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CAASE18

The Conference on Advancing Analysis & Simulation in Engineering

June 5 - 7, Cleveland, Ohio

Co-Hosted by NAFEMS DE Digital Engineering

Towards CFD Democratization

Siemens AG – Corporate Technology
T. Papadopoulos, S. Boschert

Presented by: Ruben Bons, Siemens PLM Software

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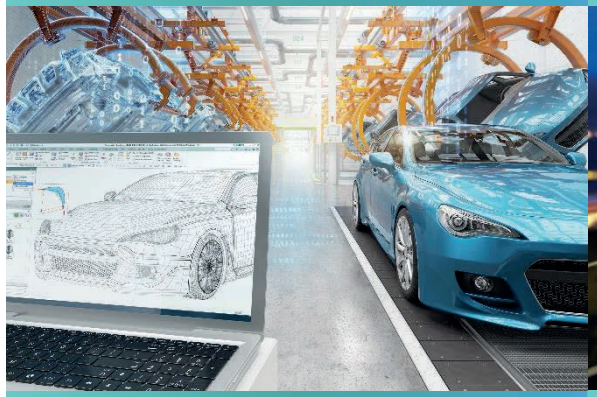
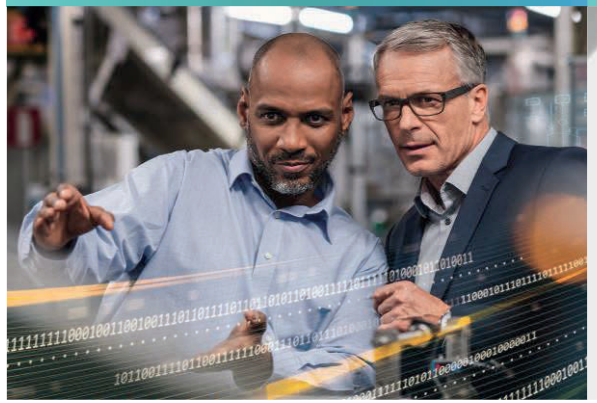
Siemens: Driving Digitalization Technologies

Digital Factory	Energy Management	Wind Power	Power and Gas, Power Generation Services
			
Process Industries and Drives	**Healthineers**	**Building Technologies**	**Mobility**
			

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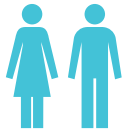
Our innovative power in figures – Siemens as a whole and Corporate Technology

Expenditures for research and development

€4.7 billion

Expenditures for R&D in fiscal 2016



33,000

R&D employees[1]

Inventions and patents – securing our future

7,500

inventions[1]

3,500

patent applications[1]

University cooperation – our knowledge edge

9

CKI universities[2]

16

Principal partner universities

1 In fiscal 2016

2 Centers of Knowledge Interchange

Corporate Technology –

Our competence center for innovation and business excellence[3]

7,400

employees worldwide

4,800

software developers

1,600

researchers

400

patent experts

3 Employee figures: As of September 30, 2016

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Our focal points – Corporate Technology at a glance

Research in Digitalization and Automation

Research and pre-development work covering all Siemens-relevant areas in digitalization and automation

Research in Energy and Electronics

Research and pre-development work covering all Siemens-relevant areas in energy/electrification, electronics, new materials and manufacturing methods

Technology and Innovation Management

- Siemens' and CT's technology and innovation agenda
- Standardization and technical compliance
- Provision of technical publications

Corporate Technology (CT)

CTO – Roland Busch

University Relations

- Management of the research partner portfolio
- Engagement management with top research partner

Corporate Intellectual Property

- Protection and defense of intellectual property (IP)
- IP licensing & commercialization
- Trademark protection

Development and Digital Platforms

- Software, firmware, and hardware engineering
- Horizontal and vertical product and system integration

Business Excellence and Quality Management

- Siemens Operating Model: excellence in PLM, SCM, project business and service
- Quality management

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- Case Study
- Parametric Model
- CFD Simulation
- Summary

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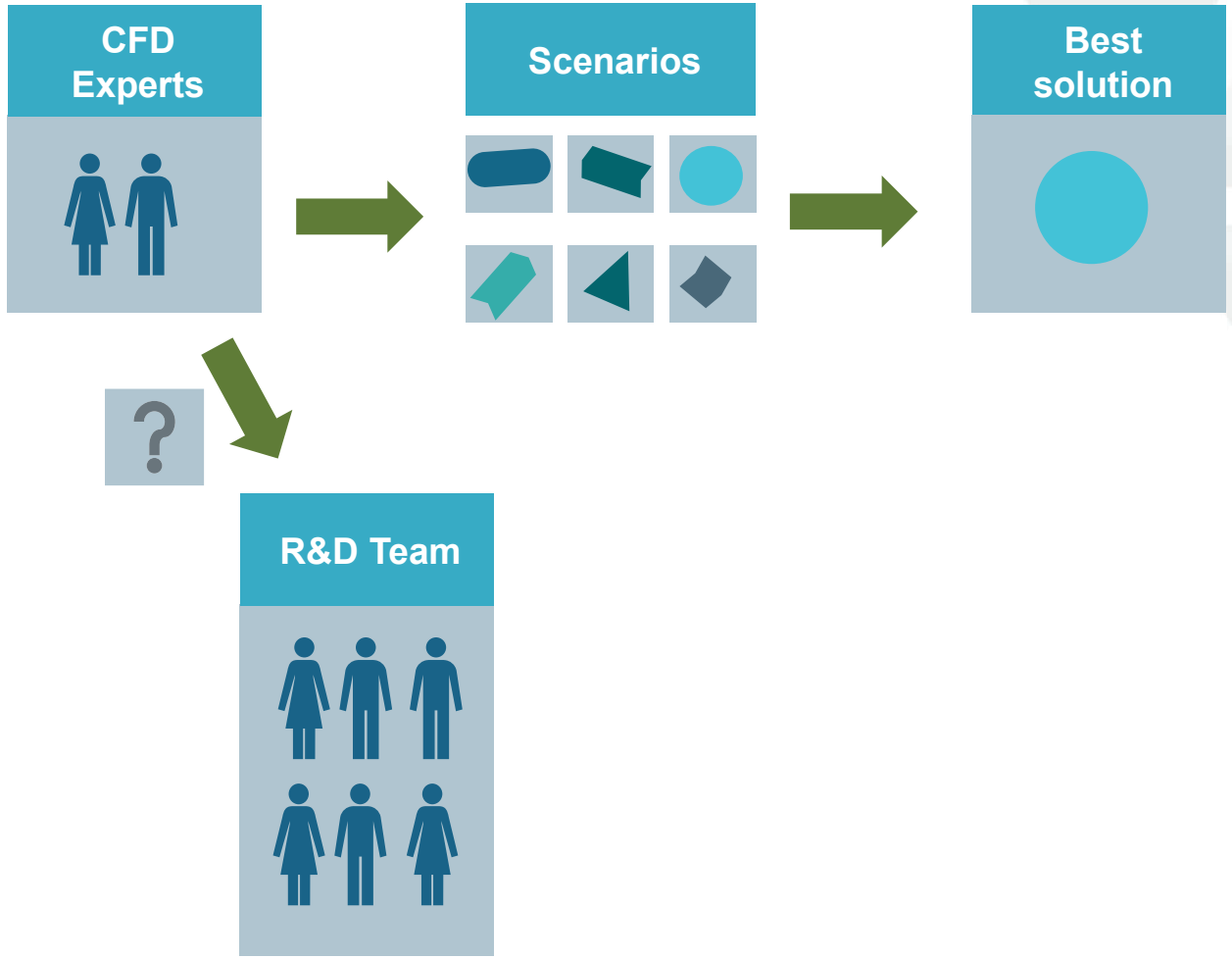
Motivation

