INFO DUMP:

A two-phase computational study extending the analytical framework of Dr. Abbas (2024) on longitudinal rectangular fins, using SolidWorks Simulation and Flow Simulation on a custom 6-fin chord-array heat sink geometry.

Important values/dimensions: Circular copper base plate: 120 mm outer diameter, 20 mm height

- Hub outer diameter: 60 mm
- Number of fins: 6, parallel chord arrangement
- Fin height: 80 mm (vertical)
- Fin taper: 5.84 mm thickness at root, 4.22 mm at tip, 5 degree taper angle
- Chord lengths: 51.99 mm (outermost pair), 98.94 mm (middle pair), 117.38 mm (innermost pair)
- Fin separation: 15.60 mm uniform
- Total fin volume: 215.99 cm^3
- Perforation diameter: 3 mm circular, staggered dual-row
- Perforation row heights: 20 mm and 50 mm from hub top face
- Perforations per fin: 4 (outermost), 10 (middle), 12 (innermost) [52 total]
- Material removed by perforations: 1.85 cm^3 (0.86% of total fin volume)
- Heat input: 100 W surface source at copper base bottom face
- Convection coefficient: 15 W/m^2K uniform, all exposed surfaces
- CFD inlet velocity: 3 m/s
- CFD fluid: air at 300 K, 101325 Pa

Phase 1 established baseline thermal performance using FEA - temperature distribution, heat flux, and fin efficiency under 100W heat input with natural convection.

Phase 2 introduced four targeted investigations the source paper omits entirely. Perforation geometry study: staggered dual-row circular perforations reduced thermal resistance by 4.3% while removing only 0.86% of fin volume.

- ❖ Conjugate (partial) CFD: Flow Simulation at 3 m/s revealed actual convection coefficient of 25.04 W/m^2K against the classically assumed 15 W/m^2K - a 67% underestimation by uniform-h theory.
- ❖ Thermo-structural coupling: thermal gradient generates 22 MPa fin root stress (FOS = 12.5 for Al 6061). Neither Abbas et al nor any of its 48 references computes structural consequences of thermal gradient.
- ❖ Material selection map: Magnesium AZ31, recommended by the paper as thermally optimal, carries 27% lower structural safety margin than Al 6061 under identical loading - a trade-off invisible to purely thermal analysis.
- ❖ A thermal-structural merit index Q/(Volume x sigma_max) ranks perforated geometry above plain across all metrics.

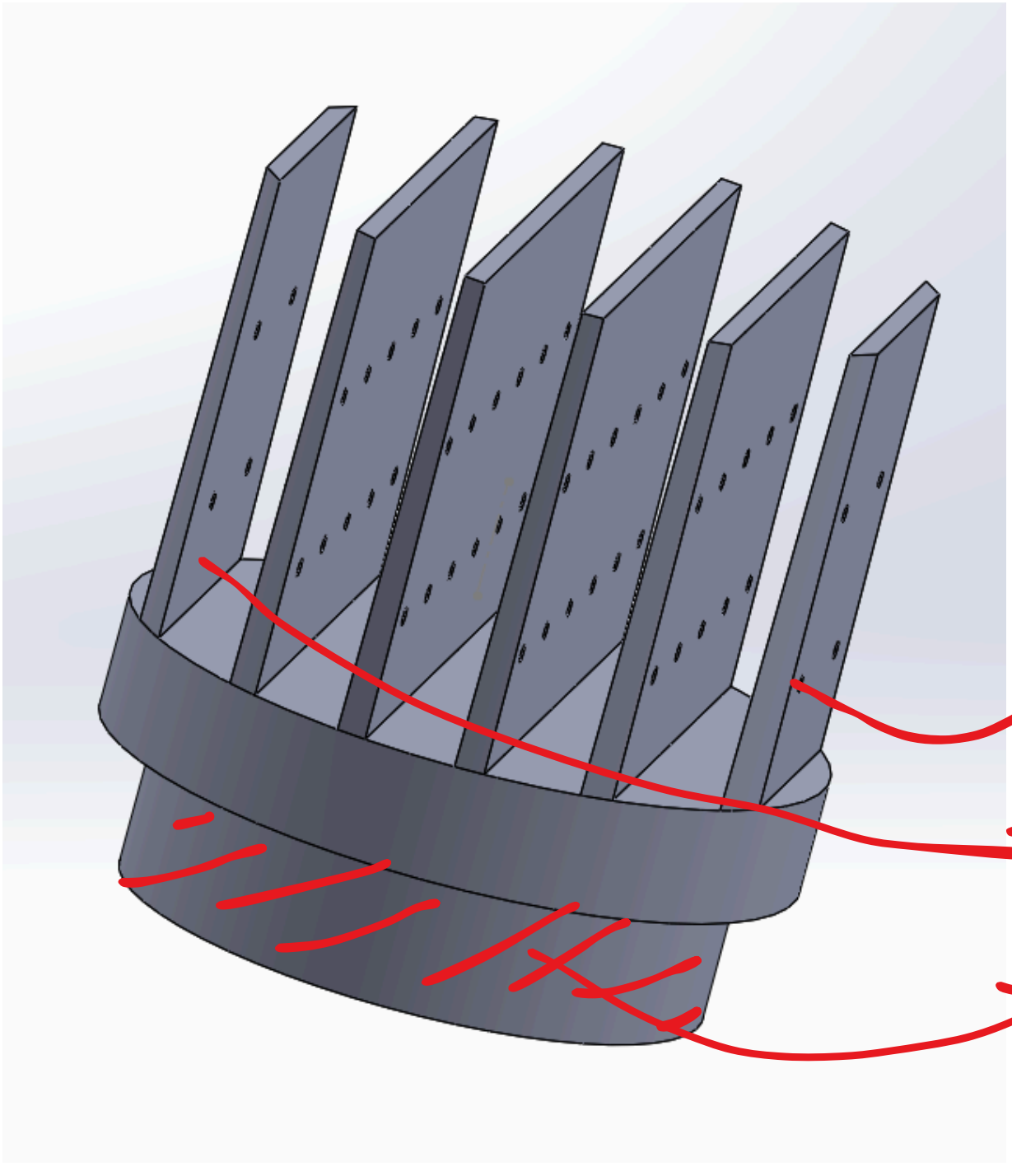
Tools: SolidWorks Simulation (thermal FEA, static structural), SolidWorks Flow Simulation.

