

## E-MOTOR CFD ANALYSIS: IKERMAQ MOTOR

FLUX-ACUSOLVE COUPLING APPLICATION (VIA SIMLAB)

June 2022, Altair Engineering Inc.



# TUTORIAL OUTLINE

## I. Introduction

## II. 2D Electromagnetic Analysis (Flux)

- II.1: Loss computation

## III. 3D CFD Analysis (SimLab / AcuSolve)

- III.1: eMotor CFD meshing
- III.2: CFD solution setup

## IV. Conclusion

# INTRODUCTION

# INTRODUCTION

## Application Case: IkerMAQ Motor

- About the machine: IkerMAQ<sup>1</sup>
  - **P**ermanent **M**agnet **S**ynchronous **M**achine
  - Performance study
    - Transient magnetic analysis
    - NVH analysis
      - Vibration analysis
      - Acoustic analysis
    - Thermal analysis

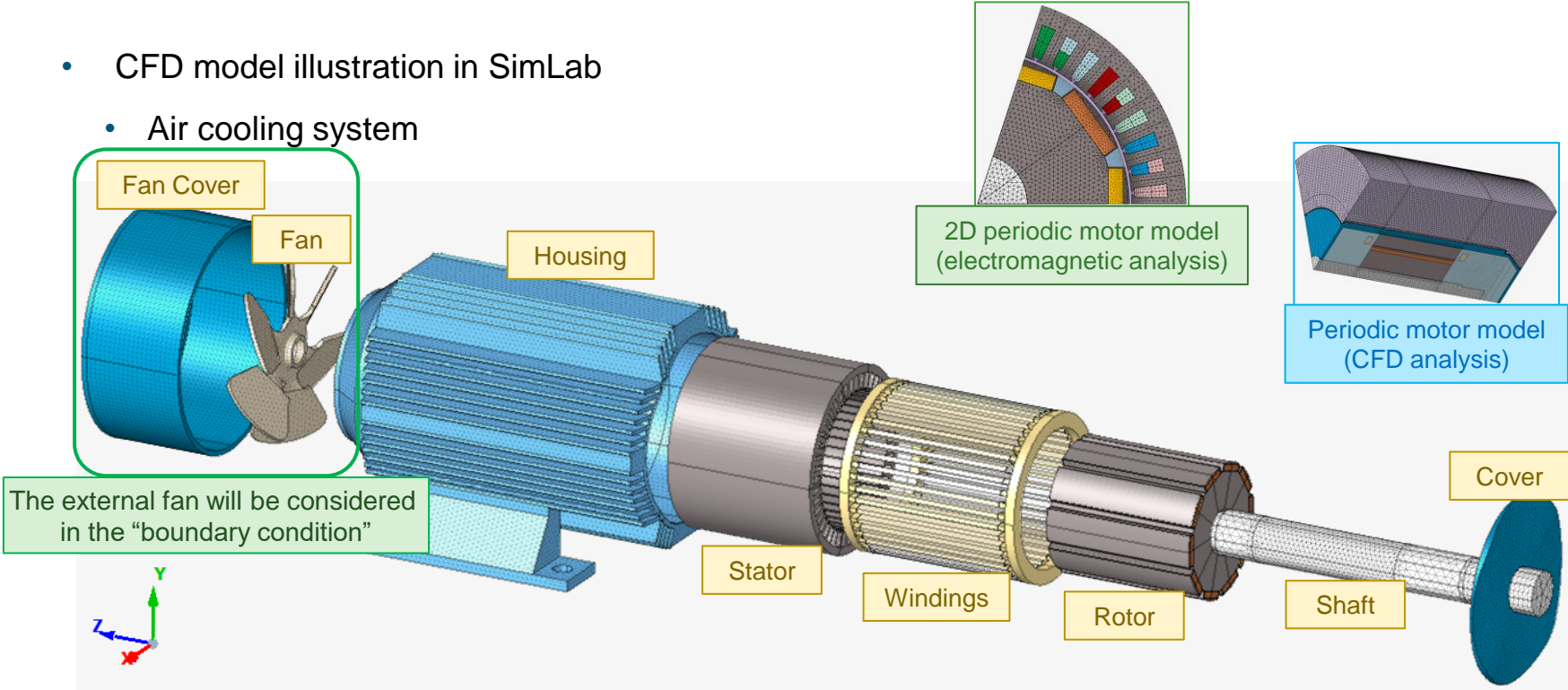


Parameter	IkerMAQ
Power	75 kW
Speed	1080 rpm
Torque	700 Nm
EMF (phase)	293 V <sub>rms</sub>
Current (phase)	87 A <sub>rms</sub>
External stator radius	0.188 m
Effective length	0.31 m
Pole pairs number	5
Slots number	45
Internal stator radius	0.139 m
Airgap	2.5 mm

# INTRODUCTION

## Application Case: IkerMAQ Motor

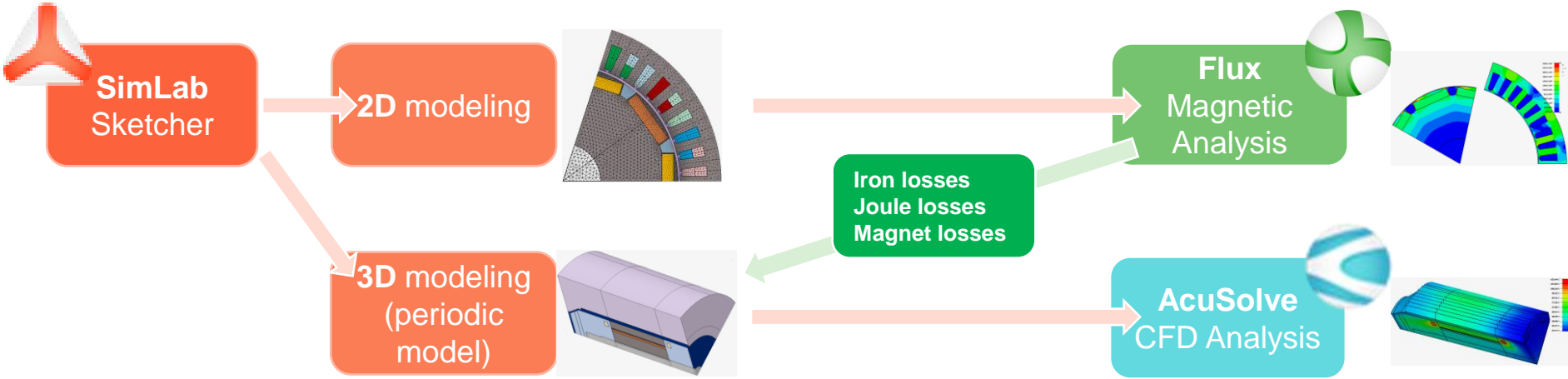
- CFD model illustration in SimLab
  - Air cooling system



# INTRODUCTION

## E-Motors CFD Analysis with SimLab

- Analysis workflow (Flux-AcuSolve one way coupling application)



# 2D ELECTROMAGNETIC ANALYSIS (FLUX)

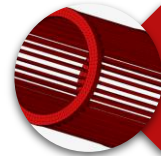
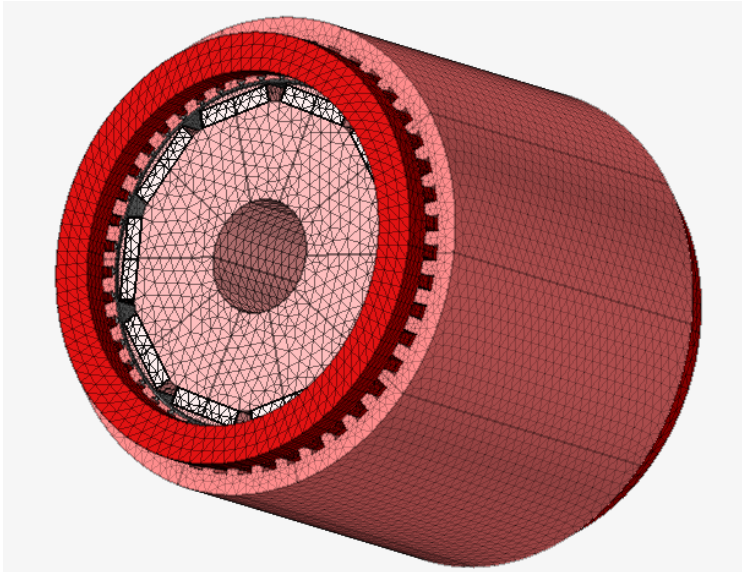
# LOSS COMPUTATION



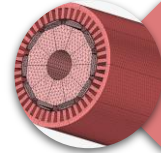
# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation

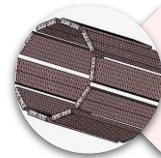
- Loss distribution inside an eMotor
  - Generally, it can be divided into the following three cases



Coil losses (**Joule** loss)



Stator / Rotor losses (**iron** loss)



Magnet losses (**Joule** loss)

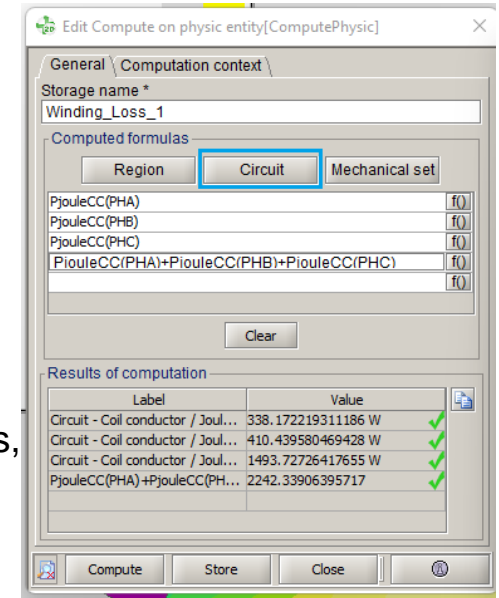
# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Total Value Method

- Loss distribution inside an eMotor
- The losses inside an eMotor will be defined as **Heat Sources** in SimLab for AcuSolve.



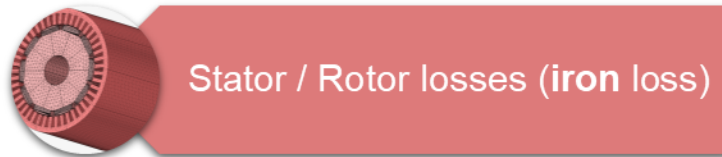
- As the temperature distribution in coil regions (both straight parts and the end-windings) and magnet regions is quite homogeneous, the Heat Source of the coil and magnet bodies can be defined using the **total loss value**.



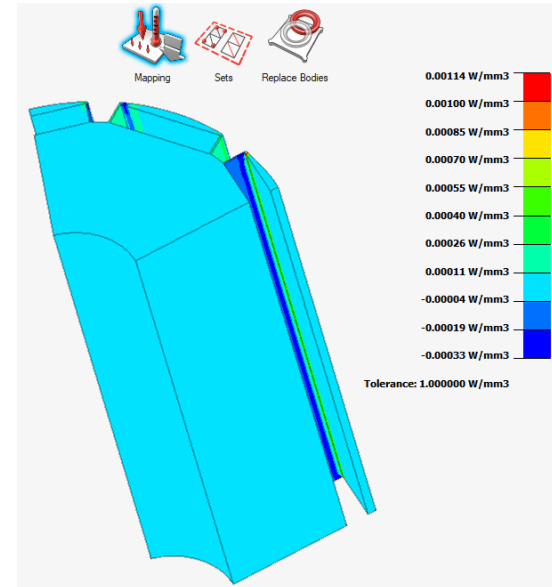
# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Nodal Mapping Method

- Loss distribution inside an eMotor
- The losses inside an eMotor will be defined as **Heat Sources** in SimLab for AcuSolve.



- As iron loss distributions in the stator region and the rotor region are not homogeneous, the Heat Source of the stator / rotor bodies is better to be defined using the **nodal mapping method**.



# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Flux Initiation

- Run the predefined 2D electromagnetic analysis (in motor mode)
- Open the project “IkerMAQ\_MotorMode.FLU” in Flux

The screenshot displays the Altair Flux 2D software interface. The top navigation bar includes tabs for 2D, Skew, 3D, and PEEC. The left sidebar contains options for 'New project', 'Open project', 'Open example', 'Python scripts', and 'Batch solve'. The main workspace is divided into several sections:

- How to proceed?:** A list of instructions: 1) Select the working module (2D, Skew, 3D or PEEC), 2) Select the working directory, 3) Select the Flux project in the current projects, 4) Click on 'Open the selected project' (or double-click directly on the selected project).
- Working directory:** E:\SimLab\CFD\IkerMAQ\_Release\IkerMAQ\_Release\IkerMAQ\_2D\_Flux\_2D
- Directory selector:** A tree view showing the project structure, including folders like 'IkerMAQ\_2D' and 'IkerMAQ\_2D\_MotorMode.FLU'.
- Current projects:** A table listing the current project:
 

Name	Size	Date	Type
IkerMAQ_MotorMode.FLU	6.903 MB	2022/06/28 11:58 AM	Flux 2D project
- Recent projects:** A table listing recent projects:
 

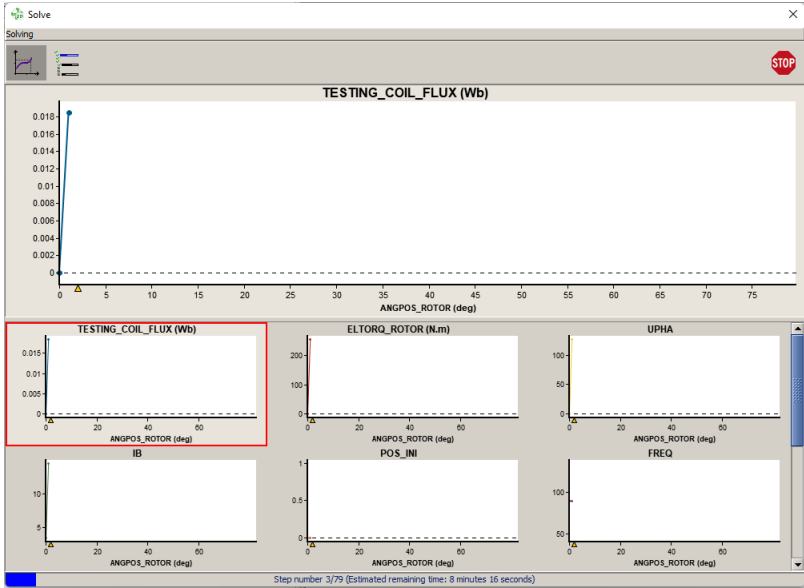
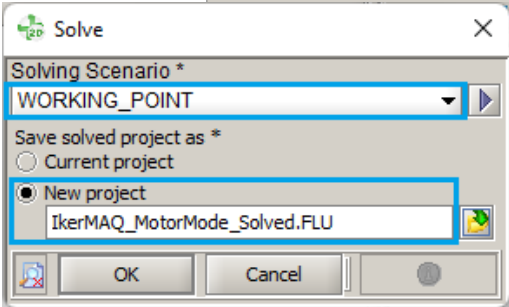
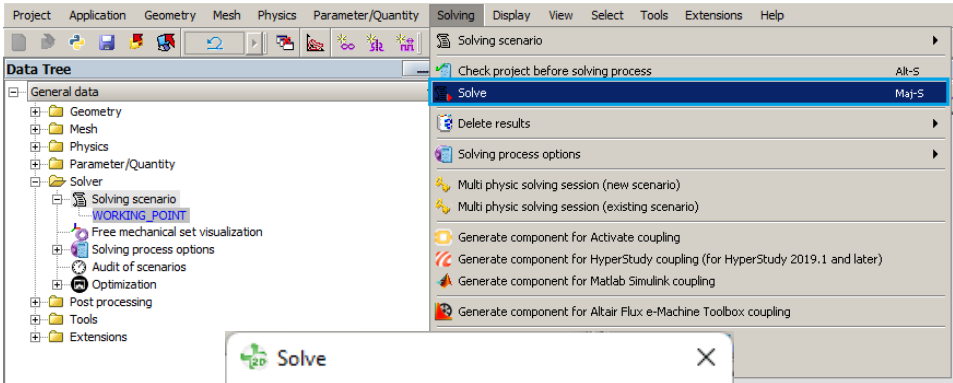
Name	Size	Date	Type
IkerMAQ_2D_MotorModeSolved.FLU	169.855 MB	2022/06/28 9:09 PM	Flux 2D project
IkerMAQ_2D_MotorMode.FLU	169.855 MB	2022/06/28 9:40 PM	Flux 2D project
IkerMAQ_2D_Solved.FLU	169.855 MB	2022/06/28 8:22 PM	Flux 2D project
IkerMAQ_2D_Solved.FLU	84.636 MB	2022/06/28 11:51 AM	Flux 2D project
- IkerMAQ\_MotorMode.FLU details:**
  - Application: Transient Magnets: 2D
  - State: Not solved
  - Version: 22.0
  - Comment: Enter your comments
- 3D Model:** A 3D visualization of the motor's cross-section, showing the stator and rotor components.

The bottom status bar shows system information: Physical memory (15.40 GB/63.76 GB), Allocable memory (15.40 GB/64.76 GB), and Disk space (1.57 TB/1.60 TB). The Altair logo is visible in the bottom right corner.

# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Flux Initiation

- Run the predefined 2D electromagnetic analysis (in motor mode)
  - [Solving] – [Solve] (as a new project “IkerMAQ\_MotorMode\_Solved.FLU”)

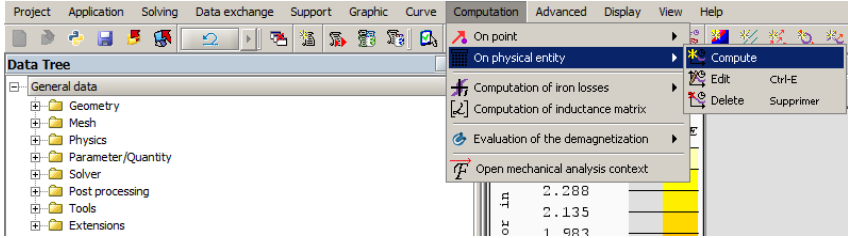


# LOSS COMPUTATION: TOTAL VALUE

# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Total Value Method

- Winding Joule losses
- [Computation] – [On physical entity] – [Compute]



The 'Edit Compute on physic entity[ComputePhysic]' dialog box is open, showing the 'Computed formulas' section with 'Circuit' selected. The 'Results of computation' table is as follows:

Label	Value
Circuit - Coil conductor / Joule...	338.172219311186 W
Circuit - Coil conductor / Joule...	410.439580469428 W
Circuit - Coil conductor / Joule...	1493.72726417655 W
PjouleCC(PHA)+PjouleCC(PH...	2242.33906395717

The 'Computation on circuit' tool is also shown, with 'Coil conductor' selected as the component type. The 'TESTING\_COIL\_CONDUCTOR' is selected in the list. The 'Formula' section contains the following entries:

Formula
PjouleCC(PHA)
PjouleCC(PHB)
PjouleCC(PHC)

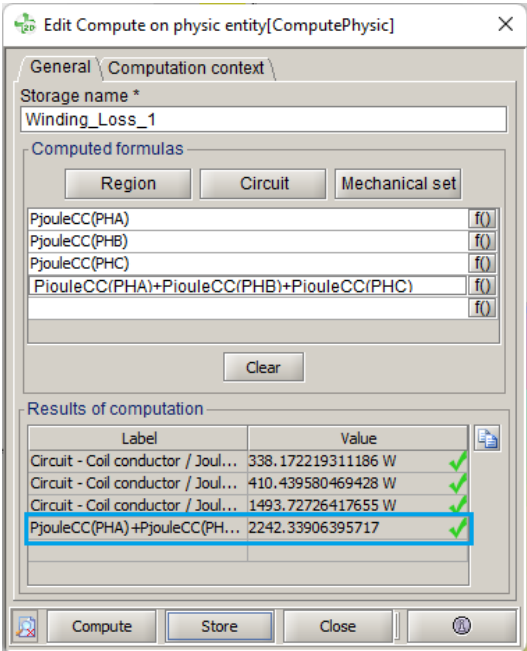
A blue callout box points to the 'Computation on circuit' tool with the text: "The value computed by the 'Computation on circuit' tool is based on the full model".