CFD Challenges in R&D

- >90% of costs derived from design phase[1]
- Multiple serial iterative processes are needed due to the restricted number of CFD experts and highly-complex numerical tools[2]
- Such iterations usually differ in only some parameters (i.e. velocity, temperature etc.)
- Time demanding and not efficient R&D process
- A new approach needed to speed-up this phase
- What if this expertise could be "extended" to other members of R&D team with minor effort using reusable templates



1) National Endowment for the Arts (2017): Industrial Design:
2) T. Abbey (2017): CAD and FEA User Interface Evolution. Digital Engineering

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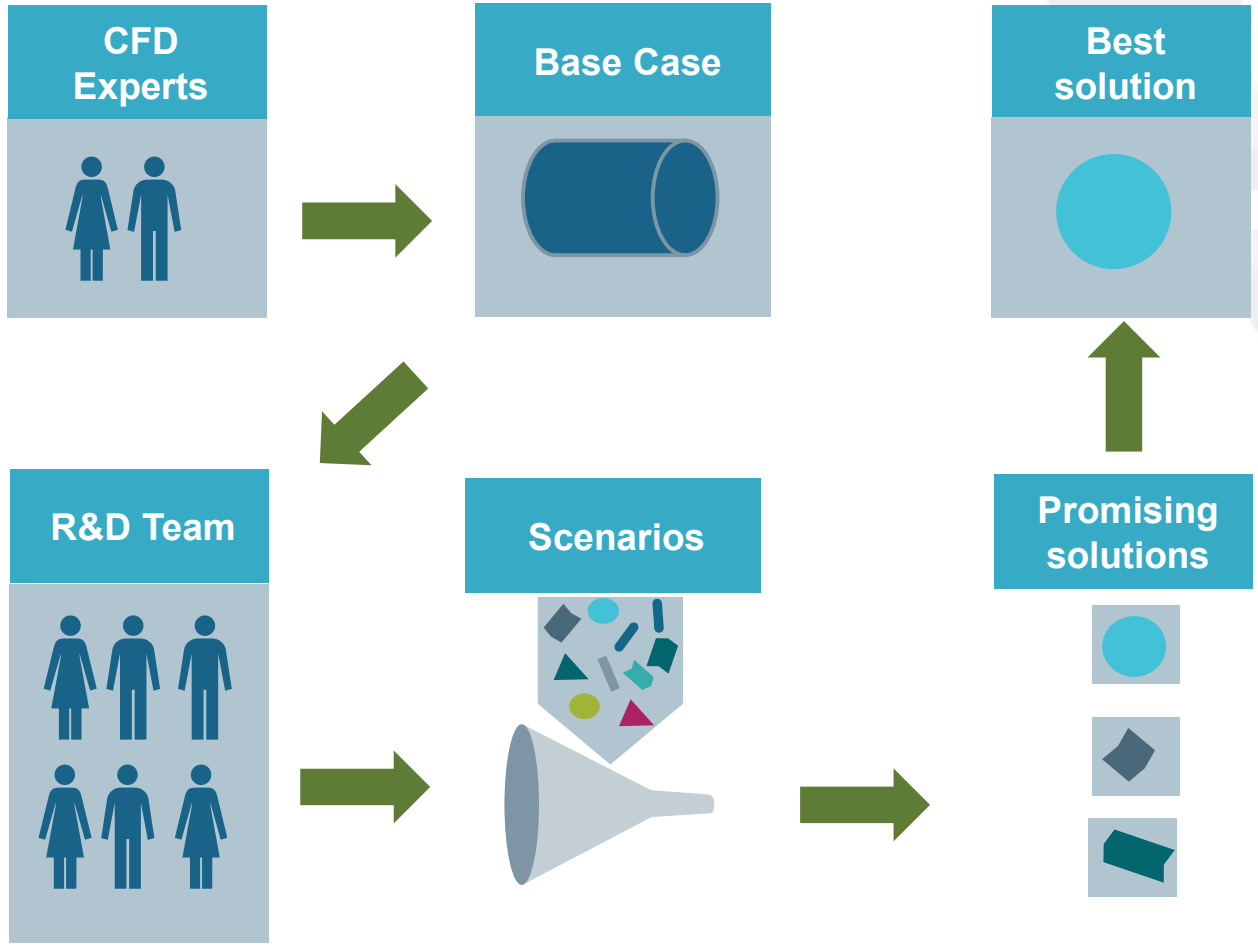
Motivation

