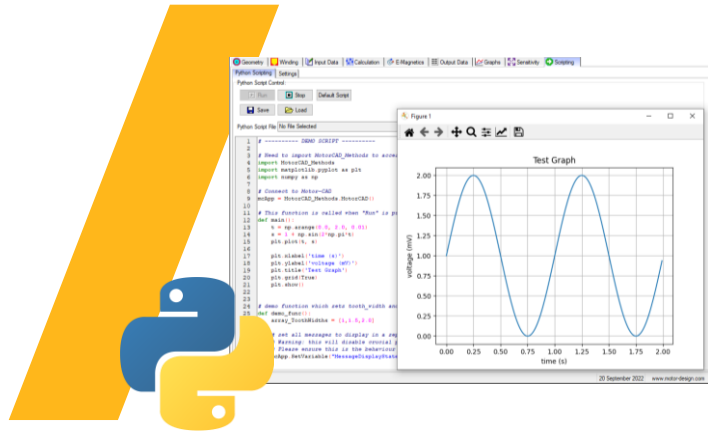


Release 2023 R1 Highlights

Ansys Motor-CAD

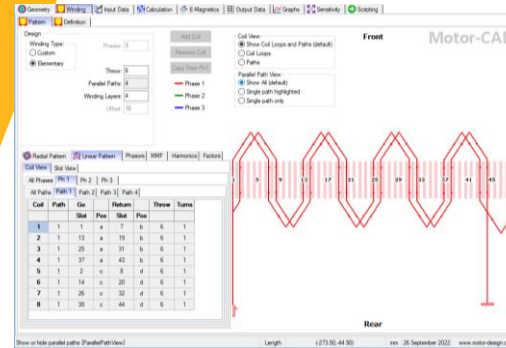


ANSYS Motor-CAD 2023 R1 Highlights



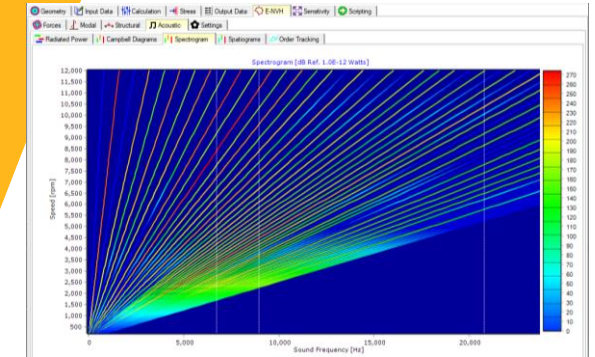
Automation and workflows

- ✓ 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



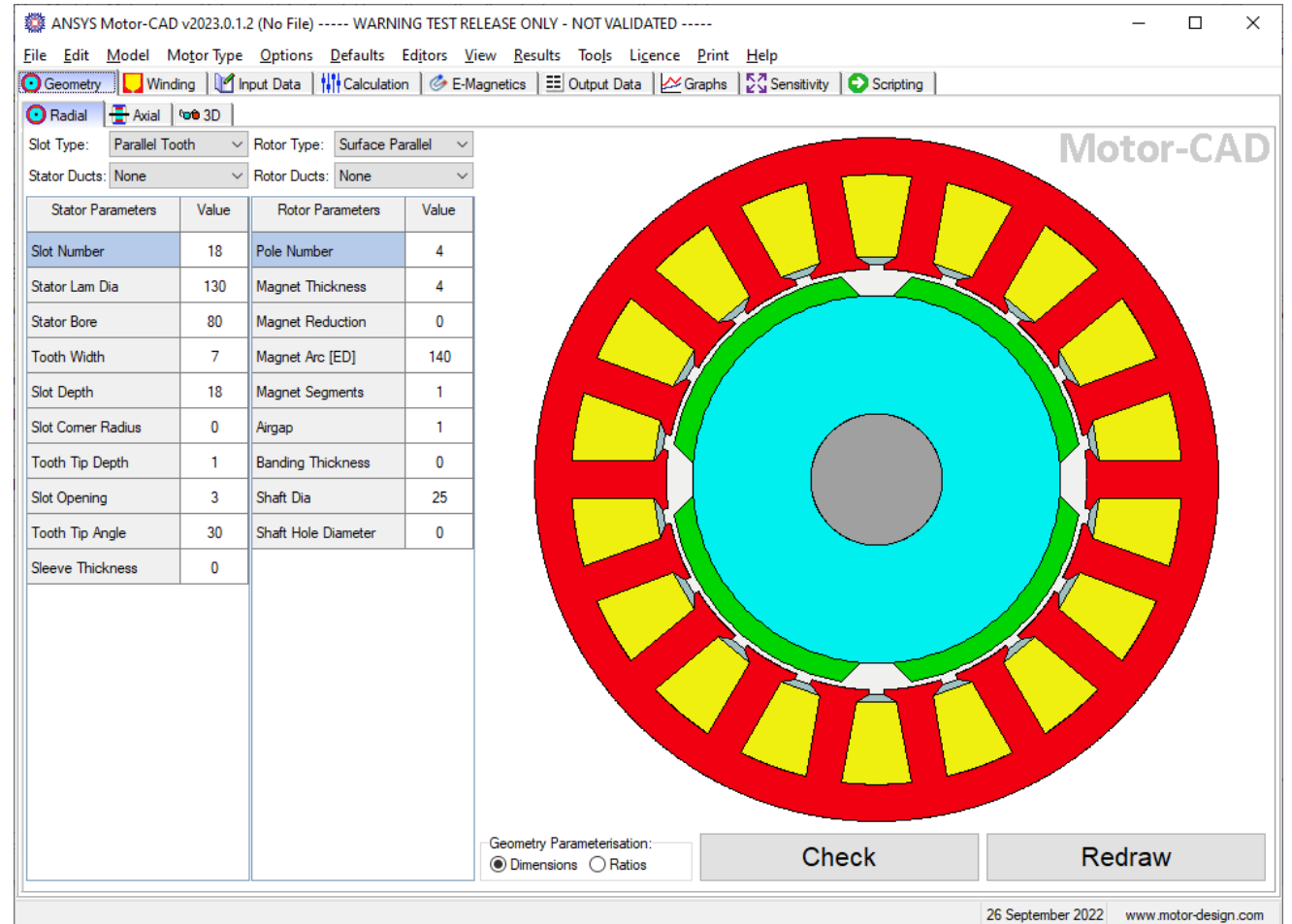
Motor-CAD 2023R1 new version names

- 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

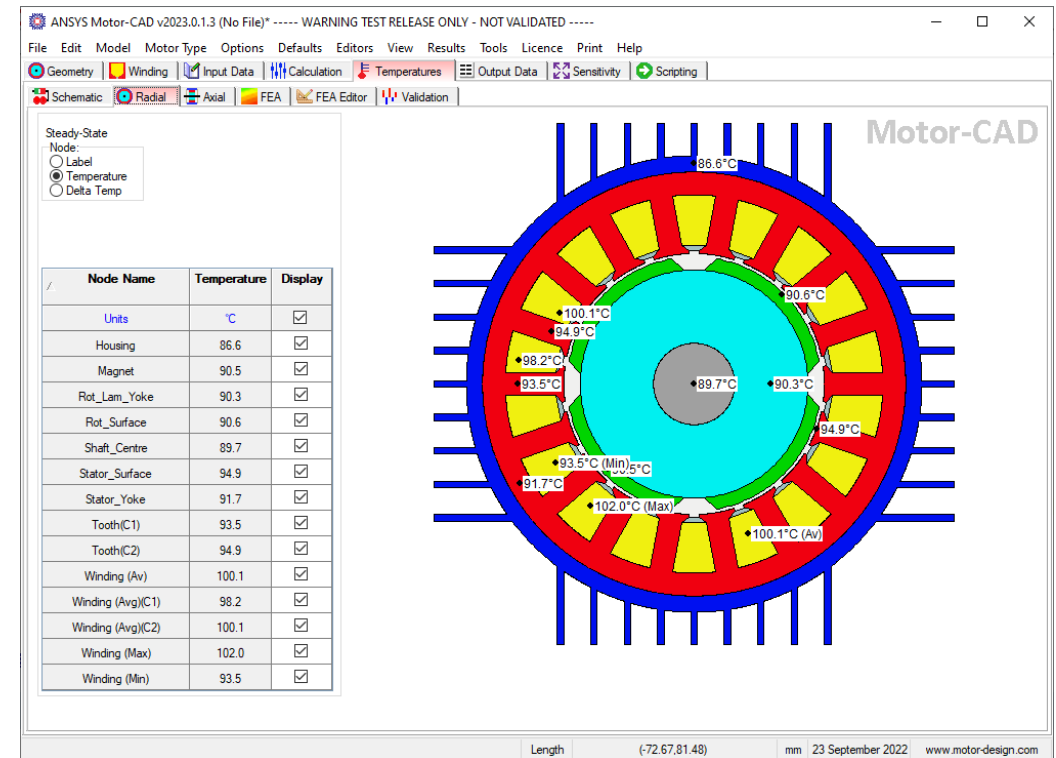


Automation and workflows

Ansys

New 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

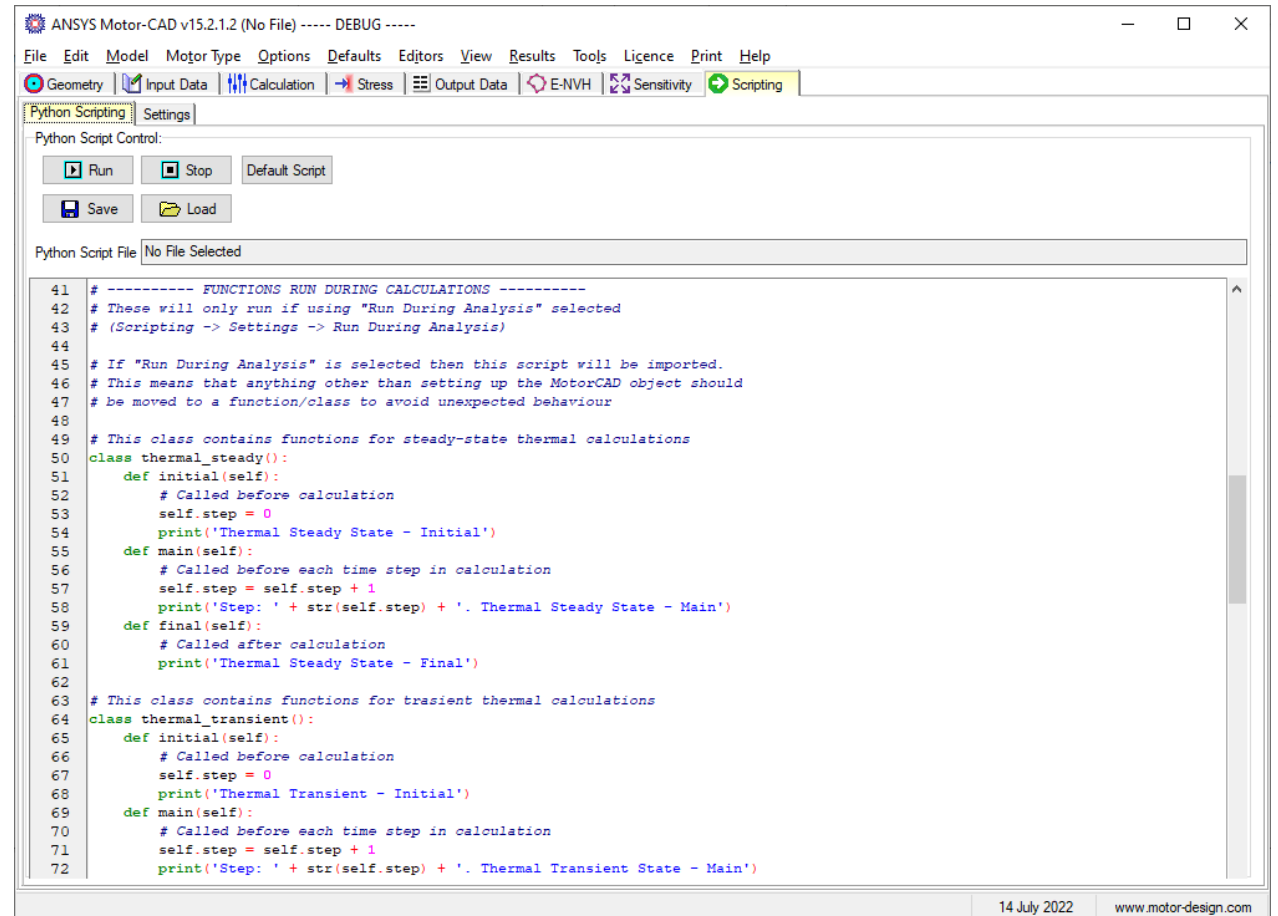


```
UserScript RunUserScript test_client x RPC_Test_All Console PyUnit
1 import MotorCAD_Methods
2
3 mc = MotorCAD_Methods.MotorCAD()
4
5 print(mc.IsOpen())
6 print(str(mc._Program_Version))
7
8
9 print("slot: " + str(mc.GetVariable("slot_depth")))
10
11 mc.DoSteadyStateAnalysis()
12
13 print("node: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

- 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



The screenshot shows the ANSYS Motor-CAD v15.2.1.2 Python Scripting interface. The window title is "ANSYS Motor-CAD v15.2.1.2 (No File) ----- DEBUG -----". The menu bar includes File, Edit, Model, Motor Type, Options, Defaults, Editors, View, Results, Tools, Licence, Print, and Help. The toolbar contains icons for Geometry, Input Data, Calculation, Stress, Output Data, E-NVH, Sensitivity, and Scripting. The Python Scripting Control panel has buttons for Run, Stop, Default Script, Save, and Load. The Python Script File field is empty. The script content is as follows:

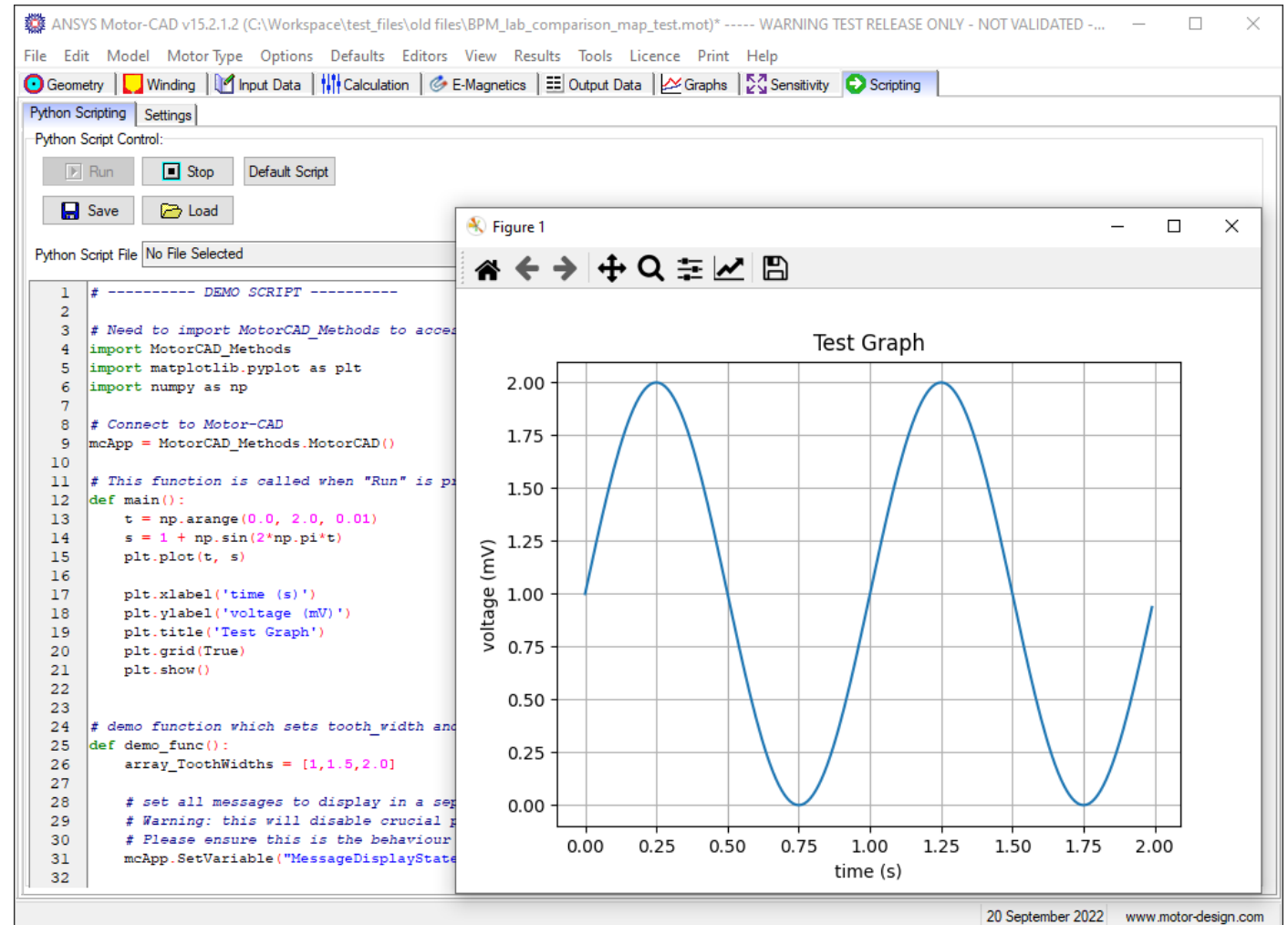
```
41 # ----- FUNCTIONS RUN DURING CALCULATIONS -----
42 # These will only run if using "Run During Analysis" selected
43 # (Scripting -> Settings -> Run During Analysis)
44
45 # If "Run During Analysis" is selected then this script will be imported.
46 # This means that anything other than setting 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')
```

The status bar at the bottom right shows the date "14 July 2022" and the website "www.motor-design.com".

Python version updates

- 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.



Enhanced Sensitivity functionality

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

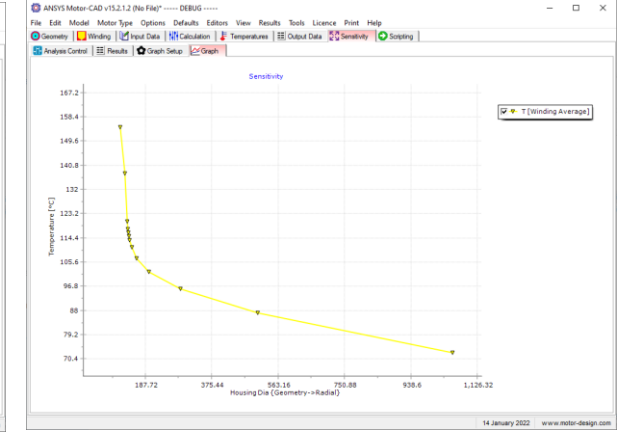
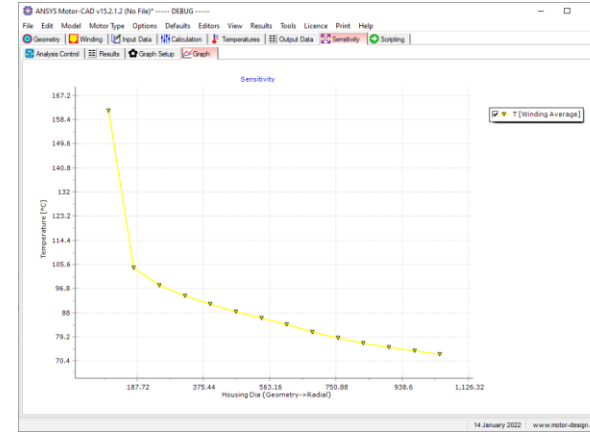
The screenshots show the 'fm_SensitivityControl' dialog box for three different parameters:

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



ANSYS Motor-CAD v15.2.1.2 (No File) - DEBUG - - - - -

Analysis Control

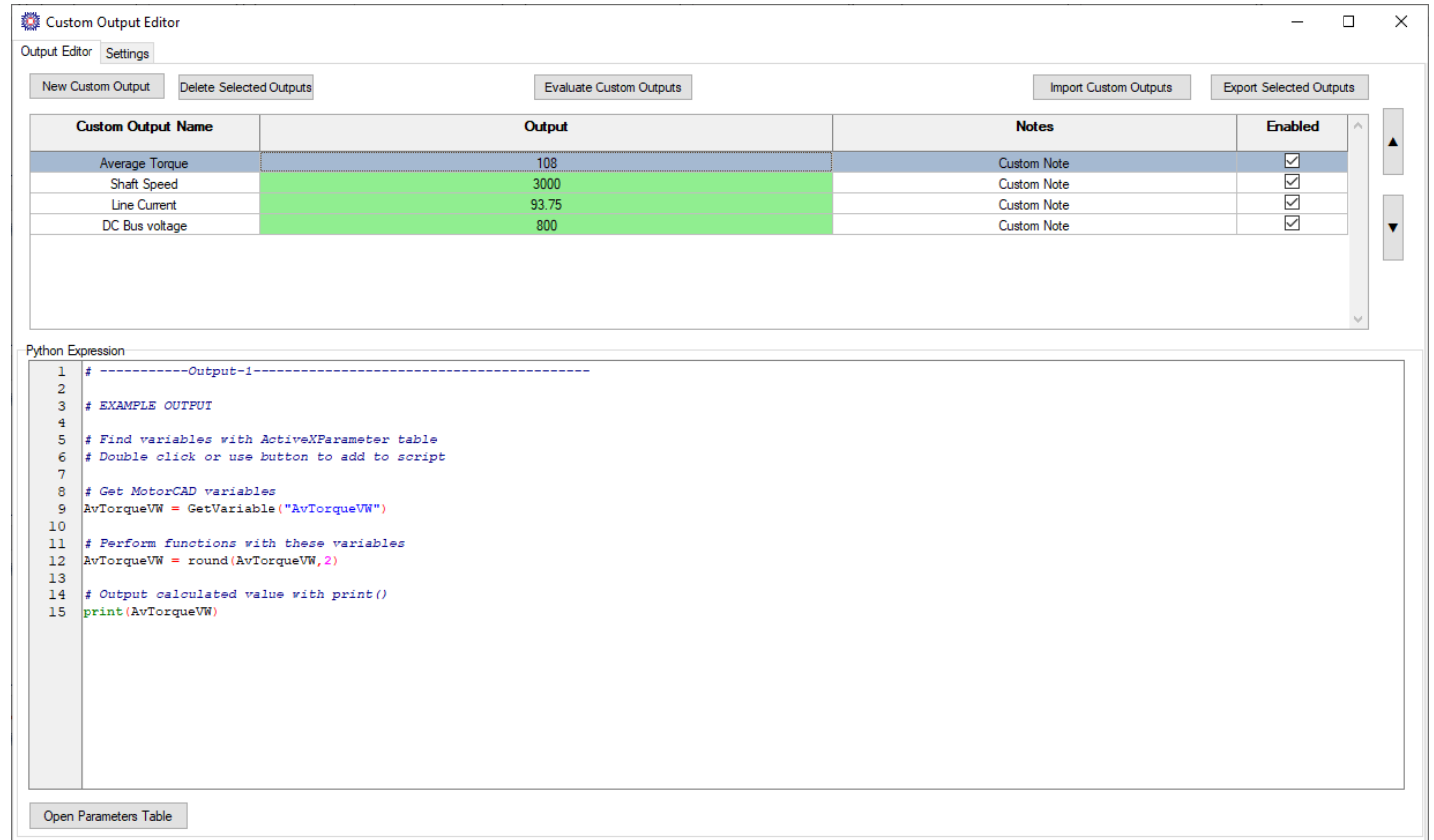
Variation Parameters Set = 3 Total Run Count = 64

Run Parameter Study

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				
Corner Cutout [°]			40				
Corner Cutout 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				

Increased flexibility for Custom outputs

- 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.



