

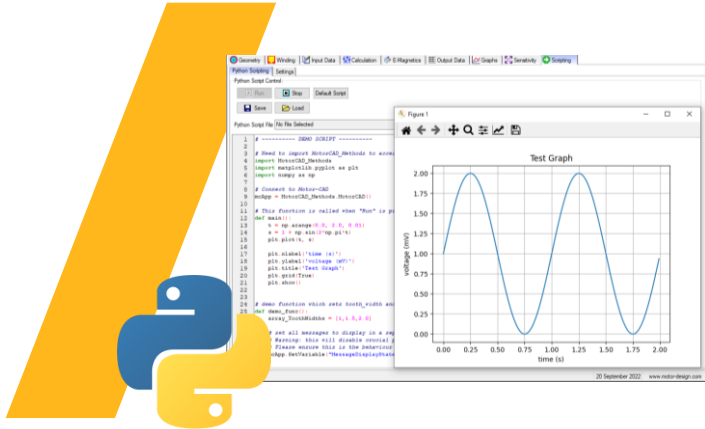


ANSYS Motor-CAD 2023 R1 新功能介绍

新科益系统与咨询（上海）有限公司

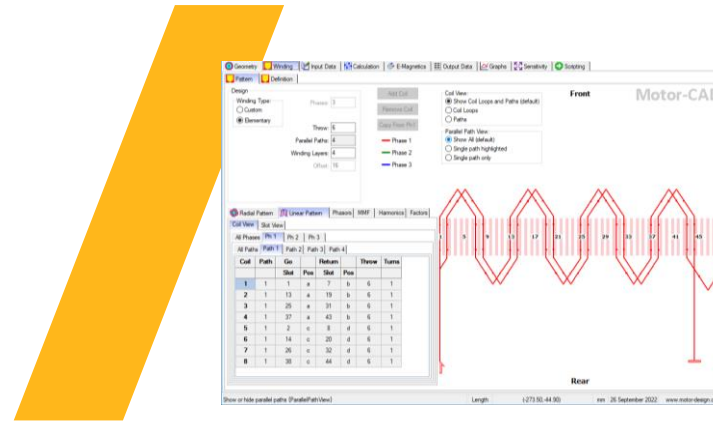


ANSYS Motor-CAD 2023 R1 Highlights



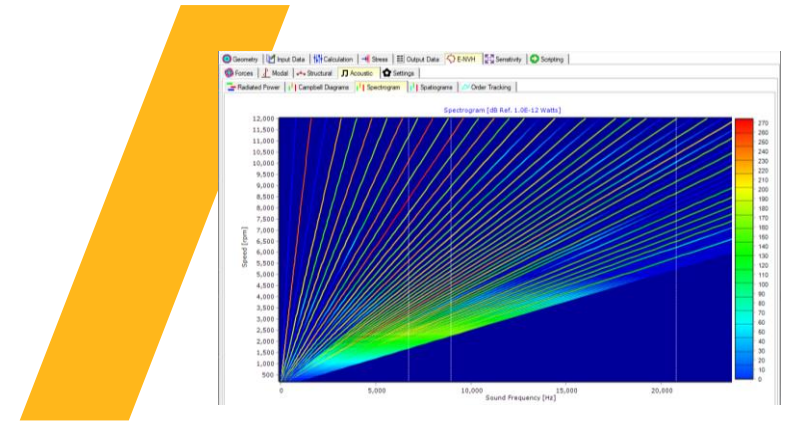
Automation and workflows

- ✓ New pymotorCAD automation interface
- ✓ New JSON-RPC communication interface
- ✓ Upgraded internal scripting
- ✓ More flexible custom outputs
- ✓ Enhanced automated export to Maxwell



New features for machines types, hairpin windings and oil cooling

- ✓ Improved models for induction machine electromagnetics
- ✓ Multi-physics optimization for wound field machines
- ✓ Enhanced winding definition and loss calculation
- ✓ New geometries and cooling methods



Mechanical and NVH enhancements

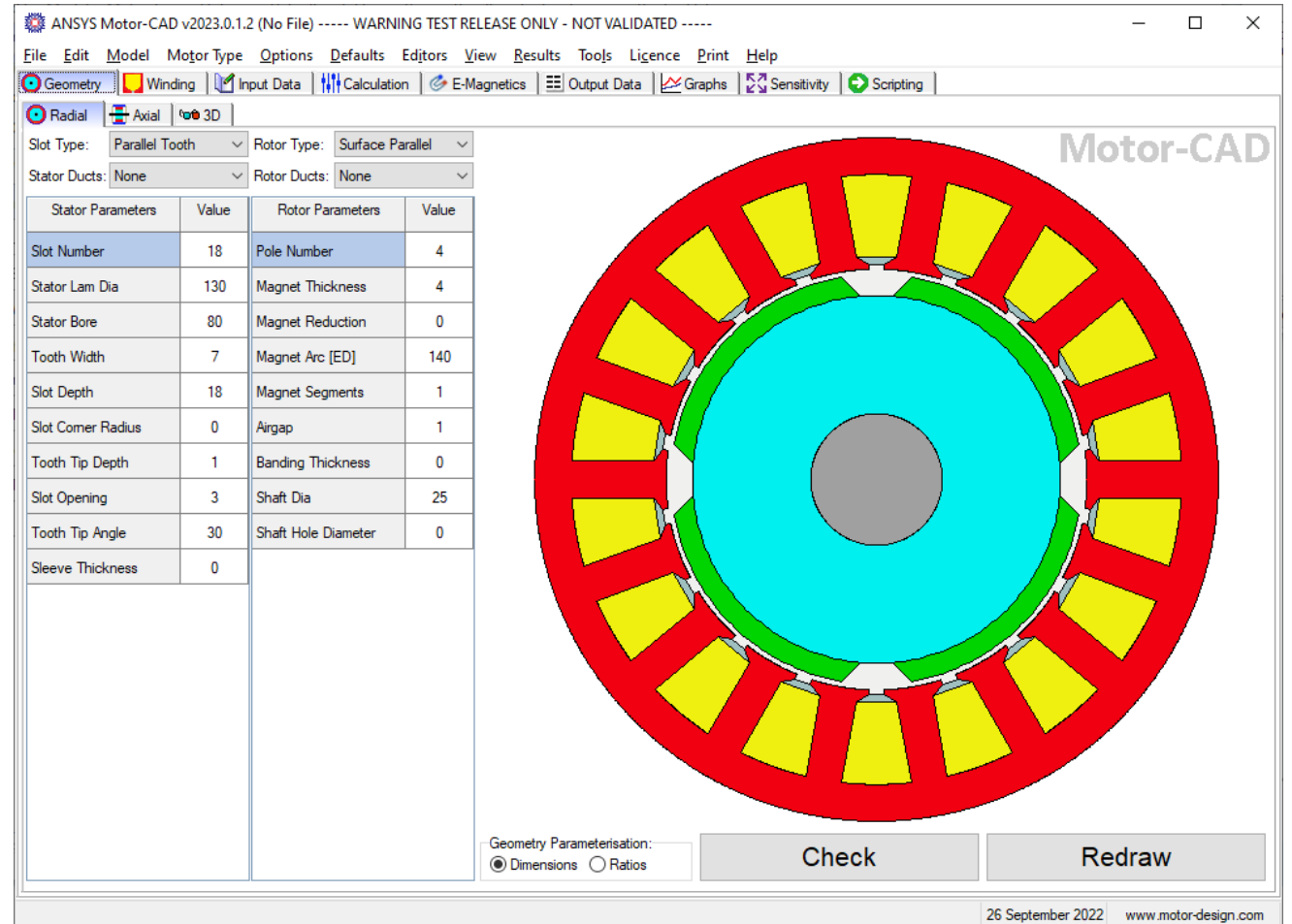
- ✓ Induction machine NVH
- ✓ Housing and winding stiffness included in the mechanical NVH model
- ✓ Faster NVH analysis and optimization of noise metrics
- ✓ Improved mechanical stress analysis for optimization workflows

2023 R1: Product Release Detail



Motor-CAD 2023R1 新版本名

- Motor-CAD version names now align with Ansys release numbers.
- Previously:
 - 2022R1 was v15.1.1
 - 2022R2 was v15.1.7
- Future:
 - 2023R1 pre-releases will be v2023.0.x
 - 2023R1 release will be v2023.1.1
 - 2023R2 release will be v2023.2.1

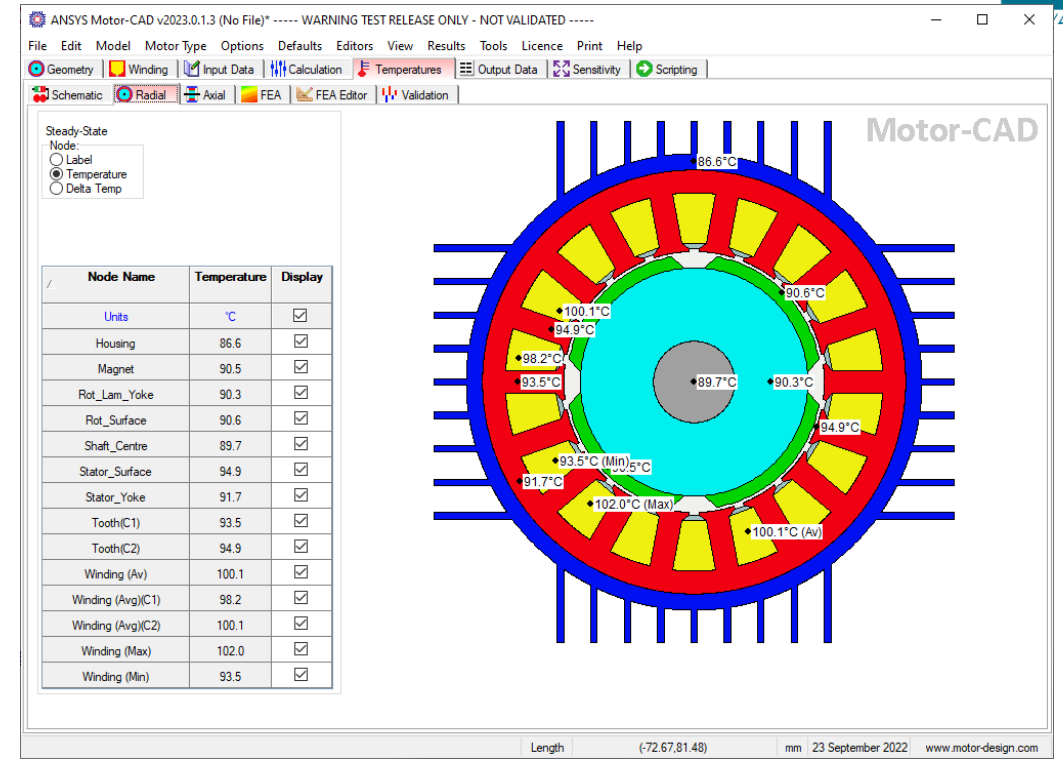


Automation and workflows

Ansys

新 pymotorcad API

- pymotorcad package used as default option in internal scripting.
- pymotorcad will be available as a pip package for 2023R1 as part of PyAnsys.
- JSON-RPC API is now used for Automation calls instead of ActiveX.
- ActiveX still supported but pymotorcad very much recommended.
- Python can easily connect to local/remote Motor-CAD instances with pymotorcad package.
- Improved/new docstrings, error messages and debugging.
- New Launch Parameters:
 - Port can be specified for RPC server on launch.
 - Motor-CAD can run script upon launch from command line



```
UserScript RunUserScript test_client x RPC_Test_All Console PyUnit
1 import MotorCAD_Methods
2
3 mc = MotorCAD_Methods.MotorCAD()
4
5 print(mc.IsOpen())
6 print(str(mc._Program_Version))
7
8
9 print("slot: " + str(mc.GetVariable("slot_depth")))
10
11 mc.DoSteadyStateAnalysis()
12
13 print("node: " + str(mc.GetNodeExists(189)))
14
15
16 mc.Quit()
17
```

```
test_client.py [debug] [C:\Program Files\Python39\python.exe]
pydev debugger: starting (pid: 25592)
True
15.1.5.1
slot: 18
node: False
```

- Internal scripting uses new JSON-RPC interface.
 - fixes issue where script would run commands on wrong Motor-CAD instance.
- Internal scripts can be used for model setup, model adjustment during run and post processing of results
- Separate scripts can be run before, during and after calculations for:
 - E-Mag
 - Thermal Steady state
 - Thermal Transient
 - Mechanical Stress
 - Mechanical Forces

