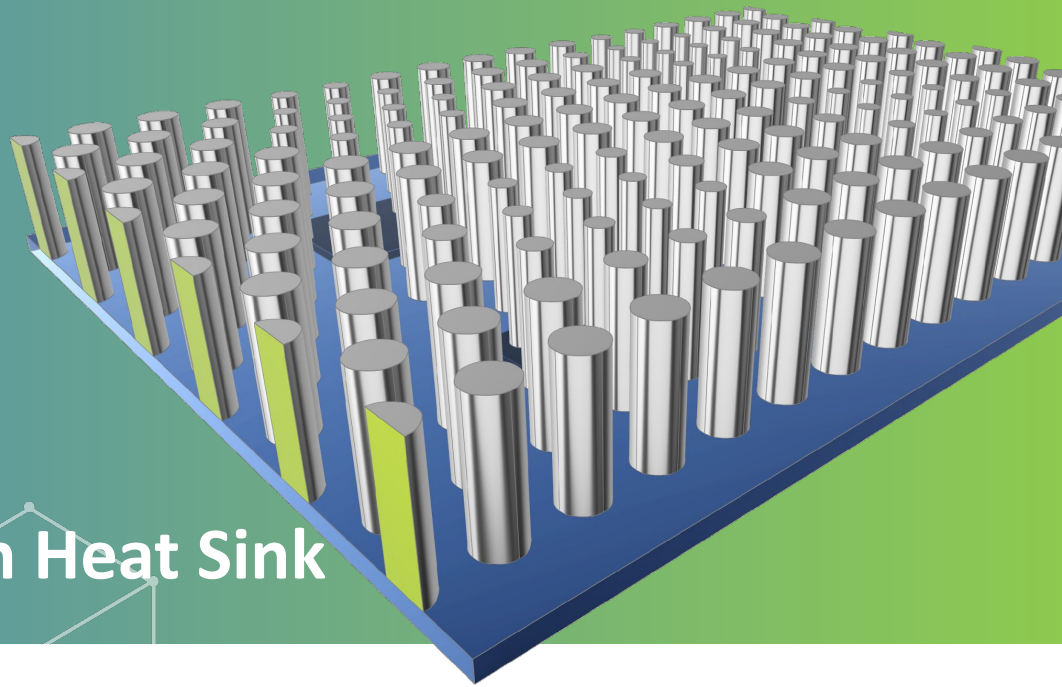


Optimization of a Pin Fin Heat Sink

using Simulation in the Cloud

SIMSCALE

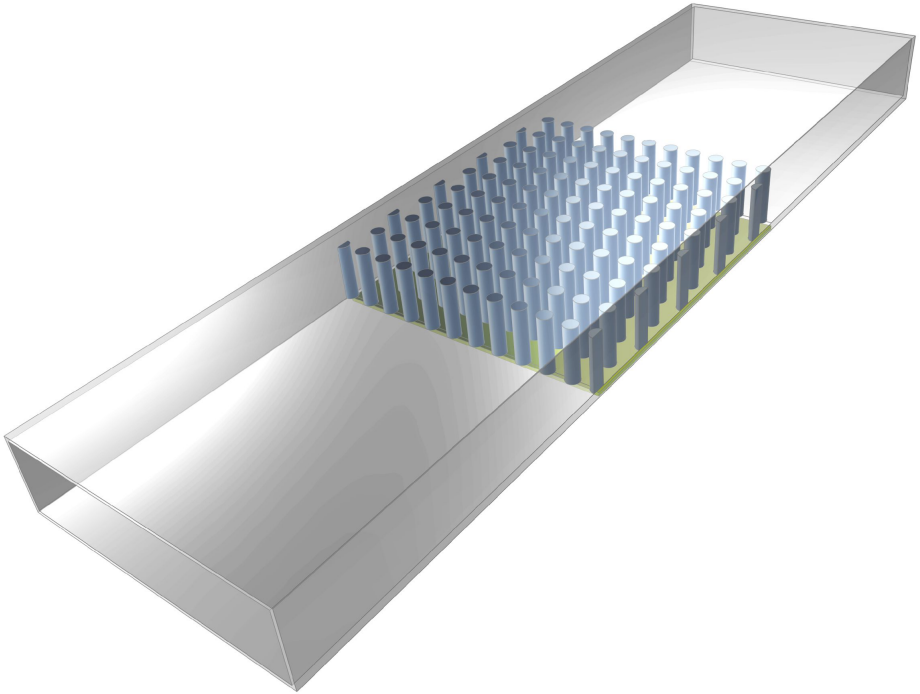
CAESES®

Optimization Task

- Pin fin heat sink for electronics cooling
- Homogeneous heat influx over base plate of pins
- Objectives
  - Reduce pressure loss across the cooling channel
  - Improve heat transfer to the fluid, therefore, reduce cooling plate temperature

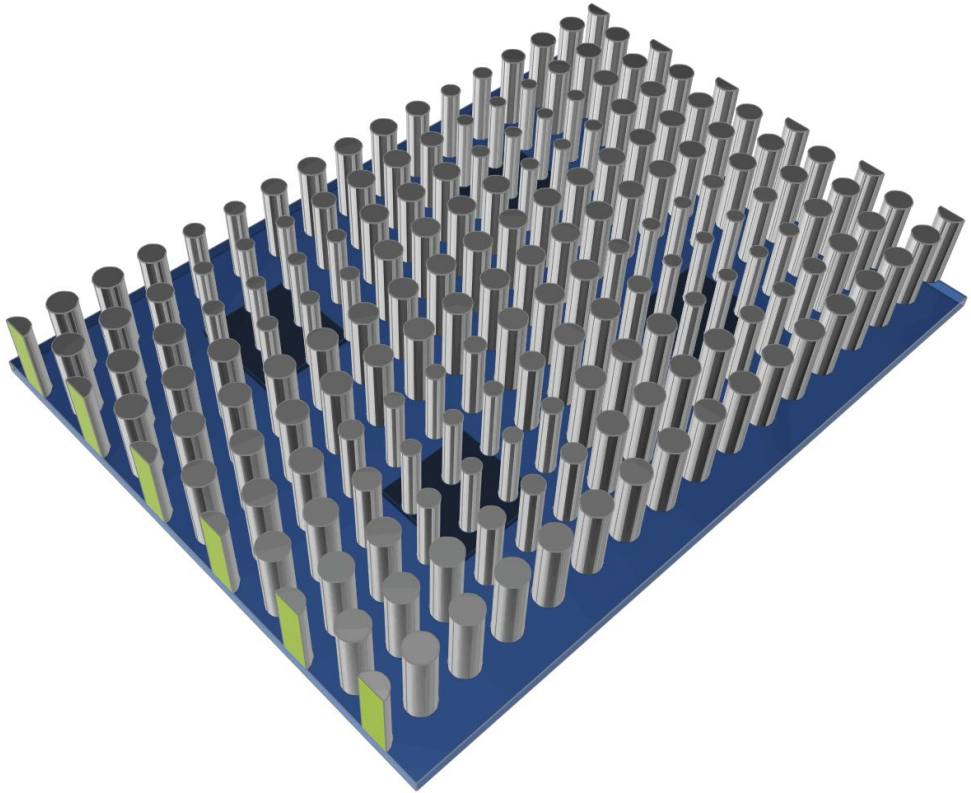
    OR

    Keep cooling plate temperature below max value



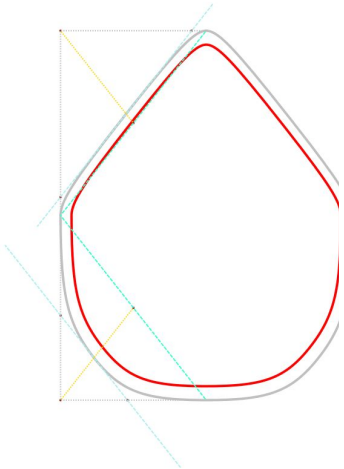
Geometry Modeling

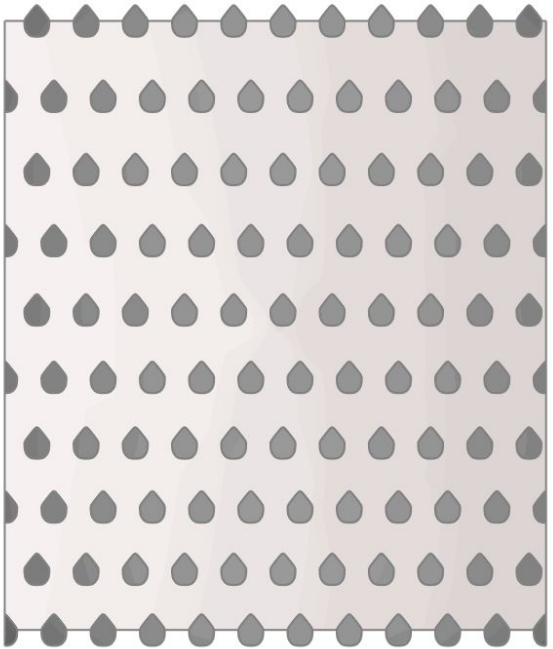
1. Modeling of pin section
2. Pin extrusion
3. Arrangement of pins
4. Auxiliary geometry for fluid and solid domains



