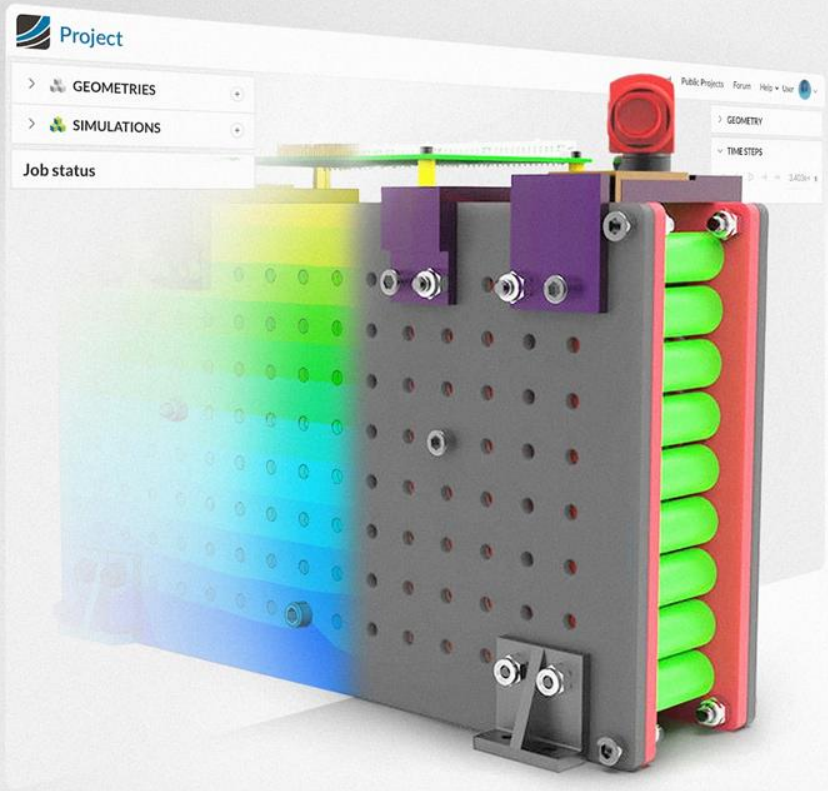
SIMSCALE | THERMAL MANAGEMENT EXPO EUROPE

Ready for AI?

Building surrogate models via Cloud-native AI simulation

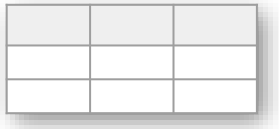


Speaker

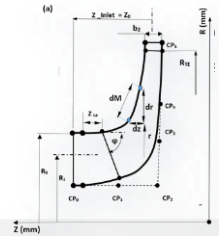
Alexander Fischer
PM & Co-founder - SimScale

AI in the engineering design process

Many steps in the engineering design process will be AI-augmented

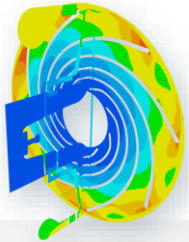


Requirements
- Q = Flow rate (m^3/h)
- H = Head (m)
- n = Rotating speed (rpm)
- P = Motor power (kW)
- η = Q*H / P = Efficiency (%)
- …

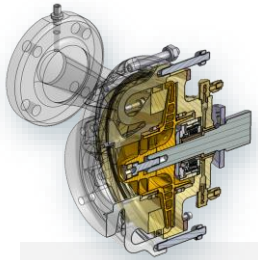


Concept 1-2D Design
- Rough hydraulic design
- Analytical calculations via Euler equations, no losses included
- …

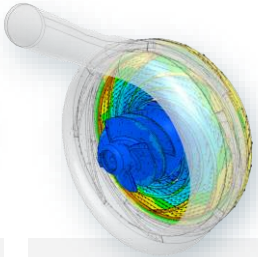
Concept 3D Design
- Just hydraulic parts, no gaps
- Main CAD parameters:
  - β = inlet angle
  - α = outlet angle
  - Number of blades
  - …



Early 3D Simulation
- Early feedback on hydraulic performance
- Early feedback on structural performance
- Inform concept design



Detailed Design
- "As built"
- All gaps / details included



Final 3D Validation
- Final hydraulic performance validation
- Final structural performance validation

AI Use Cases (Examples)

Requirements Engineering
LLMs help structure requirements faster and cleaner and break it down into atomic requirements.
Example: Valispace AI

Simulation Automation
Procedures during the simulation setup will be automatically completed / suggested based on previous human completion.
Example: ADSK Assembly Mating

AI Simulation
AI models trained on design-specific, small amounts of simulation data can be used to replace PDE-based solvers.
Example: Navasto FEA

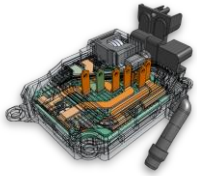
Design Automation
Based on requirements, geometry can (partially) be generated automatically using LLMs and CAD APIs, implicitly building a true digital thread
Example: BlenderGPT

