Ball Aerospace: GmAPD* Thermal Management Study

*Geiger-mode Avalanche Photodiode

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Background

- Advanced LiDAR (Light Detection and Ranging) used for tactical airborne applications sensor requires a large amount of heat removal
- Size constraints require a compact cooling solution
- System integration provides pre-existing liquid coolant of (Polyalphaoelin) PAO
- Previous generations of cooling systems have applied damaging forces to the sensor

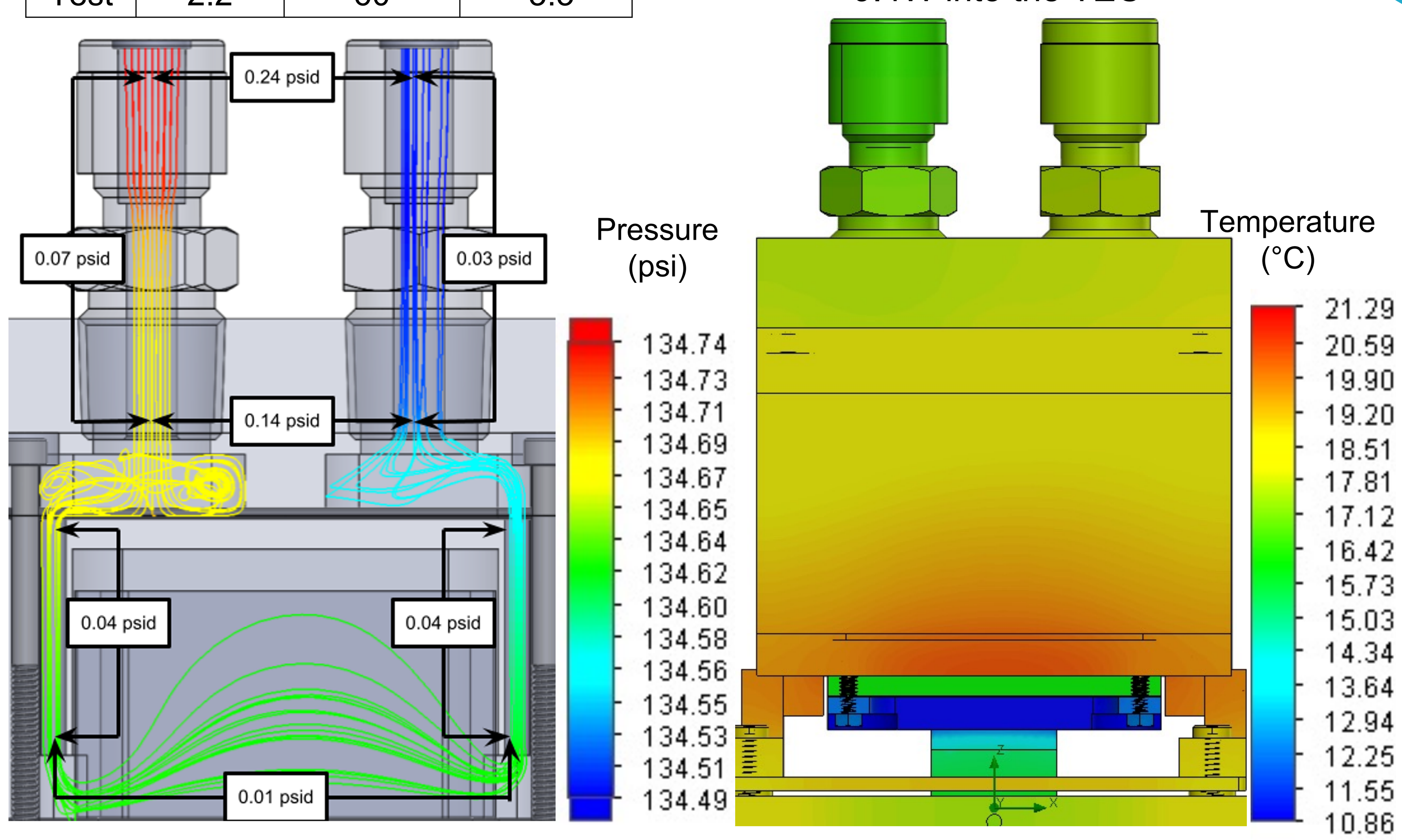
Objectives/Requirements

- ✓ 23 watts removed from 0.6”x0.6” sensor
- ✓ ≤ 15℃ must be maintained on the slug interface
- ✓ Cooling fluid provided is 15℃
- ✓ Must fit in a 2.07”x2.29”x3.68” space constraint
- ✓ Design for a factor of safety of 2 for slug torque