Parameters

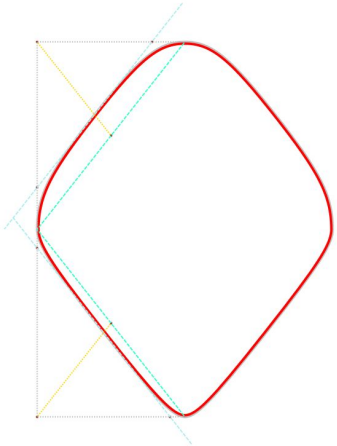
- Pin shape factor 1

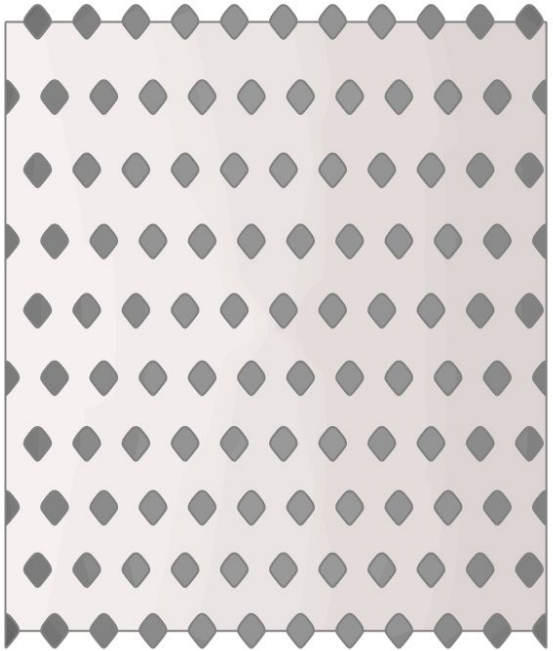




Parameters

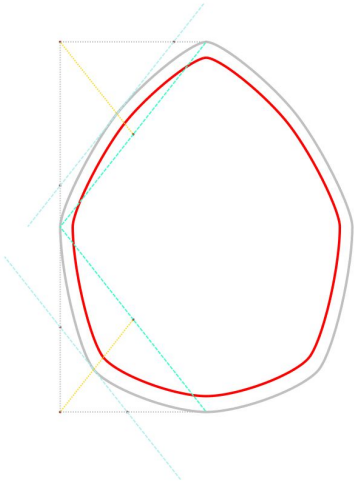
- Pin shape factor 1
- Pin shape factor 2

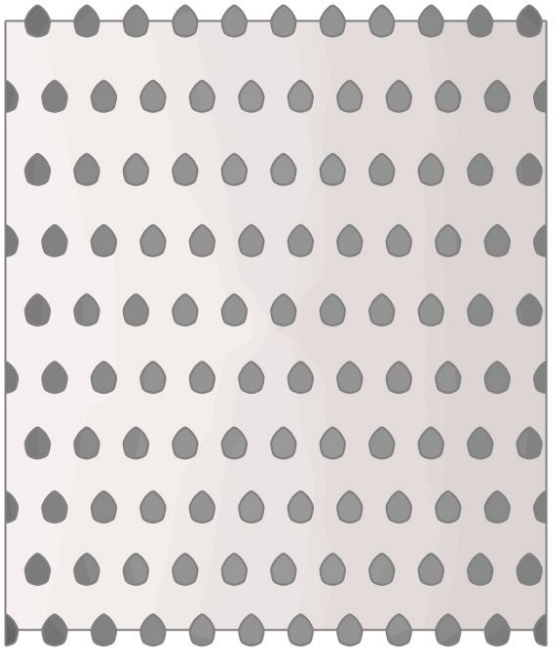




Parameters

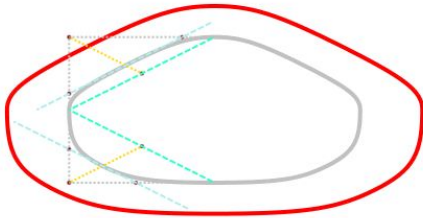
- Pin shape factor 1
- Pin shape factor 2
- Pin shape factor 3

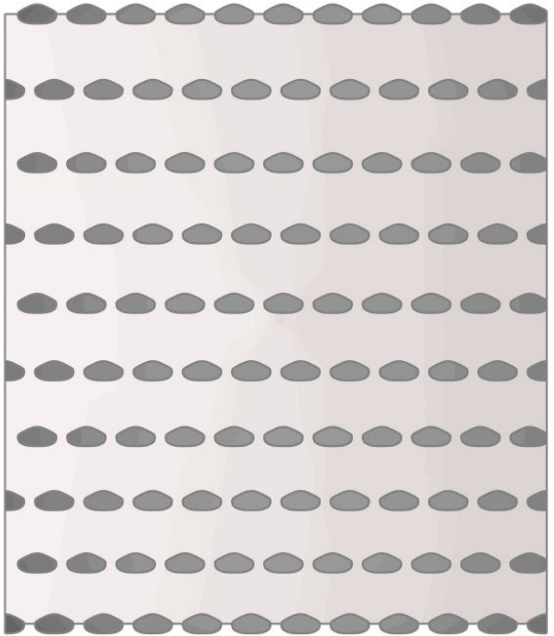




Parameters

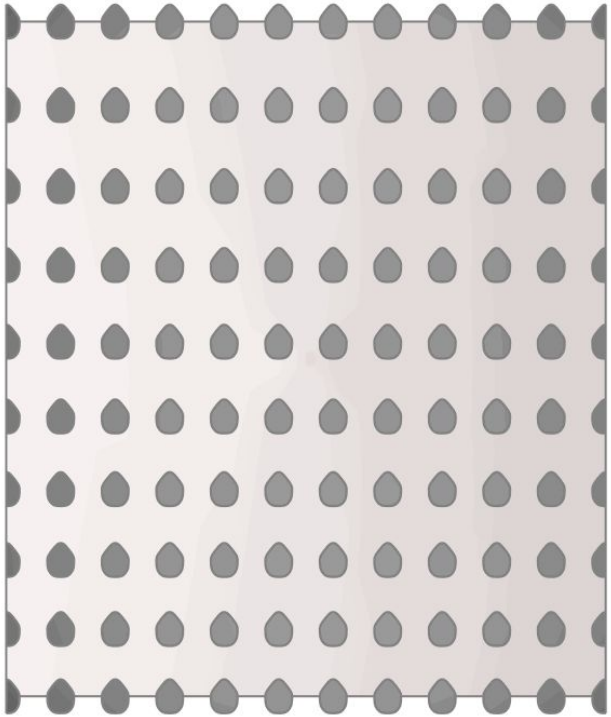
- Pin shape factor 1
- Pin shape factor 2
- Pin shape factor 3
- Pin aspect ratio





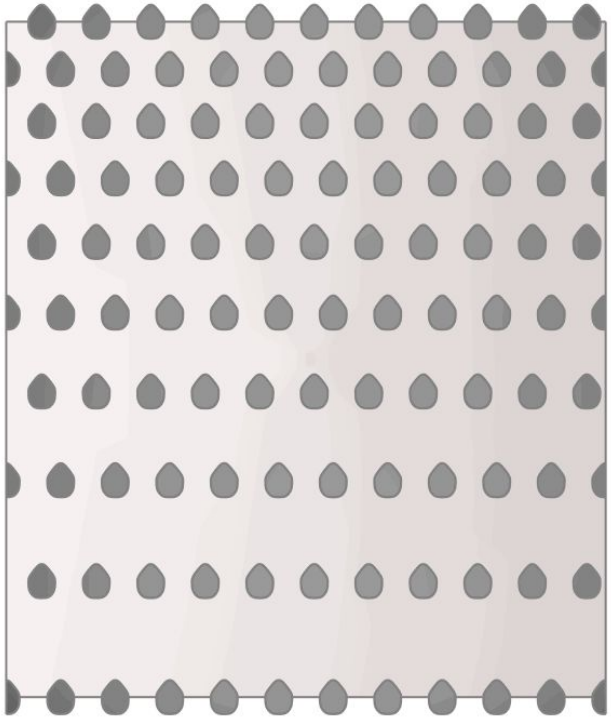
Parameters

- Pin shape factor 1
- Pin shape factor 2
- Pin shape factor 3
- Pin aspect ratio
- Side offset



