Advances in MDO at Danfoss

ENGINEERING TOMORROW

Dynardo Workshop

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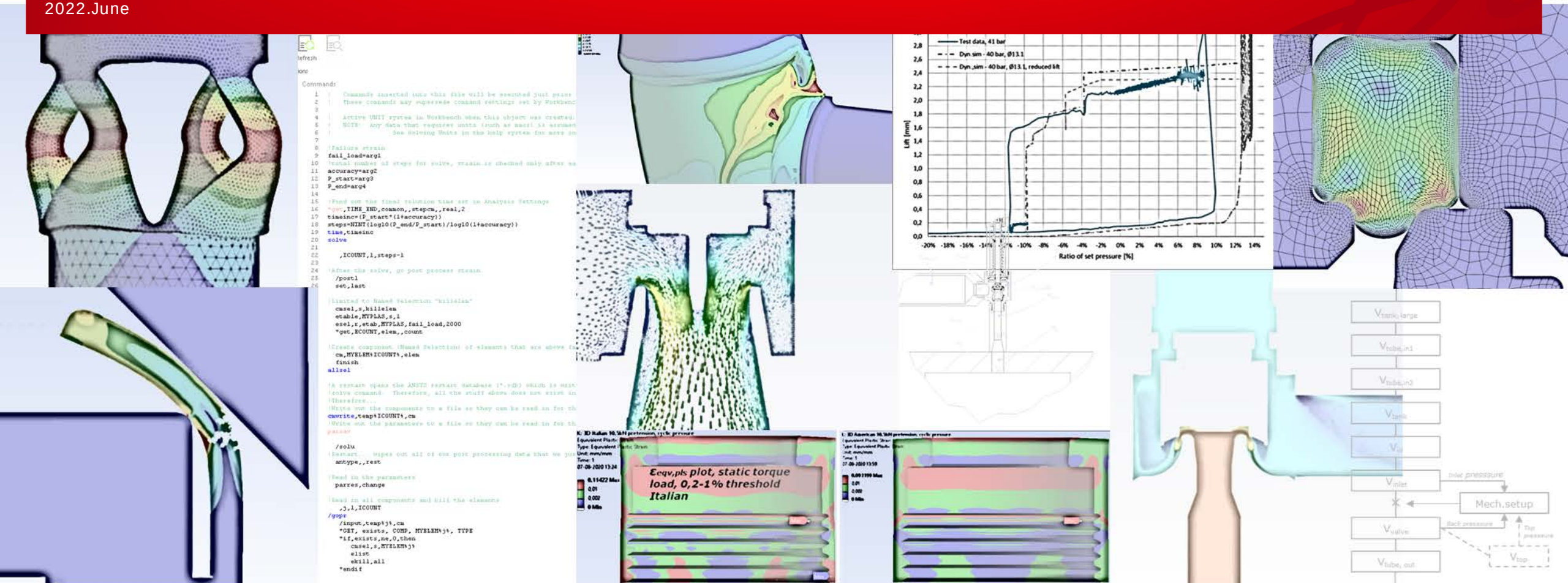