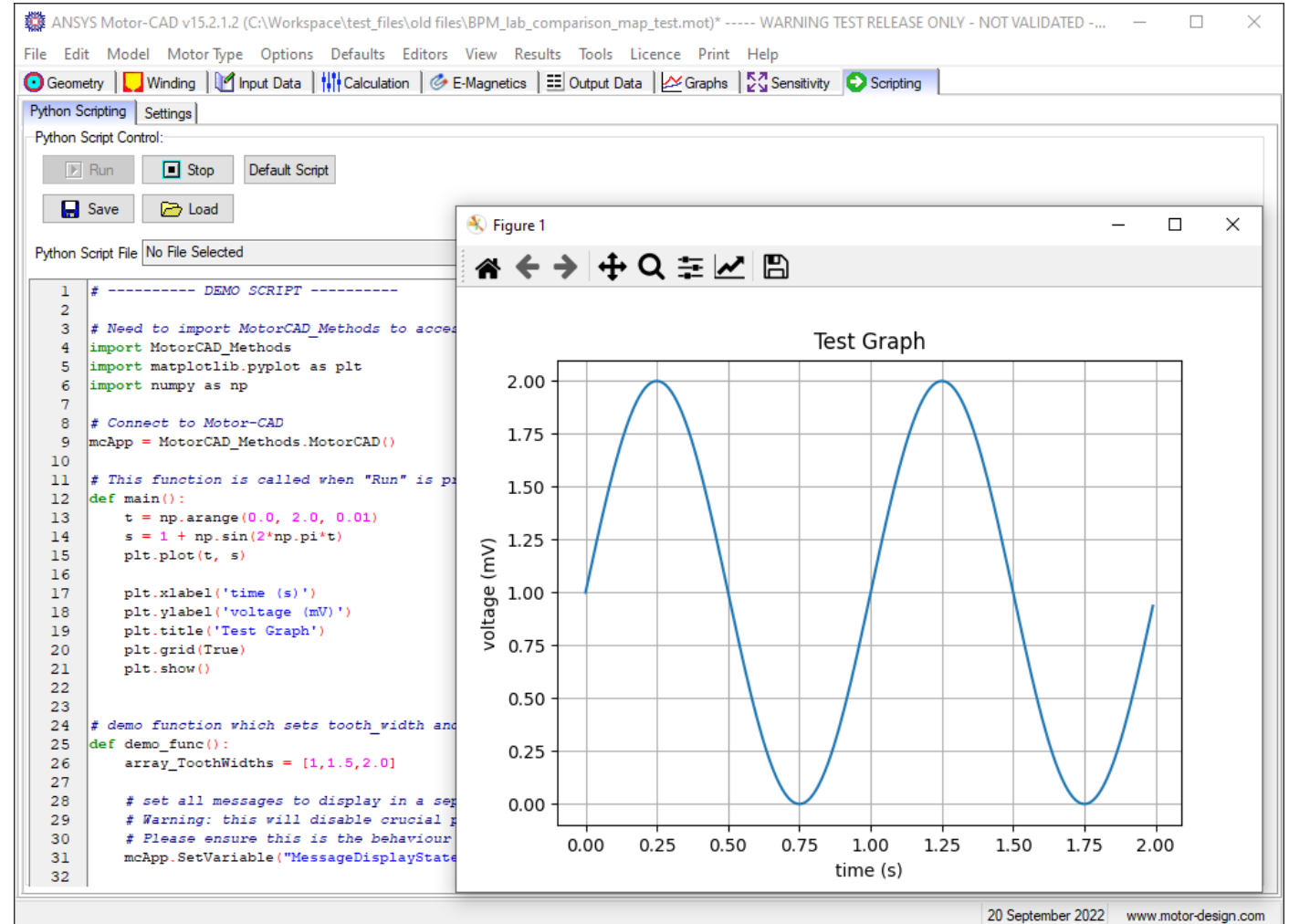
```
ANSYS Motor-CAD v15.2.1.2 (No File) ----- DEBUG -----
File Edit Model Motor Type Options Defaults Editors View Results Tools Licence Print Help
Geometry Input Data Calculation Stress Output Data E-NVH Sensitivity Scripting
Python Scripting Settings
Python Script Control:
Run Stop Default Script
Save Load
Python Script File No File Selected
41 # ----- FUNCTIONS RUN DURING CALCULATIONS -----
42 # These will only run if using "Run During Analysis" selected
43 # (Scripting -> Settings -> Run During Analysis)
44
45 # If "Run During Analysis" is selected then this script will be imported.
46 # This means that anything other than setting up the MotorCAD object should
47 # be moved to a function/class to avoid unexpected behaviour
48
49 # This class contains functions for steady-state thermal calculations
50 class thermal_steady():
51     def initial(self):
52         # Called before calculation
53         self.step = 0
54         print('Thermal Steady State - Initial')
55     def main(self):
56         # Called before each time step in calculation
57         self.step = self.step + 1
58         print('Step: ' + str(self.step) + '. Thermal Steady State - Main')
59     def final(self):
60         # Called after calculation
61         print('Thermal Steady State - Final')
62
63 # This class contains functions for transient thermal calculations
64 class thermal_transient():
65     def initial(self):
66         # Called before calculation
67         self.step = 0
68         print('Thermal Transient - Initial')
69     def main(self):
70         # Called before each time step in calculation
71         self.step = self.step + 1
72         print('Step: ' + str(self.step) + '. Thermal Transient State - Main')
```

14 July 2022 www.motor-design.com

Python 版本更新

- Updated internal Python to 3.9.13.
- Lab Python updated to 3.9.13.

- Now able to generate GUIs in python from the internal scripts.
- E.g. Matplotlib graphs can now be generated by internal scripts.



增强的灵敏度功能

- More options for setting sensitivity study values:
 - Single points, Linear range, logarithmic range

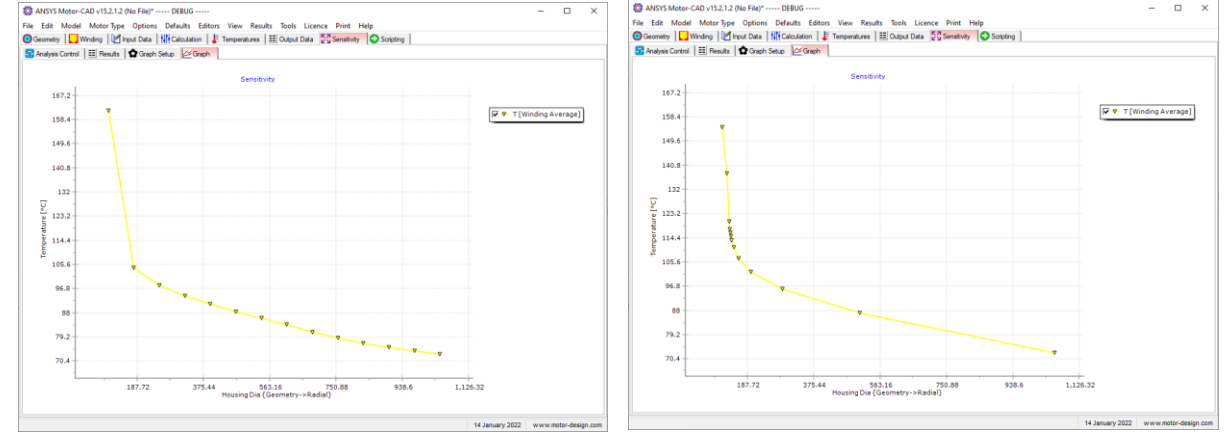
The 'fm_SensitivityControl' dialog box allows users to define sensitivity study parameters for various motor components. It includes options for Linear Step, Single Value, and Exponential, along with fields for Initial Value, Final Value, Step, Centre Value, Exponential Base, and Number of Values. Below are three examples of parameter settings:

- Slot Number:** Initial Value: 18. Variable Values: 14, 17, 20, 23.
- Stator Lam Dia:** Initial Value: 130. Variable Values: 112, 124, 128, 130, 132, 136, 148, 184.
- Housing Dia:** Initial Value: 140. Variable Values: 140, 145.

The 'Message Display' window shows the following log entries:

```

14:33:32 : New values added to the list: Linear Step
Initial Value: 14; Final Value: 25; Step: 3
14:34:46 : New value added to the list: Single Value,
140
14:34:51 : New value added to the list: Single Value,
145
14:35:50 : New values added to the list: Linear Step
Initial Value: 14; Final Value: 25; Step: 3
14:36:27 : New values added to the list of variation values: Exponential
Centre Value: 130; Exponential Base: 2
No. values below: 3; No. values above: 4
    
```



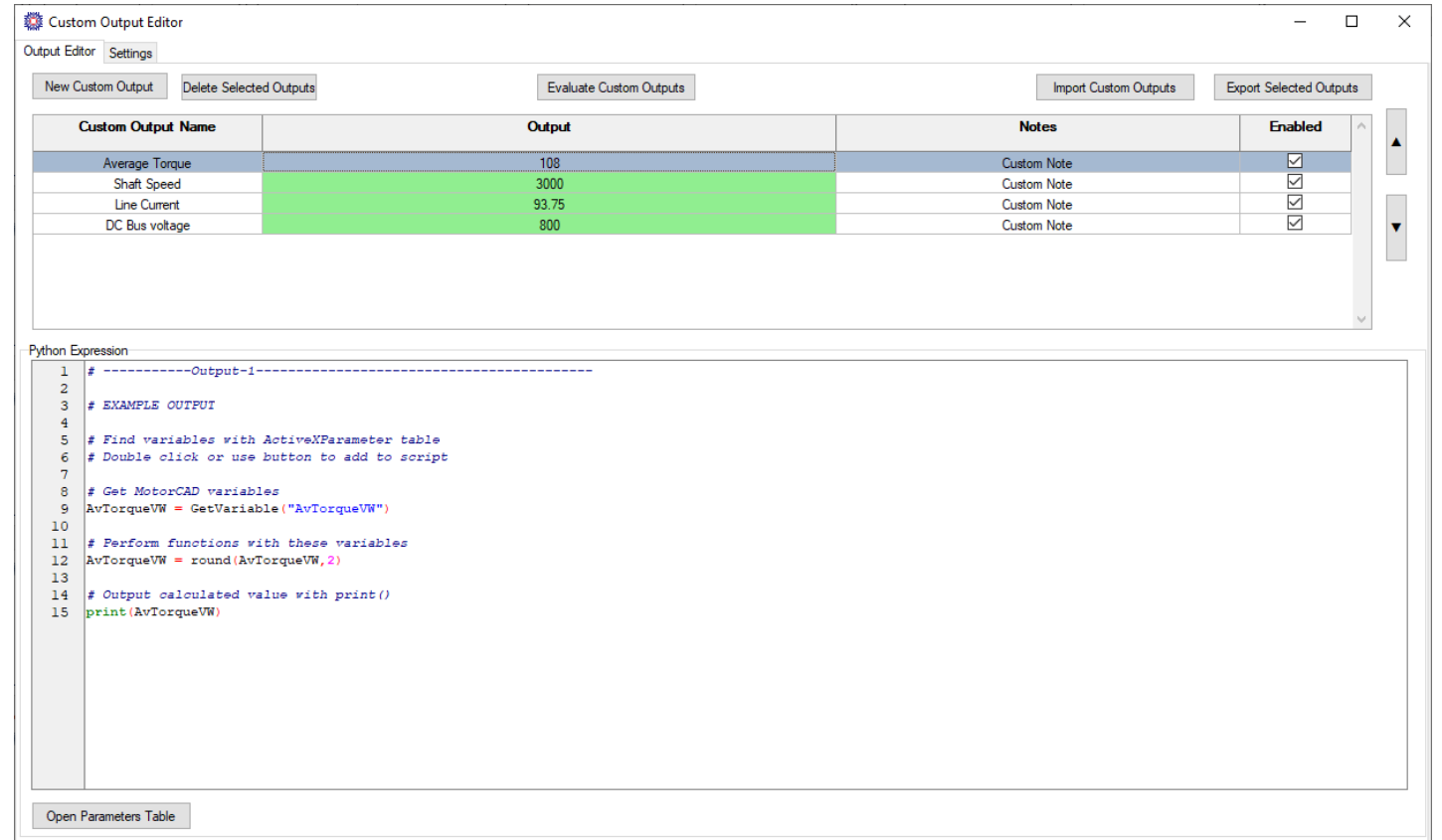
The 'Run Parameter Study' dialog shows the following settings:

- Variation Parameters Set = 3, Total Run Count = 64
- External Variation Value Data: No File Selected
- Load Variation Values, Save Variation Values, Load Variations and Results, Save Variations and Results

Parameter	Type	Units	Initial Value	Variation Values	Number of Values	Linked Multiplier	Linked Parameter
Slot Number			18	14, 17, 20, 23	4		
Housing Dia			140	140, 145	2		
Stator Lam Dia			130	112, 124, 128, 130, 132, 136, 148, 184	8		
Stator Bore			80				
Tooth Width			7				
Slot Depth			18				
Slot Corner Radius			0				
Tooth Tip Depth			1				
Slot Opening			3				
Tooth Tip Angle			30				
Sleeve Thickness			0				
Fin Extension			10				
Fin Thickness			2				
Fin Pitch/Thick			5				
Fin Pitch [Calc]			10				
Cornet Culout [°]			40				
Cornet Culout Add			0				
Plate Height			350				
Plate Width			350				
Rotor Bars			26				
Bar Opening [T]			1.5				
Bar Opening Depth [T]			1.5				
Bar Tip Angle [T]			20				
Rotor Tooth Width [T]			4				

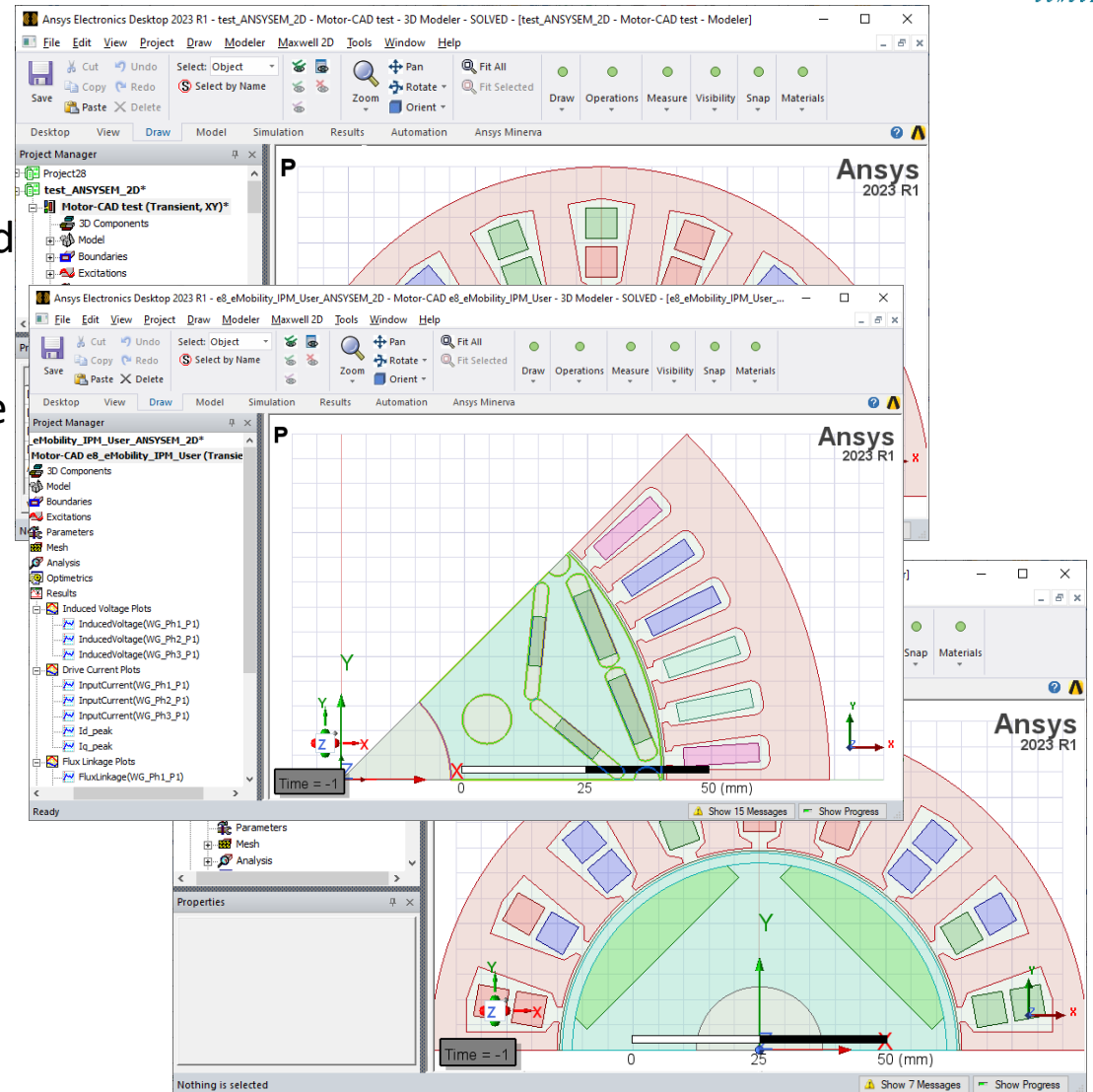
增加自定义输出的灵活性

- Python custom outputs have been added to sensitivity study.
- Added option to load default python custom output file at startup.
- Users can now have their own custom parameters setup whenever run they Motor-CAD.