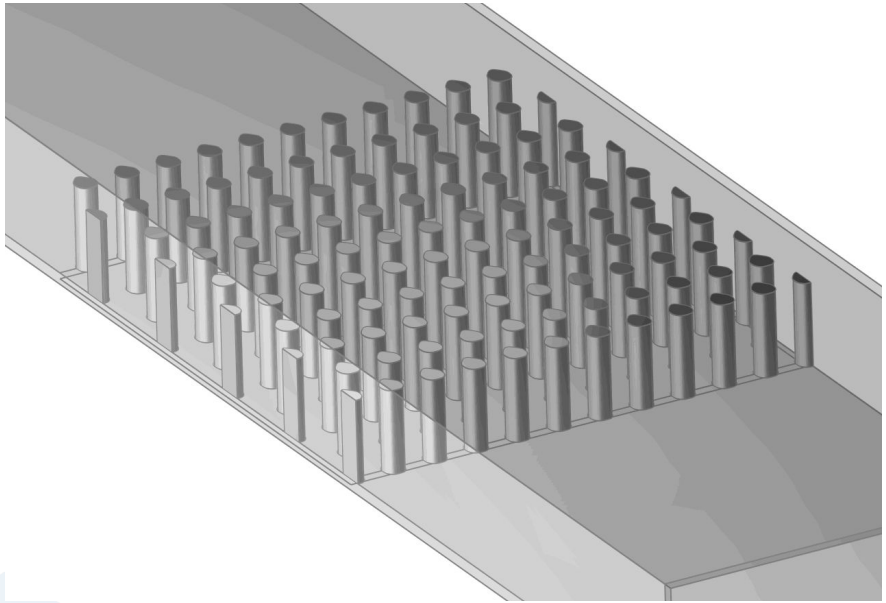
Parameters

- Pin shape factor 1
- Pin shape factor 2
- Pin shape factor 3
- Pin aspect ratio
- Side offset
- Streamwise distribution



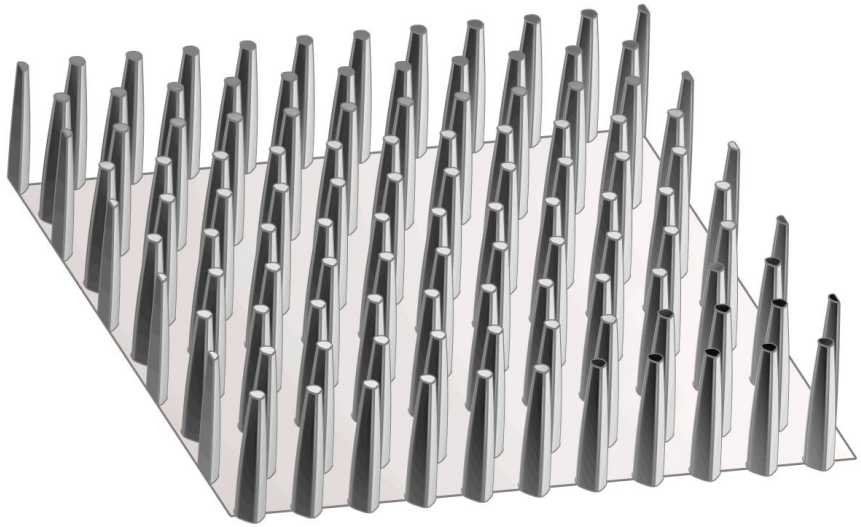
Parameters

- Pin shape factor 1
- Pin shape factor 2
- Pin shape factor 3
- Pin aspect ratio
- Side offset
- Streamwise distribution
- Pin height

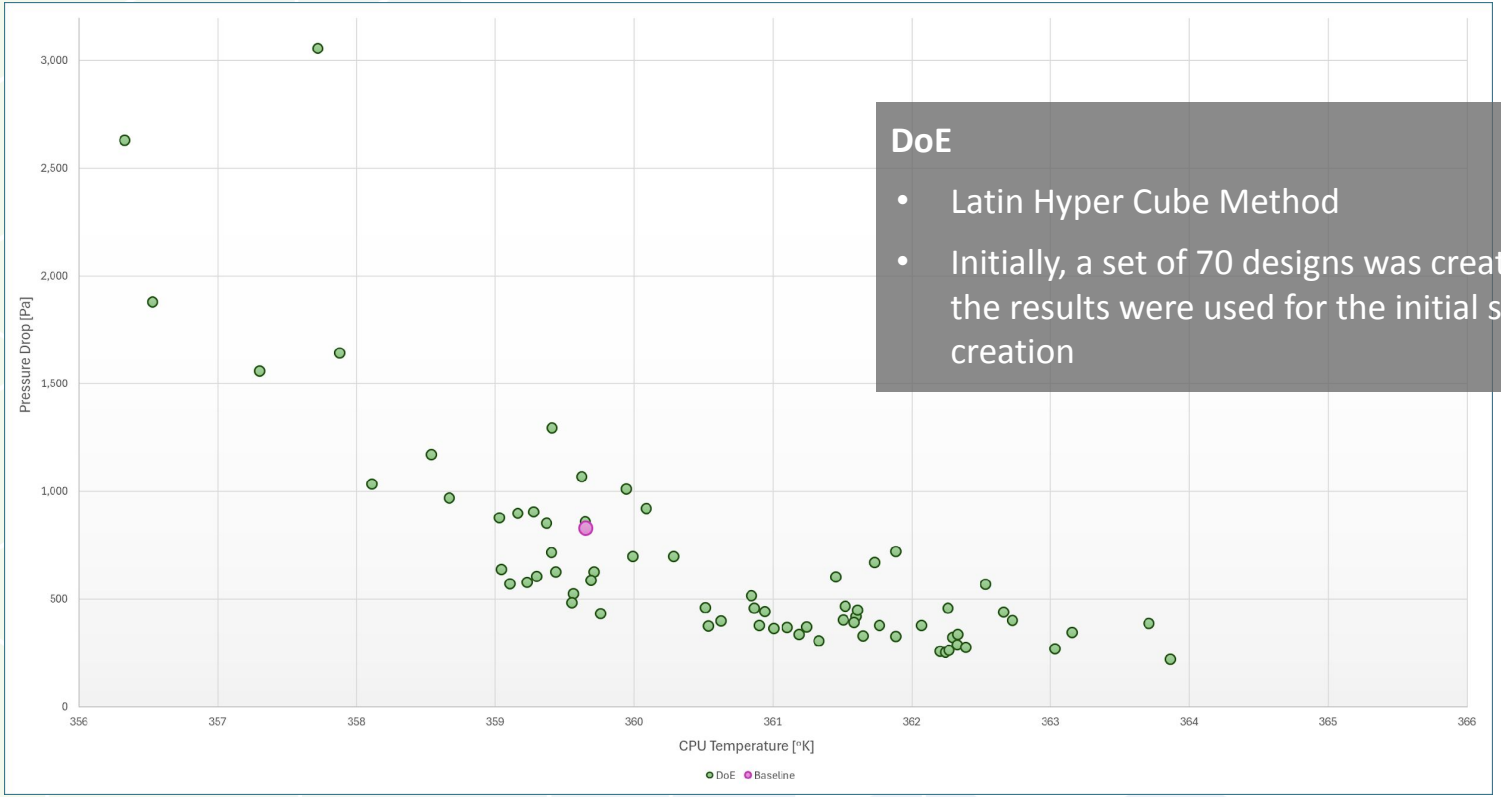


Parameters

- Pin shape factor 1
- Pin shape factor 2
- Pin shape factor 3
- Pin aspect ratio
- Side offset
- Streamwise distribution
- Pin height
- Pin taper



