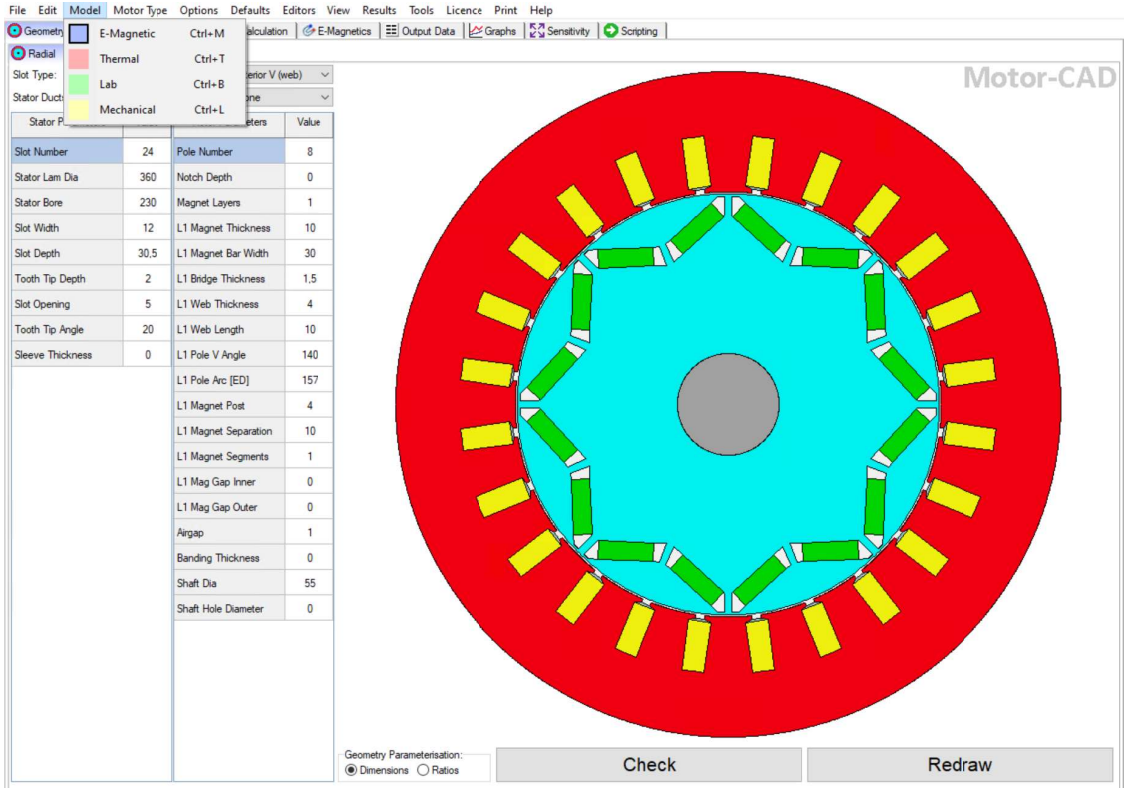
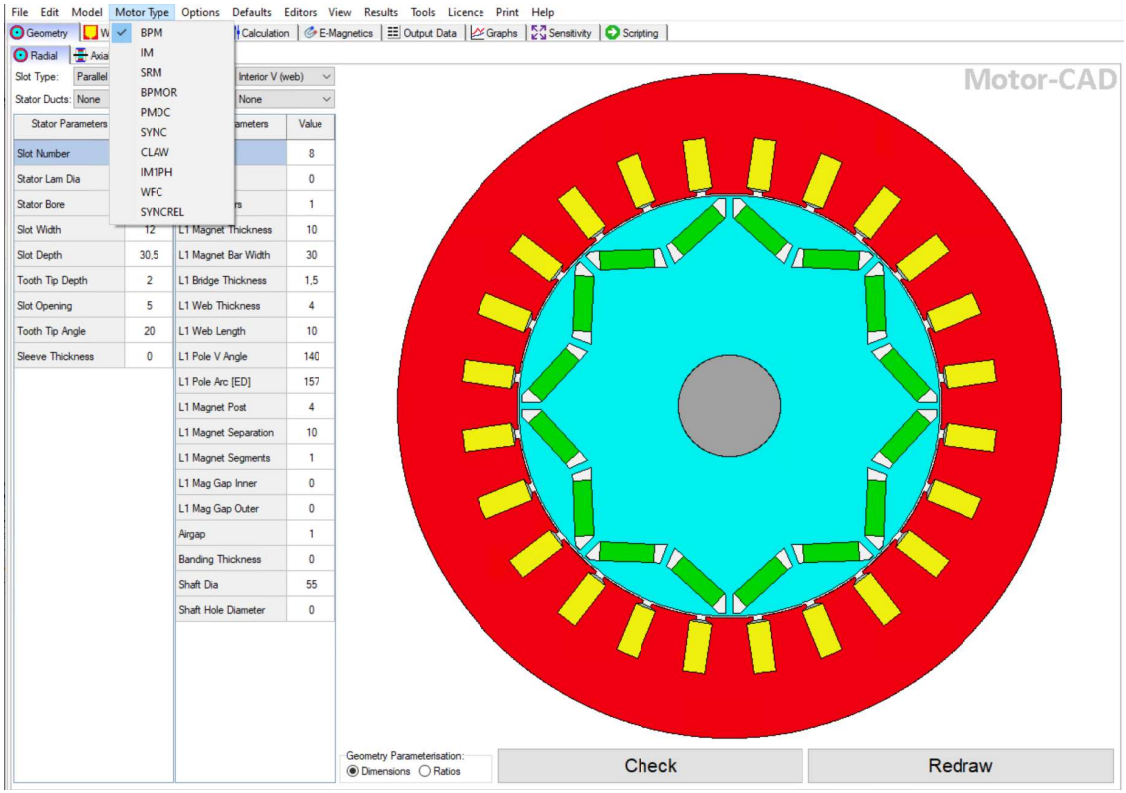
# THERMAL ANALYSIS – MOTOR-CAD EXAMPLE

- Overview of Motor-CAD
- Electromagnetic Analysis
- Thermal Analysis
- Thermo-Electromagnetic Analysis (steady-state)
- Transient Thermal Analysis
- Duty Cycle Analysis

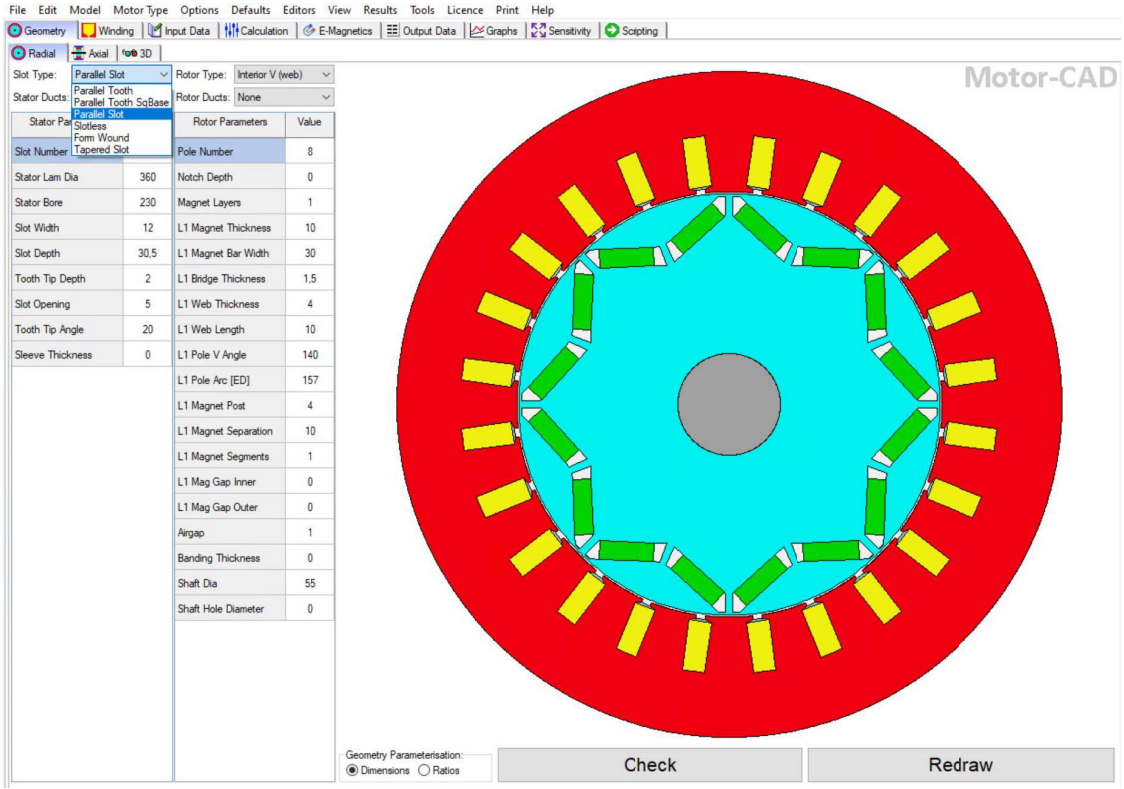
# MOTOR-CAD OVERVIEW



# MOTOR-CAD OVERVIEW



# MOTOR-CAD E-MAGNETIC RADIAL DEFINITIONS



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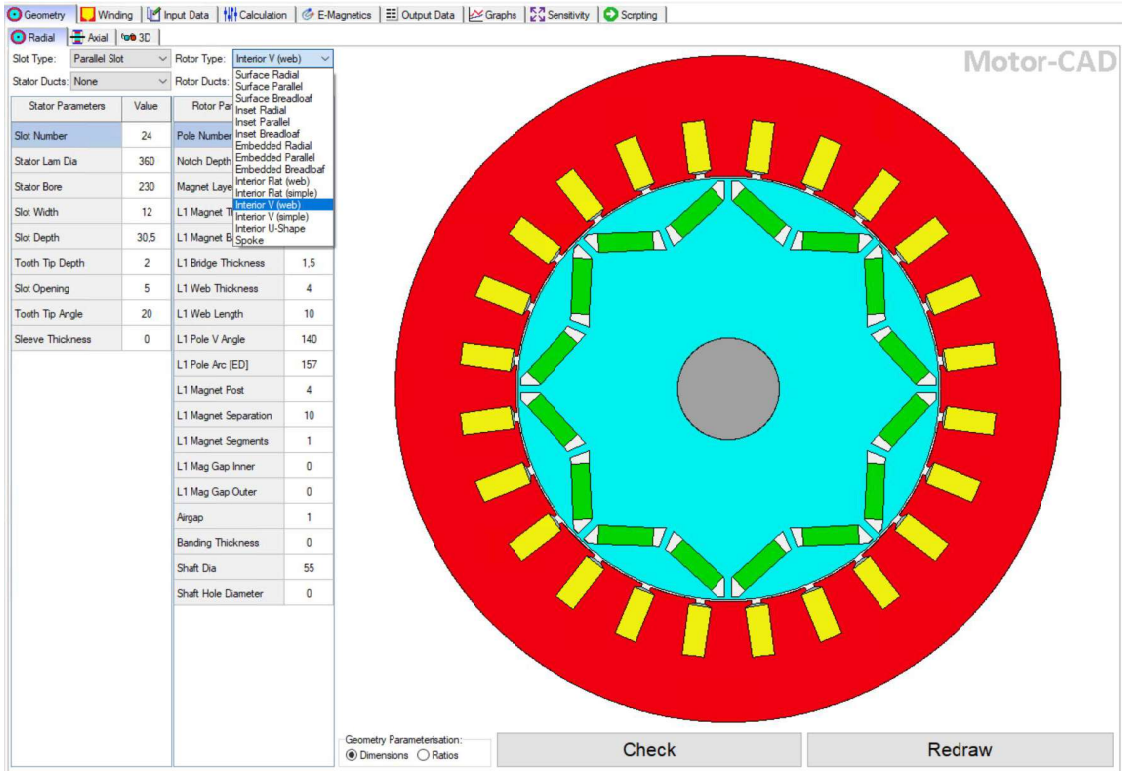
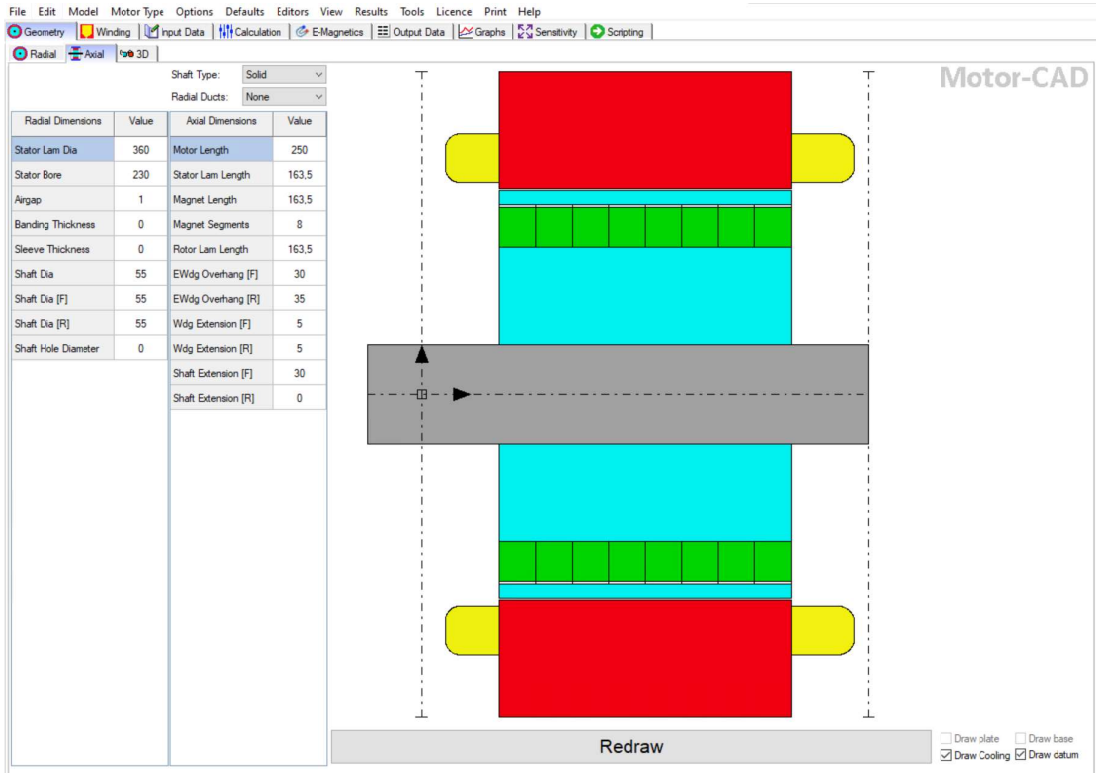
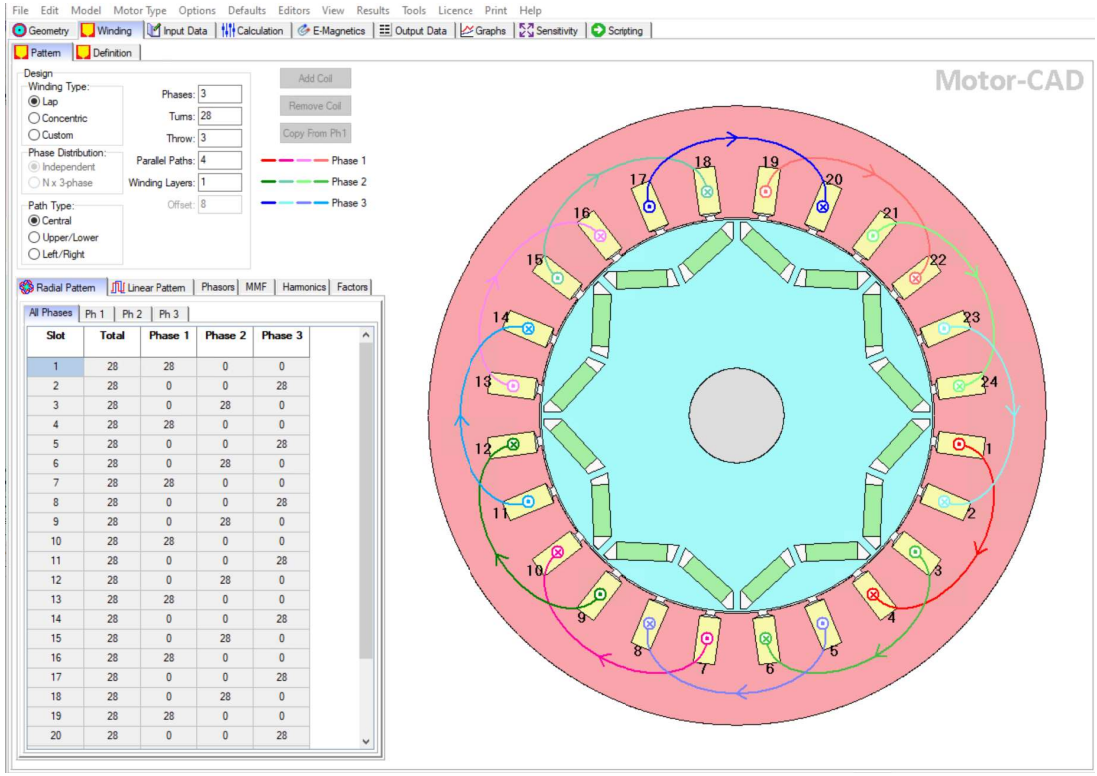