Formula to compute total Joule losses on winding area:  
 $PjouleCC(PHA)+PjouleCC(PHB)+PjouleCC(PHC)$

# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Total Value Method

- Winding Joule losses
- Straight part: 2242.34 W



Winding and Magnet characteristics					
<b>Winding</b>					
Winding connection	Wye	Winding resistance factor	1.0		
Winding temperature (°C)	20.0	Line-Line resistance (Ω)	1.073 E-1	End winding resistance (Ω)	2.916 E-2
Phase resistance (Ω)	5.365 E-2	C.S. end winding (°C)	20.0	O.C.S. end winding (°C)	20.0
In slot winding (°C)	20.0	C.S. end winding resistance (Ω)	1.737 E-2	O.C.S. end winding resistance (Ω)	1.179 E-2
Winding straight part resistance (Ω)	2.45 E-2				
<b>Magnets</b>					
Magnet name	Magnet_1	Material name	USER.N48SH-I...	Material reference temp. Tref (°C)	20.0
Remanent induction at Tref (T)	1.27	Intrinsic coercive field at Tref (A/m)	1.512 E6	Relative permeability at Tref	1.05
Magnet temperature Tmag (°C)	20.0				
Remanent induction at Tmag (T)	1.27	Intrinsic coercive field at Tmag (A/m)	1.512 E6	Relative permeability at Tmag	1.05

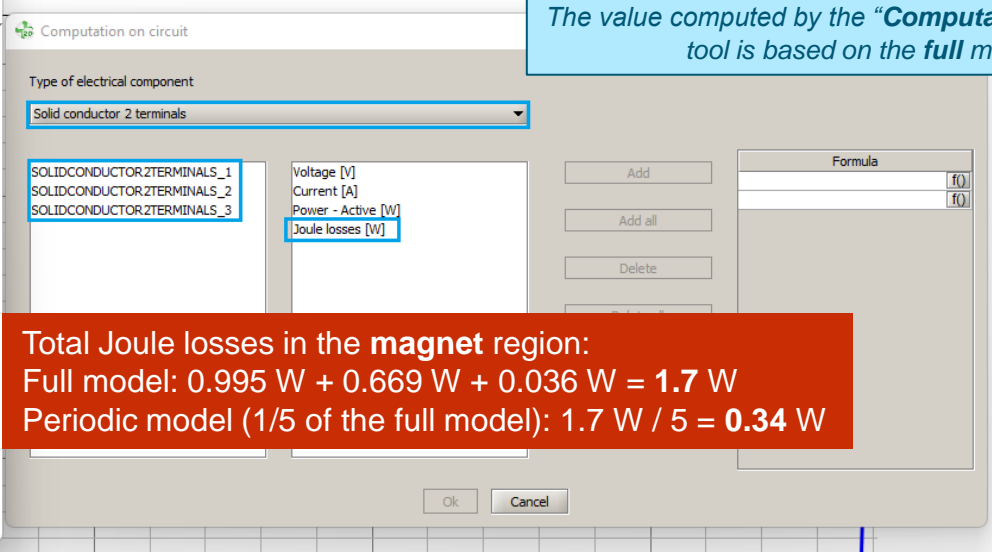
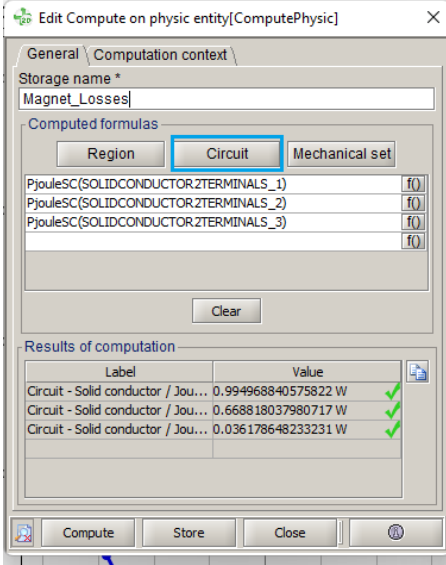
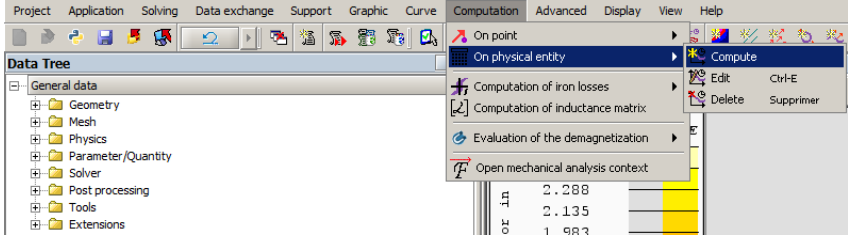
	R / Ohms	Loss (full model) / W	Loss (periodic model) / W
Straight part	0.0245	2242.34	448.47
C.S. end windings	0.0173	1583.37	316.67
O.C.S. end windings	0.0117	1070.83	214.17



# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Total Value Method

- Magnet losses
- [Computation] – [On physical entity] – [Compute]



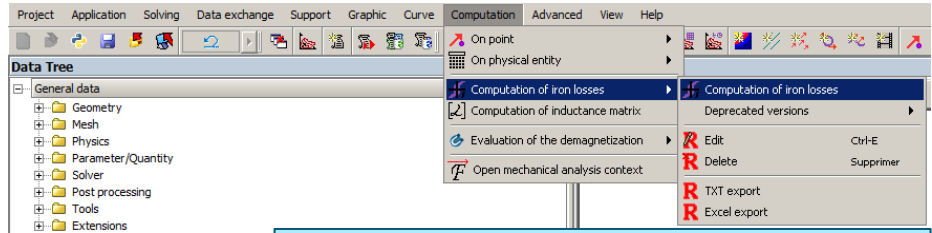
The value computed by the "Computation on circuit" tool is based on the **full model**

Total Joule losses in the **magnet** region:  
Full model:  $0.995 \text{ W} + 0.669 \text{ W} + 0.036 \text{ W} = 1.7 \text{ W}$   
Periodic model (1/5 of the full model):  $1.7 \text{ W} / 5 = 0.34 \text{ W}$

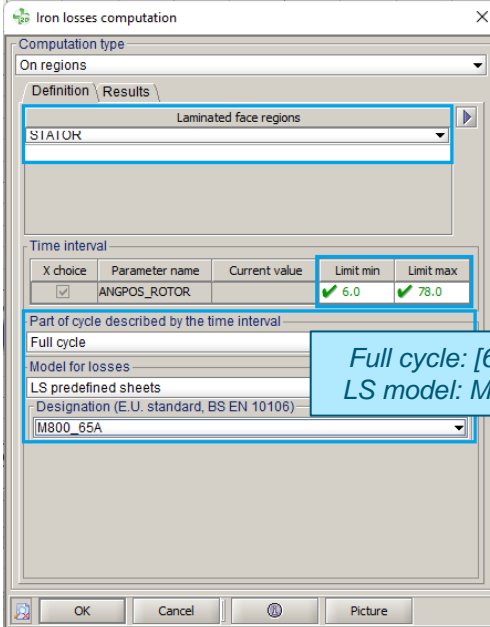
# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Total Value Method

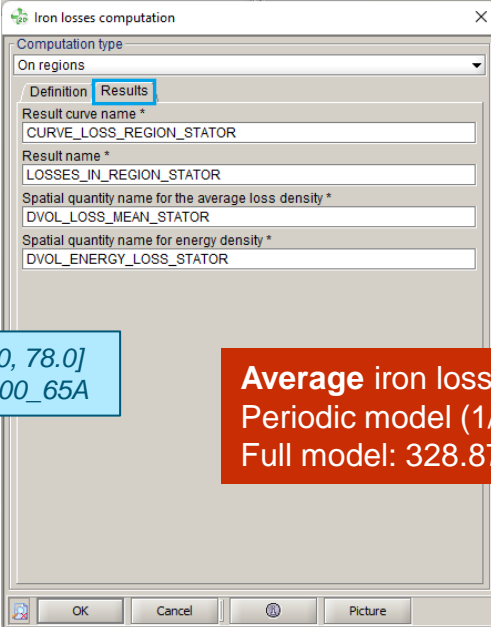
- Iron losses: stator
- [Computation] – [Computation of iron losses]



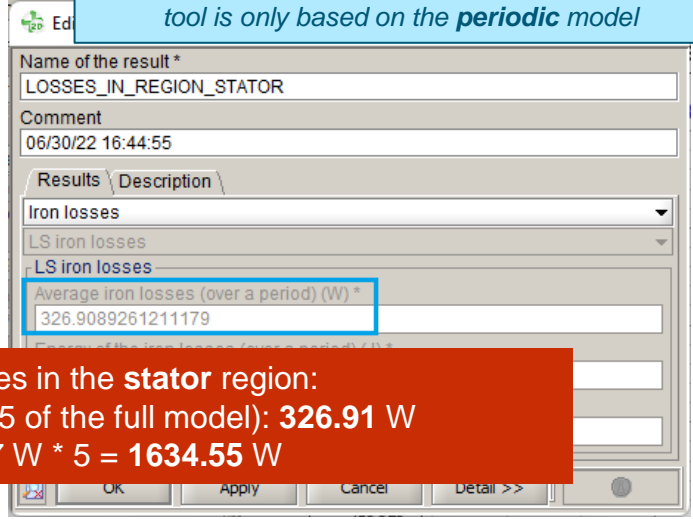
The value computed by the "Iron loss computation" tool is only based on the **periodic model**



Full cycle: [6.0, 78.0]  
LS model: M800\_65A



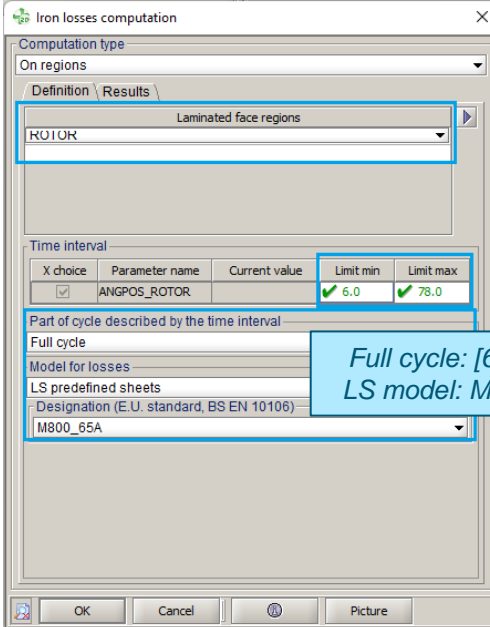
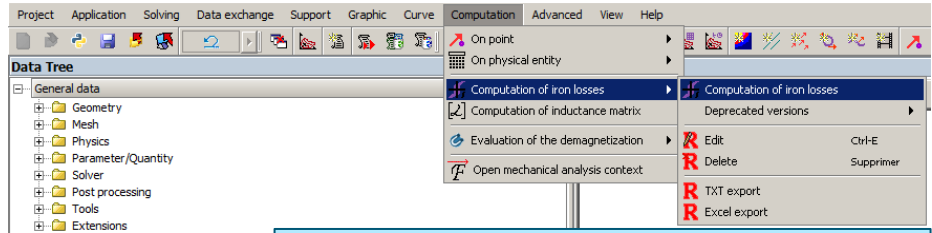
Average iron losses in the **stator** region:  
Periodic model (1/5 of the full model): **326.91 W**  
Full model:  $328.87 \text{ W} * 5 = 1634.55 \text{ W}$



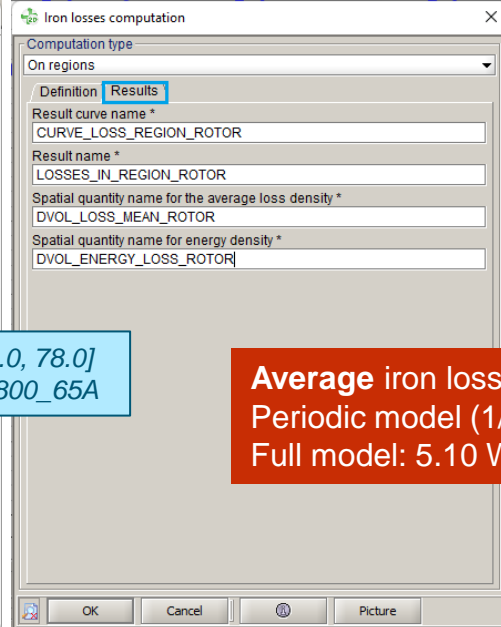
# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Total Value Method

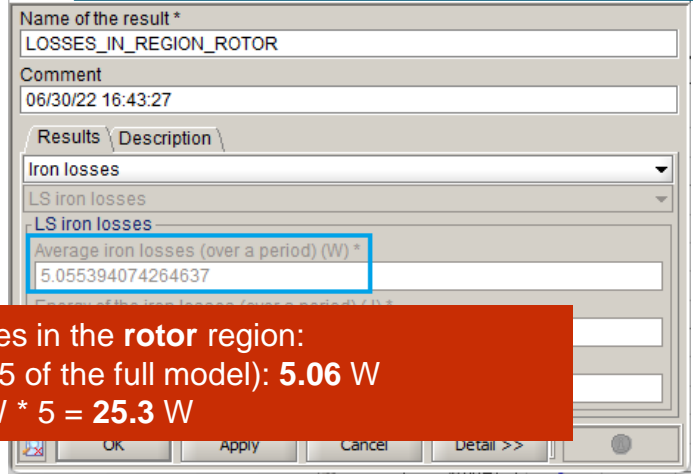
- Iron losses: **rotor**
- [Computation] – [Computation of iron losses]



Full cycle: [6.0, 78.0]  
LS model: M800\_65A



The value computed by the "Iron loss computation" tool is only based on the **periodic model**

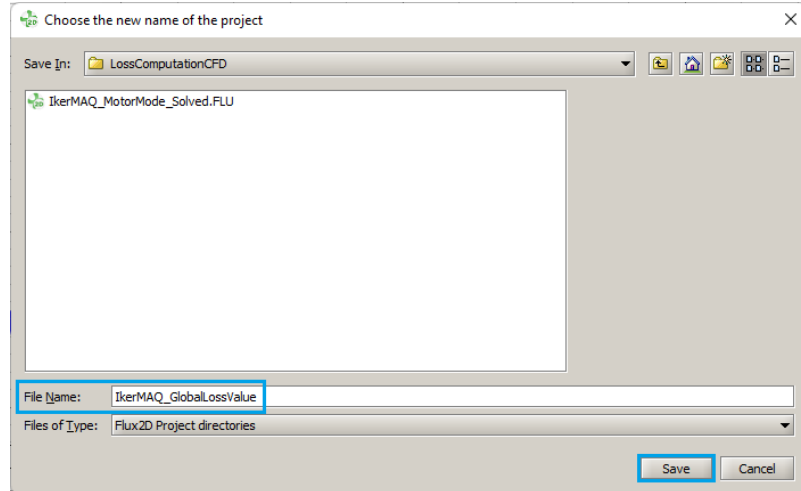
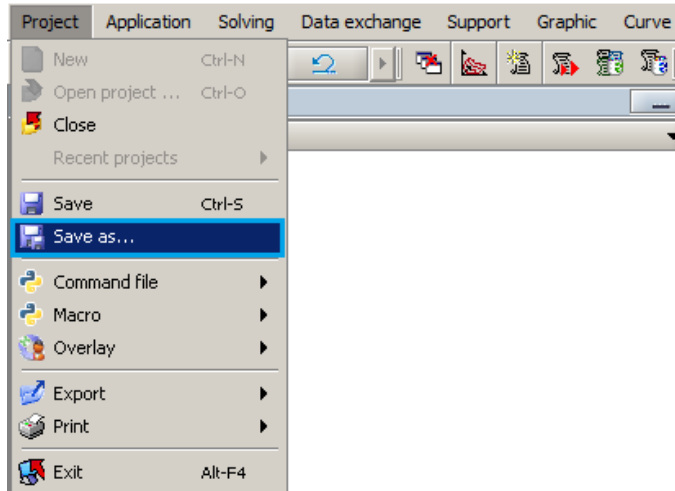


**Average iron losses in the rotor region:**  
Periodic model (1/5 of the full model): **5.06 W**  
Full model: 5.10 W \* 5 = **25.3 W**

# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Total Value Method

- Loss computation in Flux: total value method
  - Save the project as “IkerMAQ\_GlobalLossValue.FLU”

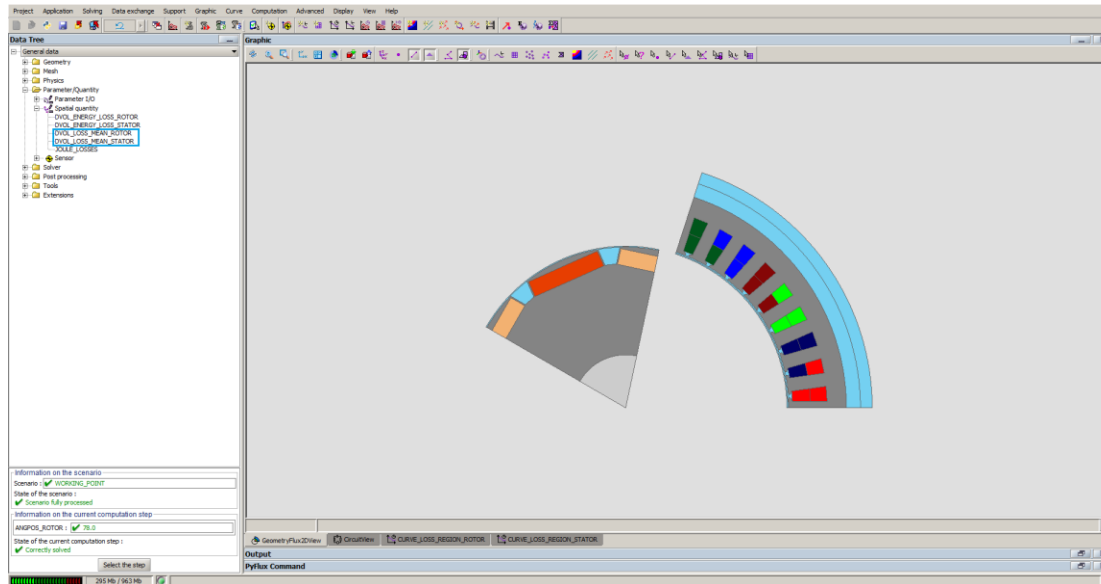


# LOSS COMPUTATION: NODAL MAPPING

# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Nodal Mapping Method

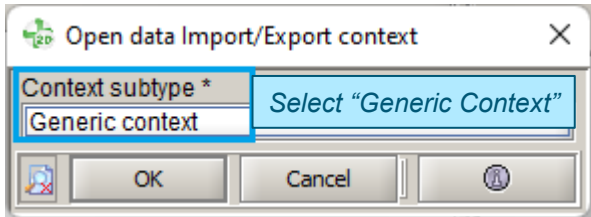
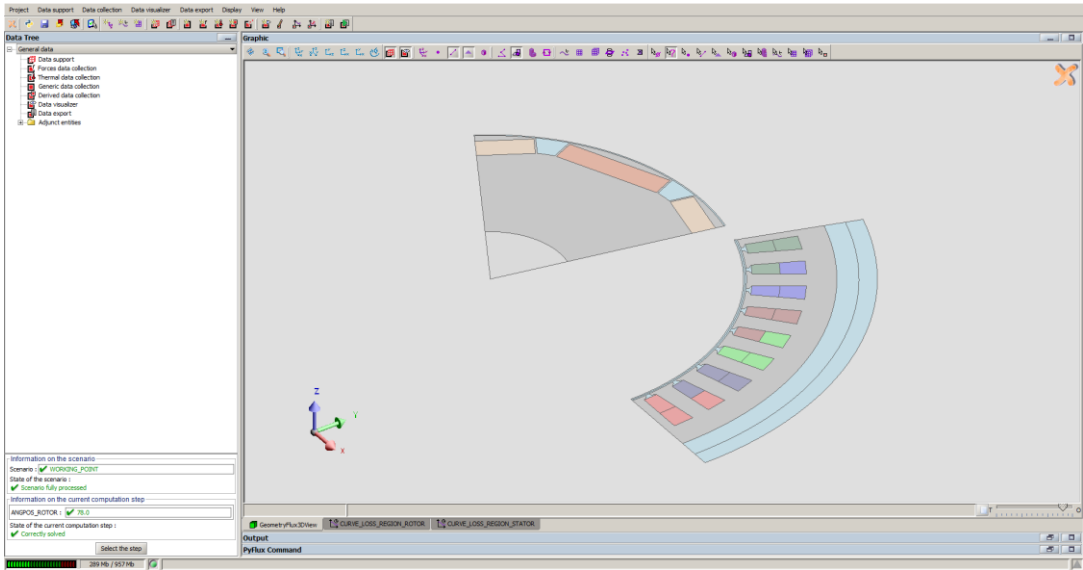
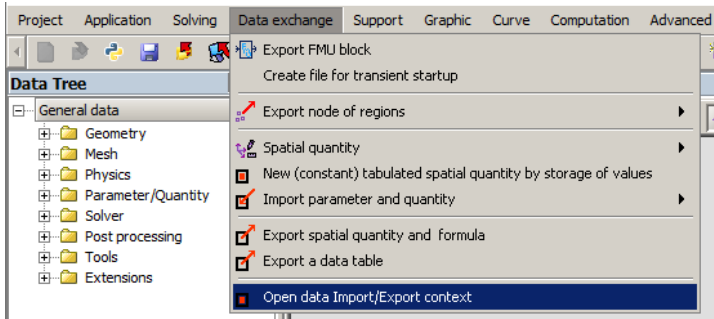
- Loss computation in Flux: nodal mapping method
- Need the spatial quantities created in the previous step
  - Continue to work on the project “IkerMAQ\_GlobalLossValue” in Flux



# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Nodal Mapping Method

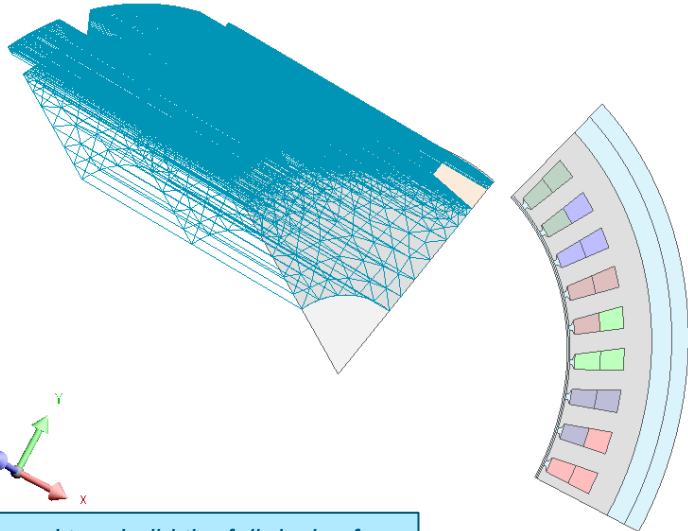
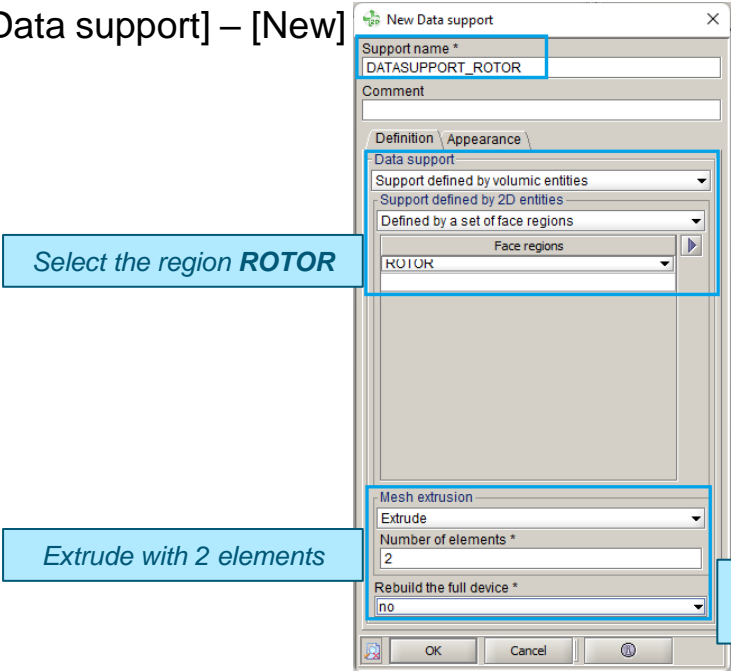
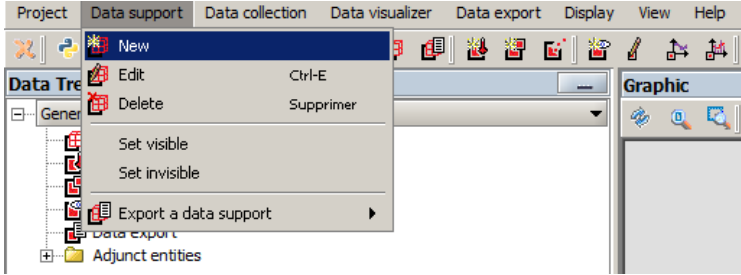
- Iron loss export from Flux
- Export the nodal loss values from Flux to AcuSolve
  - [Data exchange] – [Open data Import/Export context]



# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Nodal Mapping Method

- Iron loss export from Flux
- Create data support: **ROTOR**
  - [Data support] – [New]



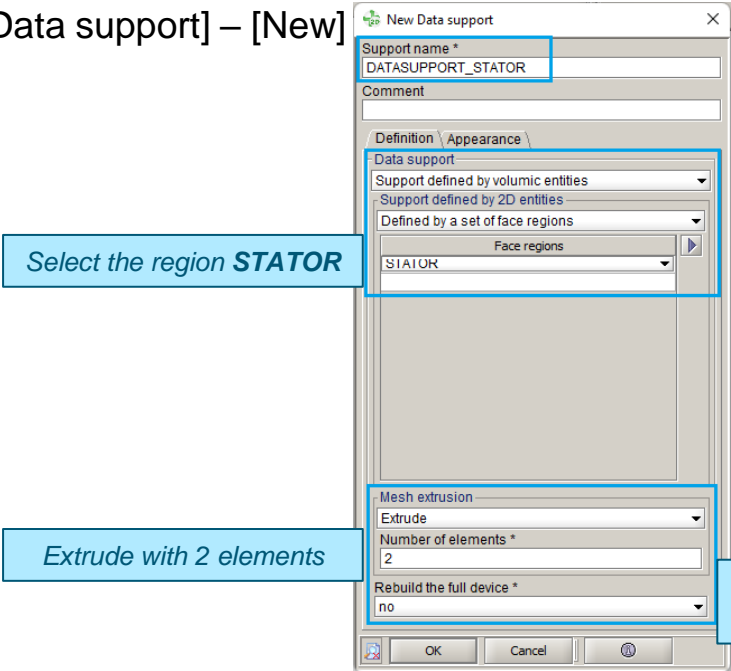
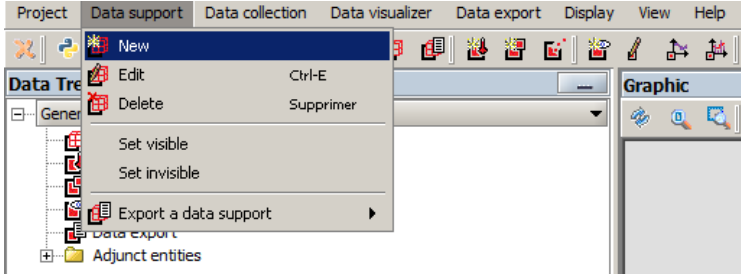
No need to rebuild the full device for the CFD analysis on a periodic model



# 2D ELECTROMAGNETIC ANALYSIS

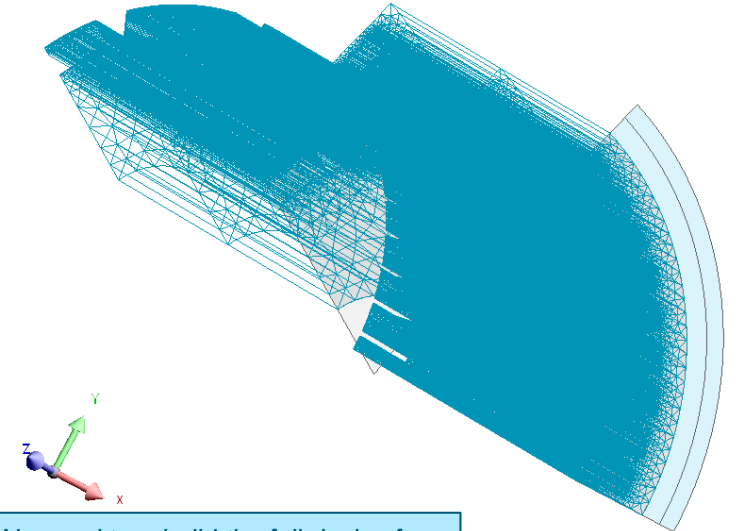
## Loss Computation: Nodal Mapping Method

- Iron loss export from Flux
- Create data support: **STATOR**
  - [Data support] – [New]



Select the region **STATOR**

Extrude with 2 elements



No need to rebuild the full device for the CFD analysis on a periodic model

# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Nodal Mapping Method

- Iron loss export from Flux
  - Create generic data collection
    - [Data collection] – [Generic data collection] – [New]

Information on the scenario  
Scenario :  WORKING\_POINT  
State of the scenario :  
 Scenario fully processed

Information on the current computation step  
ANGPOS\_ROTATOR :  78.0  
State of the current computation step :  
 Correctly solved

Select the step

Select the created DataSupport

Select the dedicated spatial quantity formula

Select "Average values in elements"

Collect the data only for the current step  
(the last EM solution step)

New Generic data collection

Name of the data collection \*  
DataCollection\_ROTATOR

Comment

Data collection  
Generic data collection

Collection support \*  
DATASUPPORT\_ROTATOR

Formula of the value to collect \*  
DVOL\_LOSS\_MEAN\_ROTATOR f()

Type of value  
Average values in elements

Collection interval  
Collect only for the current step

OK Cancel

Project Data support Data collection Data visualizer Data export Display View Help

Data Tree

- General data
  - Data support
  - Forces data collection
  - Thermal data collection
  - Generic data collection
    - Derived data collection
    - Data visualizer
    - Data export
  - Adjunct entities

Generic data collection context menu:

- New
- Edit Ctrl+E
- Delete Supprimer

New Generic data collection

Name of the data collection \*  
DATACOLLECTION\_STATOR

Comment

Data collection  
Generic data collection

Collection support \*  
DATASUPPORT\_STATOR

Formula of the value to collect \*  
DVOL\_LOSS\_MEAN\_STATOR f()

Type of value  
Average values in elements

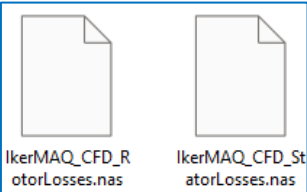
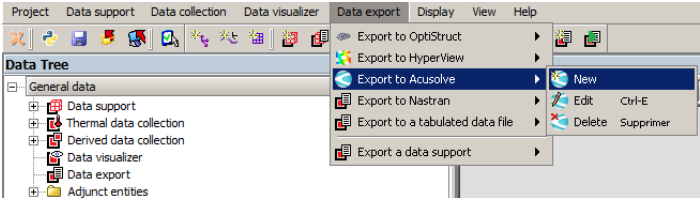
Collection interval  
Collect only for the current step

OK Cancel

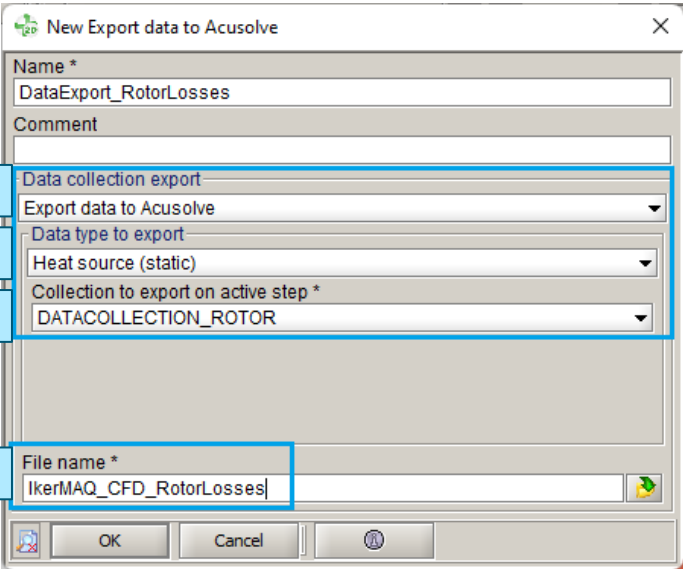
# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Nodal Mapping Method

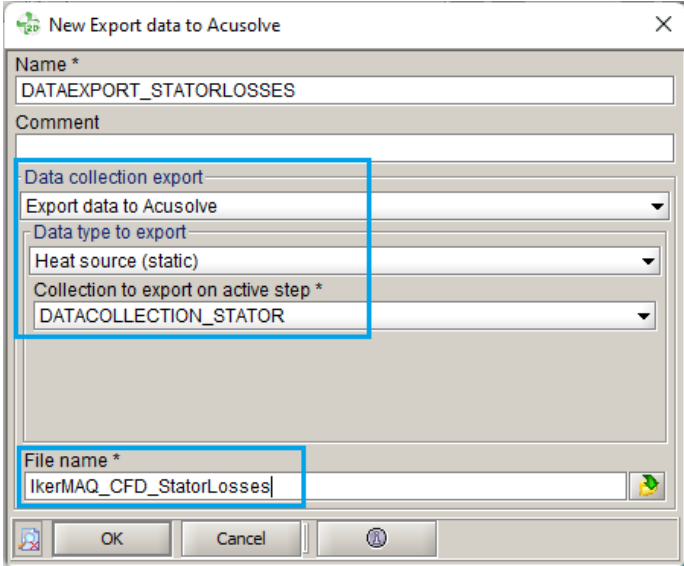
- Iron loss export from Flux
  - Create data export
    - [Data export] – [Export to AcuSolve] – [New]



- Select "Export data to AcuSolve"
- Select "Heat source (static)"
- Select the defined DataCollection



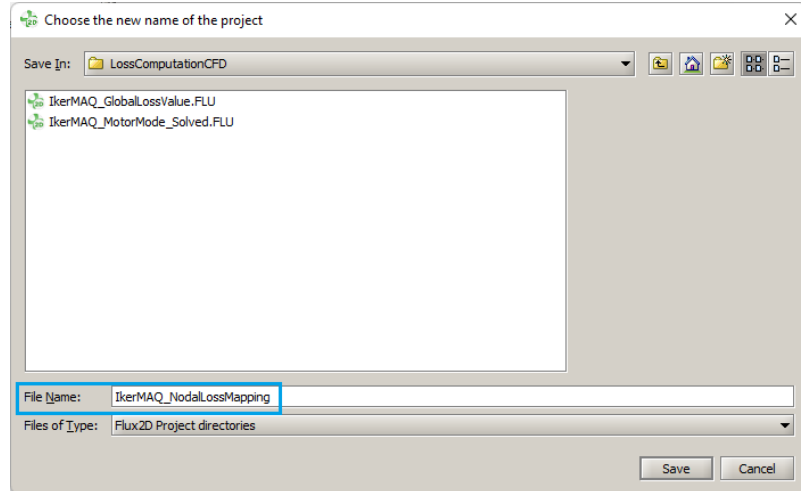
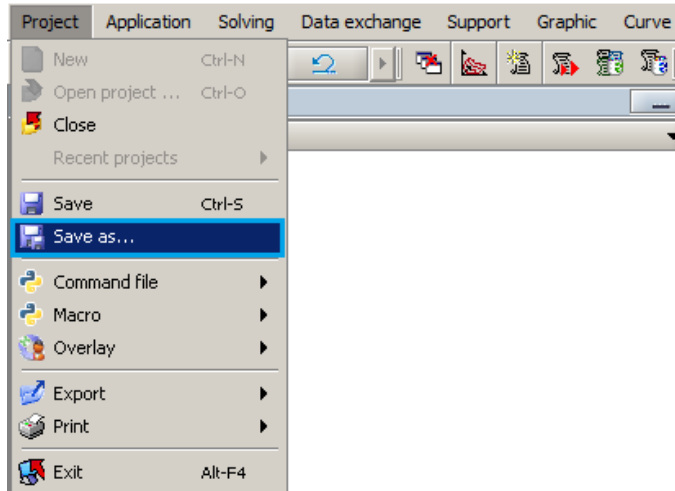
Define the export file name



# 2D ELECTROMAGNETIC ANALYSIS

## Loss Computation: Nodal Mapping Method

- Loss distribution inside an eMotor
  - Loss computation in Flux<sup>1</sup>
    - Save the project as “IkerMAQ\_NodalLossMapping.FLU”



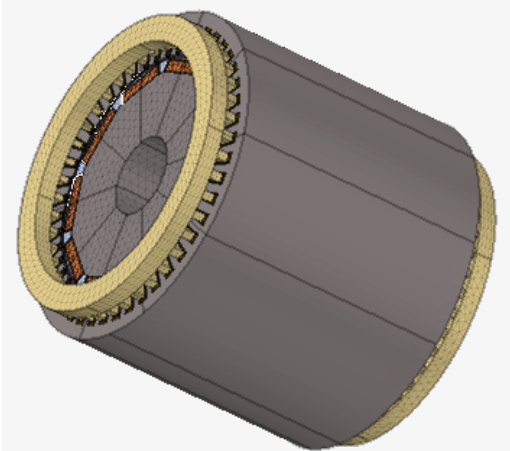
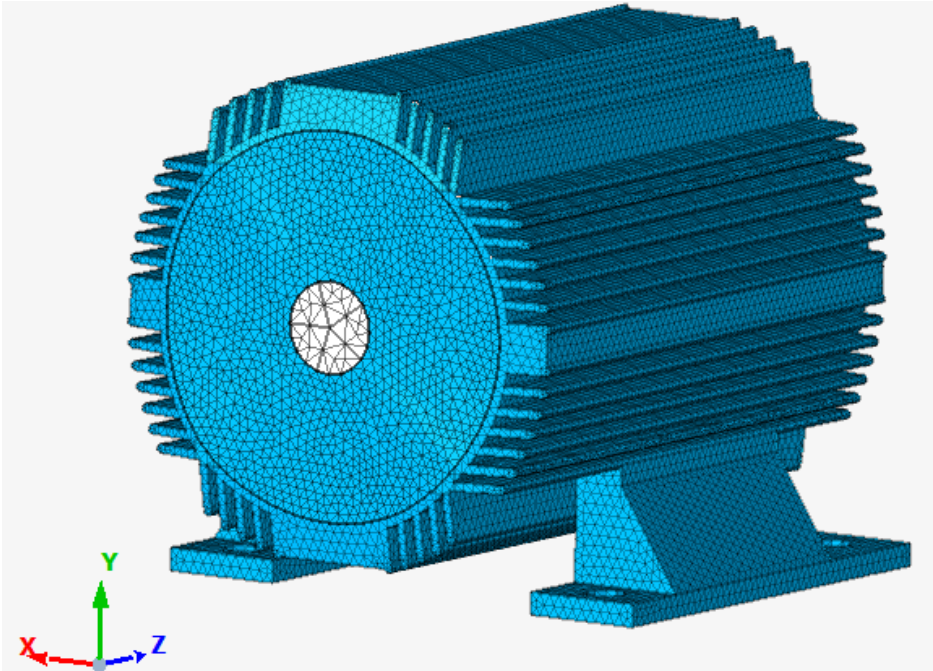
# 3D CFD ANALYSIS (SIMLAB / ACUSOLVE)