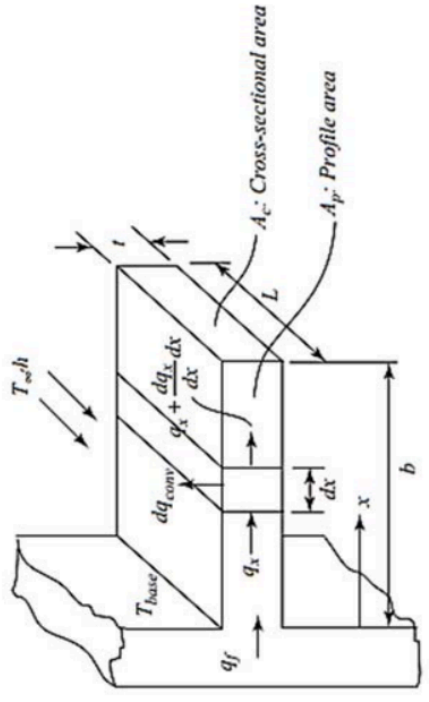
goal 1: heat transfer rate

Iteration	CPUTime	PhysTime	Travels	Value	AvValue	MinValue	MaxValue	Delta	Criteria	PrevAvRefValue	Progress		
1	23	0	0.0141720402	2.46372079e-05	2.46372079e-05	2.46372079e-05	2.46372079e-05	0	0	0	0	0	0
2	27	0	0.0283440805	0.00267421062	0.00134942391	2.46372079e-05	0.00267421062	0.00132478671		0	0	0	0
3	32	0	0.0425161207	0.00236320004	0.00168734929	2.46372079e-05	0.00267421062	0.00166271208		0	0	0	0
4	38	0	0.056688161	0.00299412009	0.00201404199	2.46372079e-05	0.00299412009	0.00198940478		0	0	0	0
5	44	0	0.0708602012	0.00542777709	0.00269678901	2.46372079e-05	0.00542777709	0.0026721518		0	0	0	0
6	49	0	0.0850322415	0.0134693295	0.00449221242	2.46372079e-05	0.0134693295	0.00446757521		0	0	0	0
7	54	0	0.0992042817	0.0398717163	0.00954642726	2.46372079e-05	0.0398717163	0.00952179005		0	0	0	0
8	59	0	0.113376322	0.0915211415	0.0197932665	2.46372079e-05	0.0915211415	0.0197686293		0	0	0	0
9	66	0	0.127548362	0.222596118	0.0423269168	2.46372079e-05	0.222596118	0.0423022795		0	0	0	0
10	71	0	0.141720402	0.436908282	0.0817850533	2.46372079e-05	0.436908282	0.0817604161		0	0	0	0
11	75	0	0.155892443	54.3797011	5.01795924	2.46372079e-05	54.3797011	5.0179346		0	0	0	0
12	79	0	0.170064483	66.3471783	10.1287275	2.46372079e-05	66.3471783	10.1287029		0	0	0	0
13	82	0	0.184236523	82.4447572	15.691499	2.46372079e-05	82.4447572	15.6914744		0	0	0	0
14	86	0	0.198408563	84.1876286	20.5840797	2.46372079e-05	84.1876286	20.5840551		0	0	0	0
15	93	0	0.212580604	86.2437276	24.9613896	2.46372079e-05	86.2437276	24.9613649		0	0	0	0
16	99	0	0.226752644	85.7379372	28.7599238	2.46372079e-05	86.2437276	28.7598991		0	0	0	0
17	104	0	0.240924684	85.7054375	32.1096599	2.46372079e-05	86.2437276	32.1096352		0	0	0	0
18	108	0	0.255096724	85.9631136	35.1015184	2.46372079e-05	86.2437276	35.1014938		0	0	0	0
19	112	0	0.269268765	86.2716283	37.7946821	2.46372079e-05	86.2716283	37.7946575		0	0	0	0
20	114	0	0.283440805	85.7993653	40.1949163	2.46372079e-05	86.2716283	40.1948916		0	0	0	0
21	118	0	0.297612845	85.7264758	42.3630858	2.46372079e-05	86.2716283	42.3630611		0	0	0	0