Maxwell 导出增强

- Added use of magnet and rotor UDPs export for BPMOR and BPM machines with Surface/Inset/Embedded Radial/Parallel/Breadloaf rotor types
- Added use of stator UDP for export of Parallel Tooth/SqBase slots for BPM, BPMOR, IM, SYNC and SYNCREL machine types.
- Included Stator Pole Taper Angle in UDP export for SRM machines.
- Improved Outlines export; polyline coordinates drawn to tolerance in Motor-CAD,
- Removed inner and outer rotating bands from airgap in Maxwell export, replacing with single central rotating band.



电机拓扑增强

Ansys

感应电机改进

- Lab and Emag modules now use the same saturation model. Increased simplicity for the user, don't have to build it twice, and can now adjust the resolution in Lab.
- Calculation improvements (rotor leakage inductance correction).
- Rotor bar slot fill factors.
- Variable stator leakage inductance in Lab (calculated at model build time).
- Lab fixed parameter calculation improvements (now calculated using model build speed, current and user specified slip).
- Power factor, D&Q flux linkages and currents outputted from Single Load Point.

ANSYS Motor-CAD v2023.0.1.3 (QA10_i9.mot) * ----- WARNING TEST RELEASE ONLY - NOT VALIDATED -----

File Edit Model Motor Type Options Defaults Editors View Results Tools Licence Print Help

Geometry Winding Input Data Calculation E-Magnetics Output Data Graphs Sensitivity

Materials Settings Material database

Geometry E-Magnetics Calculation Graphs Losses Preferences Notes

Magnetism Settings:

Manufacturing Factors:

Amature EWdg length multiplier: 1

EWdg Inductance multiplier: 1

Top Rotor Bar Fill Factor: 1

Bottom Rotor Bar Fill Factor: 1

Equivalent Circuit Inductance Multipliers:

Definition:

Constant value (default)

Calibrated

Magnetizing Inductance: 1

End Winding Inductance Calculation:

Rosa and Grover (default)

Hanselman

End Ring Inductance Calculation:

Richter (default)

Liwshitz-Garick

Equivalent Circuit Skewing Effect:

Richter (default)

Veinott

Variable	Value	Units
Peak Current (FEA on load)	408.8	Amps
Core Loss Resistance	77.85	Ohms
Stored Magnetic Energy (FEA on load)	12.09	Joules
Stored Magnetic Energy (FEA on load)	21.13	Joules
Peak Back EMF Phase Voltage (FEA on load)	530.3	Volts
Peak Back EMF Line Voltage (FEA on load)	983.3	Volts
Back EMF Phase Voltage (rms) (FEA on load)	152.4	Volts
Back EMF Line-Line Voltage (rms) (FEA on load)	276.8	Volts
D-axis flux linkage (FEA on load)	80.36	mVs
Q-axis flux linkage (FEA on load)	91.29	mVs
D-axis stator current (FEA on load)	0	Amps
D-axis stator current (FEA on load)	408.8	Amps
Torque (Virtual work) (FEA on load)	142.1	Nm
Torque (dq) (FEA on load)	133.1	Nm
Torque (Power balance) (FEA on load)	114.3	Nm
Shaft Torque (FEA on load)	131.8	Nm
Output Power (FEA on load)	89.7	kW
Input Power (FEA on load)	94.25	kW
Power factor (FEA on load)	0.602	
System Efficiency (FEA on load)	95.17	%

The Magnetizing Inductance (including any skewing effects) {MagnetizingInductanceUnsaturated}

Model Options:

Saturation Model:

Model Type:

Analytical

FEA Map (recommended)

Loss Model:

Model Type:

Analytical

FEA Map (recommended)

Custom

Machine Parameters:

Pole Number: 6

Slot Number: 72

Winding Connection:

Star Connection (default)

Delta Connection

Fixed Model Parameters:

Phase Resistance (R1): 1.953

Rotor Resistance (R2): 4.2

Stator Leakage Inductance (L1): 15.43

Rotor Leakage Inductance (L2): 61.08

Rotor Bar Height: 11.5

Rotor Bar Conductivity: 2.09E7

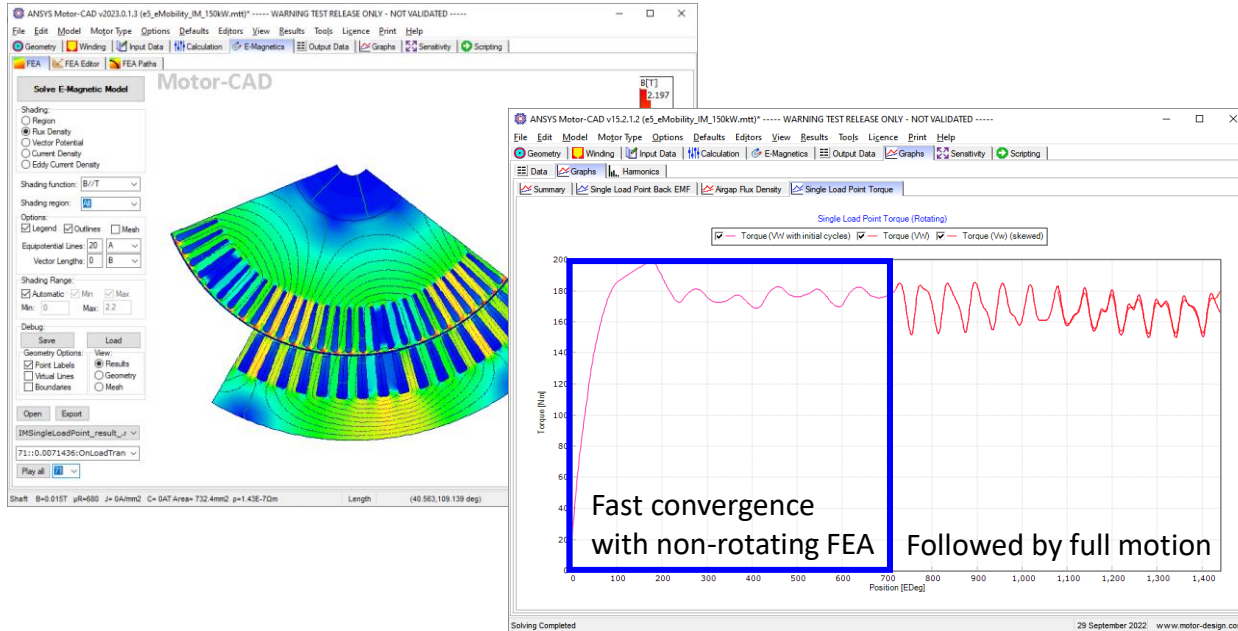
Calculation:

Slip: 0.01

Recalculate Model Parameters

瞬态感应电机计算

- New Single operating point transient electromagnetic calculation with rotation for induction machines.
- Adjustable initialisation cycles to speed up convergence.
 - Initial cycles run non-rotating analysis, for rapid rotor current convergence (resistivity adjusted to account for slip).
 - Generator mode solved at 2x synchronous speed
 - Remaining cycles run with rotation.



ANSYS Motor-CAD v2023.0.1.3 (e5_eMobility_IM_150kW_User_SkewAndIgnore.mot) - WARNING TEST RELEASE ONLY - NOT VALIDATED

ANSYS Motor-CAD v15.2.1.2 (e5_eMobility_IM_150kW.mtt) - WARNING TEST RELEASE ONLY - NOT VALIDATED

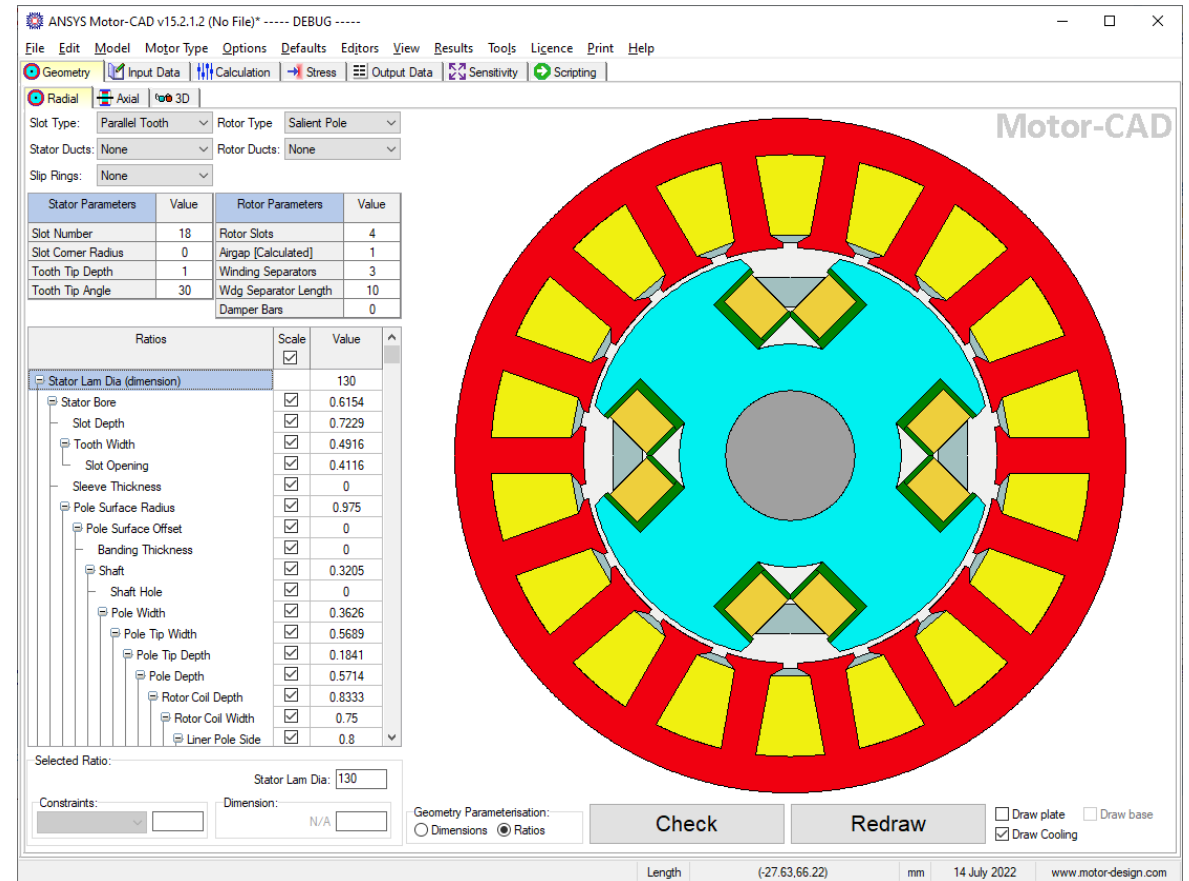
Calculation Options:

- Mesh Control: Stator Lam mesh length: 0, Stator Slot mesh length: 0, Rotor Lam mesh length: 0, Shaft mesh length: 0, Rotor Bar mesh length: 0, Min Point Separation: 0.005, Airgap Mesh: Airgap internal points: 360, Airgap surface points: 360, Airgap Layer Definition: Automatic (default), Airgap Layers: 4
- Single Load Point Calculation: Single Load Point FEA: Points per cycle: 30, Number of cycles: 2, Full motion: Initialisation cycles: 2
- Locked Rotor Calculation: Points per cycle: 30, Number of cycles: 2, Number of points: 3
- Synchronous Core Loss Calculation: Points per cycle: 10, Number of cycles: 1, Number of points: 5
- Saturation Model: Number of points: 20, Extension Factor: 2, Analytic Saturation Solver: Relaxation factor: 0.15, Tolerance: 0.001
- Equivalent Circuit Solver: Max iterations: 100, Tolerance (%): 0.01, Averaging: []
- Inductance Calculation: Number of points: 5
- Torque Speed Calculation: Number of points: 501
- Force Calculation: Stator Nodes Per Tooth: 1
- Acceleration Calculation: Points: 2.5E4, Duration: 1, Torque at 0 rpm: 0
- Skew: Skew Angle: 5, Skew Definition: Rotor
- Temperatures: Amature Winding Temperature: 40, Bar Temperature: 140, End Ring Temperature: 140, Stator Lamination Temperature: 20, Rotor Lamination Temperature: 20, Shaft Temperature: 20, Airgap Temperature: 20, Bearing Temperature [F]: 20, Bearing Temperature [R]: 20
- Performance Tests: Analytic: Single Load Point, Locked Rotor, No Load Point, Breakdown (Pull-Out) Point, Torque / Speed Characteristic, Acceleration
- Finite Element: Single Load Point (non-rotating), Single Load Point (rotating)
- Saturation Model: Calculation Method: FEA, Max Peak Current: 707.1, Max RMS Current: 500
- DC Bus Voltage: 400
- Voltage Drive: Definition: RMS, Peak Voltage: 247.2, RMS Voltage: 174.8
- Current Drive: Definition: RMS, Peak Current: 408.8, RMS Current: 289.1
- Winding Connection: Star Connection (default)

29 September 2022 www.motor-design.com

新 SYNC 电机几何比率

- Geometry Ratios added to SYNC machine templates to enable use with optiSLang.
- Salient Pole, Parallel Tooth and Parallel Slot rotor geometries.
- Avoids invalid geometry definitions.
- When using ratios the geometries are always valid.