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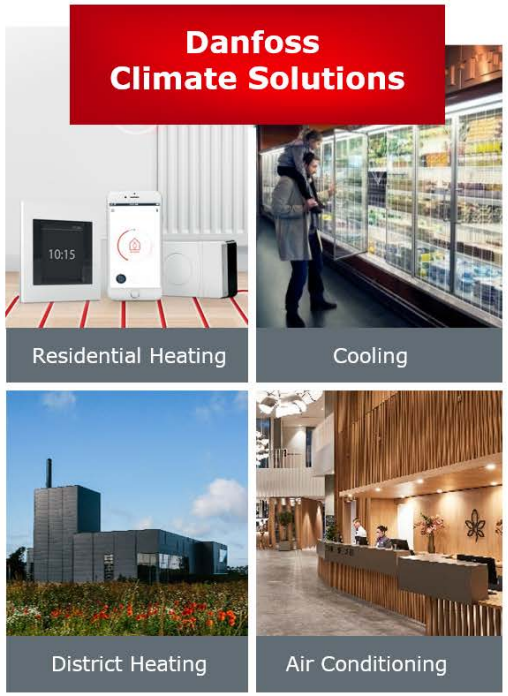
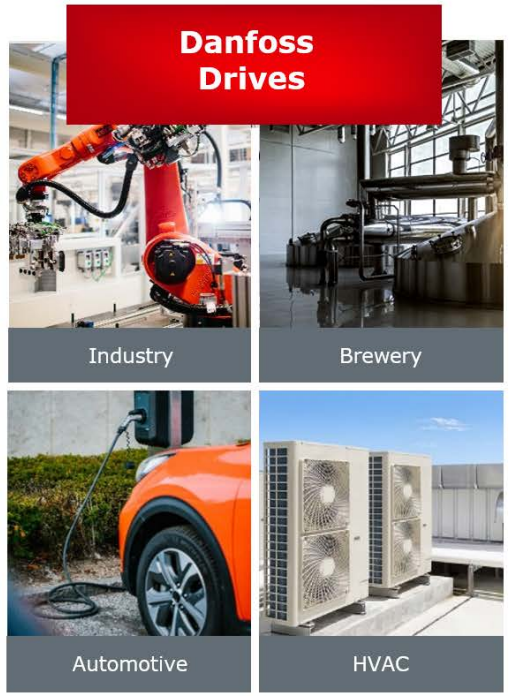
Introduction

- Context:
  - Another MDO example
  - Further MDO development
    - Family parametrization
    - System model
  - Other business unit examples:
    - HEX: dimple optimization
    - SiliconPower: cooling channel optimization





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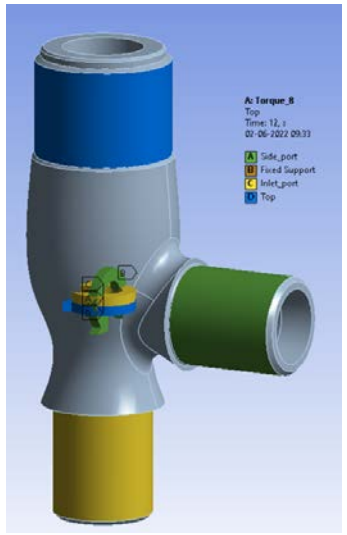
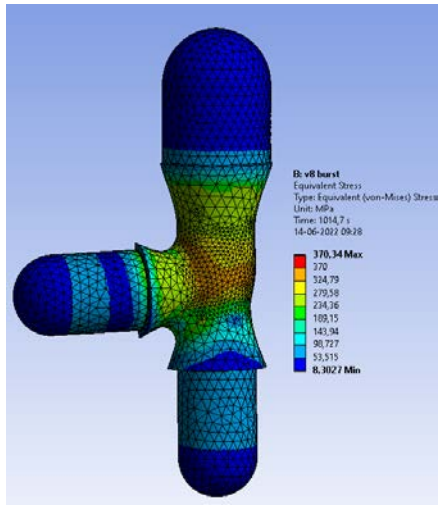
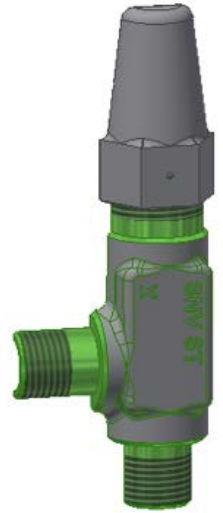
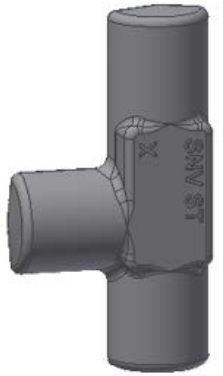
Danfoss RAC: SNV optimization