Expand CFD "users" in design phase

- Involvement of other experts i.e. designers based on criteria
  - No special CFD expertise demanded
  - Simple execution and evaluation of the results
- CFD experts can create a base case (template)
- Templates should include the appropriate numerical models like turbulence, heat transfer etc.
- Preliminary CFD investigations with minor changes to the base case i.e. one or more parameter change (air velocity) realized by other team members
- Better understanding of the problem by members without having the "corresponding theoretical knowledge"



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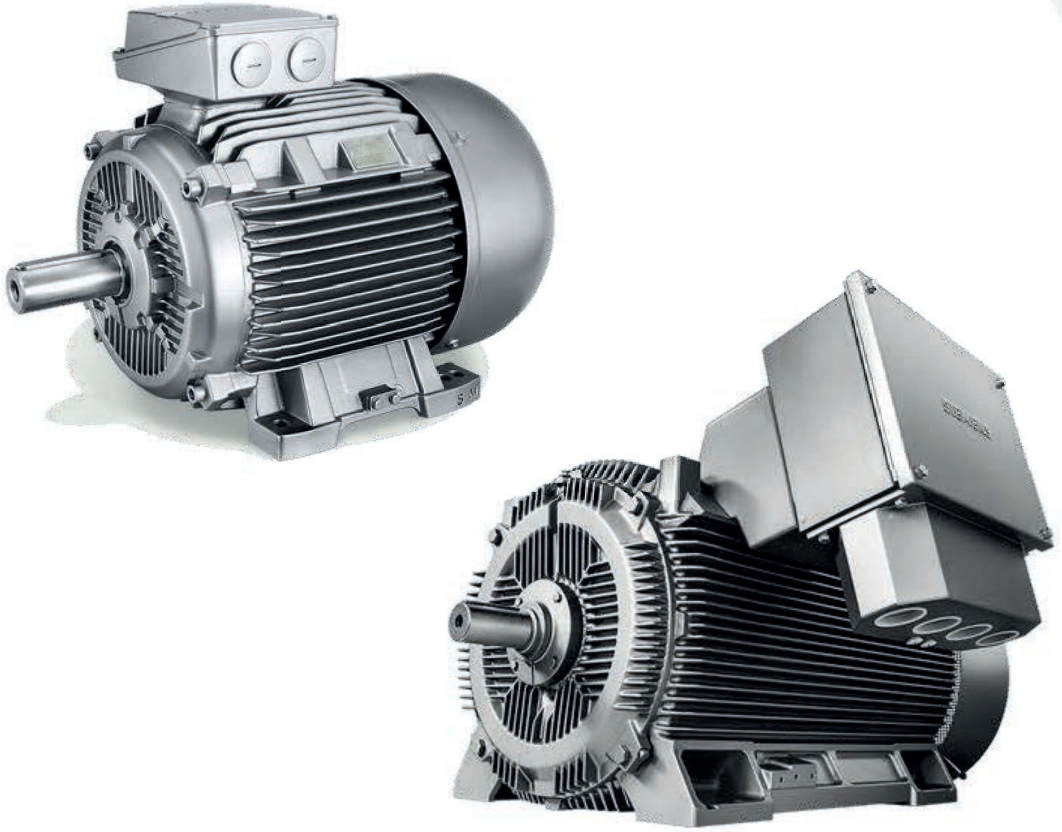
Case Study

Electric Motor Housings - Problem description

- Heat generated inside the motors during their operation
- Proper performance of an electric motor demands the dissipation of the heat to the environment
- Heat is removed for the motor through the housing
- Appropriate design of the housing is of high importance
- Design of a housing is ideal for our demonstration
- CFD simulation of the motors' cooling include the same “physics” (conjugate heat transfer) but different parameters
- Such parameters can include the size of the motors, number of fins, air mass flow etc.