# MOTOR-CAD E-MAGNETIC AXIAL DEFINITIONS

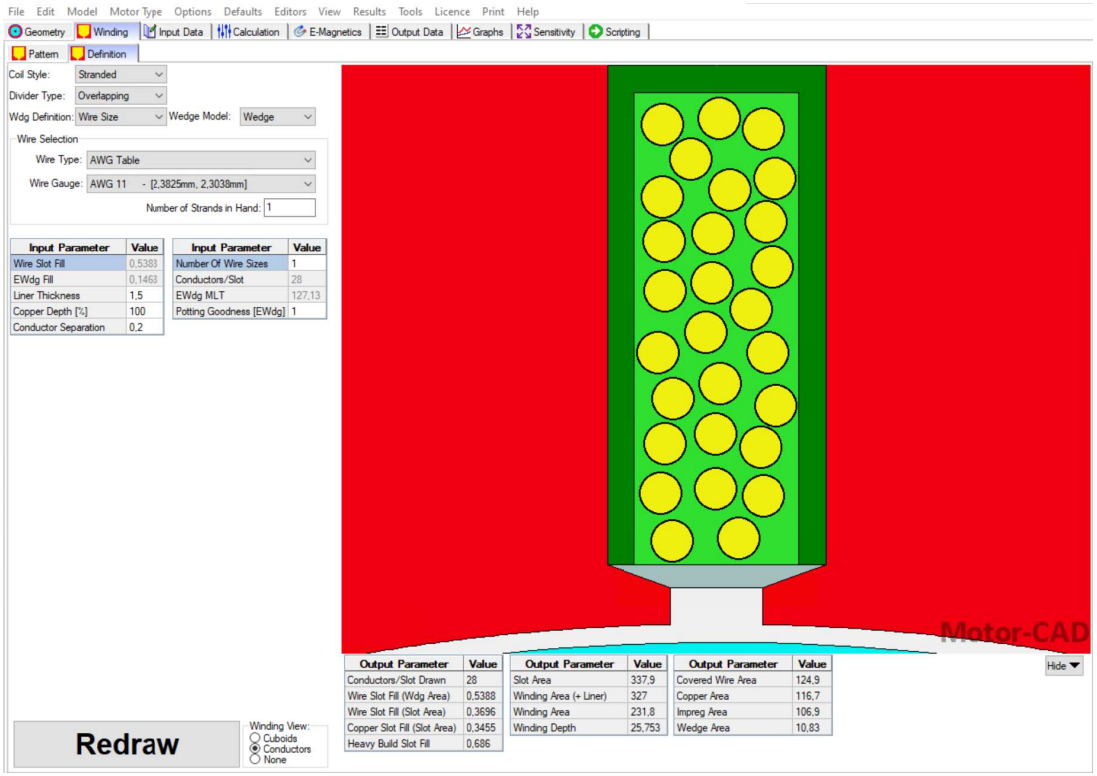


# MOTOR-CAD E-MAGNETIC WINDING

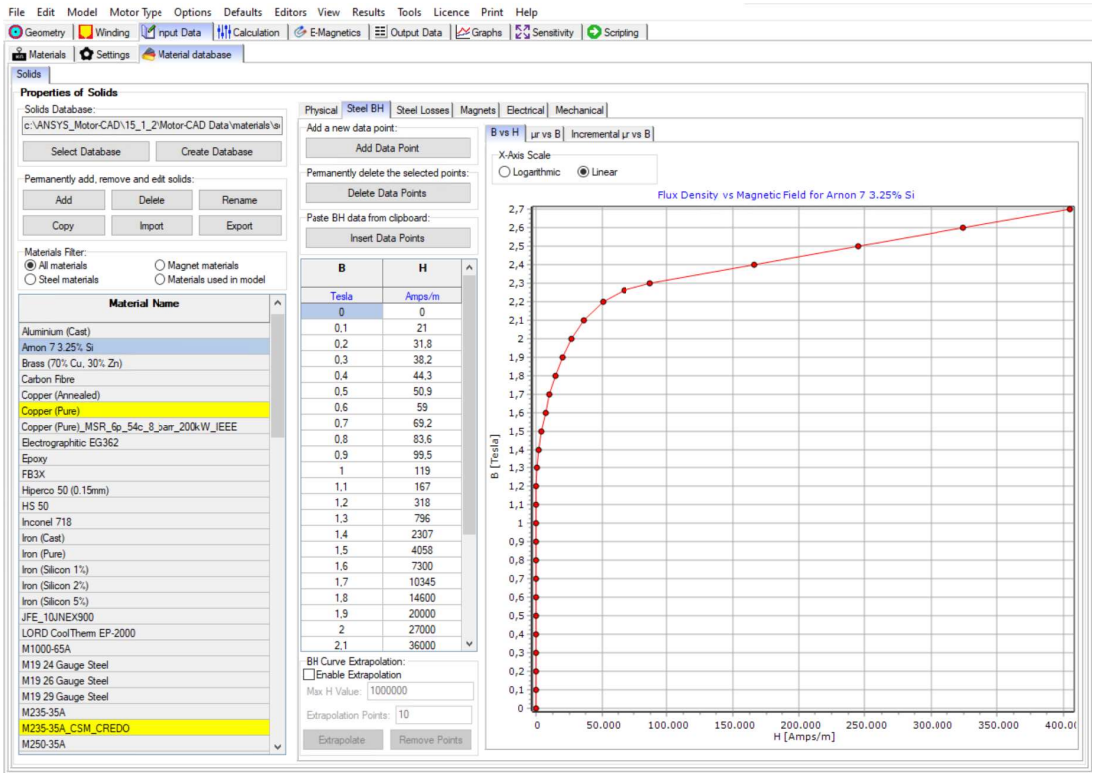



| Slot | Total | Phase 1 | Phase 2 | Phase 3 |
|---|---|---|---|---|
| 1 | 28 | 28 | 0 | 0 |
| 2 | 28 | 0 | 0 | 28 |
| 3 | 28 | 0 | 28 | 0 |
| 4 | 28 | 28 | 0 | 0 |
| 5 | 28 | 0 | 0 | 28 |
| 6 | 28 | 0 | 28 | 0 |
| 7 | 28 | 28 | 0 | 0 |
| 8 | 28 | 0 | 0 | 28 |
| 9 | 28 | 0 | 28 | 0 |
| 10 | 28 | 28 | 0 | 0 |
| 11 | 28 | 0 | 0 | 28 |
| 12 | 28 | 0 | 28 | 0 |
| 13 | 28 | 28 | 0 | 0 |
| 14 | 28 | 0 | 0 | 28 |
| 15 | 28 | 0 | 28 | 0 |
| 16 | 28 | 28 | 0 | 0 |
| 17 | 28 | 0 | 0 | 28 |
| 18 | 28 | 0 | 28 | 0 |
| 19 | 28 | 28 | 0 | 0 |
| 20 | 28 | 0 | 0 | 28 |

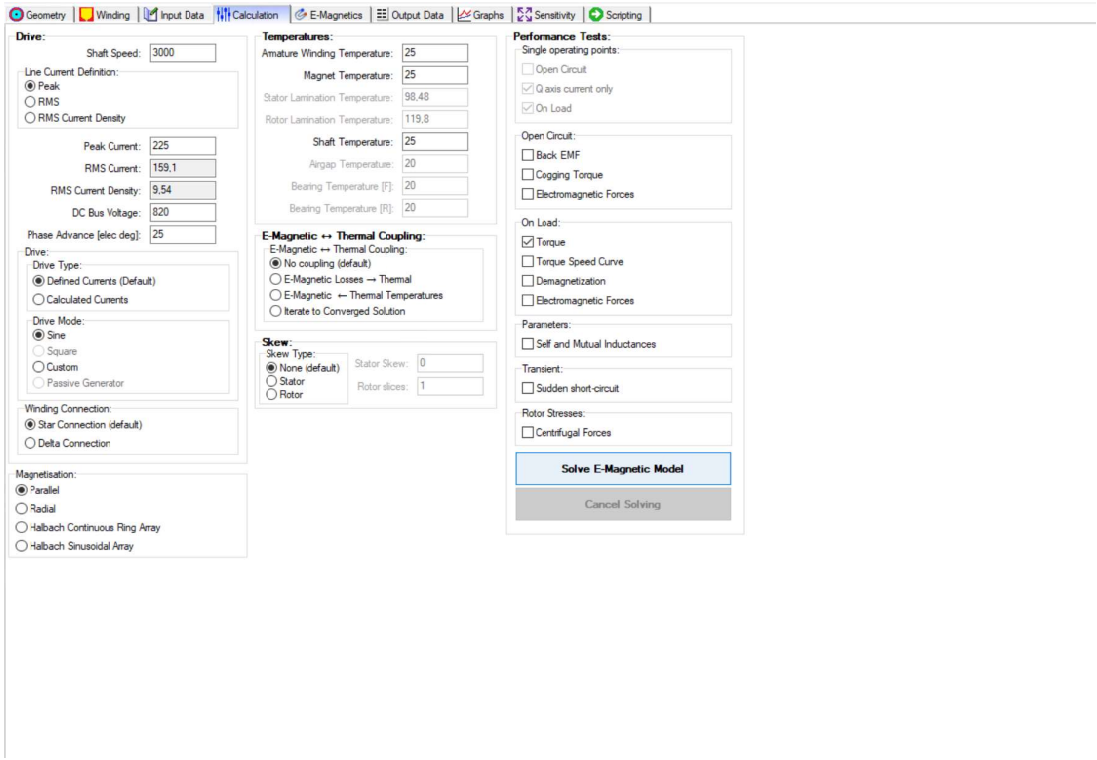
# MOTOR-CAD E-MAGNETIC WINDING



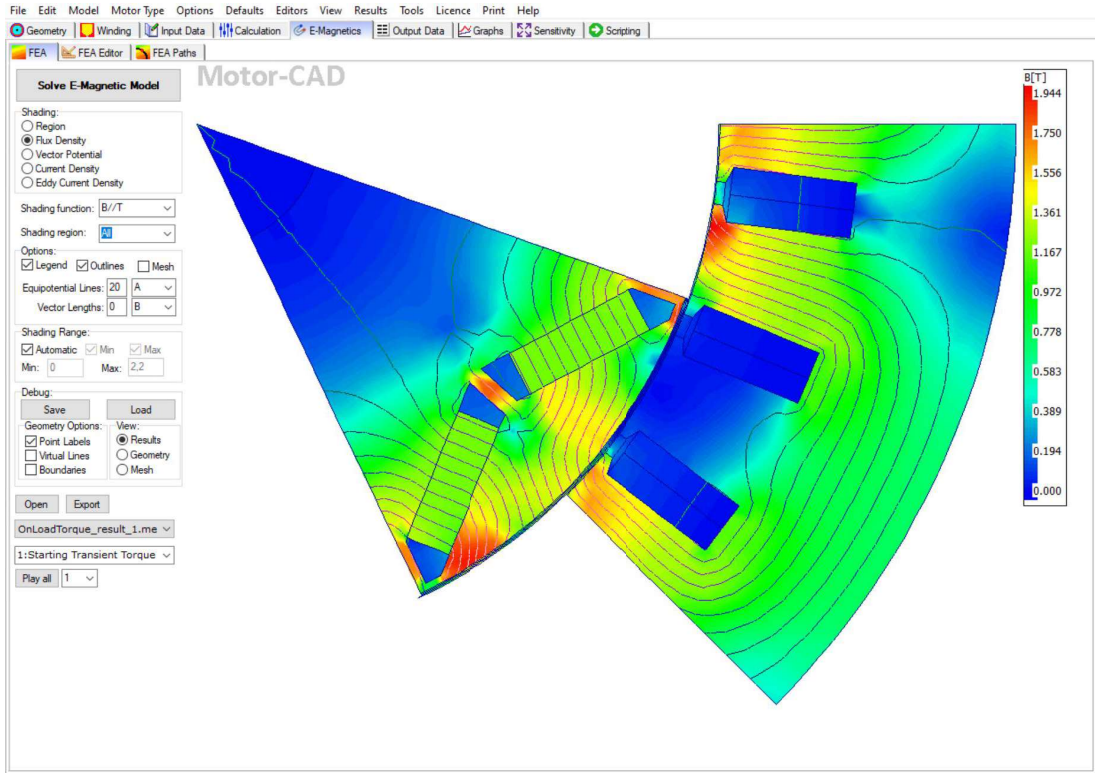
# MOTOR-CAD E-MAGNETIC MATERIAL



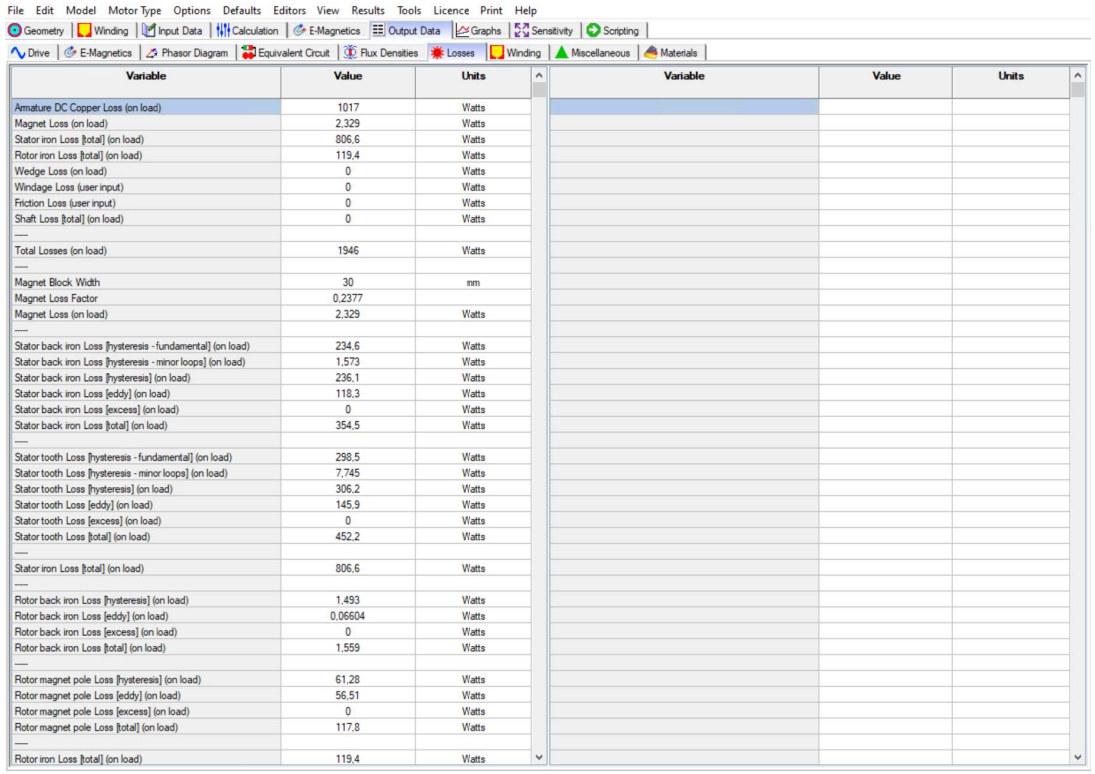
# MOTOR-CAD OVERVIEW CALCULATION SETUP



# MOTOR-CAD FEA RESULTS



# MOTOR-CAD OUTPUT DATA

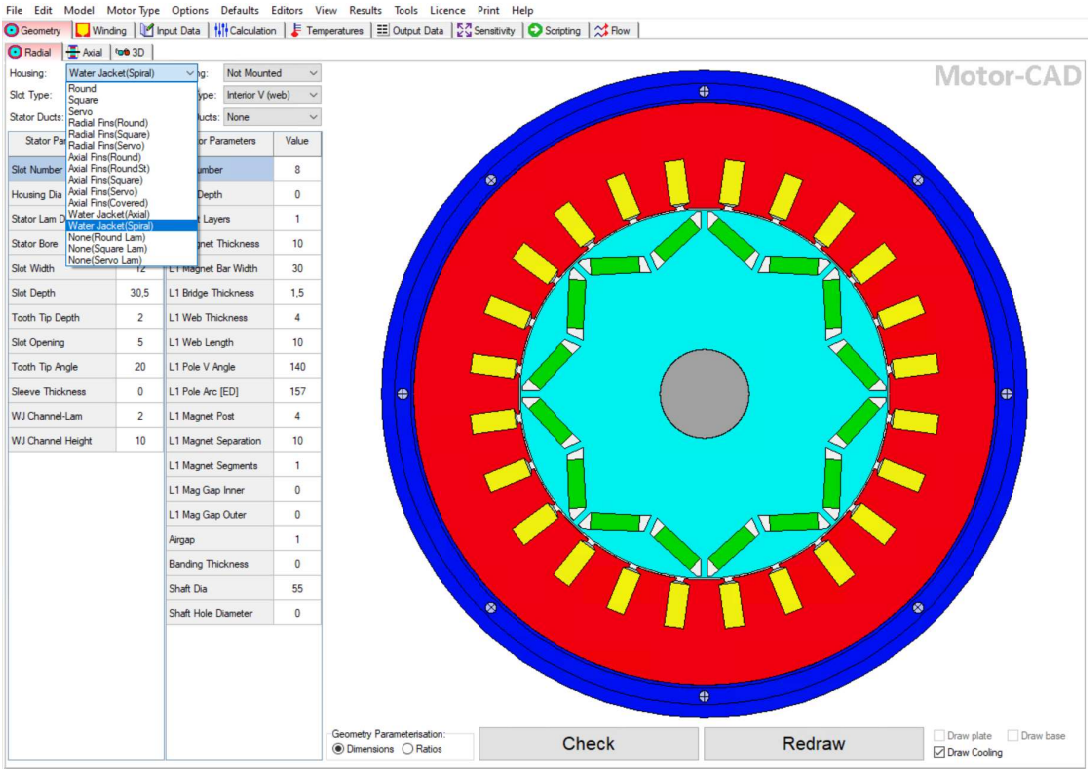



| Variable | Value | Units |
|---|---|---|
| Armature DC Copper Loss (on load) | 1017 | Watts |
| Magnet Loss (on load) | 2,329 | Watts |
| Stator iron Loss [total] (on load) | 806,6 | Watts |
| Rotor iron Loss [total] (on load) | 119,4 | Watts |
| Wedge Loss (on load) | 0 | Watts |
| Windage Loss (user input) | 0 | Watts |
| Friction Loss (user input) | 0 | Watts |
| Shaft Loss [total] (on load) | 0 | Watts |
| ---- | | |
| Total Losses (on load) | 1946 | Watts |
| ---- | | |
| Magnet Block Width | 30 | mm |
| Magnet Loss Factor | 0,2377 | |
| Magnet Loss (on load) | 2,329 | Watts |
| ---- | | |
| Stator back iron Loss [hysteresis - fundamental] (on load) | 234,6 | Watts |
| Stator back iron Loss [hysteresis - minor loops] (on load) | 1,573 | Watts |
| Stator back iron Loss [hysteresis] (on load) | 236,1 | Watts |
| Stator back iron Loss [eddy] (on load) | 118,3 | Watts |
| Stator back iron Loss [excess] (on load) | 0 | Watts |
| Stator back iron Loss [total] (on load) | 354,5 | Watts |
| ---- | | |
| Stator tooth Loss [hysteresis - fundamental] (on load) | 298,5 | Watts |
| Stator tooth Loss [hysteresis - minor loops] (on load) | 7,745 | Watts |
| Stator tooth Loss [hysteresis] (on load) | 306,2 | Watts |
| Stator tooth Loss [eddy] (on load) | 145,9 | Watts |
| Stator tooth Loss [excess] (on load) | 0 | Watts |
| Stator tooth Loss [total] (on load) | 452,2 | Watts |
| ---- | | |
| Stator iron Loss [total] (on load) | 806,6 | Watts |
| ---- | | |
| Rotor back iron Loss [hysteresis] (on load) | 1,493 | Watts |
| Rotor back iron Loss [eddy] (on load) | 0,06604 | Watts |
| Rotor back iron Loss [excess] (on load) | 0 | Watts |
| Rotor back iron Loss [total] (on load) | 1,559 | Watts |
| ---- | | |
| Rotor magnet pole Loss [hysteresis] (on load) | 61,28 | Watts |
| Rotor magnet pole Loss [eddy] (on load) | 56,51 | Watts |
| Rotor magnet pole Loss [excess] (on load) | 0 | Watts |
| Rotor magnet pole Loss [total] (on load) | 117,8 | Watts |
| ---- | | |
| Rotor iron Loss [total] (on load) | 119,4 | Watts |