# EMOTOR CFD MESHING

# 3D CFD ANALYSIS

## eMotor CFD Meshing

- Full motor modeling for thermal analysis

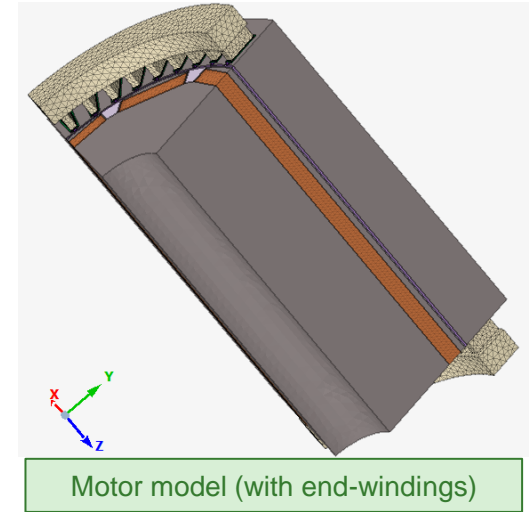
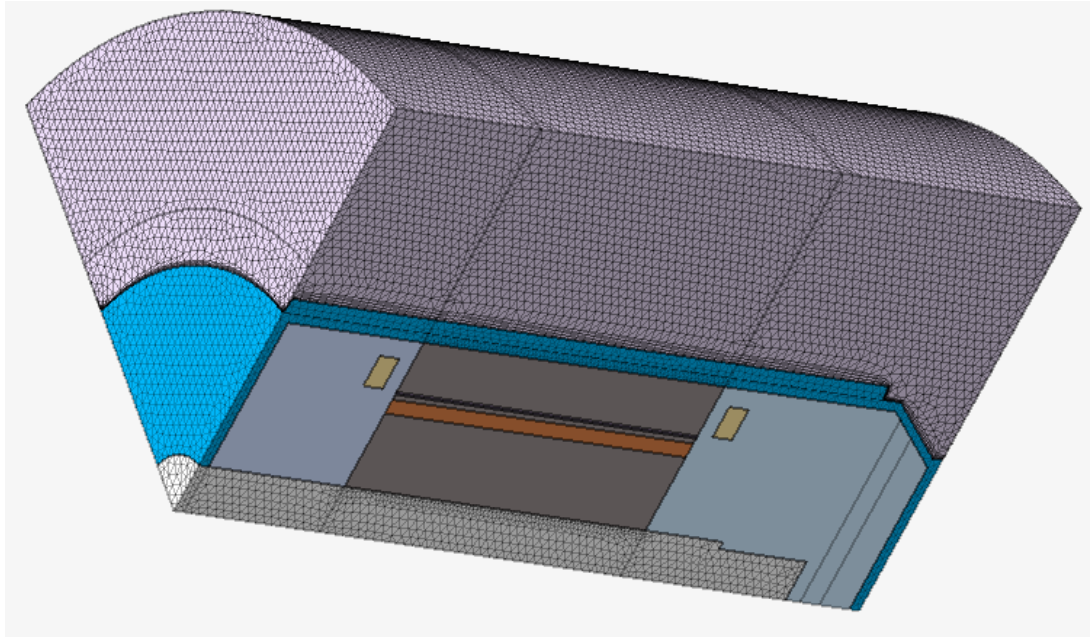


Motor model (with end-windings)

# 3D CFD ANALYSIS

## eMotor CFD Meshing

- Periodic modeling (axisymmetric model) for CFD analysis
- With outside air fluid region

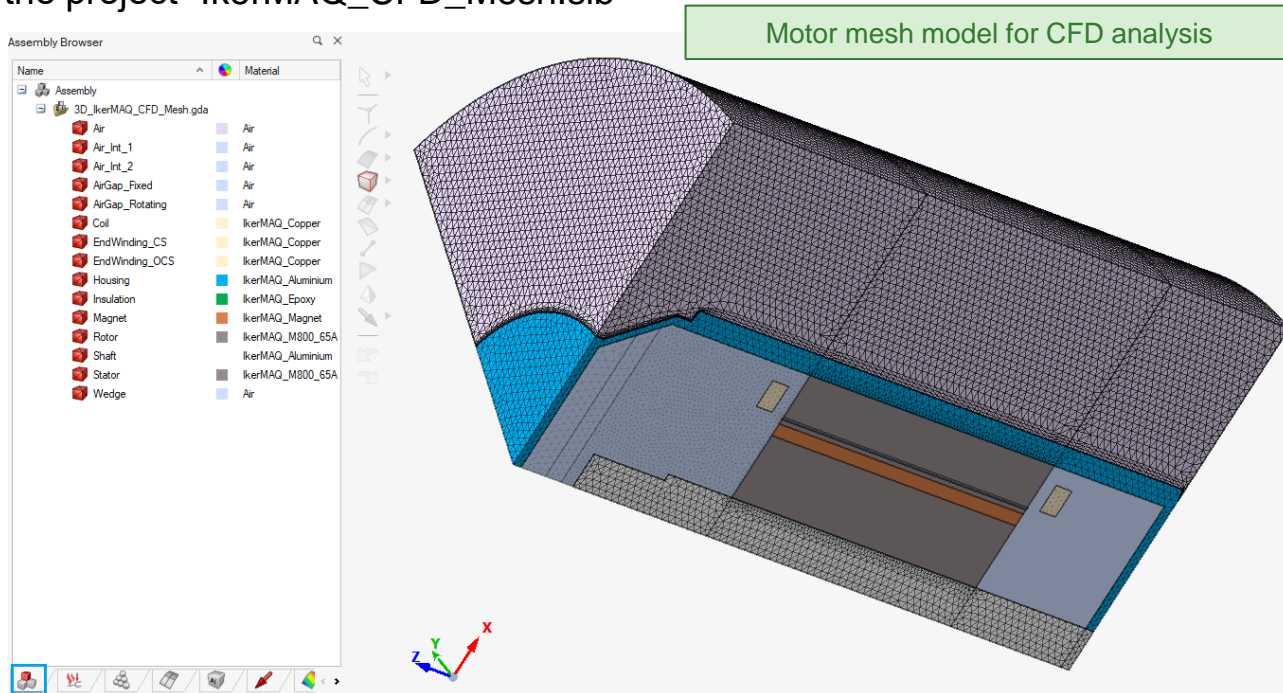




# 3D CFD ANALYSIS

## eMotor CFD Meshing

- Periodic modeling (axisymmetric model) for CFD analysis
- Open the project “IkerMAQ\_CFD\_Mesh.slb”

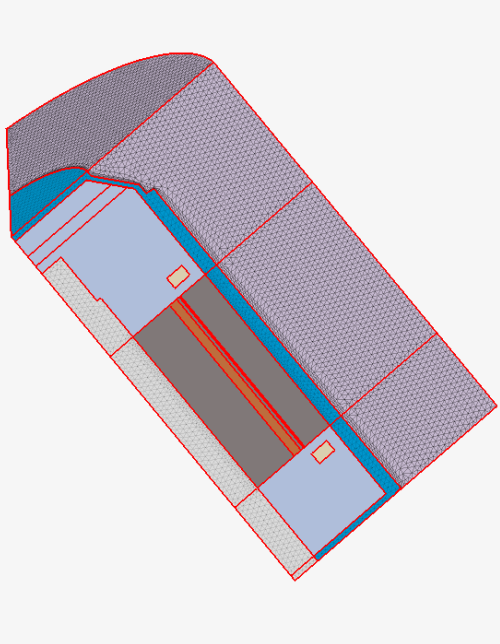
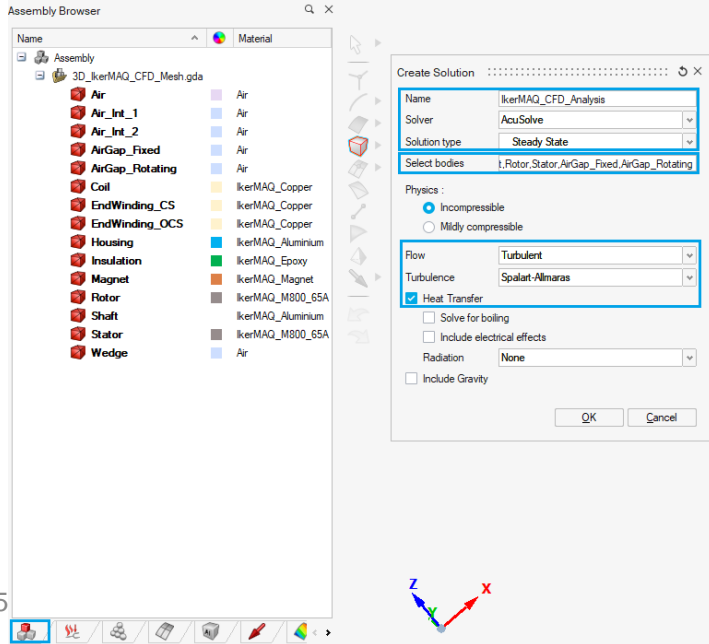
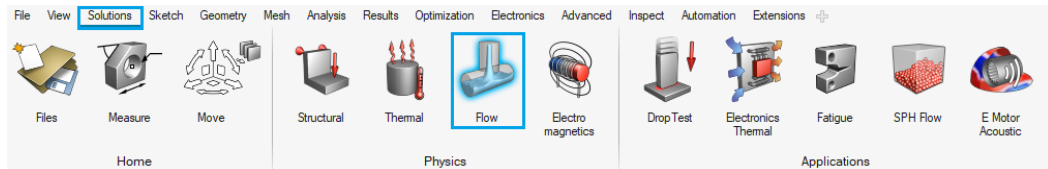


# CFD SOLUTION SETUP

# 3D CFD ANALYSIS

## CFD Solution Setup

- Create a **Solution** for CFD analysis
- [Solutions] – [Flow]

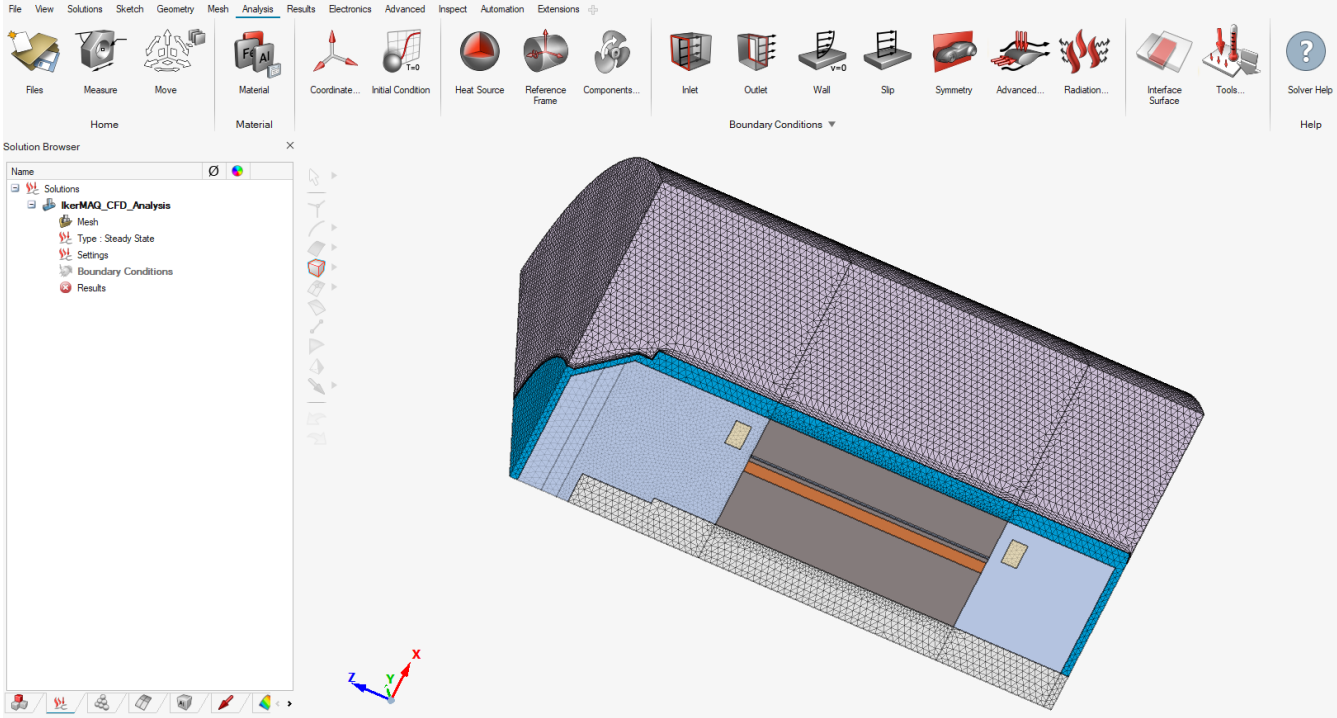


Parameter	Type / value
Name	IkerMAQ_CFD_Analysis
Solver	AcuSolve
Solution type	Steady State
Physics	Incompressible
Flow	Turbulent
Turbulence	Spalart-Allmaras

# 3D CFD ANALYSIS

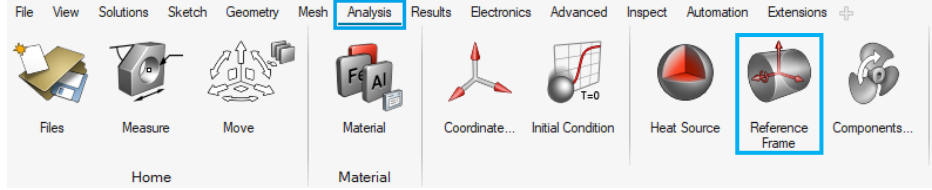
## CFD Solution Setup

- Create a **Solution** for CFD analysis

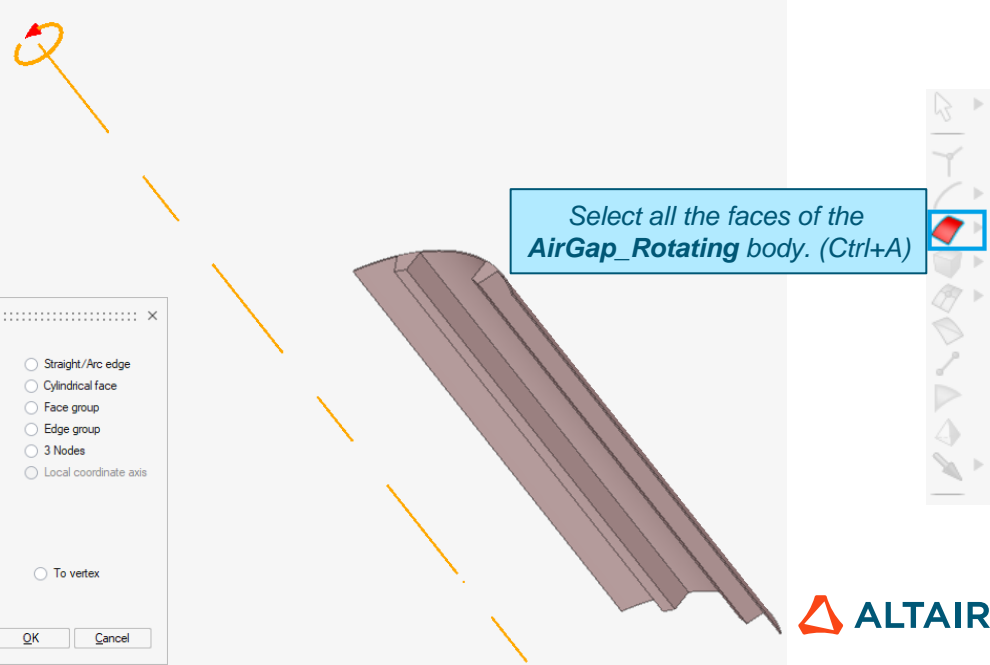
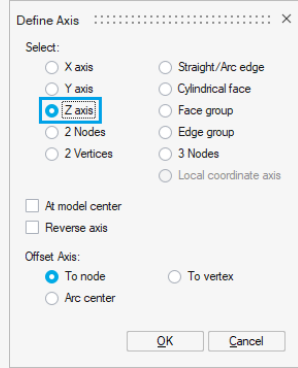
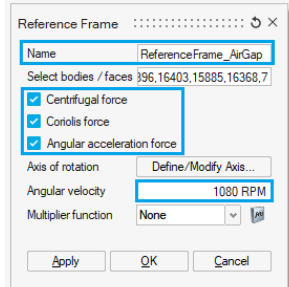


# 3D CFD ANALYSIS

## CFD Solution Setup

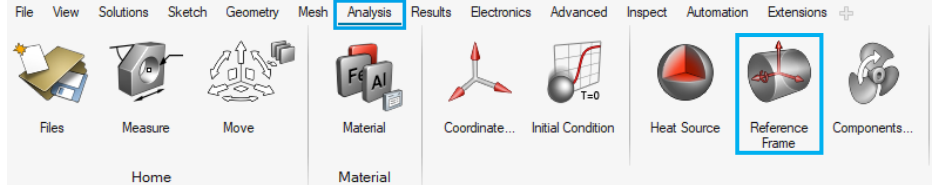


- Define **Flow Domain: Reference Frame**
- [Analysis] – [Reference Frame]
- AirGap\_Rotating



# 3D CFD ANALYSIS

## CFD Solution Setup



- Define **Flow Domain: Reference Frame**

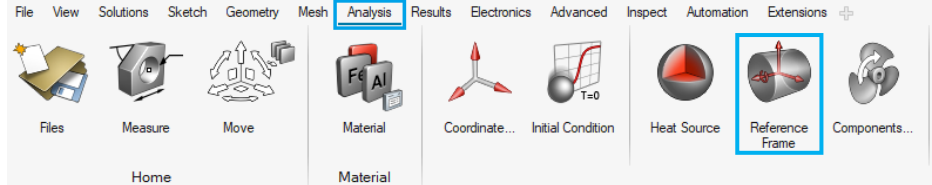
• [Analysis] – [Reference Frame]

• Rotor

A screenshot showing the 'Reference Frame' dialog box and the 'Define Axis' dialog box overlaid on a 3D mesh model of a rotor. The 'Reference Frame' dialog has 'Name: ReferenceFrame\_Rotor', 'Select bodies / faces: Rotor', and checked options for 'Centrifugal force', 'Coriolis force', and 'Angular acceleration force'. The 'Angular velocity' is set to '1080 RPM'. The 'Define Axis' dialog has 'Z axis' selected under 'Select:'. A blue callout box with the text 'Select the body Rotor' points to the rotor body in the 3D model. A small 3D coordinate system icon is visible in the bottom left corner of the dialog area.

# 3D CFD ANALYSIS

## CFD Solution Setup



- Define **Flow Domain: Reference Frame**

• [Analysis] – [Reference Frame]

• Shaft

Reference Frame

Name: ReferenceFrame\_Shaft

Select bodies / faces: Shaft

Centrifugal force

Coriolis force

Angular acceleration force

Axis of rotation: Define/Modify Axis...