Source:siemens.com

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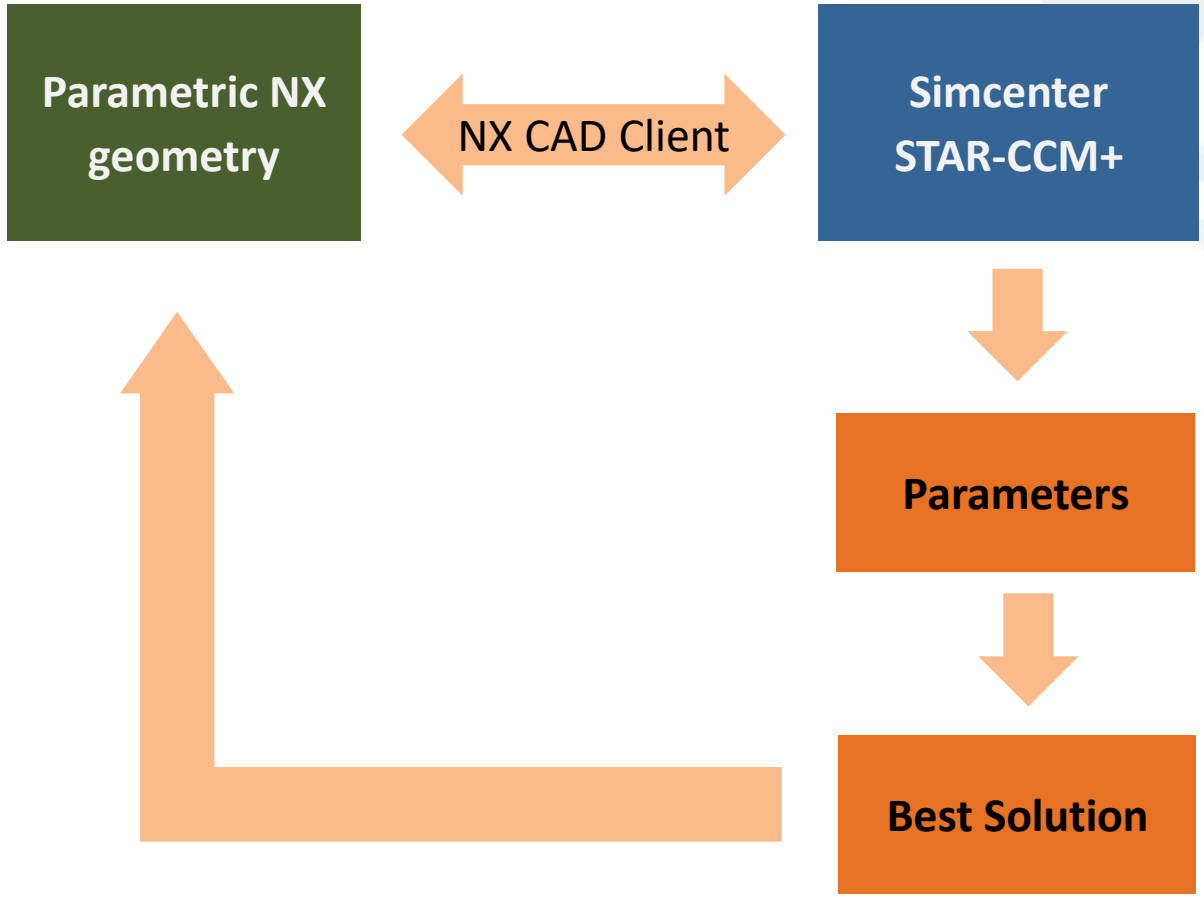
Case Study

Housing Electric Motors - Problem description

- Ambient conditions usually pre-defined
- For a given air mass flow cooling performance of the housing influenced by the fin size and number
- Typical problem where various geometrical parameters should be investigated without changing numerical models

NX CAD Client

- Enables two-way geometric coupling between NX and STAR-CCM+
- A parametric model can be created in NX and sent to STAR-CCM+ with the geometric parameters
- Design of best solution is also stored in NX for further analysis, e.g. mechanical simulation.



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Parametric model

Siemens Simcenter NX

- To demonstrate the concept a generic motor housing will be investigated within this presentation
- Geometry model constructed in Simcenter NX
- Design accounts for
  - Position and size of mounts
  - Position of "dead zones"
  - Size and distribution of fins
  - Several heat source in form of zone (surface)
- Design could be easily adapted/changed
- Minimal number of parameters (Total 12 parameters)
- Further complication/flexibility of the geometry can be easily applied

