DESIGN OF YAW AND PITCH MOTOR FOR WIND TURBINE APPLICATION

Corporate Presentation

#How it's started

#How it's goin

Turkey

1965

1997
By switching to the QS Engine series

2002
EFF1 energy efficiency level

2008
R&D center established

1989

2009
IE2 energy efficiency level

2010
IE3 energy efficiency level

2014
IE4 energy efficiency level

Worldwide

TODA
Y

2018
WAT Motor Transformatio nal Moves

#Transformati

Turkey’s Largest* Motor Company Europe’s Nr. 1 Choice from Turkey

40.000m²

Greater İstanbul Turkey

Total 956

R&D 102

+30 Countries

+200 Accounts

79 International Customers

+6k Nr. SKU’s

*In terms of Export.

Locations

Greater İstanbul

We Are Here!

Offic e

Çerkezköy
Sütlüce
Tuzla

Factory

Çerkezköy

Warehouse

Çerkezkö y
9800m2

R&D Centers

1. Çerkezköy
2. Tuzla

Liaison Office

İstanbul
Ankara
Hannover

- 163 km to EU border
- 87 km to İstanbul
- 168 km to İstanbul Sabiha Gökçen airport

Multiple Certifications

Defence Compatibility

EYDEP

*A+ 96 Score

AS9100D CERTIFIED ISO 9001

*TEI Assesment

STANDARD MIL-STD 810G

Business Segments

Sectors

Industry

General Purpose Motors
Definite Purpose Motors
EC Motors

Renewable

Wind Generators & Components
Wind Auxiliary Systems

Motion Control

Servo Motors (BLDC)
Servo Drivers
Intralogistics Solutions
Motion Control Algorithms & Embedded System Design

Defence

Payload Servo Solutions
Ground Vehicle Solutions
Aviation Alternator Systems
Guidance & Air Domain Systems

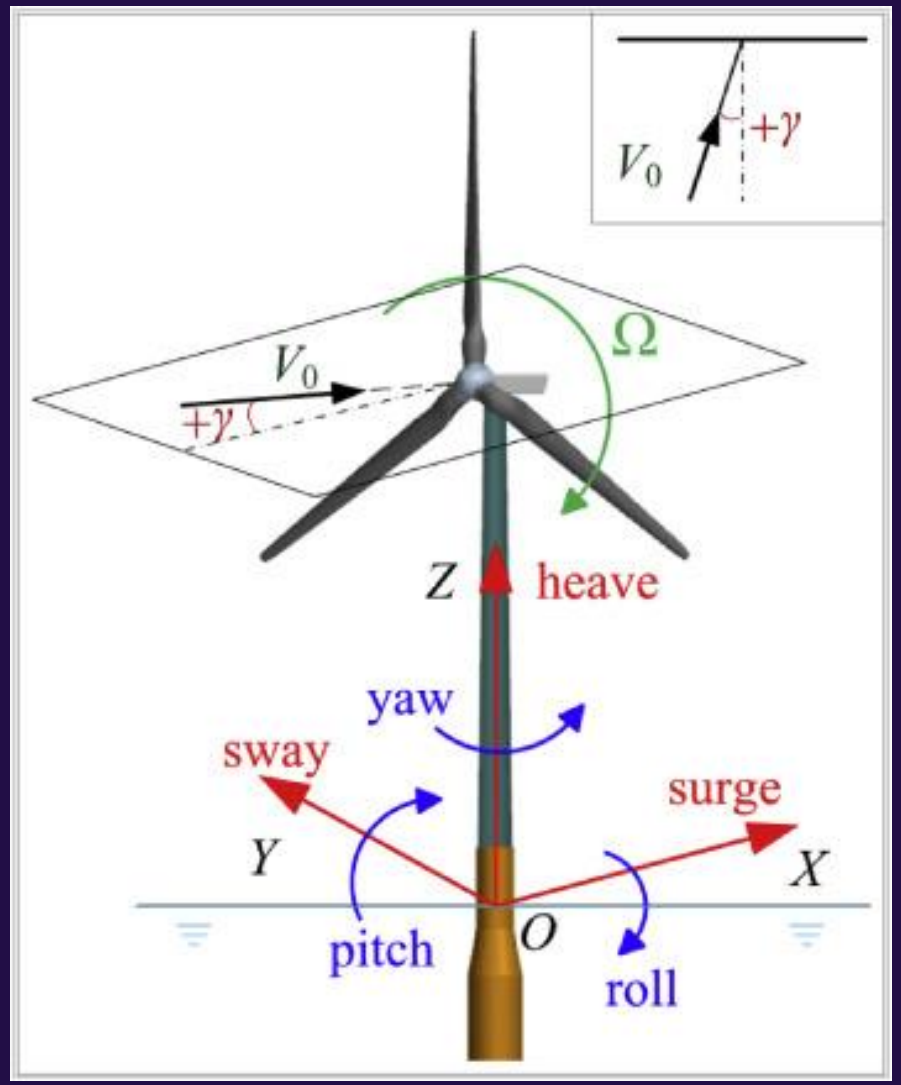
Mobility

Light E-Mobility Electrification
Automotive Traction Auxiliary Systems

EV Chargers & Charging Infrastructure

AC EV Chargers
DC EV Chargers
Digital Platform

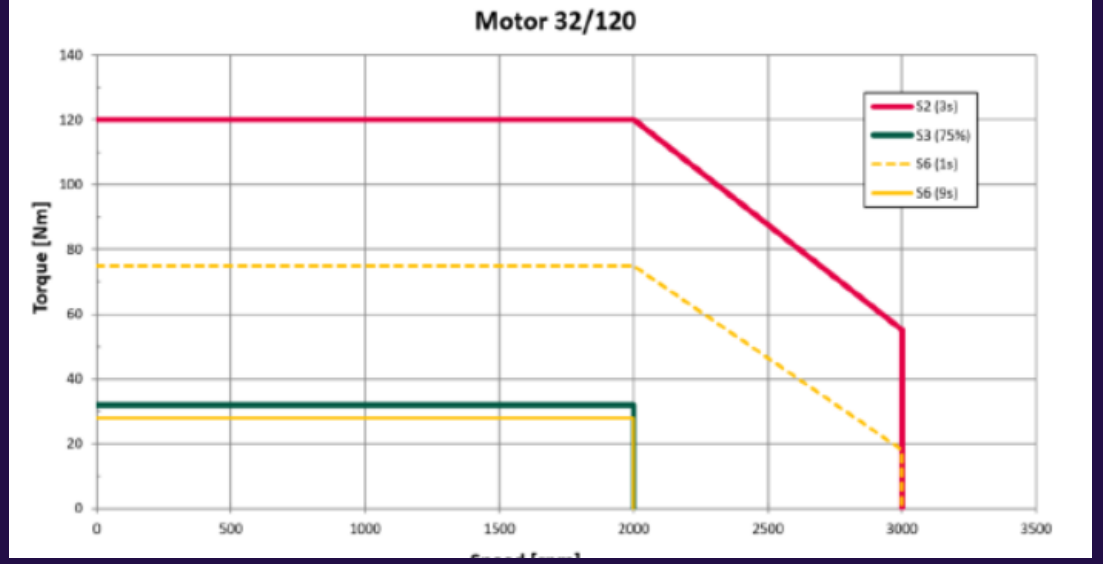
WHAT ARE MEANINGS OF YAW AND PITCH?



