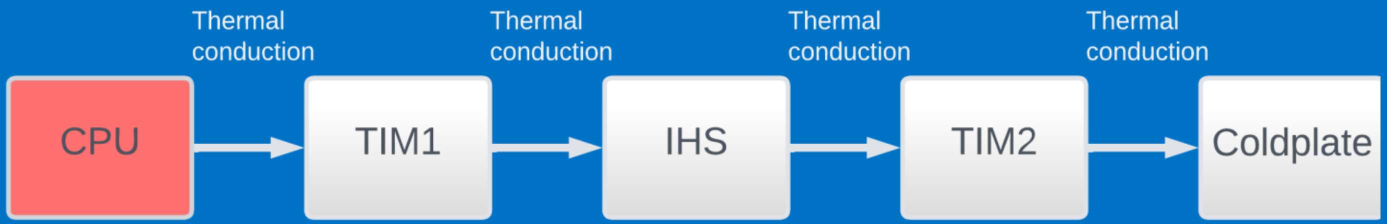


Matthew MacFarlane, Jeremy Kang, Evan Tulsky

Background

- Increase power efficiency through a water-cooled system
- Air-cooling is limited in maximum heat removal

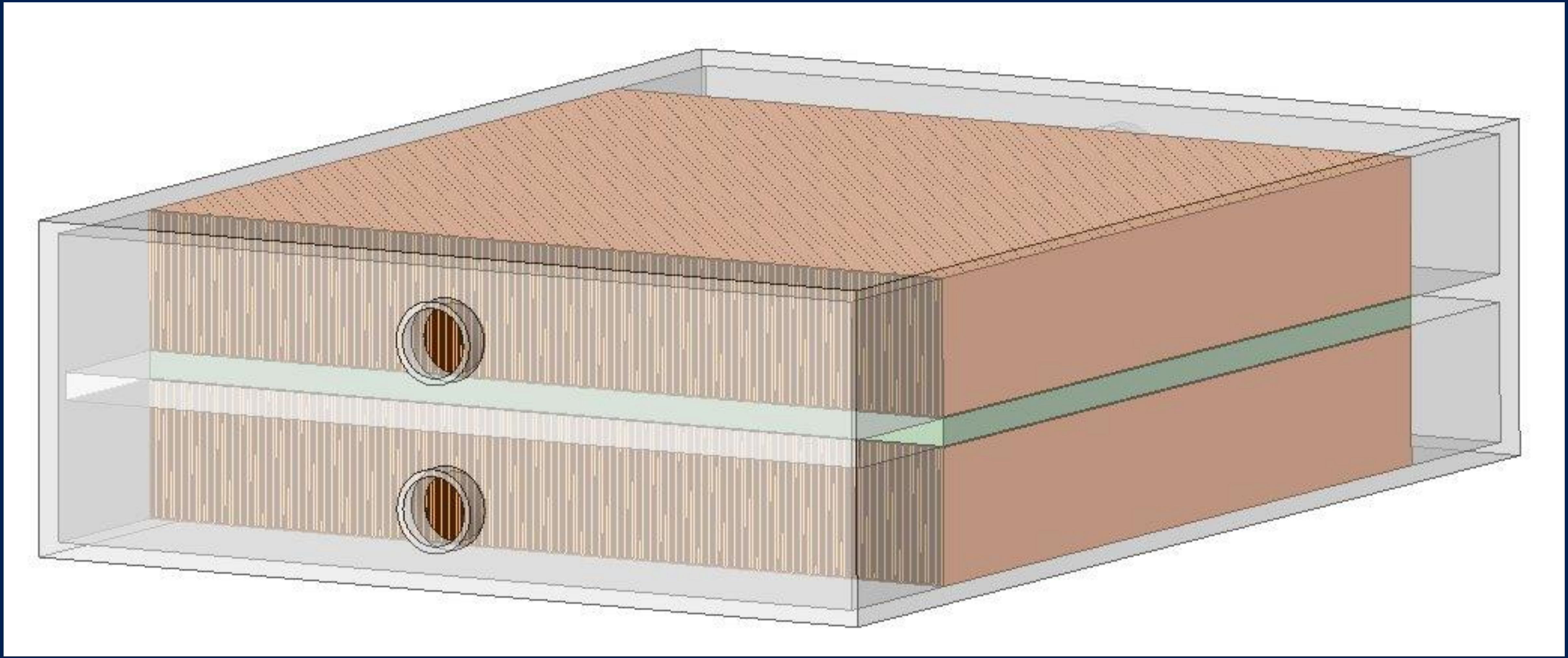
Air cooled configuration



Path of Heat Transfer

Enable 1000W chips from a current state of the art 600W chip

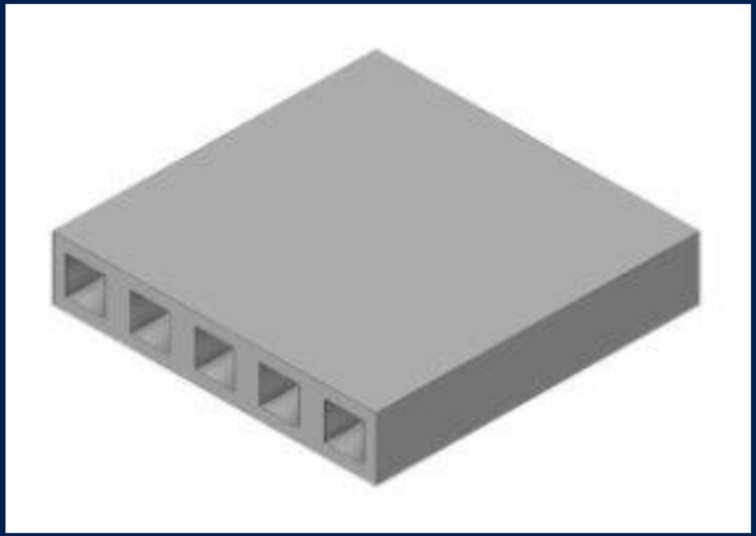
Contents



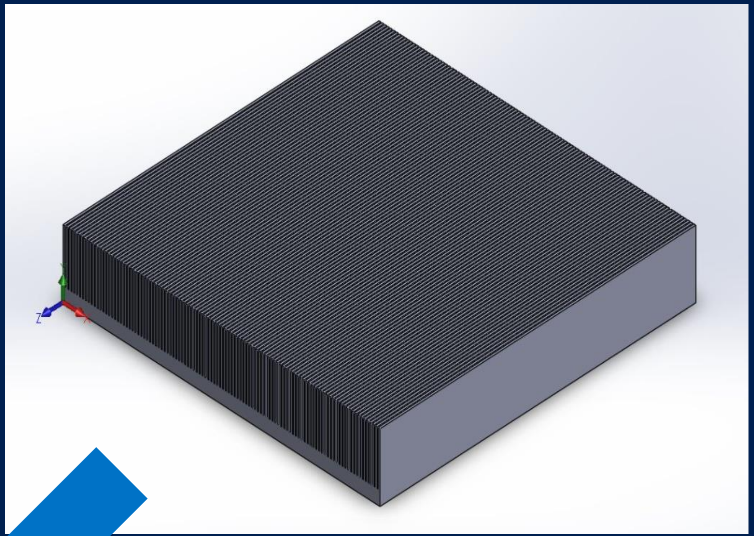
Specifications

	14 chip bottom side	1 chip top side
Total heat created	112 W	1000 W
Maximum component case operating temperature	358K	353K
Flowrate	0.16 lpm	1.5 lpm
Maximum pressure drop	< 1 bar	
Minimum wall thickness	100 microns	
Corrosion resistant, upholds electronics functions, inlet temperature 40°C, maximum total casing height of 48mm		