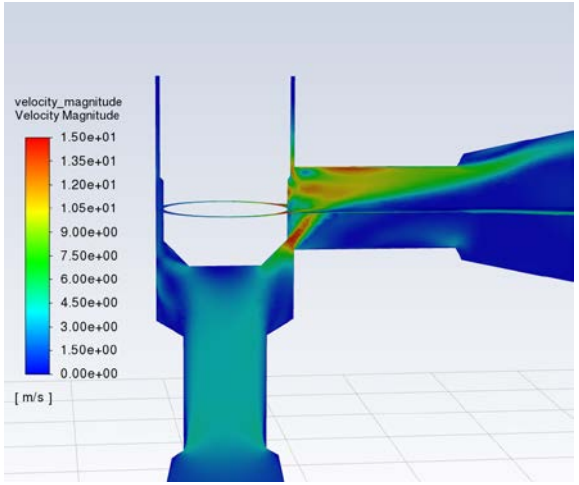
- Multidisciplinary optimization
  - Similar implementation as previous NRV case
  - FEA, CFD, cost:
    - Torque max load
    - Burst pressure
    - Flow capacity
  - Optimization objectives/constraints:
    - Minimize cost (or weight+height)
    - Maintain requirements (burst, capacity, torque)

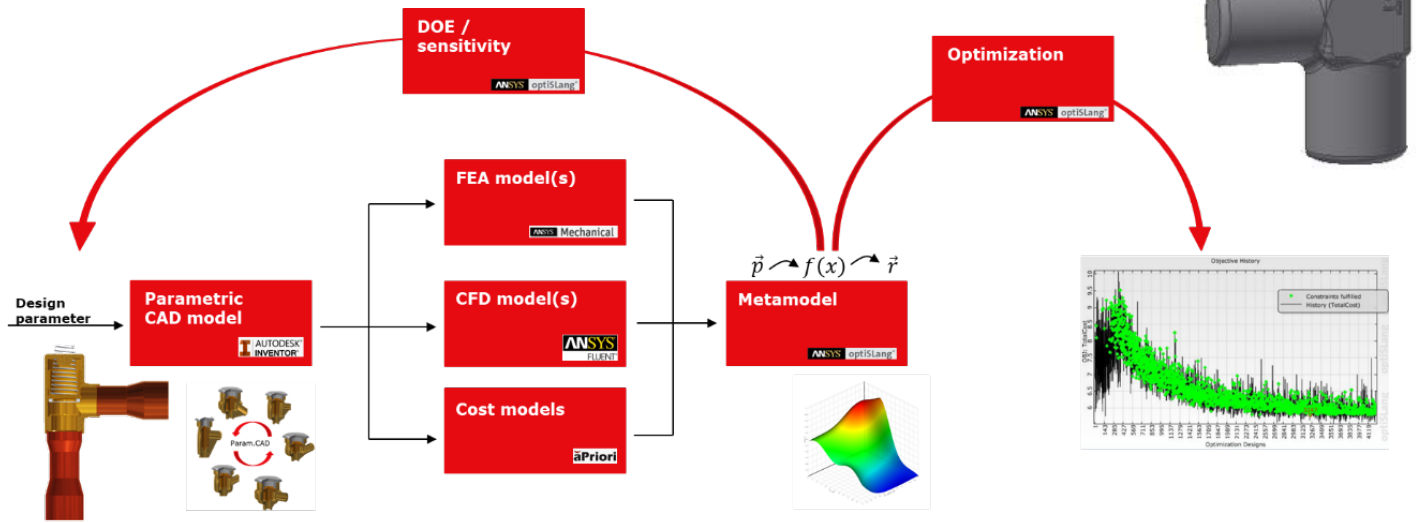












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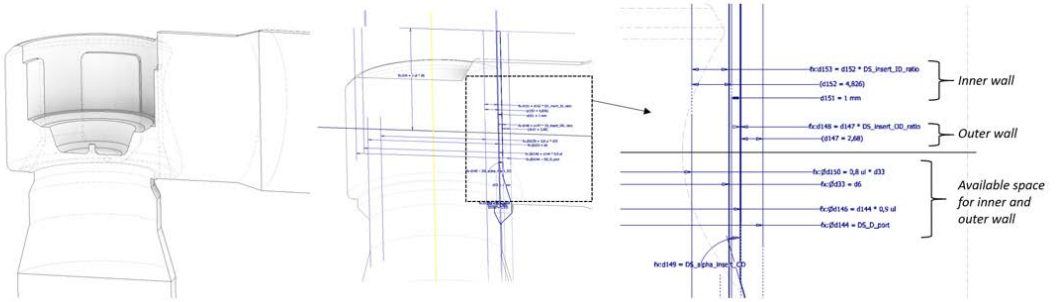
Danfoss RAC: Family automation project