SYNC 电机 optiSLang 整合

- Automatic generation of optiSLang study for the SYNC machine.
- No knowledge of scripting required.
- Ratio based geometries always valid.

The image shows the ANSYS Motor-CAD v15.2.1.2 interface with a motor cross-section. The 'Ratios' panel is open, showing various parameters like Stator Lam Dia (130), Slot Depth (0.6154), and Pole Width (0.3626). The 'ANSYS optiSLang Export' dialog box is open, showing input parameters, requirements, and optimization settings.

Stator Parameters	Value	Rotor Parameters	Value
Slot Number	18	Rotor Slots	4
Slot Corner Radius	0	Argap [Calculated]	1
Tooth Tip Depth	1	Winding Separators	3
Tooth Tip Angle	30	Wdg Separator Length	10
		Damper Bars	0

Variable	Min Value	Max Value
Max stator current (Peak)	10	20
Rotor Model Build Current	5	8

Setting	Option
Build Lab saturation model	Yes
Build Lab loss model	Yes
Lab saturation model type	Full cycle
Lab loss model type	FEA
Lab model resolution	Standard

Requirements:

- Peak Shaft Torque > 100 Nm at 3000 rpm
- Peak Shaft Torque > 50 Nm at 6000 rpm

Objectives:

- Continuous Shaft Torque at 3000 rpm

Optimization Settings:

- Save geometry and winding screenshots for each design
- Scale housing diameter with stator lamination diameter

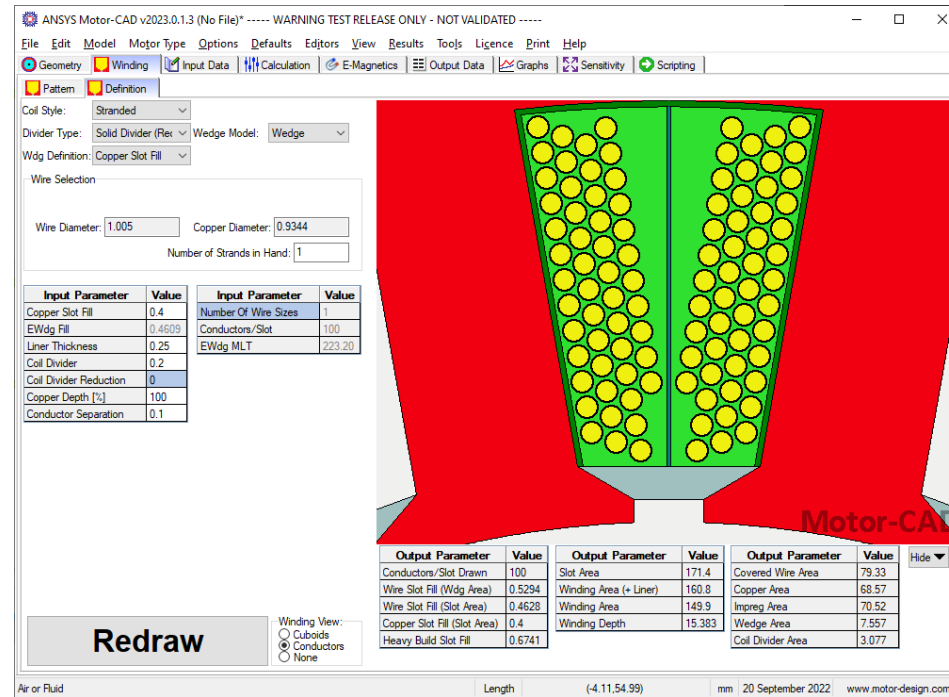
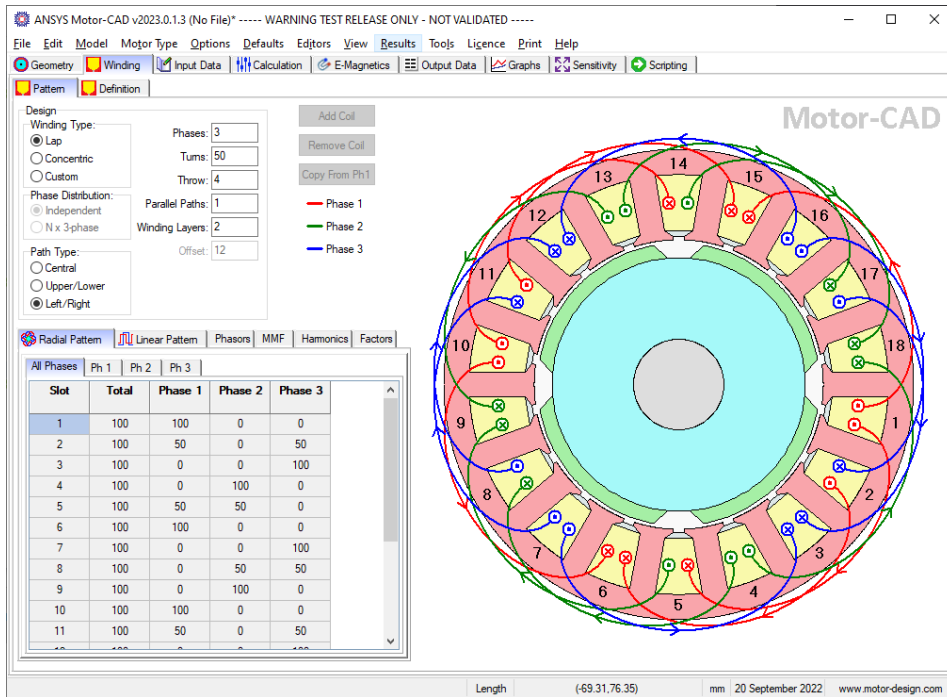
Temperatures:

- Peak Performance Machine Temperature: 40
- Duty Cycle Machine Temperature: 40
- Continuous Performance Max Winding Temperature: 160
- Continuous Performance Max Rotor Copper Temperature: 140

```
1  ### -----Motor-CAD to optiSLang coupled export script----- ###
2  ### -----Motor-CAD to optiSLang coupled export script----- ###
3  ### -----Motor-CAD to optiSLang coupled export script----- ###
4
5  import win32com.client
6  import os
7  import time as timeModule
8  from os import getcwd
9  from os.path import join, dirname, exists, basename
10 from collections import OrderedDict
11 from time import localtime, strftime, sleep, time
12 from scipy.io import loadmat
13 import sys
14 import math
15
16  ### -----Motor-CAD to optiSLang coupled export script----- ###
17  ### To be filled in by user if not being used with export --- ###
18  ### -----Motor-CAD to optiSLang coupled export script----- ###
19
20  refdir = r'To be filled in by user or optislang'
21  motFileName = r'To be filled in by user or Motor-CAD (no .mot extension)'
```


统一 Winding 定义

- Simplification of winding definition.
- Winding pattern now used as definitive source of winding data.
- No longer option to specify number of conductors in slot for thermal model.



新 hairpin winding图形生成

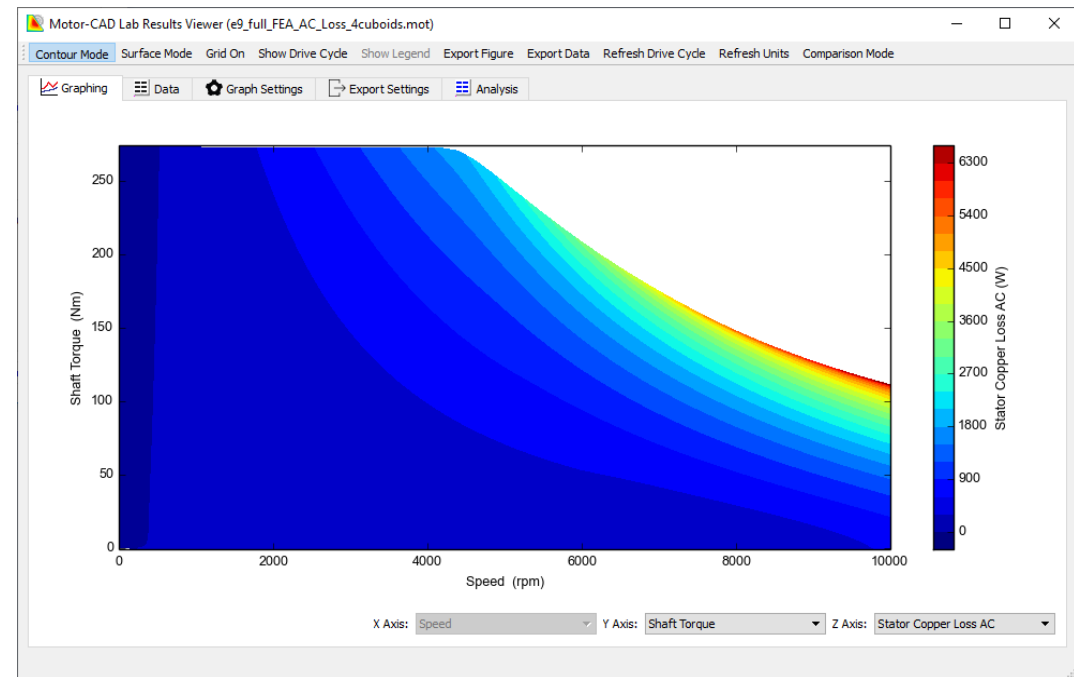
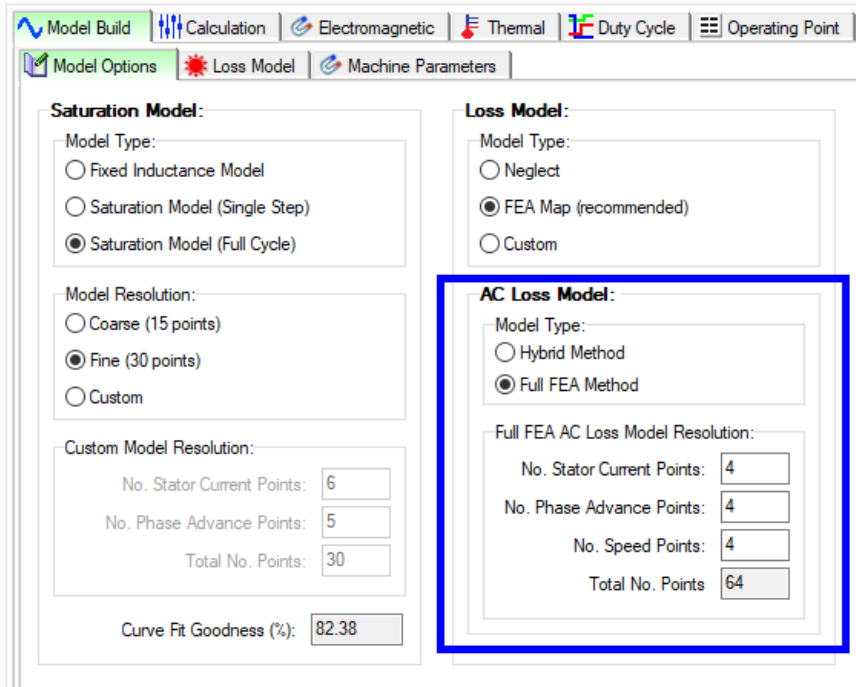
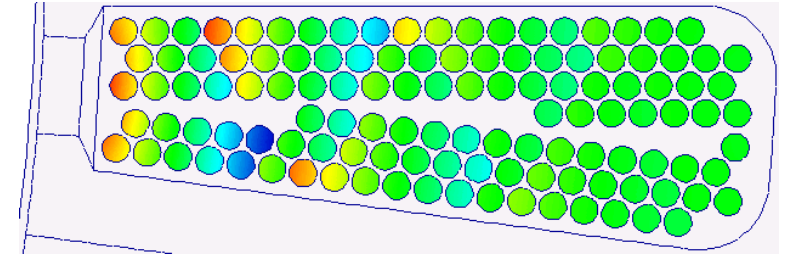
- New automatic elementary winding method.
- More accurate end-winding length calculation.
- Wave winding following parallel path impedance balancing rules.



Coil	Path	Go		Return		Throw	Turns
		Slot	Pos	Slot	Pos		
1	1	1	a	7	b	6	1
2	1	13	a	19	b	6	1
3	1	25	a	31	b	6	1
4	1	37	a	43	b	6	1
5	1	2	c	8	d	6	1
6	1	14	c	20	d	6	1
7	1	26	c	32	d	6	1
8	1	38	c	44	d	6	1

高保真Lab AC winding 损耗map图

- Calculation of the Lab AC winding loss map using full FEA method.
- Improved AC winding loss calculation accuracy with variation of speed.



不同 hairpin 导体尺寸

- Different sizes of hairpin conductors in slot.
- Used to reduce AC winding losses in conductors near slot opening.

