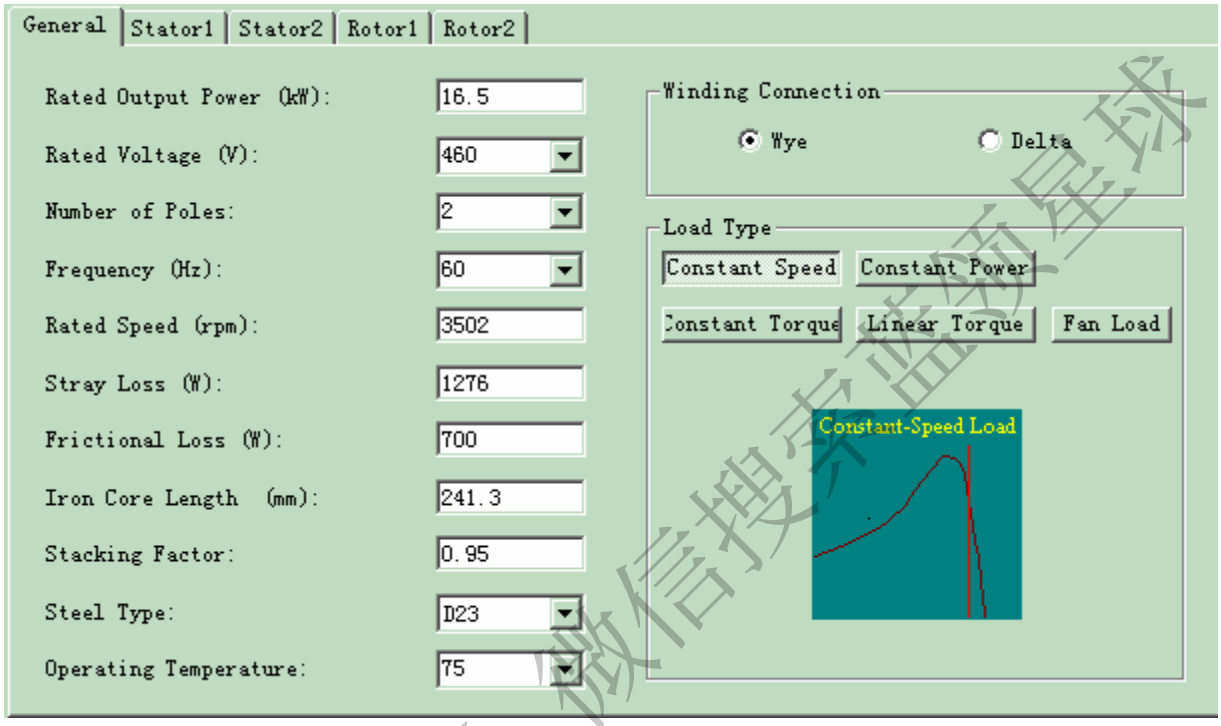
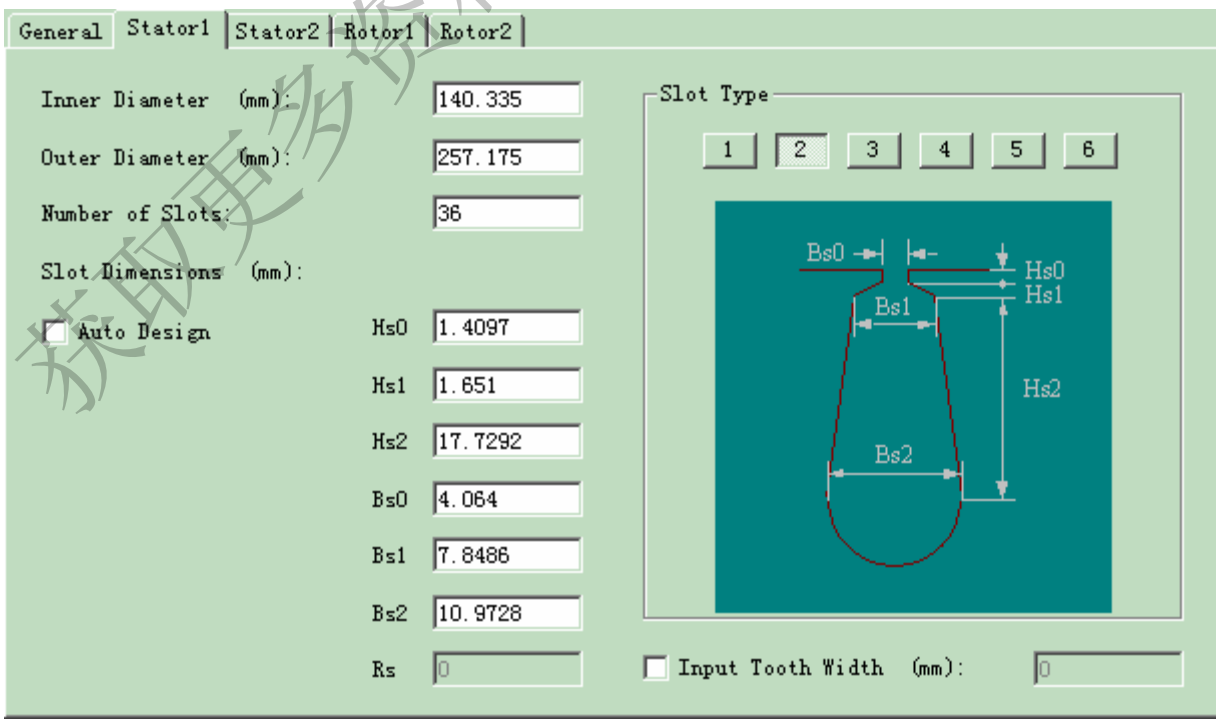
参考分析过程

一、 电机采用 RMxprt 进行路的方法计算：

1、 输入数据：



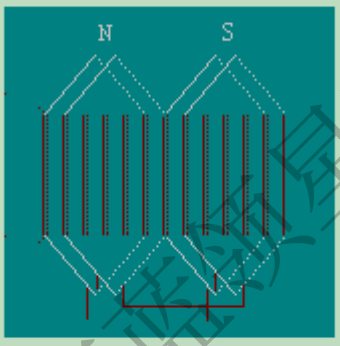


General | Stator1 | Stator2 | Rotor1 | Rotor2

Top Spare Area (%):	0
Bottom Spare Area (%):	0
Slot Insulation (mm):	0.254
End Adjustment (mm):	0
Parallel Branches:	1
Conductors per Slot:	12
Coil Pitch:	16
Wires per Conductor:	4.378
Wire Wrap (mm):	0.254
Wire Diameter (mm):	1.45001
Gauge:	15

Winding Type

10 | 11 | 12 | 20 | 21 | 22



General | Stator1 | Stator2 | Rotor1 | Rotor2

Air Gap (mm):	1.1684
Inner Diameter (mm):	47.625

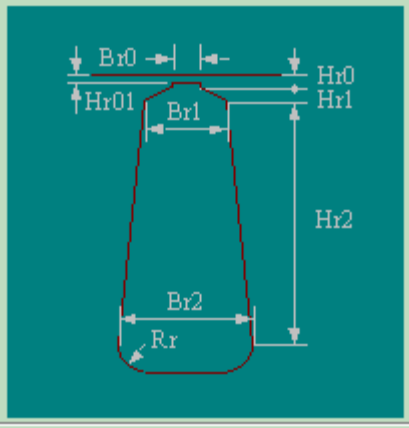
Slot Dimensions (mm):