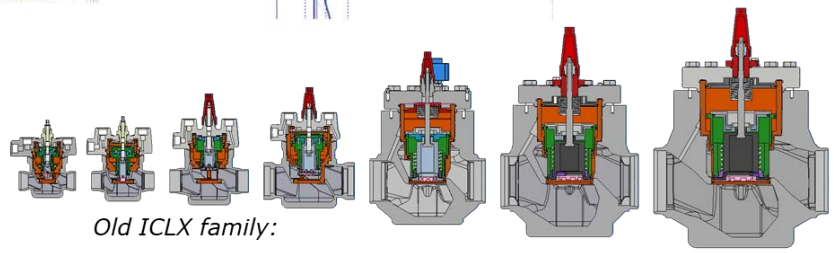
- Project:
  - How to do MDO on a full valve family?
    - Parametric geometry for full family size
    - Include system model in loop

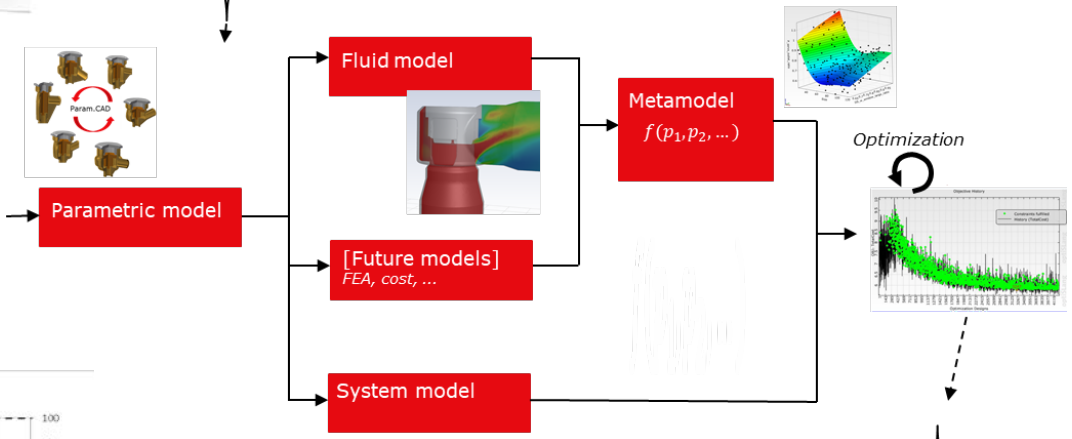
- Parametric CAD model
  - Based on housing platform
  - Parametrization: Relative to housing

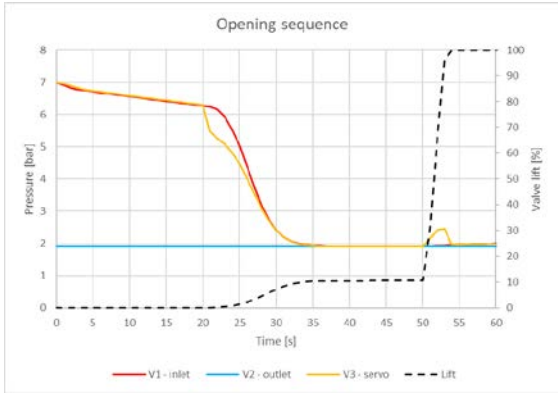
- System model
  - Interaction with customer refrigeration system (hot gas equalization)
  - Linked to CFD MOP
  - Transient valve behaviour
  - Evaluation of several operating conditions

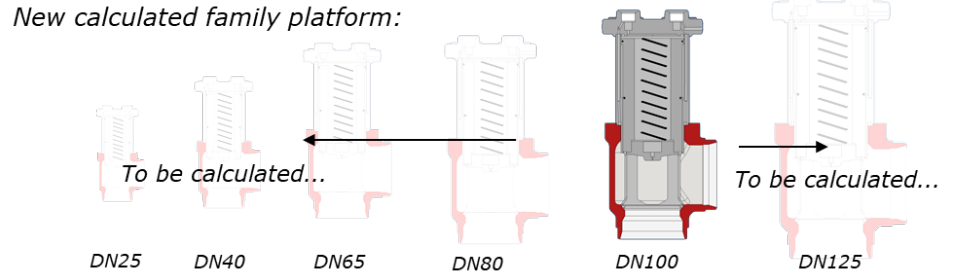
- MOP study:
  - MOP to fit entire family (lift and size)
  - Accurate MOP for each size (lift only)