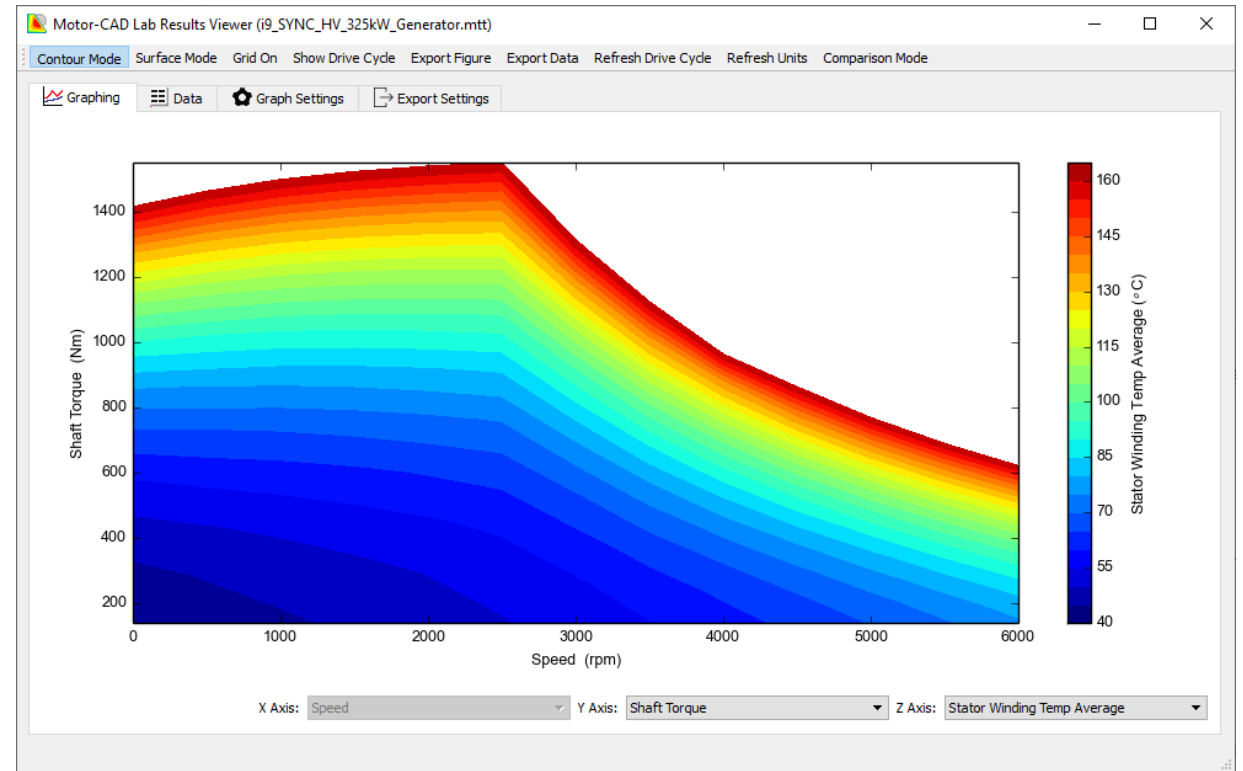
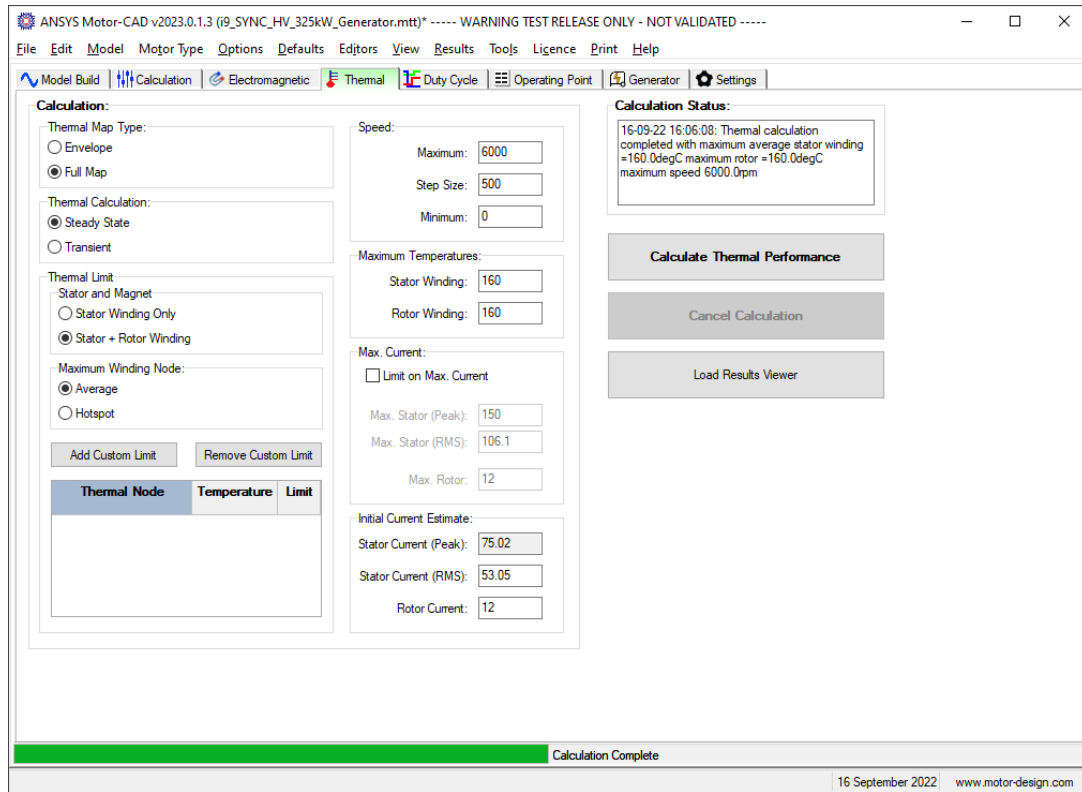
Input Parameter	Value	Input Parameter	Value
Wire Slot Fill	0.9055	Number Of Wire Sizes	4
EWdg Fill	0.6114	Conductors/Slot	4
Liner Thickness	0.25	EWdg MLT	182.12
Copper Depth [%]	100		
Conductor Separation	0.1		

Output Parameter	Value	Output Parameter	Value	Output Parameter	Value
Conductors/Slot Drawn	4	Slot Area	107.8	Covered Wire Area	87.22
Wire Slot Fill (Wdg Area)	0.9055	Winding Area (+ Liner)	106.6	Copper Area	79.97
Wire Slot Fill (Slot Area)	0.8093	Winding Area	96.33	Impreg Area	9.102
Copper Slot Fill (Slot Area)	0.742	Winding Depth	17.513	Wedge Area	1.19
Heavy Build Slot Fill	0.9069				

Output Parameter	Value
Stator_LossSlot	$p_j=0W/kg$

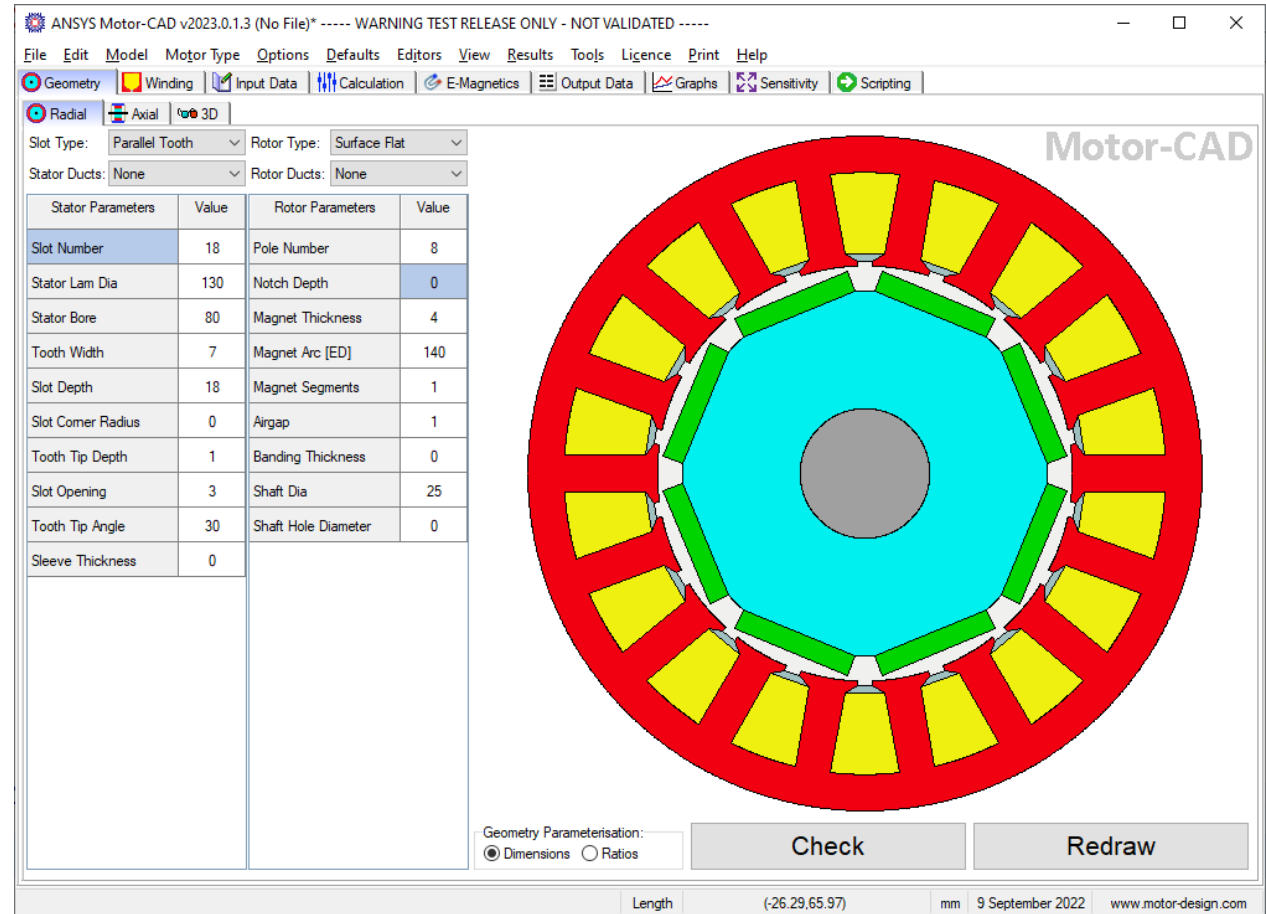
IM 与 SYNC 电机在Lab模块中热map图

- Thermal performance of Induction and Synchronous machines across full torque/speed range.



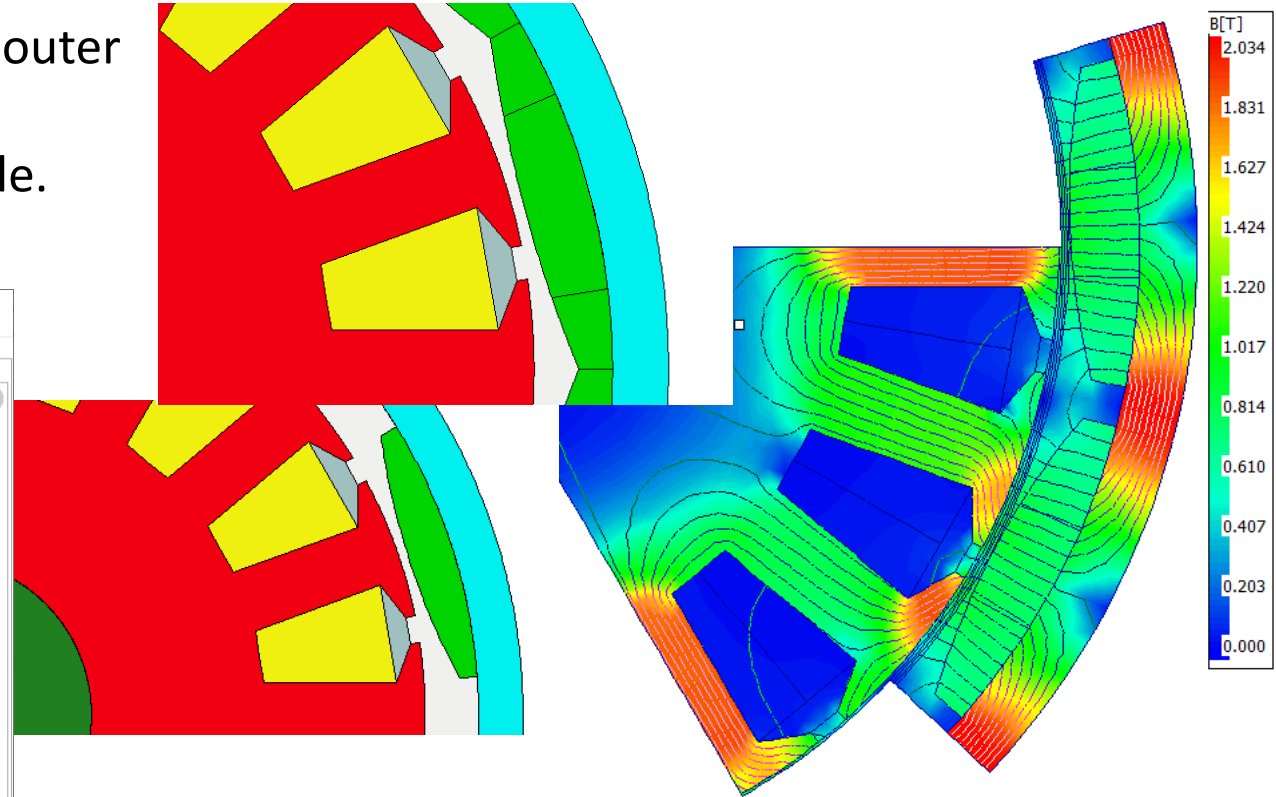
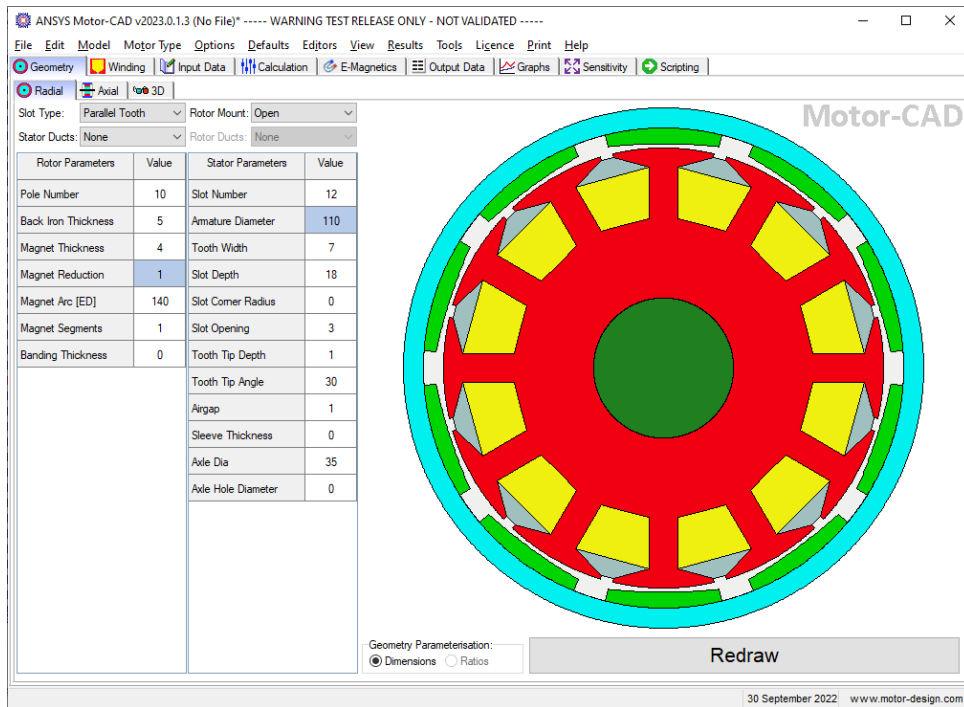
扁平表面磁体几何

- Rectangular magnets mounted on rotor lamination surface.
- Can be defined as dimensions or ratios.
- Can make use of rotor notches if required.