REQUIREMENTS

The motor shall have the following shaft torque-speed-curve for the Motor 32/120:

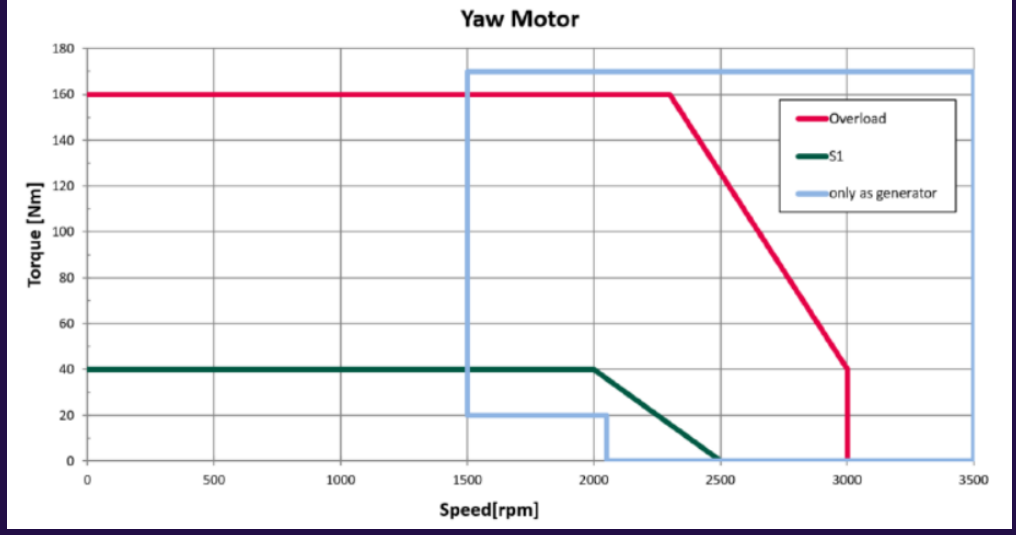
Rotational speed [rpm]	Torque (S3) 75% [Nm]	S6 Peak torque [Nm]	S6 Base torque [Nm]	Torque (S2) [Nm]
Cycle time	45s on / 15s off	1s	9s	3s
0	32	75	28	120
2000	32	75	28	120
3000	0	18	0	55



Pitch motor requirements

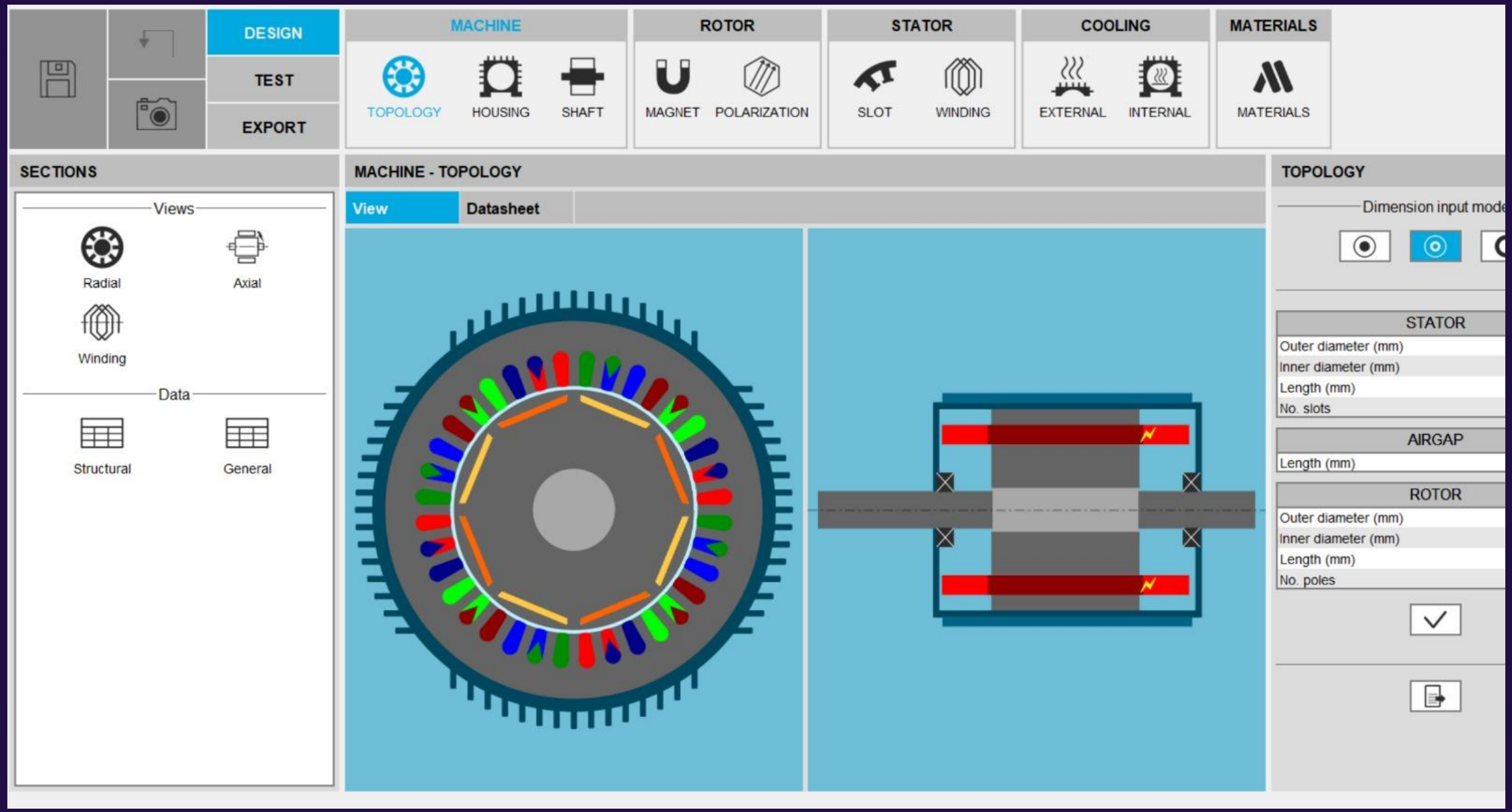
The motor shall have the following shaft torque and shaft speed curve:

Rotational shaft speed [rpm]	Shaft torque S1 [Nm]	Overload [Nm]
0	40	160
2000	40	160
2300	15	160
2500	0	125
3000		40