Angular velocity: 1080 RPM

Multiplier function: None

Apply QK Cancel

Define Axis

Select:

X axis

Y axis

Z axis

2 Nodes

2 Vertices

Straight/Arc edge

Cylindrical face

Face group

Edge group

3 Nodes

Local coordinate axis

At model center

Reverse axis

Offset Axis:

To node

To vertex

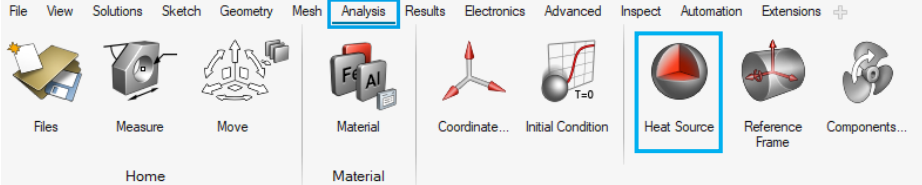
Arc center

QK Cancel

Select the body Shaft

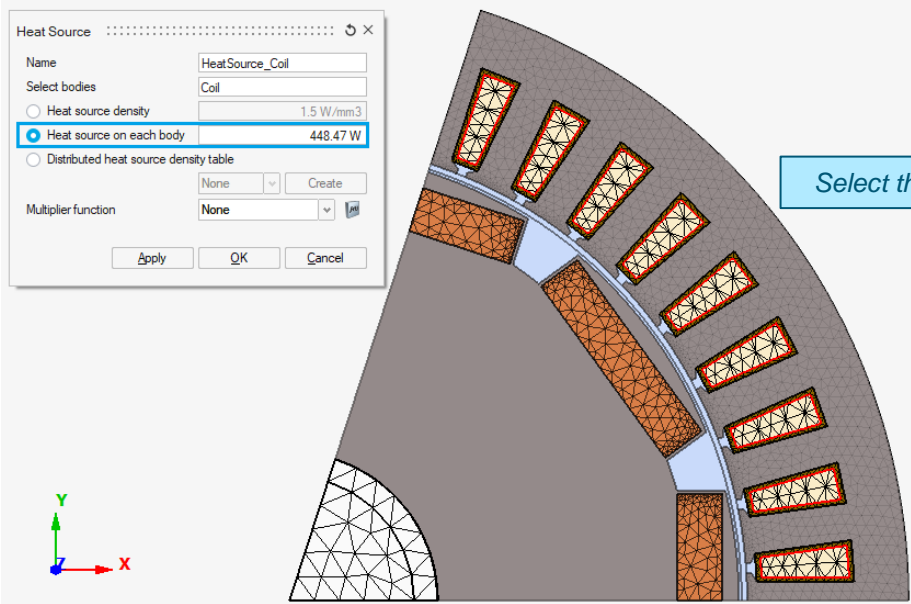
# 3D CFD ANALYSIS

## CFD Solution Setup



- Define **Flow Domain: Heat Source (total loss value)**
- [Analysis] – [Heat Source]
  - Winding loss (straight part): 448.47 W

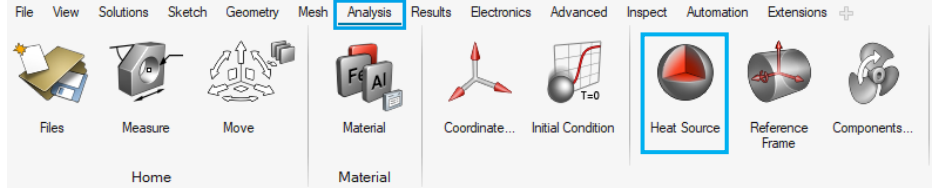
Please refer to the pages 15-16 for the winding loss (Joule loss) computation





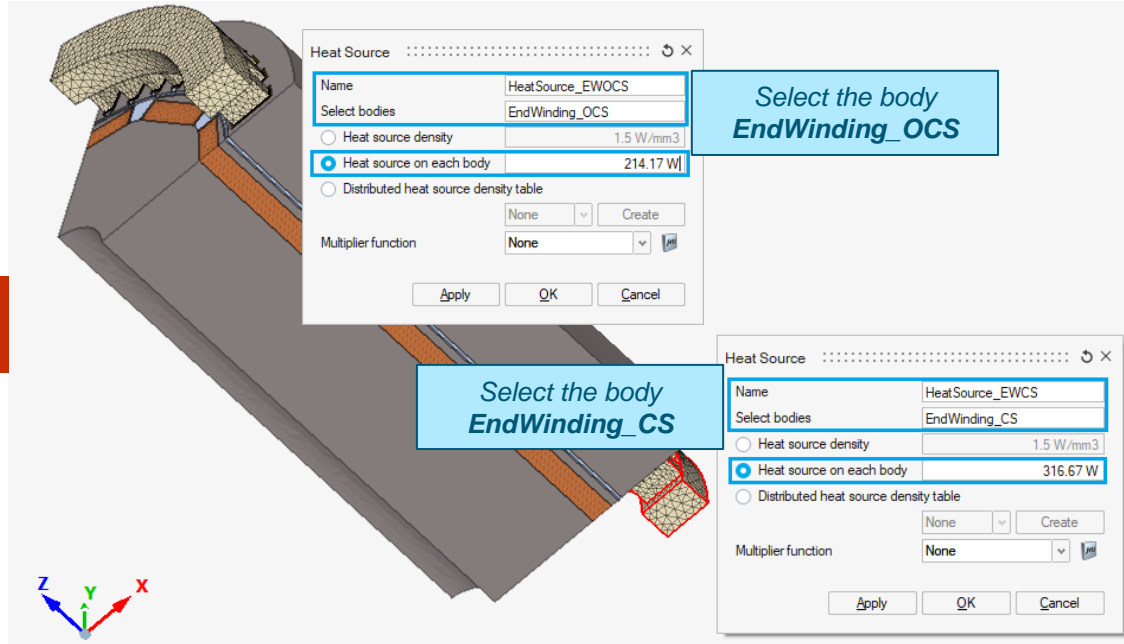
# 3D CFD ANALYSIS

## CFD Solution Setup



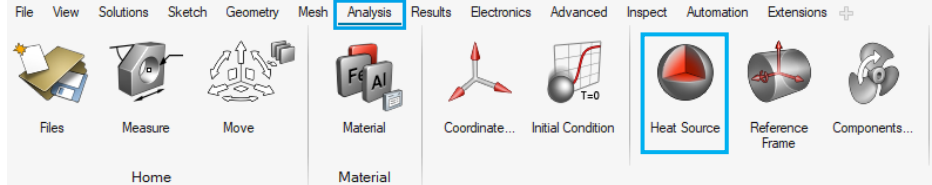
- Define **Flow Domain: Heat Source (total loss value)**
- [Analysis] – [Heat Source]
  - Winding loss (end windings)
    - C.S.: 316.67 W
    - O.C.S.: 214.17 W

Please refer to the pages 15-16 for the winding loss (Joule loss) computation



# 3D CFD ANALYSIS

## CFD Solution Setup

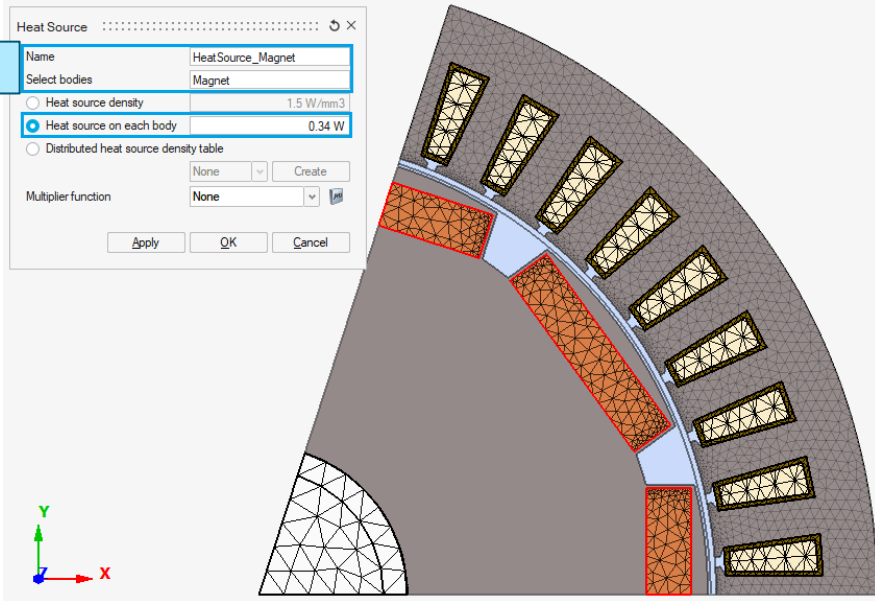


- Define **Flow Domain: Heat Source (total loss value)**
- [Analysis] – [Heat Source]
  - Magnet: 0.34 W

Please refer to the page 17 for the magnet loss (Joule loss) computation

Select the body **Magnet**

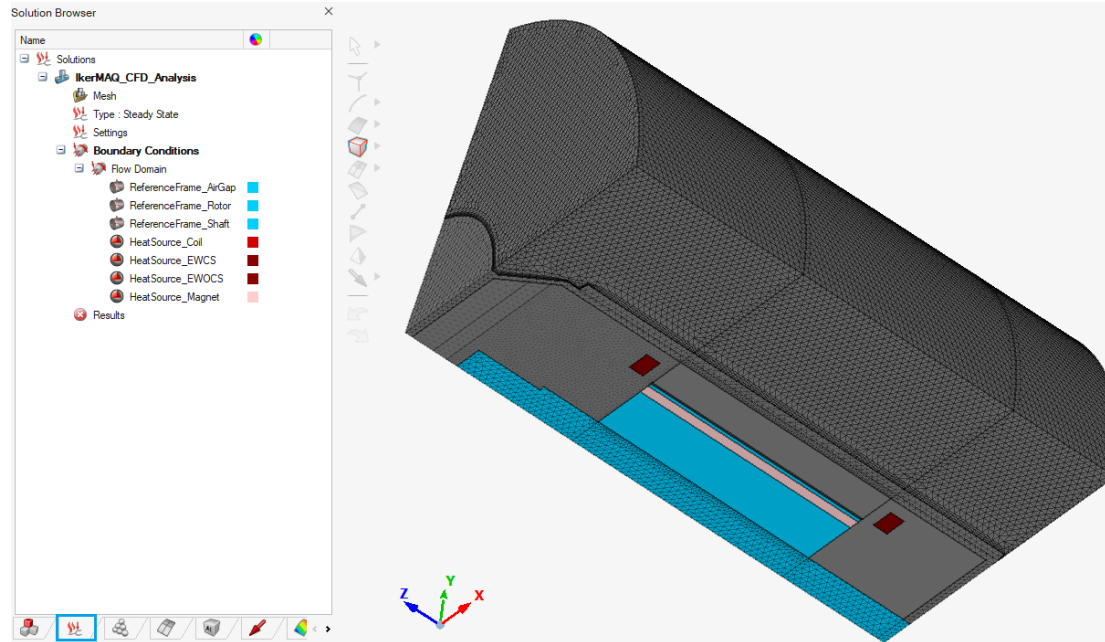
Heat Source	
Name	HeatSource_Magnet
Select bodies	Magnet
<input type="radio"/> Heat source density	1.5 W/mm3
<input checked="" type="radio"/> Heat source on each body	0.34 W
<input type="radio"/> Distributed heat source density table	
Multiplier function	None
<input type="button" value="Apply"/> <input type="button" value="OK"/> <input type="button" value="Cancel"/>	



# 3D CFD ANALYSIS

## CFD Solution Setup

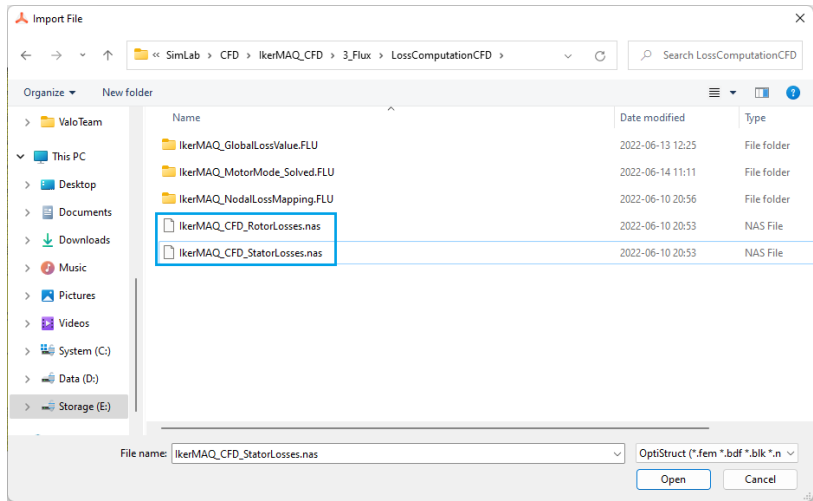
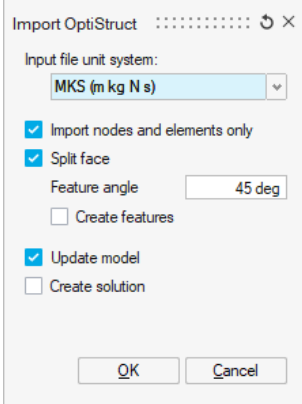
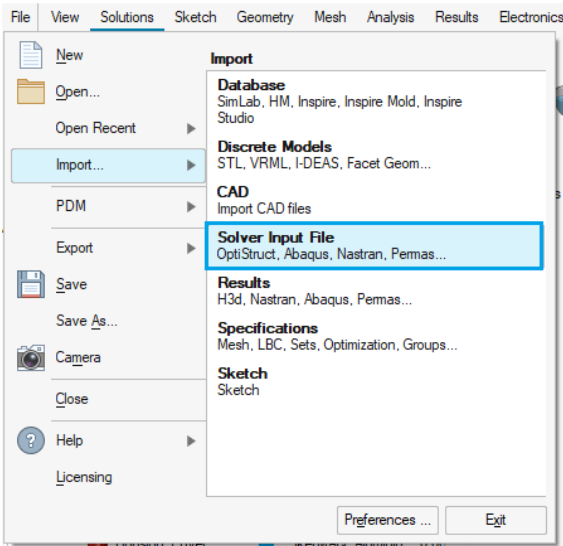
- Define **Flow Domain**
  - *Reference Frames + Heat Sources (total loss value)*



# 3D CFD ANALYSIS

## CFD Solution Setup

- Define **Flow Domain**: *Heat Source (nodal mapping)*
- Loss import: stator and rotor losses
  - [File] – [Import] – [Solver Input File]

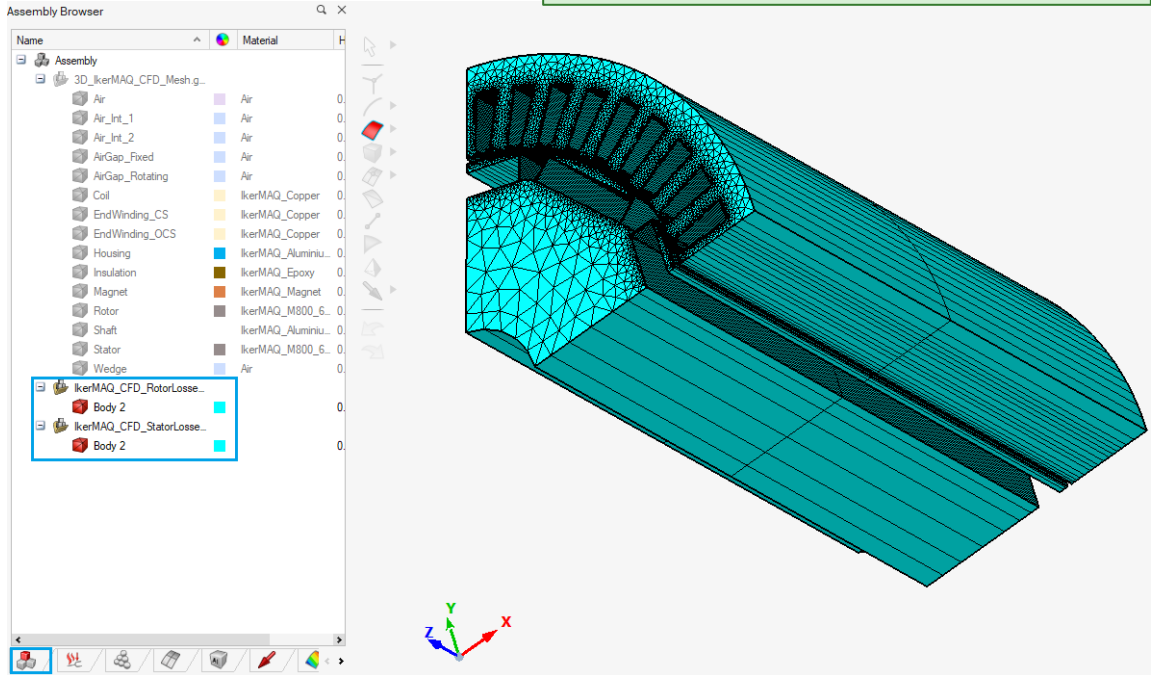


# 3D CFD ANALYSIS

## CFD Solution Setup

- Define **Flow Domain**: *Heat Source (nodal mapping)*
- Loss import: stator and rotor losses

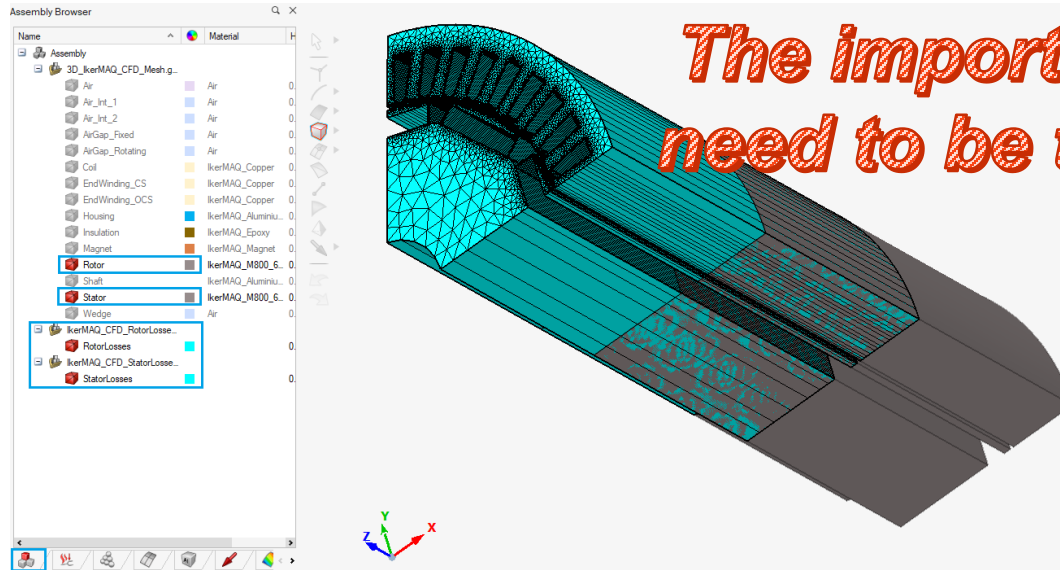
Imported meshed models for iron losses



# 3D CFD ANALYSIS

## CFD Solution Setup

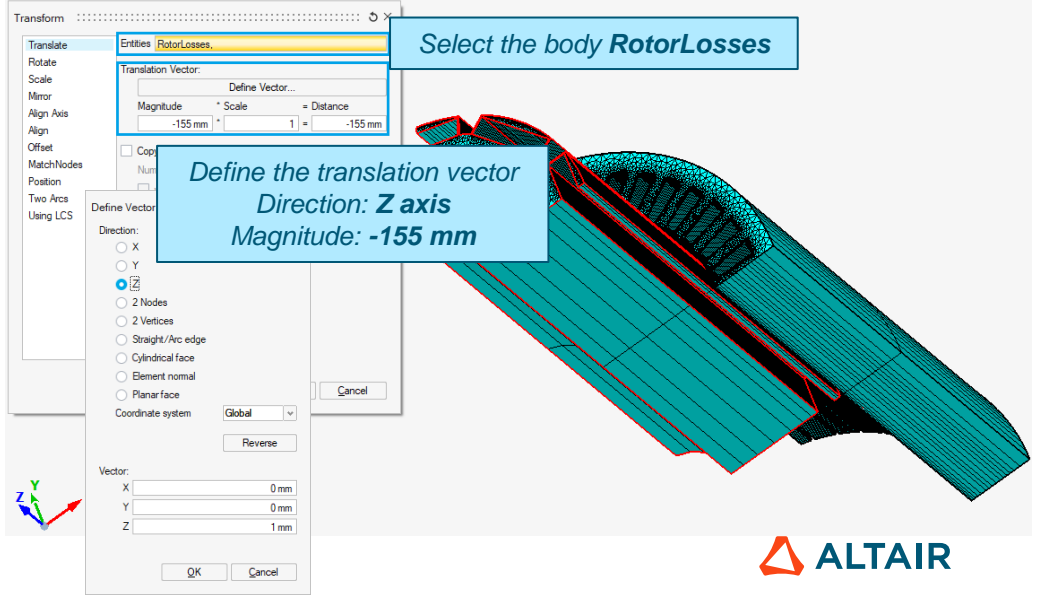
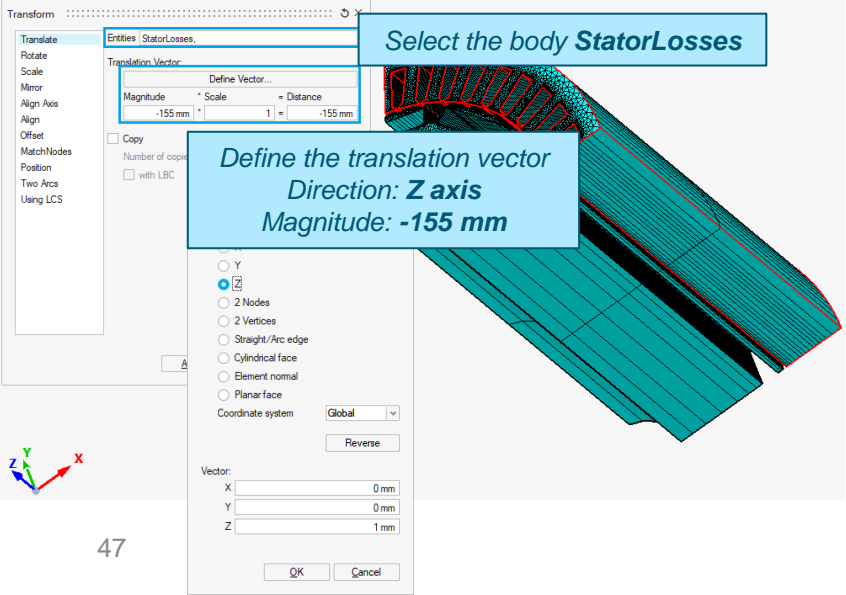
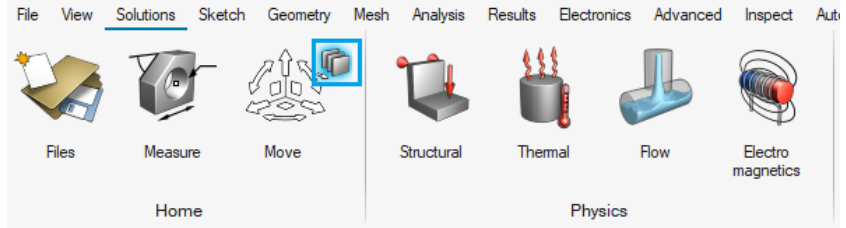
- Define **Flow Domain**: *Heat Source (nodal mapping)*
- Loss import: stator and rotor losses
  - Visualize both the import bodies (stator and rotor losses) and the original bodies to check if the bodies are well covered