22	122	0	0.311784885	84.4862902	44.2777769	2.46372079e-05	86.2716283	44.2777522		0	0	0	0
23	125	0	0.325956926	85.0357279	46.0498617	2.46372079e-05	86.2716283	46.0498371		0	0	0	0

goal 2: average heat transfer coefficient

Iteration	CPUTime	PhysTime	Travels	Value	AvValue	MinValue	MaxValue	Delta	Criteria	PrevAvRefValue	Progress		
1	23	0	0.0141720402	11251.054	11251.054	11251.054	11251.054	0	0	0	0	0	0
2	27	0	0.0283440805	38507.564	24879.309	11251.054	38507.564	13628.255		0	0	0	0
3	32	0	0.0425161207	68058.3226	39272.3135	11251.054	68058.3226	28021.2595		0	0	0	0
4	38	0	0.056688161	26722.7179	36134.9146	11251.054	68058.3226	28021.2595		0	0	0	0
5	44	0	0.0708602012	19563.5266	32820.637	11251.054	68058.3226	28021.2595		0	0	0	0
6	49	0	0.0850322415	15662.5594	29960.9574	11251.054	68058.3226	28021.2595		0	0	0	0
7	54	0	0.0992042817	7000.81513	26680.9371	7000.81513	68058.3226	28021.2595		0	0	0	0
8	59	0	0.113376322	7766.65622	24316.652	7000.81513	68058.3226	28021.2595		0	0	0	0
9	66	0	0.127548362	1804.42094	21815.293	1804.42094	68058.3226	28021.2595		0	0	0	0
10	71	0	0.141720402	561.206613	19689.8843	561.206613	68058.3226	28021.2595		0	0	0	0
11	75	0	0.155892443	148.390342	17913.3849	148.390342	68058.3226	28021.2595		0	0	0	0
12	79	0	0.170064483	61.4247337	16425.7215	61.4247337	68058.3226	28021.2595		0	0	0	0
13	82	0	0.184236523	60.6346146	15166.8687	60.6346146	68058.3226	28021.2595		0	0	0	0
14	86	0	0.198408563	56.3748892	14087.5477	56.3748892	68058.3226	28021.2595		0	0	0	0
15	93	0	0.212580604	53.7457535	13151.9609	53.7457535	68058.3226	28021.2595		0	0	0	0
16	99	0	0.226752644	49.6960795	12333.0694	49.6960795	68058.3226	28021.2595		0	0	0	0
17	104	0	0.240924684	47.5524532	11610.3919	47.5524532	68058.3226	28021.2595		0	0	0	0
18	108	0	0.255096724	46.6530929	10967.962	46.6530929	68058.3226	28304.3516		0	0	0	0
19	112	0	0.269268765	46.042192	10393.1241	46.042192	68058.3226	28879.1894		0	0	0	0
20	114	0	0.283440805	45.0042865	9875.71809	45.0042865	68058.3226	29396.5954		0	0	0	0
21	118	0	0.297612845	43.8134594	9407.53216	43.8134594	68058.3226	29864.7814		0	0	0	0