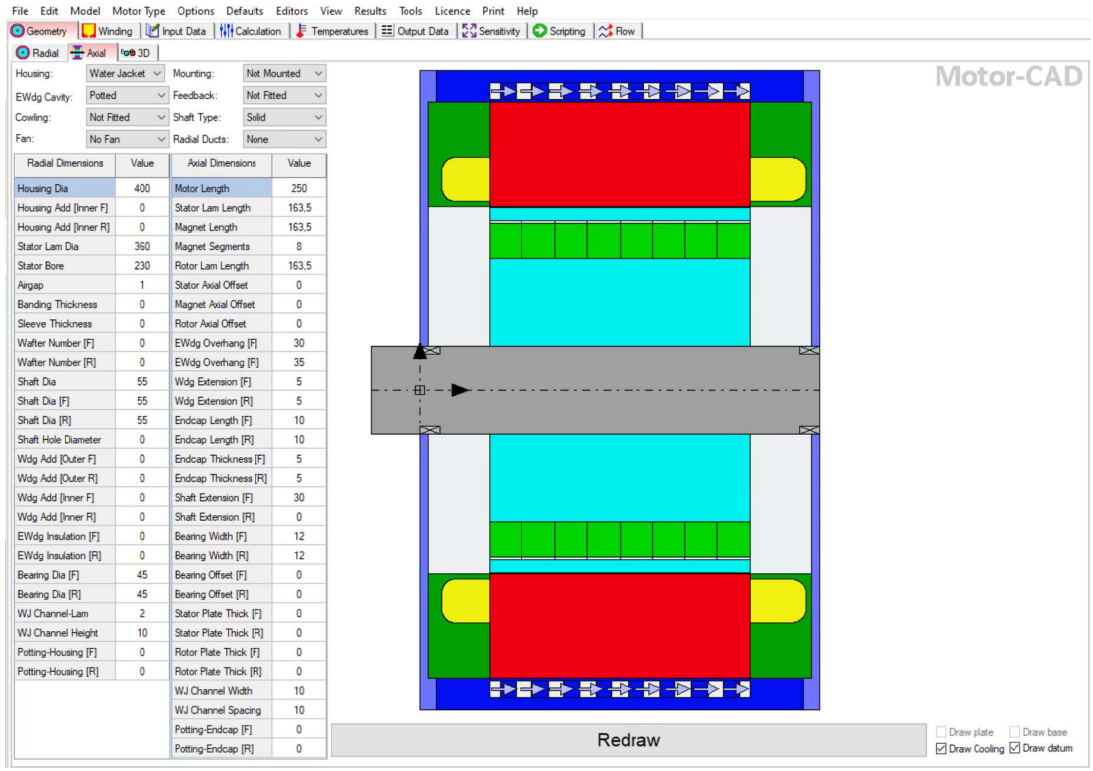
| Variable | Value | Units |
|---|---|---|

# MOTOR-CAD GRAPHS

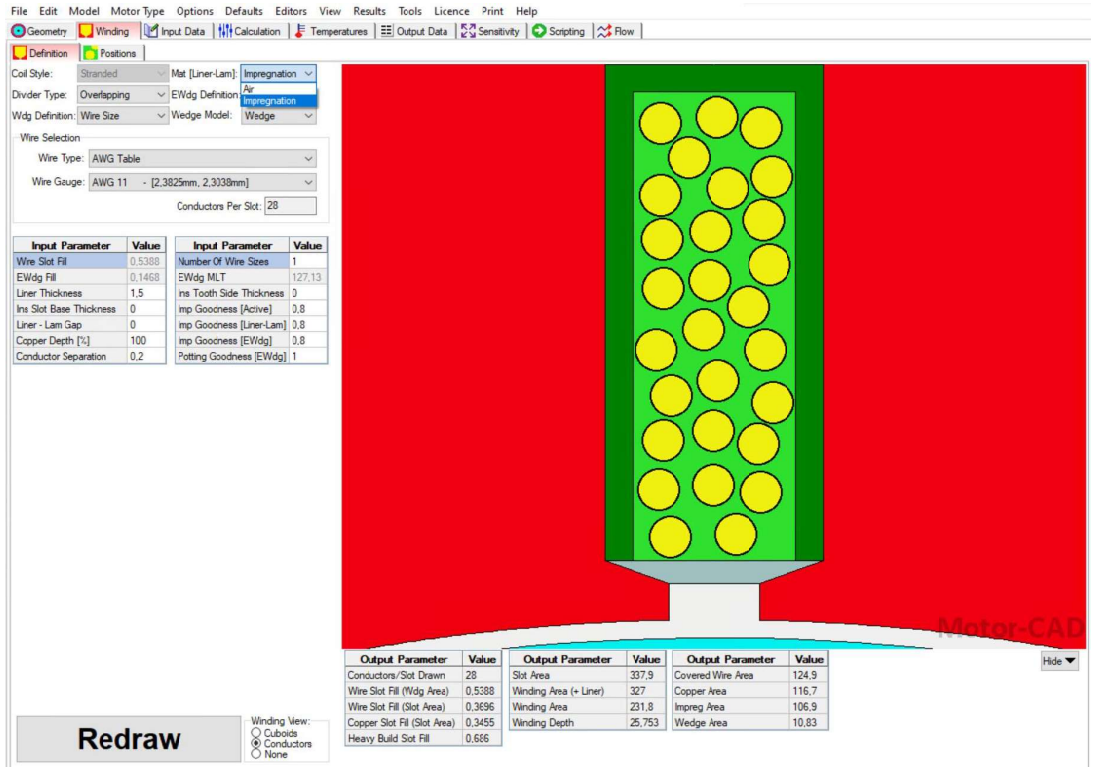
# MOTOR-CAD THERMAL RADIAL DEFINITIONS



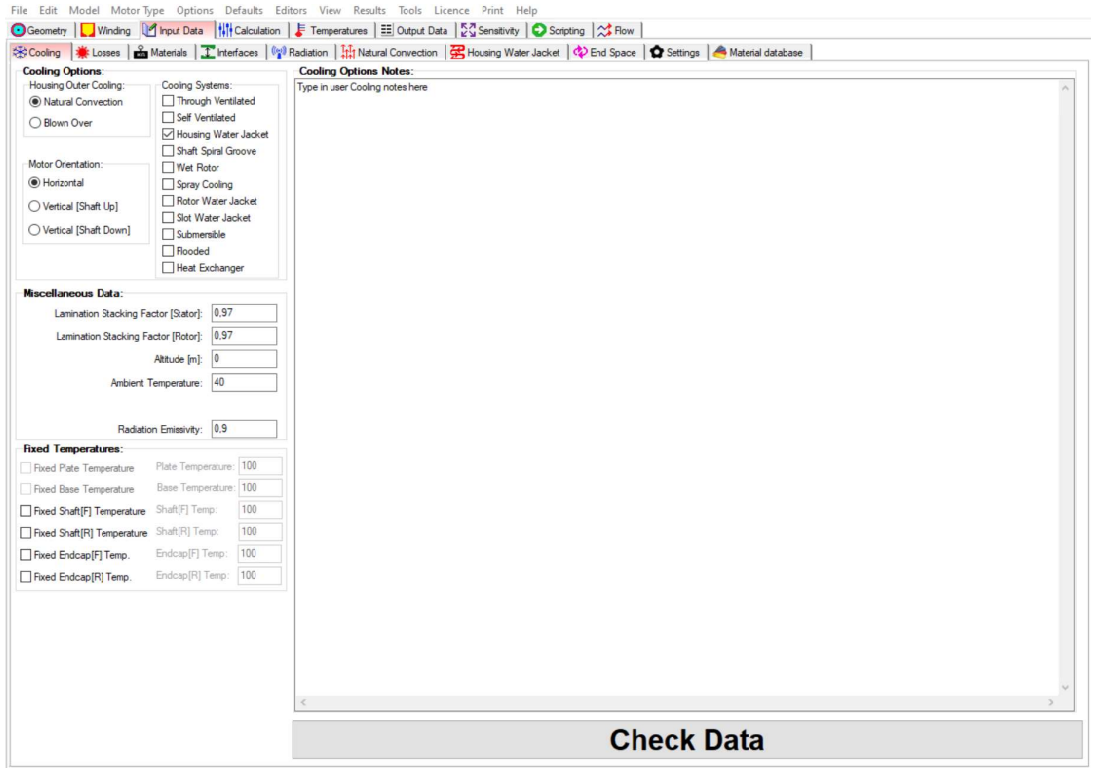
# MOTOR-CAD THERMAL AXIAL DEFINITIONS



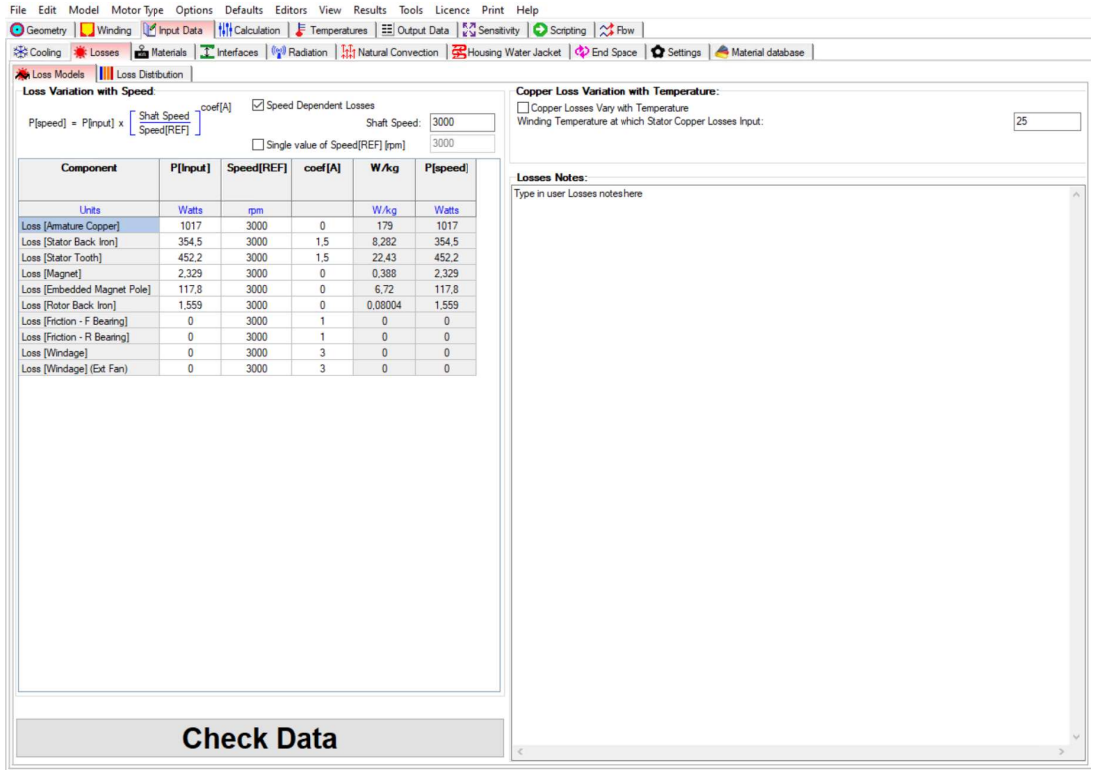
# MOTOR-CAD THERMAL WINDINGS



# MOTOR-CAD THERMAL COOLING

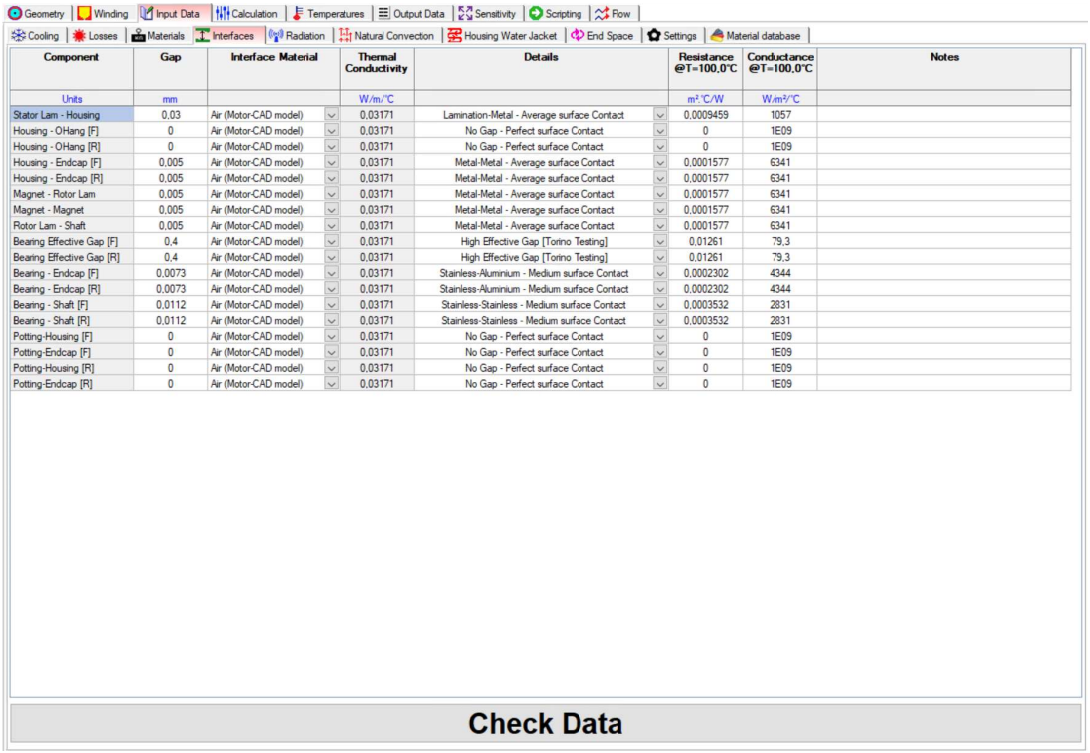


# MOTOR-CAD THERMAL LOSSES



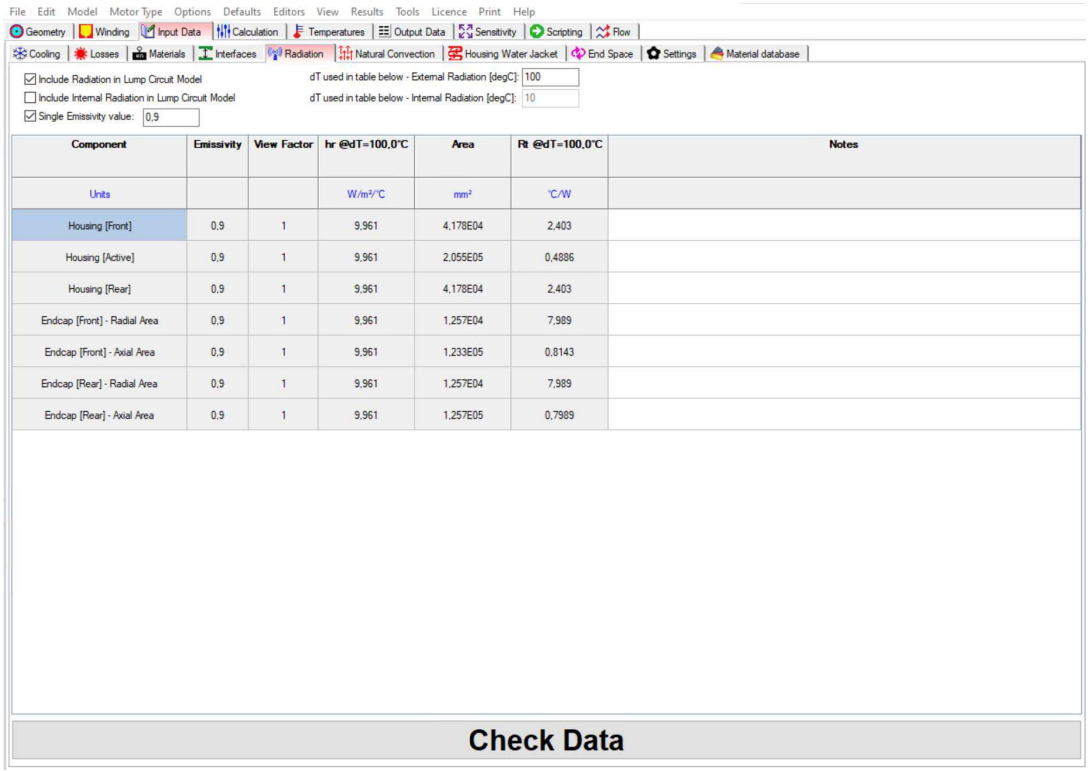

| Component | P[Input] | Speed[REF] | coef[A] | W/kg | P[speed] |
|---|---|---|---|---|---|
| Units | Watts | rpm | | W/kg | Watts |
| Loss [Armature Copper] | 1017 | 3000 | 0 | 179 | 1017 |
| Loss [Stator Back Iron] | 354,5 | 3000 | 1,5 | 8,282 | 354,5 |
| Loss [Stator Tooth] | 452,2 | 3000 | 1,5 | 22,43 | 452,2 |
| Loss [Magnet] | 2,329 | 3000 | 0 | 0,388 | 2,329 |
| Loss [Embedded Magnet Pole] | 117,8 | 3000 | 0 | 6,72 | 117,8 |
| Loss [Rotor Back Iron] | 1,559 | 3000 | 0 | 0,08004 | 1,559 |
| Loss [Friction - F Bearing] | 0 | 3000 | 1 | 0 | 0 |
| Loss [Friction - R Bearing] | 0 | 3000 | 1 | 0 | 0 |
| Loss [Windage] | 0 | 3000 | 3 | 0 | 0 |
| Loss [Windage] (Ext Fan) | 0 | 3000 | 3 | 0 | 0 |