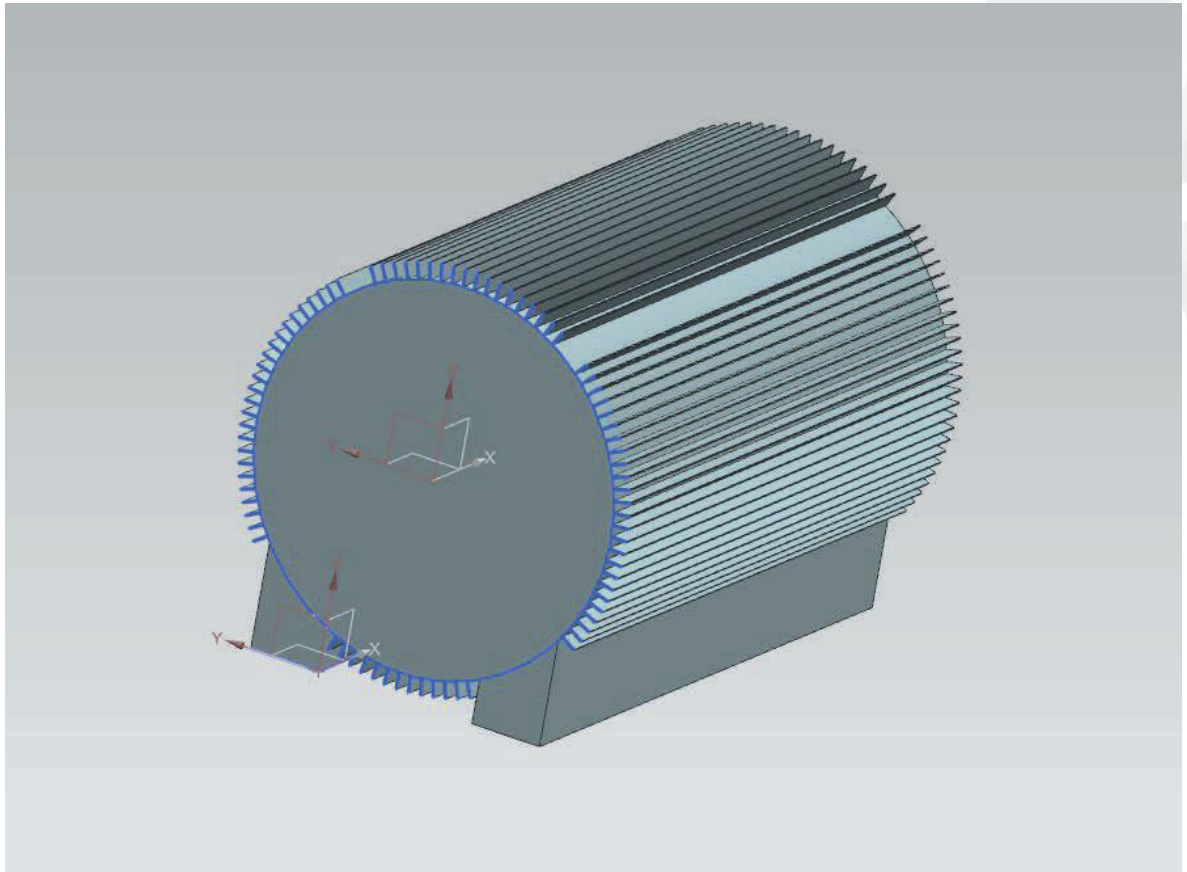

Figure : Generic housing geometry in Simcenter NX

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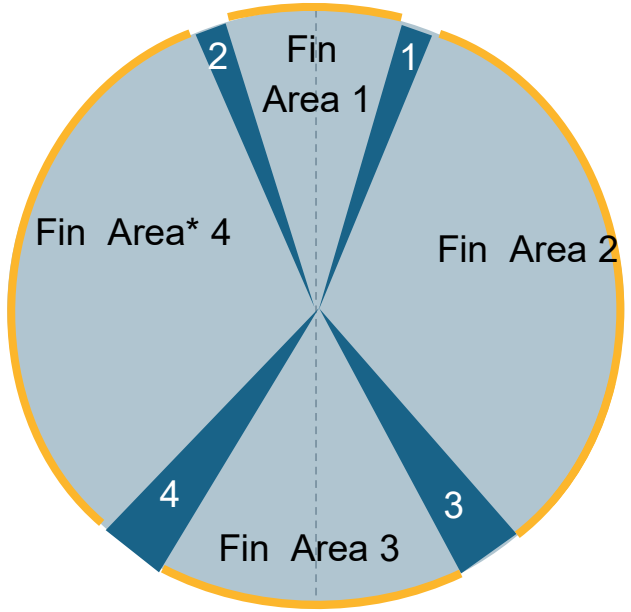
Parametric model – Key Parameters

Siemens Simcenter NX – Design concept

Parameter - Input
Inner Diameter
Length Inner Diameter
Wall Thickness
Position of electronics (1-2)
Position of mounts (3-4)
Fin width
Fin Height
Fin Gap
Length zone 1
Length zone 2
Length zone 3



Variable
“Dead zone” 1-4
Number of Fin 1
Number of Fin 2
Number of Fin 3
Number of Fin 4
New Fin Gap

*Fin Area : Available area for placement of fins
*Zone: definition for inside surface area

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CFD Simulation

Siemens Simcenter STAR-CCM+

- CFD expert creates a template for motor housing
- Record set-up process and export as java scripts
- Import geometry model with parameters
- Selection of proper numerical models like
  - SST k-ω
  - Segregated flow
  - Fluid: Air / Housing: Steel
- Set boundary conditions
  - Air temperature : 20 °C
  - Air velocity : 2 m/s
- Post-processing and determination of selection criteria (T_{ave})