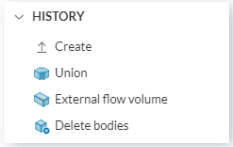
Instant Result Preview
AI models trained large amounts of generic simulation data can be used to preview PDE-based solver results.
(Currently in development at SimScale)

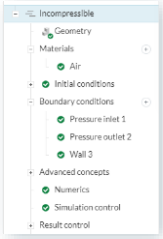
AI Optimization
Surrogate models derived from simulation data can be used to optimize without geometry creation at all.
Example: KSB, Caeses & SimScale

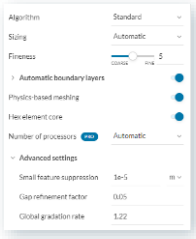
AI Architecture

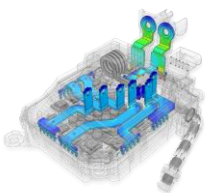
SimScale's architecture provides a mature basis for AI training and inference

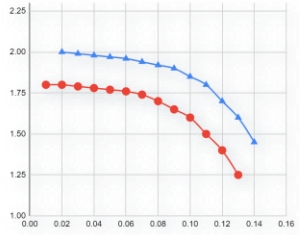








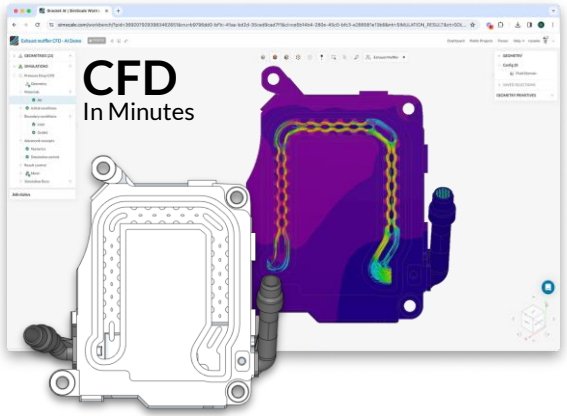


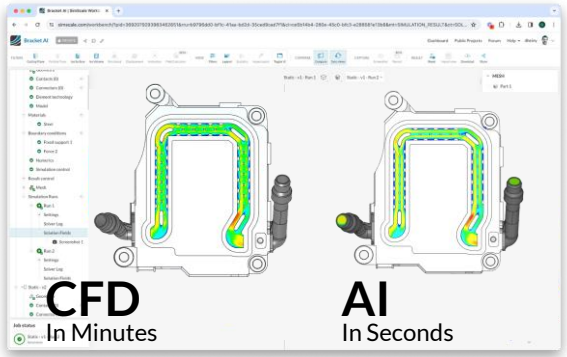


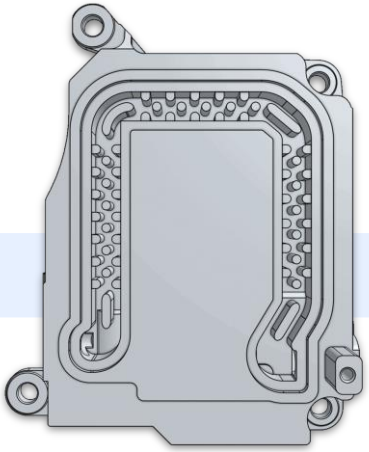
Raw Data	CAD	CAD Edit	Simulation Setup	Mesh Setup	Mesh	3D Results	Scalar Results
Aggregation	*Data Management in support of training and inference. GPUs for training. AI Model lifecycle management.*						
AI Support	Roadmap **Pre-Proc Autom.** • Automatic CAD cleaning • Automatic meshing	In development **Setup Suggestion** • Suggested setup • Best template to use	In production **Resource Prediction** • Compute Runtime • Compute resources	In production **Results Preview** • 3D Results • Scalar Results	In production **AI Simulation** • 3D Results • Scalar Results	Roadmap **Design Insights** • Problem areas • Alternative design gen	

Reducing simulation lead time

From hours to seconds: Enable accurate real-time simulation via AI







Cloud-Native CFD

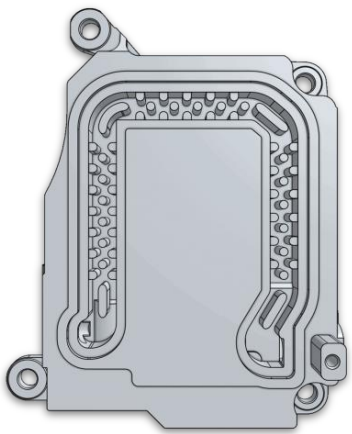
- All simulations immediately ready for AI training
- AI training on cloud GPUs
- As new data is added, re-training is straightforward