# 3D CFD ANALYSIS

## CFD Solution Setup

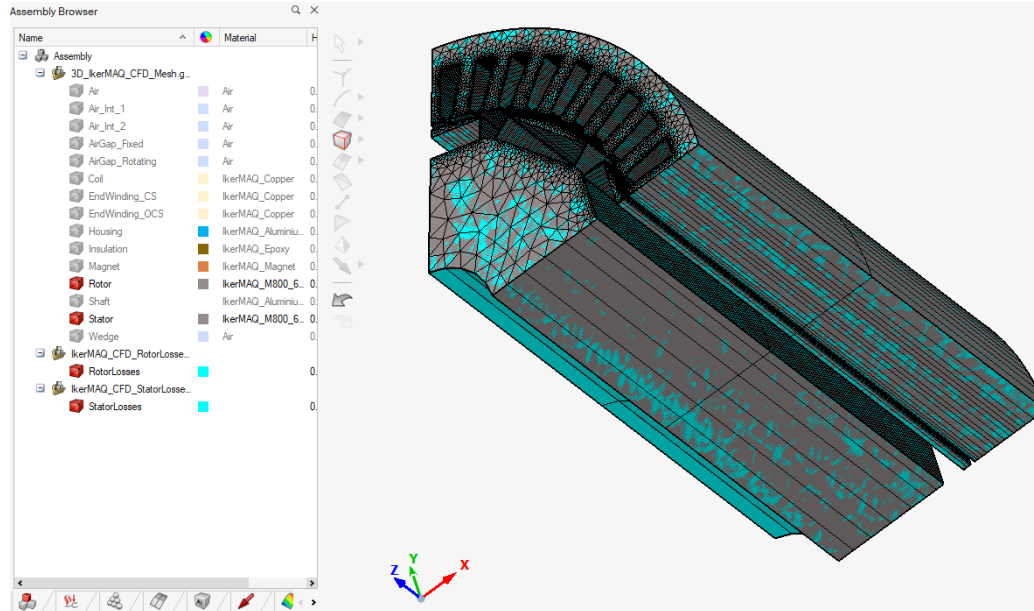
- Define **Flow Domain**: *Heat Source (nodal mapping)*
  - Loss import: stator and rotor losses
  - Translate respectively the imported bodies (stator and rotor losses)



# 3D CFD ANALYSIS

## CFD Solution Setup

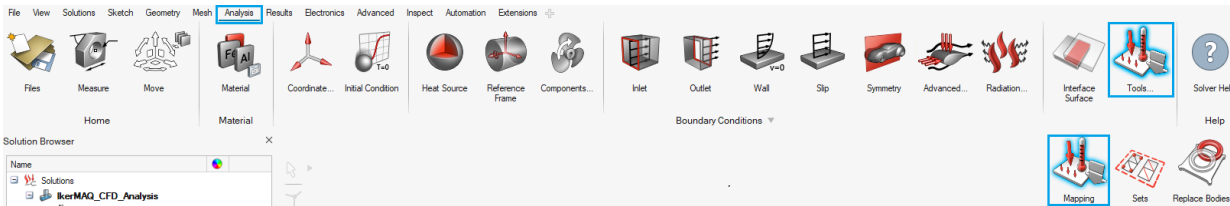
- Define **Flow Domain**: *Heat Source (nodal mapping)*
- Loss import: stator and rotor losses
  - Translate respectively the imported bodies (stator and rotor losses)





# 3D CFD ANALYSIS

## CFD Solution Setup



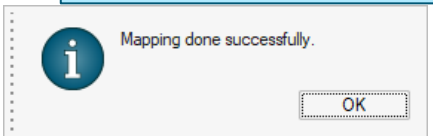
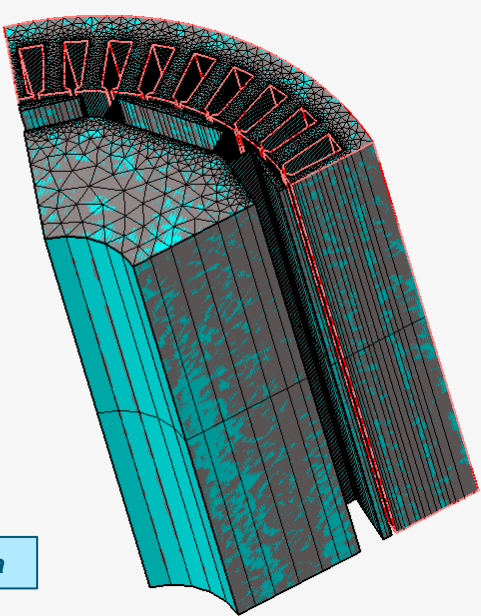
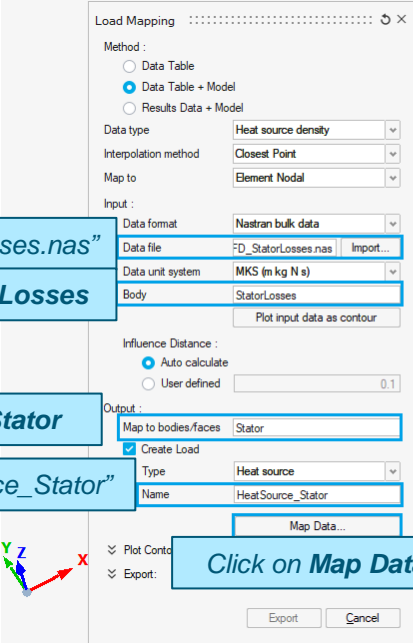
- Define **Flow Domain: Heat Source (nodal mapping)**
- Loss mapping: stator losses
  - [Analysis] – [Tools] – [Mapping]

Select the loss file "IkerMAQ\_CFD\_StatorLosses.nas"

Select the imported body **StatorLosses**

Select the body to be mapped: **Stator**

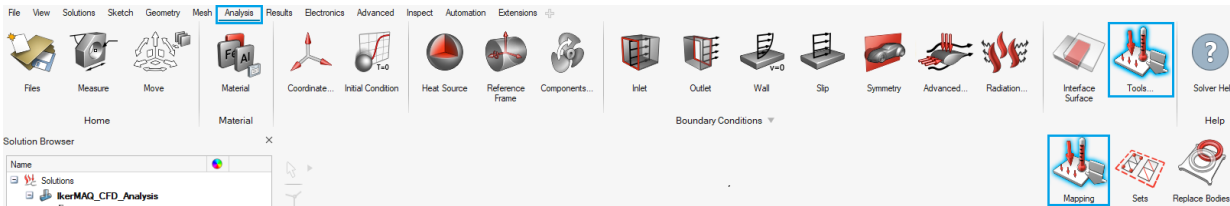
Define the generated result name: "HeatSource\_Stator"



Click on **Map Data**

# 3D CFD ANALYSIS

## CFD Solution Setup



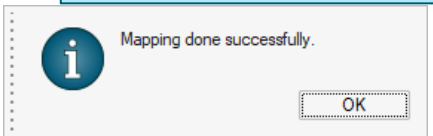
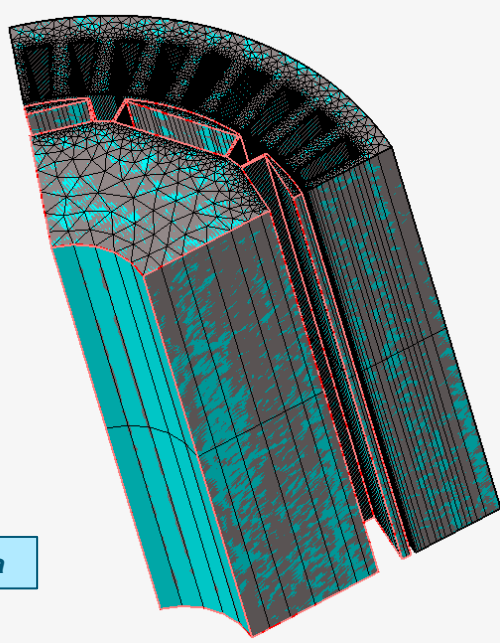
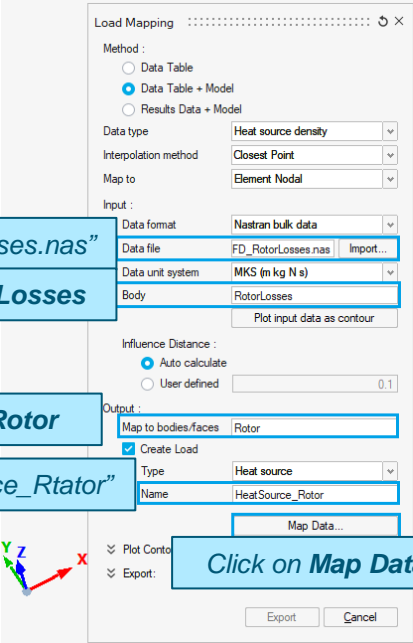
- Define **Flow Domain: Heat Source (nodal mapping)**
- Loss mapping: rotor losses
  - [Analysis] – [Tools] – [Mapping]

Select the loss file "IkerMAQ\_CFD\_RotorLosses.nas"

Select the imported body **RotorLosses**

Select the body to be mapped: **Rotor**

Define the generated result name: "HeatSource\_Rtator"

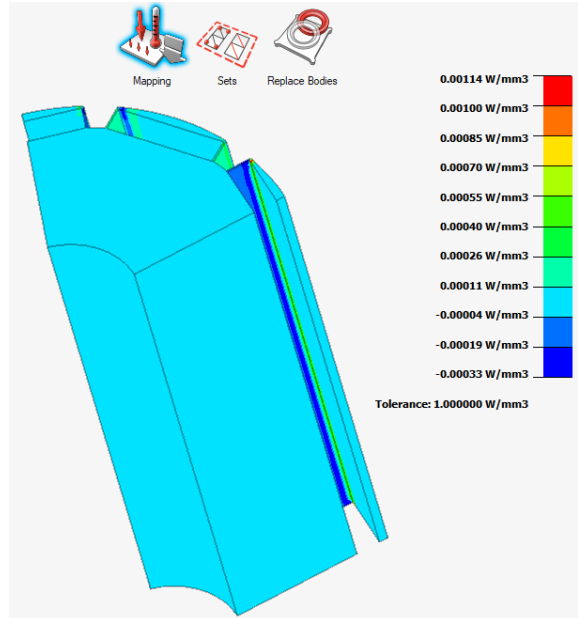
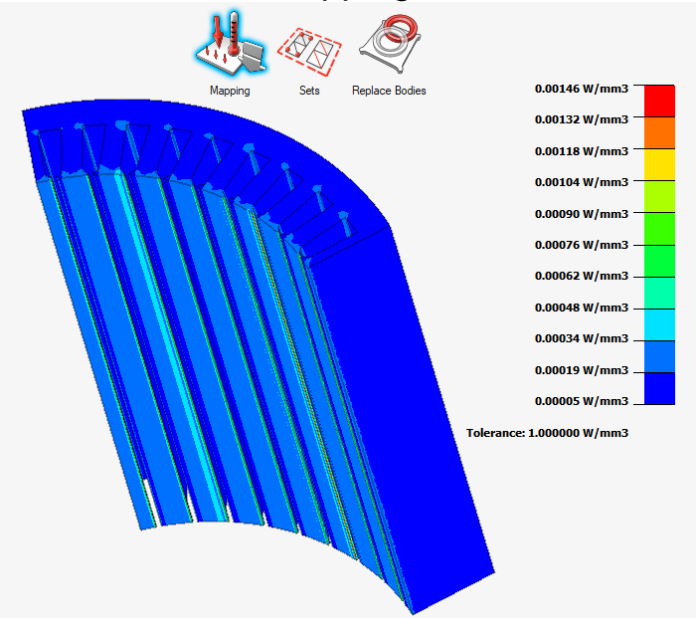


Click on **Map Data**

# 3D CFD ANALYSIS

## CFD Solution Setup

- Define **Flow Domain: Heat Source (nodal mapping)**
- Loss mapping: stator and rotor losses
  - Visualize mapping results



Load Mapping

Method :

- Data Table
- Data Table + Model
- Results Data + Model

Data type: Heat source density

Interpolation method: Closest Point

Map to: Element Nodal

Input :

Data format: Nastran bulk data

Data file: FD\_RotorLosses.nas Import...

Data unit system: MKS (m kg N s)

Body: RotorLosses

Plot input data as contour

Influence Distance :

- Auto calculate
- User defined 0.1

Output :

Map to bodies/faces: Rotor

Create Load

Type: Heat source

Name: HeatSource\_Rotor

Map Data...

**Plot Contour:**

Data type: Heat Source

1

Plot Contour

Query Contour

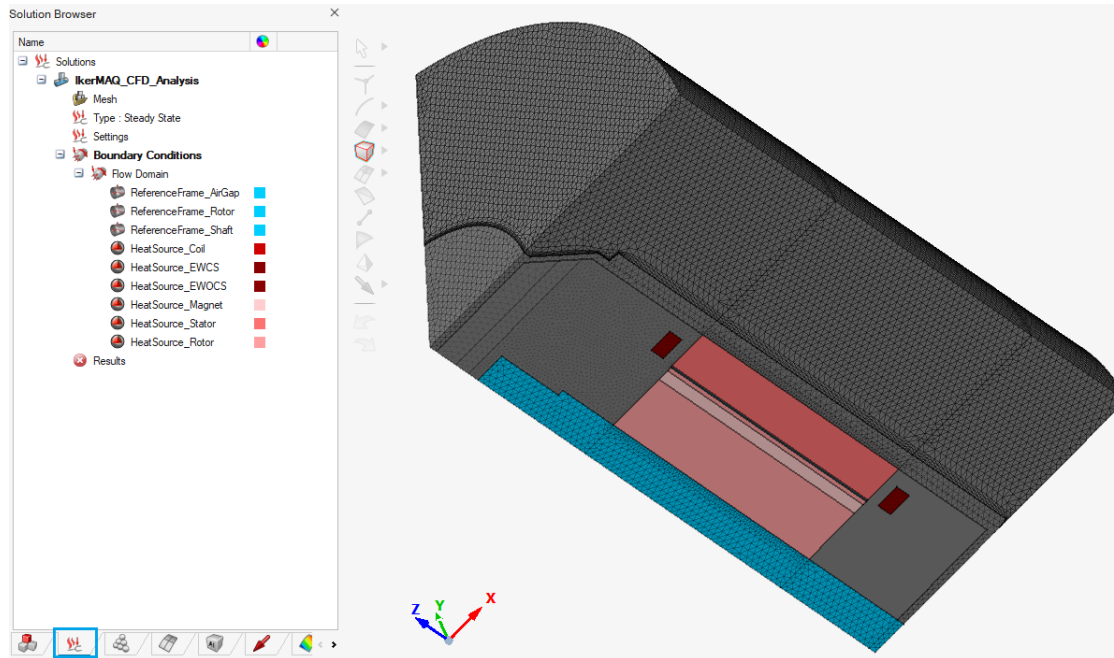
Export: Export Cancel

Click on Plot Contour

# 3D CFD ANALYSIS

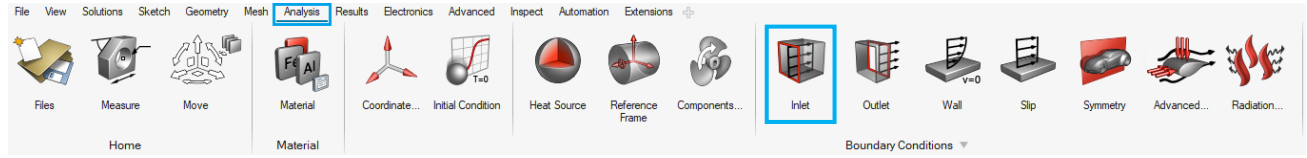
## CFD Solution Setup

- Define **Flow Domain**
  - *Reference Frames + Heat Sources (total loss value + nodal mapping)*

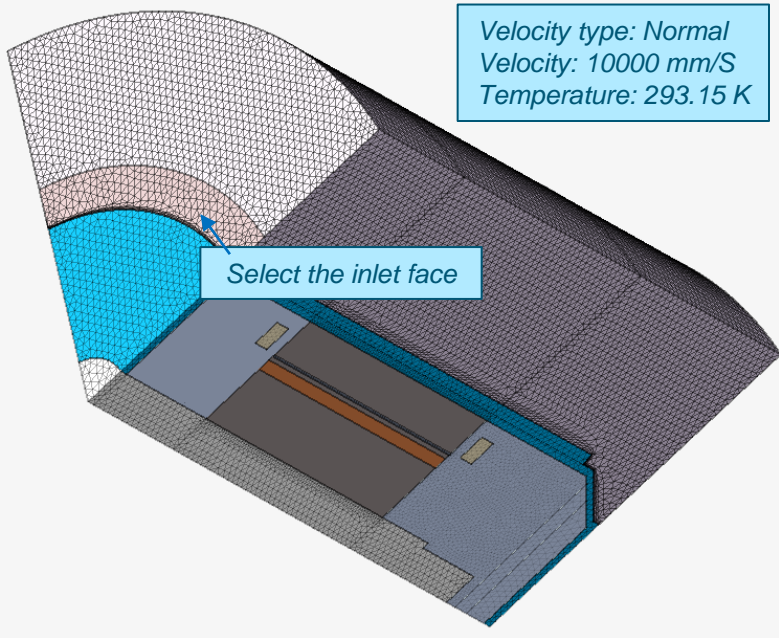
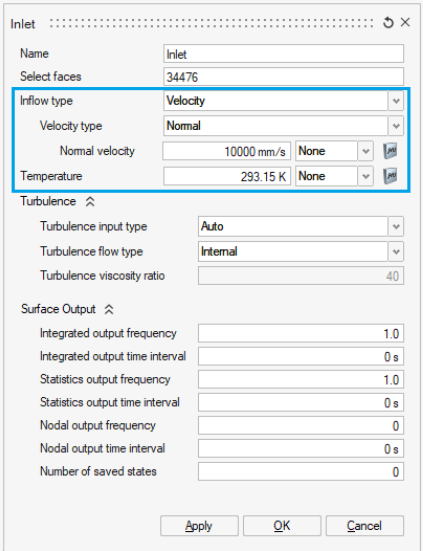