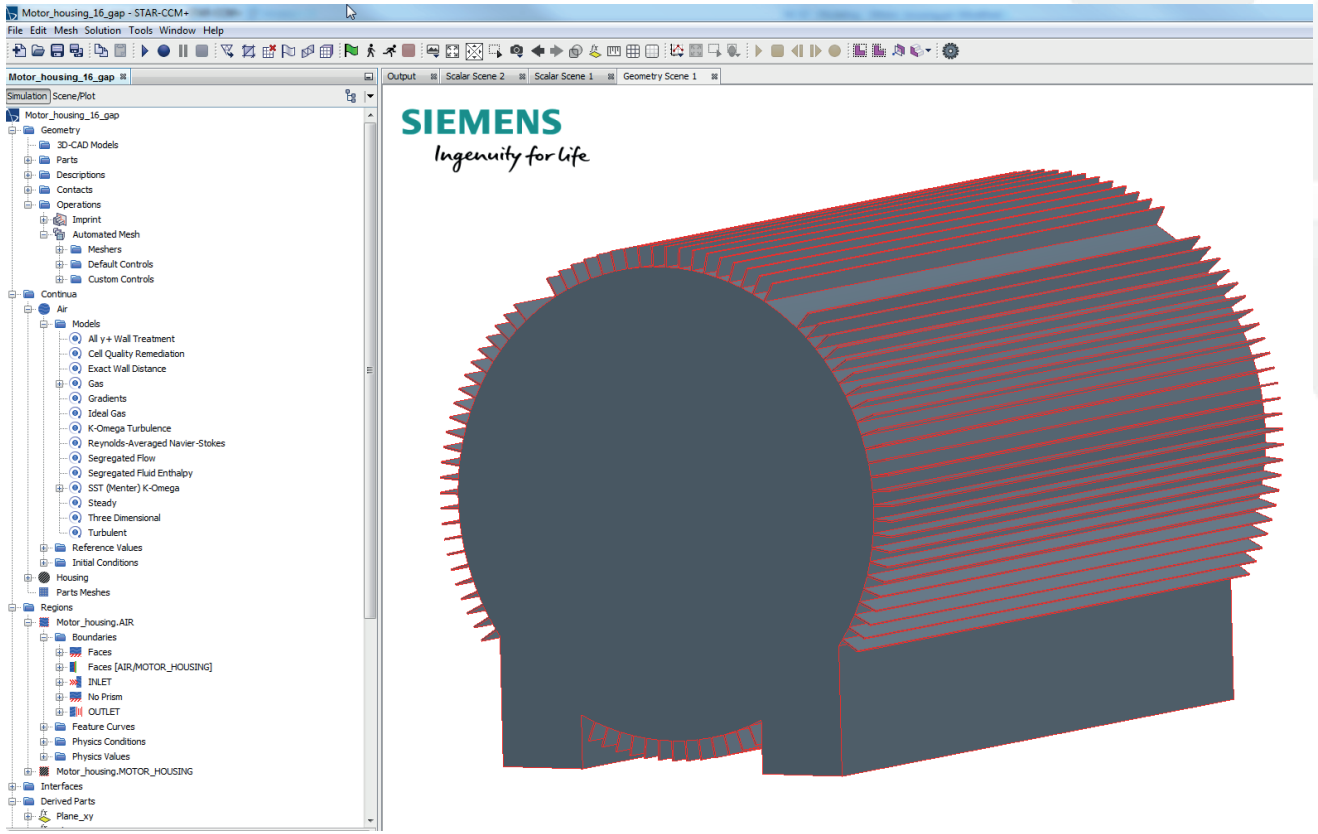

Figure : Generic housing geometry in Simcenter STAR-CCM+

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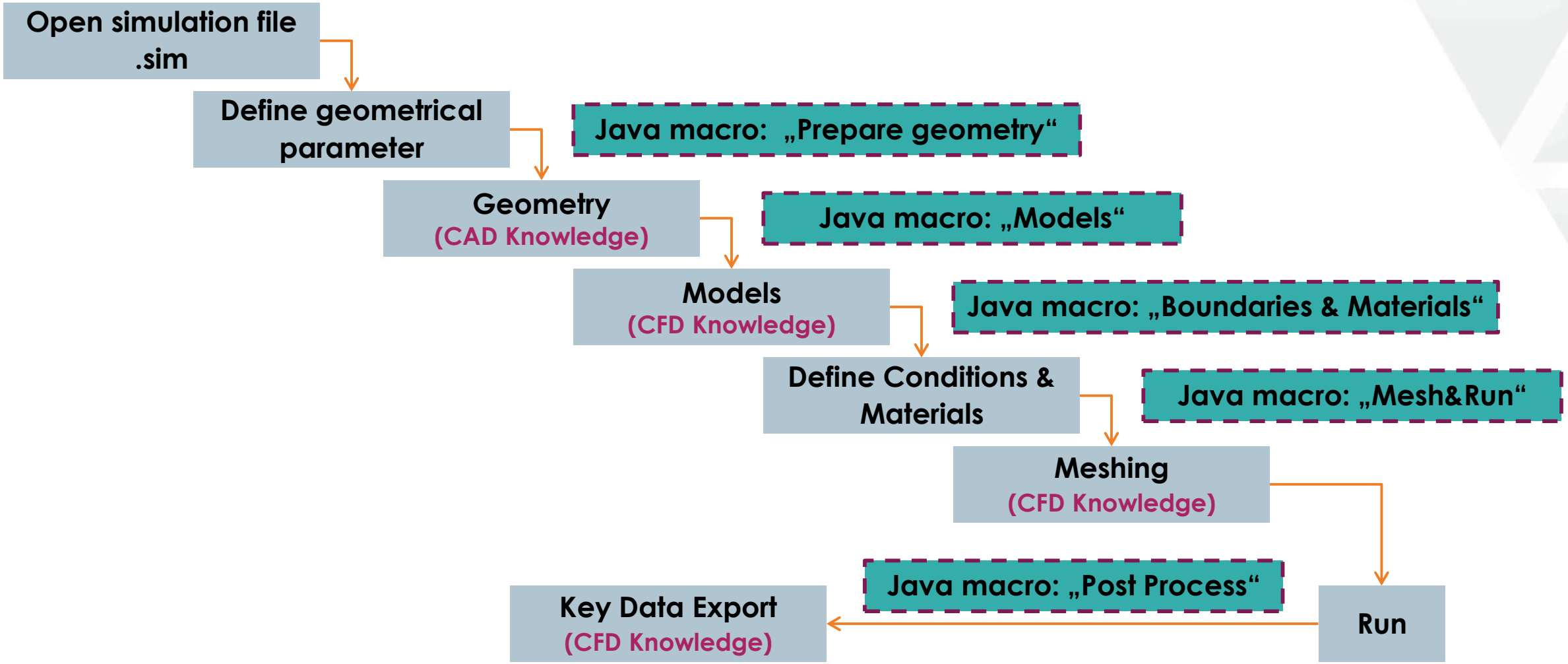
CFD Simulation – From Mess to Plug & Play



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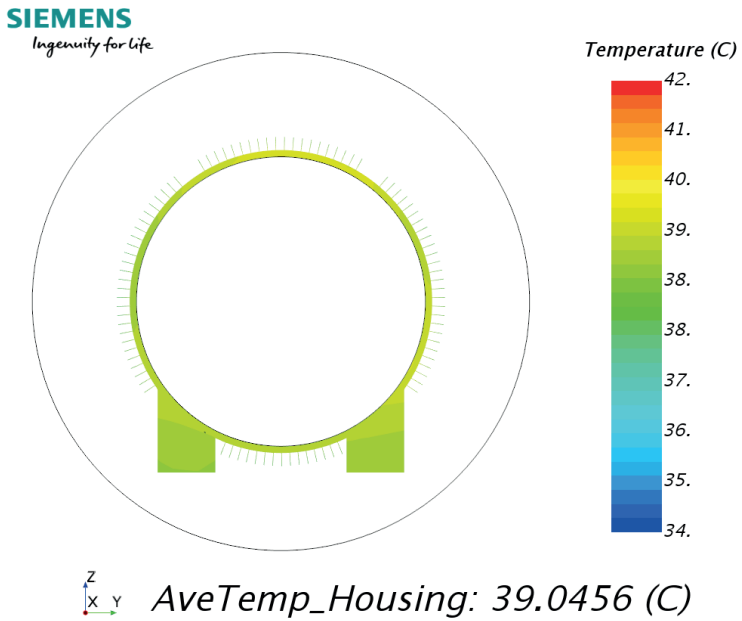
CFD Simulation – First results