Simulation/Analysis

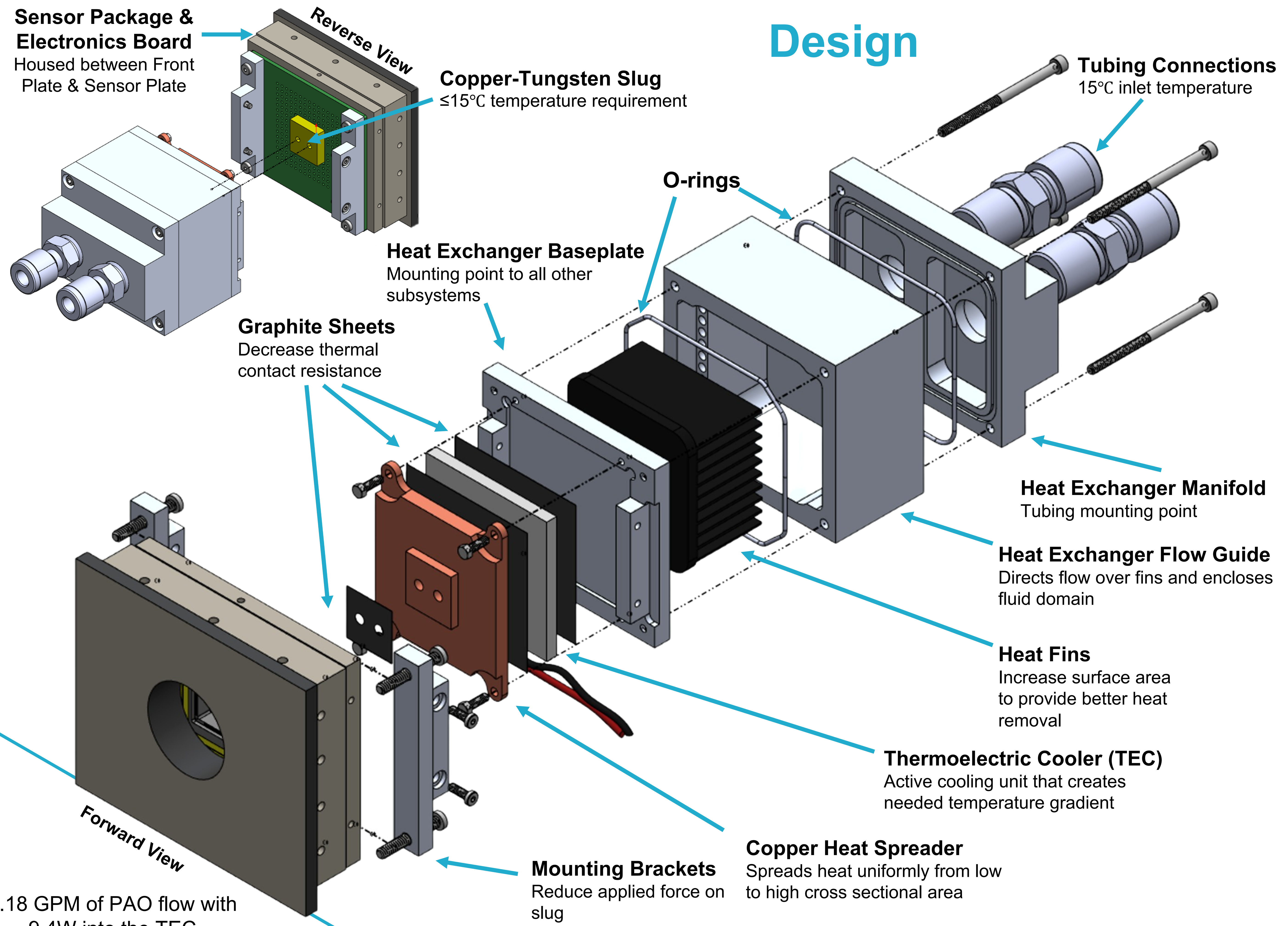
Fluid	Flowrate (gpm)	TEC Power (W)	Slug Temp (°C)
PAO	0.18	9.4	14.83
PAO	0.18	62.2	4.27
PAO	0.44	62.0	1.33
Water	2.2	57.0	-5.21
Test	2.2	60	-3.3