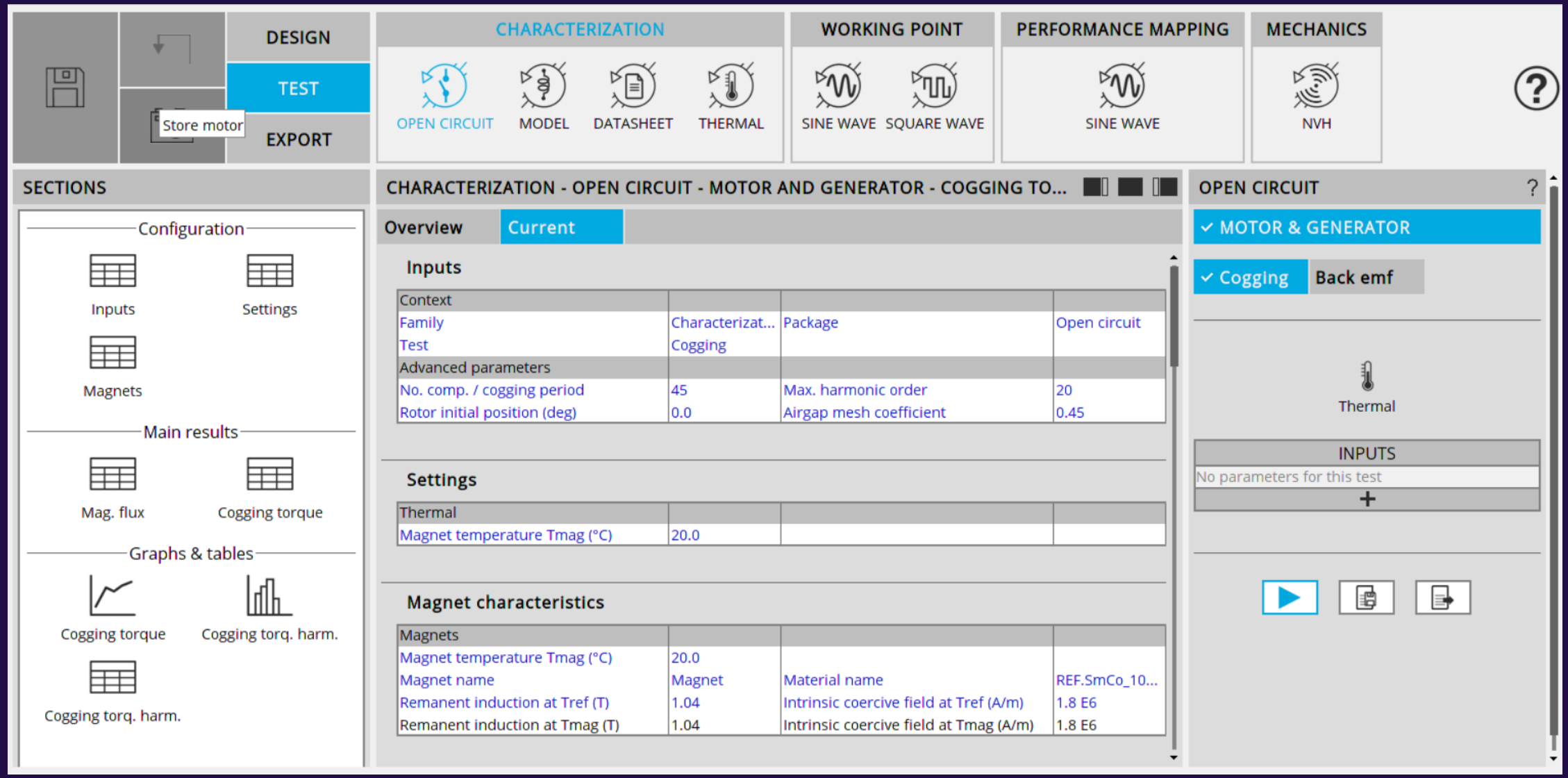


Yaw motor requirements

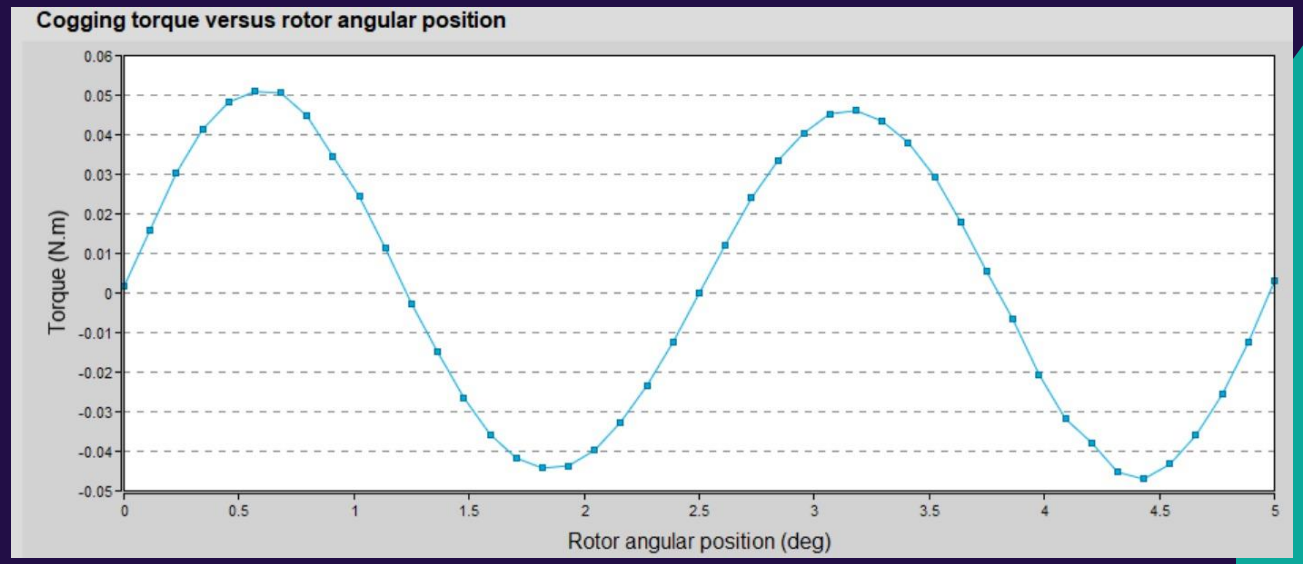
MULTIPHYSICS DESIGN



MULTIPHYSICS DESIGN

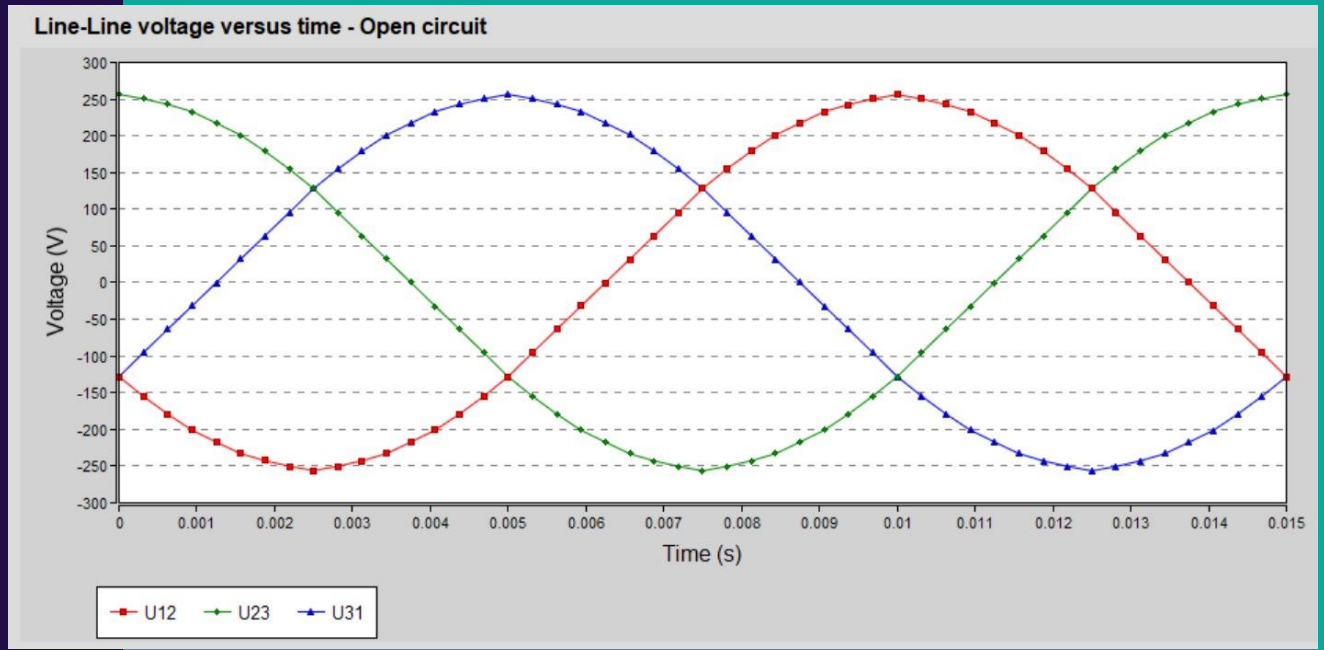


COGGING TORQUE AND BACK EMF ANALYSIS

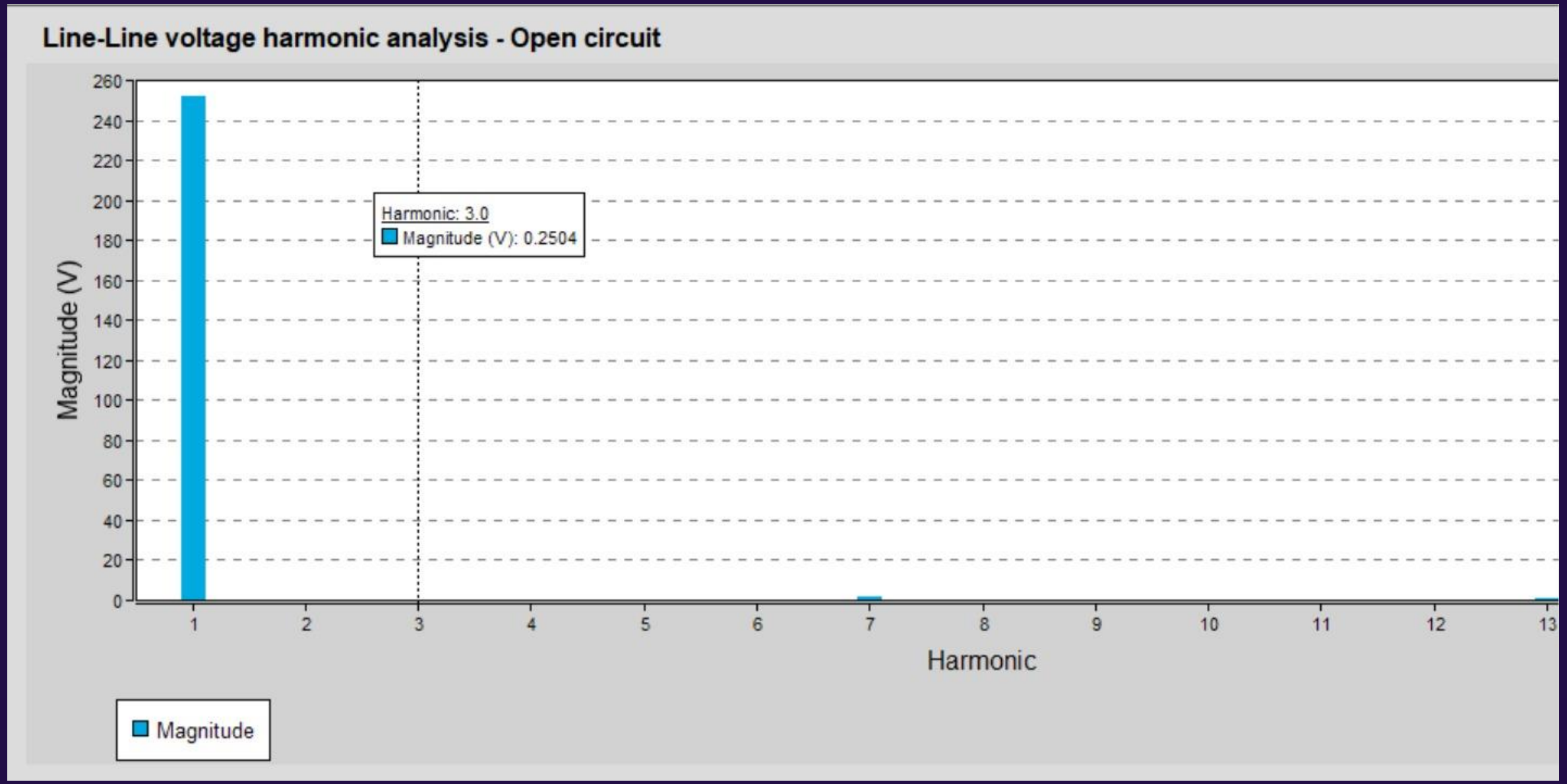


COGGİNG TORQUE

BACK EMF



BACK EMF HARMONICS

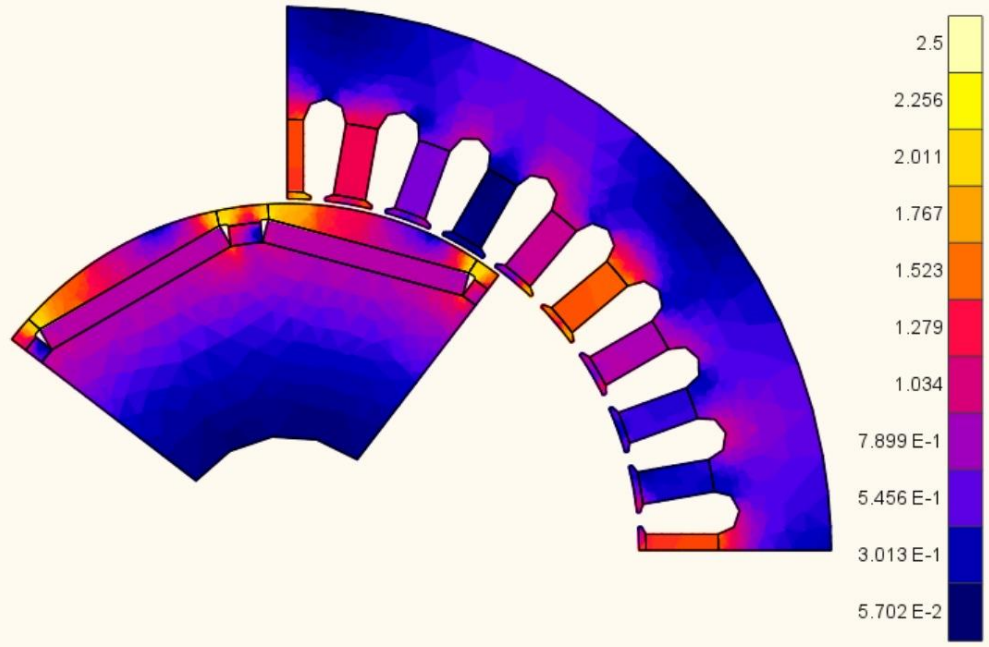


WORKING POINT ANALYSIS RESULTS

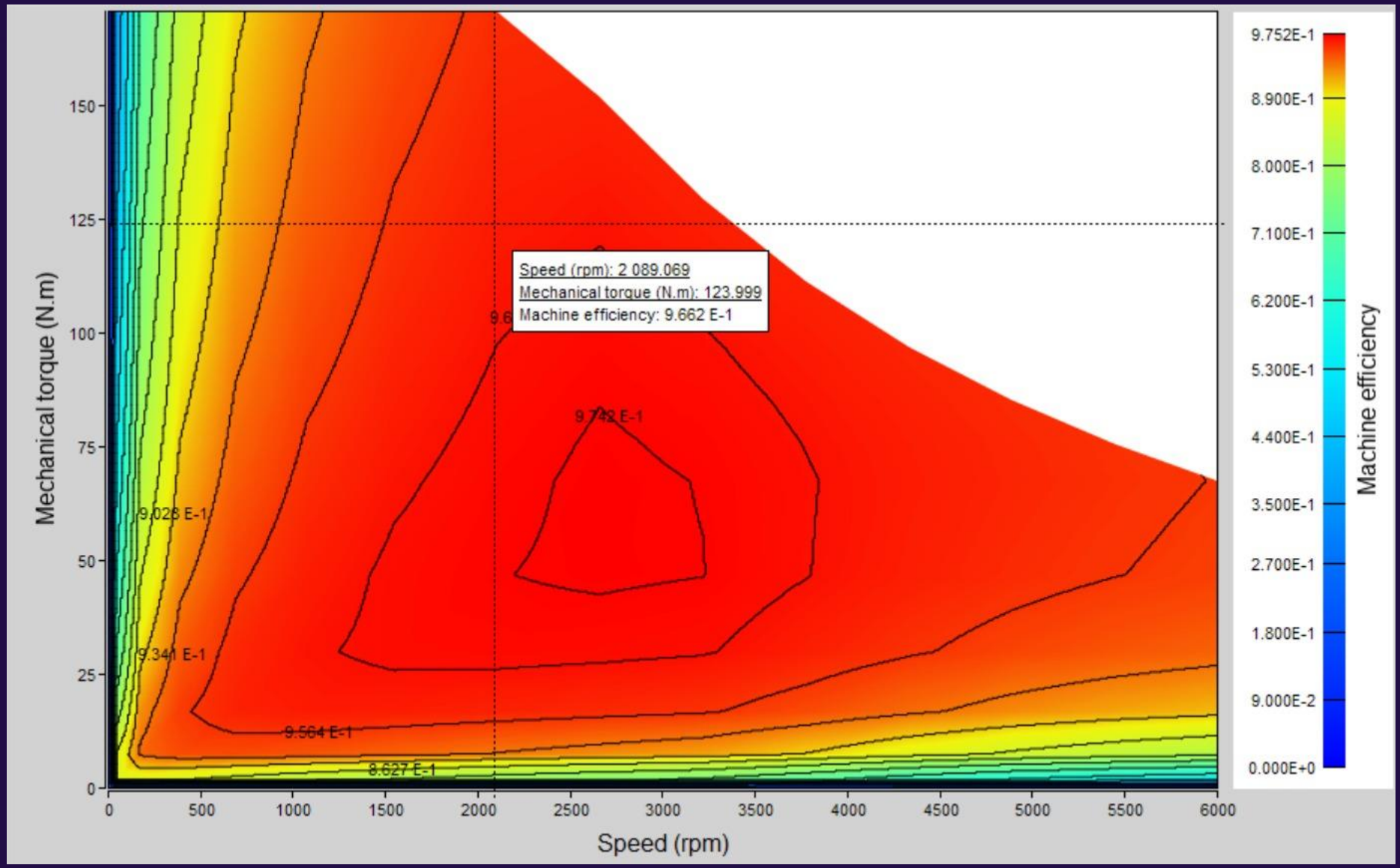
Machine performance - Working point

General data				
Operating mode	Motor			
Mechanical torque (N.m)	**40.697**	**Speed (rpm)**	**2 800.0**	Electrical frequency (Hz)