# MOTOR-CAD THERMAL INTERFACES



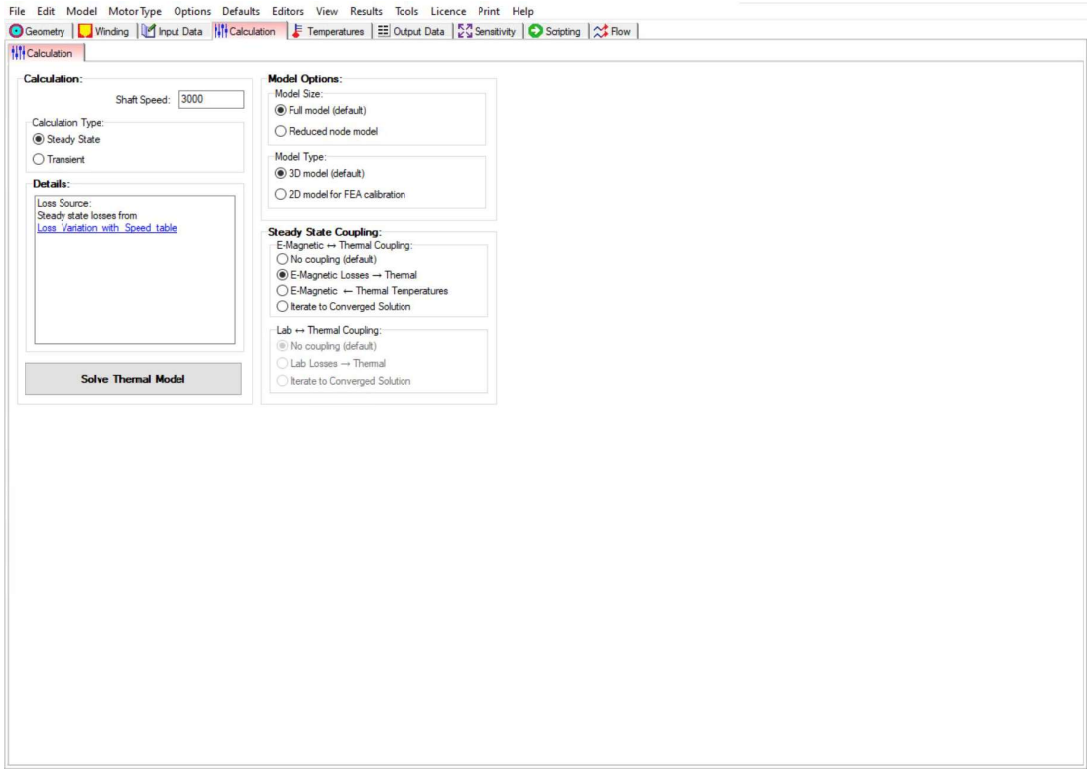

| Component | Gap | Interface Material | Thermal Conductivity | Details | Resistance @T=100.0°C | Conductance @T=100.0°C | Notes |
|---|---|---|---|---|---|---|---|
| Units | mm | | W/m/°C | | m²°C/W | W/m²/°C | |
| Stator Lam - Housing | 0.03 | Air (Motor-CAD model) | 0.03171 | Lamination-Metal - Average surface Contact | 0.0009459 | 1057 | |
| Housing - OHang [F] | 0 | Air (Motor-CAD model) | 0.03171 | No Gap - Perfect surface Contact | 0 | 1E09 | |
| Housing - OHang [R] | 0 | Air (Motor-CAD model) | 0.03171 | No Gap - Perfect surface Contact | 0 | 1E09 | |
| Housing - Endcap [F] | 0.005 | Air (Motor-CAD model) | 0.03171 | Metal-Metal - Average surface Contact | 0.0001577 | 6341 | |
| Housing - Endcap [R] | 0.005 | Air (Motor-CAD model) | 0.03171 | Metal-Metal - Average surface Contact | 0.0001577 | 6341 | |
| Magnet - Rotor Lam | 0.005 | Air (Motor-CAD model) | 0.03171 | Metal-Metal - Average surface Contact | 0.0001577 | 6341 | |
| Magnet - Magnet | 0.005 | Air (Motor-CAD model) | 0.03171 | Metal-Metal - Average surface Contact | 0.0001577 | 6341 | |
| Rotor Lam - Shaft | 0.005 | Air (Motor-CAD model) | 0.03171 | Metal-Metal - Average surface Contact | 0.0001577 | 6341 | |
| Bearing Effective Gap [F] | 0.4 | Air (Motor-CAD model) | 0.03171 | High Effective Gap [Torino Testing] | 0.01261 | 79.3 | |
| Bearing Effective Gap [R] | 0.4 | Air (Motor-CAD model) | 0.03171 | High Effective Gap [Torino Testing] | 0.01261 | 79.3 | |
| Bearing - Endcap [F] | 0.0073 | Air (Motor-CAD model) | 0.03171 | Stainless-Aluminium - Medium surface Contact | 0.0002302 | 4344 | |
| Bearing - Endcap [R] | 0.0073 | Air (Motor-CAD model) | 0.03171 | Stainless-Aluminium - Medium surface Contact | 0.0002302 | 4344 | |
| Bearing - Shaft [F] | 0.0112 | Air (Motor-CAD model) | 0.03171 | Stainless-Stainless - Medium surface Contact | 0.0003532 | 2831 | |
| Bearing - Shaft [R] | 0.0112 | Air (Motor-CAD model) | 0.03171 | Stainless-Stainless - Medium surface Contact | 0.0003532 | 2831 | |
| Potting-Housing [F] | 0 | Air (Motor-CAD model) | 0.03171 | No Gap - Perfect surface Contact | 0 | 1E09 | |
| Potting-Endcap [F] | 0 | Air (Motor-CAD model) | 0.03171 | No Gap - Perfect surface Contact | 0 | 1E09 | |
| Potting-Housing [R] | 0 | Air (Motor-CAD model) | 0.03171 | No Gap - Perfect surface Contact | 0 | 1E09 | |
| Potting-Endcap [R] | 0 | Air (Motor-CAD model) | 0.03171 | No Gap - Perfect surface Contact | 0 | 1E09 | |

# MOTOR-CAD THERMAL RADIATION

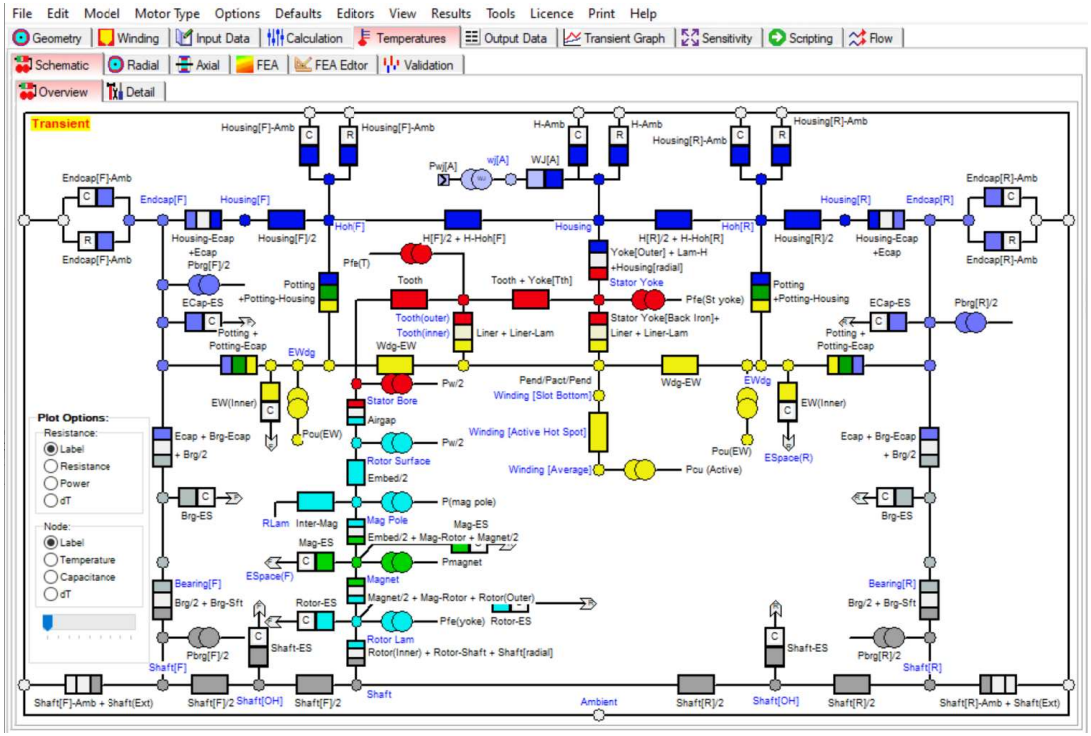



| Component | Emissivity | View Factor | hr @dT=100,0°C | Area | Rt @dT=100,0°C | Notes |
|---|---|---|---|---|---|---|
| Units | | | W/m²/°C | mm² | °C/W | |
| Housing [Front] | 0,9 | 1 | 9,961 | 4,178E04 | 2,403 | |
| Housing [Active] | 0,9 | 1 | 9,961 | 2,055E05 | 0,4886 | |
| Housing [Rear] | 0,9 | 1 | 9,961 | 4,178E04 | 2,403 | |
| Endcap [Front] - Radial Area | 0,9 | 1 | 9,961 | 1,257E04 | 7,989 | |
| Endcap [Front] - Axial Area | 0,9 | 1 | 9,961 | 1,233E05 | 0,8143 | |
| Endcap [Rear] - Radial Area | 0,9 | 1 | 9,961 | 1,257E04 | 7,989 | |
| Endcap [Rear] - Axial Area | 0,9 | 1 | 9,961 | 1,257E05 | 0,7989 | |

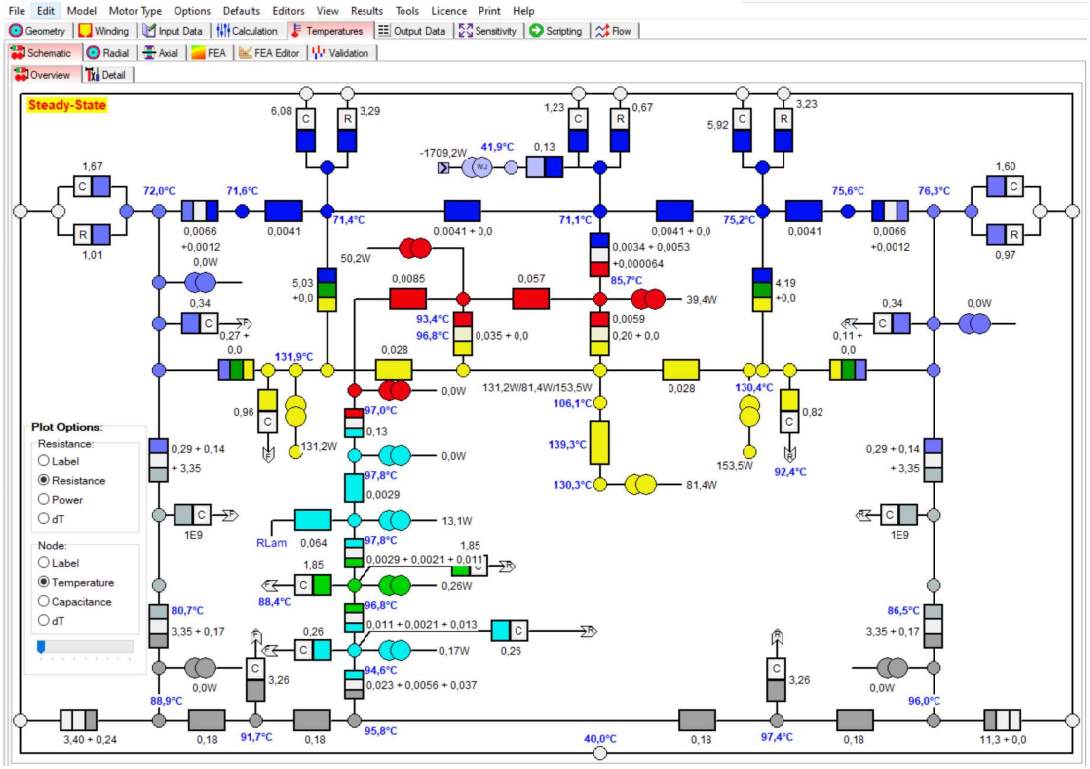
# MOTOR-CAD THERMAL CALCULATION STEADY STATE



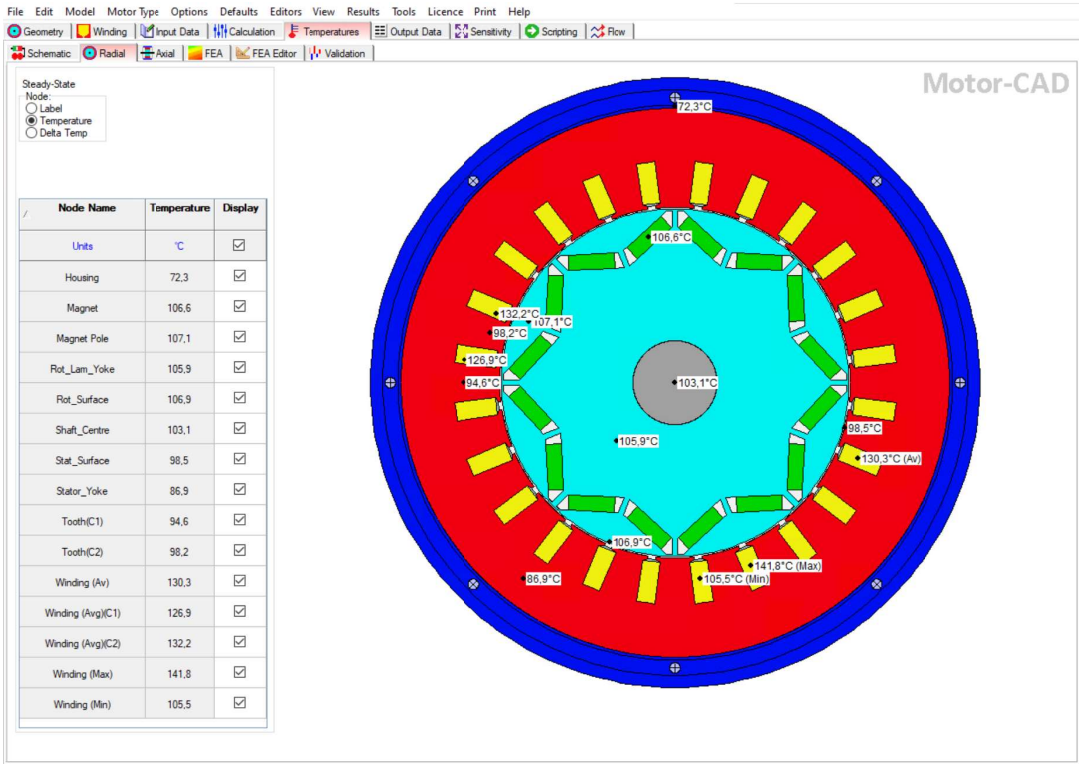
# MOTOR-CAD THERMAL CALCULATION STEADY STATE