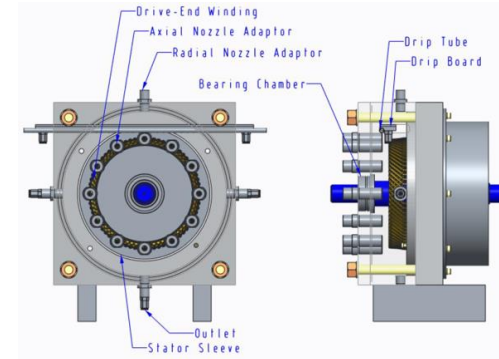
Outer rotor magnet reduction geometry

- New geometry parameter to shape the outer rotor magnets.
- Shaping of airgap to reduce torque ripple.



喷洒冷却方法改进

- Improved modelling following research project with University of Nottingham
- Independent cooling circuits for axial, radial drip and rotor/shaft nozzles
- New Heat Transfer Coefficient correlations – simplifies HTC calibration



ANSYS Motor-CAD v15.2.1.2 (No File) * ----- WARNING TEST RELEASE ONLY - NOT VALIDATED -----

File Edit Model Motor Type Options Defaults Editors View Results Tools Licence Print Help

Geometry Winding Input Data Calculation Temperatures Output Data Sensitivity Scripting

Cooling Losses Materials Interfaces Radiation Natural Convection Spray Cooling End Space Settings Material database

Flow Options Radial (from Housing)

Fluid Flow Heat Transfer

Component	Input h?	Correlation	Stationary h[input] or h[adjust]	Rotational h[input] or h[adjust]	Area Multiplier	Sprayed Area	h Stationary	h Rotational	Correlation Factor	h Mixed	Rt	Note
Units			W/m ² /°C	W/m ² /°C	pu	mm ²	W/m ² /°C	W/m ² /°C	pu	W/m ² /°C	°C/W	
EW Inner [Front] (Layer a)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	3296	3113	76.78	1	3190	0.09513	
EW Outer [Front] (Layer a)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	3296	3113	76.78	0.3	956.9	0.3171	
EW Front [Front] (Layer a)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	627.7	3113	76.78	0.7	2233	0.7135	
EW Rear [Front] (Layer a)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	627.7	3113	76.78	0.7	2233	0.7135	
EW Inner [Front] (Layer b)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	6397	3113	76.78	1	3190	0.04901	
EW Outer [Front] (Layer b)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	6397	3113	76.78	0.3	956.9	0.1634	
EW Front [Front] (Layer b)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1218	3113	76.78	0.7	2233	0.3676	
EW Rear [Front] (Layer b)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1218	3113	76.78	0.7	2233	0.3676	
EW Inner [Front] (Layer c)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	6208	3113	76.78	1	3190	0.05051	
EW Outer [Front] (Layer c)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	6208	3113	76.78	0.3	956.9	0.1684	
EW Front [Front] (Layer c)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1182	3113	76.78	0.7	2233	0.3788	
EW Rear [Front] (Layer c)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1182	3113	76.78	0.7	2233	0.3788	
EW Inner [Front] (Layer d)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	6020	3113	76.78	1	3190	0.05208	
EW Outer [Front] (Layer d)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	6020	3113	76.78	0.3	956.9	0.1736	
EW Front [Front] (Layer d)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1147	3113	76.78	0.7	2233	0.3906	
EW Rear [Front] (Layer d)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1147	3113	76.78	0.7	2233	0.3906	
EW Inner [Front] (Layer e)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	5834	3113	76.78	1	3190	0.05374	
EW Outer [Front] (Layer e)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	5834	3113	76.78	0.3	956.9	0.1791	
EW Front [Front] (Layer e)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1111	3113	76.78	0.7	2233	0.403	
EW Rear [Front] (Layer e)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1111	3113	76.78	0.7	2233	0.403	
EW Inner [Front] (Layer f)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	5650	3113	76.78	1	3190	0.05549	
EW Outer [Front] (Layer f)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	5650	3113	76.78	0.3	956.9	0.185	
EW Front [Front] (Layer f)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1076	3113	76.78	0.7	2233	0.4162	
EW Rear [Front] (Layer f)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	1076	3113	76.78	0.7	2233	0.4162	
EW Inner [Front] (Layer g)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	2729	3113	76.78	1	3190	0.1149	
EW Outer [Front] (Layer g)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	2729	3113	76.78	0.3	956.9	0.383	
EW Front [Front] (Layer g)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	610.0	3113	76.78	0.7	2233	0.6617	
EW Rear [Front] (Layer g)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	610.0	3113	76.78	0.7	2233	0.6617	

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ANSYS Motor-CAD v15.2.1.2 (No File) * ----- WARNING TEST RELEASE ONLY - NOT VALIDATED -----

File Edit Model Motor Type Options Defaults Editors View Results Tools Licence Print Help

Geometry Winding Input Data Calculation Temperatures Output Data Sensitivity Scripting

Cooling Losses Materials Interfaces Radiation Natural Convection Spray Cooling End Space Settings Material database

Flow Options Radial (from Housing)

Fluid Flow Heat Transfer

Fluid Data:

Fluid Volume Flow Rate:

Inlet Temperature:

Fluid Properties:

ATF134 fluid

Thermal Conductivity: 0.1358

Density: 828.6

Cp: 2160

Kinematic Viscosity: 2.9E-5

Dynamic Viscosity: 0.02403

Pr - Prandtl Number: 382.2

Nozzle Data:

Number of Nozzles (Front):

Number of Nozzles (Rear):

Nozzle Diameter (Front):

Nozzle Diameter (Rear):

Fluid Exit Velocity (Front):

Fluid Exit Velocity (Rear):

Flow Proportion:

Front:

Rear:

Inlet Coupling:

None

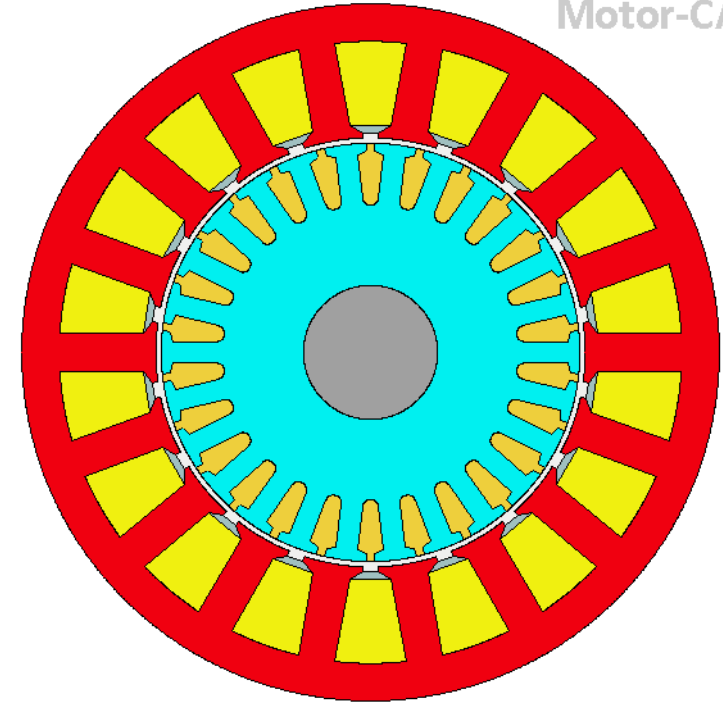
Housing Water Jacket

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机械与 NVH

Ansys

- New Induction machine NVH calculation
 - Define multi-speed operating points using RPM, line current and slip.
 - Enables full NVH calculation and force export for IM.
 - Transient IM calculation improvements significantly speed up calculation for reasonable results.



ANSYS Motor-CAD v2023.0.1.3 (test3.mot) ----- WARNING TEST RELEASE ONLY - NOT VALIDATED -----

File Edit Model Motor Type Options Defaults Editors View Results Tools Licence Print Help

Geometry Input Data Calculation Stress Output Data E-NVH Sensitivity Scripting

Rotor Stress Forces

Load Points:

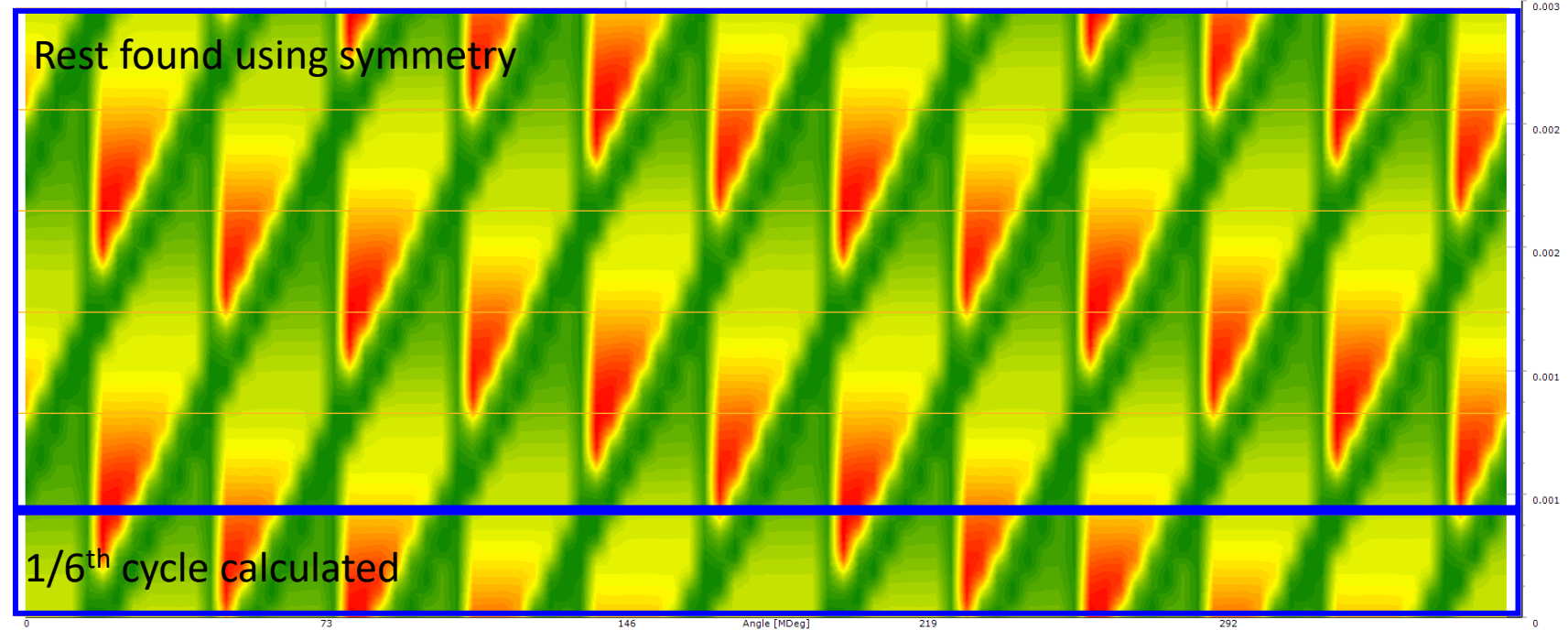
Calculated Torque	Speed	Peak Line Current	Slip
Nm	rpm	Amps	
1.56259	1000	5	0.03
1.62007	2000	10	0.01

Load Point:
Add Point
Clear Points
Delete Point

Calculation:
Generate Forces Data
Cancel

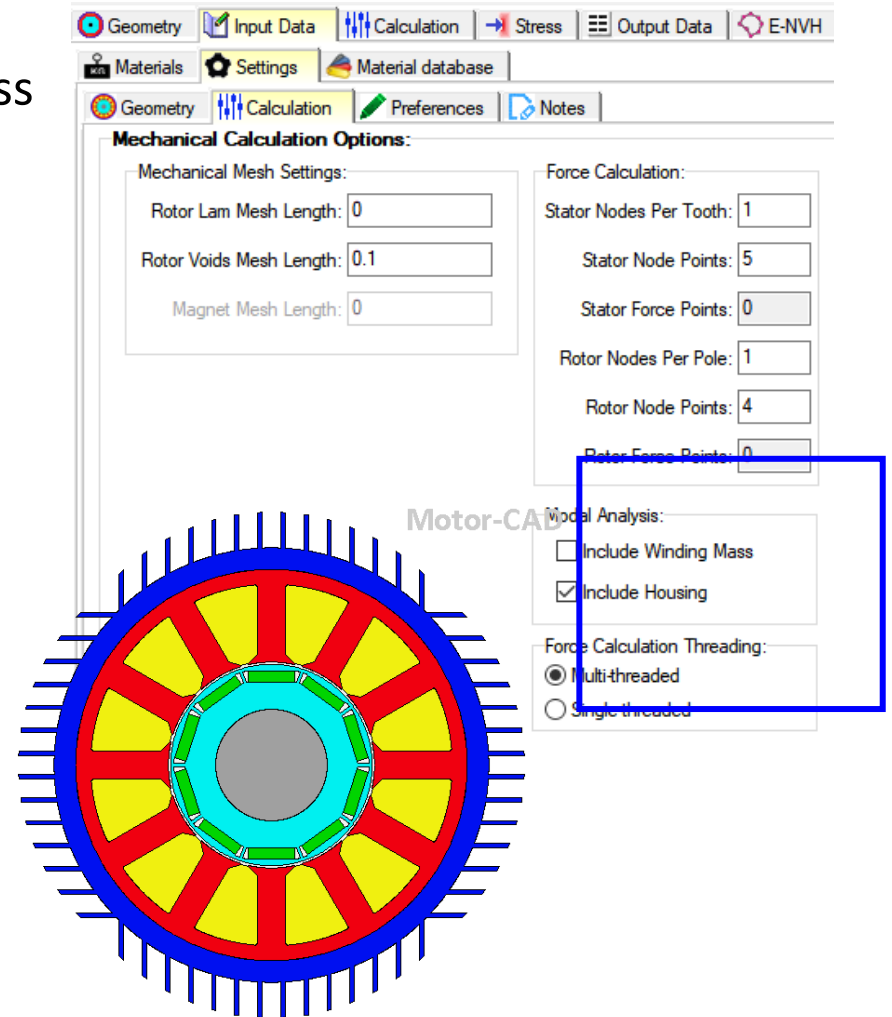
降循环 NVH

- Use 1/6 electrical cycle symmetry
 - Forces calculated for 1/6th of the cycle, rest populated using rotor and stator symmetry
- Use EMag multistatic FEA solver
- Speed up of NVH calculations
- Transient solver remains the default, reduced multistatic can be selected if preferred