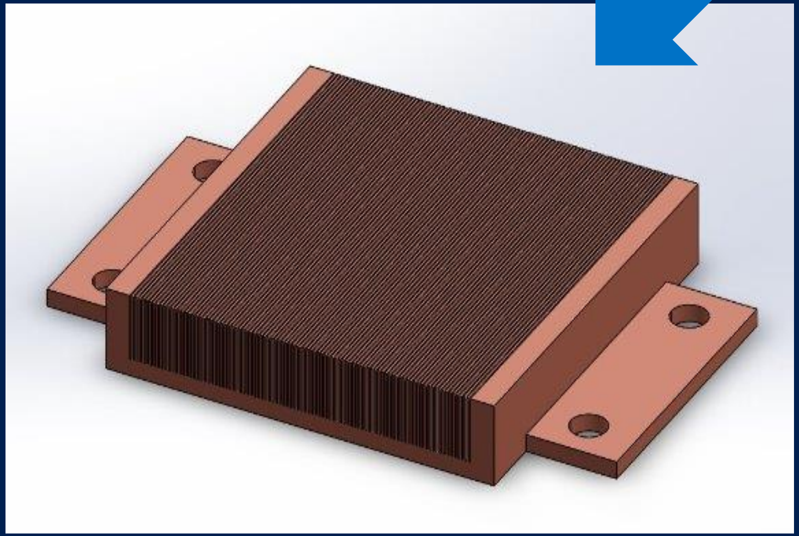
Path of Design



Initial Cold Plate Design



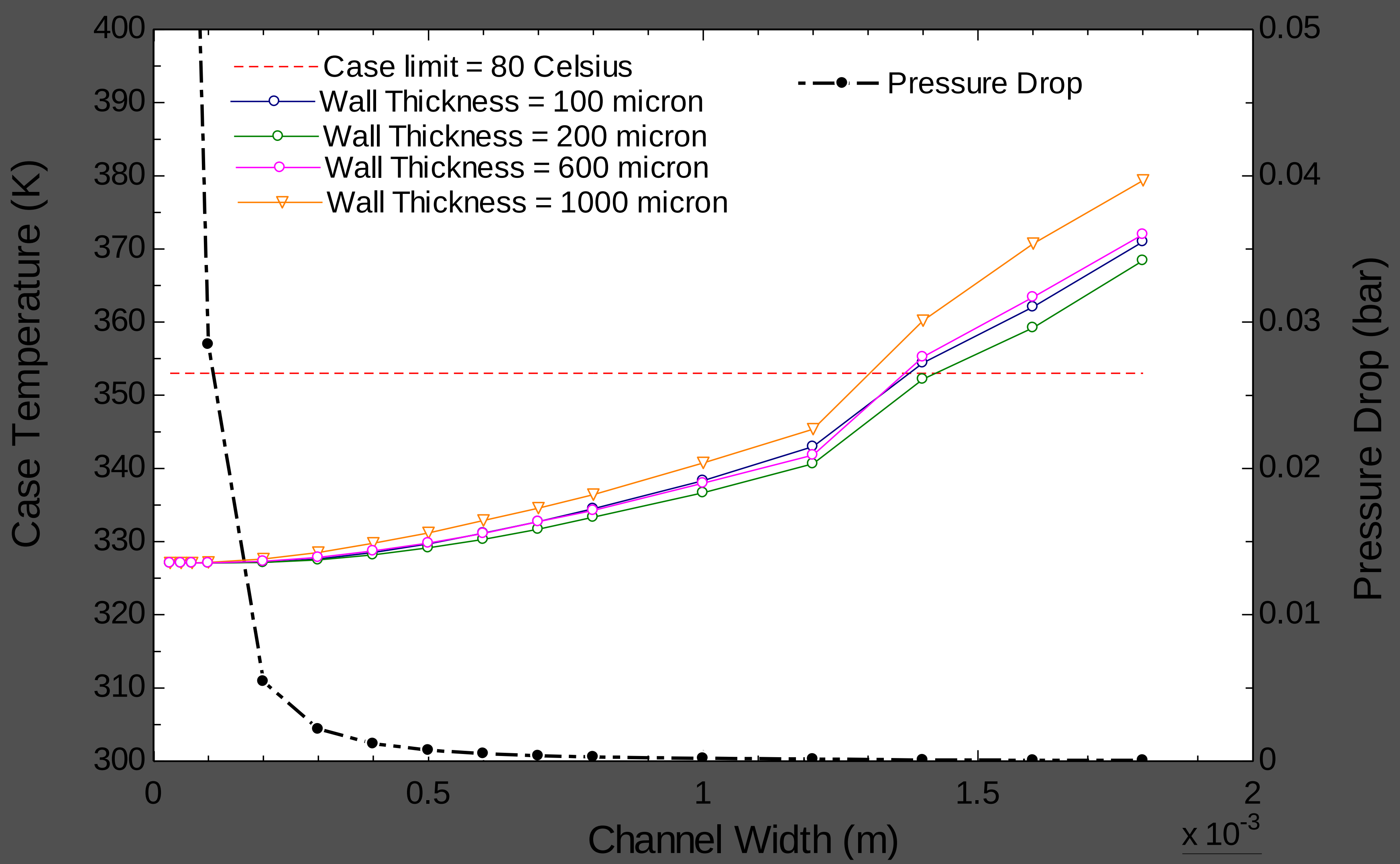
Optimal Cold Plate Design

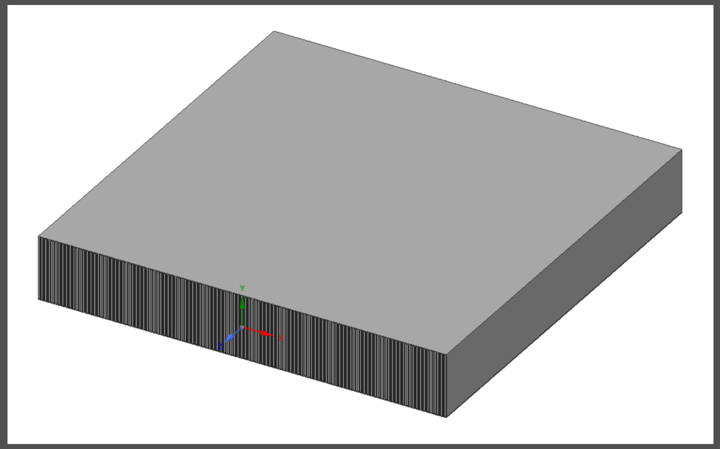


Final Cold Plate Design

Manufactured Cold Plate

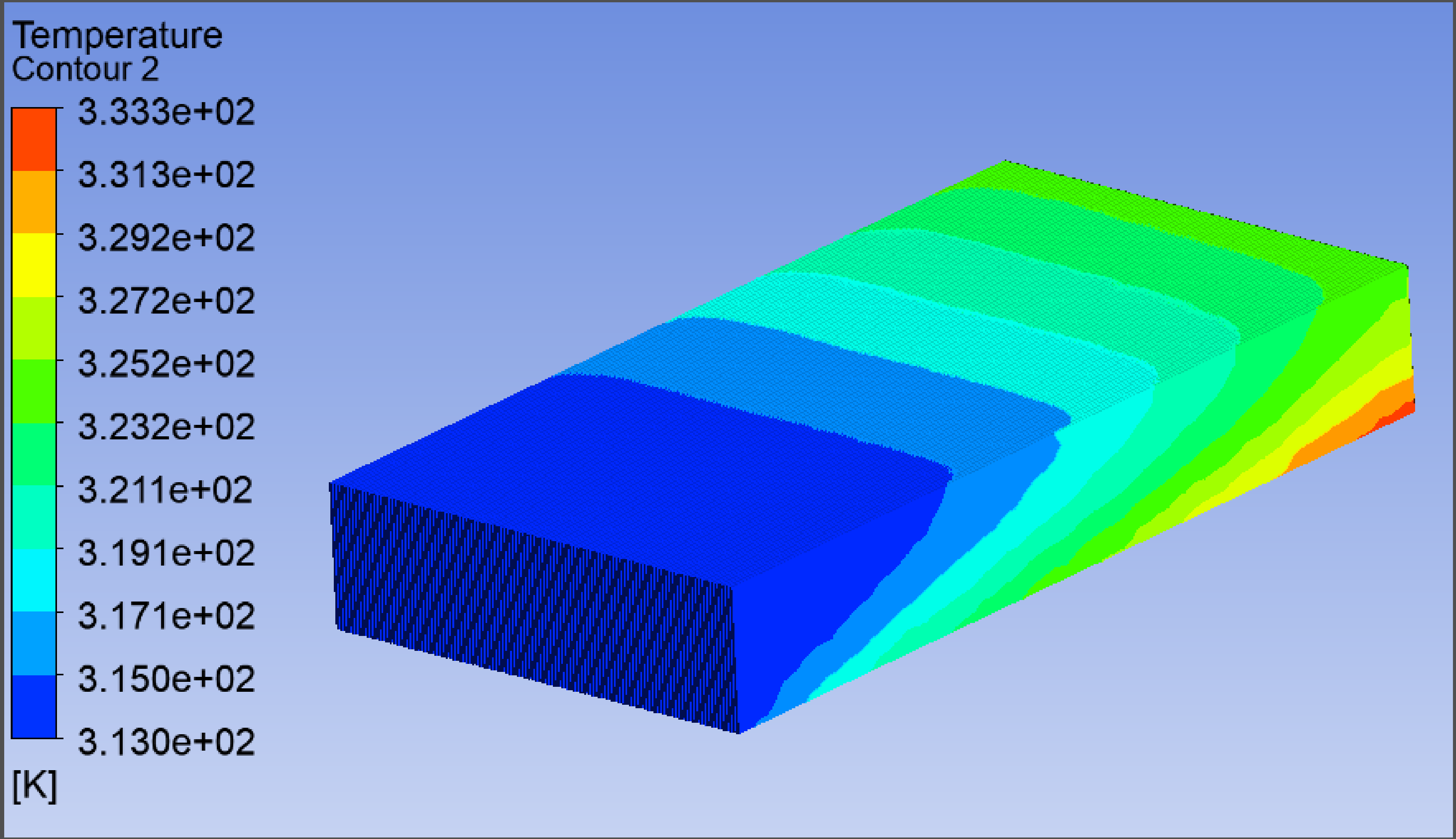
Design Concepts (Front Side)