	Top slot	Bottom slot
No.	28	28
Hr0	0.5461	0
Hr01	0.5461	
Hr1	0.254	0
Hr2	5.588	11.176
Br0	0.254	4.064
Br1	3.81	7.62
Br2	4.064	5.08
Rr	0	0

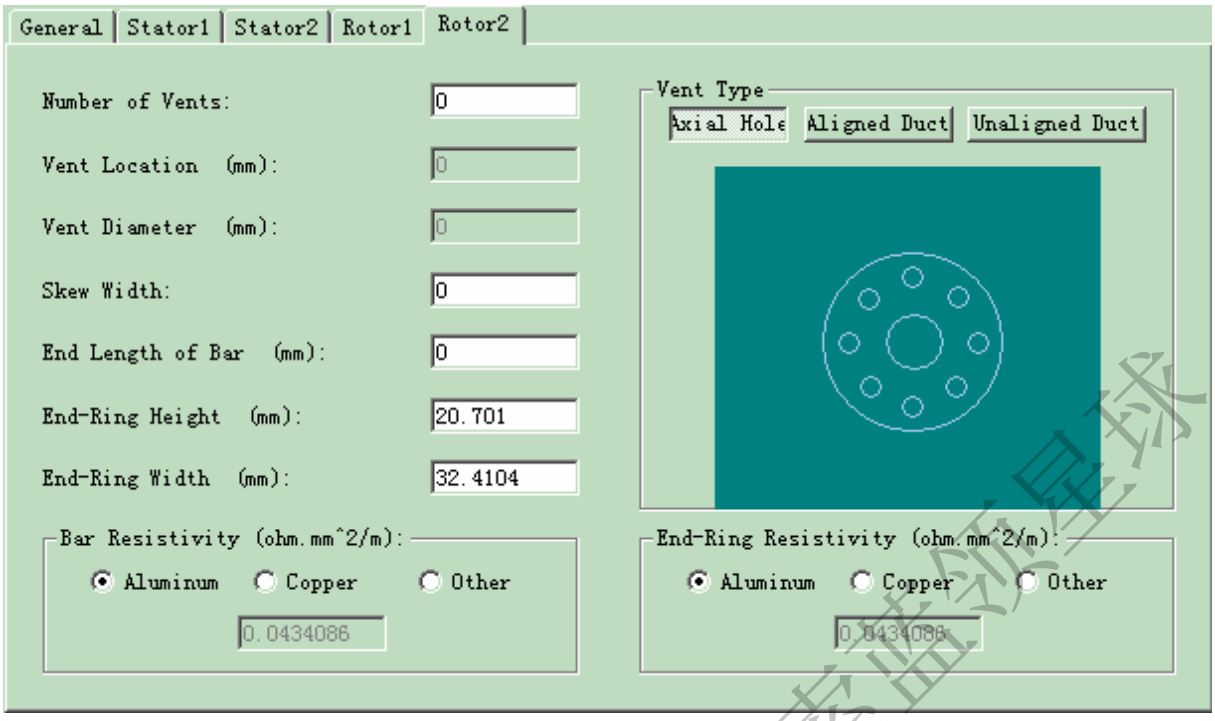
Slot Type

Top: 1 | 2 | 3 | 4

Bottom: 1 | 2 | 3 | 4



☑ Cast Rotor ☐ Half Slot



二、计算详细输出结果-数据部分

Three-Phase Induction Motor Design

File: d:/demo/machine/3phind-1.pjt/3phind-1.res

GENERAL DATA

Given Output Power (kW):	16.5
Rated Voltage (V):	460
Winding Connection:	Wye
Number of Poles:	2
Given Speed (rpm):	3502
Frequency (Hz):	60
Stray Loss (W):	1276
Friction and Wind Loss (W):	700
Type of Load:	Constant Speed
Iron Core Length (mm):	241.3
Stacking Factor of Iron Core:	0.95
Type of Steel:	D23
Operating Temperature (C):	75

STATOR DATA

Number of Stator Slots:	36
Outer Diameter of Stator (mm):	257.175

Inner Diameter of Stator (mm):	140.335
Type of Stator Slot:	2
Dimension of Stator Slot	
hs0_stator (mm):	1.4097
hs1_stator (mm):	1.651
hs2_stator (mm):	17.7292
bs0_stator (mm):	4.064
bs1_stator (mm):	7.8486
bs2_stator (mm):	10.9728
Top Tooth Width (mm):	4.93213
Bottom Tooth Width (mm):	4.90226
Number of Conductors per Slot:	12
Number of Parallel Branches:	1
Number of Wires per Conductor:	4.378
Type of Coils:	21
Coil Pitch:	16
Wire Diameter (mm):	1.45001
Wire Wrap Thickness (mm):	0.254
Slot Insulation Thickness (mm):	0.254
Top Free Space in Slot (%):	0
Bottom Free Space in Slot (%):	0
Conductor Length Adjustment (mm):	0

ROTOR DATA

Number of Rotor Slots:	28
Air Gap (mm):	1.1684
Inner Diameter of Rotor (mm):	47.625
Type of Rotor Slot:	3
Dimension of Rotor Slot	
hr0_top (mm):	0.5461
hr01_top (mm):	0.5461
hr1_top (mm):	0.254
hr2_top (mm):	5.588
br0_top (mm):	0.254
br1_top (mm):	3.81
br2_top (mm):	4.064
rr_top (mm):	0
Type of Bottom Rotor Slot:	3
Dimension of Bottom Rotor Slot	
hr0_bottom (mm):	0
hr1_bottom (mm):	0
hr2_bottom (mm):	11.176
br0_bottom (mm):	4.064
br1_bottom (mm):	7.62

br2_bottom (mm):	5.08
rr_bottom (mm):	0
Cast Rotor:	Yes
Half Slot:	No
Skew Width:	0
End Length of Bar (mm):	0
Height of End Ring (mm):	20.701
Width of End Ring (mm):	32.4104
Resistivity of Rotor Bar at 75 Centigrade (ohm.mm^2/m):	0.0434086
Resistivity of Rotor Ring at 75 Centigrade (ohm.mm^2/m):	0.0434086

MATERIAL CONSUMPTION

Armature Copper Density (kg/m^3):	8900
Rotor Bar Material Density (kg/m^3):	2700
Rotor Ring Material Density (kg/m^3):	2700
Armature Core Steel Density (kg/m^3):	7800
Rotor Core Steel Density (kg/m^3):	7800
Armature Copper Weight (kg):	1.62757
Rotor Bar Material Weight (kg):	1.70536
Rotor Ring Material Weight (kg):	1.32265
Armature Core Steel Weight (kg):	50.4387
Rotor Core Steel Weight (kg):	18.8777
Total Net Weight (kg):	73.972
Armature Core Steel Consumption (kg):	93.3773
Rotor Core Steel Consumption (kg):	27.6565

RATED-LOAD OPERATION

Stator Resistance (ohm):	0.253089
Stator Leakage Reactance (ohm):	1.0228
Rotor Resistance (ohm):	0.287023
Rotor Leakage Reactance (ohm):	1.20946
Resistance Corresponding to Iron-Core Loss (ohm):	782.242
Magnetizing Reactance (ohm):	45.0353
Stator Phase Current (A):	25.1328
Current Corresponding to Iron-Core Loss (A):	0.319865
Magnetizing Current (A):	5.55592