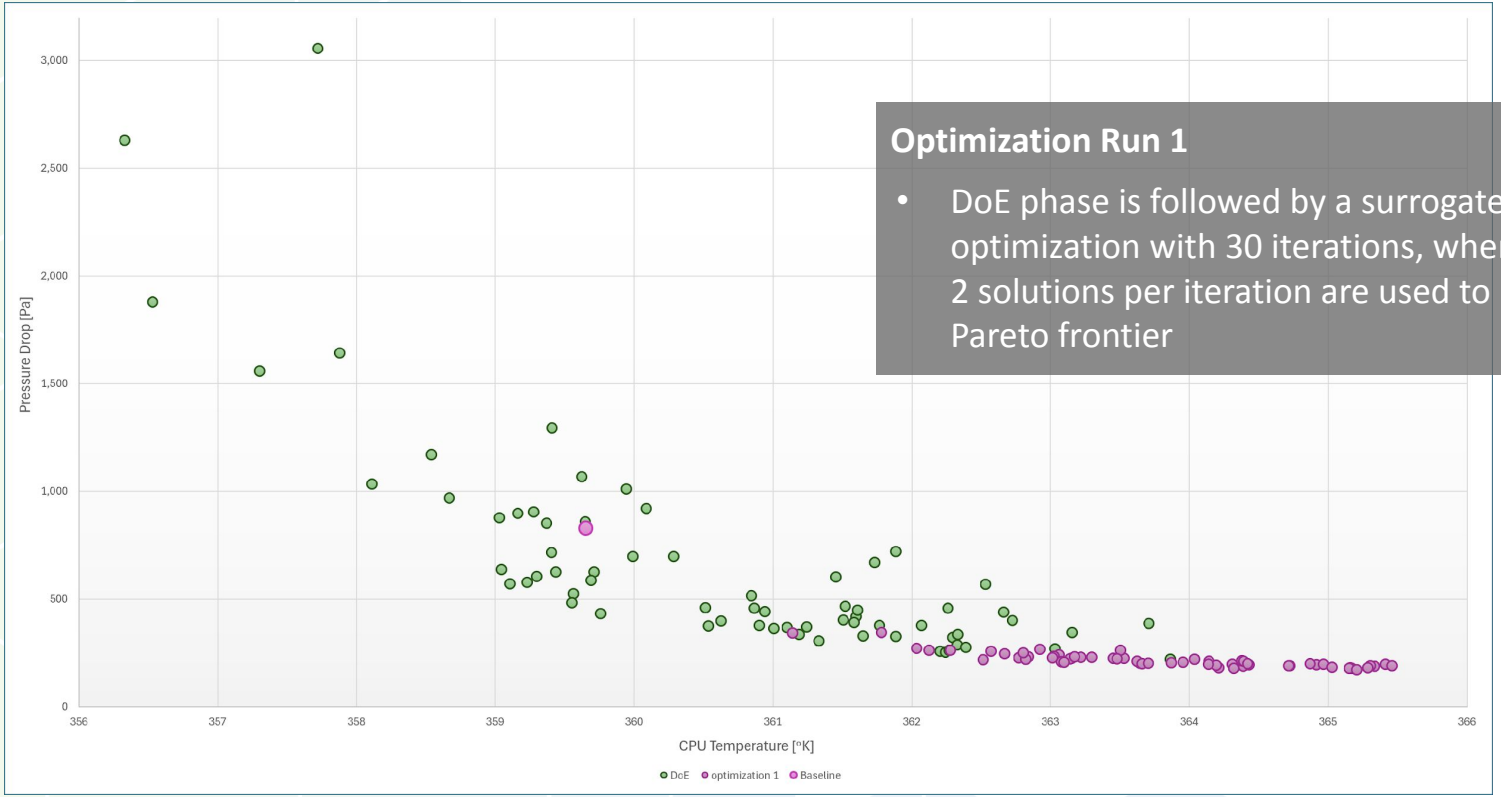
Results



DoE

- Latin Hyper Cube Method
- Initially, a set of 70 designs was created, where the results were used for the initial surrogate creation

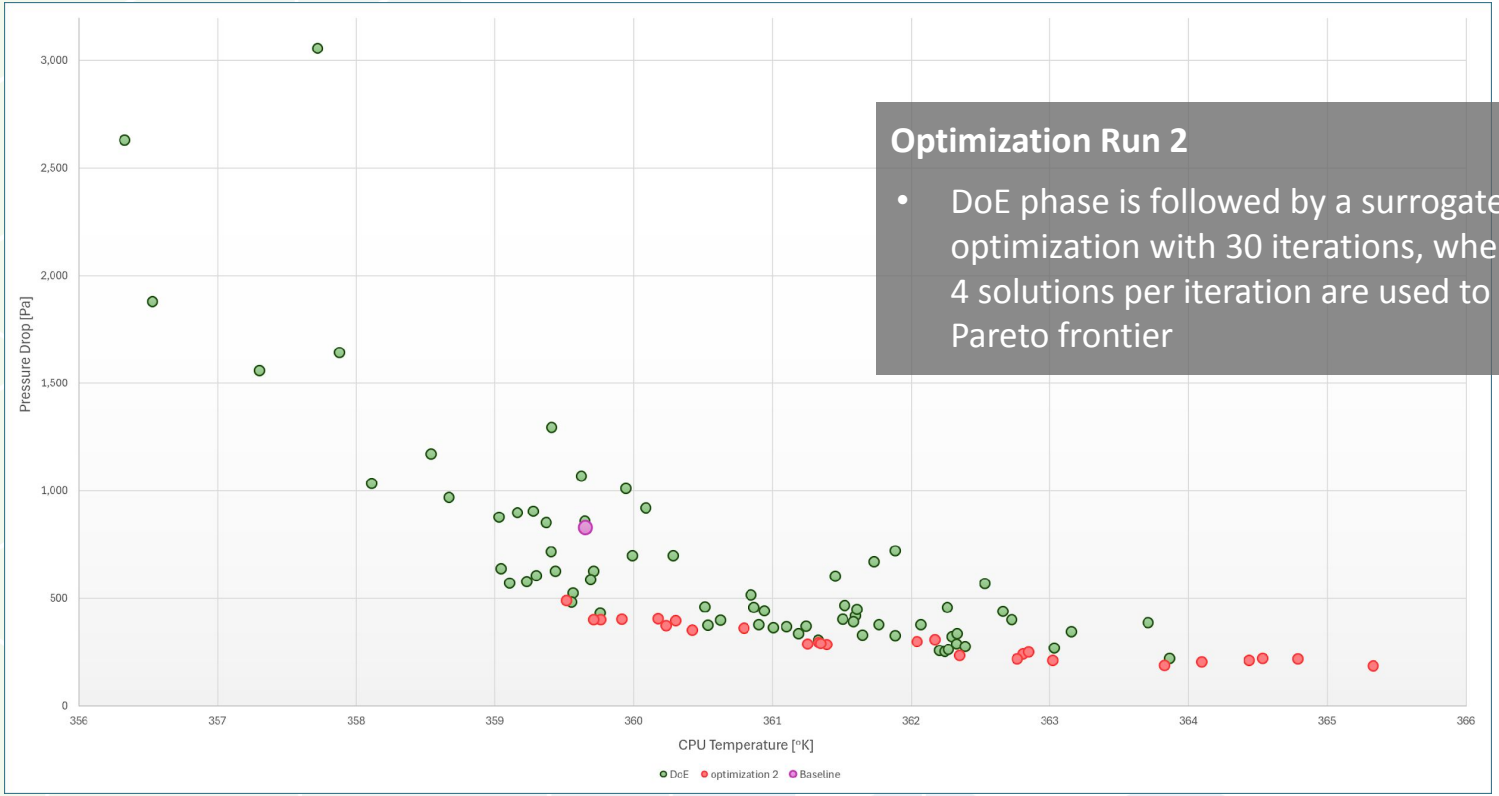
Results



Optimization Run 1

- DoE phase is followed by a surrogate assisted optimization with 30 iterations, where 2 solutions per iteration are used to update the Pareto frontier