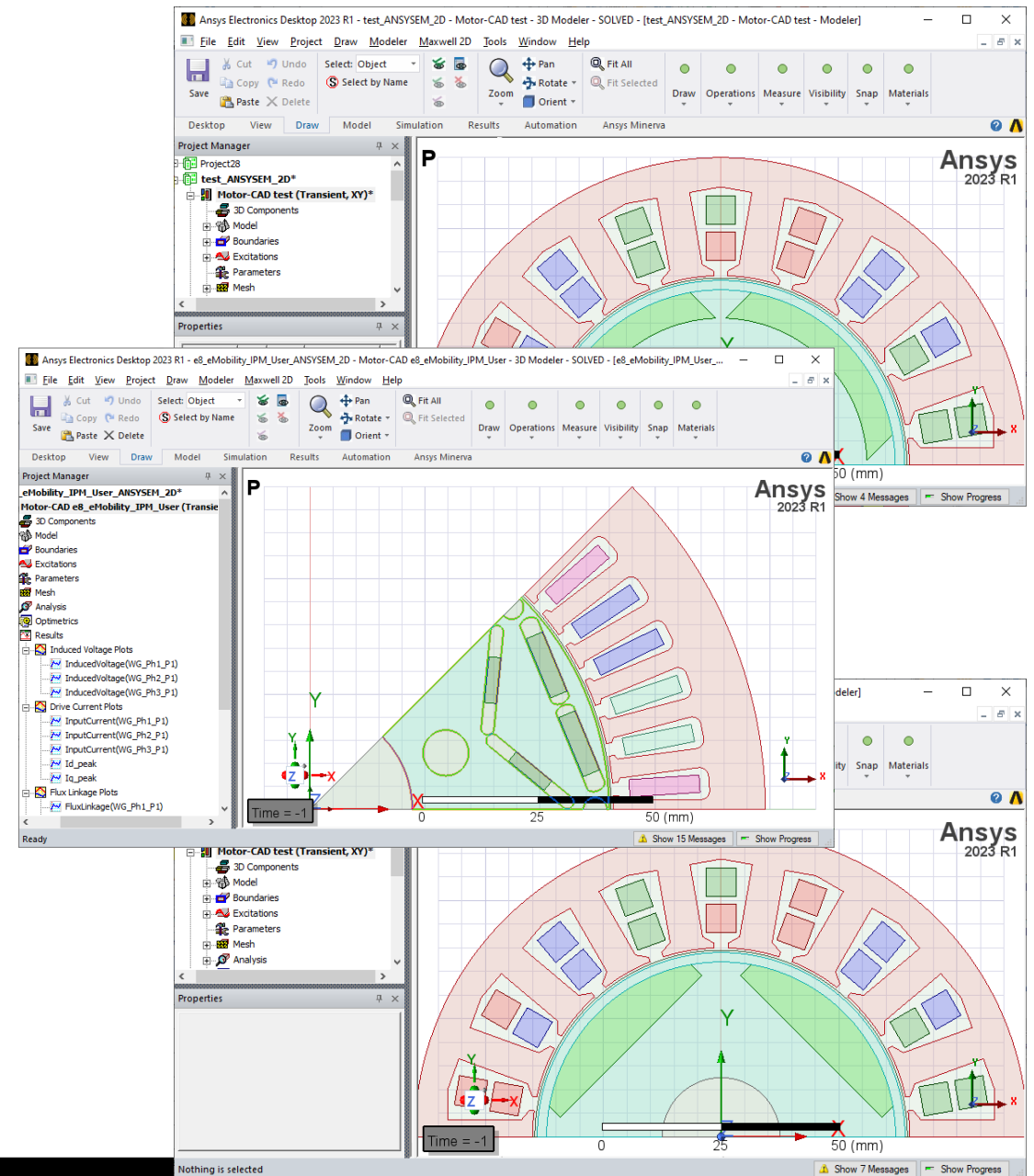
The screenshot displays the 'Custom Output Editor' window. At the top, there are tabs for 'Output Editor' and 'Settings', and buttons for 'New Custom Output', 'Delete Selected Outputs', 'Evaluate Custom Outputs', 'Import Custom Outputs', and 'Export Selected Outputs'. Below this is a table with four columns: 'Custom Output Name', 'Output', 'Notes', and 'Enabled'. The table contains four rows of data, with the second, third, and fourth rows highlighted in green. Below the table is a 'Python Expression' editor with a text area containing a sample Python script. At the bottom left, there is an 'Open Parameters Table' button.

Custom Output Name	Output	Notes	Enabled
Average Torque	108	Custom Note	<input checked="" type="checkbox"/>
Shaft Speed	3000	Custom Note	<input checked="" type="checkbox"/>
Line Current	93.75	Custom Note	<input checked="" type="checkbox"/>
DC Bus voltage	800	Custom Note	<input checked="" type="checkbox"/>

```
1 # -----Output-1-----
2
3 # EXAMPLE OUTPUT
4
5 # Find variables with ActiveXParameter table
6 # Double click or use button to add to script
7
8 # Get MotorCAD variables
9 AvTorqueVM = GetVariable("AvTorqueVM")
10
11 # Perform functions with these variables
12 AvTorqueVM = round(AvTorqueVM,2)
13
14 # Output calculated value with print()
15 print(AvTorqueVM)
```

Maxwell export enhancements

- 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.





Electric machine topology enhancements

Ansys

Induction Machine Improvements

- 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.

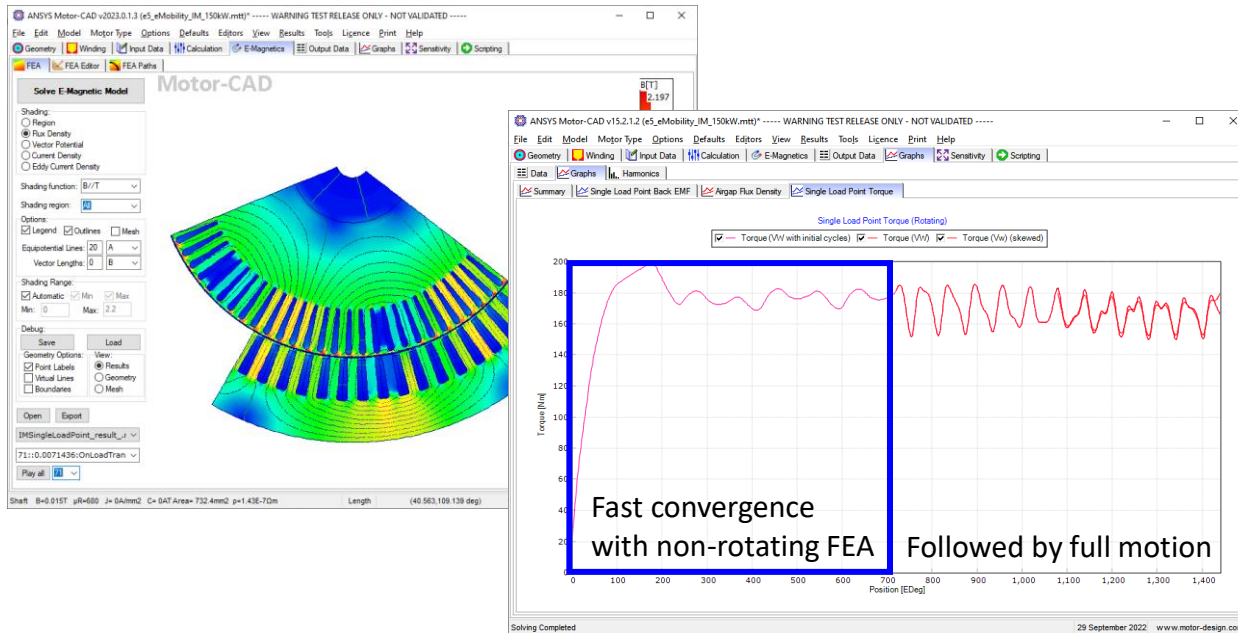
The screenshot displays the ANSYS Motor-CAD v2023.0.1.3 interface. The top menu bar includes File, Edit, Model, Motor Type, Options, Defaults, Editors, View, Results, Tools, Licence, and Print. The main workspace is divided into several panels:

- Magnetism Settings:** Shows 'Cores' with 'Rotor Iron' set to 'Laminated (default)'. 'Manufacturing Factors' includes 'Top Rotor Bar Fill Factor' and 'Bottom Rotor Bar Fill Factor', both set to 1. 'Equivalent Circuit Inductance Multipliers' has 'Definition' set to 'Constant value (default)'. 'Magnetizing Inductance' and 'Stator Leakage Inductance' are both set to 1.
- Results Table:** A table with columns 'Variable', 'Value', and 'Units'. The following rows are highlighted with blue boxes:

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	%
- Model Options:** Shows 'Saturation Model' set to 'Analytical' and 'Loss Model' set to 'Analytical'. 'Machine Parameters' includes Pole Number (6) and Slot Number (72). 'Fixed Model Parameters' includes 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, and Rotor Bar Conductivity 2.09E7. A 'Slip' field is set to 0.01, and a 'Recalculate Model Parameters' button is visible.

Transient IM calculation

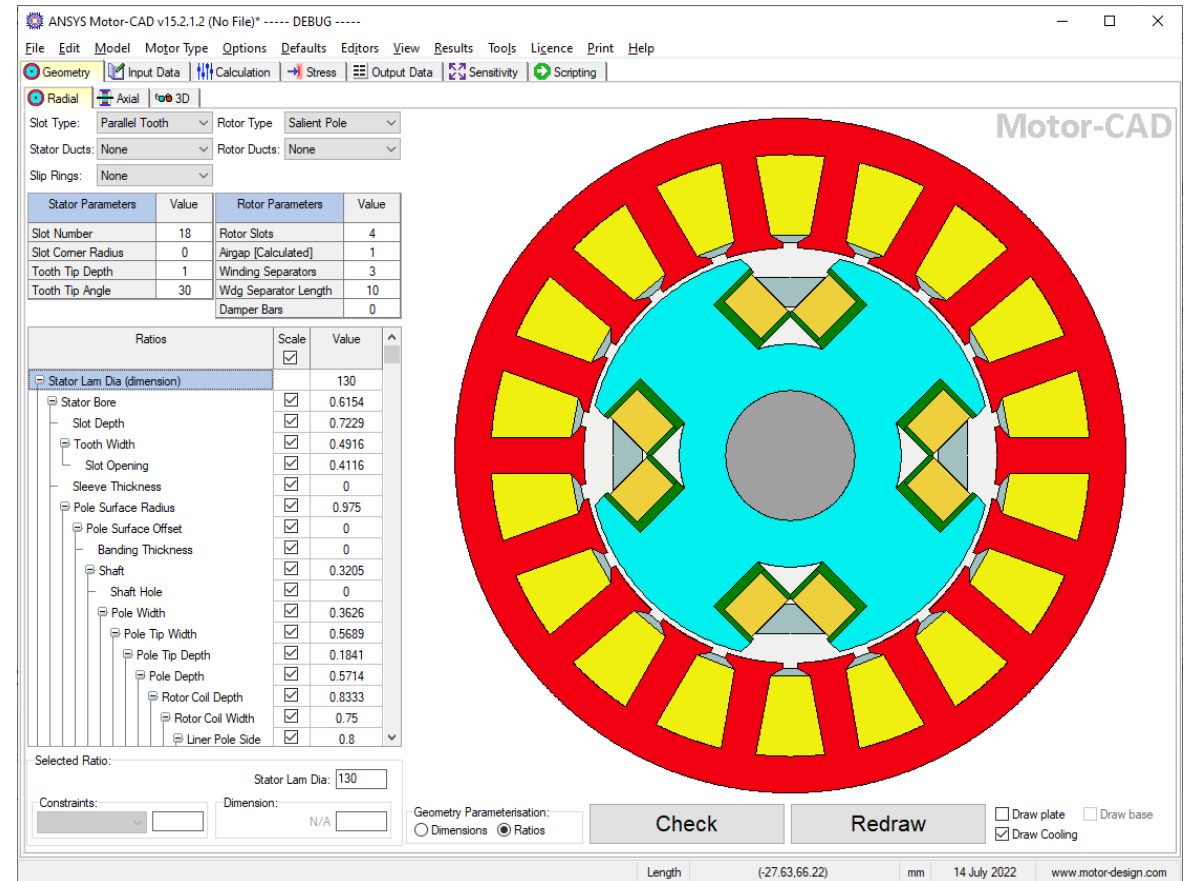
- New Single operating point transient electromagnetic calculation with rotation for induction machines.