Rotor Phase Current (A):	23.5764
Copper Loss of Stator Winding (W):	479.595
Copper Loss of Rotor Winding (W):	478.621
Iron-Core Loss (W):	240.103
Friction & Wind Loss (W):	700
Stray Loss (W):	1276
Total Loss (W):	3174.32
Input Power (kW):	19.5777
Output Power (kW):	16.4034
Mechanical Shaft Torque (N.m):	44.7289
Efficiency (%):	83.786
Power Factor:	0.913971
Rated Slip:	0.0272222
Rated Shaft Speed (rpm):	3502

NO-LOAD OPERATION

No-Load Stator Resistance (ohm):	0.253089
No-Load Stator Leakage Reactance (ohm):	1.02329
No-Load Rotor Resistance (ohm):	0.286993
No-Load Rotor Leakage Reactance (ohm):	8.04386
No-Load Stator Phase Current (A):	5.92145
No-Load Iron-Core Loss (W):	257.943
No-Load Input Power (W):	2284.21
No-Load Power Factor:	0.213701
No-Load Slip:	0.00103014
No-Load Shaft Speed (rpm):	3596.29

BREAK-DOWN OPERATION

Break-Down Slip:	0.17
Break-Down Torque (N.m):	132.277
Break-Down Torque Ratio:	2.9573
Break-Down Phase Current (A):	101.661

LOCKED-ROTOR OPERATION

Locked-Rotor Torque (N.m):	54.3284
Locked-Rotor Phase Current (A):	149.589
Locked-Rotor Torque Ratio:	1.21461
Locked-Rotor Current Ratio:	5.95195

Locked-Rotor Stator Resistance (ohm):	0.253089
Locked-Rotor Stator Leakage Reactance (ohm):	1.01599
Locked-Rotor Rotor Resistance (ohm):	0.325616
Locked-Rotor Rotor Leakage Reactance (ohm):	0.67378

DETAILED DATA AT RATED OPERATION

Stator Slot Leakage Reactance (ohm):	0.549208
Stator End-Winding Leakage Reactance (ohm):	0.396411
Stator Differential Leakage Reactance (ohm):	0.0771798
Rotor Slot Leakage Reactance (ohm):	0.943582
Rotor End-Winding Leakage Reactance (ohm):	0.0526411
Rotor Differential Leakage Reactance (ohm):	0.213249
Skewing Leakage Reactance (ohm):	0
Slot Fill Factor (%):	78.4847
Stator Winding Factor:	0.941617
Stator-Teeth Flux Density (Tesla):	1.06718
Rotor-Teeth Flux Density (Tesla):	0.642609
Lower-Part Rotor-Teeth Flux Density (Tesla):	1.04649
Stator-Yoke Flux Density (Tesla):	0.891501
Rotor-Yoke Flux Density (Tesla):	0.696282
Air-Gap Flux Density (Tesla):	0.402755
Stator-Teeth Ampere Turns (A.T):	9.59168
Rotor-Teeth Ampere Turns (A.T):	1.12198
Lower-Part Rotor-Teeth Ampere Turns (A.T):	4.79376
Stator-Yoke Ampere Turns (A.T):	36.9241
Rotor-Yoke Ampere Turns (A.T):	5.52483
Air-Gap Ampere Turns (A.T):	450.687
Correction Factor for Magnetic Circuit Length of Stator Yoke:	0.7
Correction Factor for Magnetic Circuit Length of Rotor Yoke:	0.567404
Saturation Factor for Teeth:	1.03441

Saturation Factor for Teeth & Yoke:	1.1286
Induced-Voltage Factor:	0.942131
Stator Current Density (A/mm^2):	3.47642
Specific Electric Loading (A/mm):	24.6268
Stator Thermal Load (A^2/mm^3):	85.6133
Rotor Bar Current Density (A/mm^2):	3.66388
Rotor Ring Current Density (A/mm^2):	2.27977
Half-Turn Length of Stator Winding (mm):	585.542

WINDING ARRANGEMENT

The 3-phase, 2-layer winding can be arranged in 18 slots as below:

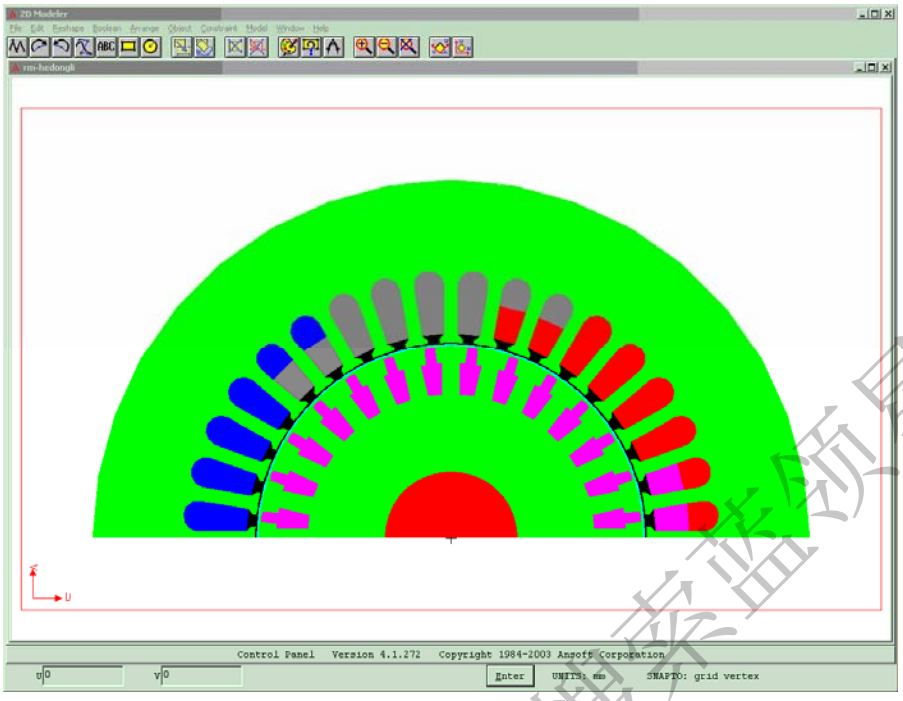
AAAAAAZZZZZZBBBBBB

Angle per slot (elec. degrees):	10
Phase-A axis (elec. degrees):	105
First slot center (elec. degrees):	0