Mechanical power (W)	11 932.852	Machine electrical power (W)	12 279.933	Machine total losses (W)
Machine efficiency (%)	**97.174**	Apparent power (VA)	12 414.377	Reactive power (VAr)
Control angle (deg)	**26.0**	Power factor	9.892 E-1	Phase angle (deg)
Line current, rms (A)	**14.6**	Phase current, rms (A)	14.6	
Line-Line voltage, rms (V)	**490.921**	Phase voltage, rms (V)	283.433	
Machine constants				
Current density, rms (A/mm2)	3.254	Electrical loading, rms (A/m)	17 623.28	Power density (W/kg)
kT (N.m/A)	1.971			
Power balance				
Machine total losses (W)	347.082	Joule losses (W)	163.88	
Mechanical losses (W)	0.0	Total Iron losses (W)	183.202	Additional losses (W)
Flux in airgap				
Flux density, ARV (T)	**4.568 E-1**	Flux density 1st harm., rms (T)	4.893 E-1	Flux density, peak (T)
Flux / pole, ARV (Wb)	**4.058 E-3**	Flux / pole 1st harm., rms (Wb)	4.347 E-3	Flux / pole, peak (Wb)
Flux density in iron				
Stator tooth, max (T)	1.504	Stator tooth, mean (T)	8.253 E-1	
Stator foot tooth, max (T)	1.913	Stator foot tooth, mean (T)	8.516 E-1	
Stator yoke, max (T)	1.472	Stator yoke, mean (T)	4.935 E-1	
Rotor yoke, max (T)	1.446	Rotor yoke, mean (T)	4.964 E-1	
Rotor bridge, max (T)	2.3	Rotor bridge, mean (T)	1.648	
Rotor pole shoe, max (T)	2.291	Rotor pole shoe, mean (T)	1.132	
Interpole, max (T)	1.739	Interpole, mean (T)	7.574 E-1	