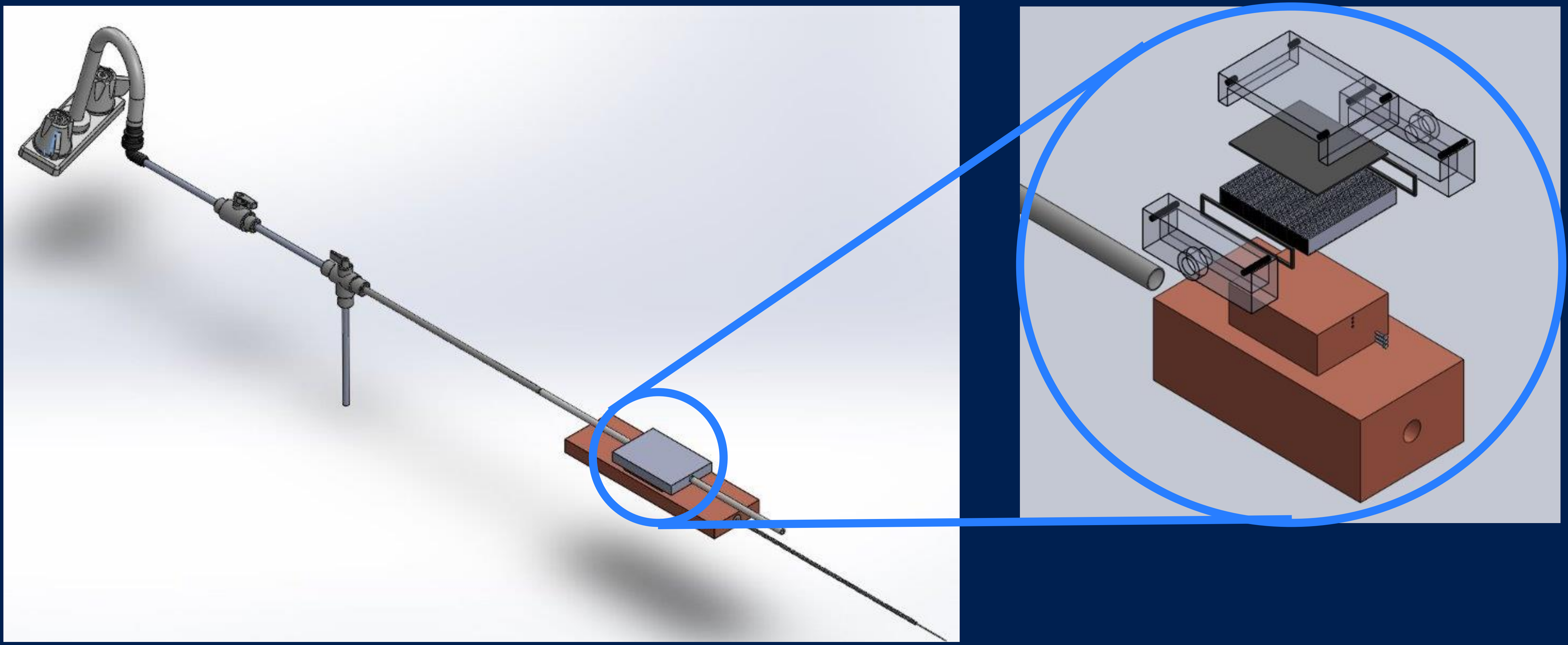
- Constant heat flux
- Top surface insulated
- Total height = 10 mm
- Flowrate = 1.5 lpm per kW
- Inlet Temperature = 40 Celsius
- One vertical channel

Simulation Results



Global Temperature

Assembly



Copper

- Better thermal conductivity

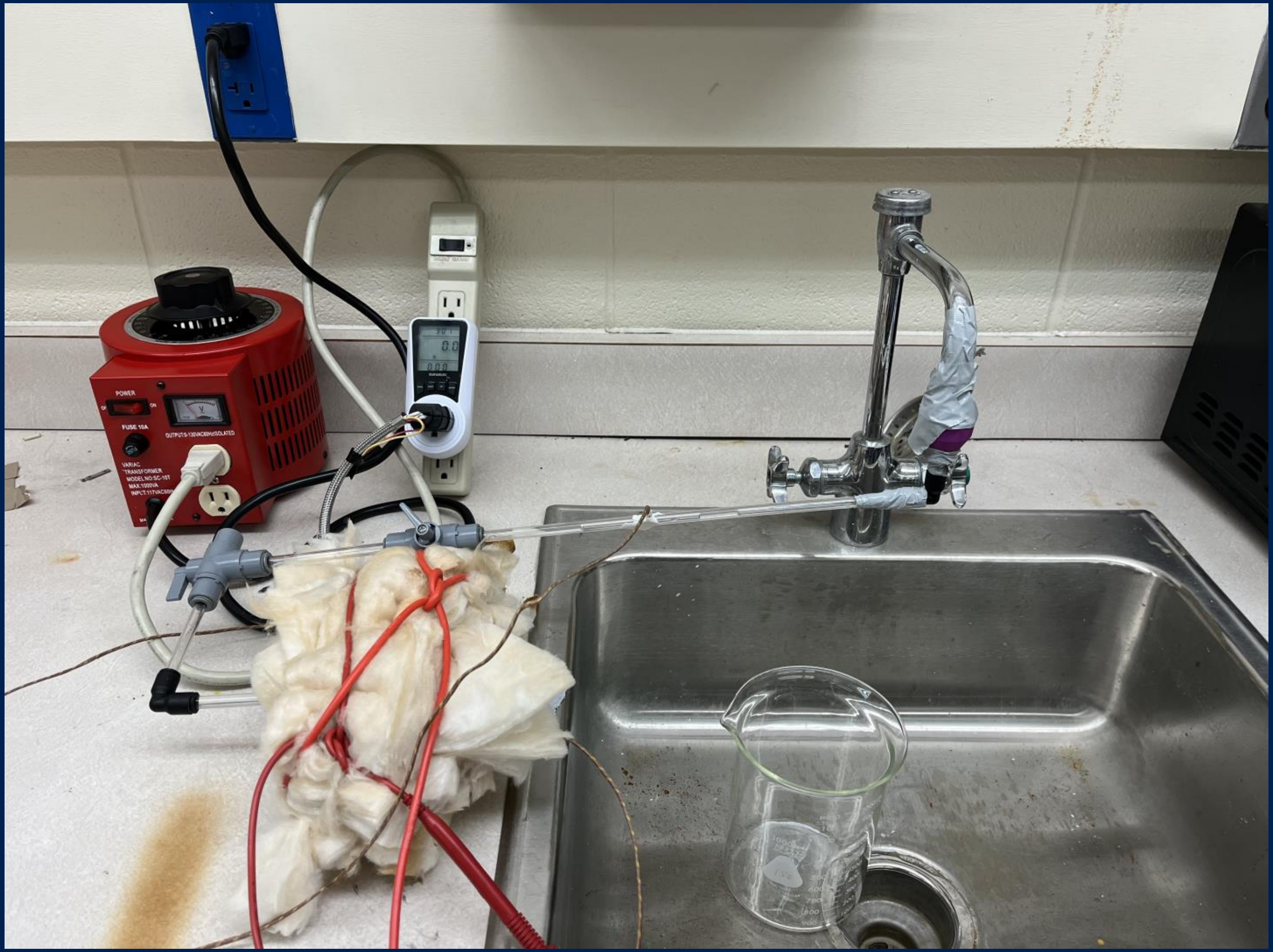
Brass

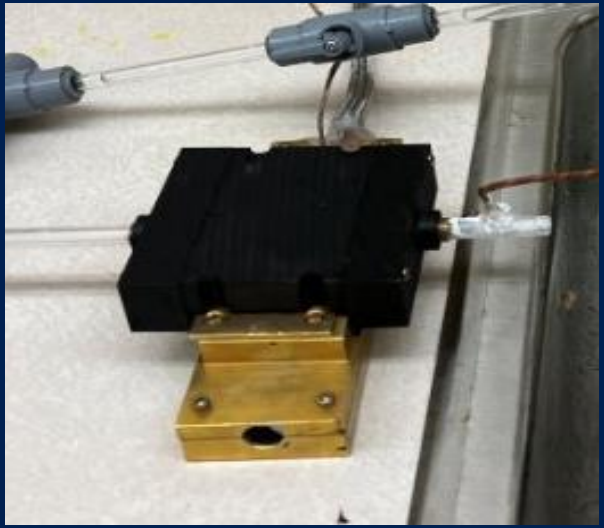
- Easier to manufacture

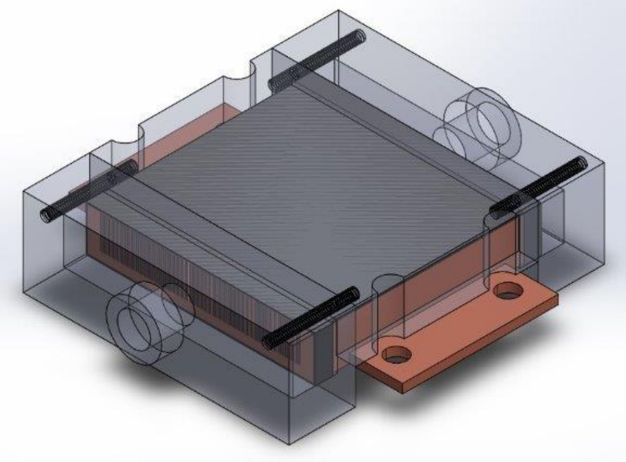
In conclusion, brass was the choice of material used for the cold plate due the ease in manufacturing