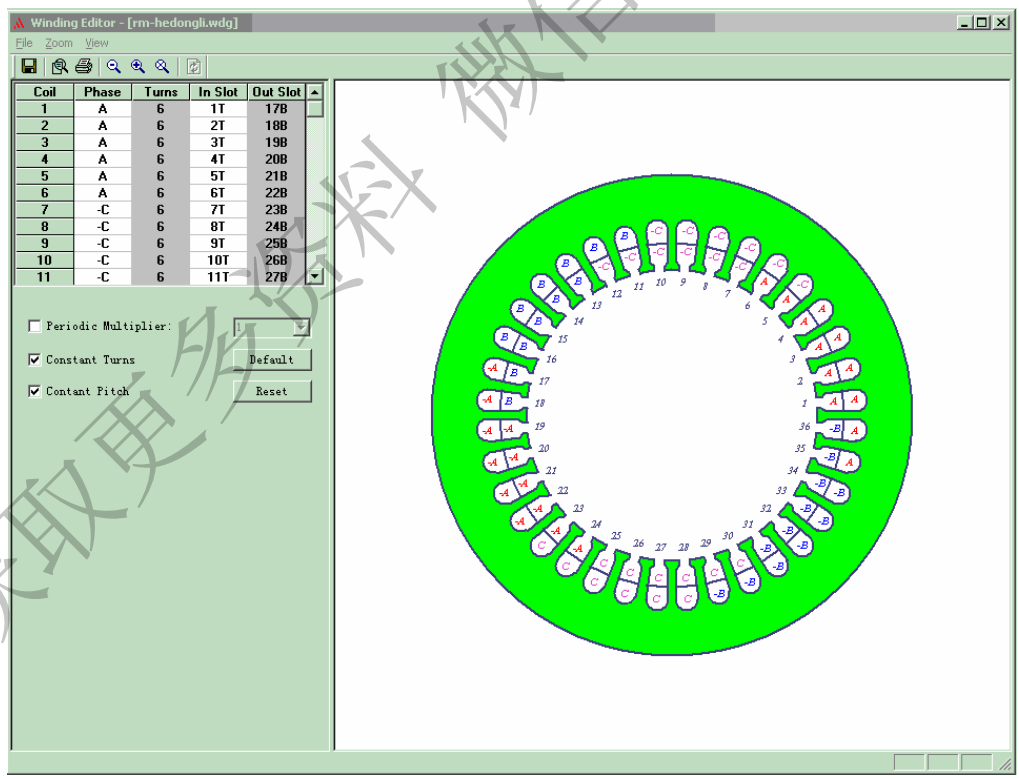
TRANSIENT FEA INPUT DATA

For one phase of the Stator Winding:	
Number of Turns:	72
Parallel Branches:	1
Terminal Resistance (ohm):	0.253089
End Leakage Inductance (H):	0.00105151
For Rotor End Ring Between Two Bars of One Side:	
End Ring Resistance (ohm):	8.44E-07
End Ring Leakage Inductance (H):	1.78E-09
Skew Leakage Inductance (H):	0
2D Equivalent Value:	
Equivalent Air-Gap Length (mm):	241.3
Equivalent Stator Stacking Factor:	0.95
Equivalent Rotor Stacking Factor:	0.95
Estimated Rotor Inertial Moment (kg m^2):	0.0670109