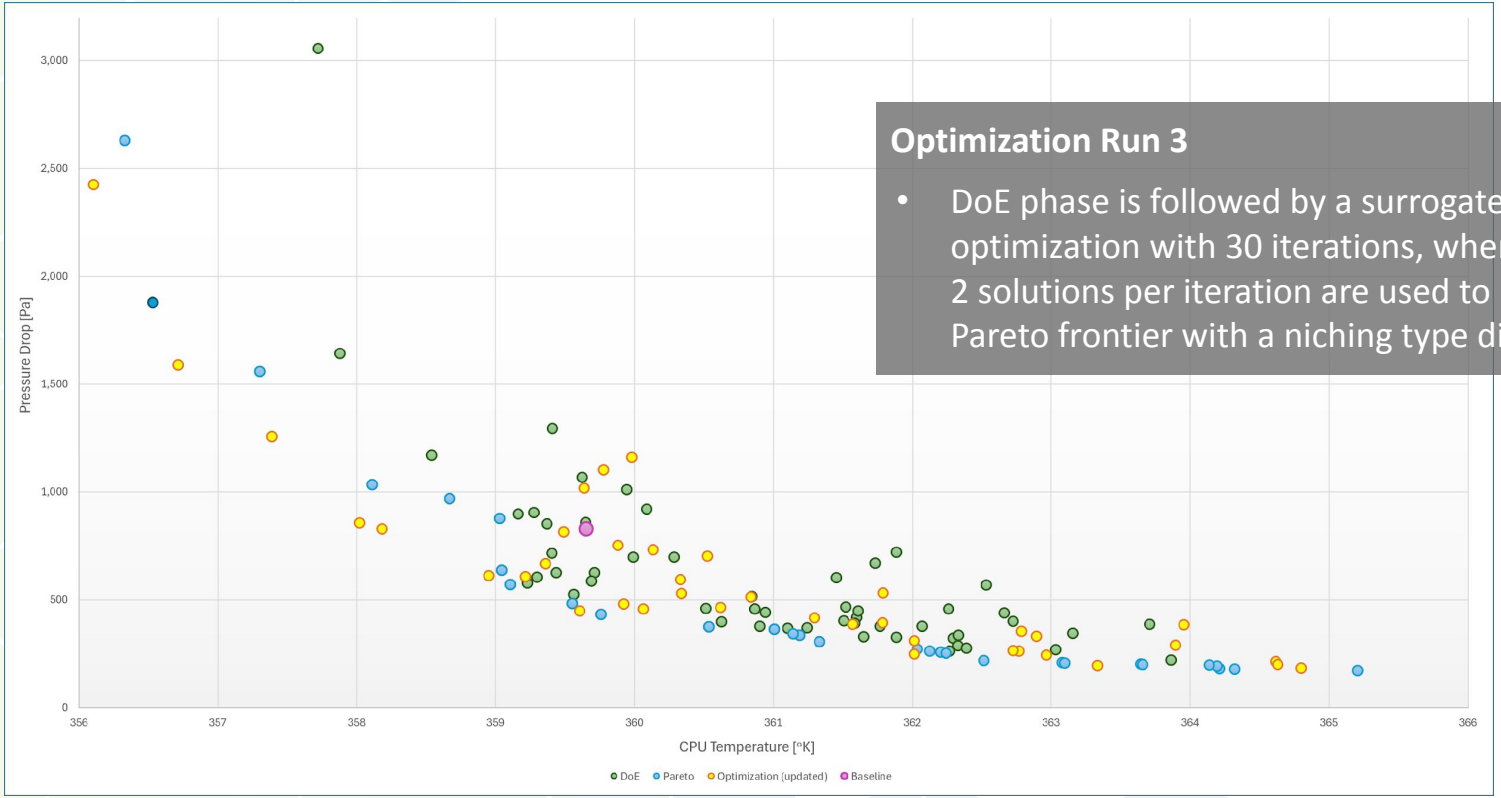
Results



Optimization Run 2

- DoE phase is followed by a surrogate assisted optimization with 30 iterations, where 4 solutions per iteration are used to update the Pareto frontier

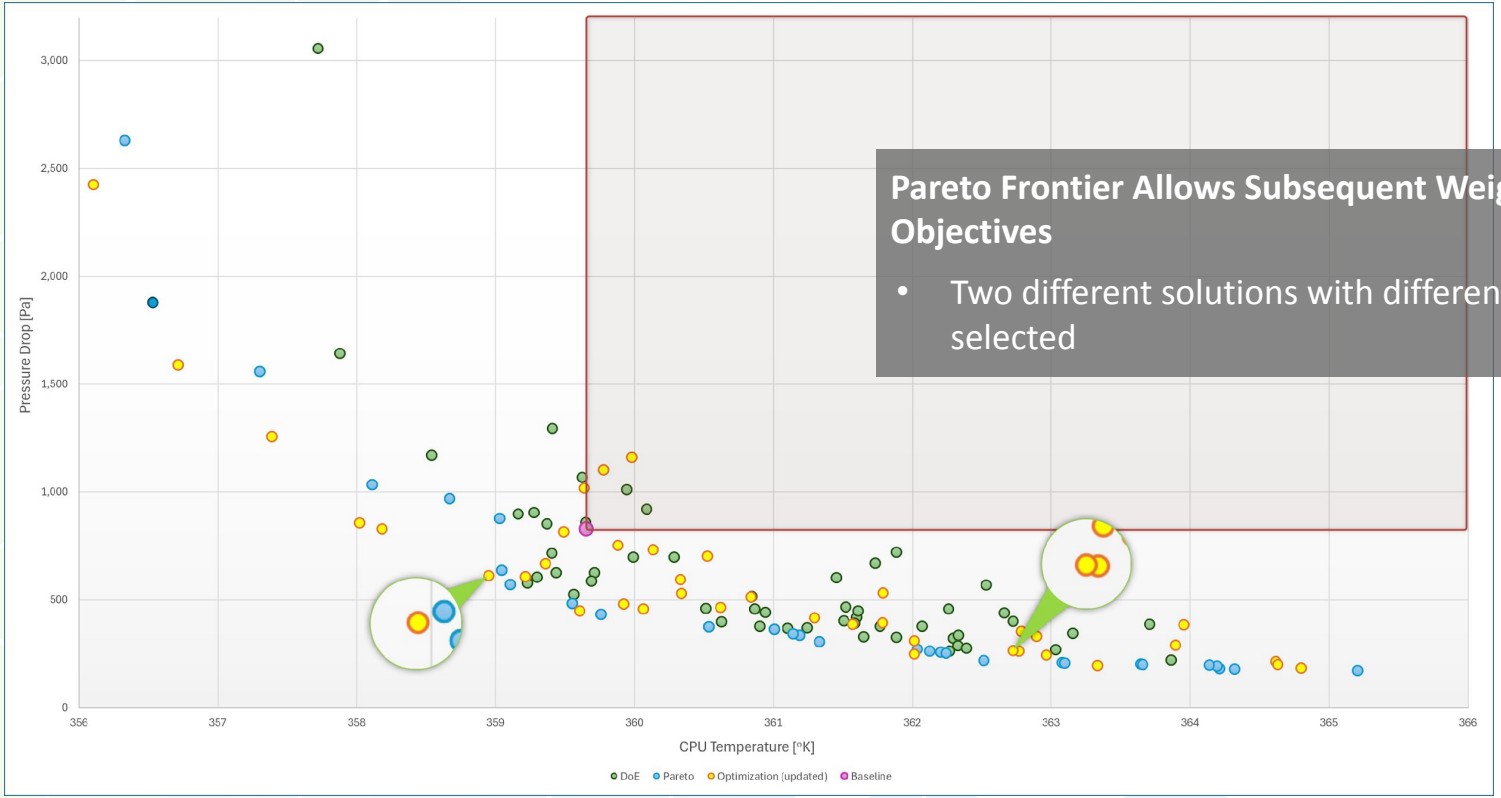
Results



Optimization Run 3

- DoE phase is followed by a surrogate assisted optimization with 30 iterations, where 2 solutions per iteration are used to update the Pareto frontier with a niching type distance of 0.5