# MOTOR-CAD THERMAL NETWORK MODEL

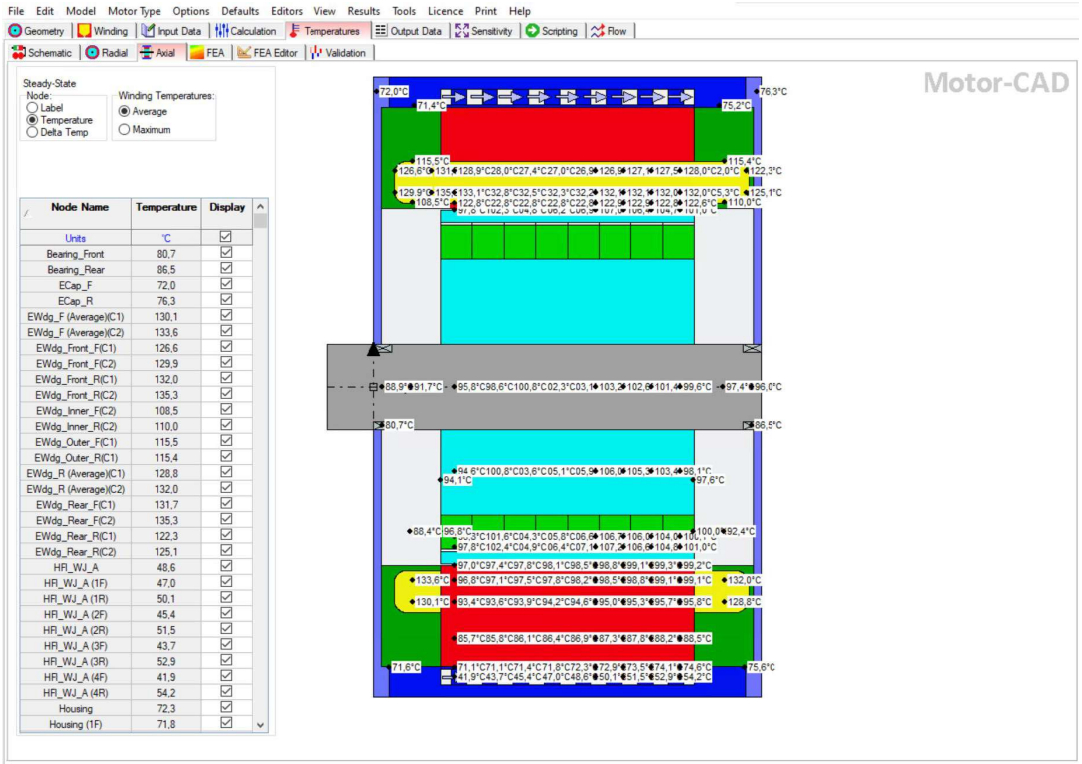


# MOTOR-CAD THERMAL RESULTS



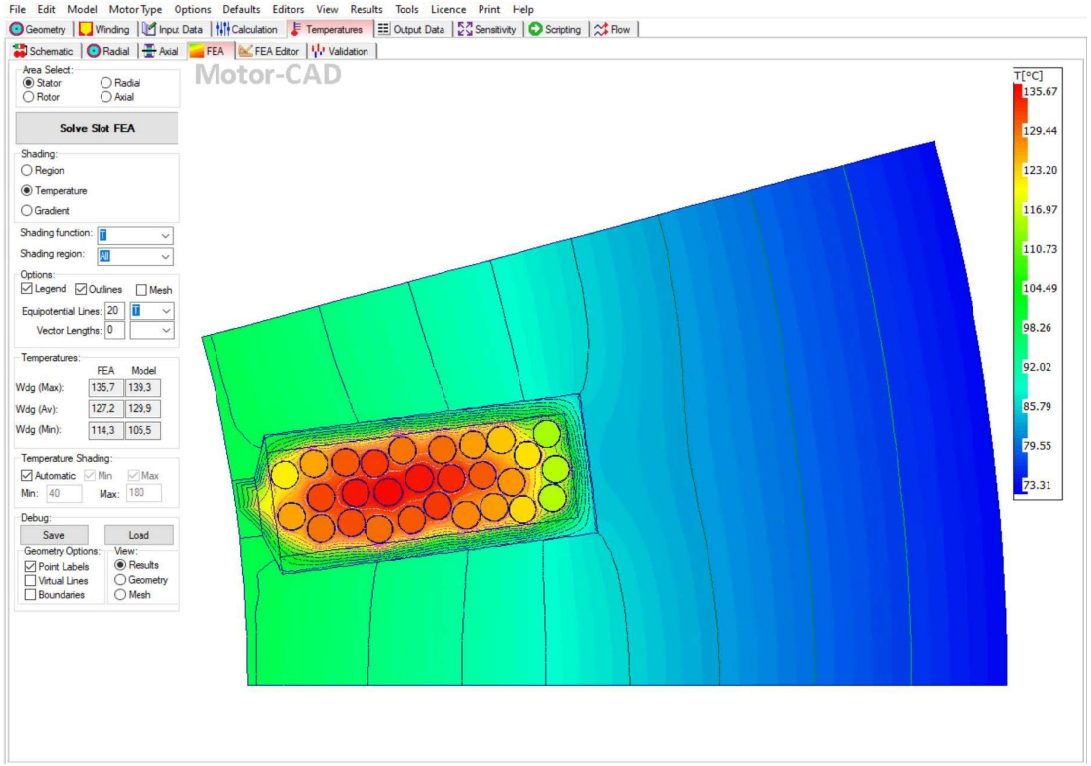

| Node Name | Temperature | Display |
|---|---|---|
| Units | °C | ☑ |
| Housing | 72,3 | ☑ |
| Magnet | 106,6 | ☑ |
| Magnet Pole | 107,1 | ☑ |
| Rot_Lam_Yoke | 105,9 | ☑ |
| Rot_Surface | 106,9 | ☑ |
| Shaft_Centre | 103,1 | ☑ |
| Stat_Surface | 98,5 | ☑ |
| Stator_Yoke | 86,9 | ☑ |
| Tooth(C1) | 94,6 | ☑ |
| Tooth(C2) | 98,2 | ☑ |
| Winding (Av) | 130,3 | ☑ |
| Winding (Avg)(C1) | 126,9 | ☑ |
| Winding (Avg)(C2) | 132,2 | ☑ |
| Winding (Max) | 141,8 | ☑ |
| Winding (Min) | 105,5 | ☑ |

# MOTOR-CAD THERMAL RESULTS

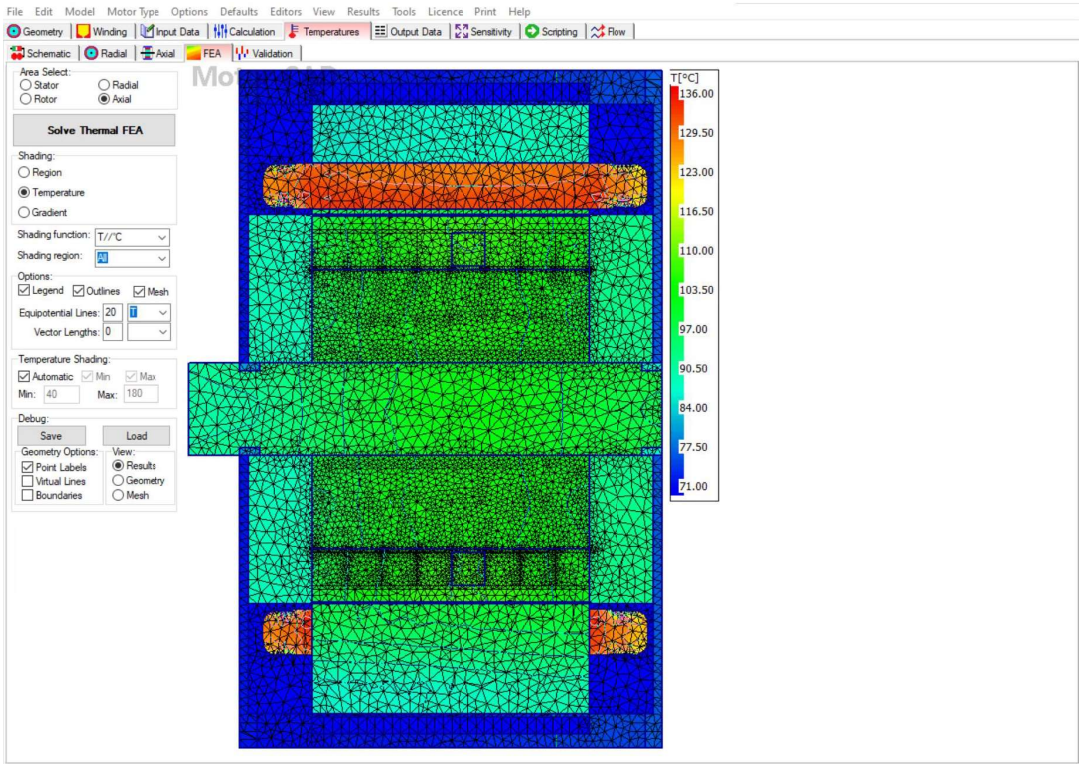



| Node Name | Temperature | Display |
|---|---|---|
| Units | °C | |
| Bearing_Front | 80,7 | |
| Bearing_Rear | 86,5 | |
| ECap_F | 72,0 | |
| ECap_R | 76,3 | |
| EWdg_F (Average)(C1) | 130,1 | |
| EWdg_F (Average)(C2) | 133,6 | |
| EWdg_Front_F(C1) | 126,6 | |
| EWdg_Front_F(C2) | 129,9 | |
| EWdg_Front_R(C1) | 132,0 | |
| EWdg_Front_R(C2) | 135,3 | |
| EWdg_Inner_F(C2) | 108,5 | |
| EWdg_Inner_R(C2) | 110,0 | |
| EWdg_Outer_F(C1) | 115,5 | |
| EWdg_Outer_R(C1) | 115,4 | |
| EWdg_R (Average)(C1) | 128,8 | |
| EWdg_R (Average)(C2) | 132,0 | |
| EWdg_Rear_F(C1) | 131,7 | |
| EWdg_Rear_F(C2) | 135,3 | |
| EWdg_Rear_R(C1) | 122,3 | |
| EWdg_Rear_R(C2) | 125,1 | |
| HR_WJ_A | 48,6 | |
| HR_WJ_A (1F) | 47,0 | |
| HR_WJ_A (1R) | 50,1 | |
| HR_WJ_A (2F) | 45,4 | |
| HR_WJ_A (2R) | 51,5 | |
| HR_WJ_A (3F) | 43,7 | |
| HR_WJ_A (3R) | 52,9 | |
| HR_WJ_A (4F) | 41,9 | |
| HR_WJ_A (4R) | 54,2 | |
| Housing | 72,3 | |
| Housing (1F) | 71,8 | |