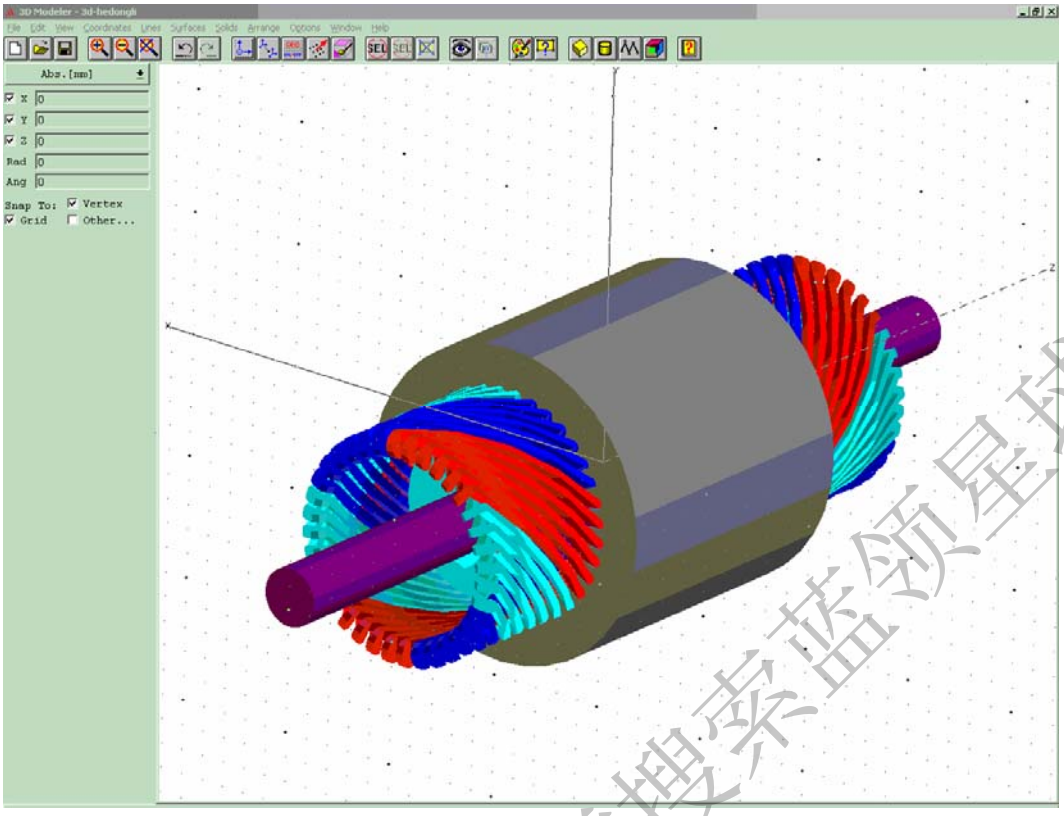
三、计算详细输出结果-图形与曲线部分



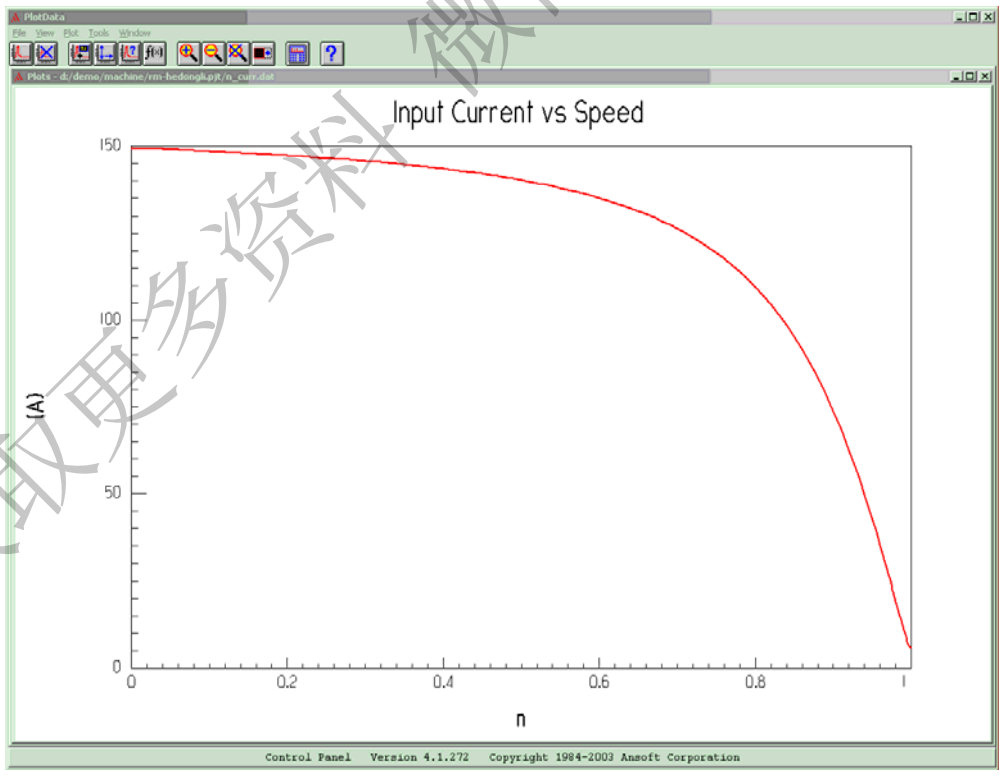
自动根据最小对称条件生成有限元模型



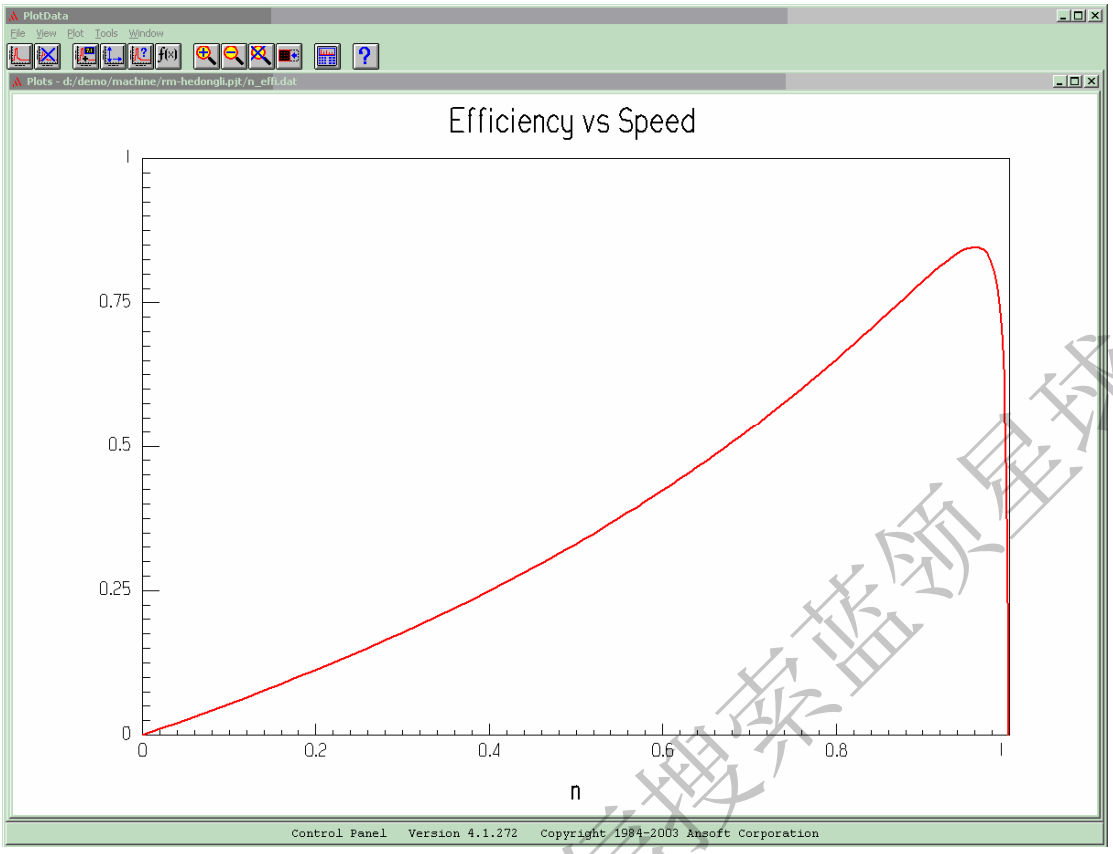
自定义绕组编辑器与绕组安放图



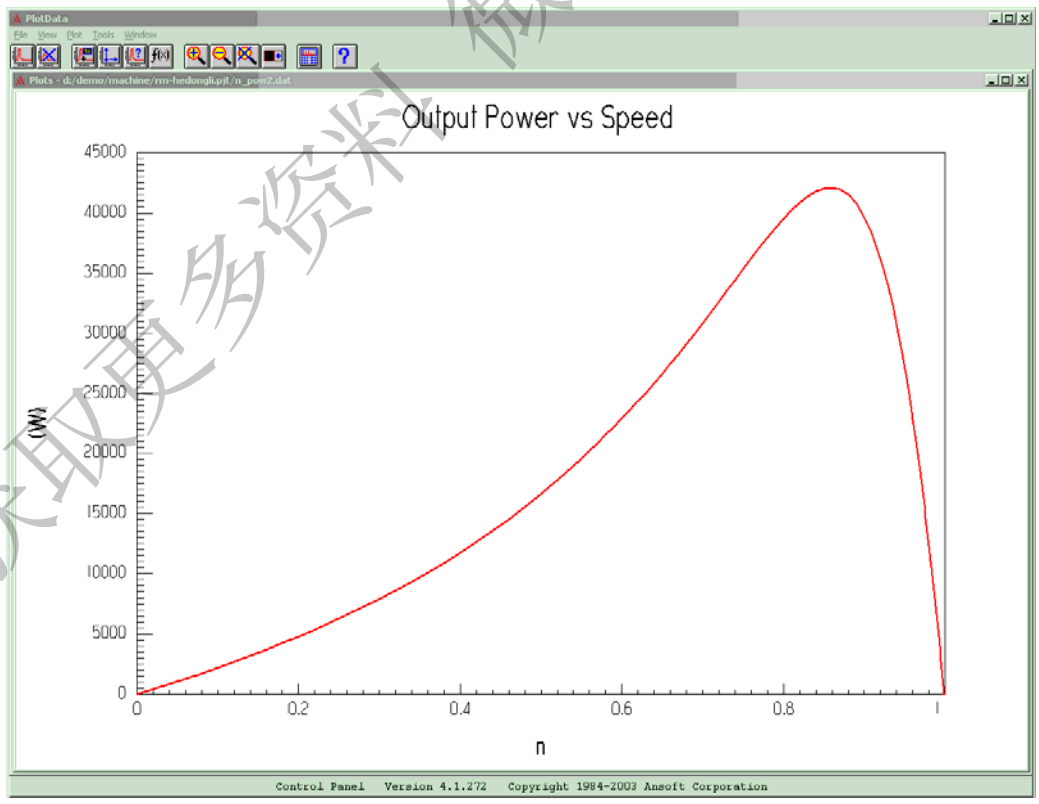
自动生成的三维分析模型



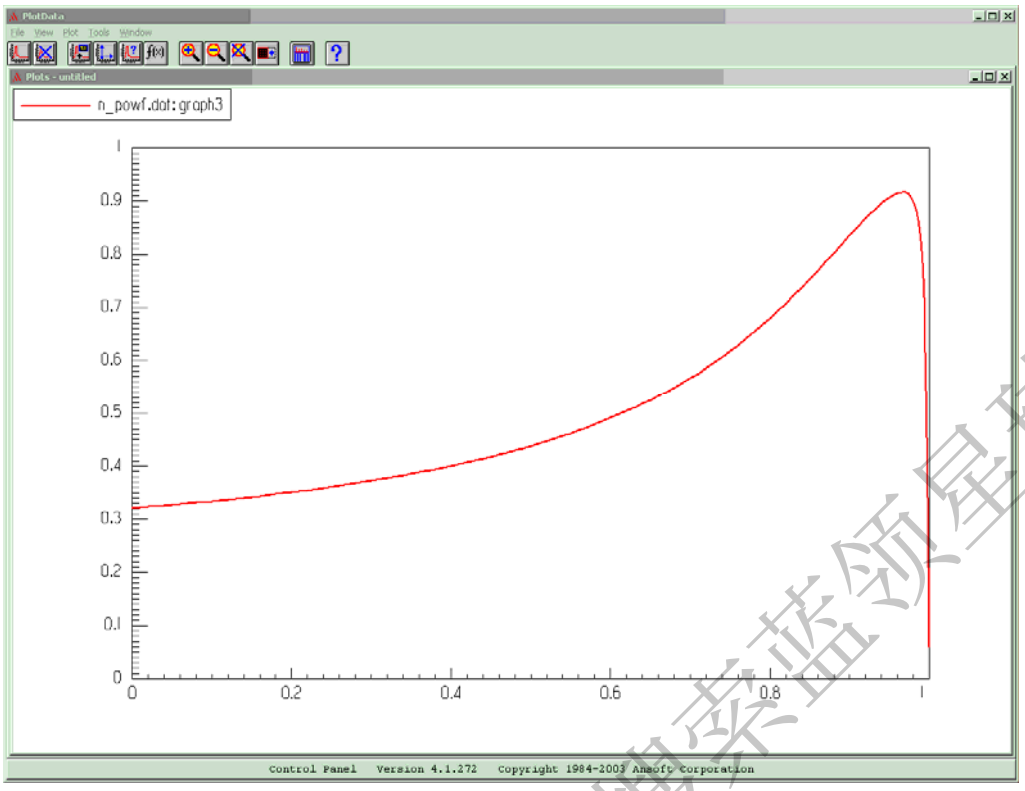
输入电流/速度曲线



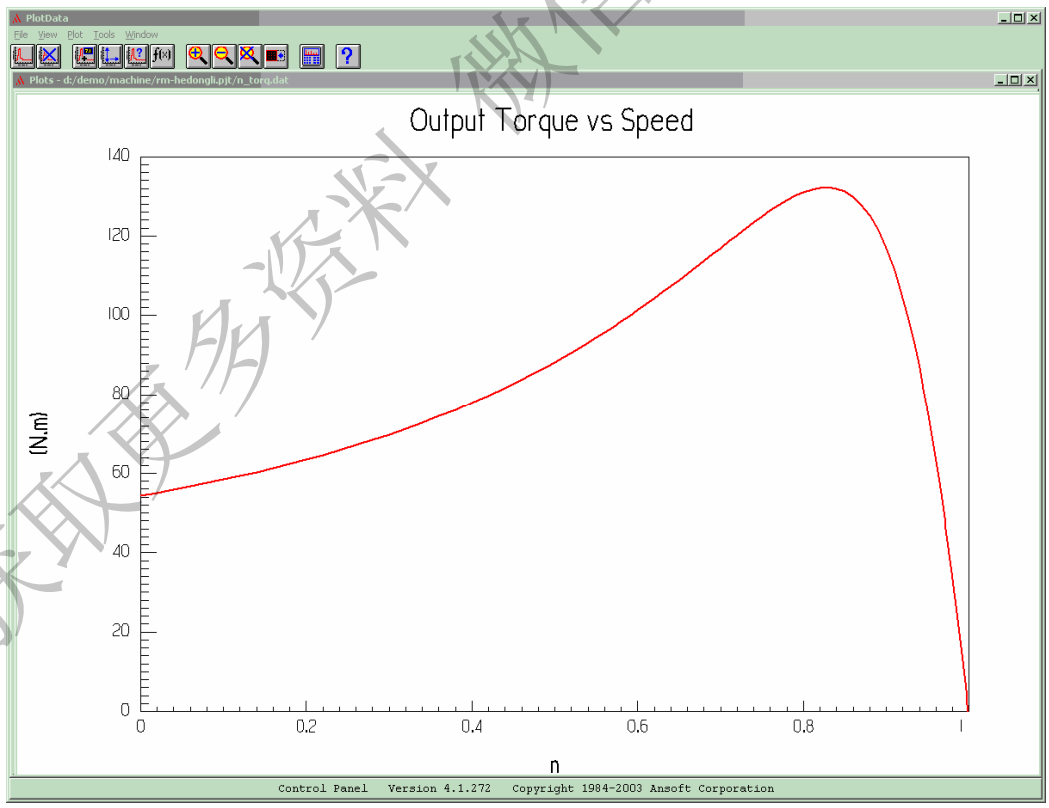
效率/转速曲线



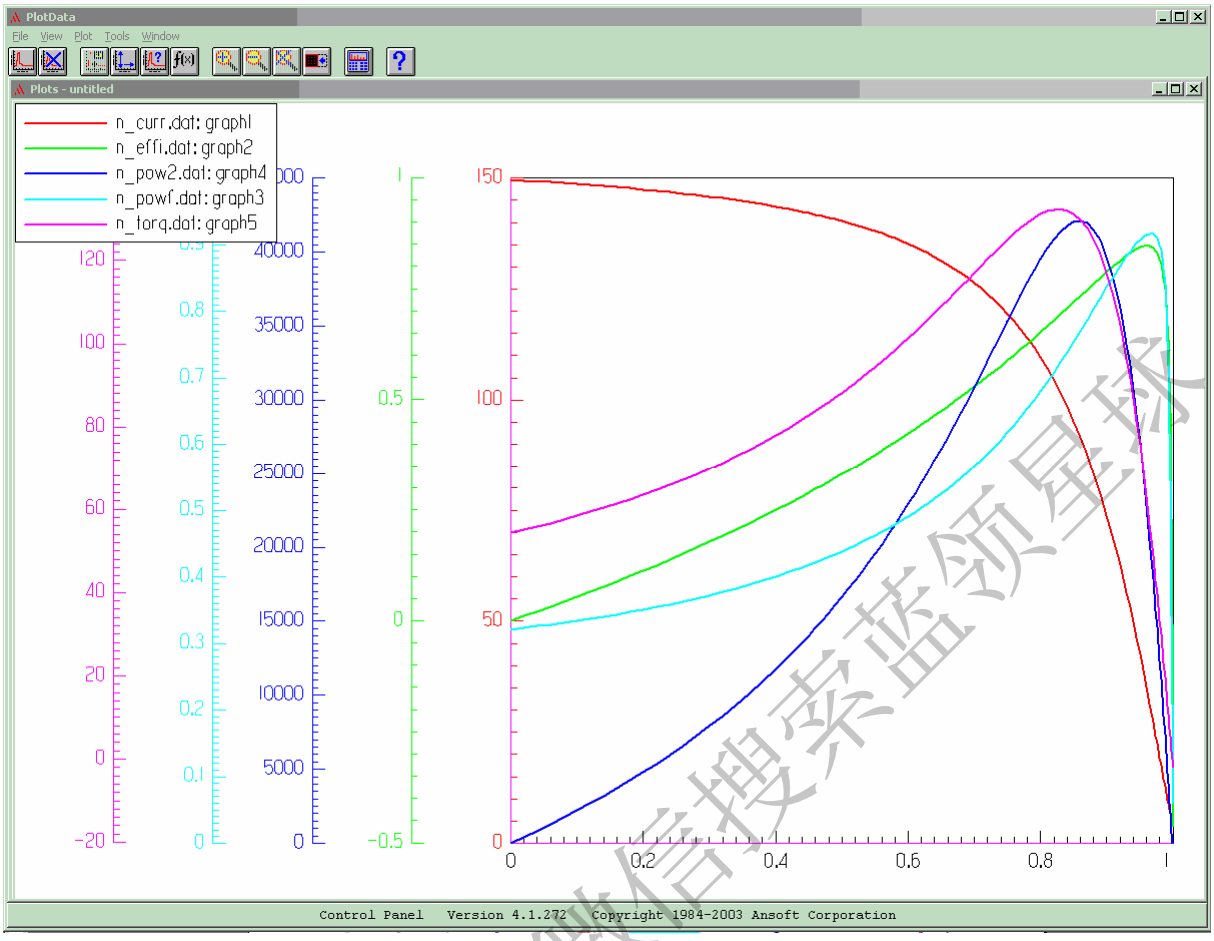
输出功率/转速曲线



功率因数/转速曲线



输出转矩/转速曲线



合并特性曲线

四、参数化设计和优化设计