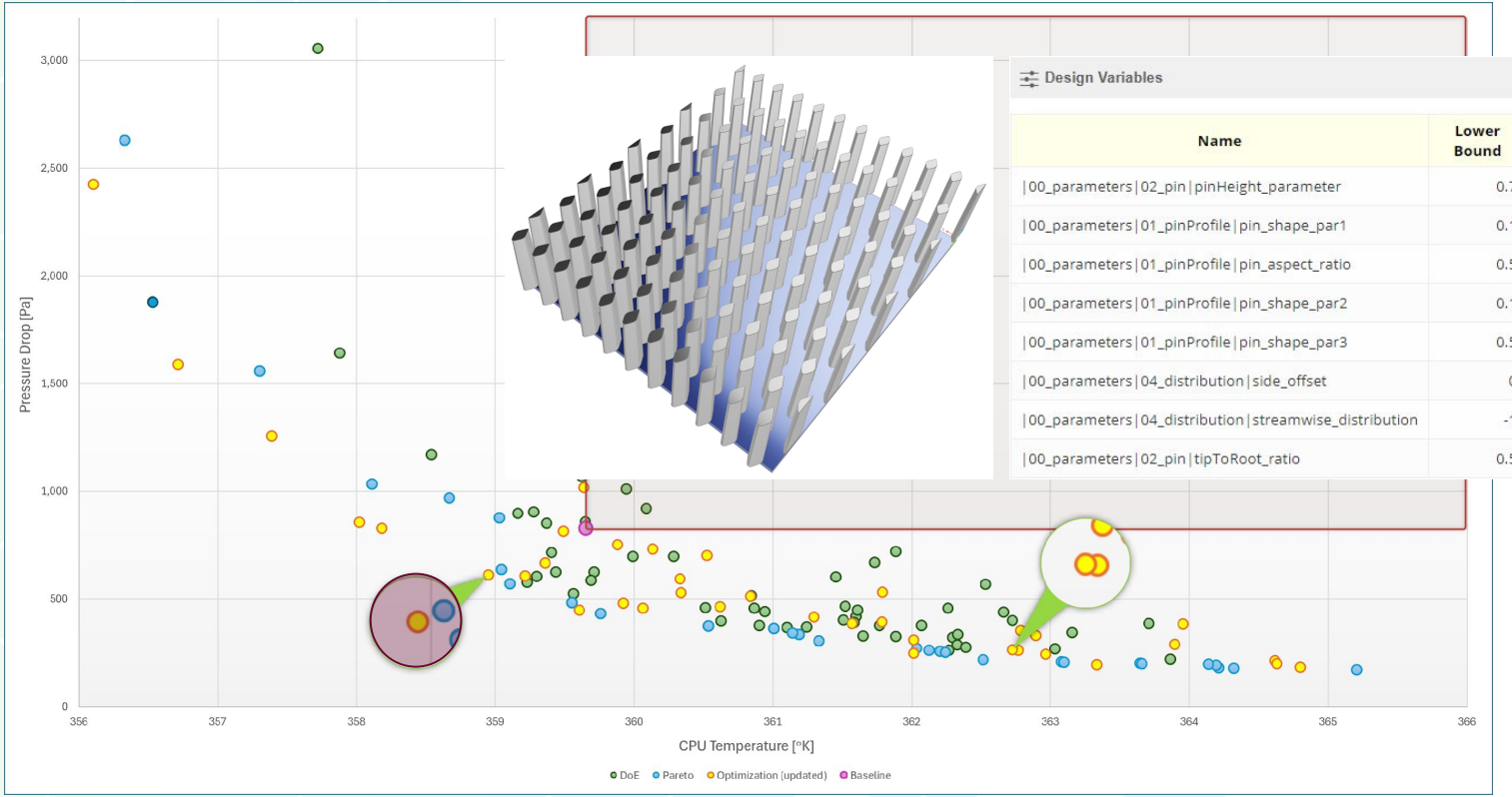
Results



Pareto Frontier Allows Subsequent Weighting of Objectives

- Two different solutions with different focus where selected

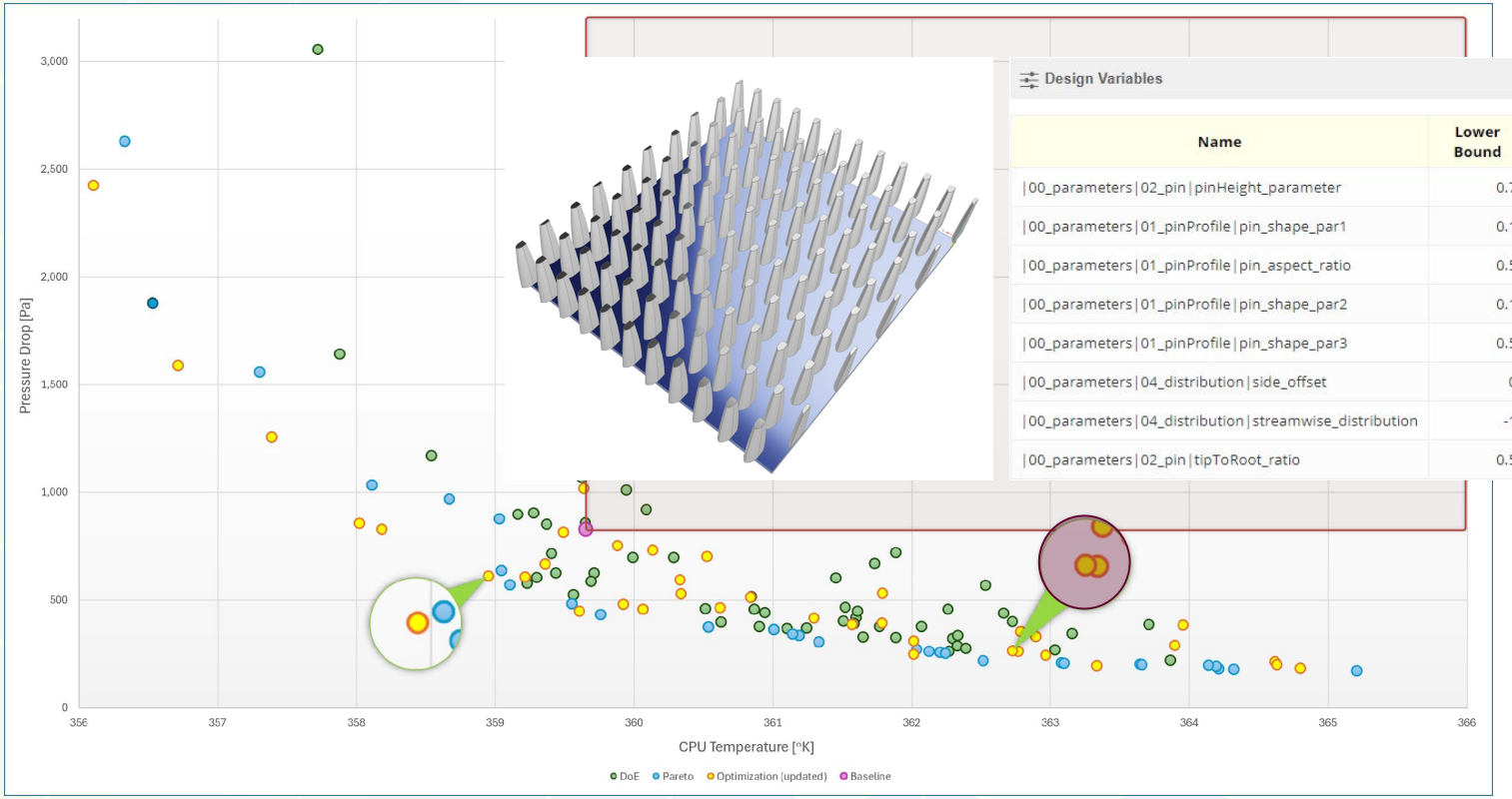
Results



Design Variables

Name	Lower Bound	Value	Upper Bound
|00_parameters|02_pin|pinHeight_parameter	0.7	**0.939437**	0.95
|00_parameters|01_pinProfile|pin_shape_par1	0.1	**0.260336**	0.9
|00_parameters|01_pinProfile|pin_aspect_ratio	0.5	**1.75931**	2
|00_parameters|01_pinProfile|pin_shape_par2	0.1	**0.101074**	0.9
|00_parameters|01_pinProfile|pin_shape_par3	0.5	**2.71168**	3
|00_parameters|04_distribution|side_offset	0	**0.768788**	1
|00_parameters|04_distribution|streamwise_distribution	-1	**-0.665286**	1
|00_parameters|02_pin|tipToRoot_ratio	0.5	**0.844683**	1

Results



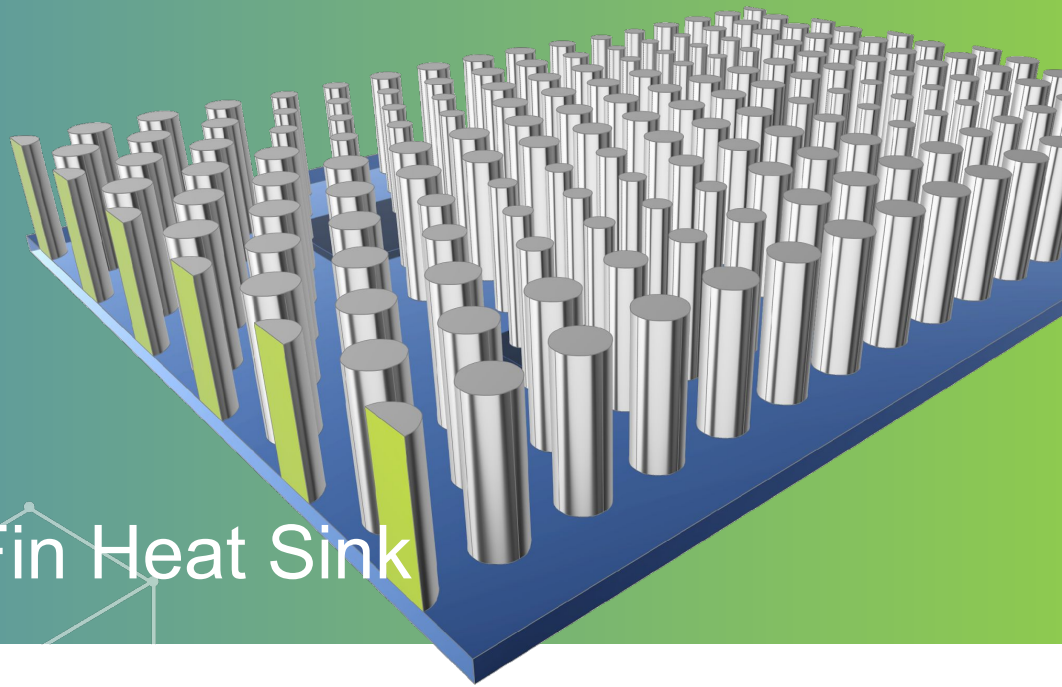
Design Variables

Name	Lower Bound	Value	Upper Bound
|00_parameters|02_pin|pinHeight_parameter	0.7	**0.718189**	0.95
|00_parameters|01_pinProfile|pin_shape_par1	0.1	**0.314557**	0.9
|00_parameters|01_pinProfile|pin_aspect_ratio	0.5	**1.72547**	2
|00_parameters|01_pinProfile|pin_shape_par2	0.1	**0.887573**	0.9
|00_parameters|01_pinProfile|pin_shape_par3	0.5	**0.645344**	3
|00_parameters|04_distribution|side_offset	0	**0.431257**	1
|00_parameters|04_distribution|streamwise_distribution	-1	**-0.229469**	1
|00_parameters|02_pin|tipToRoot_ratio	0.5	**0.536729**	1

Thank you for your attention!

brenner@friendship-systems.com

www.CAESES.com



Optimization of a Pin Fin Heat Sink

using Simulation in the Cloud

SIMSCALE

CAESES®

The Product

The next generation cloud-native engineering simulation platform

Cloud-Native

No VPN, No remote desktop. True SaaS with instant access anywhere & anytime from a browser without any special hardware.

One Platform, Broad Physics

No disconnected tools used in silos. A single platform with broad physics capabilities for both rough early- and detailed late-stage simulations.