0.18 GPM of PAO flow with 9.4W into the TEC

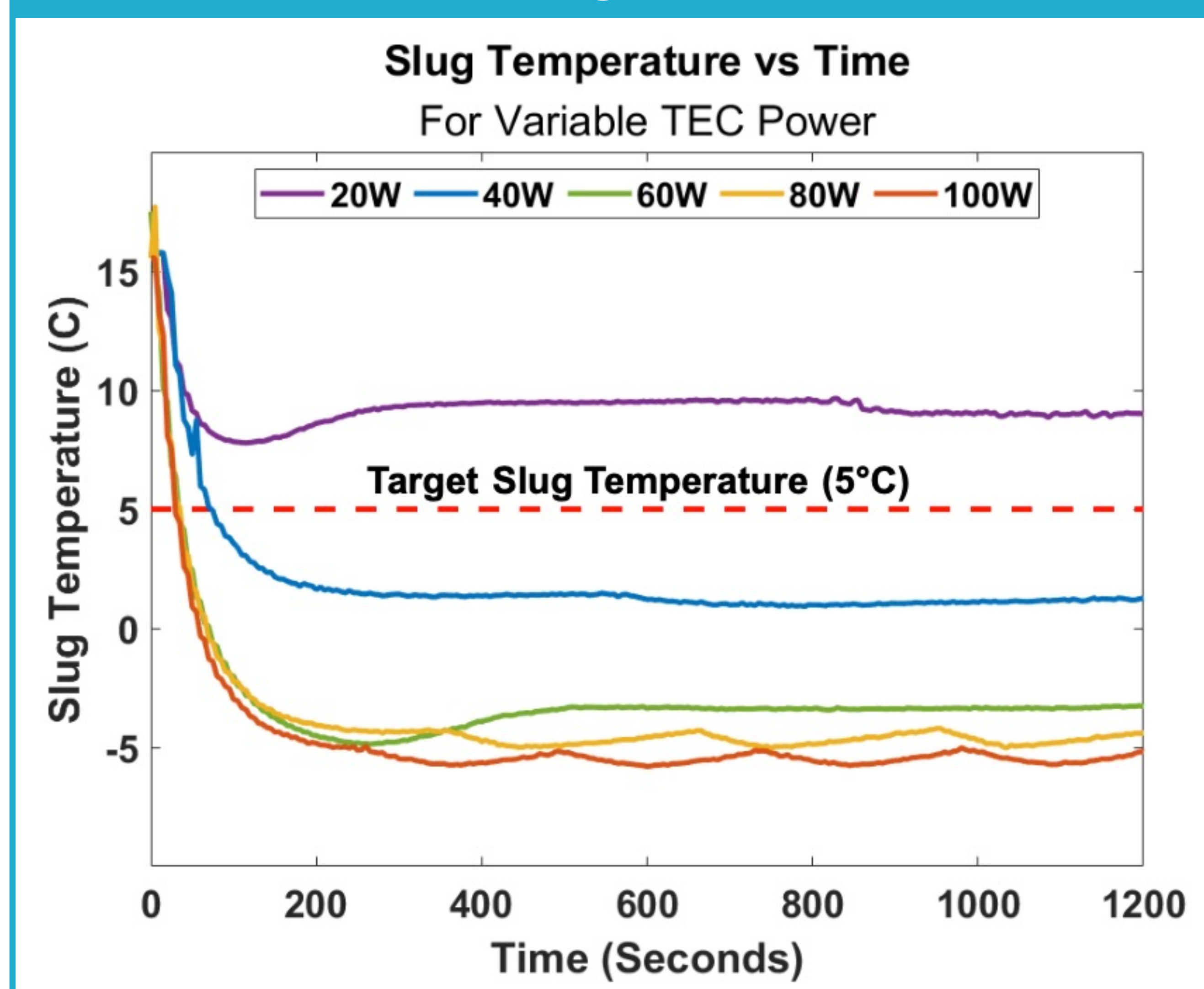


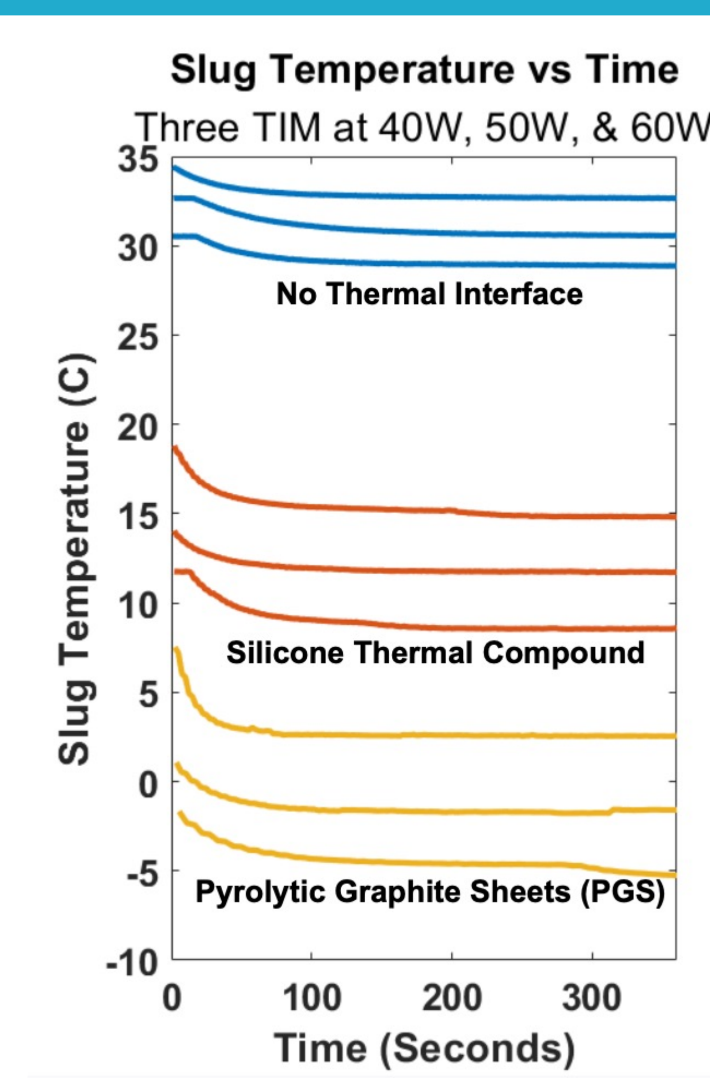
- Able to meet cooling requirements with 9.4W electrical input at minimum coolant flowrate
- Temperature difference of 10 °C between testing and consumer applications