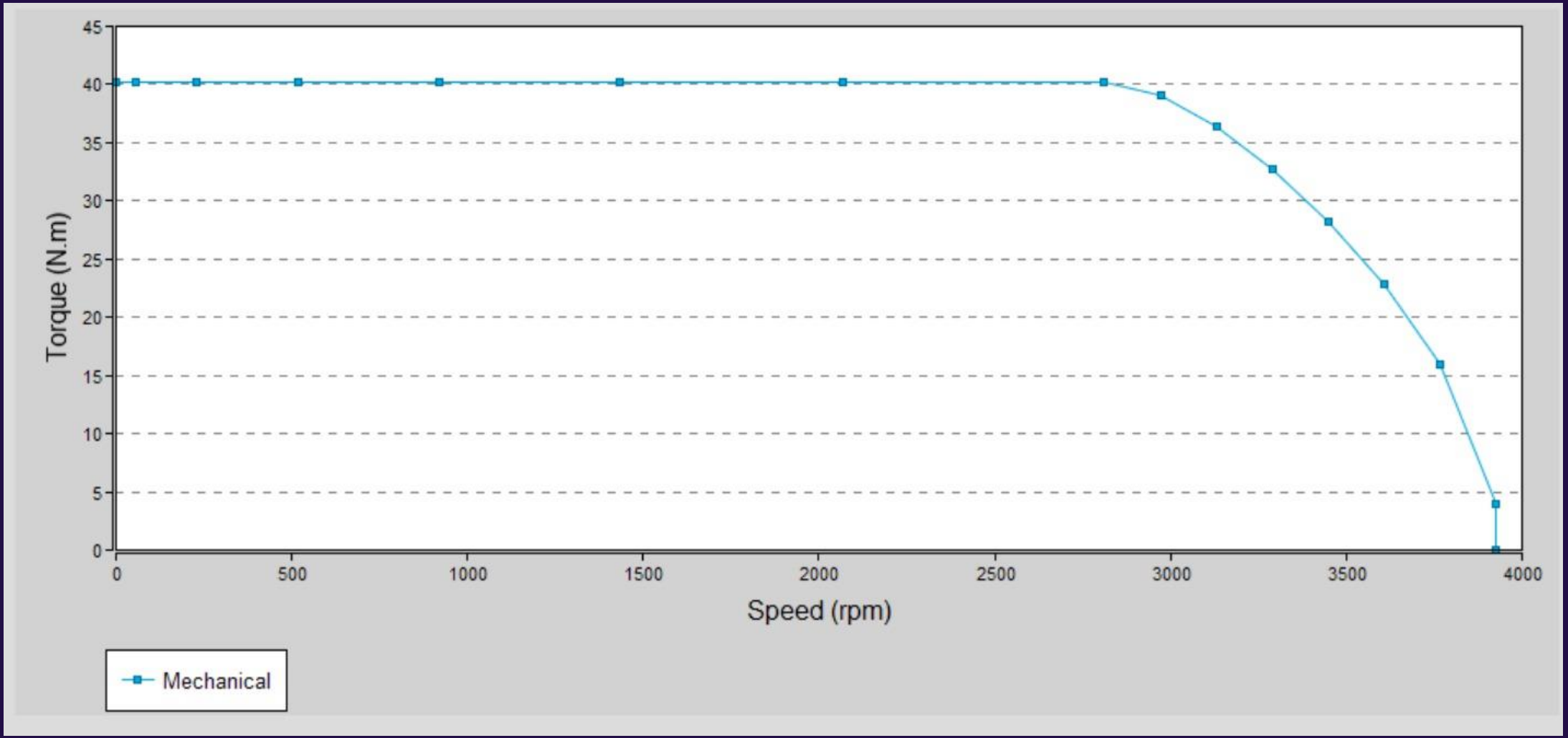
Isovalues



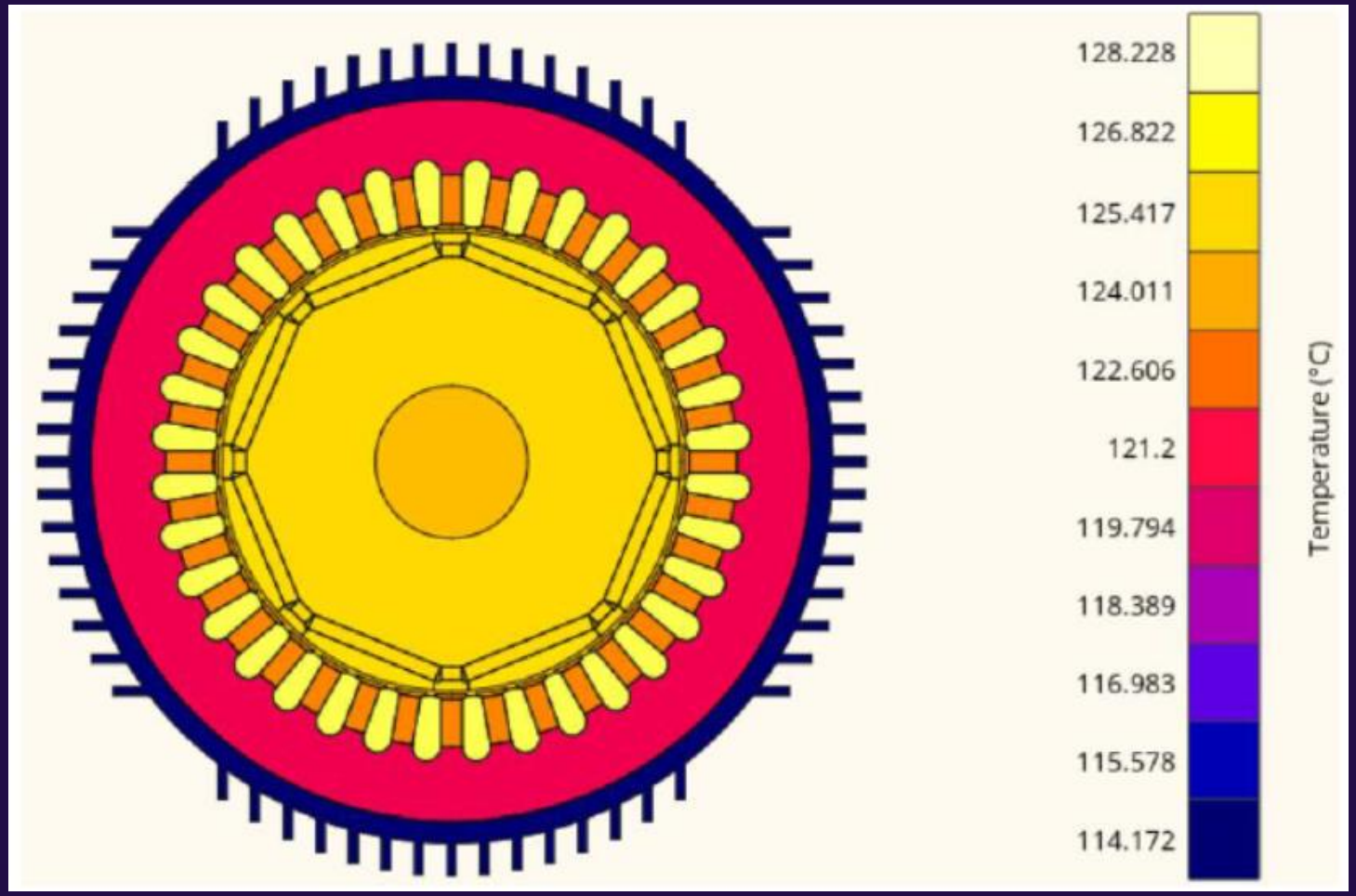
EFFICIENCY MAP



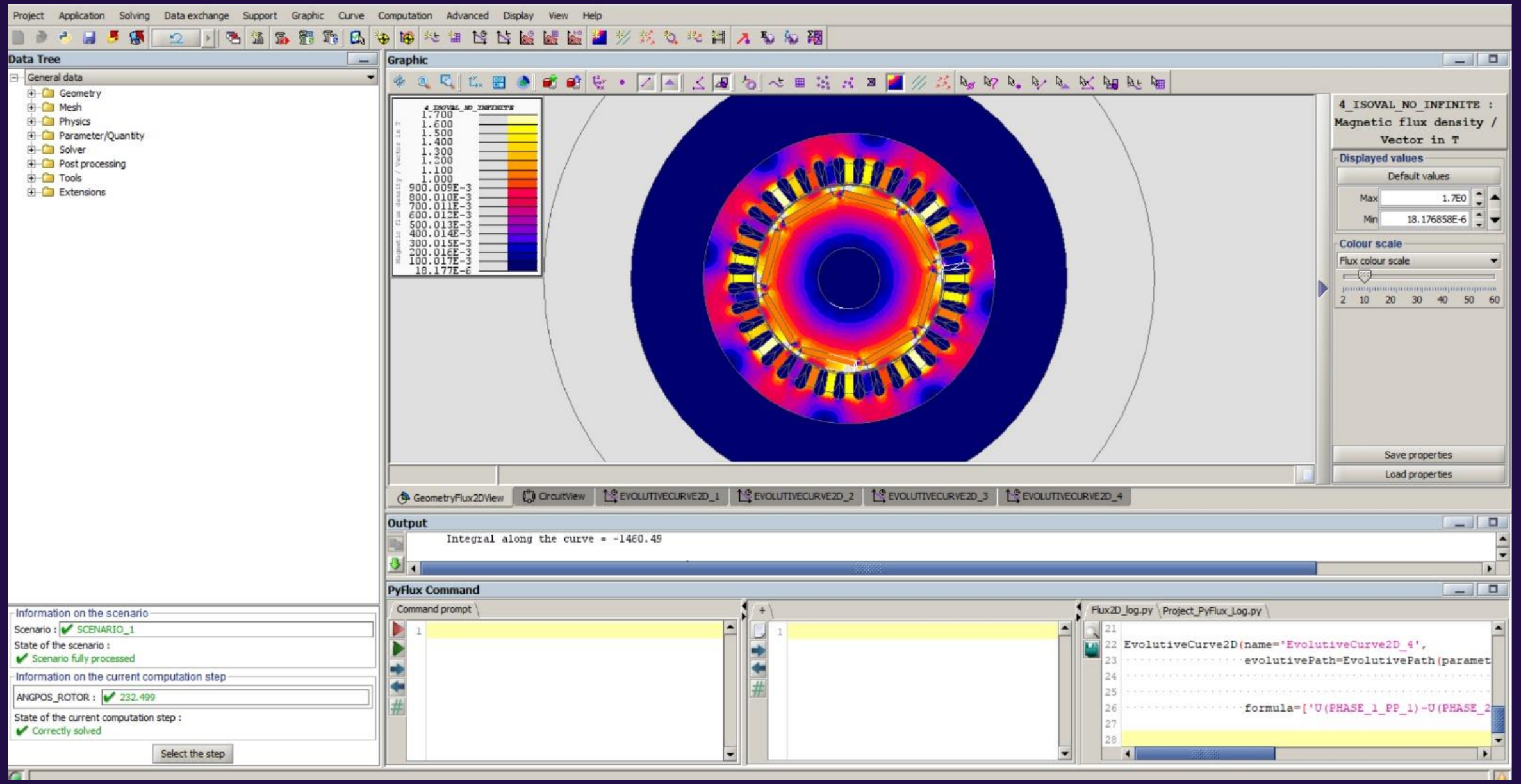
TORQUE VS SPEED MAP



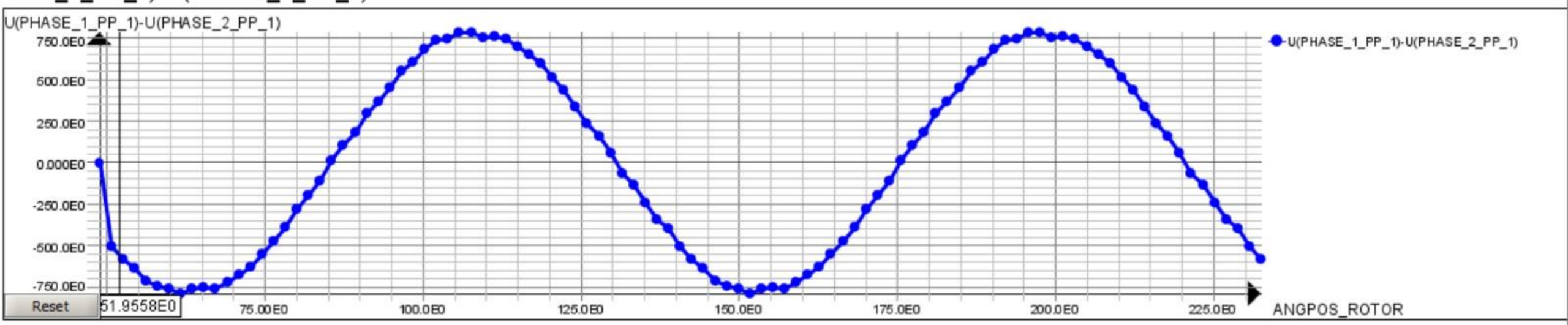
THERMAL RESULTS

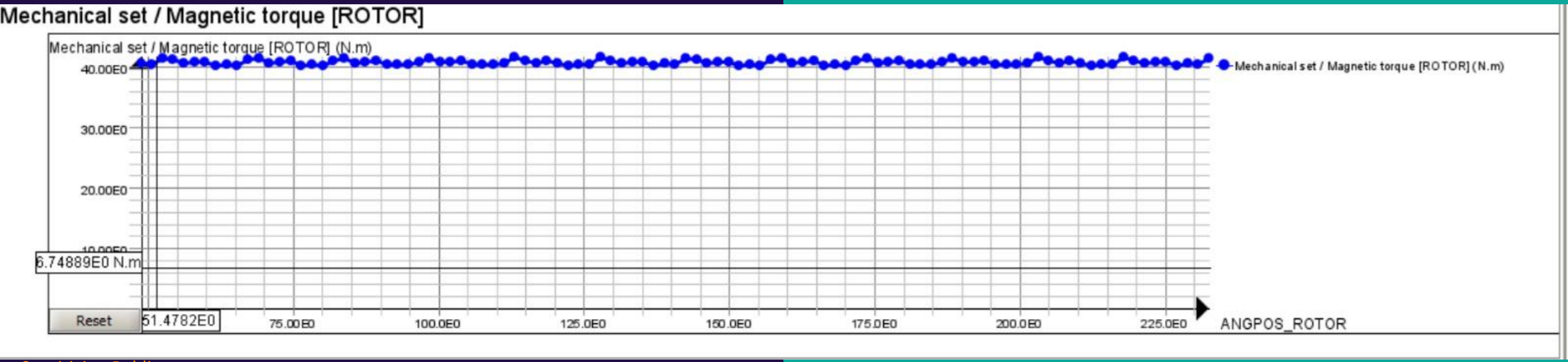