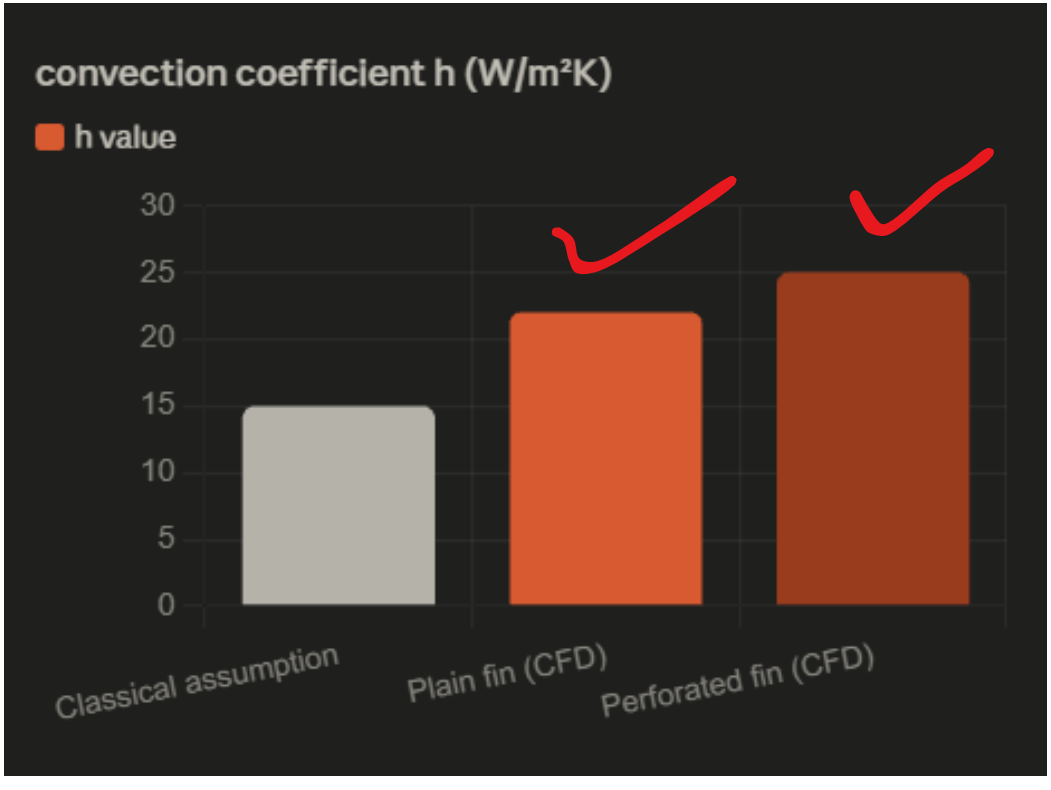




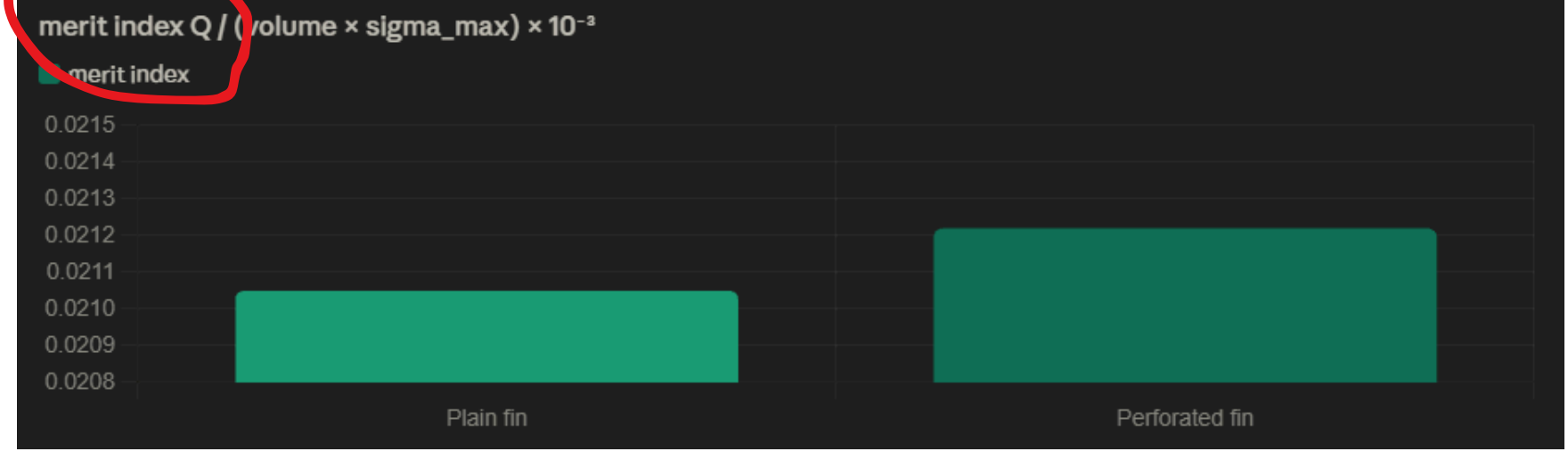
perforation holes radius:
1.5mm.
only 0.86% of volumetric
material removal