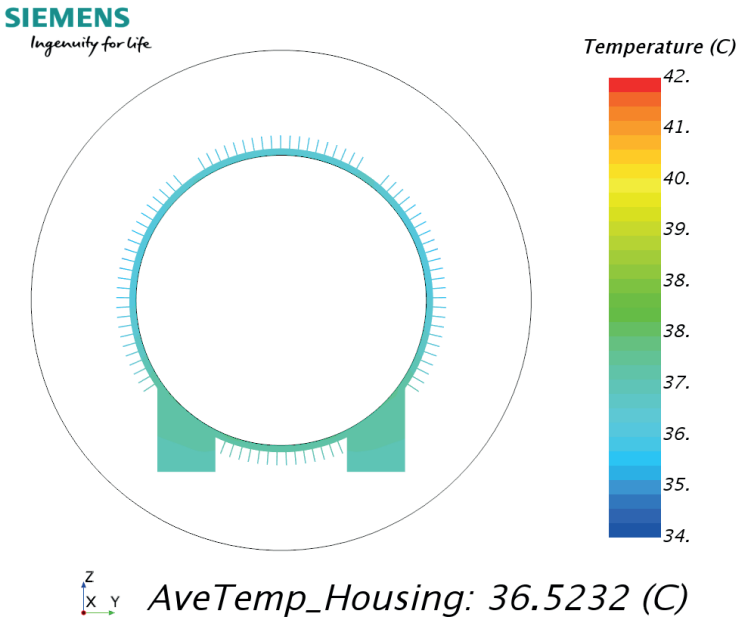
Fin Width

1 mm



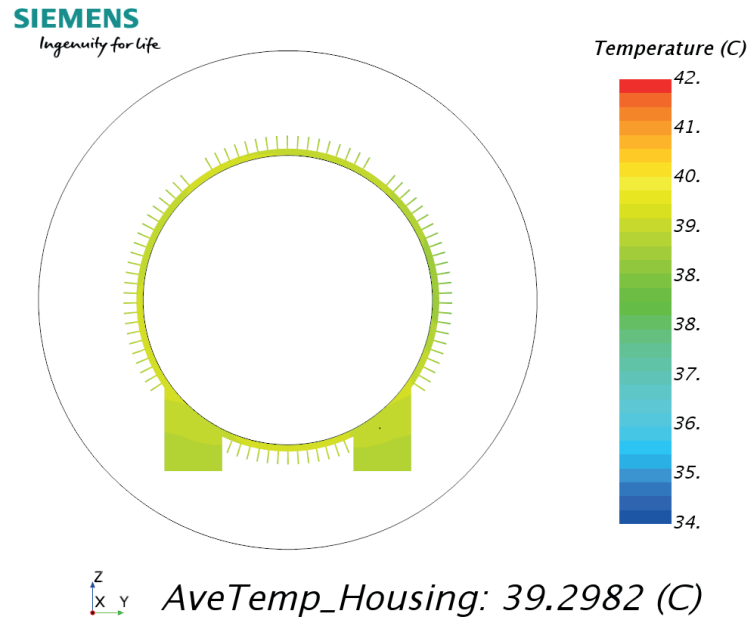
AveTemp_Housing: 39.0456 (C)

2 mm (Base case)



AveTemp_Housing: 36.5232 (C)

3 mm



AveTemp_Housing: 39.2982 (C)

Very thin fins do not always enhance cooling – larger fins have a negative impact motor's cooling

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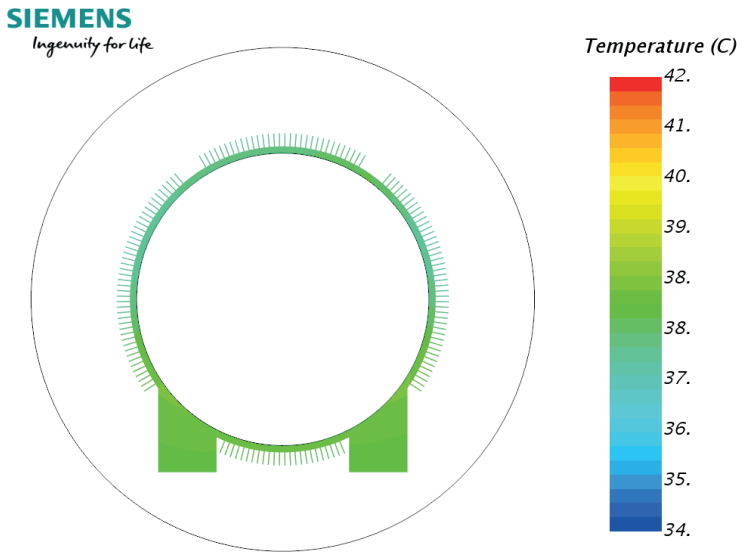
CFD Simulation – First results