Part Manufacturing

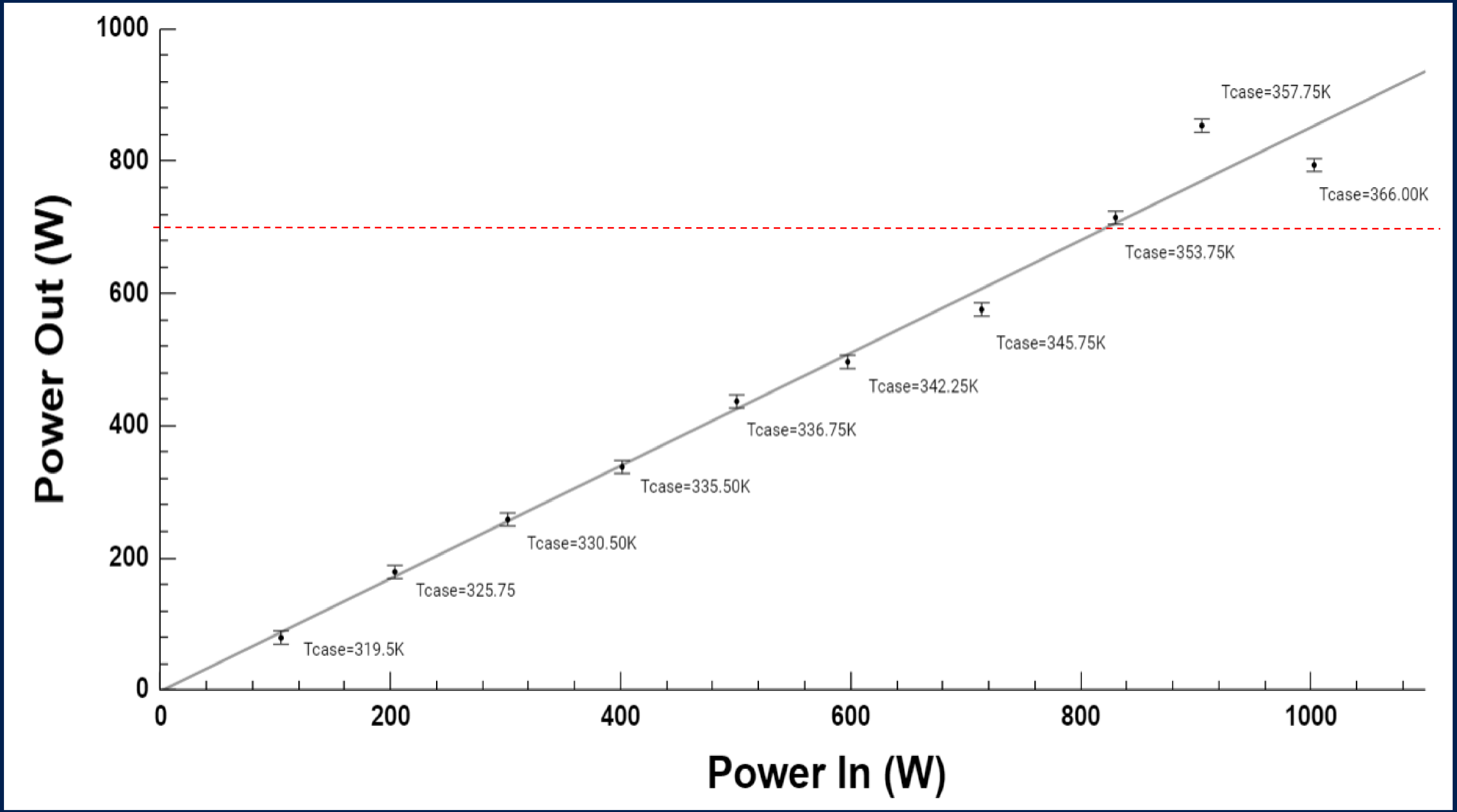
System Testing



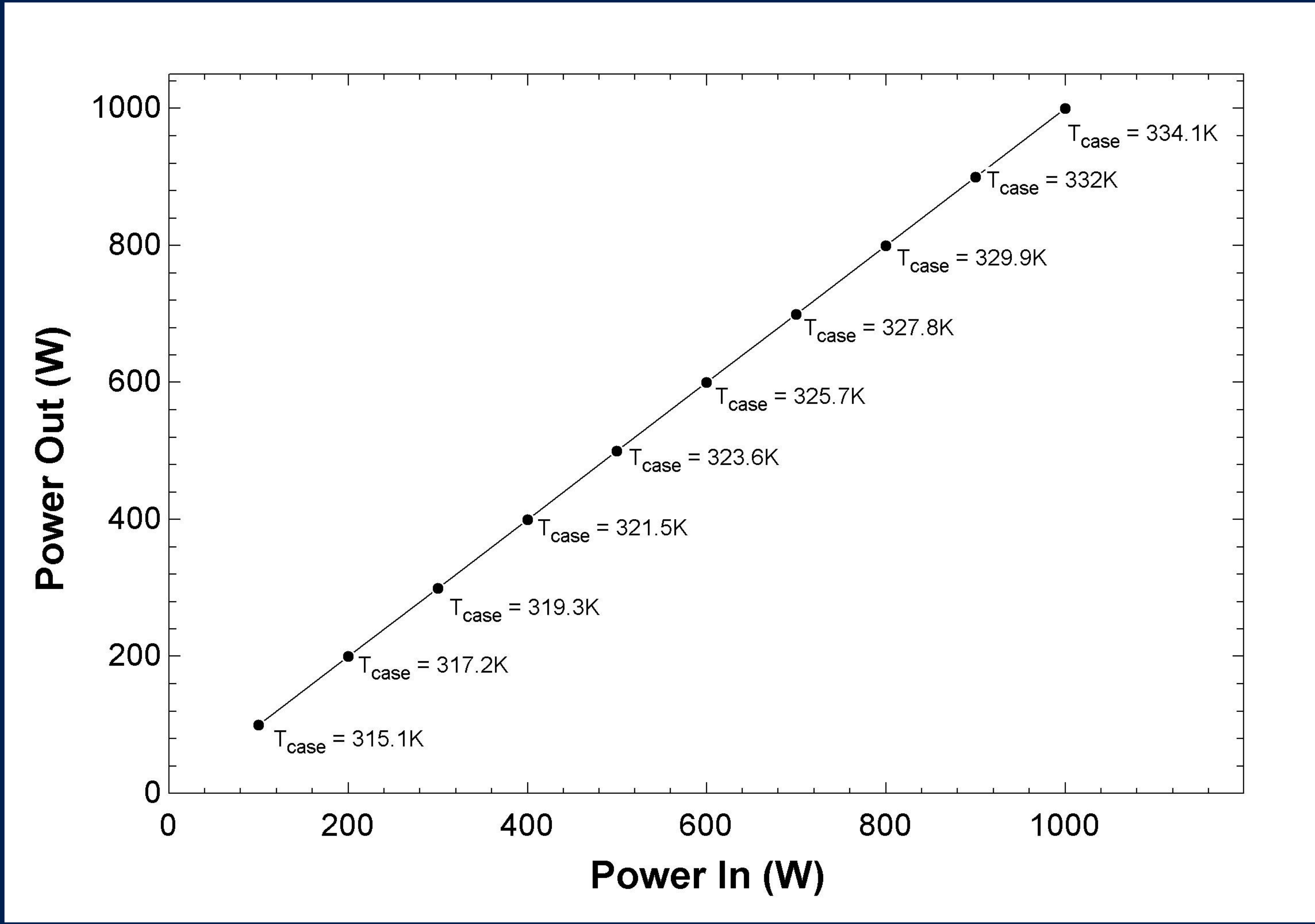




Experimental Results



Theoretical Results



What we learned

- Theoretical solution of a cold plate
- Application of a heat sink through FLUENT
- Manufacturing restrictions
- Data collection and uncertainty analysis

Special Thanks

Microsoft Team: Dr. Kathryn Oseen-Senda, Dr. Oscar Farias Moguel, Courtney Huddleston

Syracuse Advisor: Dr. Shalabh Maroo

Professors: Dr. Daddis, Dr. Sarimurat, Dr. Bogucz, Dr. Deyhim

Machine Technicians: Andrew Newman, Thomas Braga

Syracuse University

Microsoft

Questions and Discussion

Design Theory of internal flow of a rectangular channel

1

$$Re = \frac{\rho v D_h}{\mu}$$

$$Re < 2000 \therefore laminar\,flow$$

Channel width / height	Nu of constant heat flux	Friction factor, f
1	3.61	59.92/Re
2	4.12	62.20/Re
3	4.79	68.36/Re
4	5.33	72.92/Re
6	6.05	73.80/Re
8	6.49	82.32/Re
∞	8.24	96.00/Re