fin material:
plain carbon steel -> AL 6061
Alloy → Magnesium Alloy AZ31

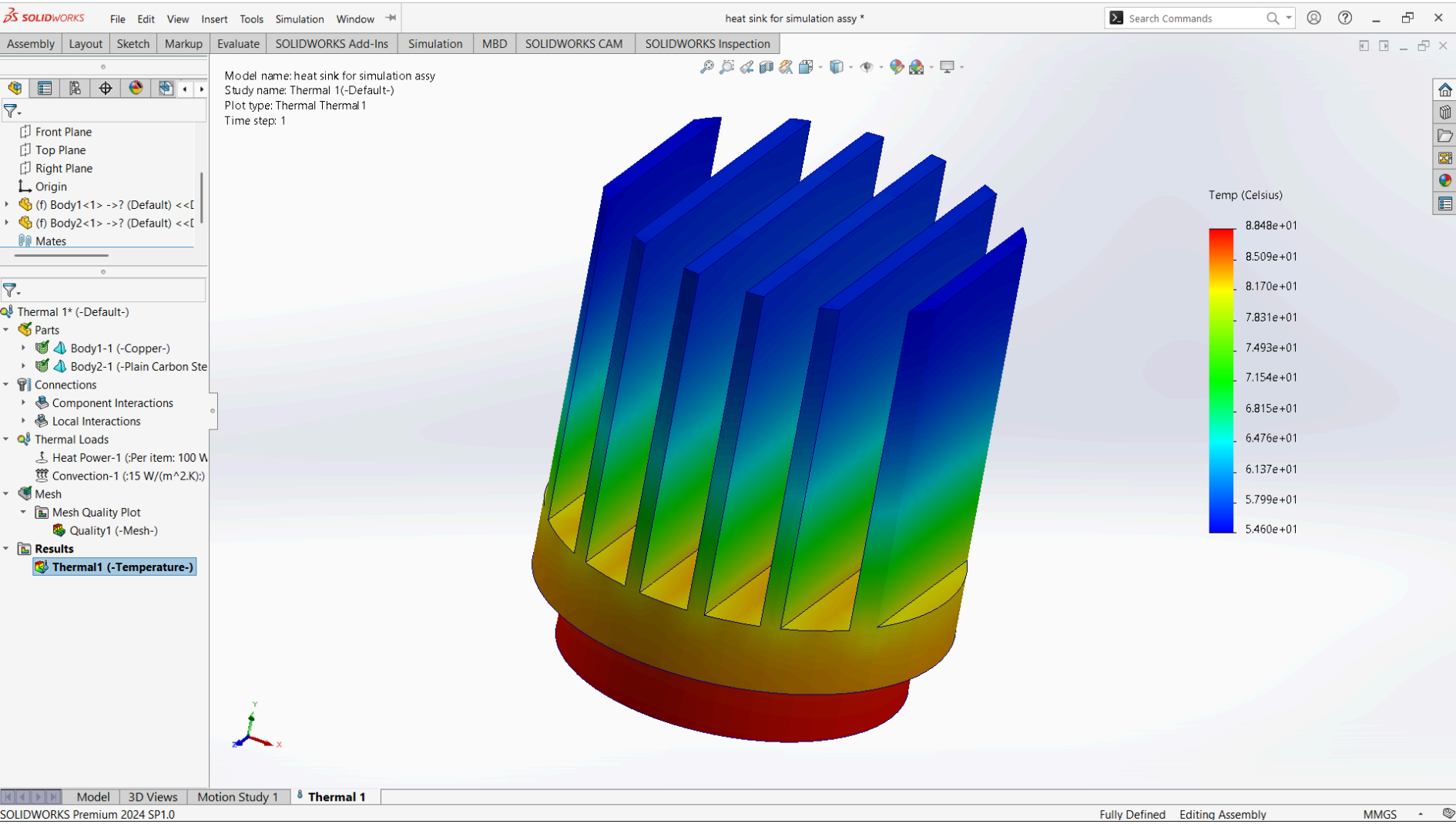