Real-time Collaboration

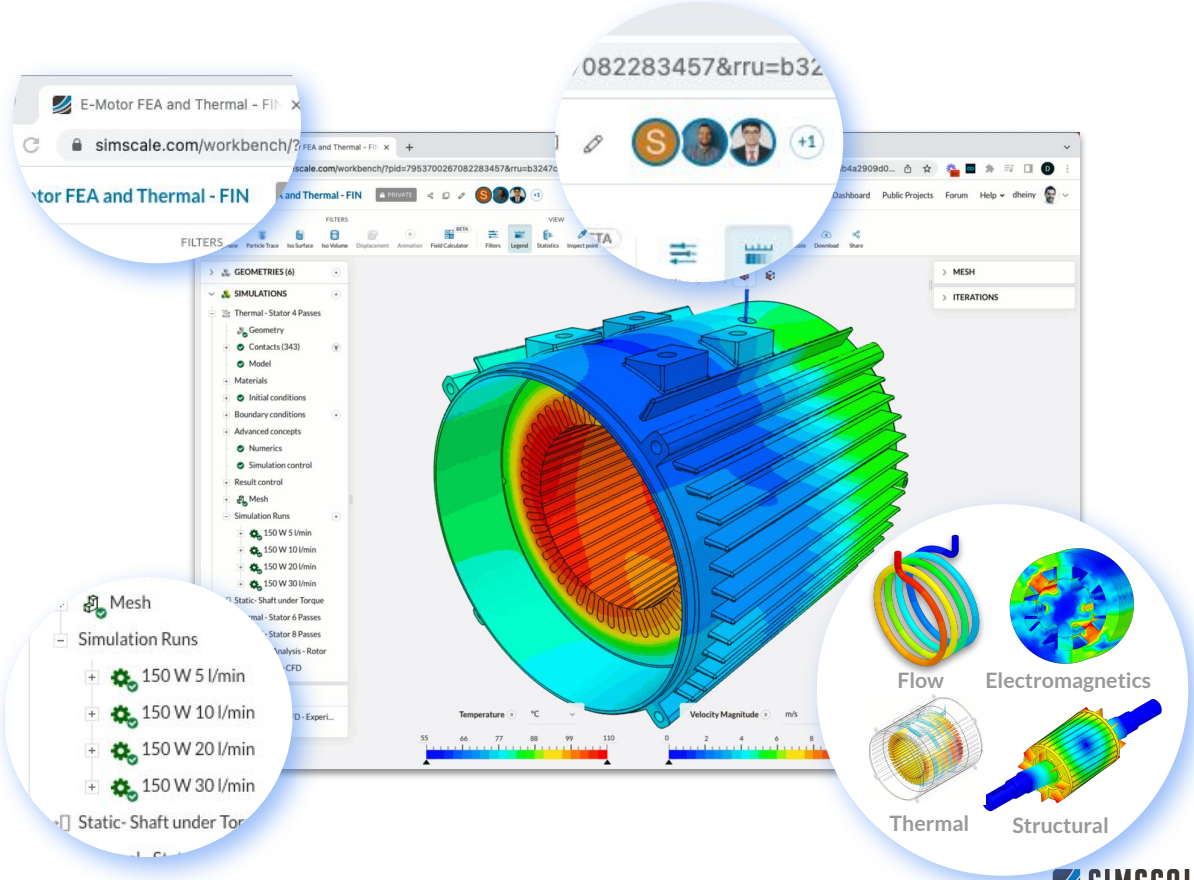
Google-Docs-style collaboration built-in, enabling unparalleled in-app support as well as sharing simulations with colleagues.

AI Powered

All data on SimScale ready for AI training and inference. Built-in AI workflows such as AI-based physics prediction and computing selection

Any Scale

Practically no limits to simulation size, number of parallel simulations and storage. From one-off runs to programmatic design space exploration.

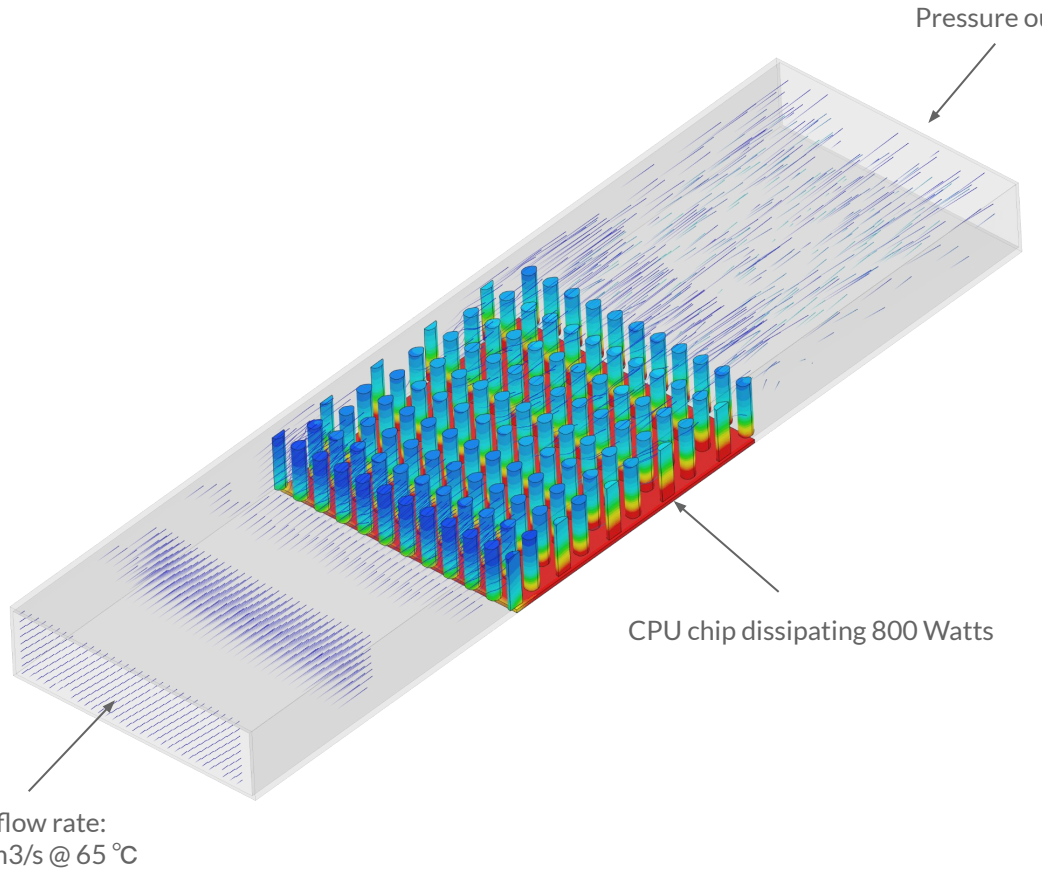


SIMSCALE

Summary

Key insights

- SimScale and CAESES are connected, with SimScale's **Python API script automating simulations directly within CAESES.**
- **192 simulation** were ran in **parallel**, with an average simulation time of **~ 60 minutes**
- This would have taken **8 days** if those simulations were ran in **series**.