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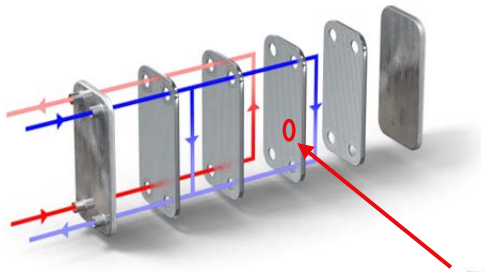
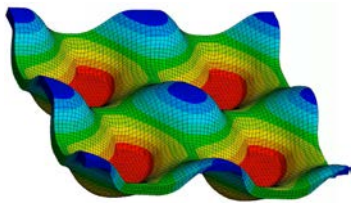
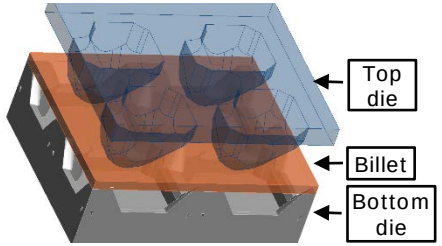
Danfoss HEX: Optimal dimple designs for new brazed plate heat exchanger





Formability analysis

Brazed plate heat exchanger



Simulation of dimple die forming process

- **Optimal design**: best compromise between the enhancement of the total heat transfer and the reduction in the overall pressure drop.
- The relationship between thermal and fluid dynamic performance, manufacturing feasibility, and cost was explored upfront in concept development.
  - Simulations of the sheet metal forming process were included in the optimization workflow.
- Evaluated design robustness considering performance cost and formability.
- Multi-disciplinary team to cut through barriers to good design.

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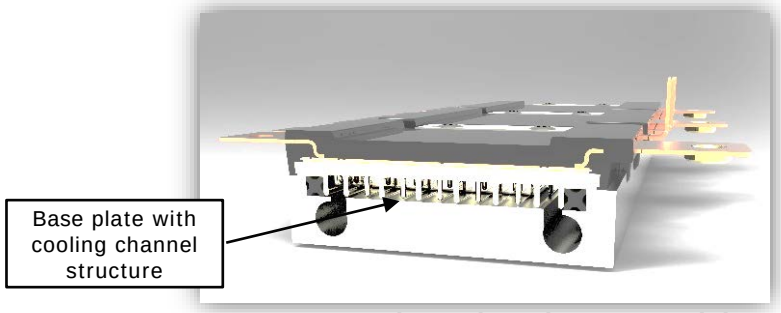
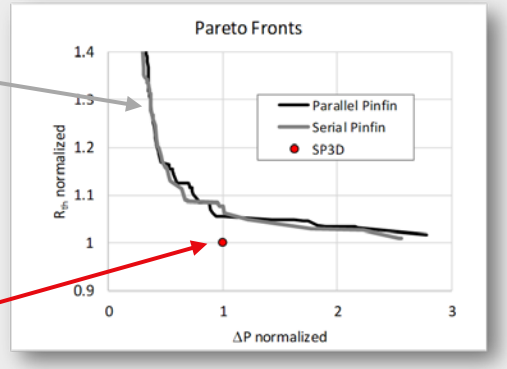
Danfoss SiliconPower: Optimized cooling channel structure for high-power density inverter module



1200V, 660A three-phase inverter module

Traditional pinfin design

ShowerPower® 3D (SP3D) design



- **Optimal design**: best compromise between the reduction of thermal resistance (R_{th}) and the reduction in the overall pressure drop (Δp).
- Comparison of two topologies: exploration of the pinfin design space (Pareto solutions, see figure) vs. current SP3D design.
  - *There is no pinfin design that can outperform the current SP3D solution (for the given operating conditions).*
- Exploration of various SP3D design alternatives; predicted performance improvement if overcoming current manufacturing limitations.

Backup slides

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