FEA ANALYSIS

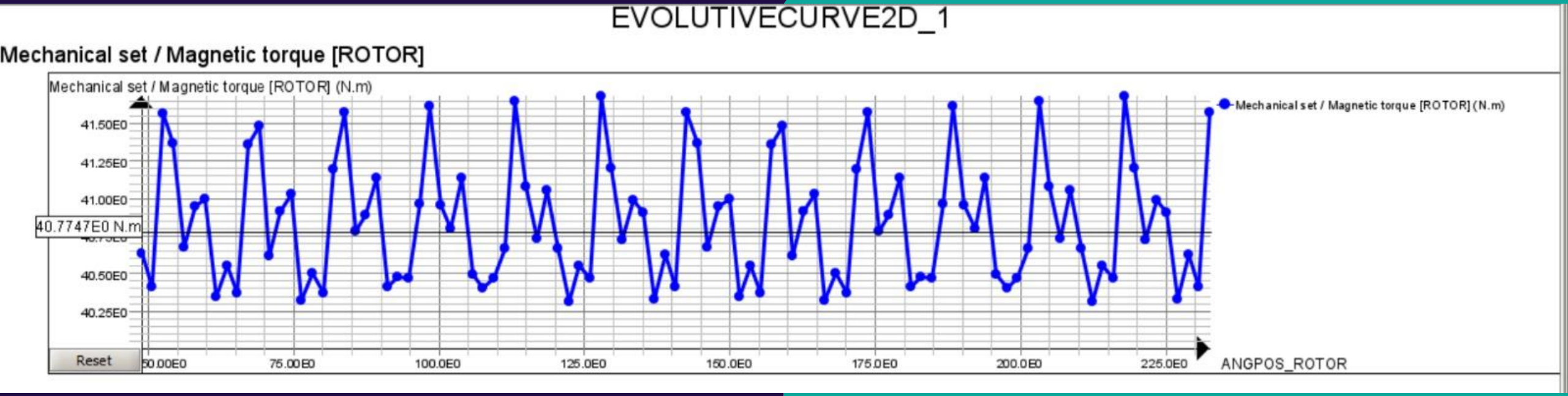


FEA ANALYSIS



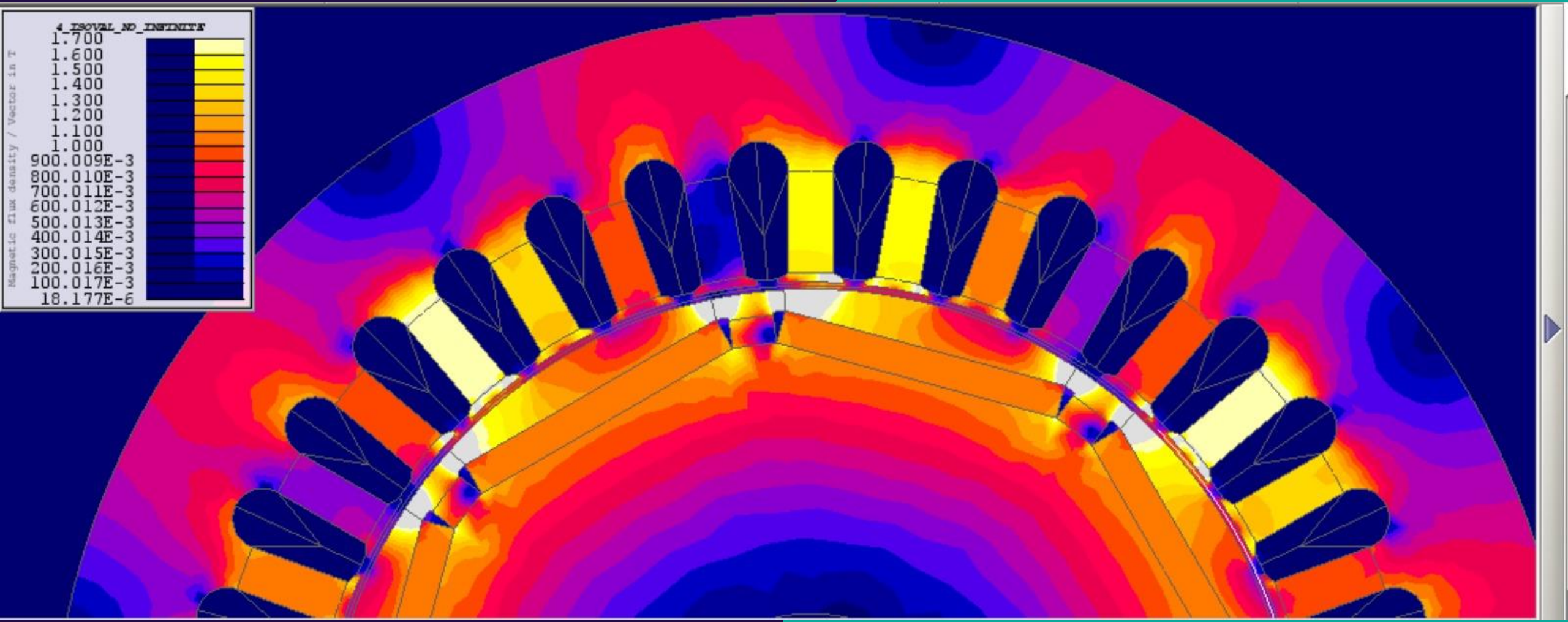


TORQUE RIPPLE ANALYSIS



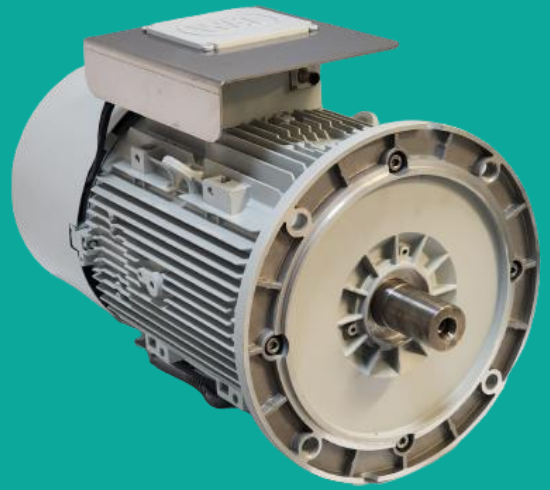
Torque Ripple =3,06

MAGNETIC SATURATION



DESIGN RESULTS

	Design Requirements	Design Results
Max. Current	<15 A	14.6 A
Maximum speed	<4400 rpm	4000 rpm
Maximum torque	160 Nm	160 Nm
Minimum Efficiency	92	96,67
Cooling Type	Self cooling	Self cooling decided



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