3

$$h = \frac{Nu k_{water}}{D_h}$$

2

$$\Delta P = \frac{f W_{plate} v^2}{2 D_h}$$

$$\Delta P < 1bar$$

4

$$R_{tot} = R_{conduction} + R_{convection}$$

$$R_{tot} = \frac{H - \frac{h}{2}}{K_{cp}(sW)} + \frac{1}{\eta h A_t}$$

5

$$T_e = \frac{Q}{channels * \dot{m} * c_p}$$

6

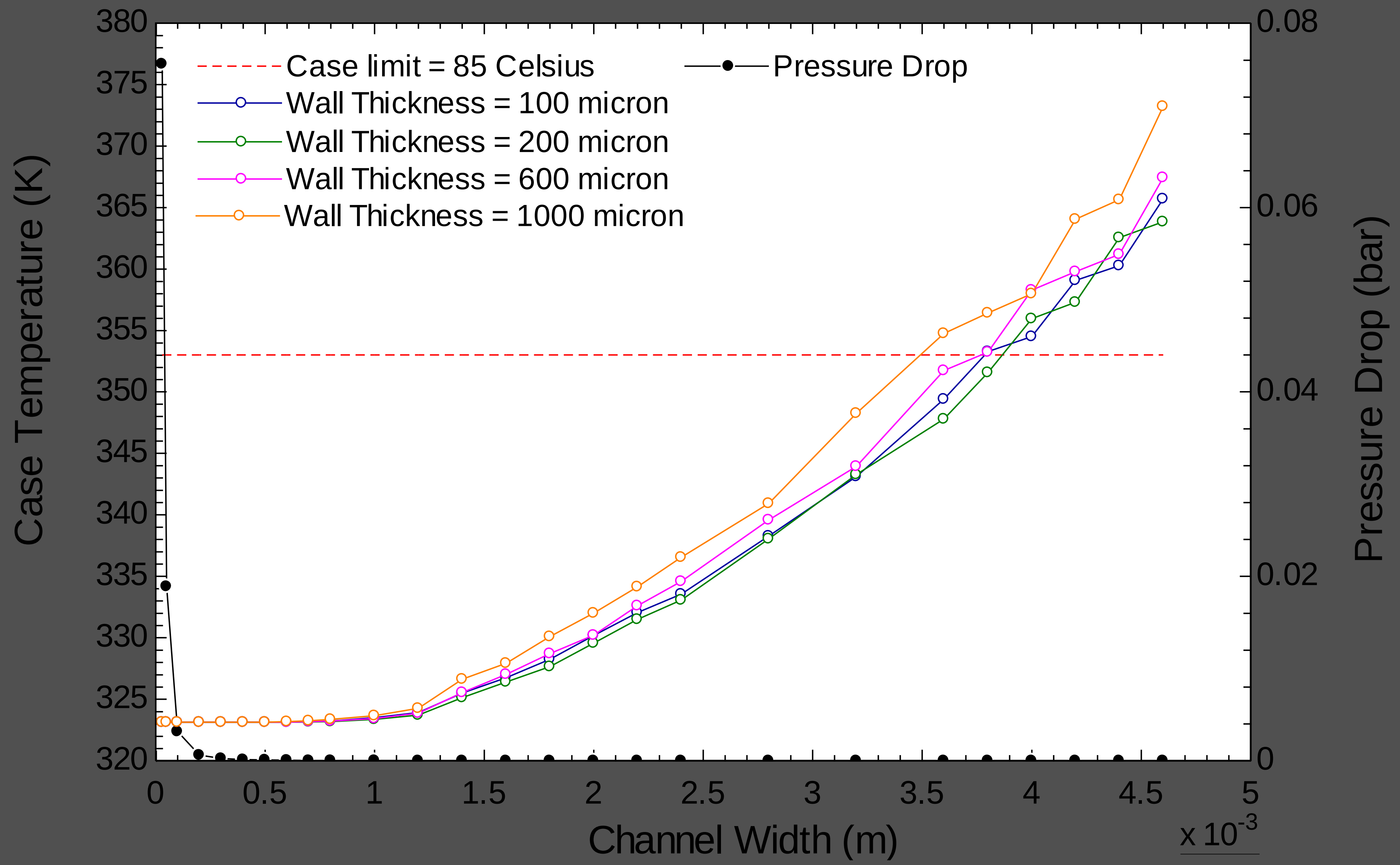
$$\frac{(T_s - T_e)}{(T_s - T_i)} = e^{\frac{-1}{\dot{m} c_p R_{tot}}}$$

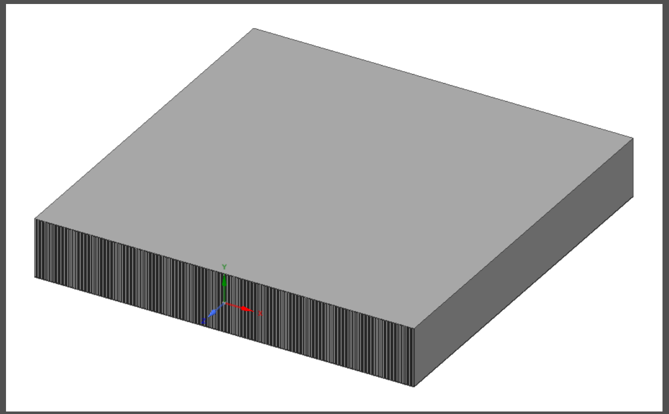
7

$$T_{case} = T_s + \frac{\dot{q}}{k_{IHS} L_{IHS}}$$

$$T_{case} < 80C$$

Design Concepts (Back Side)





- Constant heat flux
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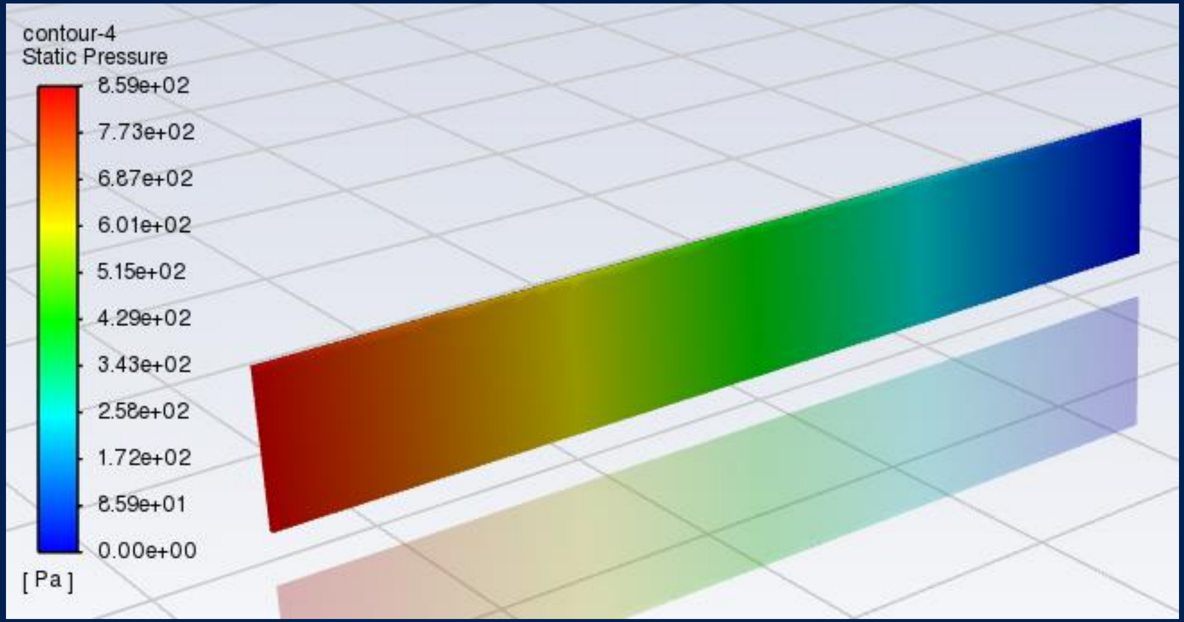
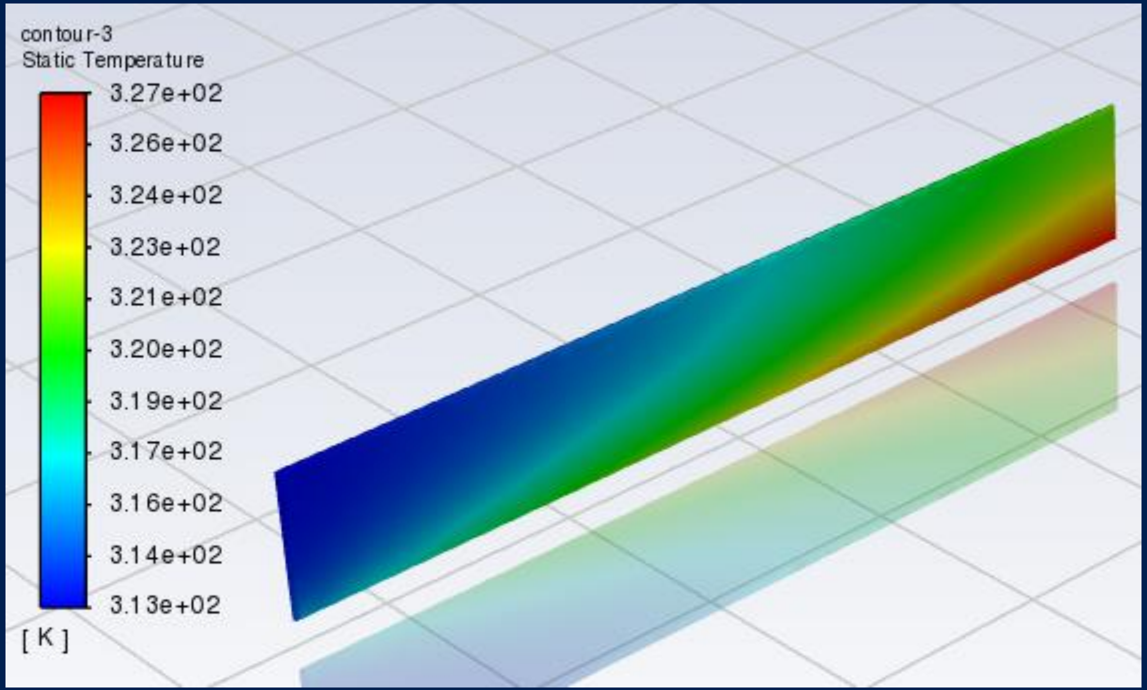
- Total height = 10 mm
- Flowrate = 0.16 lpm per kW
- Inlet Temperature = 40 Celsius
- One vertical channel