copper base kept constant



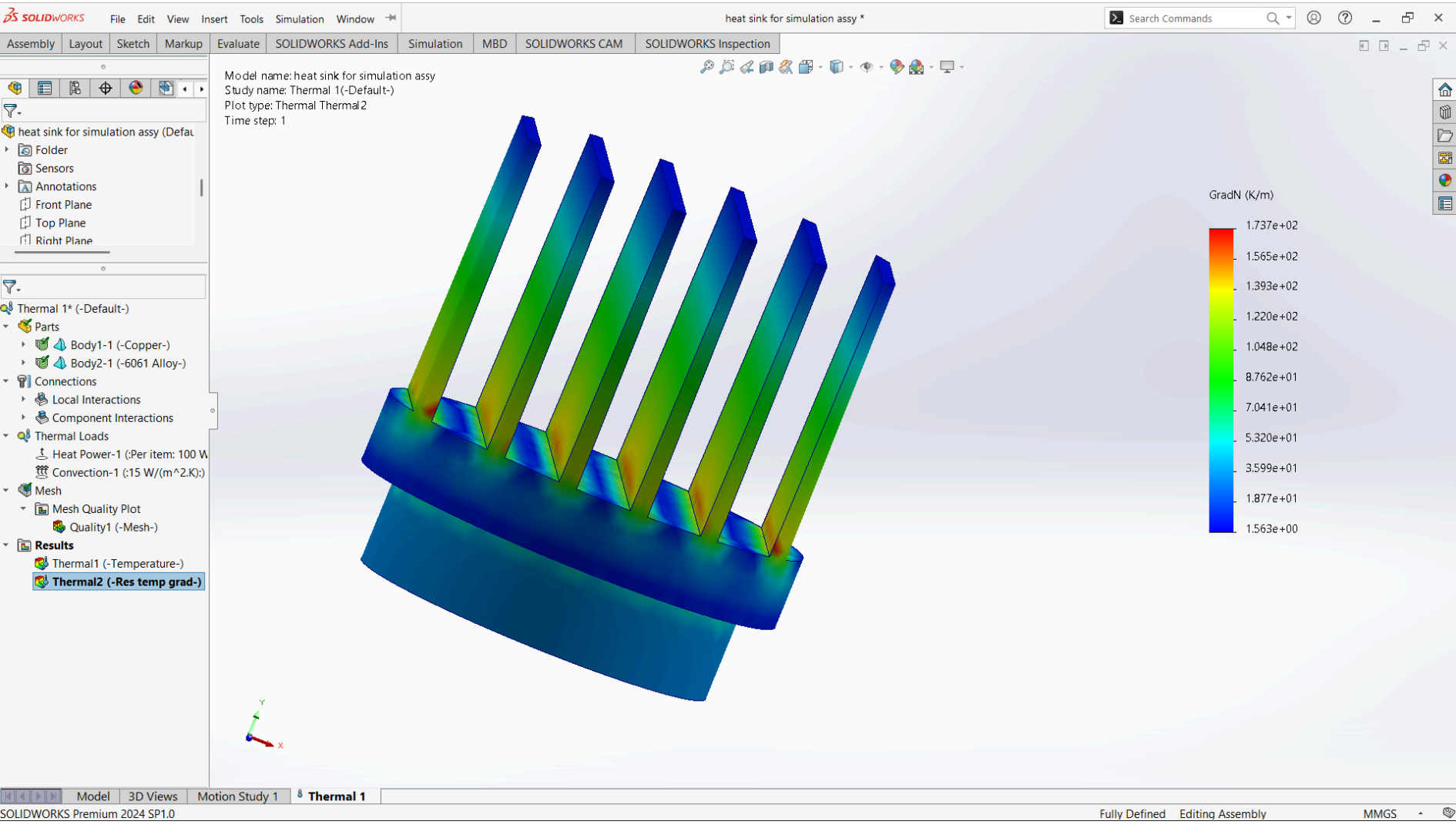
self designed metric