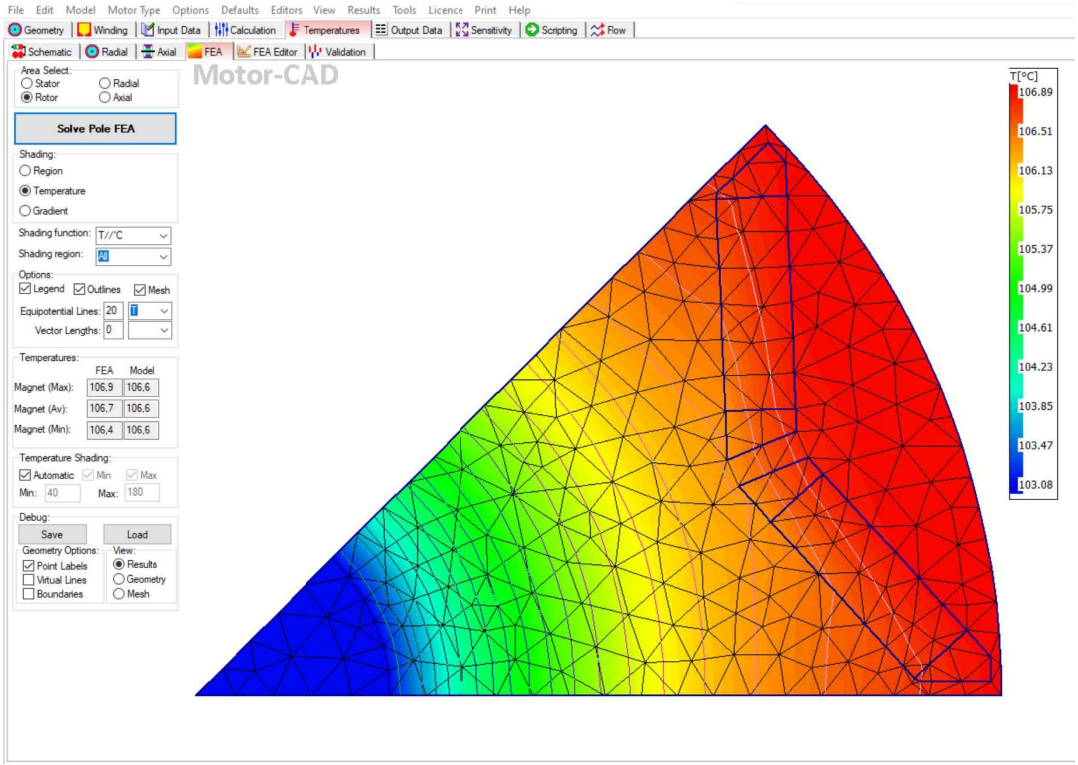
# MOTOR-CAD THERMAL FEA RESULTS



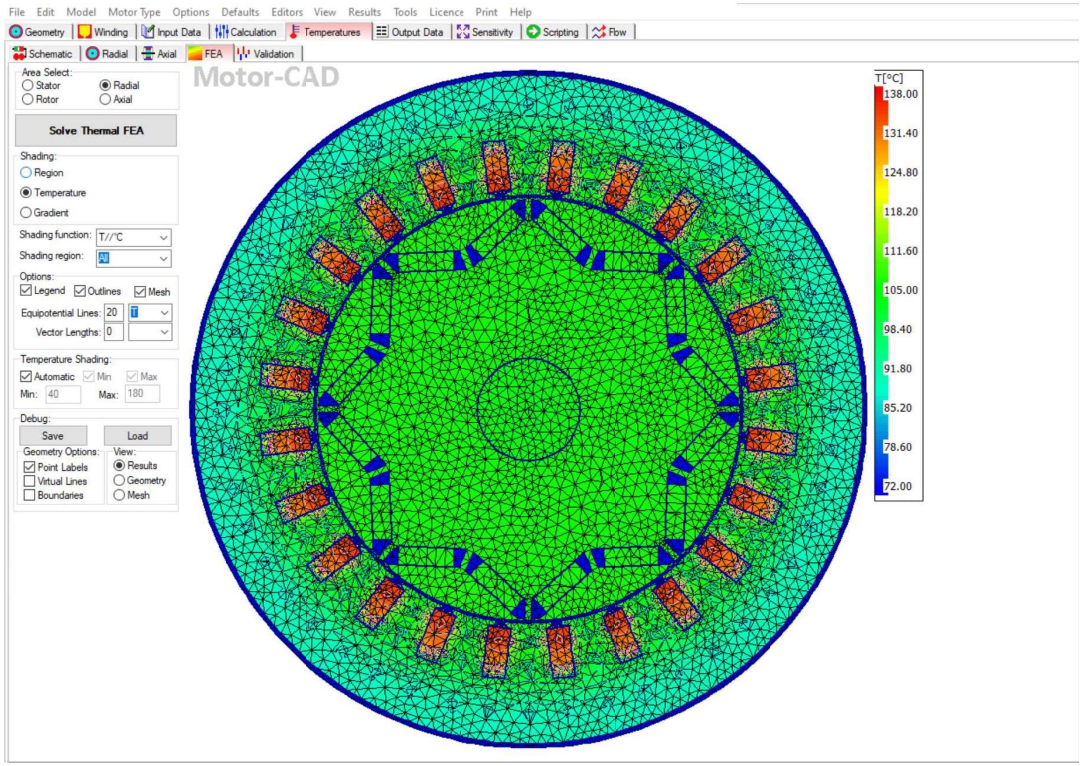
# MOTOR-CAD THERMAL FEA RESULTS



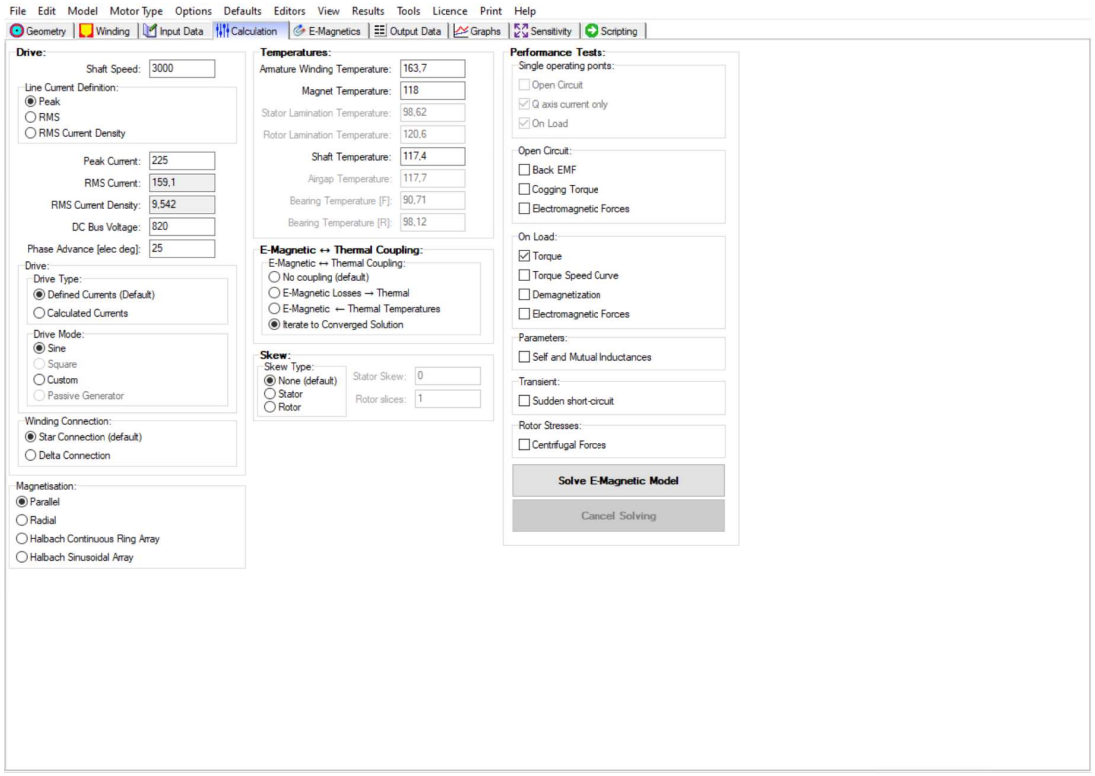
# MOTOR-CAD THERMAL FEA RESULTS



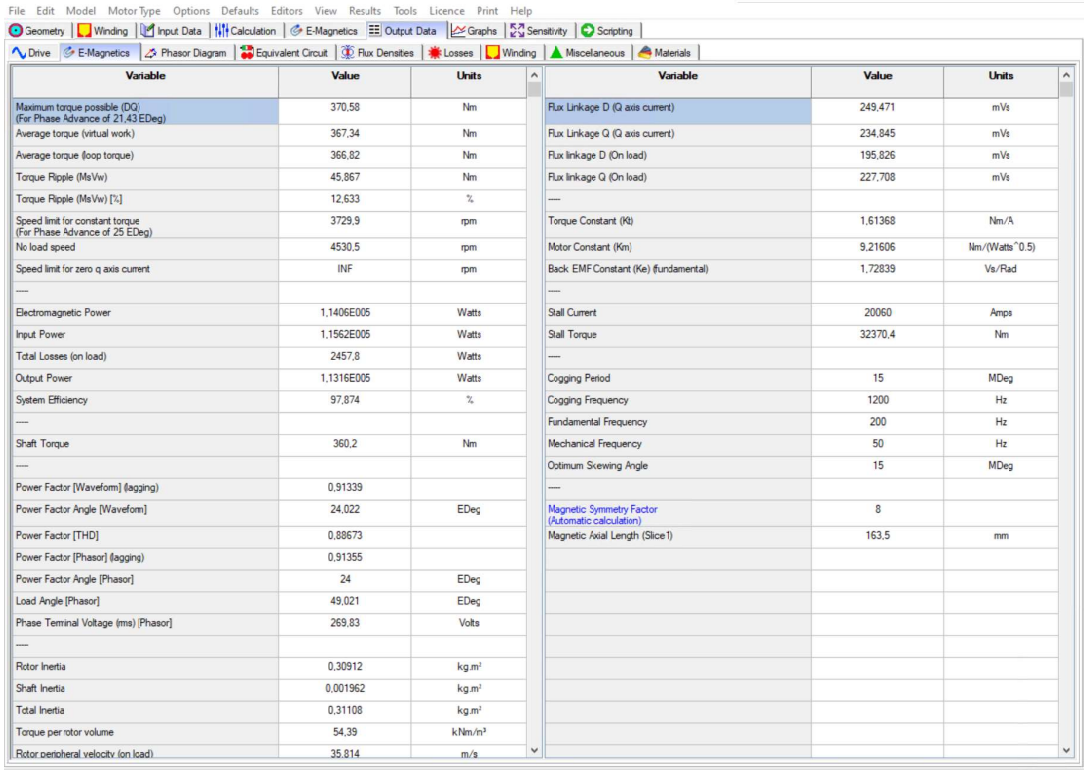
# MOTOR-CAD THERMAL FEA RESULTS



# MOTOR-CAD THERMO-ELECTROMAGNETIC ANALYSIS



# MOTOR-CAD THERMO-ELECTROMAGNETIC ANALYSIS



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

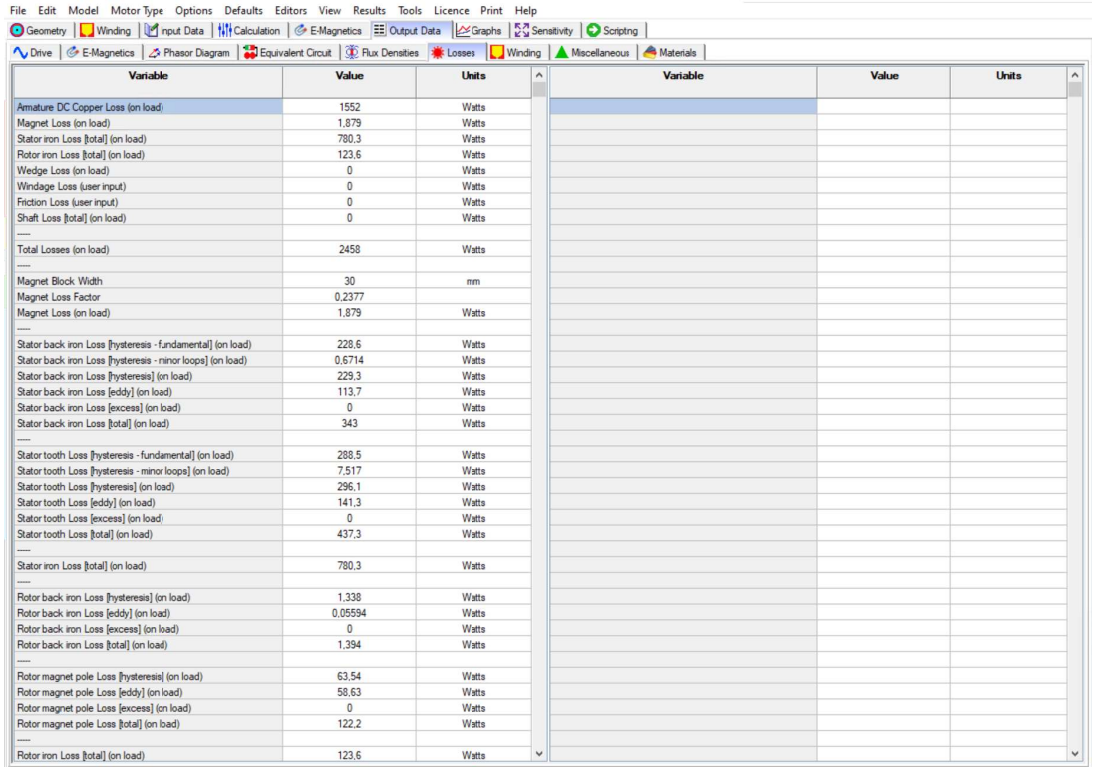
Geometry | Winding | Input Data | Calculation | E-Magnetics | Output Data | Graphs | Sensitivity | Scripting

Drive | E-Magnetics | Phasor Diagram | Equivalent Circuit | Flux Densities | Losses | Winding | Miscelaneous | Materials

| Variable | Value | Units |
|---|---|---|
| Maximum torque possible (DQ) (For Phase Advance of 21,43 EDeg) | 370,58 | Nm |
| Average torque (virtual work) | 367,34 | Nm |
| Average torque (loop torque) | 366,82 | Nm |
| Torque Ripple (MsVw) | 45,867 | Nm |
| Torque Ripple (MsVw) [%] | 12,633 | % |
| Speed limit for constant torque (For Phase Advance of 25 EDeg) | 3729,9 | rpm |
| No load speed | 4530,5 | rpm |
| Speed limit for zero q axis current | INF | rpm |
| ---- | | |
| Electromagnetic Power | 1,1406E005 | Watts |
| Input Power | 1,1562E005 | Watts |
| Total Losses (on load) | 2457,8 | Watts |
| Output Power | 1,1316E005 | Watts |
| System Efficiency | 97,874 | % |
| ---- | | |
| Shaft Torque | 360,2 | Nm |
| ---- | | |
| Power Factor [Waveform] (lagging) | 0,91339 | |
| Power Factor Angle [Waveform] | 24,022 | EDeg |
| Power Factor [THD] | 0,88673 | |
| Power Factor [Phasor] (lagging) | 0,91355 | |
| Power Factor Angle [Phasor] | 24 | EDeg |
| Load Angle [Phasor] | 49,021 | EDeg |
| Phase Terminal Voltage (rms) [Phasor] | 269,83 | Volts |
| ---- | | |
| Rotor Inertia | 0,30912 | kg.m² |
| Shaft Inertia | 0,001962 | kg.m² |
| Total Inertia | 0,31108 | kg.m² |
| Torque per rotor volume | 54,39 | kNm/m³ |
| Rotor peripheral velocity (on load) | 35,814 | m/s |

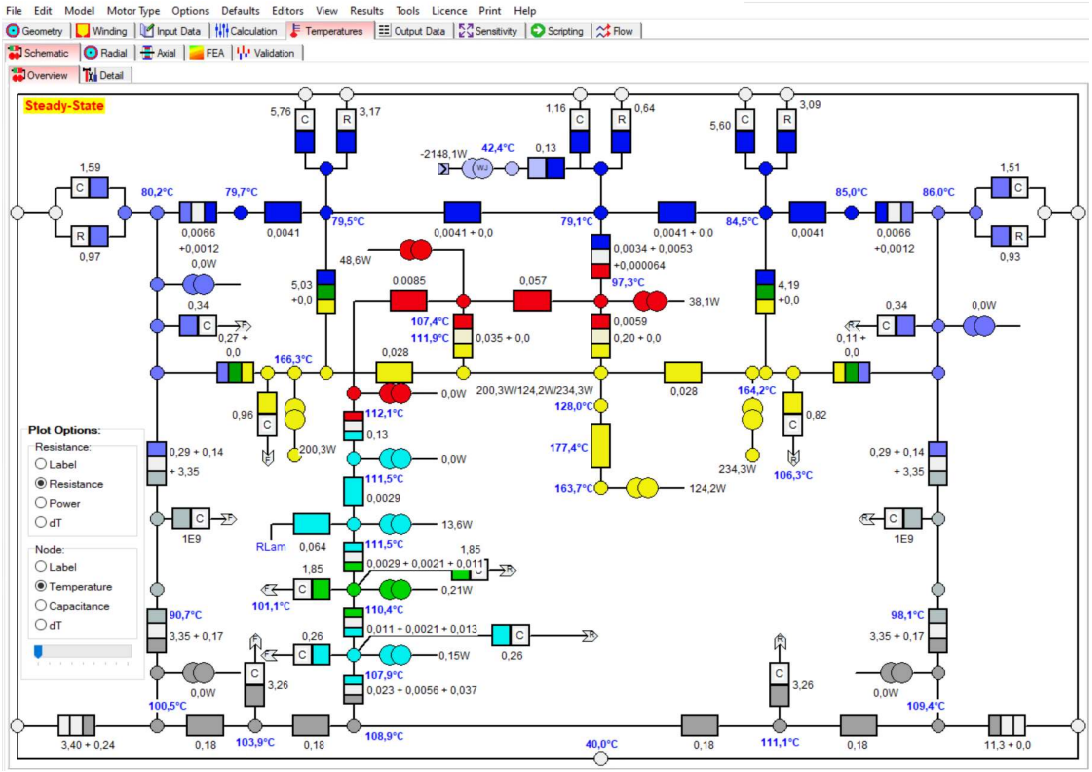
| Variable | Value | Units |
|---|---|---|
| Flux Linkage D (Q axis current) | 249,471 | mVs |
| Flux Linkage Q (Q axis current) | 234,845 | mVs |
| Flux linkage D (On load) | 195,826 | mVs |
| Flux linkage Q (On load) | 227,708 | mVs |
| ---- | | |
| Torque Constant (Kt) | 1,61368 | Nm/A |
| Motor Constant (Km) | 9,21606 | Nm/(Watts^0.5) |
| Back EMF Constant (Ke) (fundamental) | 1,72839 | Vs/Rad |
| ---- | | |
| Stall Current | 20060 | Amps |
| Stall Torque | 32370,4 | Nm |
| ---- | | |
| Cogging Period | 15 | MDeg |
| Cogging Frequency | 1200 | Hz |
| Fundamental Frequency | 200 | Hz |
| Mechanical Frequency | 50 | Hz |
| Optimum Skewing Angle | 15 | MDeg |
| ---- | | |
| Magnetic Symmetry Factor (Automatic calculation) | 8 | |
| Magnetic Axial Length (Slice1) | 163,5 | mm |

# MOTOR-CAD THERMO-ELECTROMAGNETIC ANALYSIS

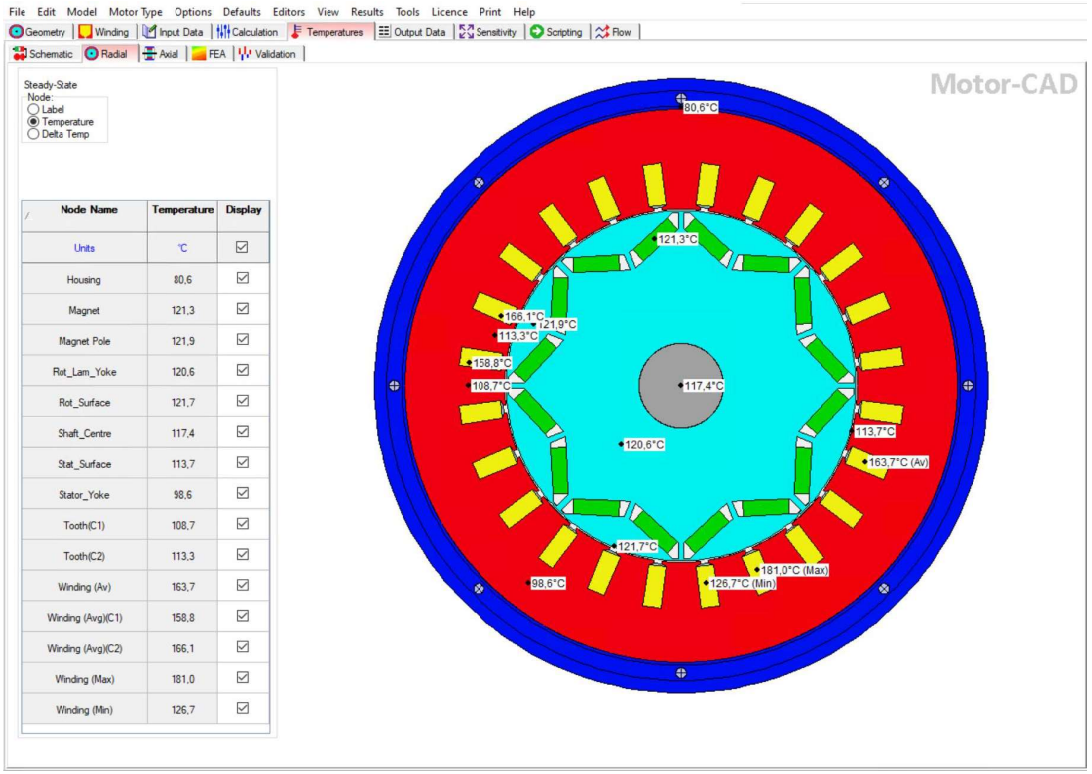



| Variable | Value | Units |
|---|---|---|
| Armature DC Copper Loss (on load) | 1552 | Watts |
| Magnet Loss (on load) | 1,879 | Watts |
| Stator iron Loss [total] (on load) | 780,3 | Watts |
| Rotor iron Loss [total] (on load) | 123,6 | Watts |
| Wedge Loss (on load) | 0 | Watts |
| Windage Loss (user input) | 0 | Watts |
| Friction Loss (user input) | 0 | Watts |
| Shaft Loss [total] (on load) | 0 | Watts |
| ---- | | |
| Total Losses (on load) | 2458 | Watts |
| ---- | | |
| Magnet Block Width | 30 | mm |
| Magnet Loss Factor | 0,2377 | |
| Magnet Loss (on load) | 1,879 | Watts |
| ---- | | |
| Stator back iron Loss [hysteresis - fundamental] (on load) | 228,6 | Watts |
| Stator back iron Loss [hysteresis - minor loops] (on load) | 0,6714 | Watts |
| Stator back iron Loss [hysteresis] (on load) | 229,3 | Watts |
| Stator back iron Loss [eddy] (on load) | 113,7 | Watts |
| Stator back iron Loss [excess] (on load) | 0 | Watts |
| Stator back iron Loss [total] (on load) | 343 | Watts |
| ---- | | |
| Stator tooth Loss [hysteresis - fundamental] (on load) | 288,5 | Watts |
| Stator tooth Loss [hysteresis - minor loops] (on load) | 7,517 | Watts |
| Stator tooth Loss [hysteresis] (on load) | 296,1 | Watts |
| Stator tooth Loss [eddy] (on load) | 141,3 | Watts |
| Stator tooth Loss [excess] (on load) | 0 | Watts |
| Stator tooth Loss [total] (on load) | 437,3 | Watts |
| ---- | | |
| Stator iron Loss [total] (on load) | 780,3 | Watts |
| ---- | | |
| Rotor back iron Loss [hysteresis] (on load) | 1,338 | Watts |
| Rotor back iron Loss [eddy] (on load) | 0,05594 | Watts |
| Rotor back iron Loss [excess] (on load) | 0 | Watts |
| Rotor back iron Loss [total] (on load) | 1,394 | Watts |
| ---- | | |
| Rotor magnet pole Loss [hysteresis] (on load) | 63,54 | Watts |
| Rotor magnet pole Loss [eddy] (on load) | 58,63 | Watts |
| Rotor magnet pole Loss [excess] (on load) | 0 | Watts |
| Rotor magnet pole Loss [total] (on load) | 122,2 | Watts |
| ---- | | |
| Rotor iron Loss [total] (on load) | 123,6 | Watts |