Simulation Results (Single Channel)

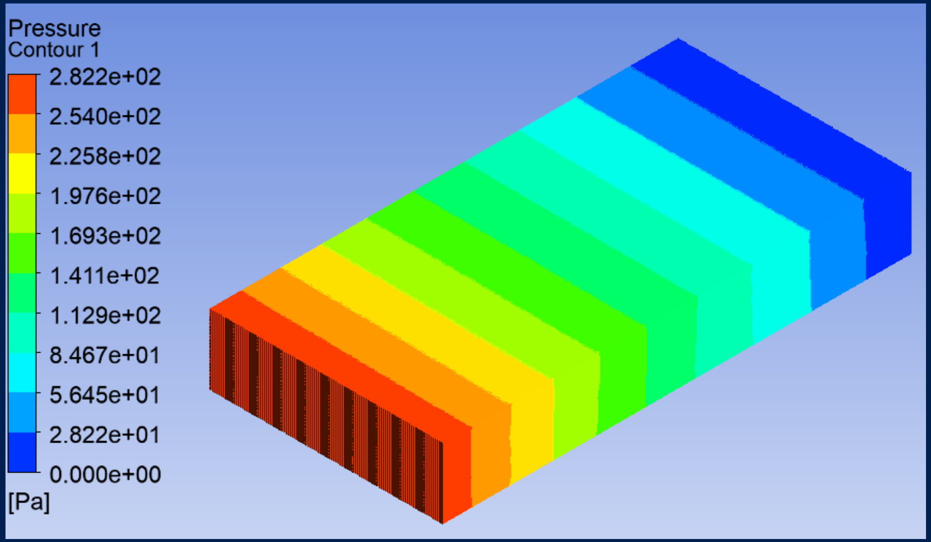


Pressure Drop

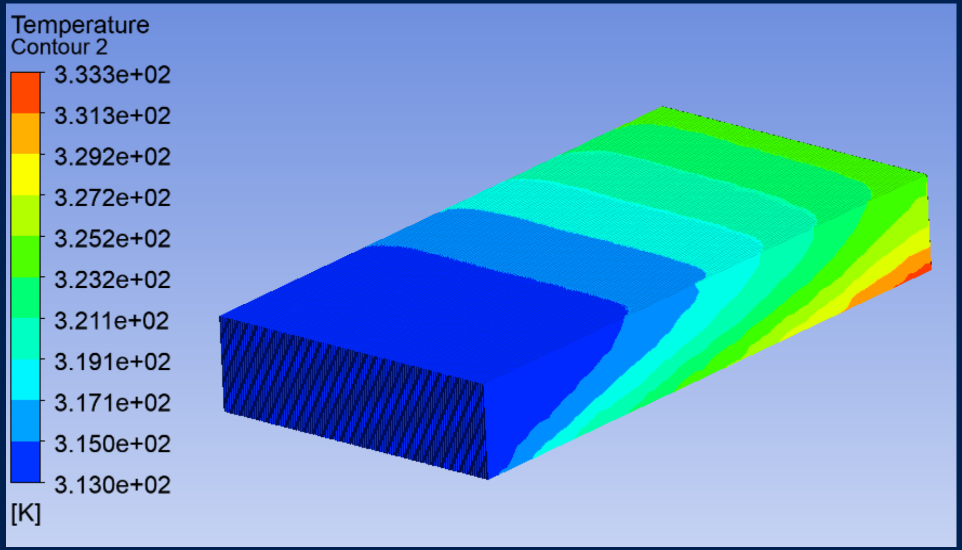


Global Temperature

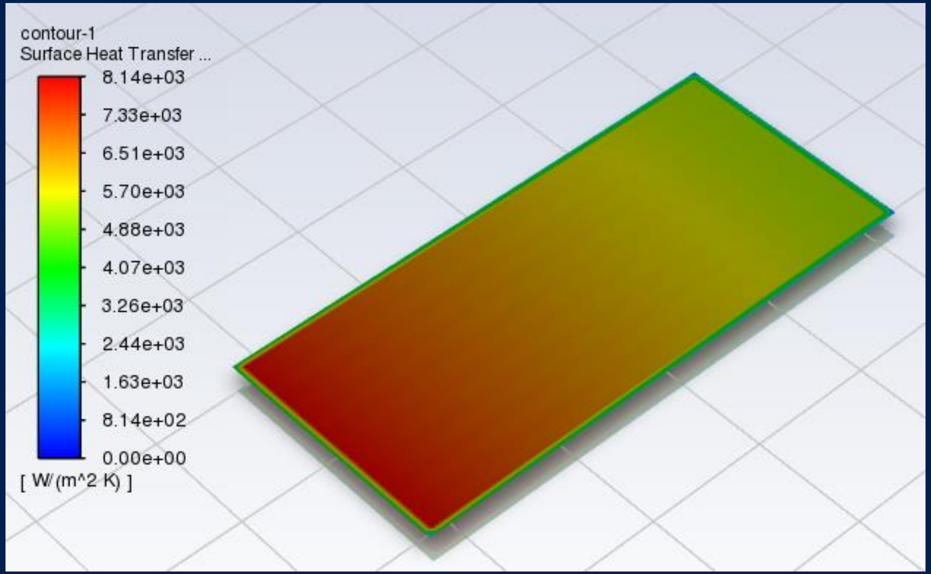
Simulation Results



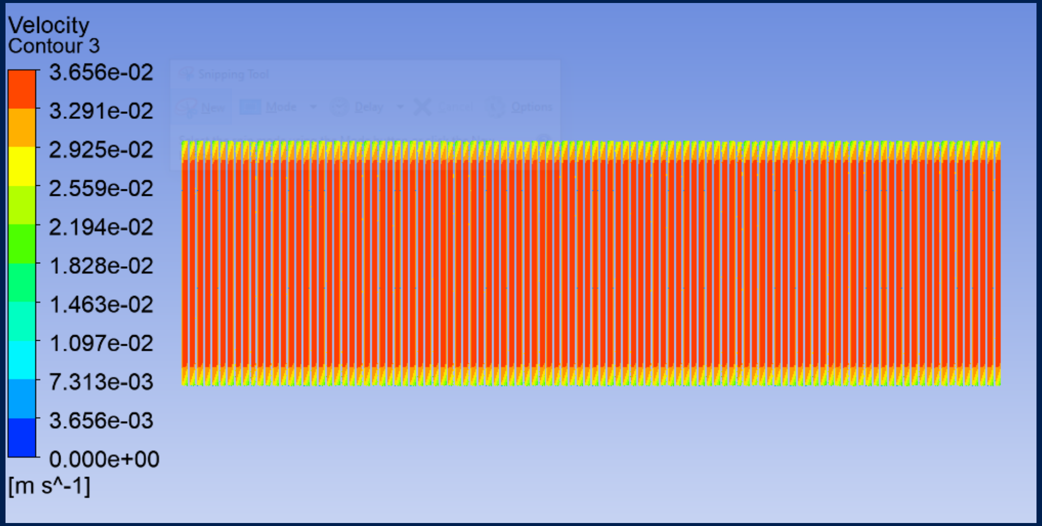
Pressure Drop



Global Temperature

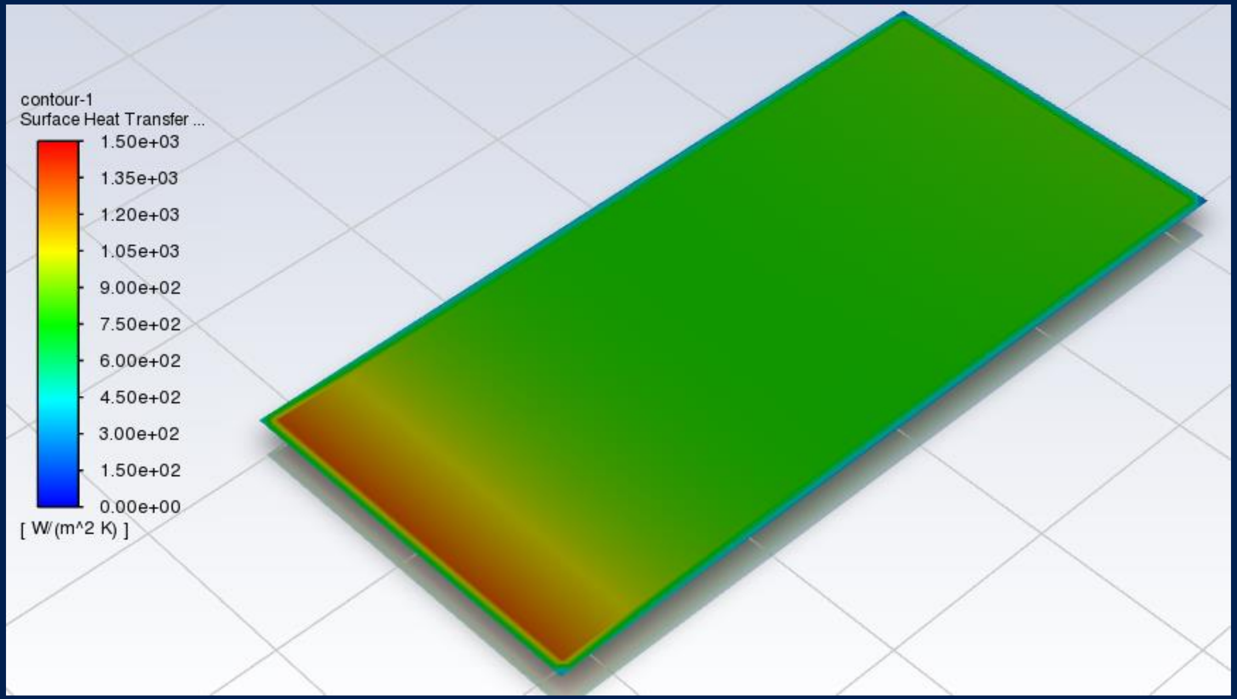


Heat Transfer Coefficient

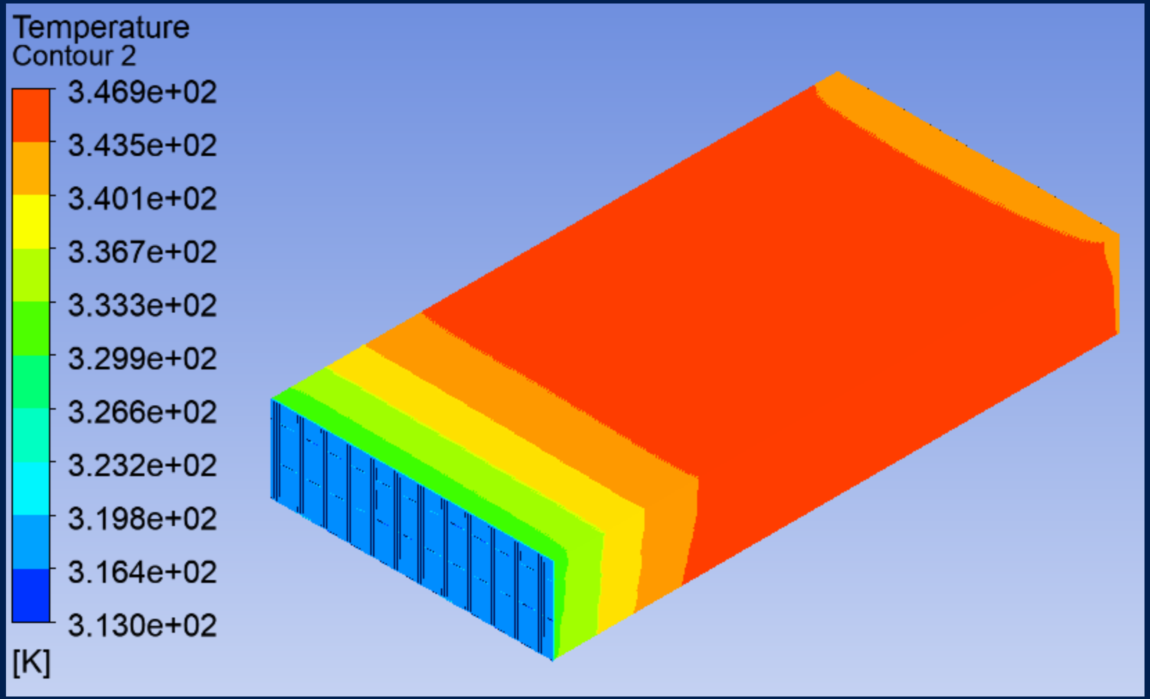