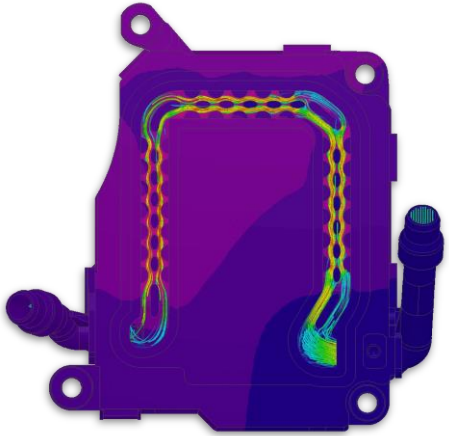
Cloud-Native AI CAE

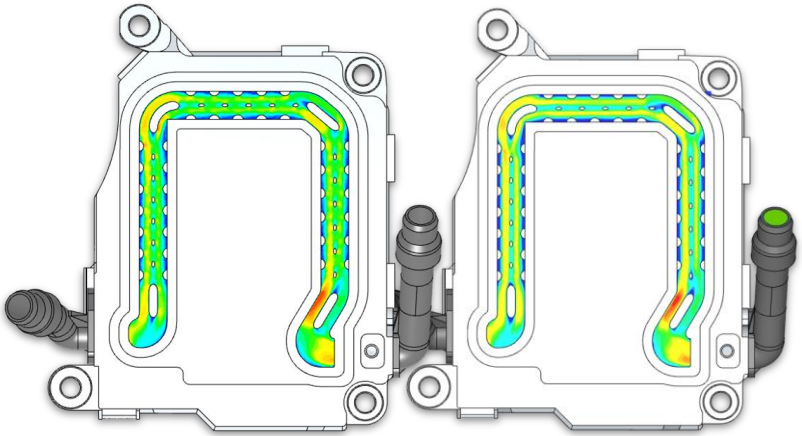
- AI CAE Models are deployed right next to CFD simulations
- AI used for fast evaluations, CFD available for validation

Case Study

AI Preview Demo: EV Power Inverter







CFD Reference

AI Prediction

EV Power Inverter Model

- MOSFET **temperature** & **pressure drop**
- **Geometry variations** for turbulence elements in:
  - Shape (8 variations)
  - Thickness (10+ variations)

CFD via API on SimScale

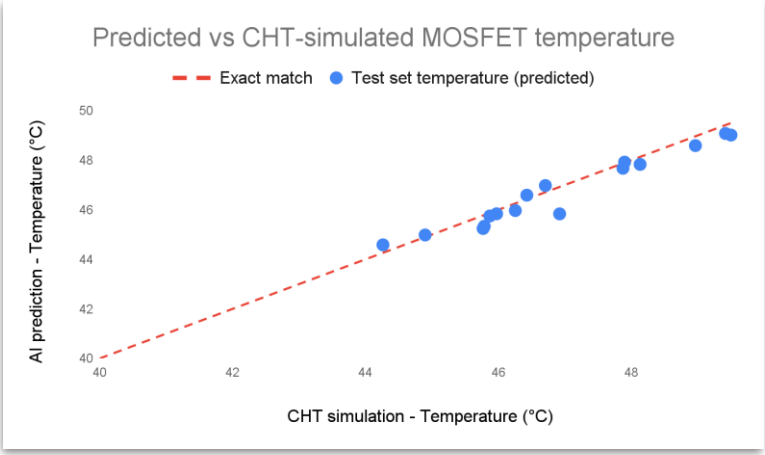
- Run all 104 variants in parallel on 16 core instances
- Complete dataset generation within 25 minutes, 15 min avg

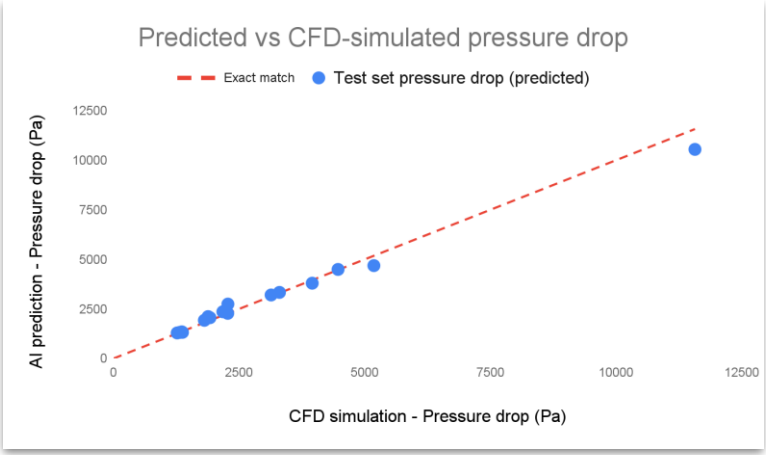
AI model generation and deploy

- Model generation with fully data-driven Graph Neural Network (GNN)
- Automatic hyperparameter optimization, best model selection
- Total runtime <24h on single GPU

Case Study

AI Preview Demo: EV Power Inverter





AI Prediction test set

- **89** of 104 simulations used to **train** the AI model
- **15** configurations used as **test set**
- Comparison of AI prediction and simulation result on 'unseen' test set

AI Prediction confidence

- Test set **accuracy** for results of main interest
- **Confidence** interval describing configuration fit to training data
- Additional **metrics** indicating max and avg errors in test set configurations

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Thank you for your time!