Ansoft 软件能够通过选择设计可以改变的量和优化目标，自动进行参数化设计和优化设计

参数化设计实例（改变转子槽深(hr2)时起动电流（LC）和起动转矩(LT)的变化）

Setup	hr2	Solved	Solve	LT	LC
setup1	4	Y	N	57.6147	153.617
setup2	4.5	Y	N	56.4156	152.281
setup3	5	Y	N	55.3737	151.008
setup4	5.5	Y	N	54.4733	149.796
setup5	6	Y	N	53.7011	148.644
setup6	6.5	Y	N	53.044	147.549
setup7	7	Y	N	52.4892	146.509
setup8	7.5	Y	N	52.0279	145.526
setup9	8	Y	N	51.6468	144.594
setup10	8.5	Y	N	51.3371	143.712
setup11	9	Y	N	51.0905	142.88
setup12	9.5	Y	N	50.8981	142.094
setup13	10	Y	N	50.7558	141.359

五、场分析结果实例

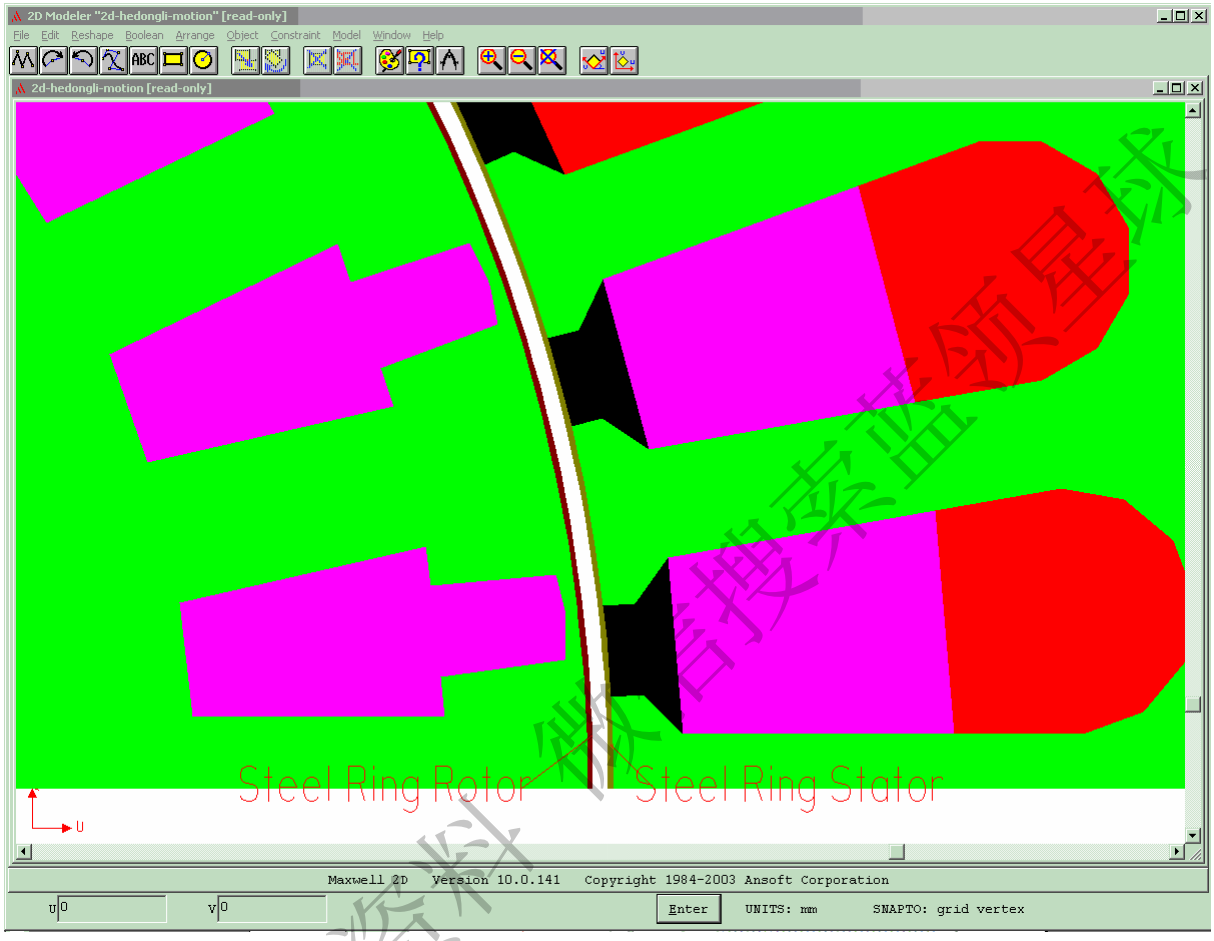
利用 Ansoft 二维和三维有限元电机设计分析和优化软件可以解决以下问题

- 从结构到性能的有限元分析,包括
  - 电磁场分析
  - 冲片设计
  - 温度场分析
  - 性能计算
  - 电机参数计算等
- 基于参数的电机设计方案探索、比较
- 电机静态和动态分析
  - 稳态特性
  - 加减速特性
  - 突加突减负载
  - 可编程负载特性
- 电机参数计算等
- 电机故障软件模拟分析-如导条断裂、绝缘击穿等
- 异步电机,无刷电机等在变频器供电下(非正弦供电)下的特性分析
- 电机驱动电路与有限元的耦合仿真
- 在考虑材料非线性等情况下回答有关
  - 转矩脉动
  - 损耗
  - 温升
  - 转矩、转速特性
  - 效率