Design



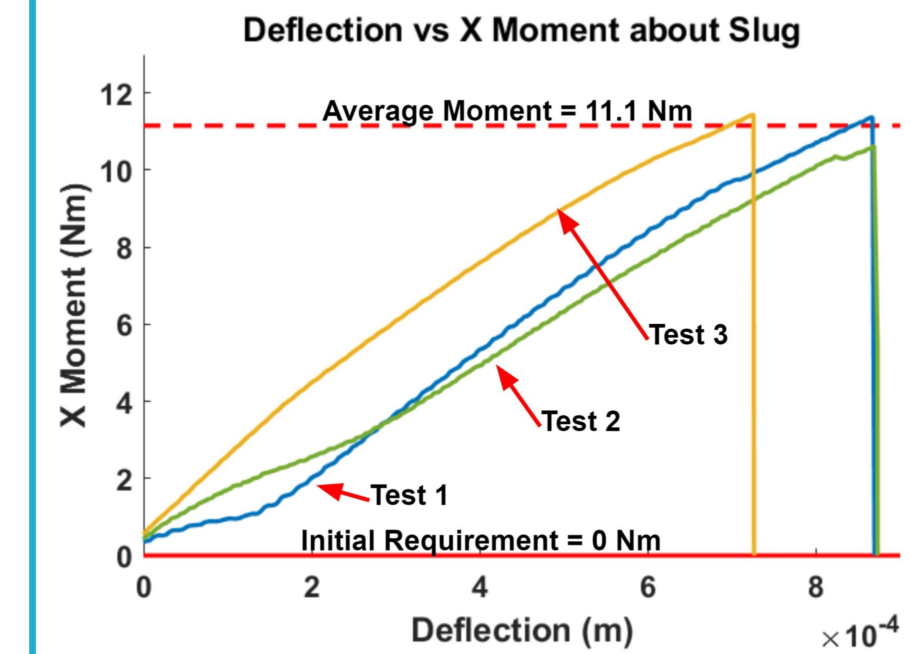
Thermal Testing and Results

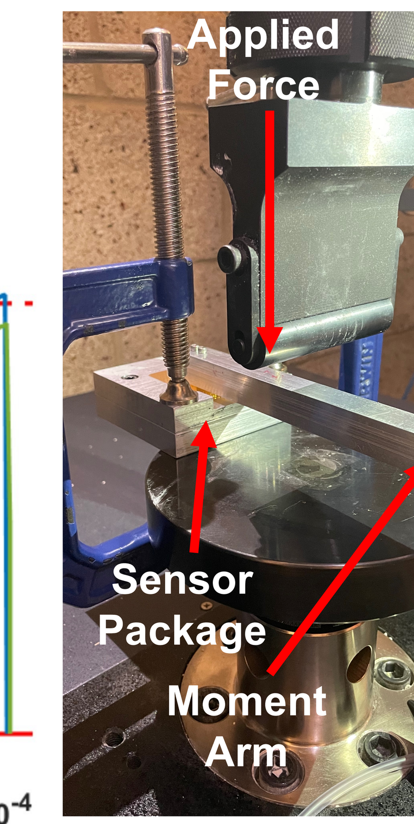




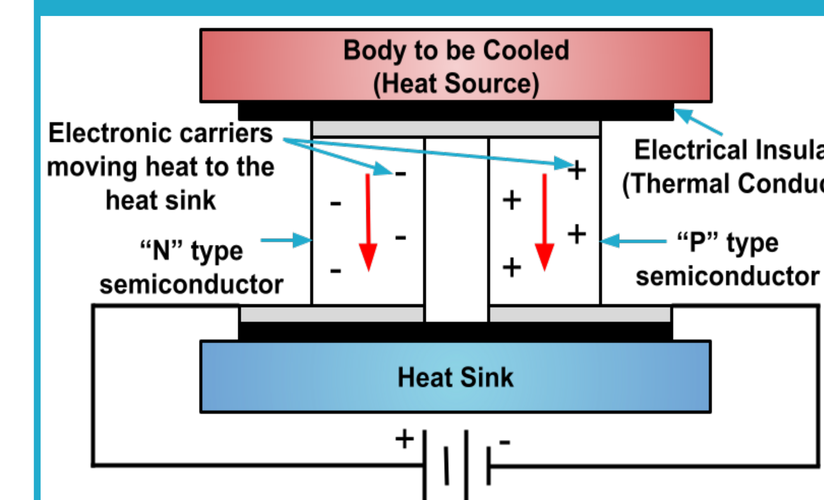
Slug Moment Failure Testing

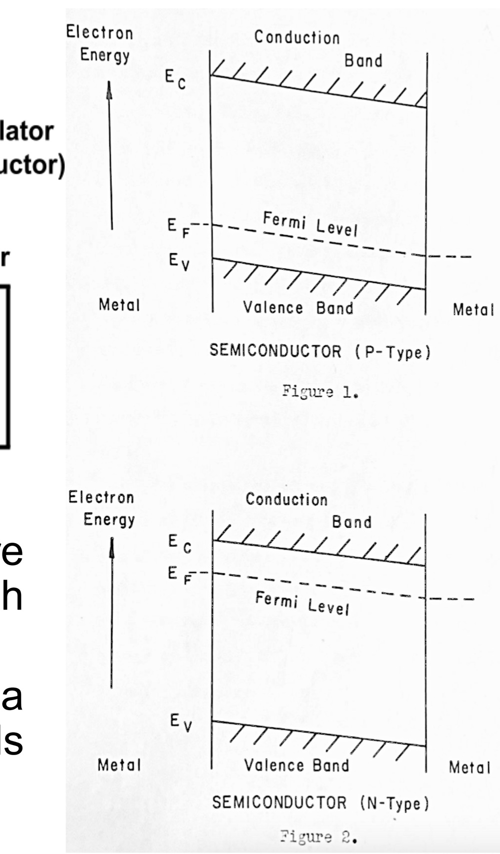
- System input of 0.7 Nm under 5G with factor of safety of 15.8
- System input of 0.8 Nm during assembly



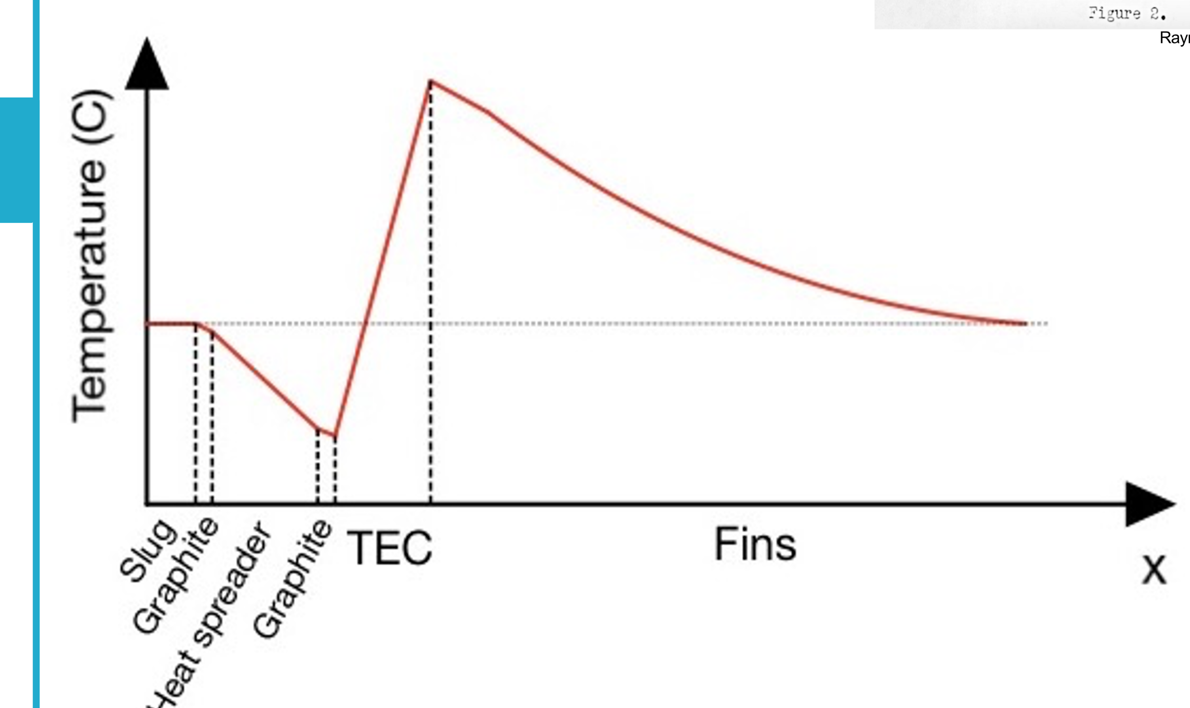


Thermoelectric Cooler (TEC)





- TEC devices create a temperature difference, driving heat flow through our system
- This is done by applying a current to a series circuit of 2 dissimilar metals with different base energies



Conclusions and Future Work

- The system removes the concern for slug breakage
- Exceeding thermal requirements means a redesign for ease of manufacturing and assembly would be beneficial
- Thermal interface materials such as the graphite sheets had the greatest effect on thermal performance
- Copper has corrosion issues
- Our correlation between PAO and water for our design proves that our design exceeds cooling requirements

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