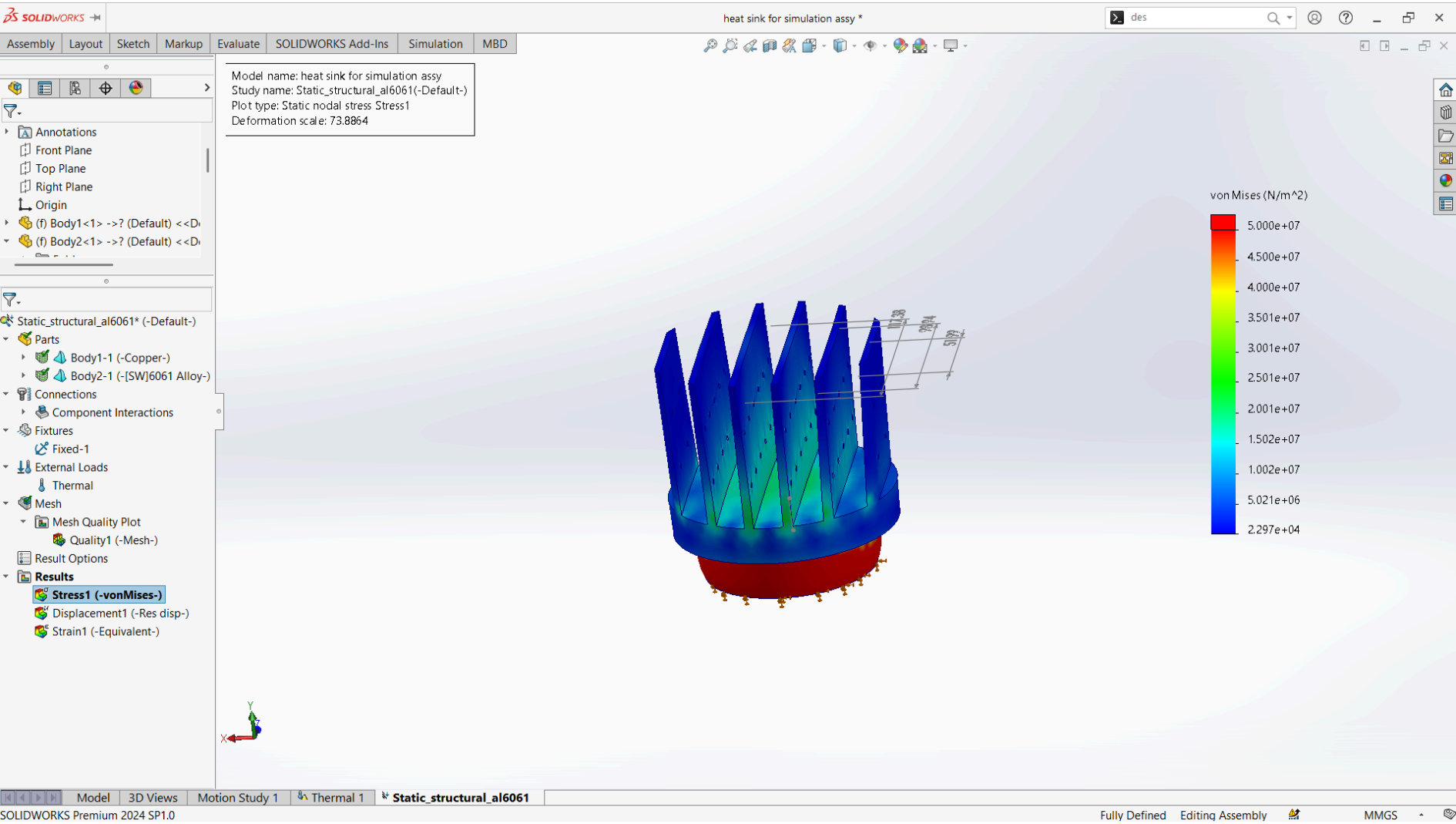
non perforated heat sink (phase 1): only temperature distribution