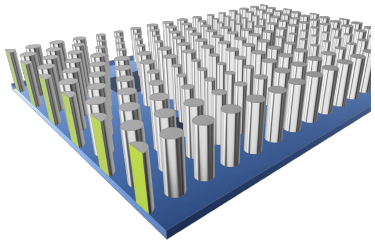


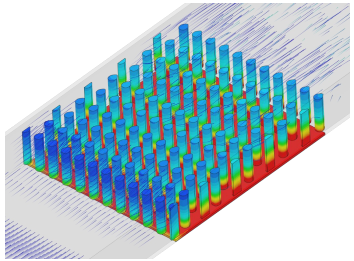
SIMSCALE

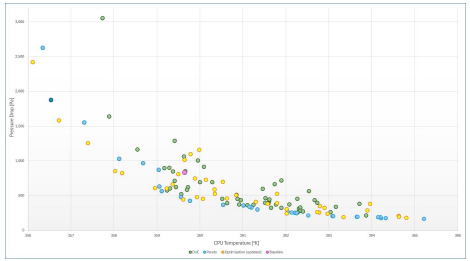
Summary

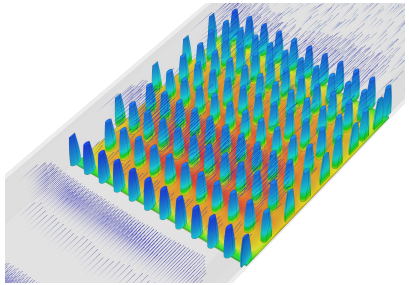
Workflow

CAD Design → Simulation → Optimization → AI preview









CAESES

SIMSCALE

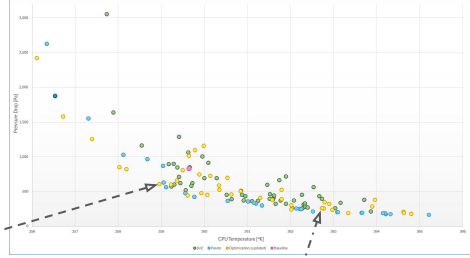
CAESES

SIMSCALE

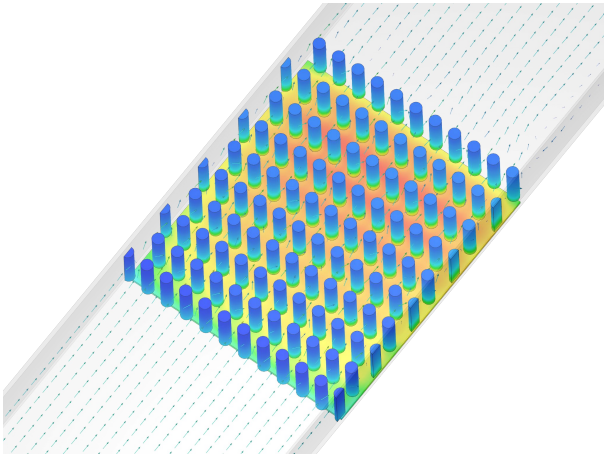
NAVASTO

Results

Comparison : Baseline vs Proposed Designs



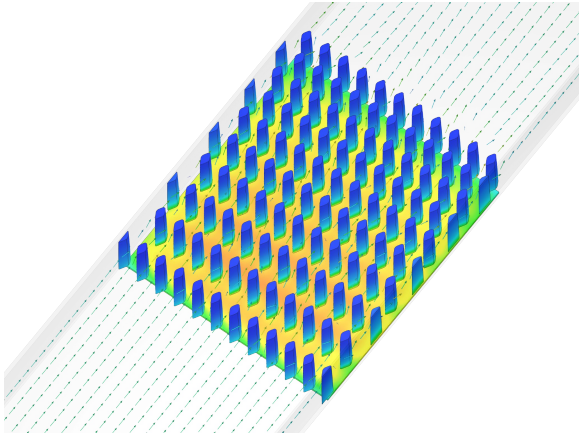
Baseline design



CPU average temperature: 87 ℃

Pressure drop: 831 Pa

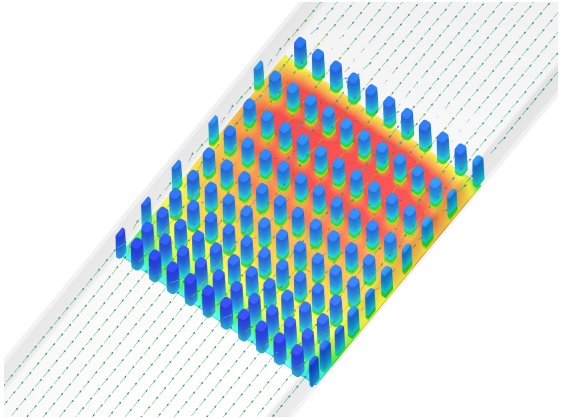
Potential Design (1)



CPU average temperature: 85.5 ℃

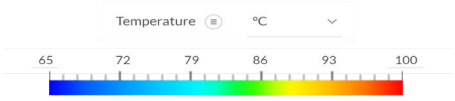
Pressure drop: 610 Pa

Potential Design (2)



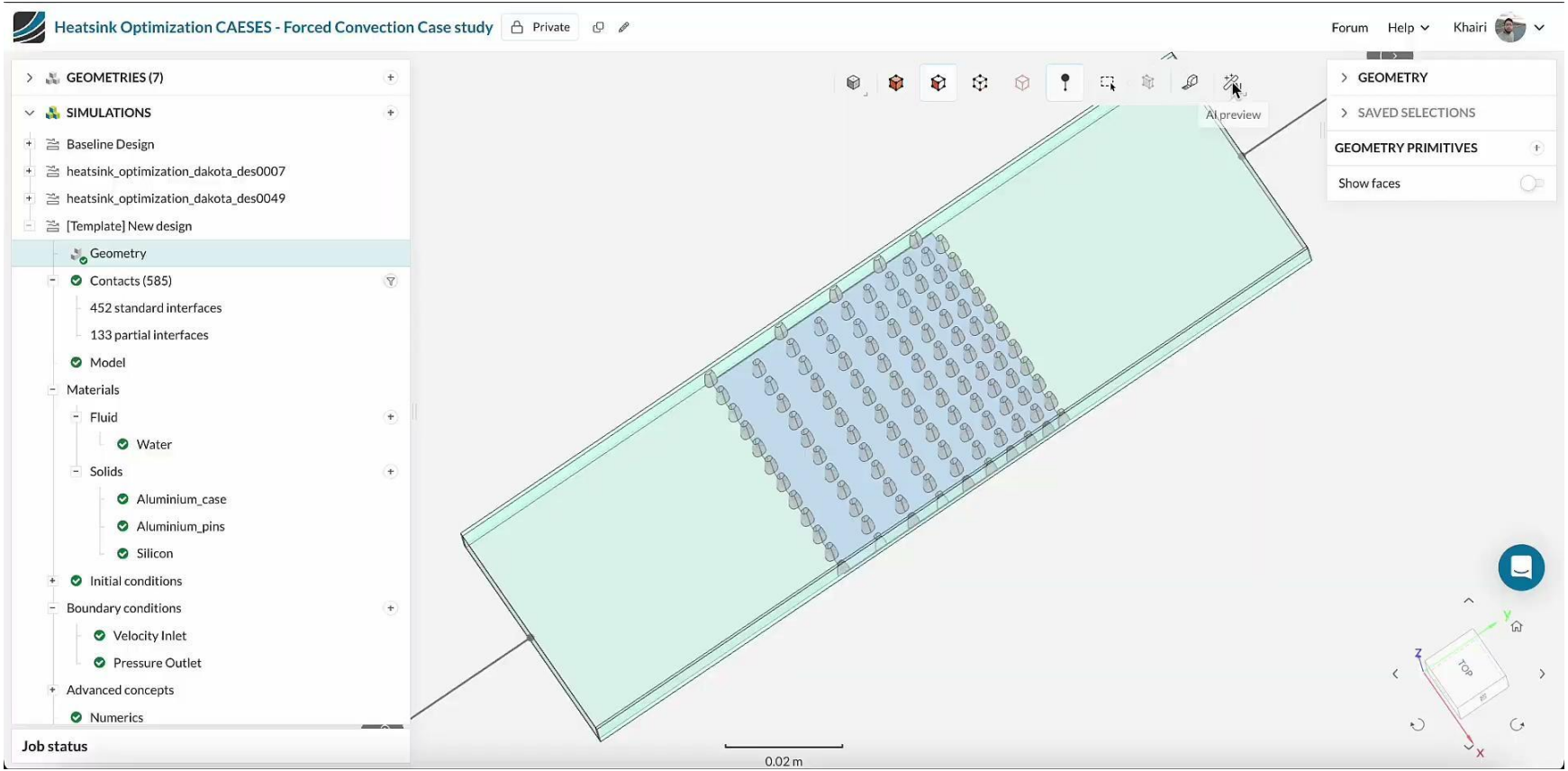
CPU average temperature: 90 ℃

Pressure drop: 392 Pa



Results

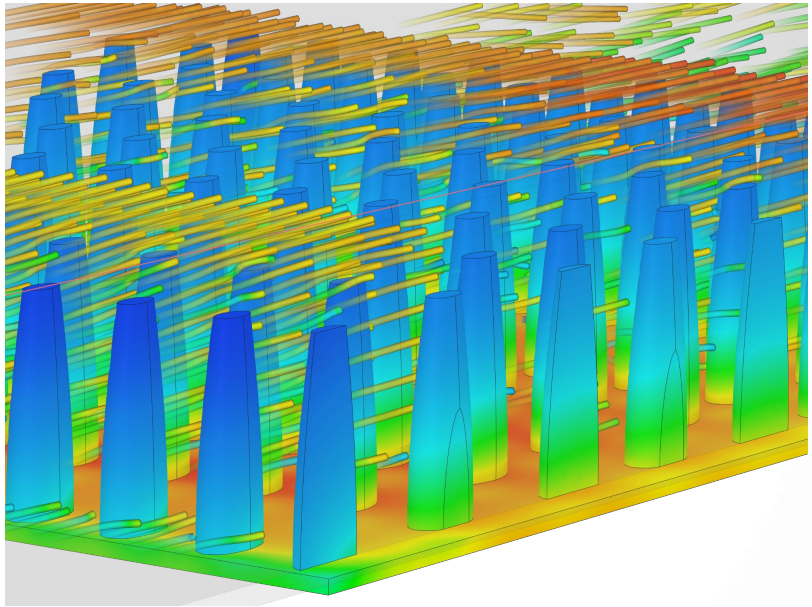
Making Use of Optimization Data for AI prediction



SIMSCALE CAESES

Thank you!

Q&A?



Signup and start simulating now! https://www.simscale.com/signup/

OR

Request a 1:1 demo by contacting us directly sales@simscale.com