Velocity (Cross-Section)

Simulation Results (Back Side)



Heat Transfer Coefficient

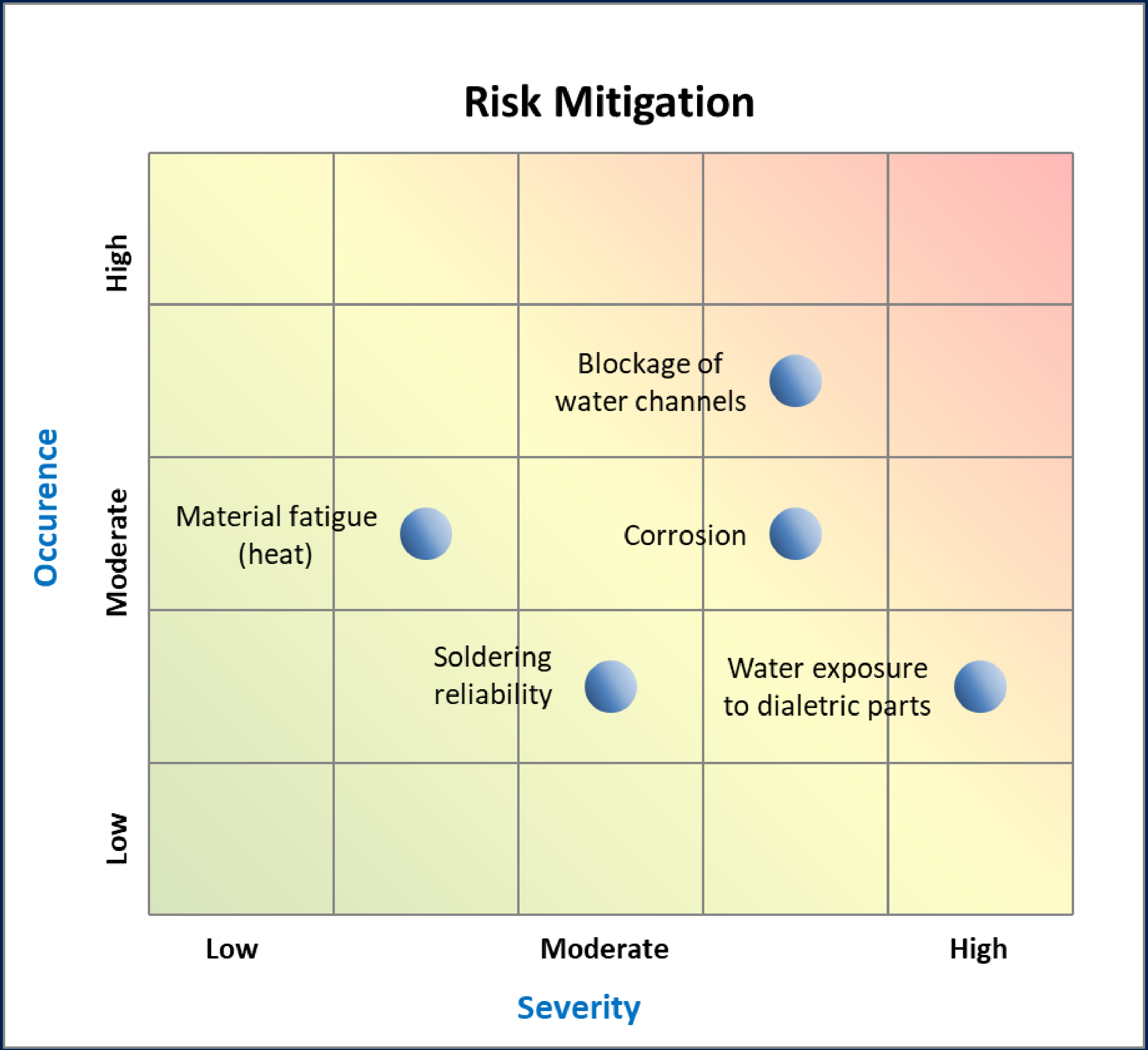


Global Temperature

Risk Management

- Corrosion: **RPN = 144**
- Material Fatigue (Heat): **RPN = 78**
- Fin Deformation: **RPN = 42**
- Soldering reliability: **RPN = 64**
- Blockage of Channels: **RPN = 128**
- Water exposure to dielectric parts:

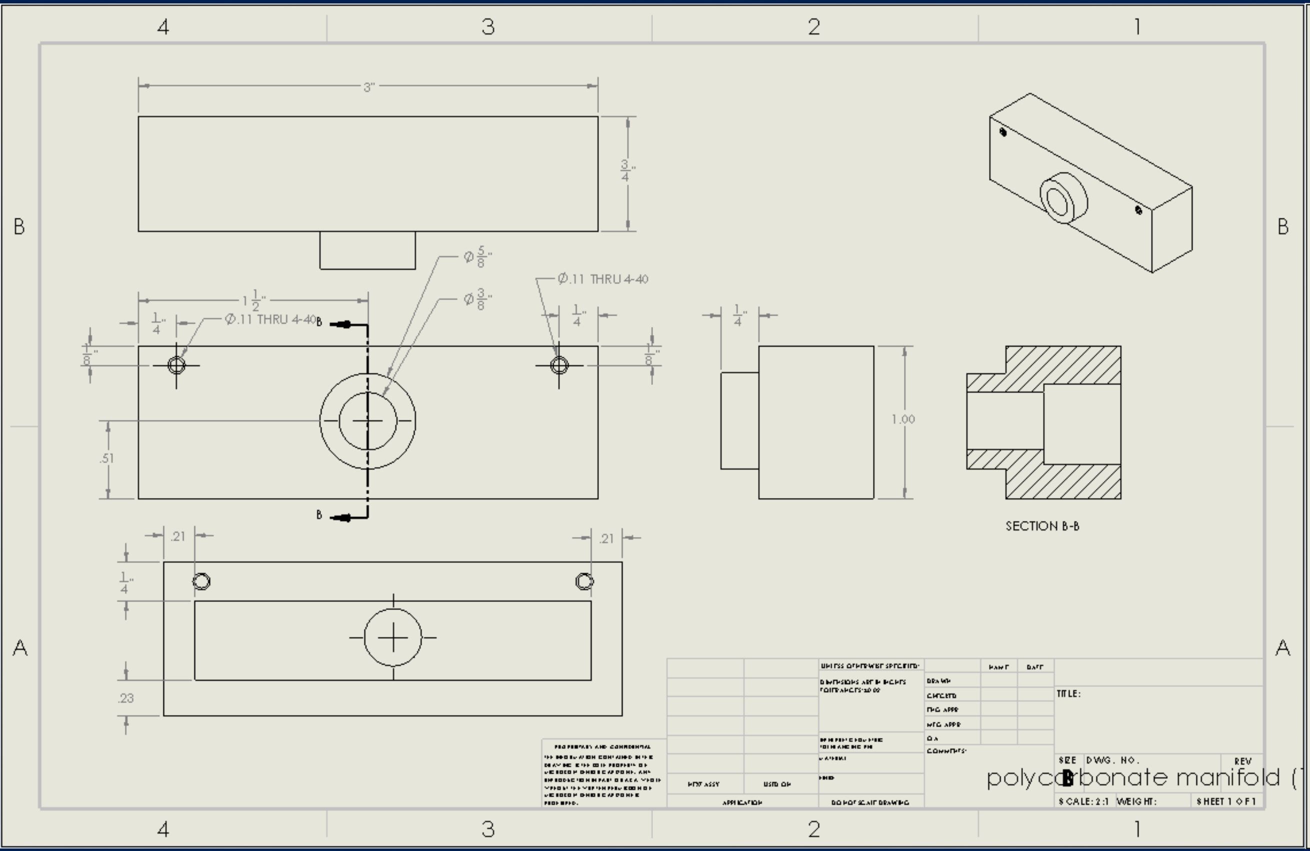
  RPN = 162

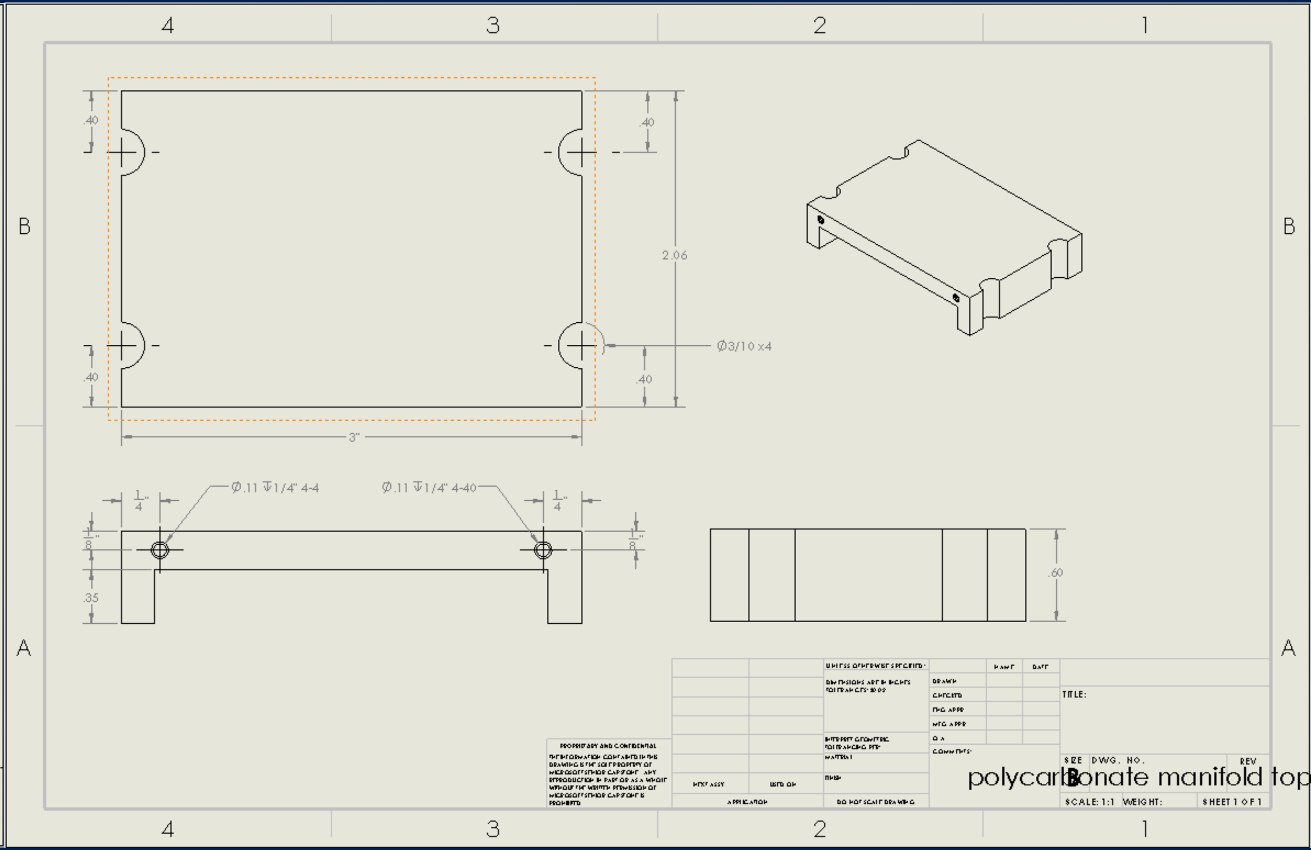


Bill of Materials

Purchacing List				
Item	**Notes**	**Number of items**	**Cost per part**	**Total Cost**
Brass block		1	$ 57.45	$ 57.45
		1	$ 93.52	$ 93.52
insertion heater for copper block	0.5 diam, 6 in length, 1000W, get 120V	1	$ 140.77	$ 140.77
Thermocouple for pipes	Type J	3	$ 27.03	$ 81.09
Plastic pipe	6 ft cut into two	1	$ 5.07	$ 5.07
Diverting valve	Works as tee	1	$ 28.46	$ 28.46
Flow valve	control flowrate	1	$ 19.74	$ 19.74
Elbow connector	Sink to plastic pipe	2	$ 6.60	$ 13.20
Arduino MAX6675 connector		1	$ 20.77	$ 20.77
Arduino uno		1	$ 27.60	$ 27.60
Bread board		1	$ 8.99	$ 8.99
Thermal paste		1	$ 5.38	$ 5.38
Gasket	Weather-Resistant EPDM Rubber Sheet, 6" x 6", 1/64" Thick	1	$ 1.36	$ 1.36
Housing unit	SU machine shop materials	2	$ 21.97	$ 43.94
Fiberglass insulation		1	$ 21.00	$ 21.00
Heat sink/ cold plate	Physics machine shop: this parts total cost = 284.65	1	$ 100.66	$ 100.66
		1	$ 60.81	$ 60.81
		5	$ 18.95	$ 94.75
		1	$ 28.43	$ 28.43
Screws		1	$ 6.35	$ 6.35
Shipping Costs				$ 87.09
Total Cost				$ 946.43

Drawings of Housing Unit





Drawing of Cold Plate