- Adjustable initialisation cycles to speed up convergence.
 - Initial cycles run non-rotating analysis, for rapid rotor current convergence (resistivity adjusted to account for slip).
 - Generator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



The figure shows two screenshots of the ANSYS Motor-CAD software interface. The top screenshot displays the 'Calculation Options' dialog box. The 'Full motion: Initialisation cycles' field is highlighted with a blue box and set to 2. Other settings include 'Points per cycle: 30', 'Number of cycles: 2', and 'Number of points: 3'. The bottom screenshot shows the 'E-Magnetic' model settings. The 'Finite Element' section has 'Single Load Point (rotating)' selected, which is also highlighted with a blue box. Other settings include 'Skew Angle: 5', 'Temperatures' (Amature Winding: 40, Bar: 140, End Ring: 140, Stator Lamination: 20, Rotor Lamination: 20, Shaft: 20, Airgap: 20, Bearing: 20), and 'Saturation Model' (FEA, Max Peak Current: 707.1, Max RMS Current: 500). A 'Calculate Saturation Model' button is visible.

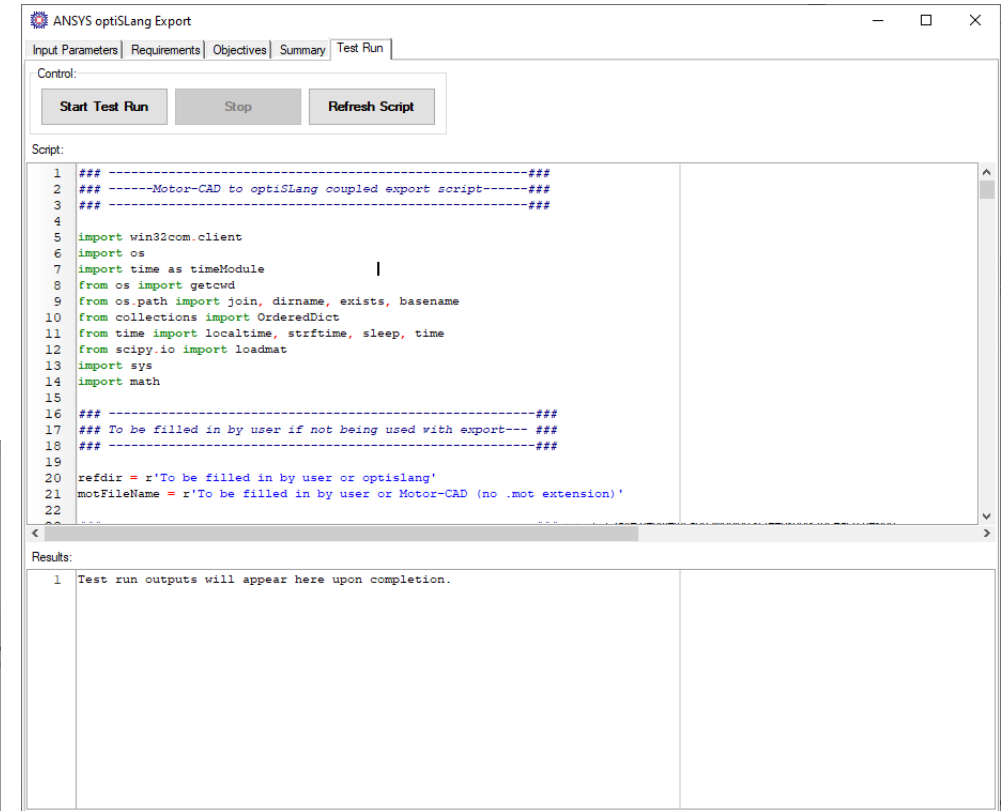
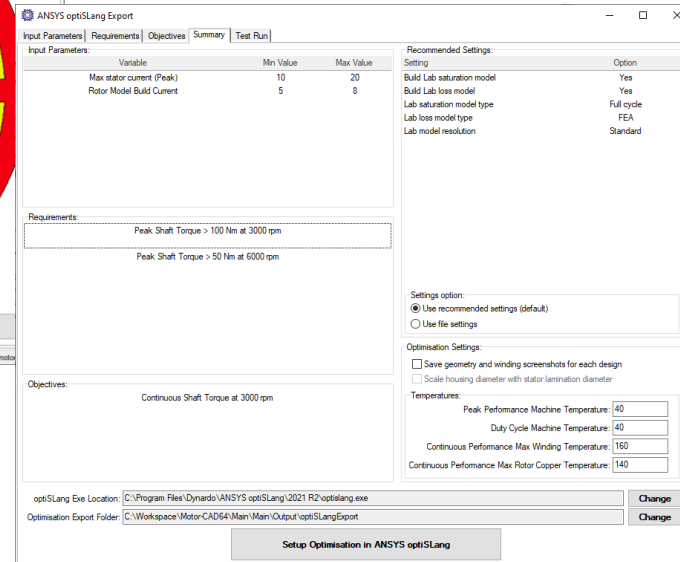
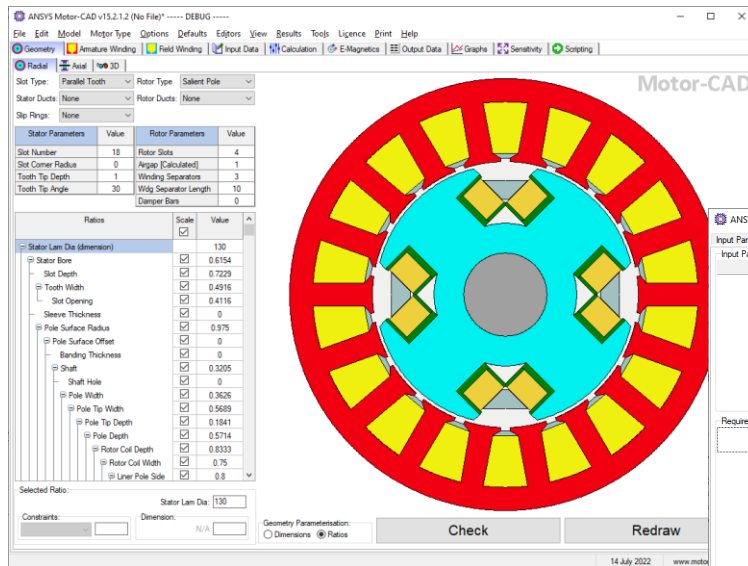
New SYNC Geometry Ratios

- 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.



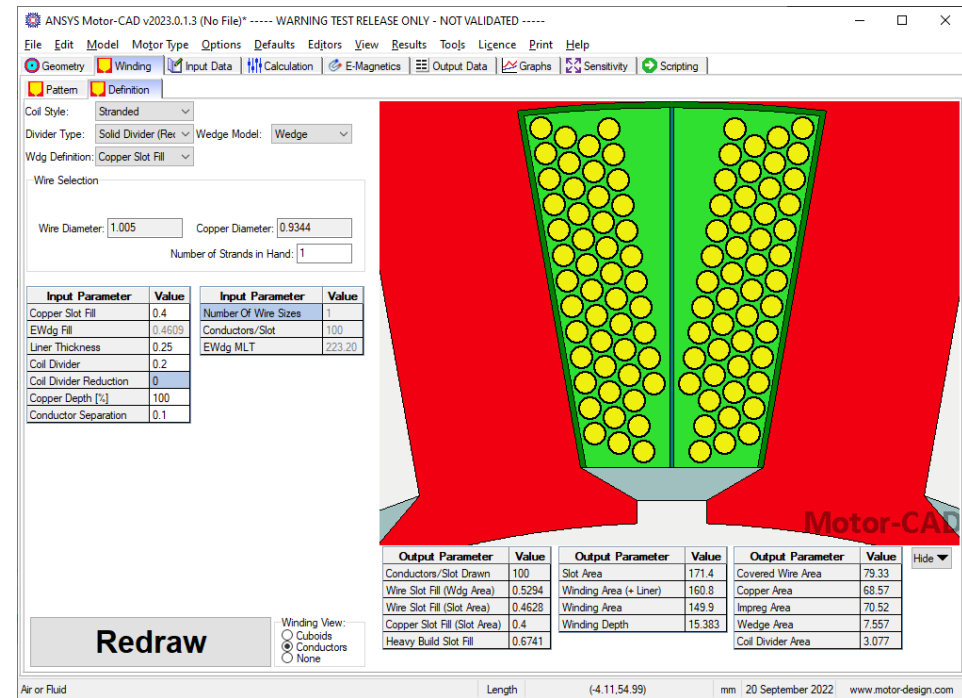
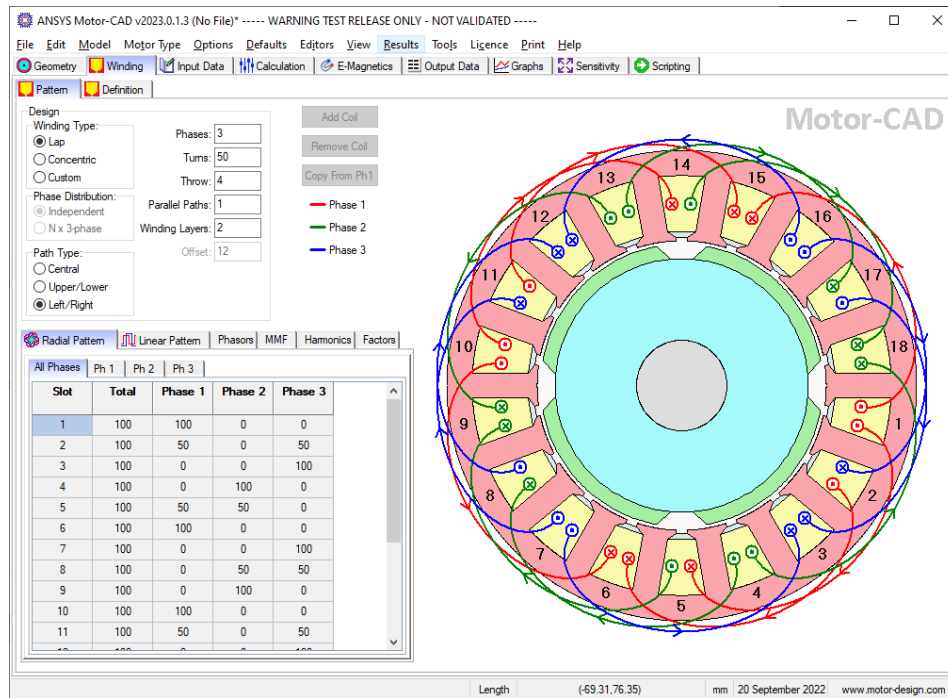
optiSLang integration for SYNC machines

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



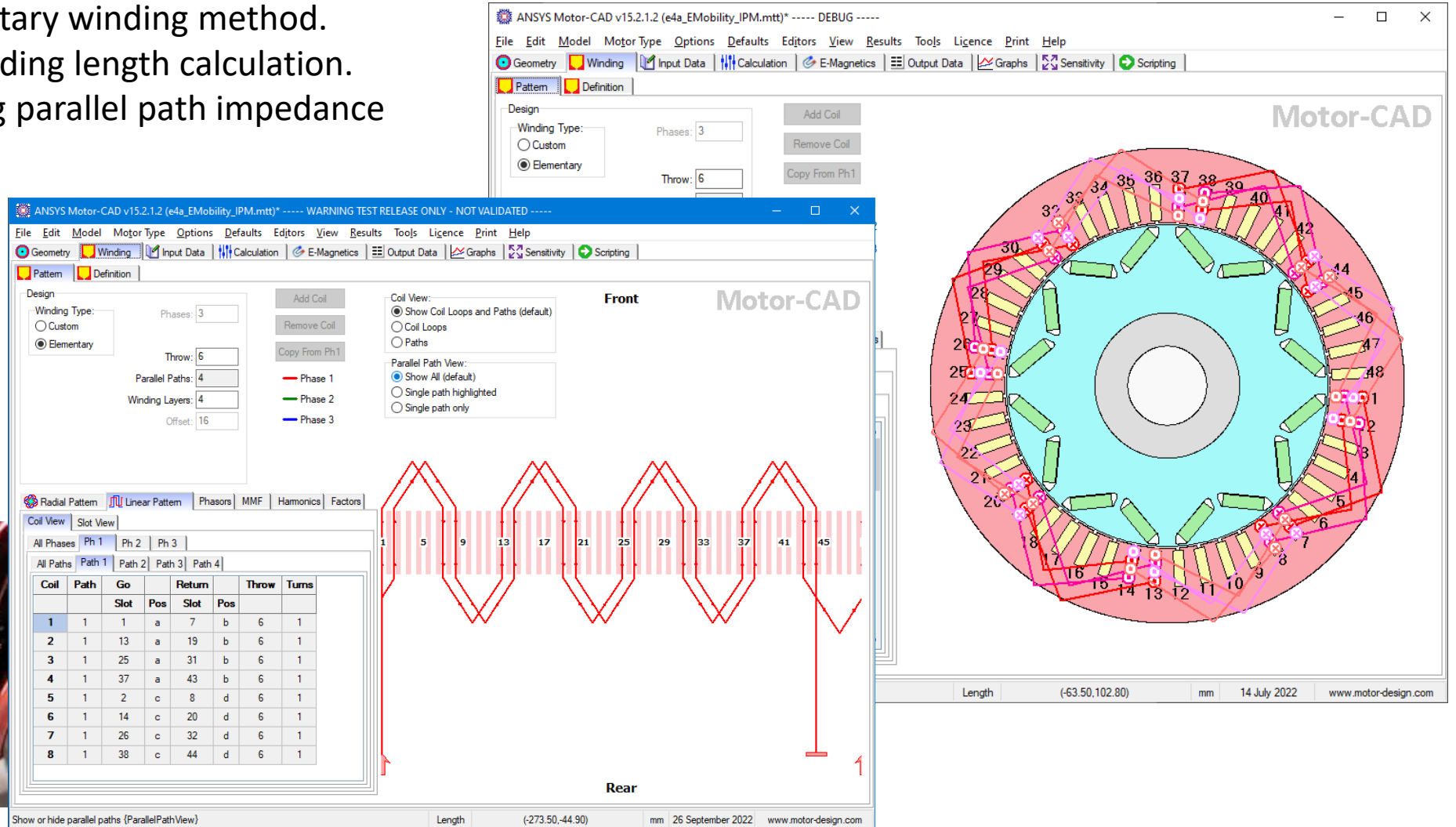
Standardised Winding definition

- 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.