# MOTOR-CAD THERMO-ELECTROMAGNETIC ANALYSIS

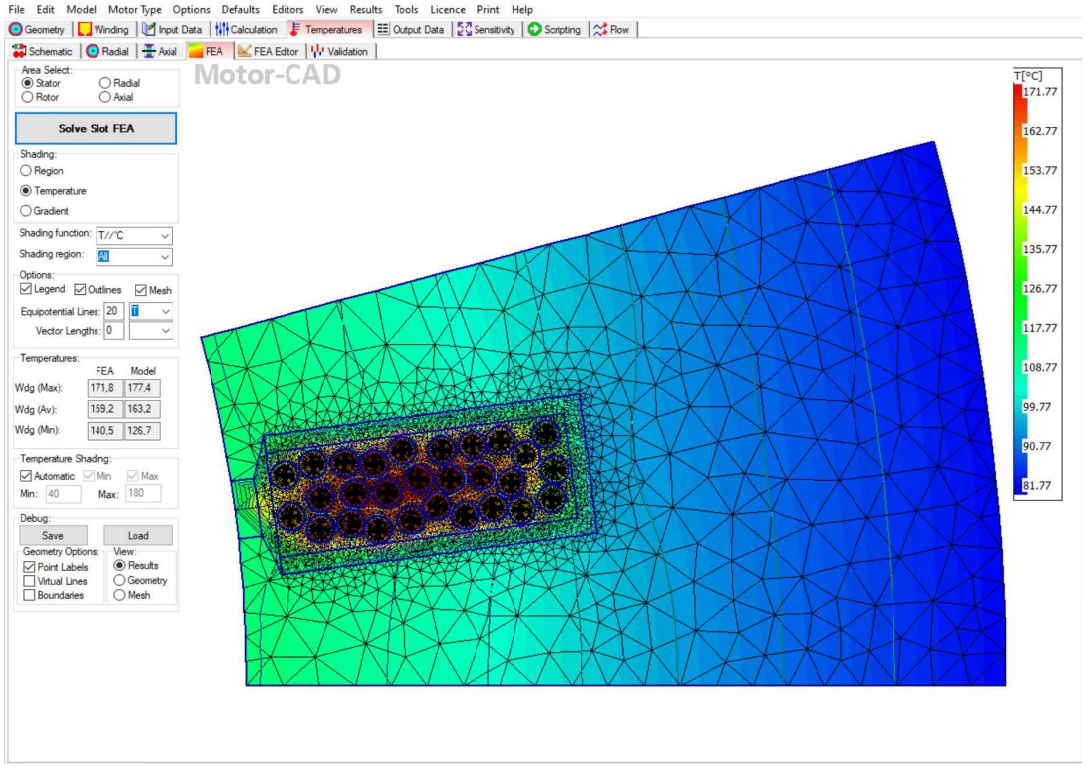


# MOTOR-CAD THERMO-ELECTROMAGNETIC ANALYSIS

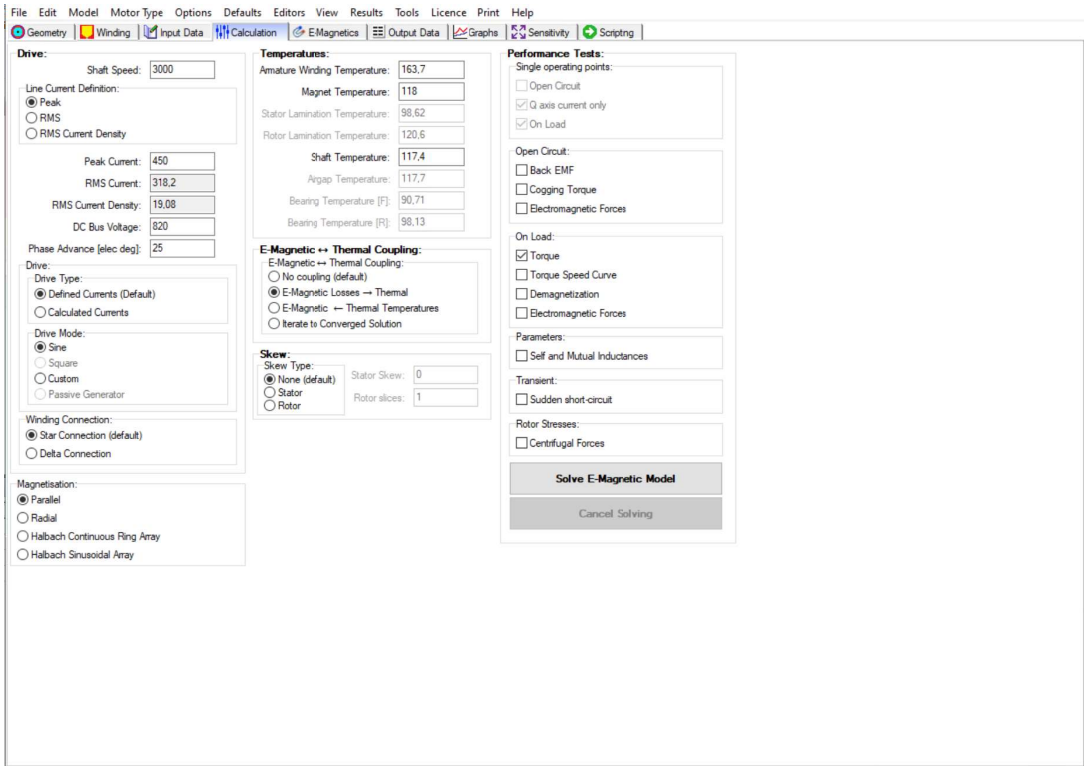



| Node Name | Temperature | Display |
|---|---|---|
| Units | °C | ☑ |
| Housing | 80,6 | ☑ |
| Magnet | 121,3 | ☑ |
| Magnet Pole | 121,9 | ☑ |
| Rot_Lam_Yoke | 120,6 | ☑ |
| Rot_Surface | 121,7 | ☑ |
| Shaft_Centre | 117,4 | ☑ |
| Stat_Surface | 113,7 | ☑ |
| Stator_Yoke | 98,6 | ☑ |
| Tooth(C1) | 108,7 | ☑ |
| Tooth(C2) | 113,3 | ☑ |
| Winding (Av) | 163,7 | ☑ |
| Winding (Avg)(C1) | 158,8 | ☑ |
| Winding (Avg)(C2) | 166,1 | ☑ |
| Winding (Max) | 181,0 | ☑ |
| Winding (Min) | 126,7 | ☑ |

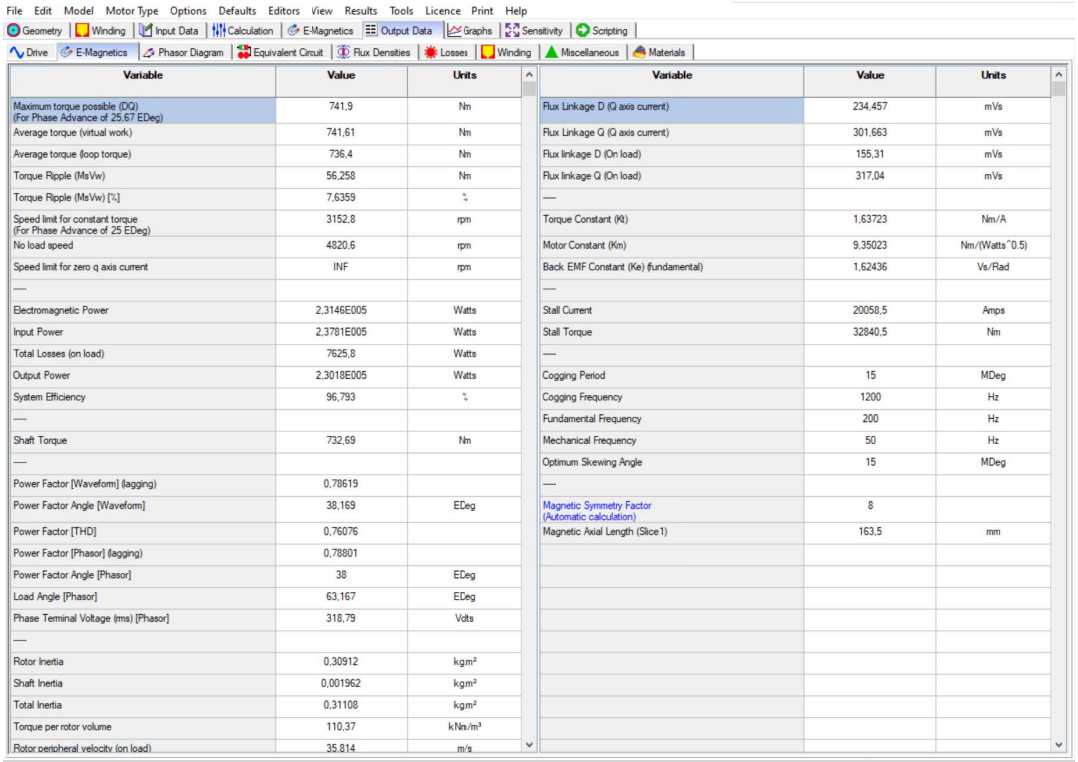
# MOTOR-CAD THERMO-ELECTROMAGNETIC ANALYSIS



# MOTOR-CAD TRANSIENT ANALYSIS



# MOTOR-CAD TRANSIENT ANALYSIS



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

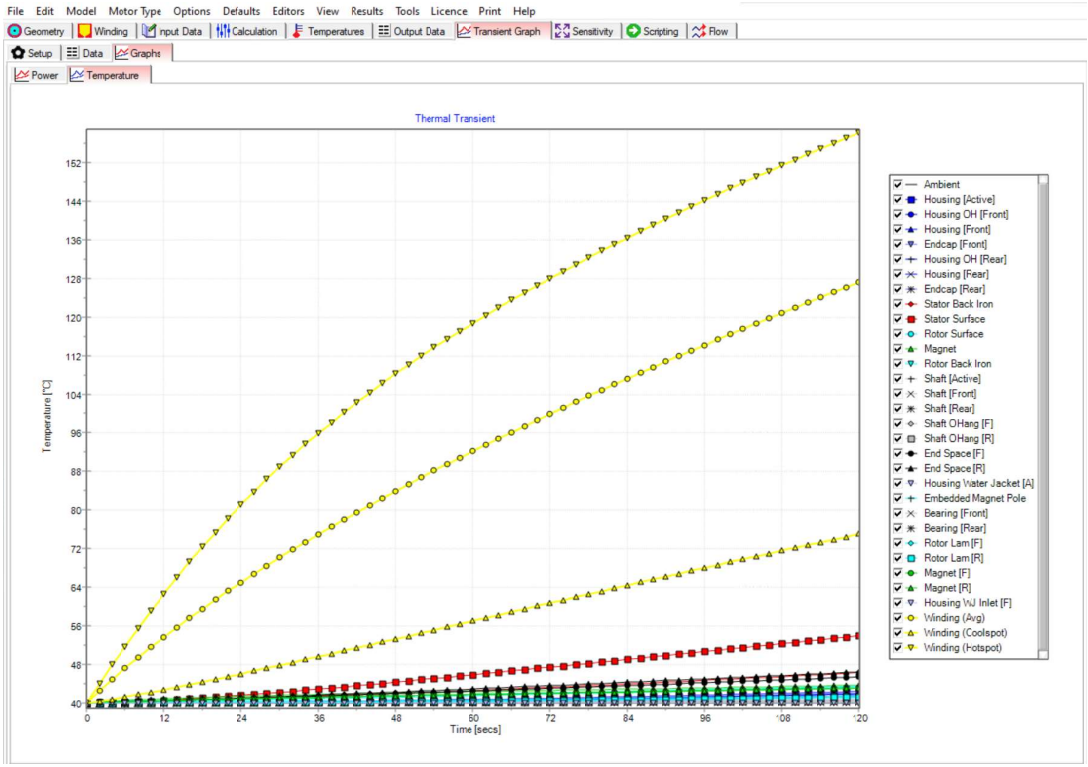
Geometry | Winding | Input Data | Calculation | E-Magnetics | Output Data | Graphs | Sensitivity | Scripting

Drive | E-Magnetics | Phasor Diagram | Equivalent Circuit | Flux Densities | Losses | Winding | Miscellaneous | Materials

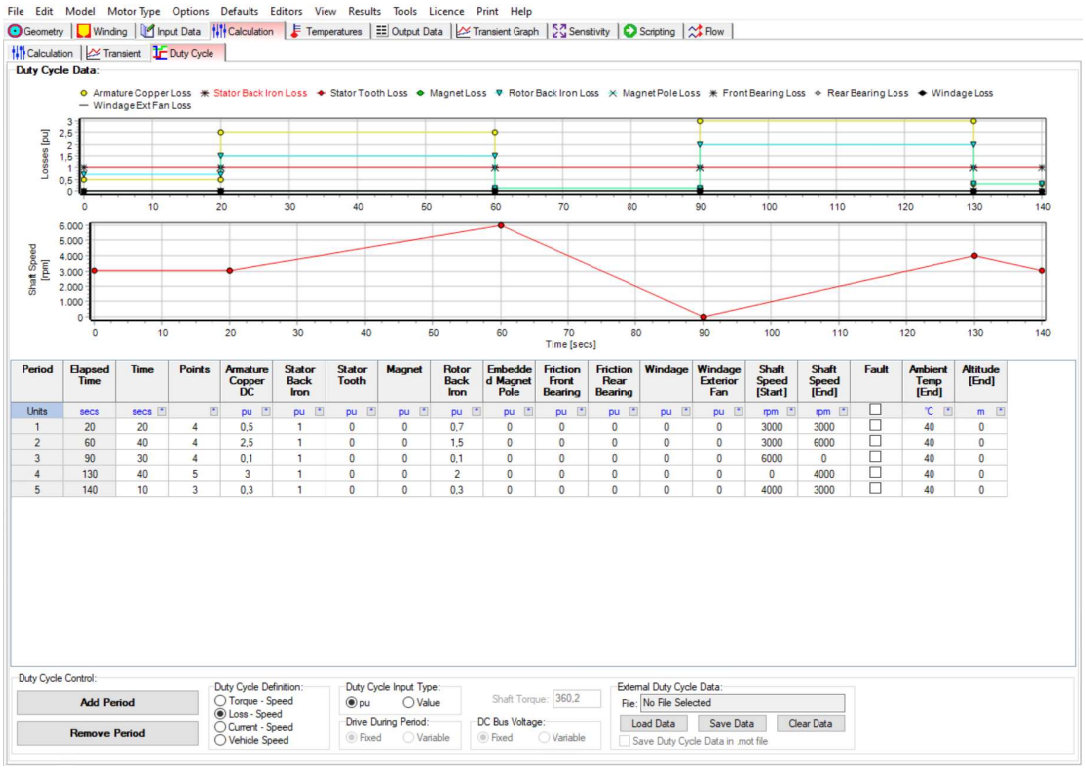
| Variable | Value | Units |
|---|---|---|
| Maximum torque possible (DQ) (For Phase Advance of 25,67 EDeg) | 741,9 | Nm |
| Average torque (virtual work) | 741,61 | Nm |
| Average torque (loop torque) | 736,4 | Nm |
| Torque Ripple (MsVw) | 56,258 | Nm |
| Torque Ripple (MsVw) [%] | 7,6359 | % |
| Speed limit for constant torque (For Phase Advance of 25 EDeg) | 3152,8 | rpm |
| No load speed | 4820,6 | rpm |
| Speed limit for zero q axis current | INF | rpm |
| ---- | | |
| Electromagnetic Power | 2,3146E005 | Watts |
| Input Power | 2,3781E005 | Watts |
| Total Losses (on load) | 7625,8 | Watts |
| Output Power | 2,3018E005 | Watts |
| System Efficiency | 96,793 | % |
| ---- | | |
| Shaft Torque | 732,69 | Nm |
| ---- | | |
| Power Factor [Waveform] (lagging) | 0,78619 | |
| Power Factor Angle [Waveform] | 38,169 | EDeg |
| Power Factor [THD] | 0,76076 | |
| Power Factor [Phasor] (lagging) | 0,78801 | |
| Power Factor Angle [Phasor] | 38 | EDeg |
| Load Angle [Phasor] | 63,167 | EDeg |
| Phase Terminal Voltage (rms) [Phasor] | 318,79 | Volts |
| ---- | | |
| Rotor Inertia | 0,30912 | kgm² |
| Shaft Inertia | 0,001962 | kgm² |
| Total Inertia | 0,31108 | kgm² |
| Torque per rotor volume | 110,37 | kNm/m³ |
| Rotor peripheral velocity (on load) | 35,814 | m/s |

| Variable | Value | Units |
|---|---|---|
| Flux Linkage D (Q axis current) | 234,457 | mVs |
| Flux Linkage Q (Q axis current) | 301,663 | mVs |
| Flux linkage D (On load) | 155,31 | mVs |
| Flux linkage Q (On load) | 317,04 | mVs |
| ---- | | |
| Torque Constant (Kt) | 1,63723 | Nm/A |
| Motor Constant (Km) | 9,35023 | Nm/(Watts^0.5) |
| Back EMF Constant (Ke) (fundamental) | 1,62436 | Vs/Rad |
| ---- | | |
| Stall Current | 20058,5 | Amps |
| Stall Torque | 32840,5 | Nm |
| ---- | | |
| Cogging Period | 15 | MDeg |
| Cogging Frequency | 1200 | Hz |
| Fundamental Frequency | 200 | Hz |
| Mechanical Frequency | 50 | Hz |
| Optimum Skewing Angle | 15 | MDeg |
| ---- | | |
| Magnetic Symmetry Factor (Automatic calculation) | 8 | |
| Magnetic Axial Length (Slice1) | 163,5 | mm |