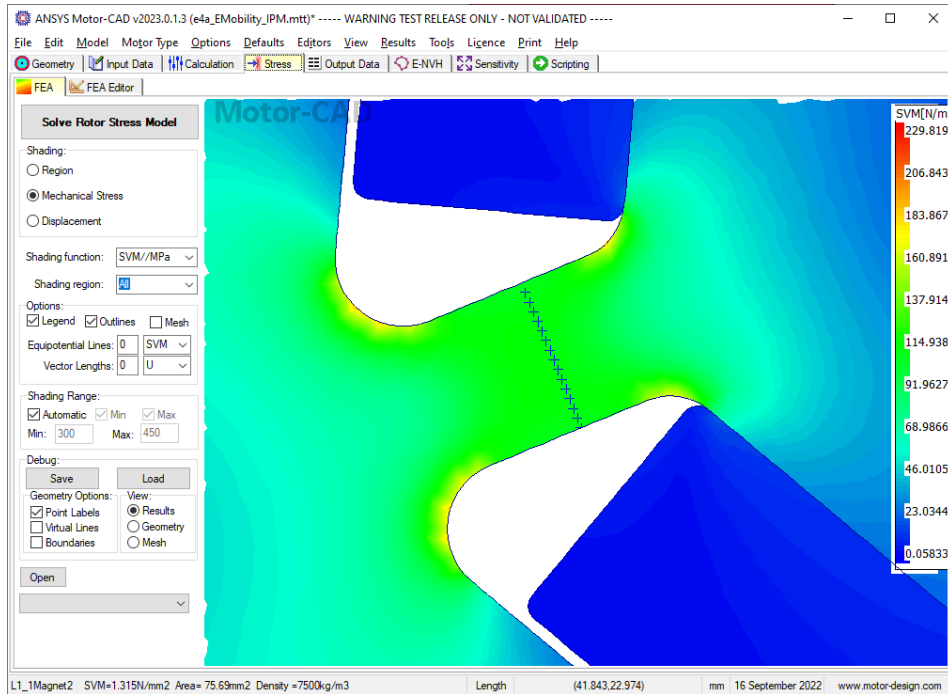
Calculated forces for one electrical cycle around the stator

- Option to include housing as well as stator in analytical stiffness & modal calculation.
- Single threaded solver option for increased reliability.
- Outputs defined to allow NVH assessment to be included with OptiSLang optimisation.
- Results exported for improved integration with Ansys Mechanical/VRExperience/Sound NVH process.
- Improvements in useability.



平均柱体和隔磁桥应力- V web 与 U magnets

- Gives a measure of the stresses in important parts of rotor lamination.
- Particularly useful for optimisation studies.
- Enable verbose FEA outputs to show measurement locations in FEA viewer.



Variable	Value	Units	Variable	Value	Units
Shaft Speed	1.485E004	rpm	Rotor Lamination displacement (average)	0.01212	mm
---	---	---	Rotor Lamination displacement (max)	0.01834	mm
Rotor Lamination Material Yield Stress	445	MPa	---	---	---
---	---	---	---	---	---
Rotor Lamination Stress (average)	40.4	MPa	---	---	---
Rotor Lamination Stress (max)	229.8	MPa	---	---	---
---	---	---	---	---	---
Rotor Lamination Yield Stress ratio	0.5164	---	---	---	---
Rotor Lamination Safety Factor	1.936	---	---	---	---
---	---	---	---	---	---
Rotor Lamination Hoop Stress (inner) [analytical]	58.82	MPa	---	---	---
Rotor Lamination Hoop Stress (outer) [analytical]	23.83	MPa	---	---	---
---	---	---	---	---	---
Average Magnet Post Stress (L1)	110.9	MPa	---	---	---
Average Magnet Bridge Stress (L1)	156	MPa	---	---	---

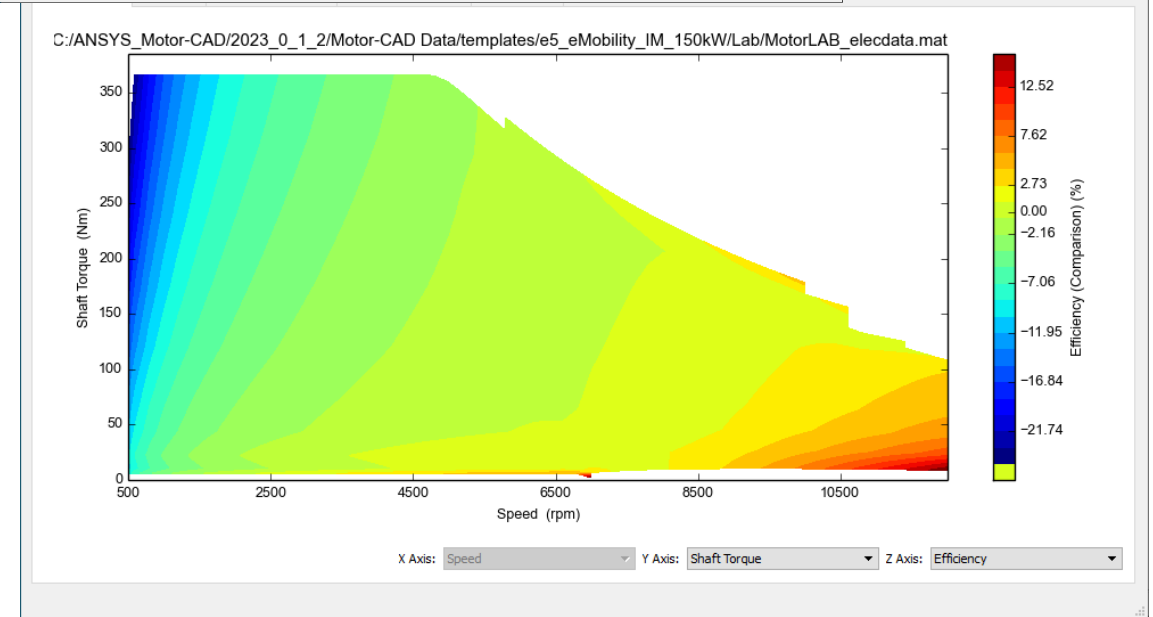
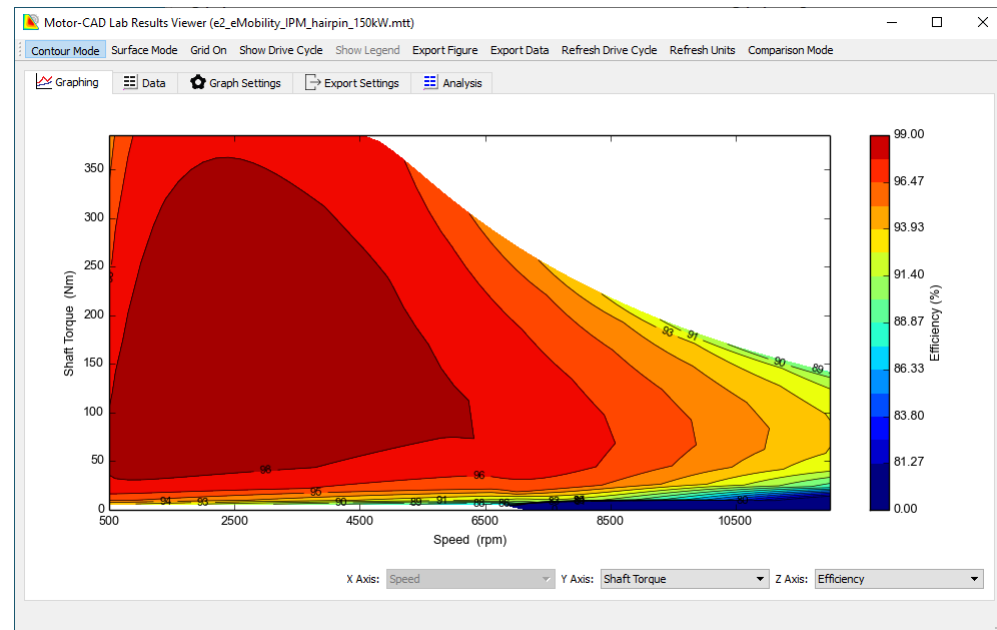
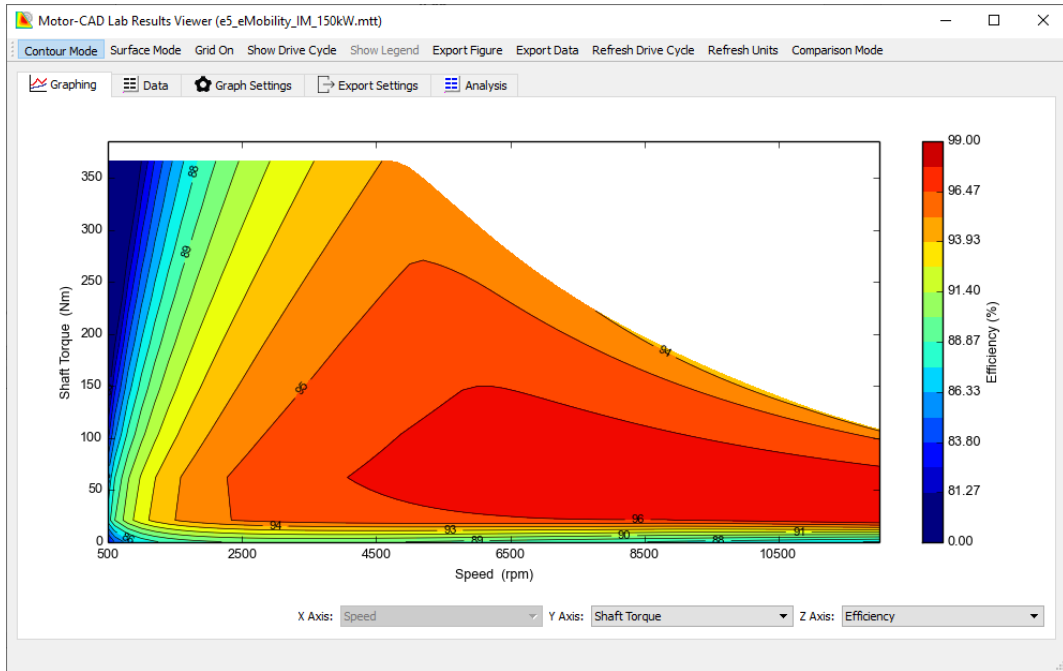
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通用增强

Ansys

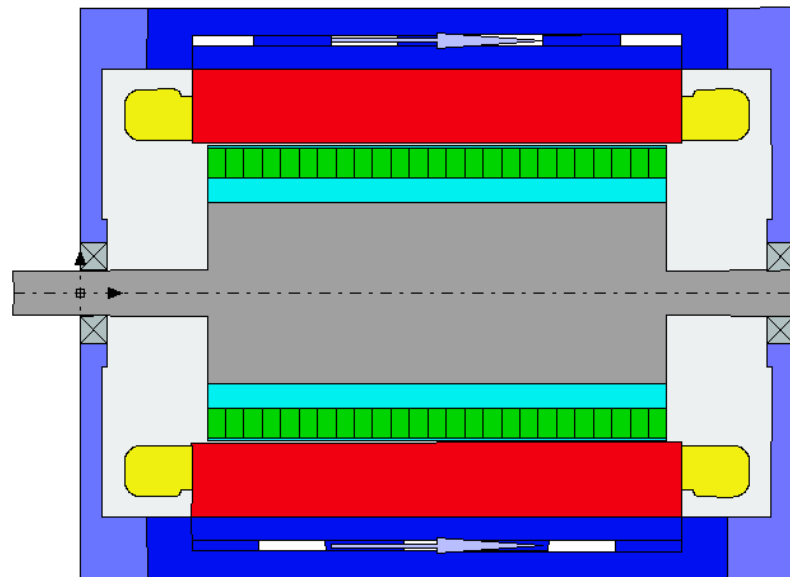
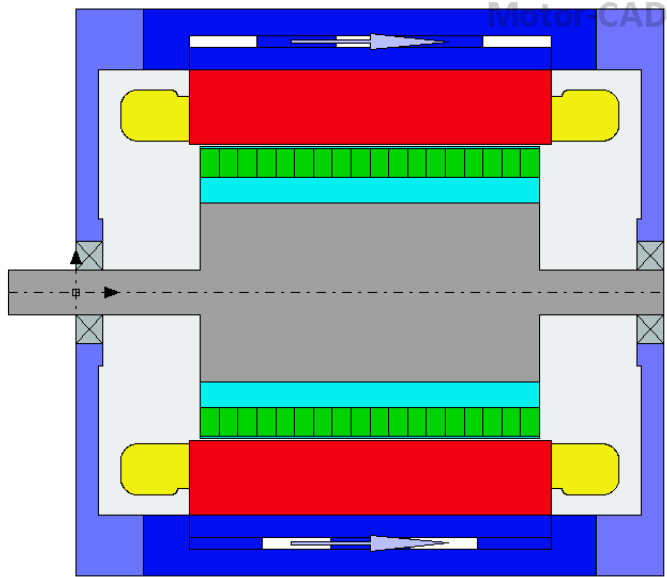
Efficiency Map 比照

- Improved efficiency map comparison option.
- Allows comparison of data with different x/y ranges.
- Data points are interpolated.



Lab轴向扩展

- Active length scaling for stator, rotor & magnet length.
- Accurate performance & loss calculations without rebuilding Lab model for different axial lengths.
- Thermal model axial length adjustments for coupled solution.
- Significant speed up of geometry optimisation e.g. optiSLang.