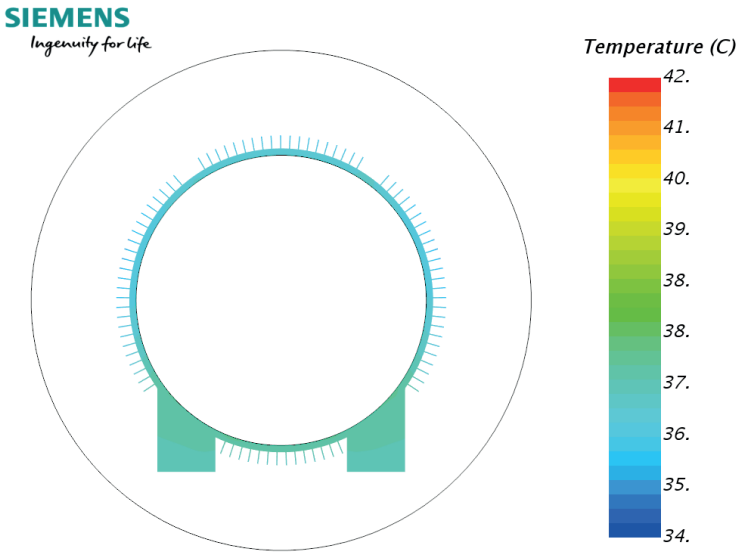
Air gap between fins

8 mm



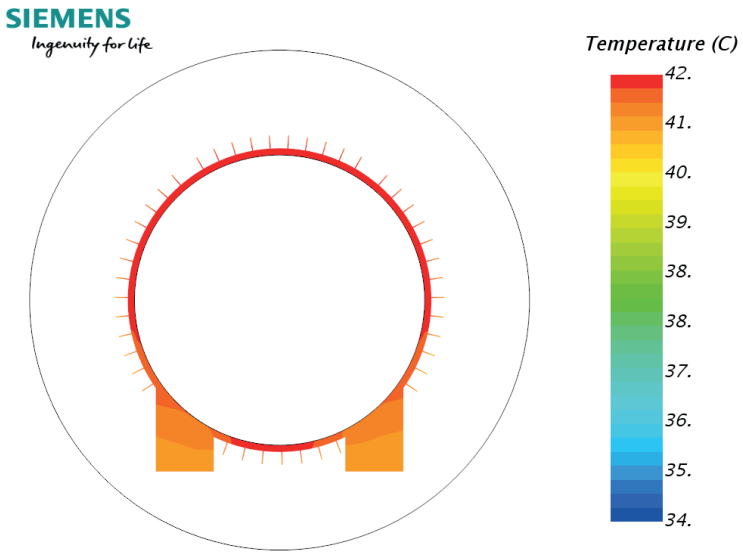
AveTemp_Housing: 37.7778 (C)

16 mm (Base case)



AveTemp_Housing: 36.5232 (C)

32 mm



AveTemp_Housing: 41.5788 (C)

Large or very small air gaps do not necessarily lead to better cooling – number of fins is indirectly influenced

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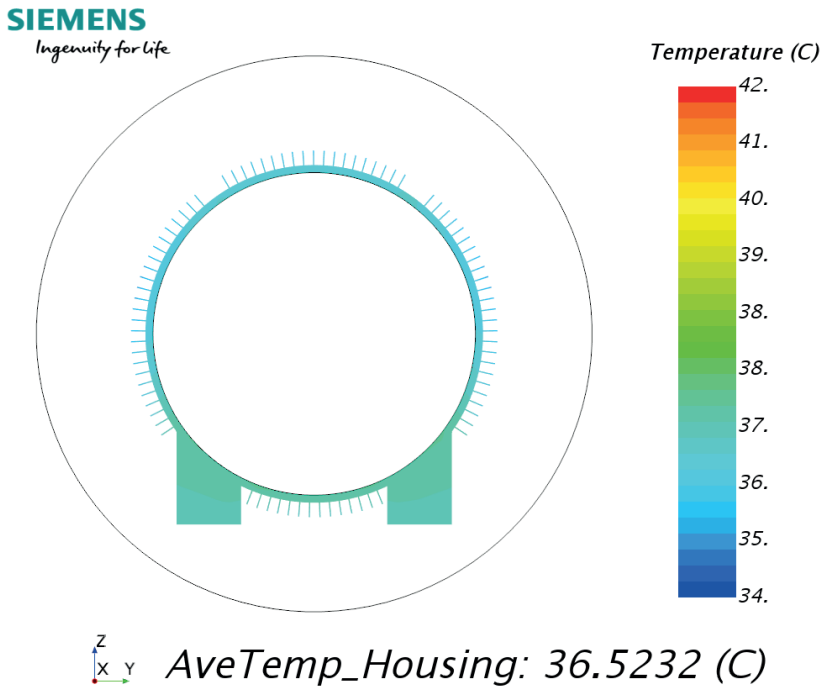
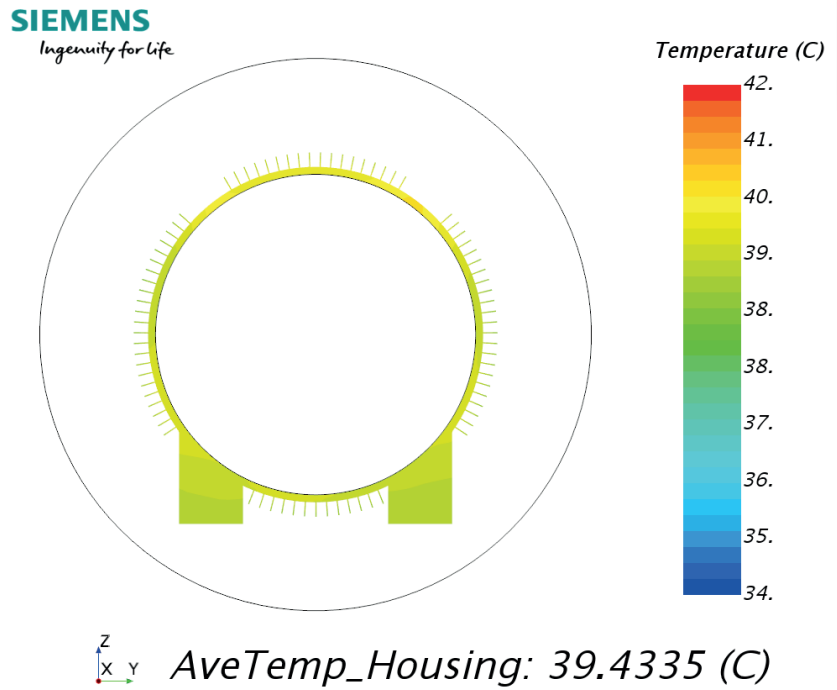
CFD Simulation – First results

Size of electronics plug

90mm (Base case)



135mm



Larger electronic plugs lead to less effective cooling – less area available for fins

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Summary

- An **automated simulation configuration** presented to enable "CFD Democratization in R&D Process"
- Motor housing design selected as case study
- A 3D parametric model has been developed using **Simcenter Siemens NX & STAR-CCM+**
- Automation of the process through the use of parameters and java scripts
- Template created and various parameters have been tested based on it
- Easy identification of the influence of various parameters on the cooling process and housing design
- **Expand knowledge to other team members** even without having the theoretical background (CFD)
- **Know-how can be applied in future designs**

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Co-Hosted by NAFEMS DE Digital Engineering

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Ingenuity for life

Thank You!

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