# MOTOR-CAD TRANSIENT ANALYSIS

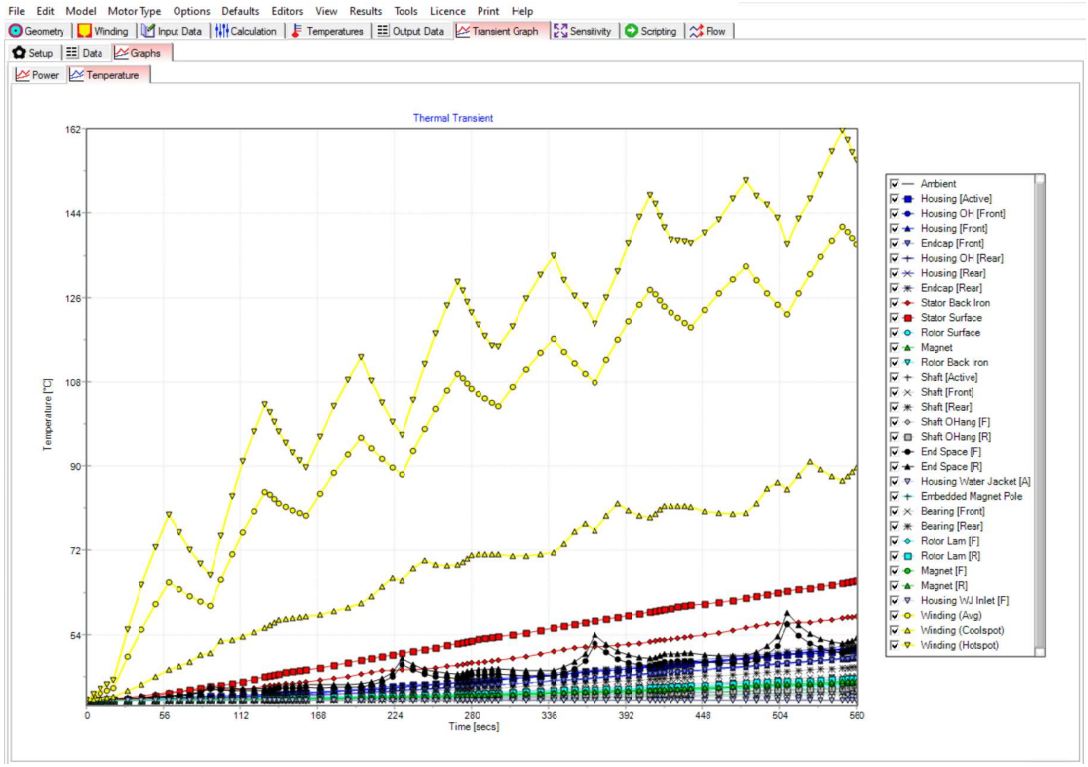


# MOTOR-CAD DUTY CYCLE

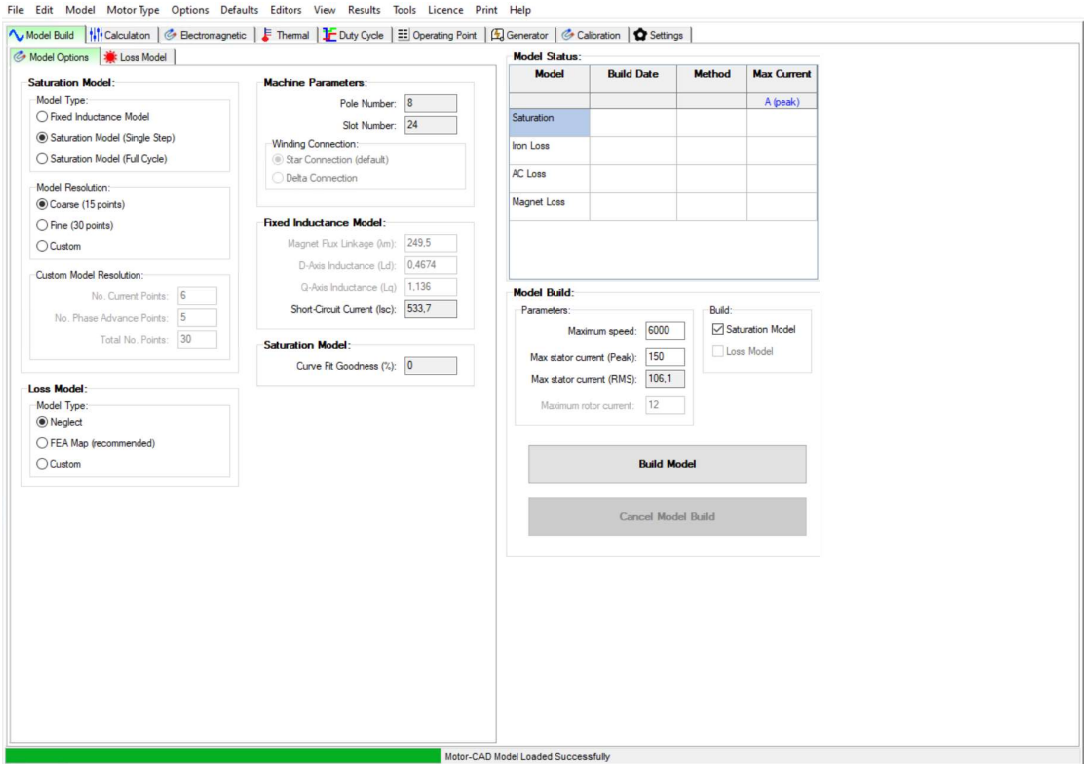



| Period | Elapsed Time | Time | Points | Armature Copper DC | Stator Back Iron | Stator Tooth | Magnet | Rotor Back Iron | Embedded Magnet Pole | Friction Front Bearing | Friction Rear Bearing | Windage | Windage Exterior Fan | Shaft Speed [Start] | Shaft Speed [End] | Fault | Ambient Temp [End] | Altitude [End] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Units | secs | secs | | pu | pu | pu | pu | pu | pu | pu | pu | pu | pu | rpm | rpm | | °C | m |
| 1 | 20 | 20 | 4 | 0,5 | 1 | 0 | 0 | 0,7 | 0 | 0 | 0 | 0 | 0 | 3000 | 3000 | ☐ | 40 | 0 |
| 2 | 60 | 40 | 4 | 2,5 | 1 | 0 | 0 | 1,5 | 0 | 0 | 0 | 0 | 0 | 3000 | 6000 | ☐ | 40 | 0 |
| 3 | 90 | 30 | 4 | 0,1 | 1 | 0 | 0 | 0,1 | 0 | 0 | 0 | 0 | 0 | 6000 | 0 | ☐ | 40 | 0 |
| 4 | 130 | 40 | 5 | 3 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 4000 | ☐ | 40 | 0 |
| 5 | 140 | 10 | 3 | 0,3 | 1 | 0 | 0 | 0,3 | 0 | 0 | 0 | 0 | 0 | 4000 | 3000 | ☐ | 40 | 0 |

# MOTOR-CAD DUTY CYCLE



# MOTOR-CAD LAB MODEL



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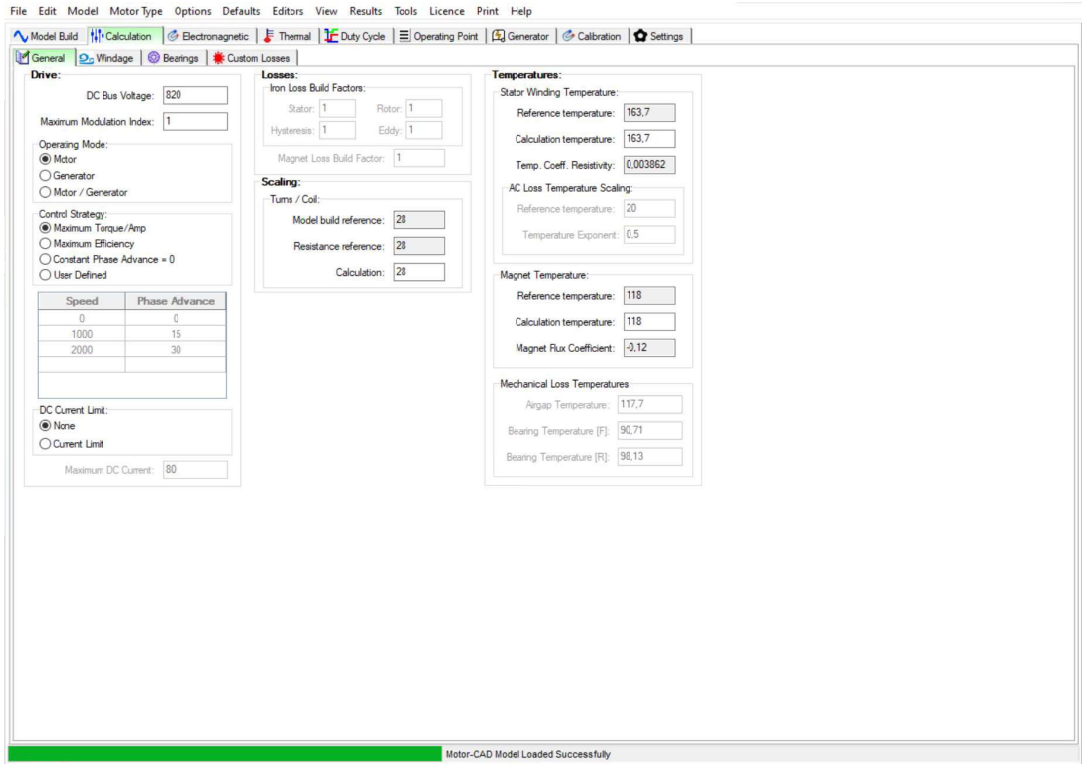
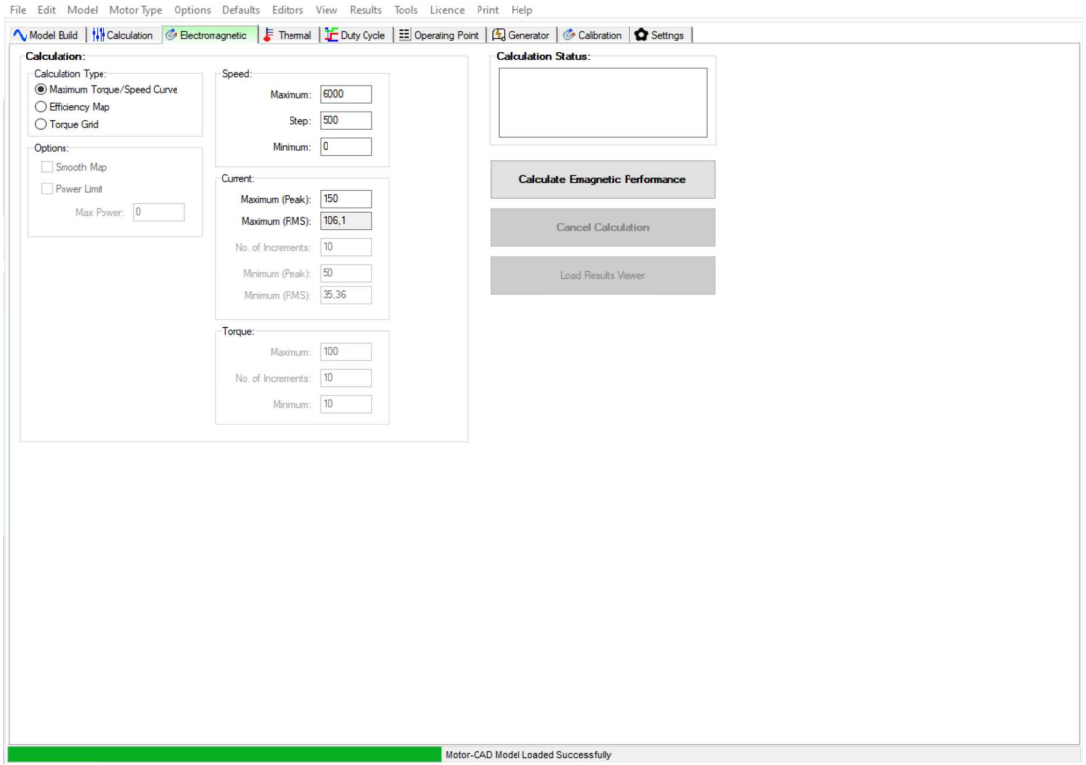
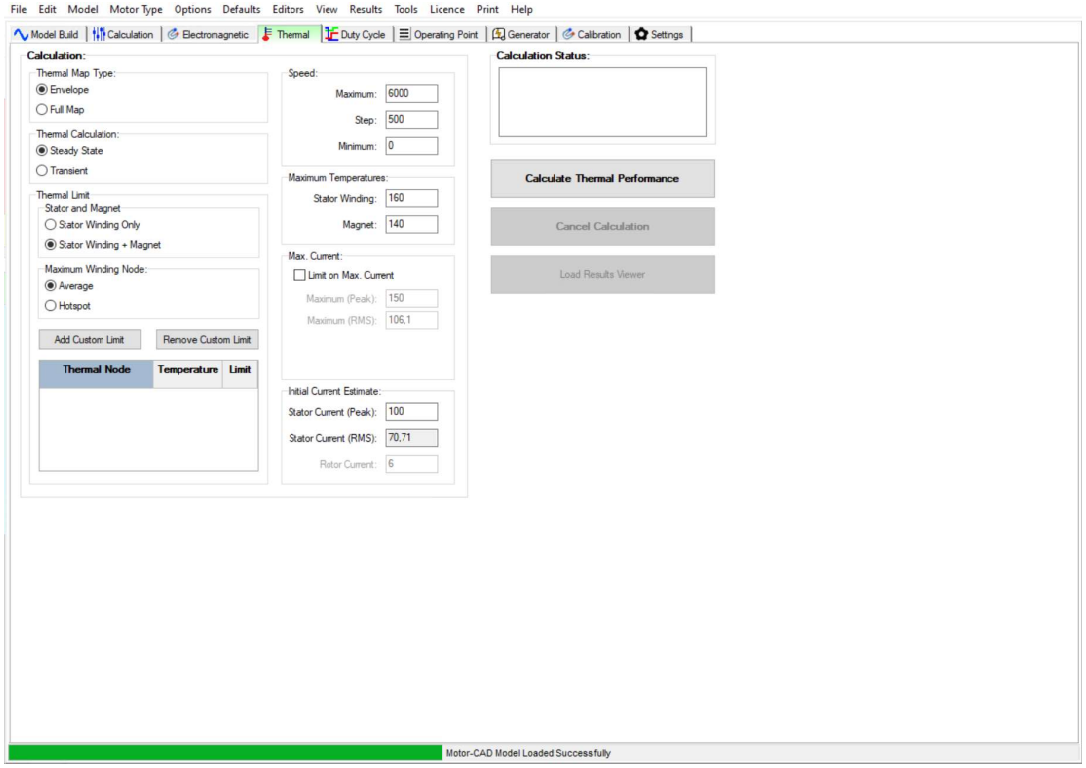


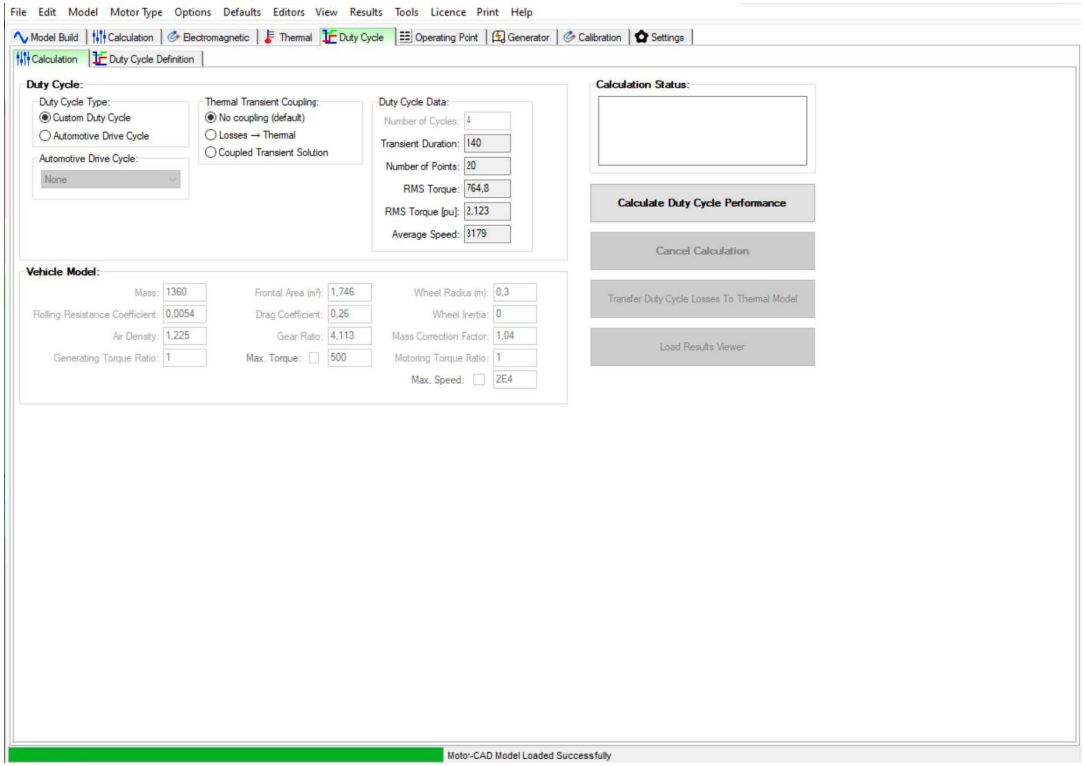
# MOTOR-CAD LAB MODEL

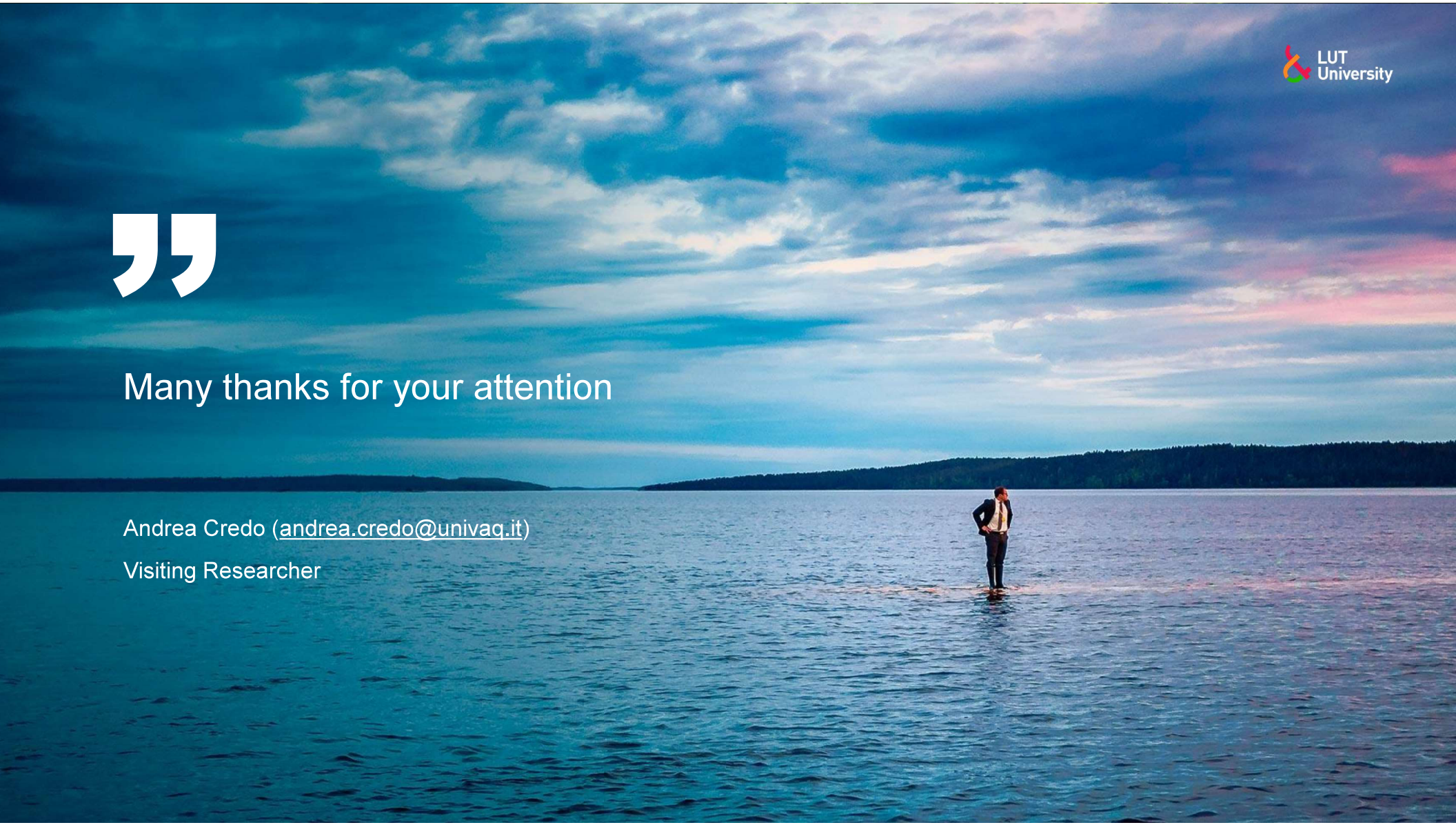


# MOTOR-CAD LAB MODEL



# MOTOR-CAD LAB MODEL






# Many thanks for your attention

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Visiting Researcher