New hairpin winding pattern generation

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

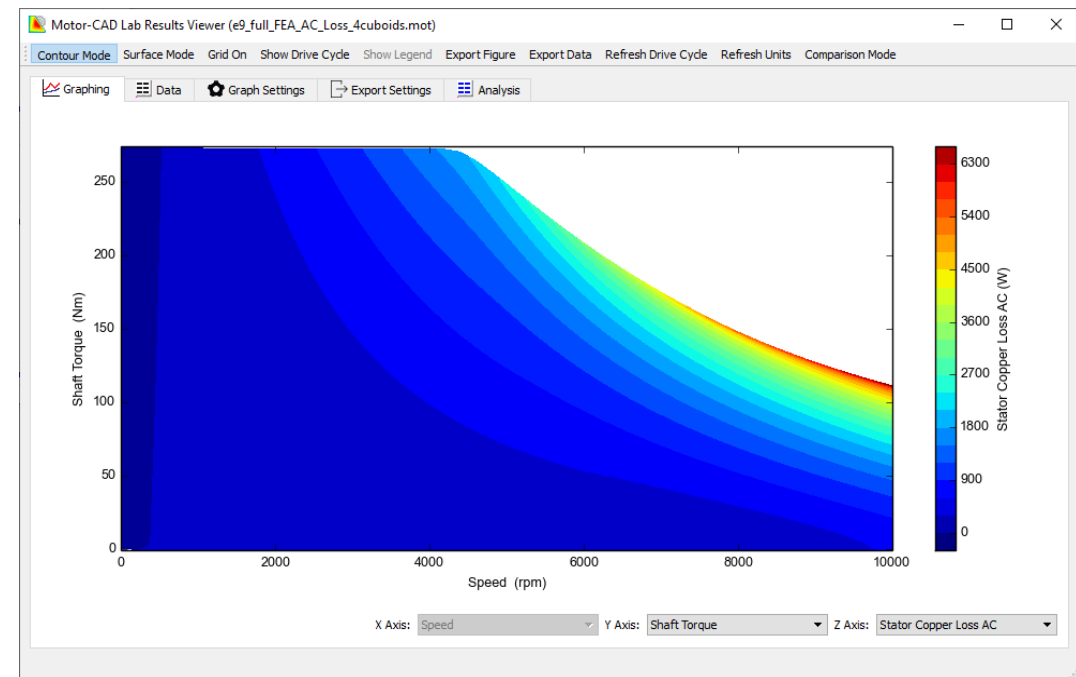
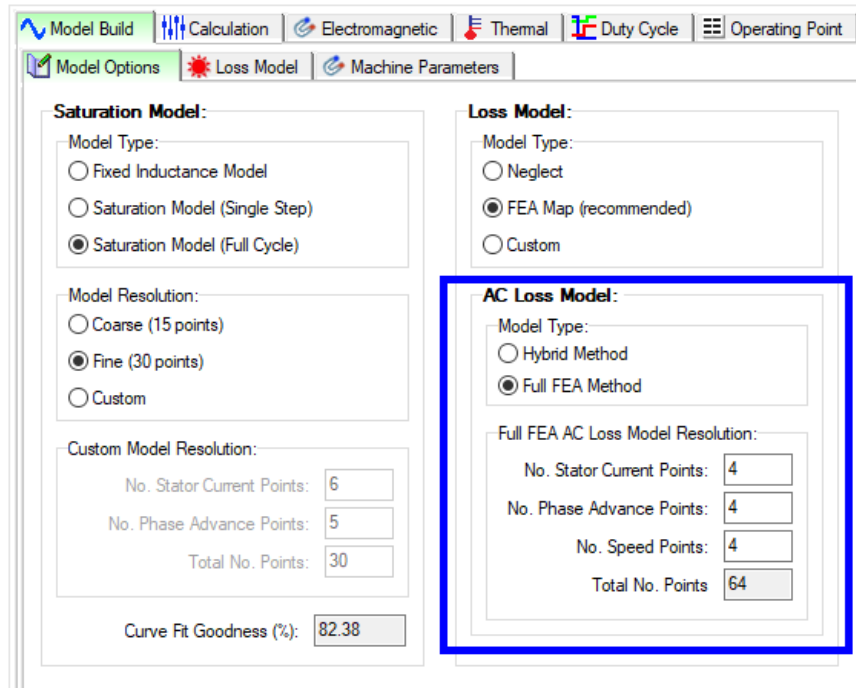
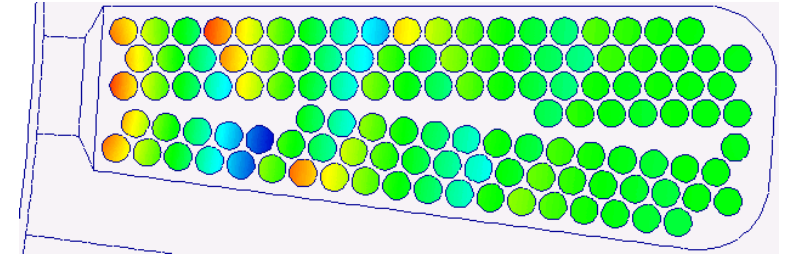


Coil	Path	Go		Return		Throw	Turns
		Slot	Pos	Slot	Pos		
1	1	1	a	7	b	6	1
2	1	13	a	19	b	6	1
3	1	25	a	31	b	6	1
4	1	37	a	43	b	6	1
5	1	2	c	8	d	6	1
6	1	14	c	20	d	6	1
7	1	26	c	32	d	6	1
8	1	38	c	44	d	6	1



High fidelity Lab AC winding loss map

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



Different hairpin conductor sizes

- 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		
Conductor 1 Width	5	Conductor 1 Height	6
Conductor 2 Width	5	Conductor 2 Height	6
Conductor 3 Width	5	Conductor 3 Height	2
Conductor 4 Width	5	Conductor 4 Height	2

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
Min	0
Max	2.2

Thermal Map in Lab for IM and SYNC machines

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

ANSYS Motor-CAD v2023.0.1.3 (i9_SYNC_HV_325kW_Generator.mtt) * WARNING TEST RELEASE ONLY - NOT VALIDATED

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

Model Build Calculation Electromagnetic Thermal Duty Cycle Operating Point Generator Settings

Calculation:

Thermal Map Type:
 Envelope
 Full Map

Thermal Calculation:
 Steady State
 Transient

Thermal Limit
Stator and Magnet
 Stator Winding Only
 Stator + Rotor Winding

Maximum Winding Node:
 Average
 Hotspot

Add Custom Limit Remove Custom Limit

Thermal Node	Temperature	Limit
--------------	-------------	-------

Speed:
Maximum: 6000
Step Size: 500
Minimum: 0

Maximum Temperatures:
Stator Winding: 160
Rotor Winding: 160

Max. Current:
 Limit on Max. Current
Max. Stator (Peak): 150
Max. Stator (RMS): 106.1
Max. Rotor: 12

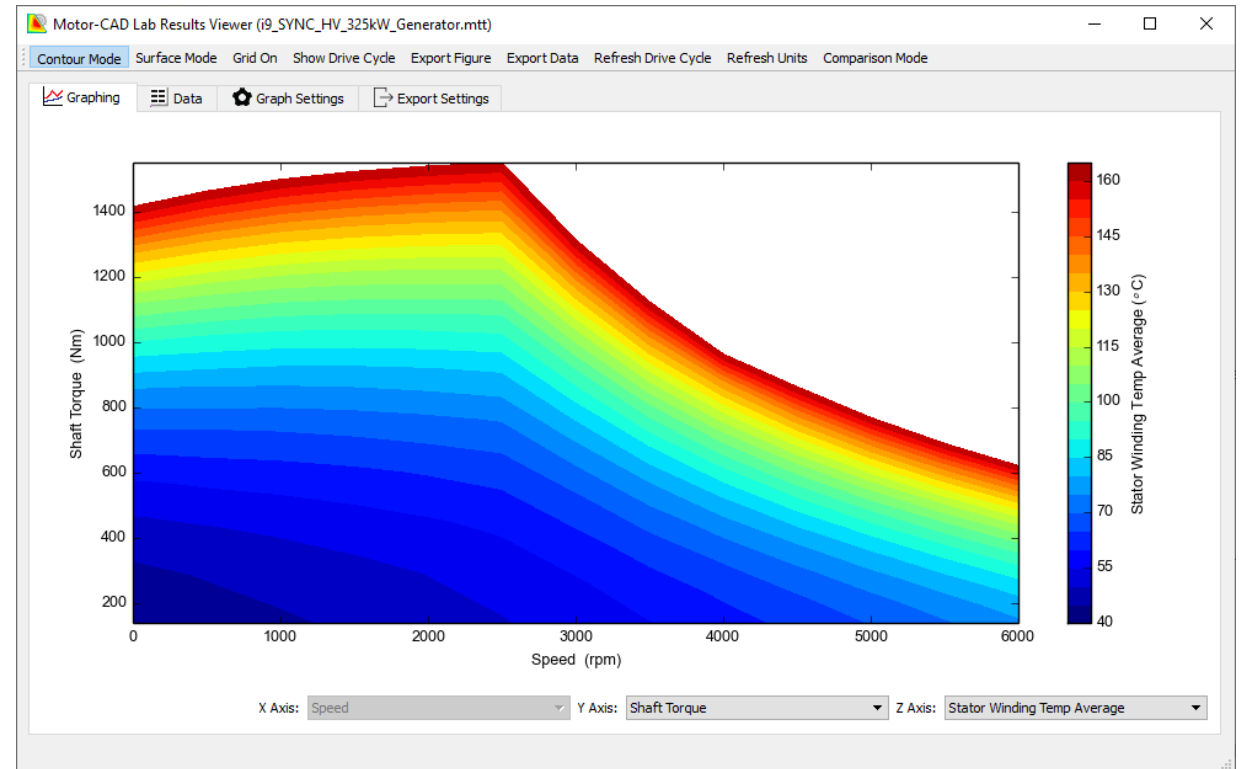
Initial Current Estimate:
Stator Current (Peak): 75.02
Stator Current (RMS): 53.05
Rotor Current: 12

Calculation Status:
16-09-22 16:06:08: Thermal calculation completed with maximum average stator winding =160.0degC maximum rotor =160.0degC maximum speed 6000.0rpm

Calculate Thermal Performance
Cancel Calculation
Load Results Viewer

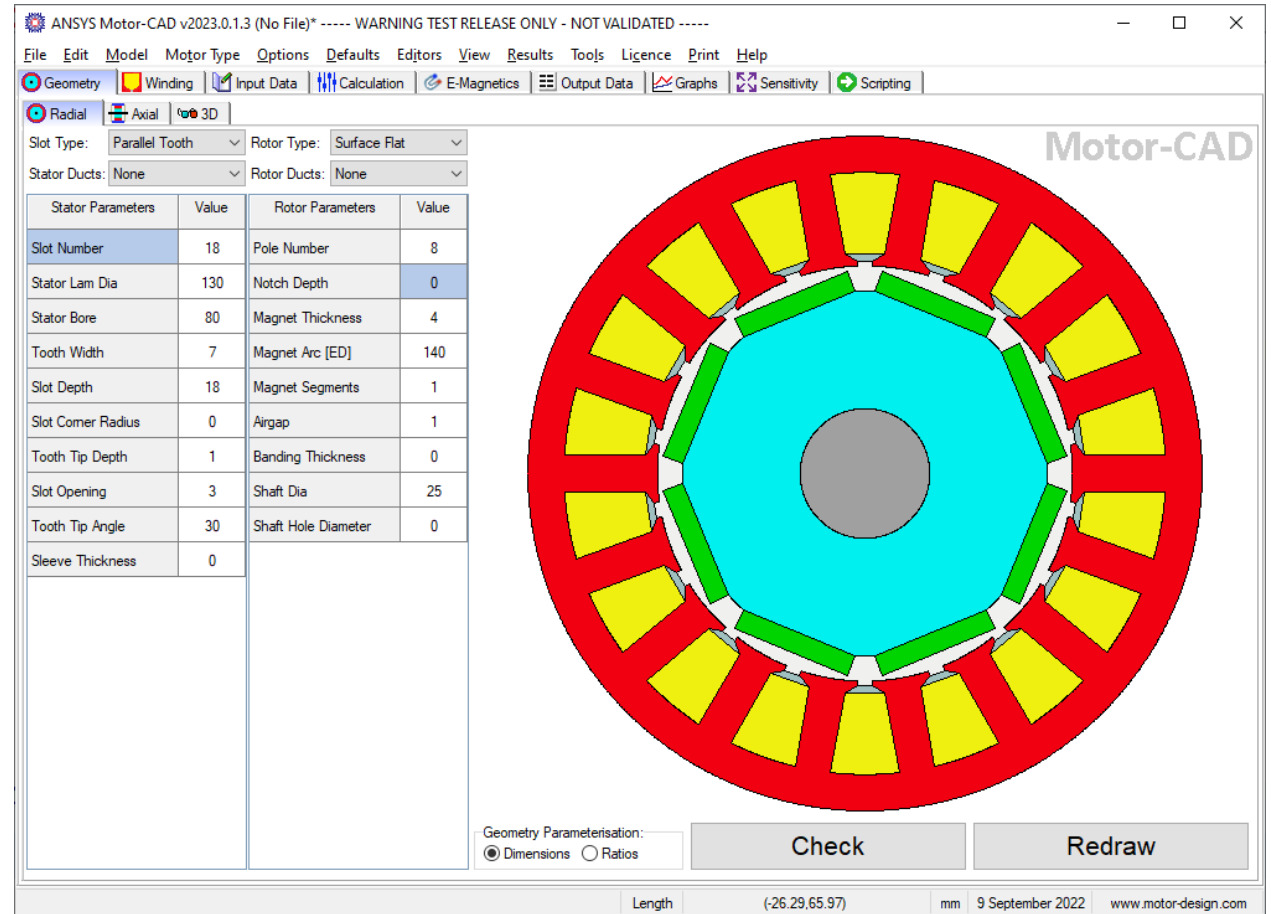
Calculation Complete

16 September 2022 www.motor-design.com



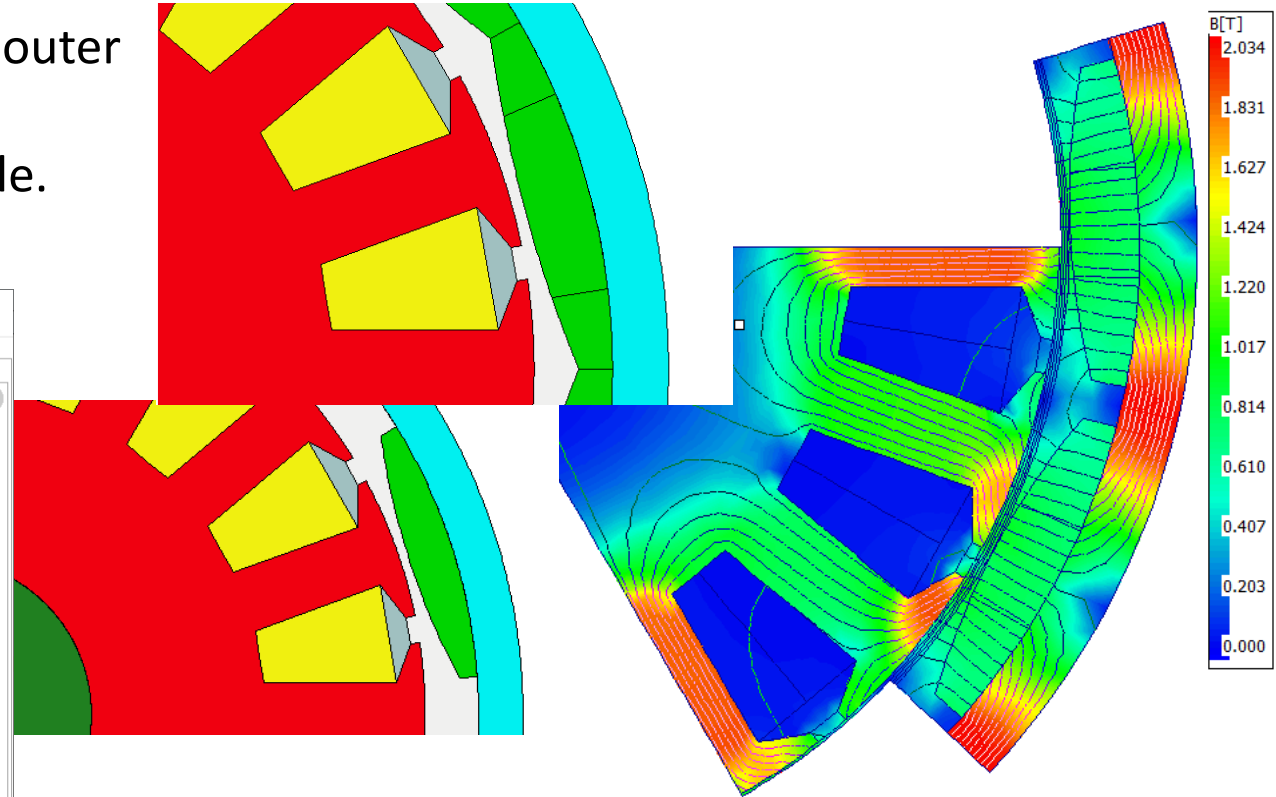
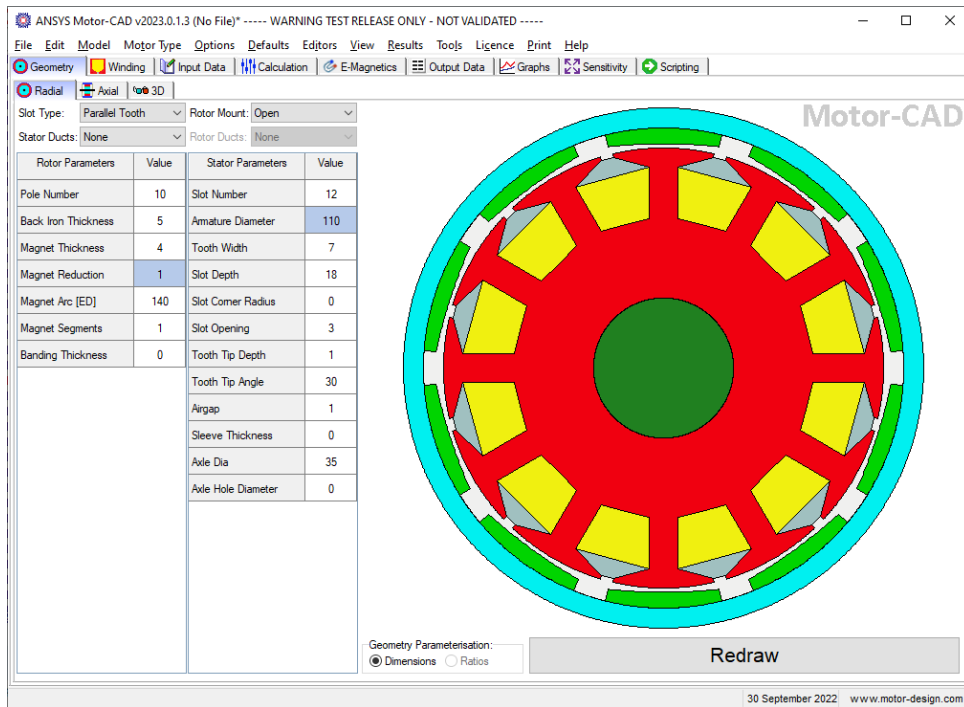
Flat surface magnet geometry

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



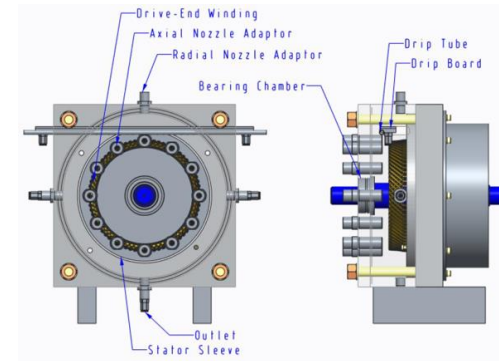
Outer rotor magnet reduction geometry

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



Spray cooling method improvements