# 3D CFD ANALYSIS

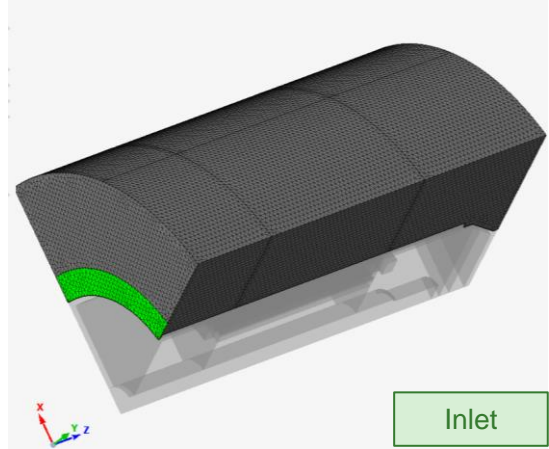
## CFD Solution Setup



- Define **Flow Boundaries: Inlet**
- [Analysis] – [Inlet]

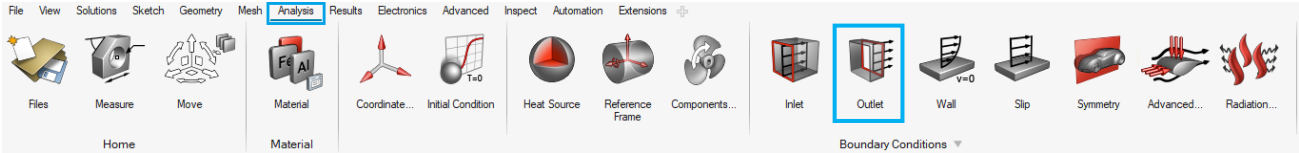


Velocity type: Normal  
Velocity: 10000 mm/S  
Temperature: 293.15 K

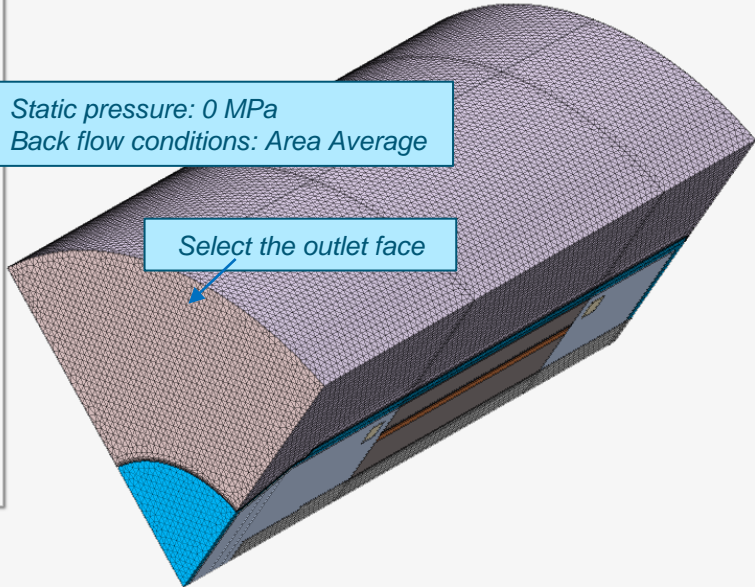
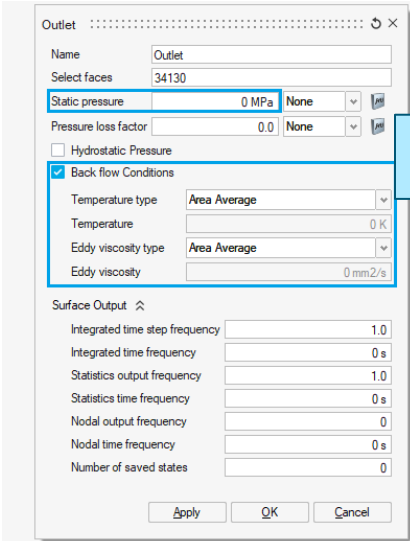


# 3D CFD ANALYSIS

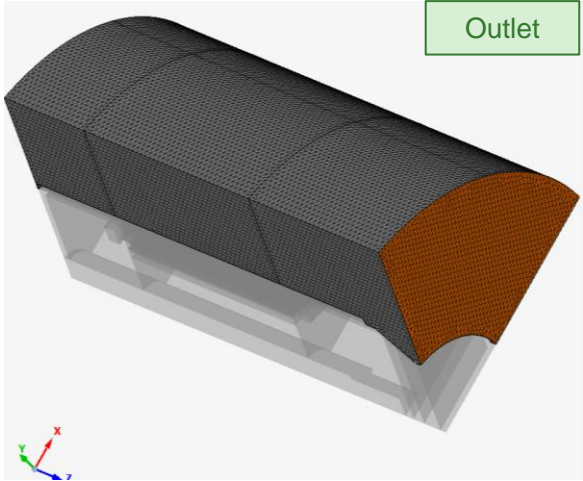
## CFD Solution Setup



- Define Flow Boundaries: *Outlet*
- [Analysis] – [Outlet]

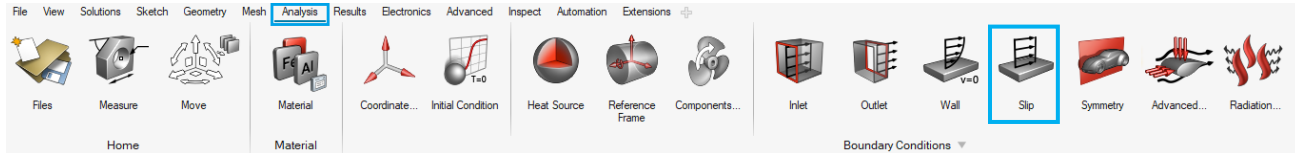


Static pressure: 0 MPa  
Back flow conditions: Area Average



# 3D CFD ANALYSIS

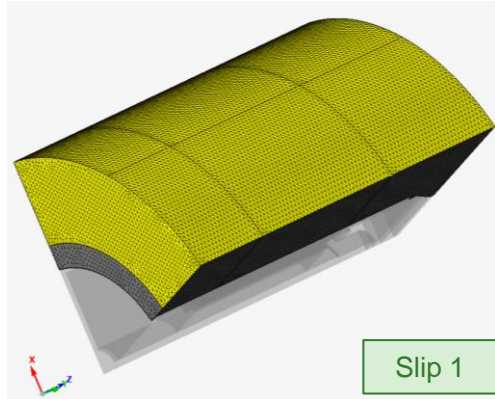
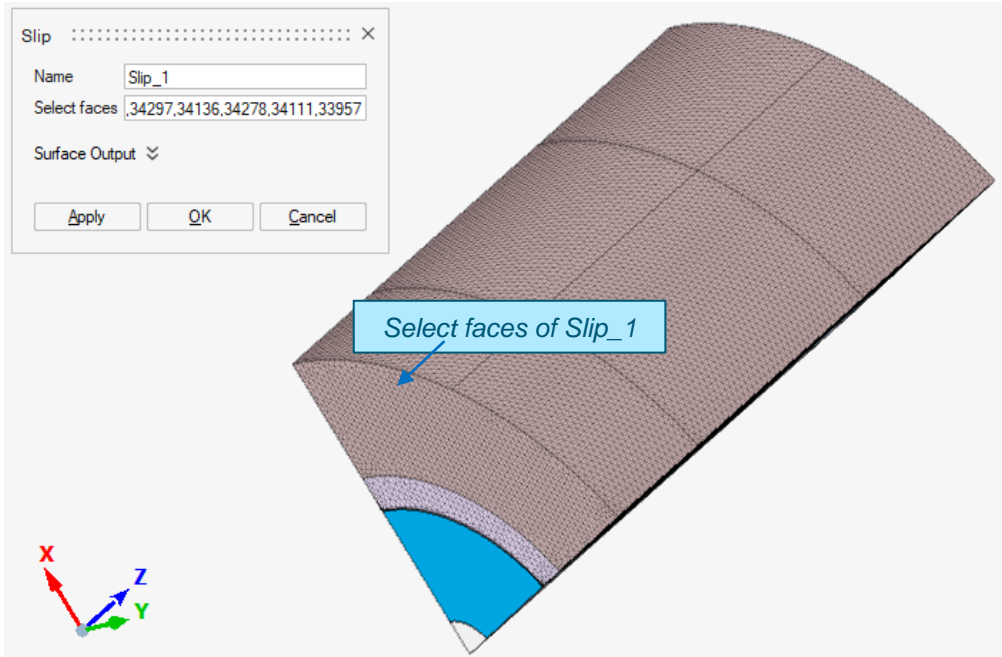
## CFD Solution Setup



- Define **Flow Boundaries: Slip**

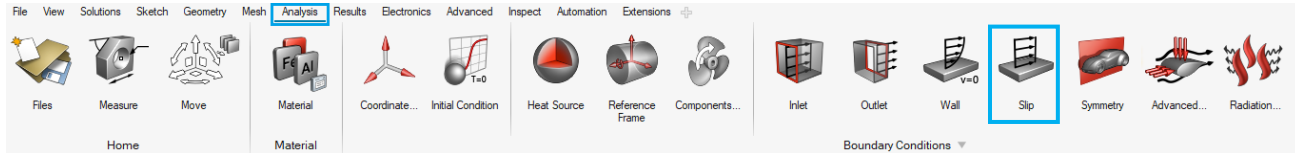
- [Analysis] – [Slip]

- Slip 1

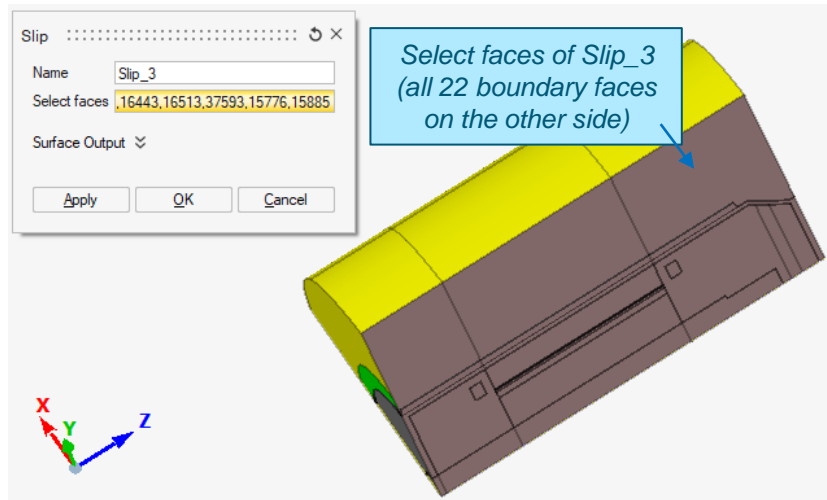
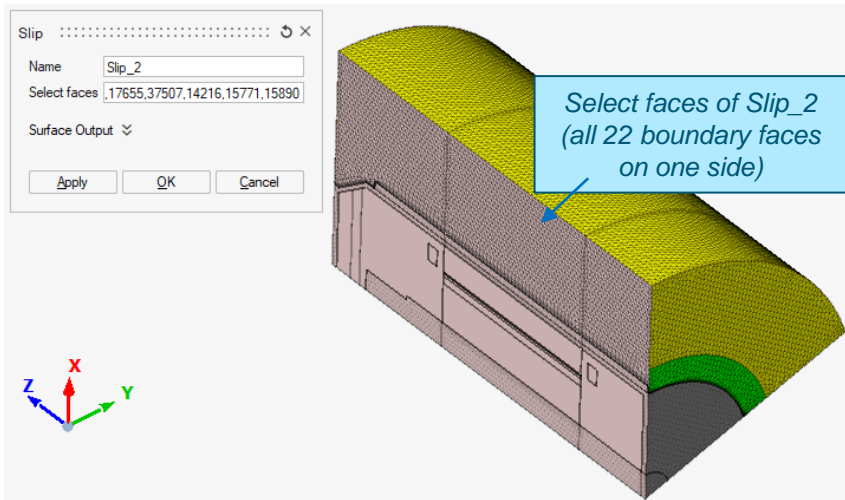


# 3D CFD ANALYSIS

## CFD Solution Setup



- Define **Flow Boundaries: Slip**
  - [Analysis] – [Slip]
    - Slip 2 and 3

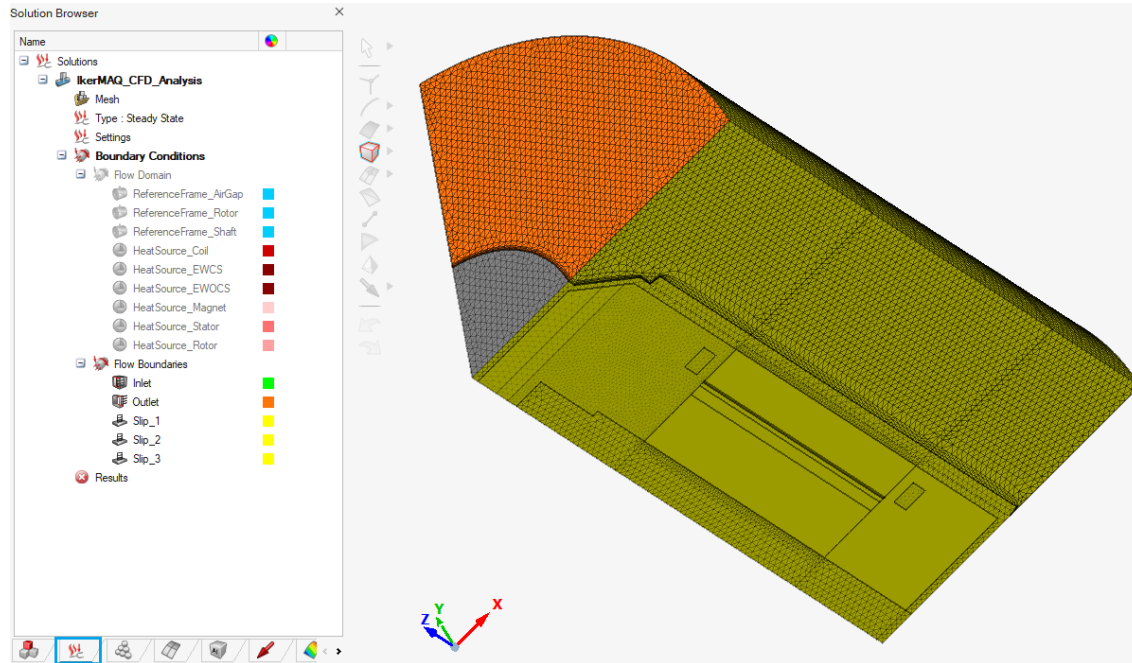




# 3D CFD ANALYSIS

## CFD Solution Setup

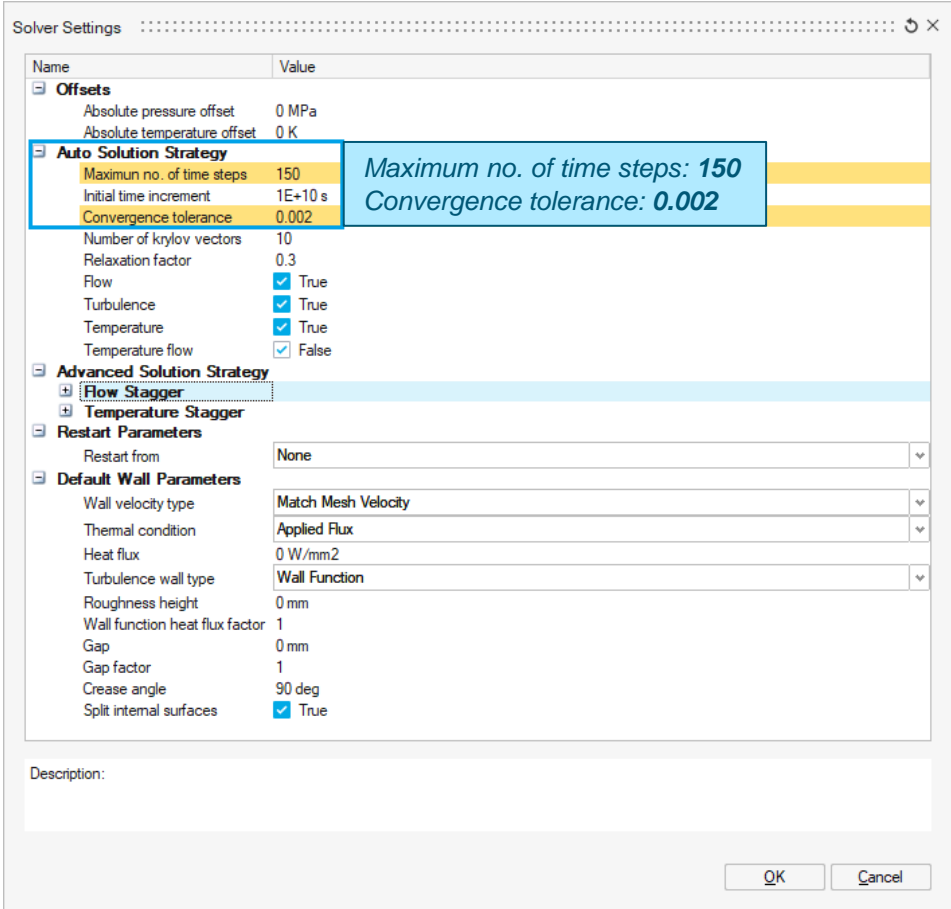
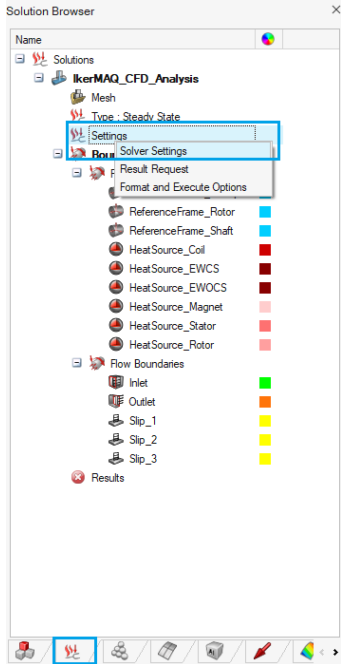
- Define **Flow Boundaries**
  - *Inlet + Outlet + Slip*



# 3D CFD ANALYSIS

## CFD Solution Setup

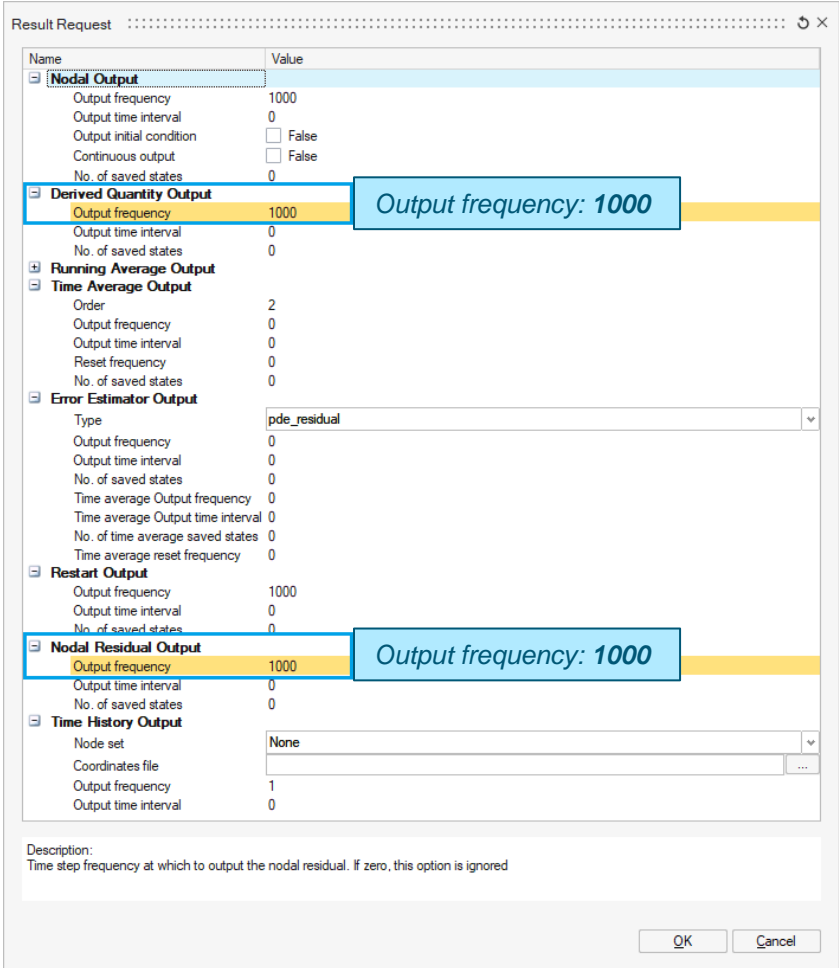
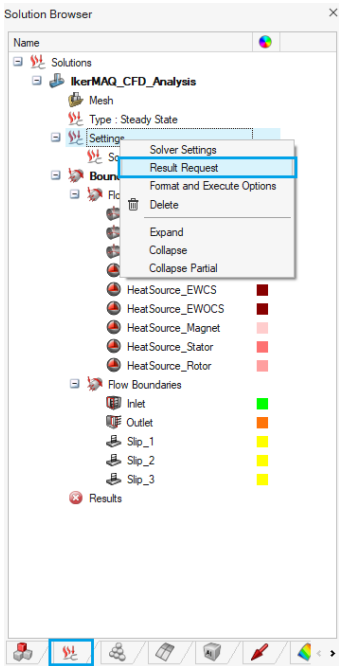
- Define **Solution Settings**
- Define **Solver Settings**