Model Build | Calculation | Electromagnetic | Thermal | Duty Cycle | Operating Point

General | Windage | Bearings | Custom Losses

Drive:

DC Bus Voltage: 400

Maximum Modulation Index: 1

Operating Mode:

Motor

Generator

Motor / Generator

Control Strategy:

Maximum Torque/Amp

Maximum Efficiency

Constant Phase Advance = 0

User Defined

Speed	Phase Advance
0	0
1000	15
2000	30

Losses:

Iron Loss Build Factors:

Stator: 1.5 Rotor: 1.5

Hysteresis: 1 Eddy: 1

Magnet Loss Build Factor: 1

Scaling:

Turns / Coil:

Model build reference: 6

Resistance reference: 6

Calculation: 6

Active Length:

Model build reference: 160

Resistance reference: 160

Calculation: 220

Toda Kogyo 粘合磁体的Granta 材料数据

Material	Type	Thermal Conductivity	Specific Heat	Density	Resistivity	Temp. Coef. of Resistivity	Poisson's ratio	Young's Coefficient	Yield Stress	Magnet BH Values	Notes
Units		W/m/°C	J/kg/°C	kg/m³	Ohm.m			MPa	MPa		
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	4100	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 27-80p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	4500	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 30-60p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	4400	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 32-80p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	4500	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 37-60p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	4700	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 38-80p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	4700	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 42-60p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	5000	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 43-80p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	5200	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 46-80p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	4800	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 48-60p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	5300	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 49-80p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	5200	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 55-60p. Data provided by
<input type="checkbox"/> MS-Schramberg NdFeB	Magnet	0	0	4800	0	0	0	0	0	12	Bonded molded magnet - MS-Schramberg - NdFeB 76-110p. Data provided by
<input type="checkbox"/> Spacemagnets HT-N10	Magnet	0	0	6050	0	0	0	0	0	15	Bonded molded magnet - Spacemagnets - HT-N10 - Compression Molded. Data
<input type="checkbox"/> Spacemagnets HT-N10H	Magnet	0	0	6050	0	0	0	0	0	15	Bonded molded magnet - Spacemagnets - HT-N10H - Compression Molded. Data
<input type="checkbox"/> Spacemagnets HT-N10S	Magnet	0	0	6150	0	0	0	0	0	35	Bonded molded magnet - Spacemagnets - HT-N10S - Compression Molded. Data
<input type="checkbox"/> Spacemagnets HT-N12	Magnet	0	0	6150	0	0	0	0	0	15	Bonded molded magnet - Spacemagnets - HT-N12 - Compression Molded. Data
<input type="checkbox"/> Spacemagnets HT-N12S	Magnet	0	0	6150	0	0	0	0	0	78	Bonded molded magnet - Spacemagnets - HT-N12S - Compression Molded. Data
<input type="checkbox"/> Spacemagnets HT-N8L	Magnet	0	0	5950	0	0	0	0	0	15	Bonded molded magnet - Spacemagnets - HT-N8L - Compression Molded. Data
<input checked="" type="checkbox"/> Toda Kogyo TP-A27N	Magnet	0	0	3750	0	0	0	32000	0	640	Bonded molded magnet - Toda Kogyo - TP-A27N. Anisotropic Ferrite PA12
<input checked="" type="checkbox"/> Toda Kogyo TP-S68	Magnet	0	0	3770	0	0	0.28	5700	0	640	Bonded molded magnet - Toda Kogyo - TP-S68. Anisotropic Ferrite PA6 compound
<input checked="" type="checkbox"/> Toda Kogyo TP-S73	Magnet	0	0	3420	0	0	0	4500	0	640	Bonded molded magnet - Toda Kogyo - TP-S73. Anisotropic Ferrite PPS compound
<input checked="" type="checkbox"/> Toda Kogyo TRP-M760	Magnet	0	0	5300	0.0012004	0	0.24	31000	0	560	Bonded molded magnet - Toda Kogyo - TRP-M760. Isotropic NdFeB PPS compound
<input checked="" type="checkbox"/> Toda Kogyo TRP-T710C	Magnet	0	0	5000	0.0016	0	0	0	0	560	Bonded molded magnet - Toda Kogyo - TRP-T710C. Anisotropic NdFeB PPS

Found 114 materials

Import Selected Cancel

- Recoma 28_Alom
- Recoma 28_QA78
- Recoma 28_QA85
- Recoma 30S
- Recoma 32
- Sm2Co17 175/160w
- Toda Kogyo | TP-A27N
- Toda Kogyo | TP-S68
- Toda Kogyo | TP-S73
- Toda Kogyo | TRP-M760
- Toda Kogyo | TRP-T710C
- Transcend_Ferrite_FB9H_Calibrated
- UnitMagnet
- VacoDym
- Vacomax 225 HR
- Vinyl Ferrite
- Y32
- Y34

-40	-162469	0.100593
-40	-159590	0.10763
-40	-157311	0.113821
-40	-154732	0.119597
-40	-152154	0.124891
-40	-149575	0.129794
-40	-146996	0.134396
-40	-144417	0.138761
-40	-141838	0.142939
-40	-139259	0.146961

Magnet Parameters

Calculate Magnet Parameters

Update Database Values

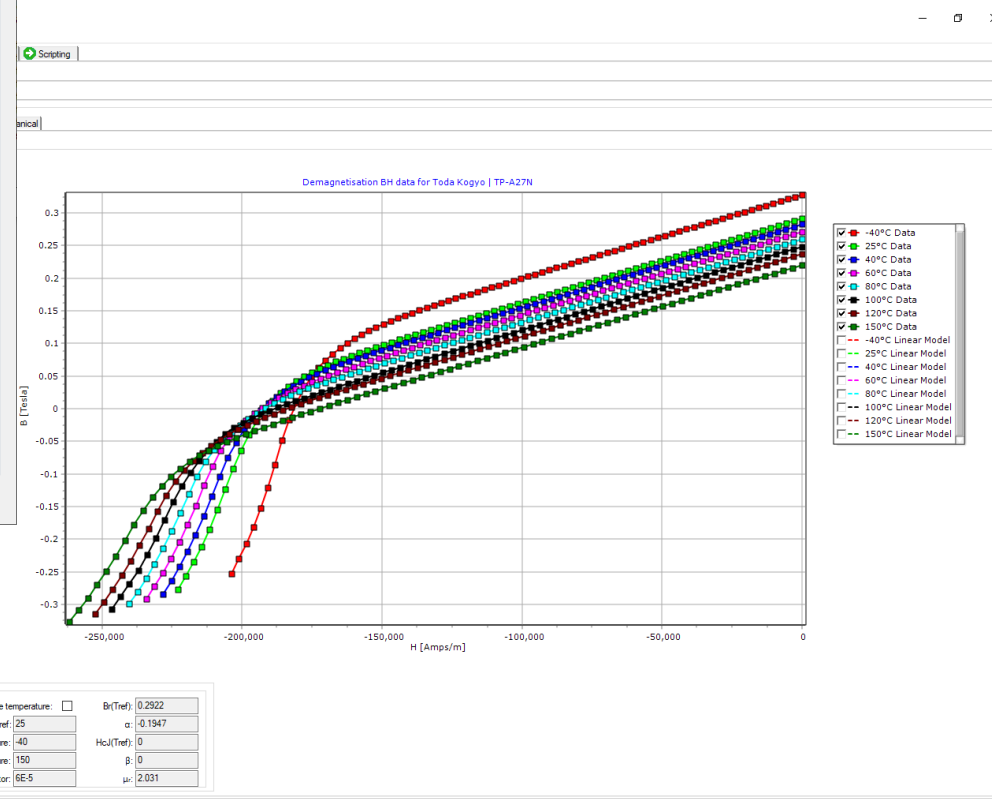
Specify reference temperature: $B_r(Tref)$ 0.2922

Reference Temperature Tref: 25 α 0.1947

Minimum Valid Temperature: -40 $H_{cJ}(Tref)$ 0

Maximum Valid Temperature: 150 β 0

Squareness Factor: 6E-5 μ 2.031



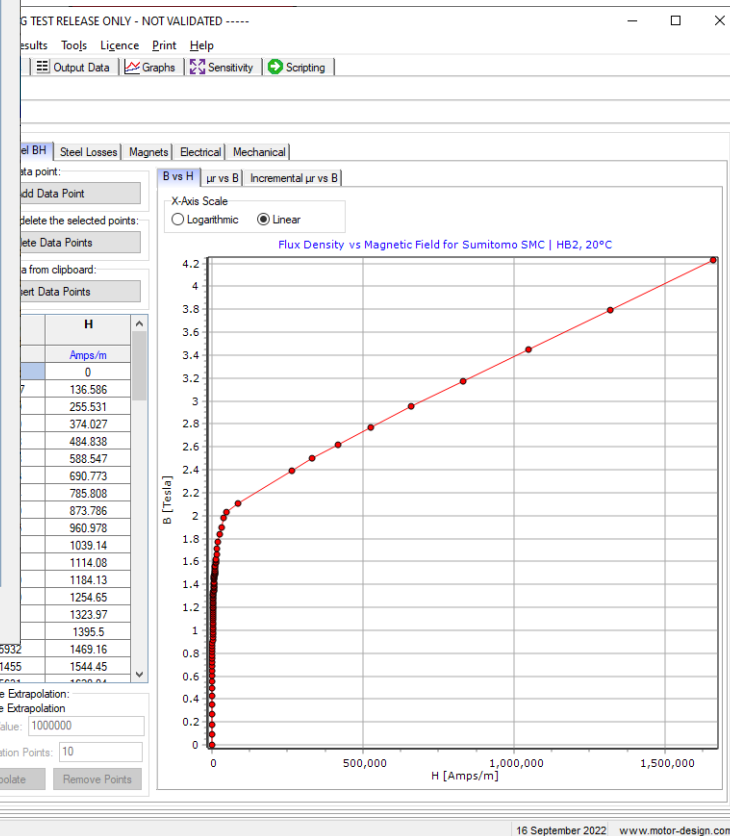
Sumitomo SMC 钢材的Granta 材料数据



Import Material Database

Material	Type	Thermal Conductivity	Specific Heat	Density	Resistivity	Temp. Coef. of Resistivity	Lamination Thickness	Kh (Steinmetz)	Kh (Bertotti Classical)	Kh (Bertotti Maxwell)	Keddy	Kexc (Bertotti Classical)	Kexc (Bertotti Maxwell)	Alpha (Steinmetz)	Alpha (Bertotti Classical)	Alpha (Bertotti Maxwell)
Units		W/m/°C	J/kg/°C	kg/m³	Ohm.m											
Micrometals 66 Material	Steel	0	0	6200	0.5	0	5	0.1	0.1	0.1	7.079	0.0010631899	0.0018624799	1.0924325	1.2521041	
Micrometals 70 Material	Steel	0	0	7400	0.5	0	5	0.0468557	0.049046037	0.048824026	1E-7	6.3783316E-5	6.9324554E-5	2.0576971	1.9820241	
Micrometals 8 Material	Steel	0	0	6500	0.5	0	5	0.1	0.1	0.1	5.087	0.00087548237	0.0016192772	1.131776	1.3262971	
Micrometals M125 Material	Steel	0	0	7700	0.5	0	5	0.0466896	0.045500353	0.045592817	1E-7	7.0245108E-5	9.5223213E-5	1.7344902	1.8511834	
PMG S280b	Steel	0	0	7000	10	0	5	0.1	0.1	0.083549279	2.022	0.0017891377	0.0021527161	1.5216064	1.9240691	
PMG S300b	Steel	0	0	7000	10	0	5	0.1	0.1	0.090373151	2.170	0.0019156407	0.0021196626	1.512042	1.9455777	
PMG S400b	Steel	0	0	7000	10	0	5	0.1	0.1	0.078460958	2.053	0.001823507	0.0022918553	1.4821793	1.8912986	
PMG S720	Steel	0	0	7000	10	0	5	0.1	0.049674941	0.1	1.894	0.0028016536	0.0017560312	1.4707484	2.6465067	
PMG STestb	Steel	0	0	7000	10	0	5	0.1	0.1	0.07784309	1.977	0.0017459808	0.0022393606	1.4962163	1.8946676	
Sintex B7	Steel	0	0	7450	0.001	0	5	0.1	0.066656984	0.067688441	2.048	0.002369494	0.0021626949	1.5843499	2.0116706	
Sintex B7X	Steel	0	0	7500	0.0007	0	5	0.0562431	0.017604187	0.03577057	3.093	0.0031787175	0.0025479262	1.8357595	3.1760455	
Sintex M7	Steel	0	0	7450	0.0004	0	5	0.0935959	0.05103864	0.06755147	2.672	0.0030042313	0.0020912655	1.7328156	2.3077099	
Sintex S10	Steel	0	0	7560	7E-5	0	5	0.1	0.06081615	0.078666565	3.160	0.0031683486	0	1.7628553	2.2466303	
Sintex S7	Steel	0	0	7570	0.0002	0	5	0.0992634	0.073808943	0.072650449	2.164	0.002130552	0.0012497233	1.7035131	1.8999704	
Sintex S7b	Steel	0	0	7520	0.0006	0	5	0.1	0.075508965	0.06414864	2.180	0.0021862285	0.0021969771	1.6161737	1.8804588	
Sumitomo SMC HB1, 20°C	Steel	33	453	7500	0.00099	0	0	0.1	0.093144087	0.080085907	1.075	0.00095366947	0.0012440173	1.6992429	1.7393471	
Sumitomo SMC HB2, 20°C	Steel	37	440	7450	0.00085	0	0	0.0700351	0.056735423	0.05178212	1.089	0.0010925885	0.001241511	1.6969579	1.8631	
Sumitomo SMC HB3, 20°C	Steel	33	453	7500	0.00029	0	0	0.1	0.093304122	0.082274099	1.227	0.0010701167	0.0013295864	1.7605528	1.7944588	
Sumitomo SMC HF1, 20°C	Steel	31	434	7200	0.00952	0	0	0.1	0.1	0.1	3.144	0.00087289501	0.00065276534	1.5406612	2.7404348	
Sumitomo SMC HF3, 20°C	Steel	10	455	7250	0.4209	0	0	0.0974358	0.093963313	0.08892647	1E-7	0.0001731877	0.0003452605	1.6964624	1.7244968	
Sumitomo SMC HX1, 20°C	Steel	8.9	460	6900	0.0219	0	0	0.1	0.097055337	0.099126921	1E-7	0.00013640398	0.00019396733	1.8827474	1.8614585	
Sumitomo SMC NM, 20°C	Steel	23	464	7450	0.003341	0	0	0.1	0.1	0.1	7.129	0.0012346151	0.0012190808	1.572055	2.0383101	

Found 56 materials



The Ansys logo consists of a yellow slanted bar followed by the word "Ansys" in a bold, black, sans-serif font.

Ansys