- 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	Notes
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	610.6	3113	76.78	0.7	2233	0.6617	
EW Rear [Front] (Layer g)	<input type="checkbox"/>	Radial Jets from Housing	1	1	1	610.6	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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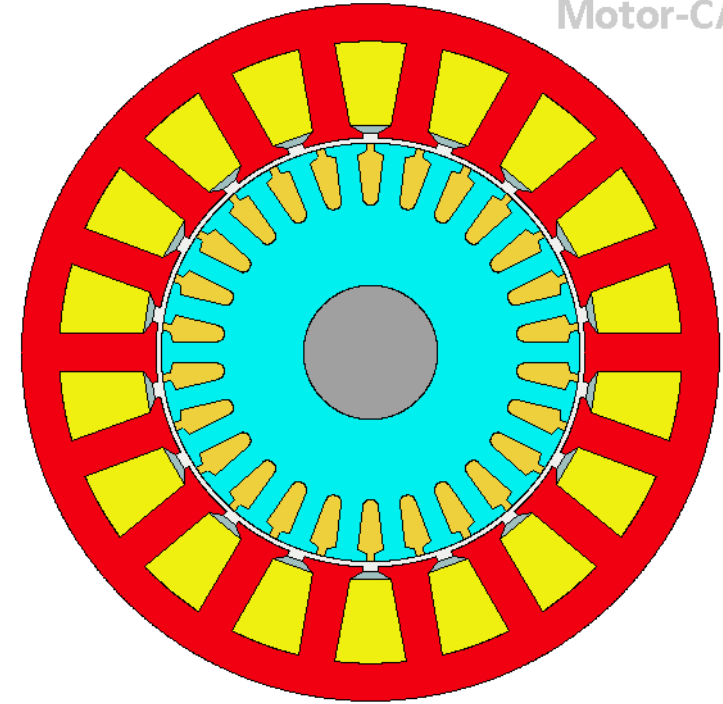
Mechanical and NVH

Ansys

NVH improvements

Motor-CAD

- 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:

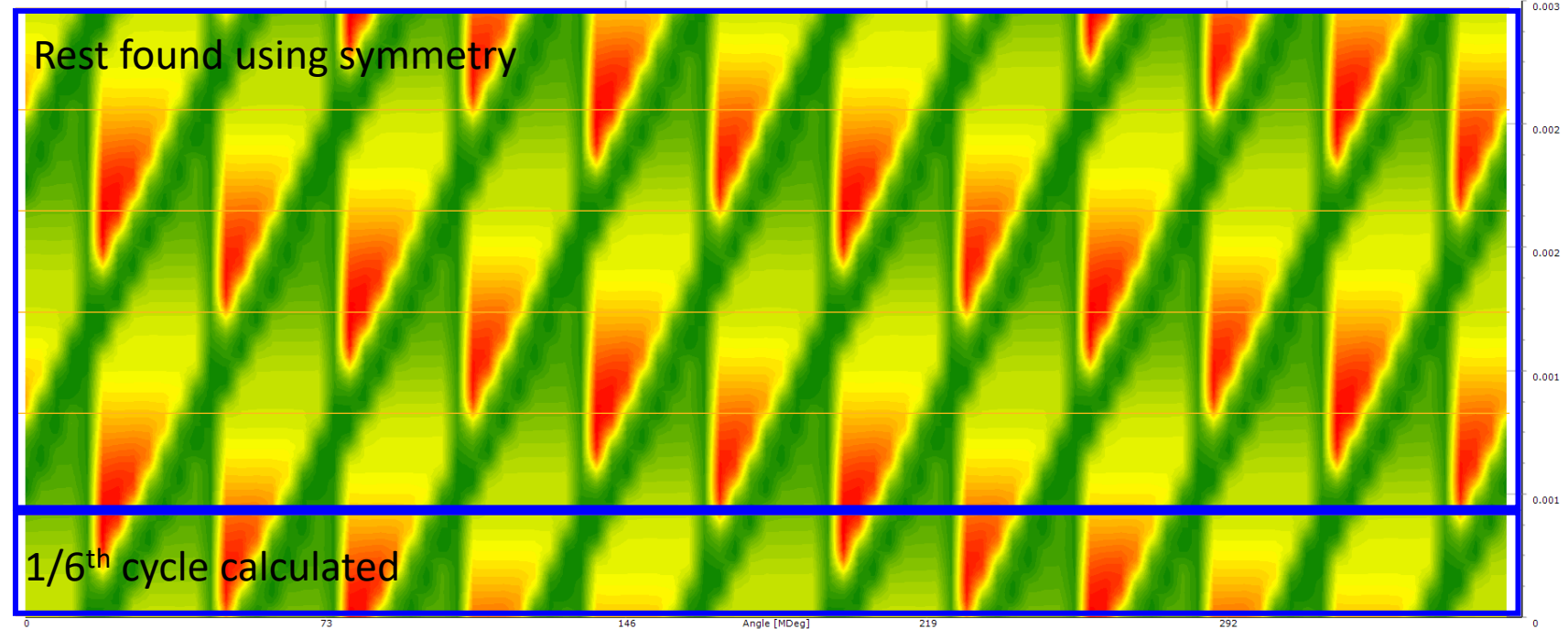
Calculated Torque	Speed	Peak Line Current	Slip
Nm	rpm	Amps	
1.56259	1000	5	0.03
1.62007	2000	10	0.01

Load Point:
Add Point
Clear Points
Delete Point

Calculation:
Generate Forces Data
Cancel

Reduced cycle NVH

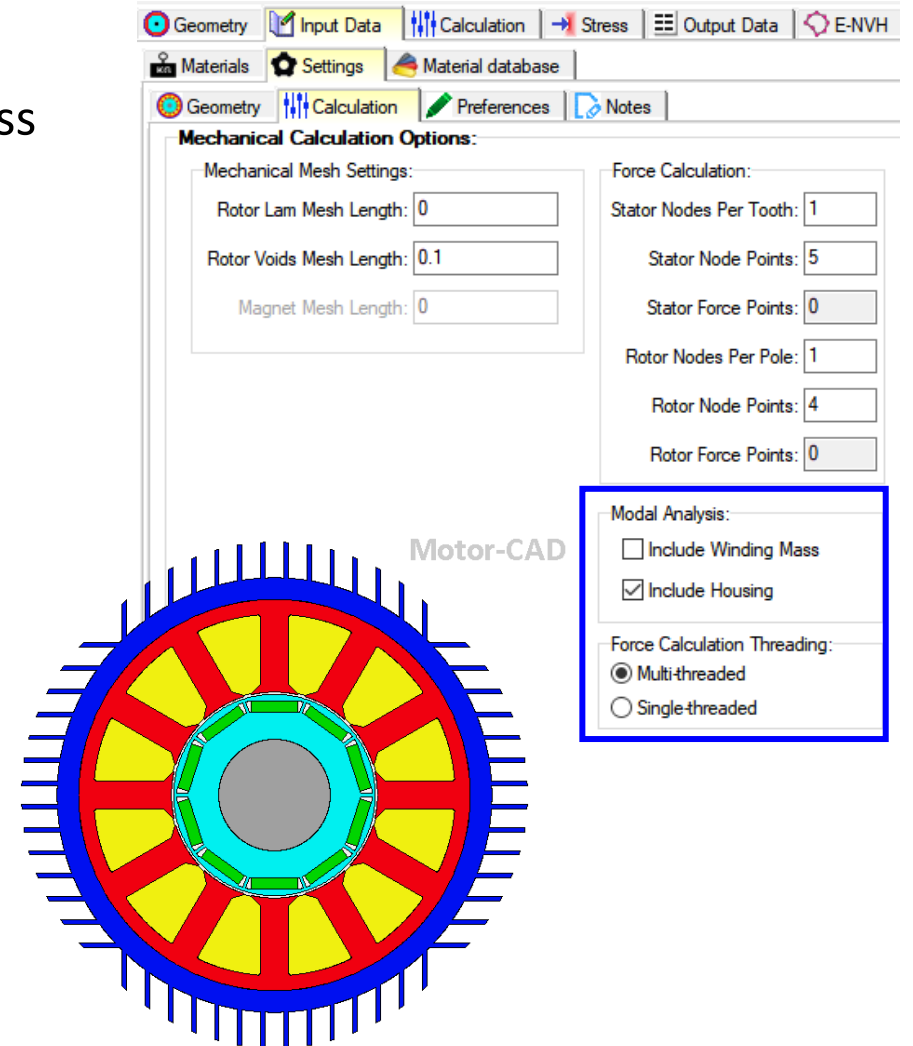
- Use 1/6 electrical cycle symmetry
 - Forces calculated for 1/6th of the cycle, rest populated using rotor and stator symmetry
- Use EMag multistatic FEA solver
- Speed up of NVH calculations
- Transient solver remains the default, reduced multistatic can be selected if preferred



Calculated forces for one electrical cycle around the stator

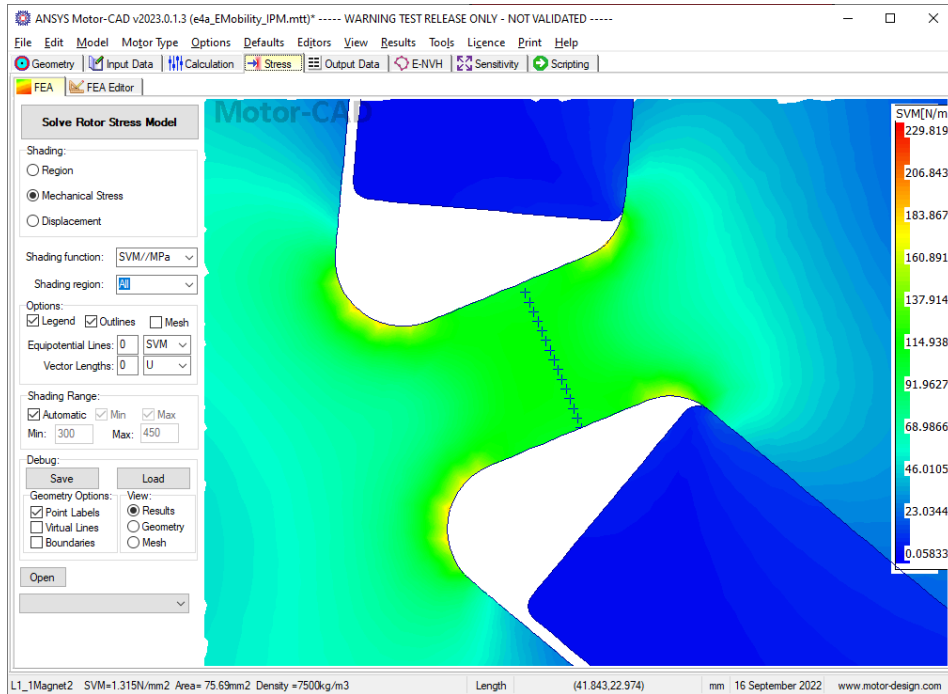
NVH improvements

- 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.