# 3D CFD ANALYSIS

## CFD Solution Setup

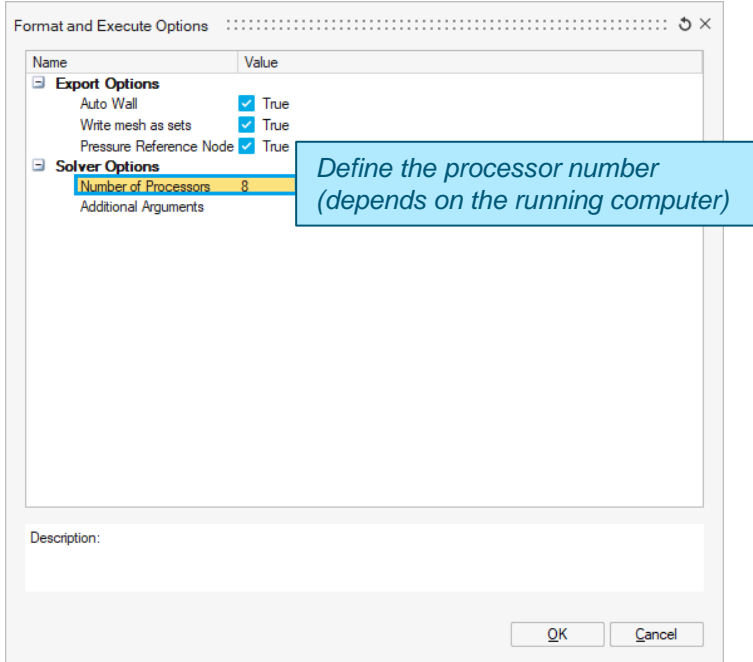
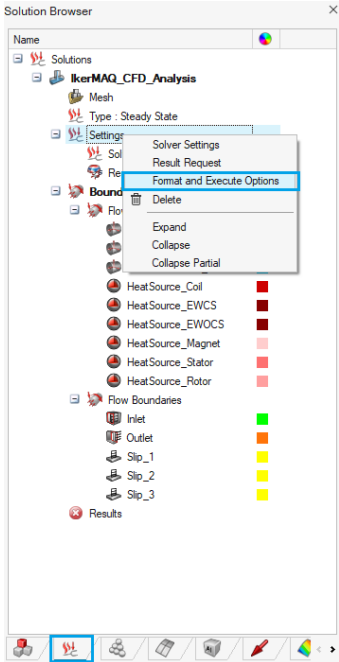
- Define **Solution Settings**
- Define **Result Request**



# 3D CFD ANALYSIS

## CFD Solution Setup

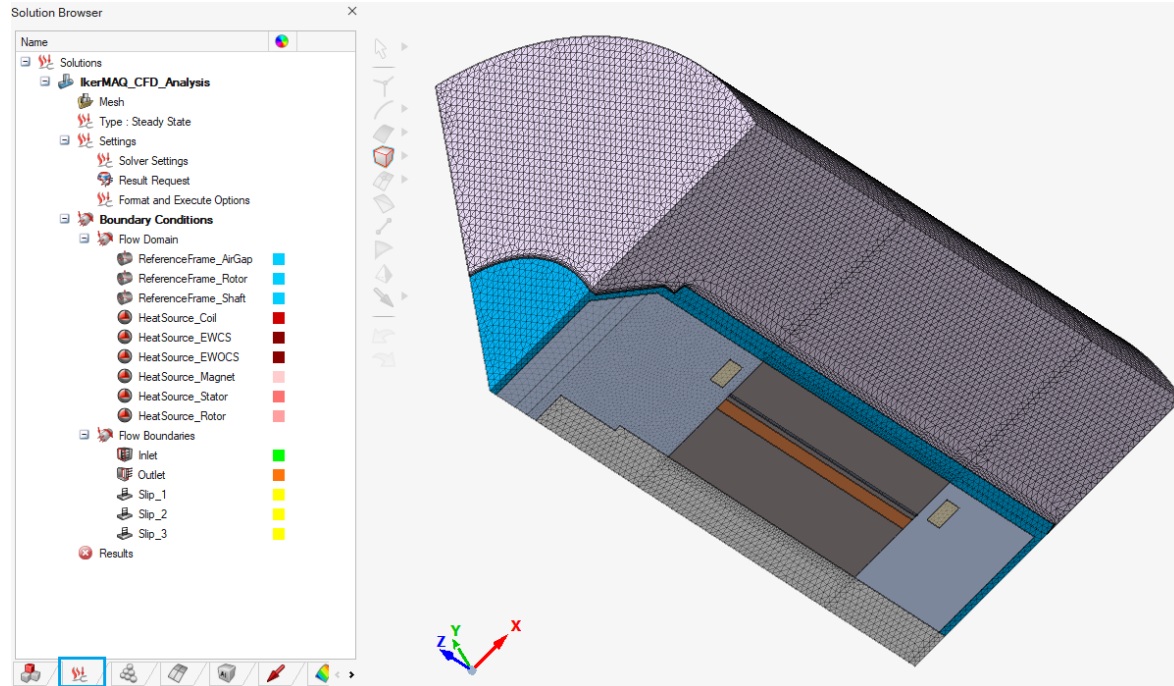
- Define **Solution Settings**
- Define **Format and Execute Options**



# 3D CFD ANALYSIS

## CFD Solution Setup

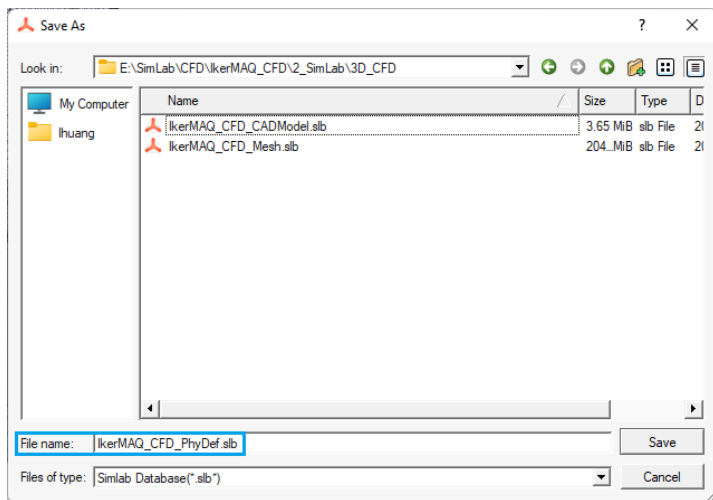
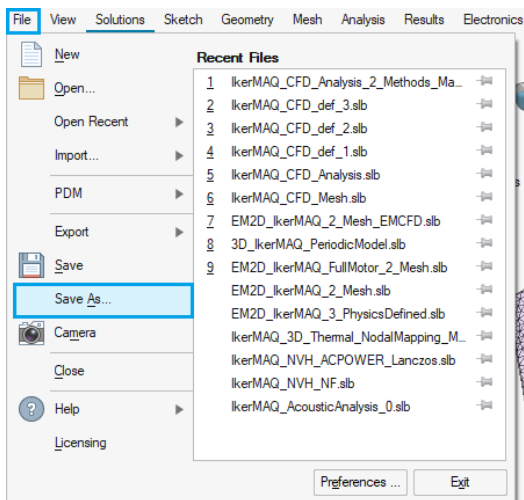
- Final CFD solution setup
  - *Flow Domain + Flow Boundaries + Solver Settings*



# 3D CFD ANALYSIS

## CFD Solution Setup

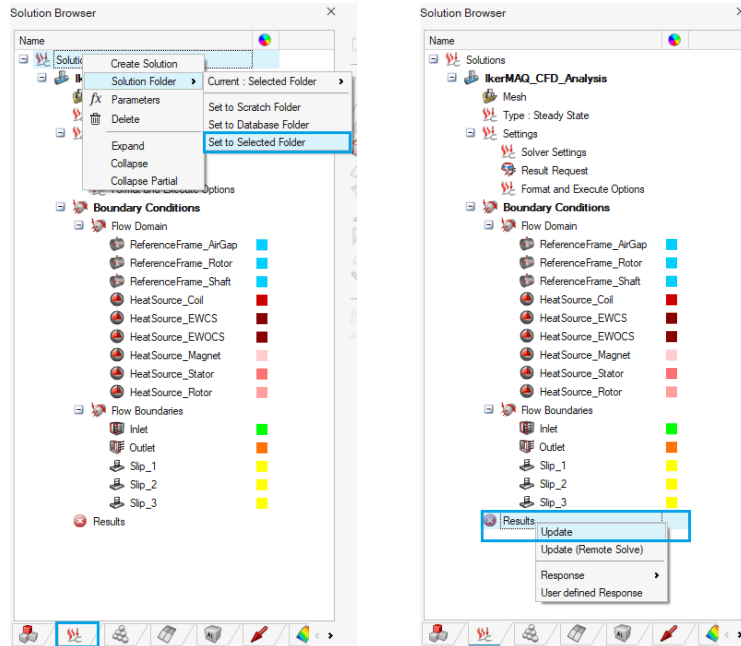
- Final CFD solution setup
- Save the project [File] – [Save As]
  - Save the project as “IkerMAQ\_CFD\_PhyDef”



# 3D CFD ANALYSIS

## CFD Solution Setup

- Solve the CFD simulation project
- Right click on the “Solutions” and select the solving folder for AcuSolve



### Notes:

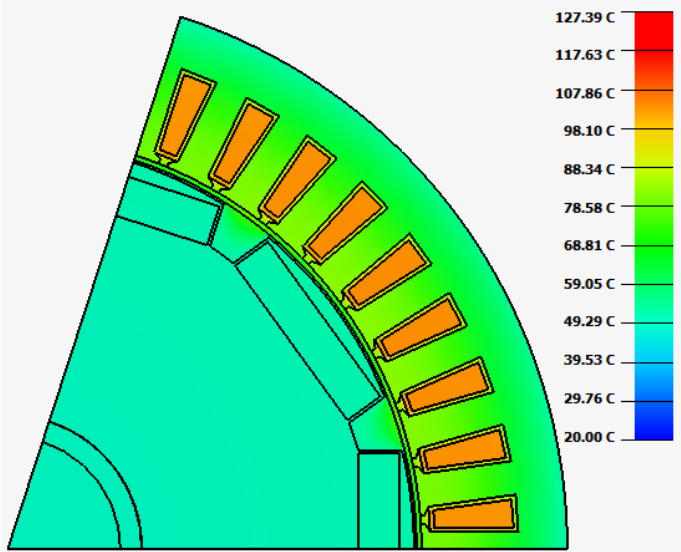
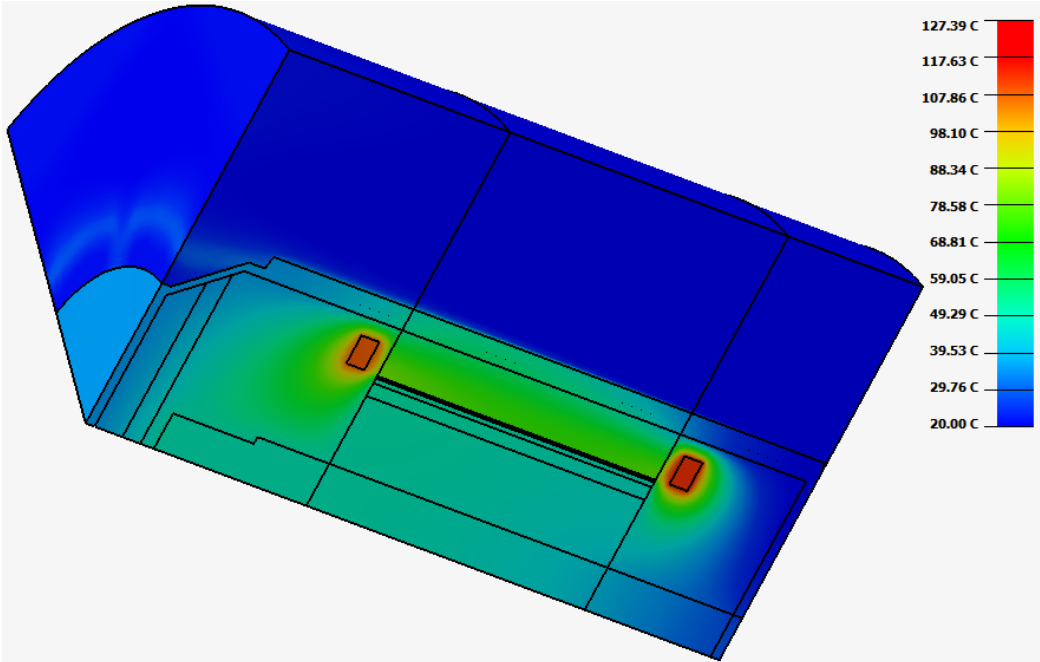
The solving process takes about 45 min depending on the computer on which it is run.

- ✓ Results means that the solving process is completed
- Results means that the solving process is in progress

# 3D CFD ANALYSIS

## CFD Solution Setup

- Solve the CFD simulation project
  - Temperature distribution

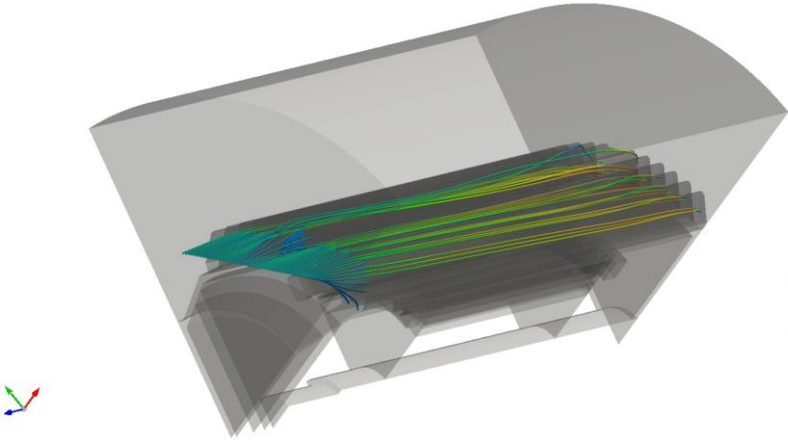
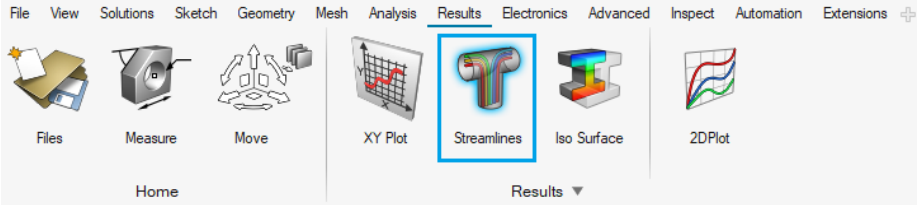




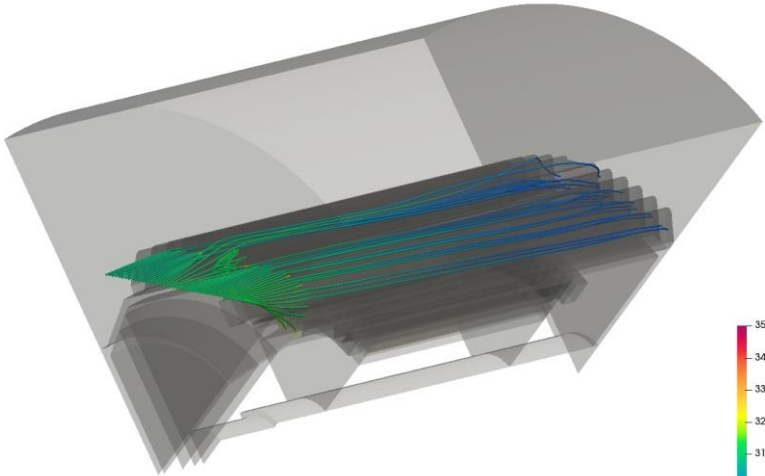
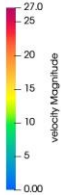
# 3D CFD ANALYSIS

## CFD Solution Setup

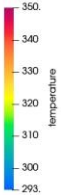
- Solve the CFD simulation project
- Streamline results



Flow velocity



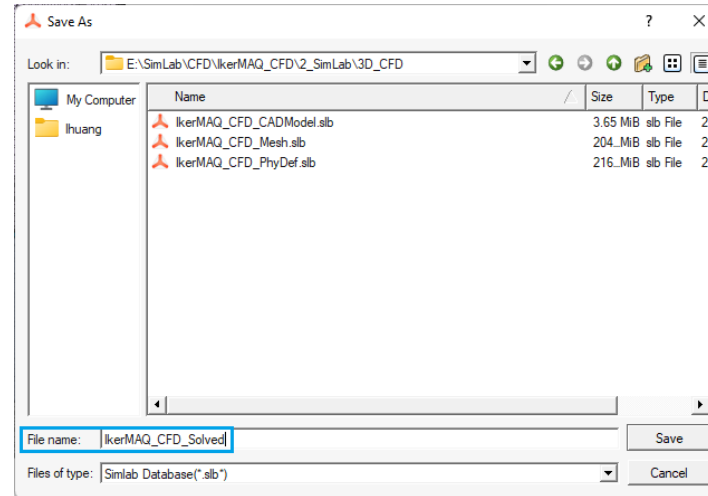
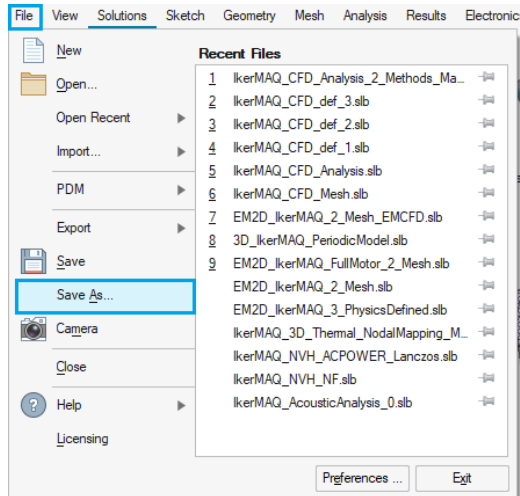
Temperature



# 3D CFD ANALYSIS

## CFD Solution Setup

- Solve the CFD simulation project
- Save the project [File] – [Save As]
  - Save the project as “IkerMAQ\_CFD\_Solved”



# CONCLUSION

## CONCLUSION

- In this application case, a **Permanent Magnet Synchronous Machine** (IkerMAQ motor) is modeled in **Flux** for 2D electromagnetic analysis.
- All the eMotor loss information computed by **Flux** serve as Heat Source in **AcuSolve** to run CFD analysis.
- The eMotor CFD analysis is simulated with **AcuSolve** (via **SimLab**) .Preliminary CFD analysis results are reasonable. The temperature simulation results are close to the actual values.



# THANK YOU

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