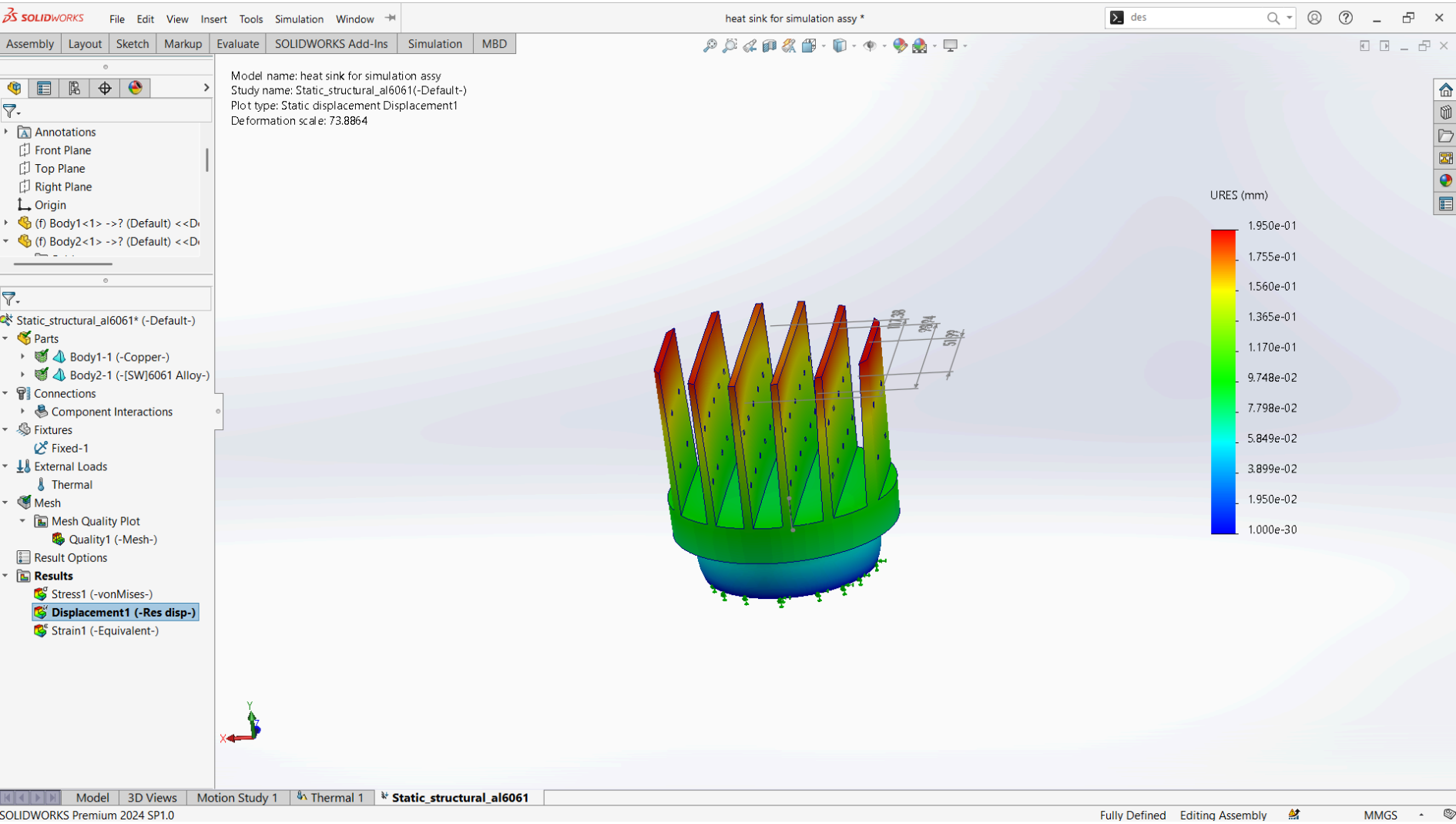
non perforated heat sink (phase 1, but tapered), res. temp gradient



perforated heat sink (phase 2), von mises stress



perforated heat sink (phase 2), displacements



Results Summary

Model:	heat sink for simulation assy.SLDASM	
Project Directory:	C:\Users\ARNAV KUMAR\OneDrive\Documents\1	
Project Name:	rev a - 3 mps	
Configuration:	Default	
Results File:	C:\Users\ARNAV KUMAR\OneDrive\Documents\1\1.fld	
Version:	Flow Simulation 2024 / 6234	
File Type	FLD	
Iteration	71	
Physical time	0 s	
CPU time	302 s	
Total cells	76675	
Fluid cells	43915	
Solid cells	32760	
Fluid cells contacting solids	22273	
Trimmed Cells	0	
Maximum refinement level	4	
X min	-0.061 m	
X max	0.060 m	
Y min	-0.048 m	
Y max	0.117 m	
Z min	-0.080 m	
Z max	0.108 m	
X size	0.122 m	
Y size	0.165 m	
Z size	0.188 m	
High Mach number flow	No	
Time-dependent	No	
Heat Conduction in Solids	Yes	
Radiation	No	
Porous Media	No	
Internal	No	
Gravity	No	
Basic Mesh Dimensions	Nx = 8, Ny = 8, Nz = 10	
Pressure	[102227.20 Pa; 102804.39 Pa]	
Velocity	[0 m/s; 19.024 m/s]	
Temperature	[293.08 K; 349.00 K]	
Density (Fluid)	[1.03 kg/m^3; 1.22 kg/m^3]	
Reference pressure	101325.00 Pa	
Calculation warnings:		
Conflict boundary conditions	Single flow condition in the closed subdomain	

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results summary of cfd
meshing parameters: globall-3
local1,2: 4,3
kept low for computer rendering