Average post and bridge stresses – V web and 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			

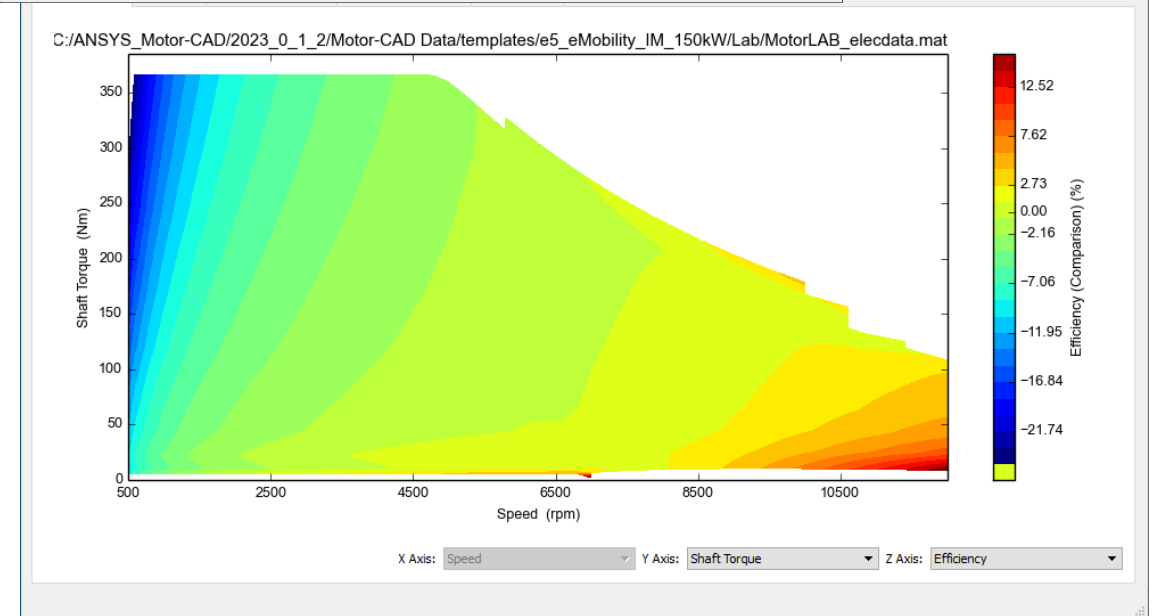
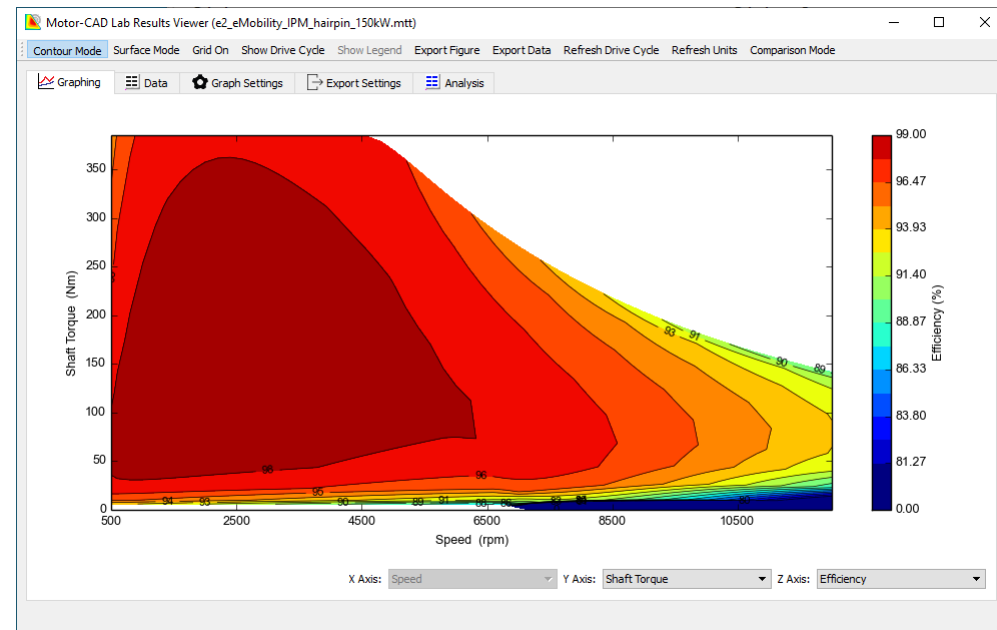
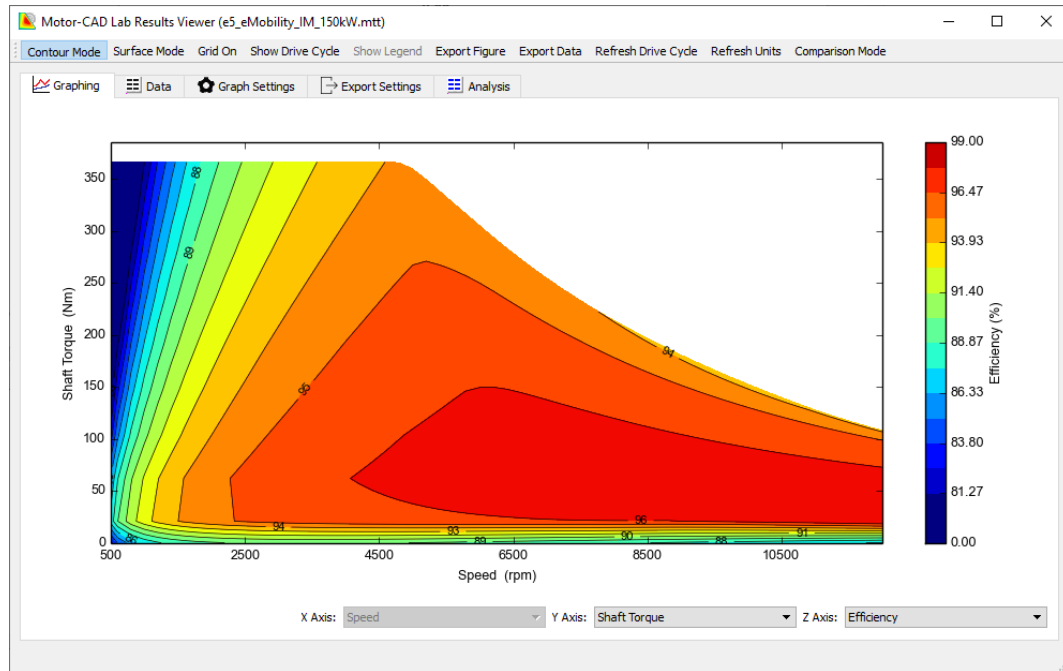
Average Magnet Post Stress (L1)	110.9	MPa			
Average Magnet Bridge Stress (L1)	156	MPa			

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General enhancements

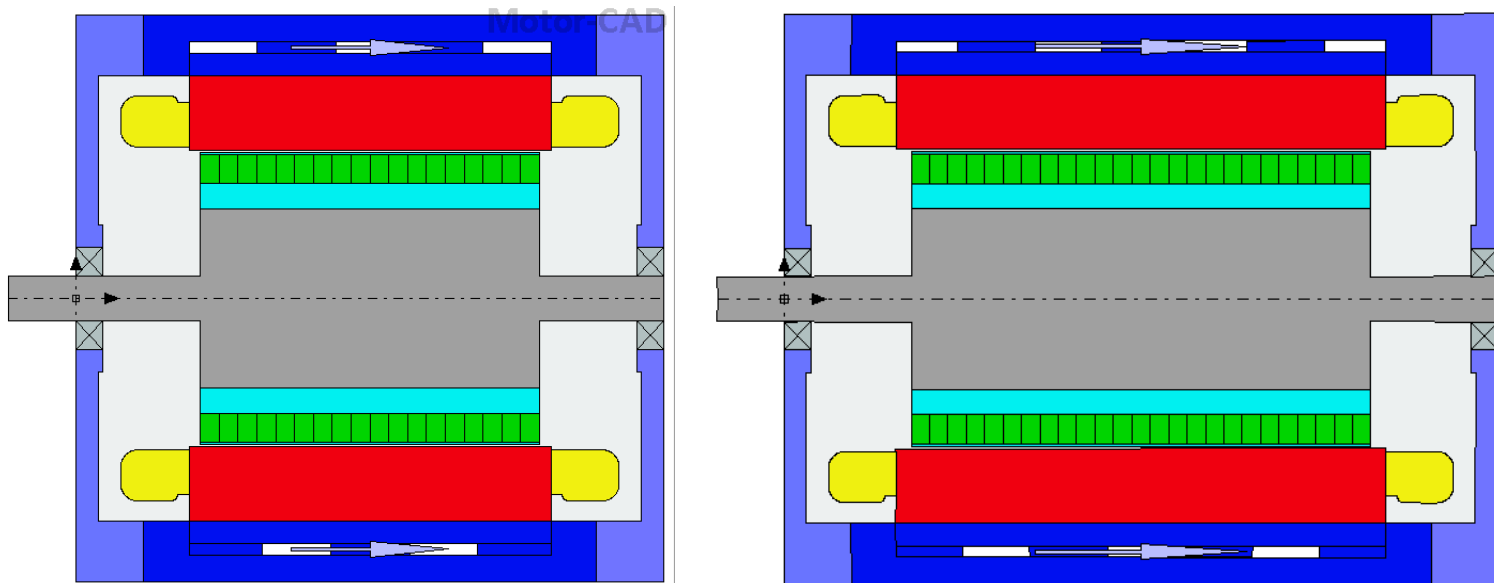
Efficiency Map comparison

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



Lab axial scaling

- 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:

Tums / Coil:

Model build reference: 6

Resistance reference: 6

Calculation: 6

Active Length:

Model build reference: 160

Resistance reference: 160

Calculation: 220

Granta material data for Toda Kogyo bonded magnets

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	0.10753
-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

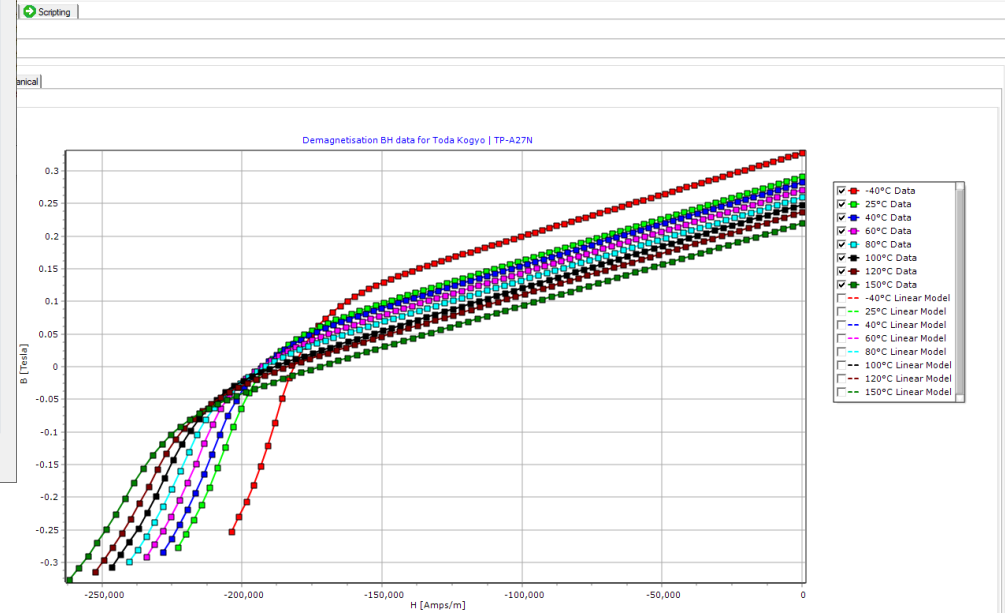
Specify reference temperature: $B_r(Tref)$ 0.2922

Reference Temperature Tref: 25 α 0.1947

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

Maximum Valid Temperature: 150 β 0

Squareness Factor: 6E-5 μ 2.031



Granta material data for Sumitomo SMC steels

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

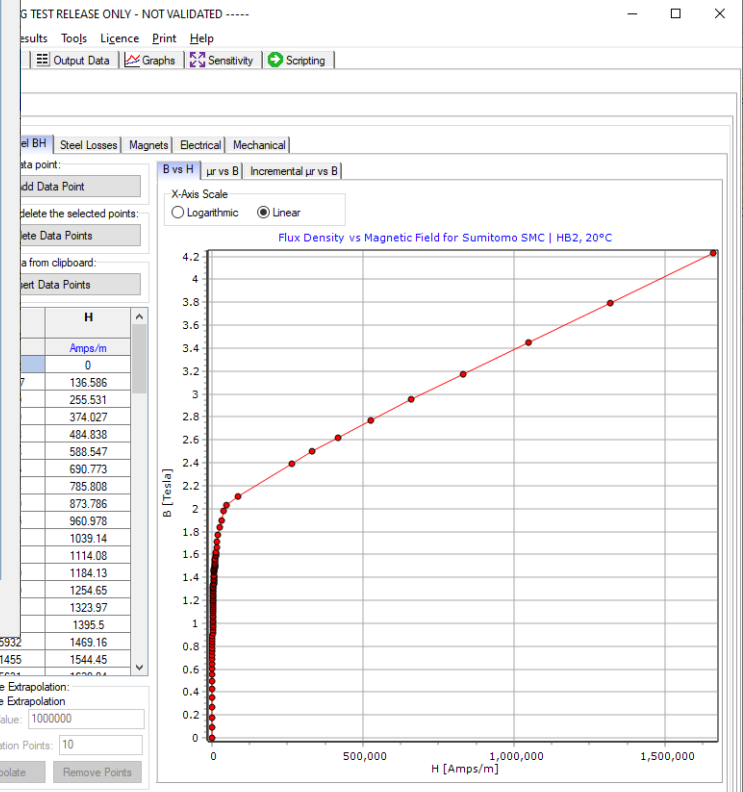
Import Selected

Cancel

- NO30
- NO30_Walter
- POLYCOR 0.3% Si
- POSCO 27PN1350_HVH220_WRSM_V1
- POSCO 30PNX1450F
- Stahl 37**
- Stahl37
- Stahl37_QA46_Sync_Hairpin
- Sumitomo.SMC.I.HR1_20°C

0.885932 1469.16
0.891455 1544.45

BH Curve Extrapolation:
 Enable Extrapolation
 Max H Value: 1000000
 Extrapolation Points: 10
 Extrapolate Remove Points



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