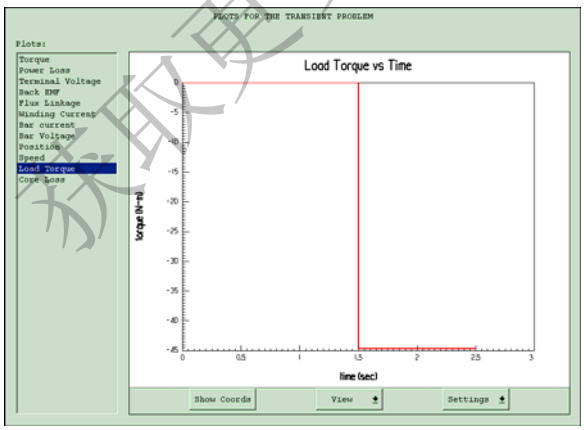
等问题并对其进行优化

以下举几个典型实例的计算结果：

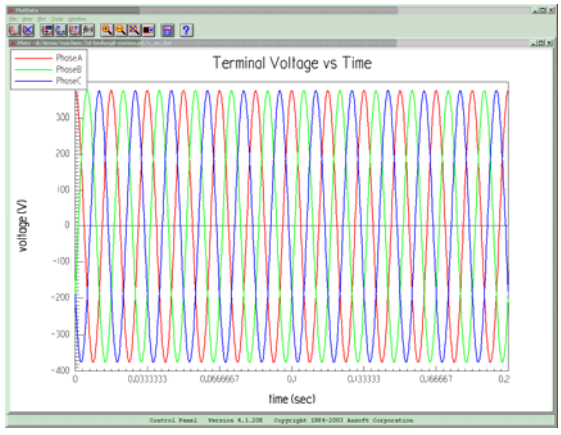
首先编辑模型。在定转子气隙处加入钢套



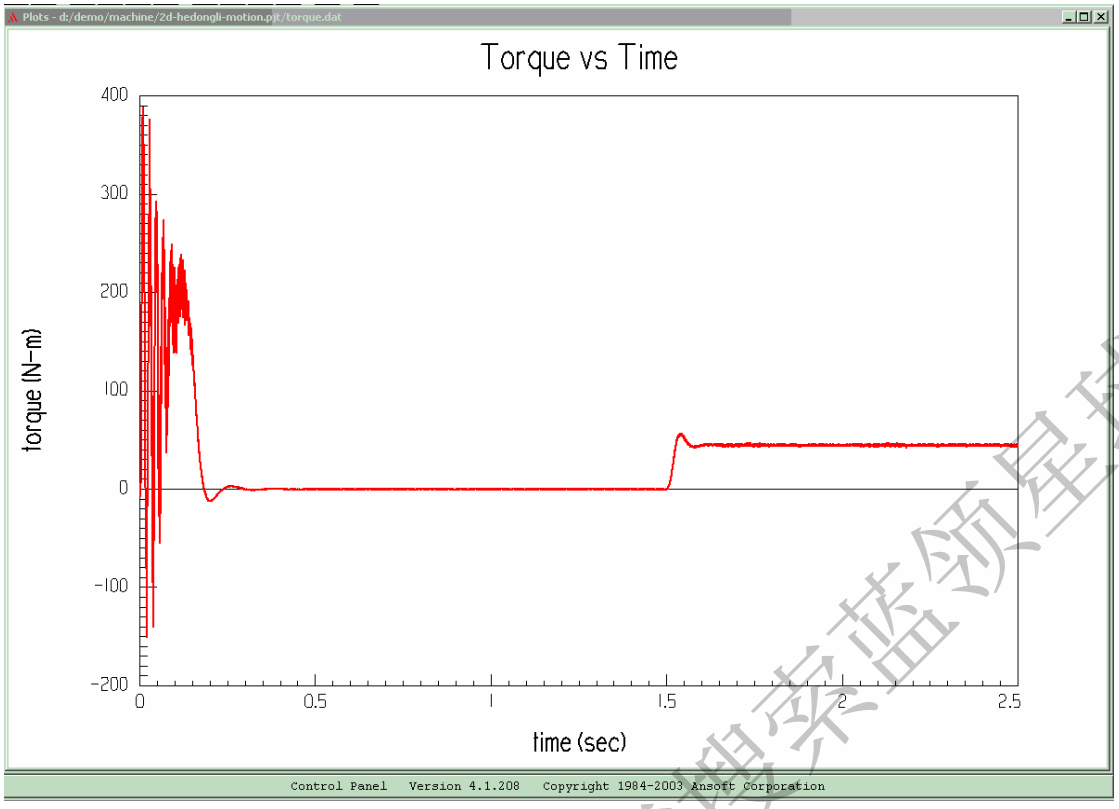
1、空载启动，在1.5秒钟时突加满载



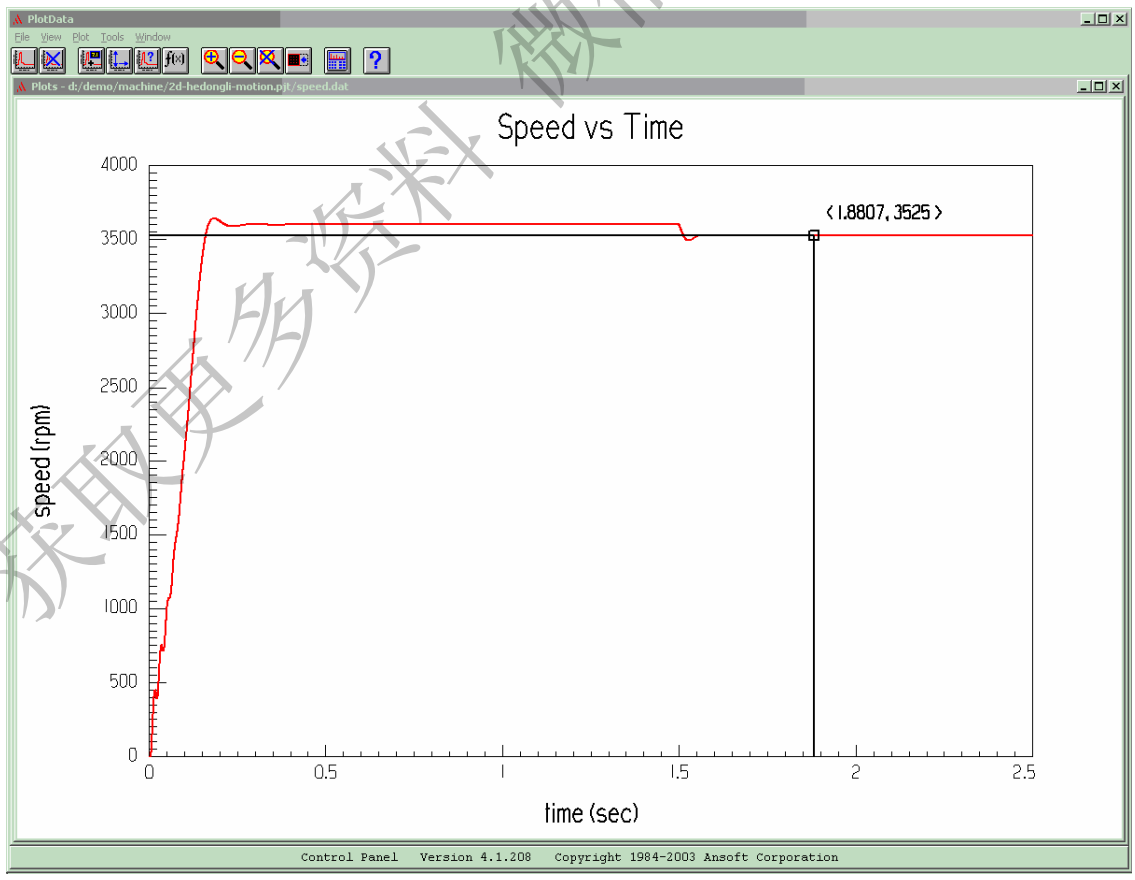
突加负载



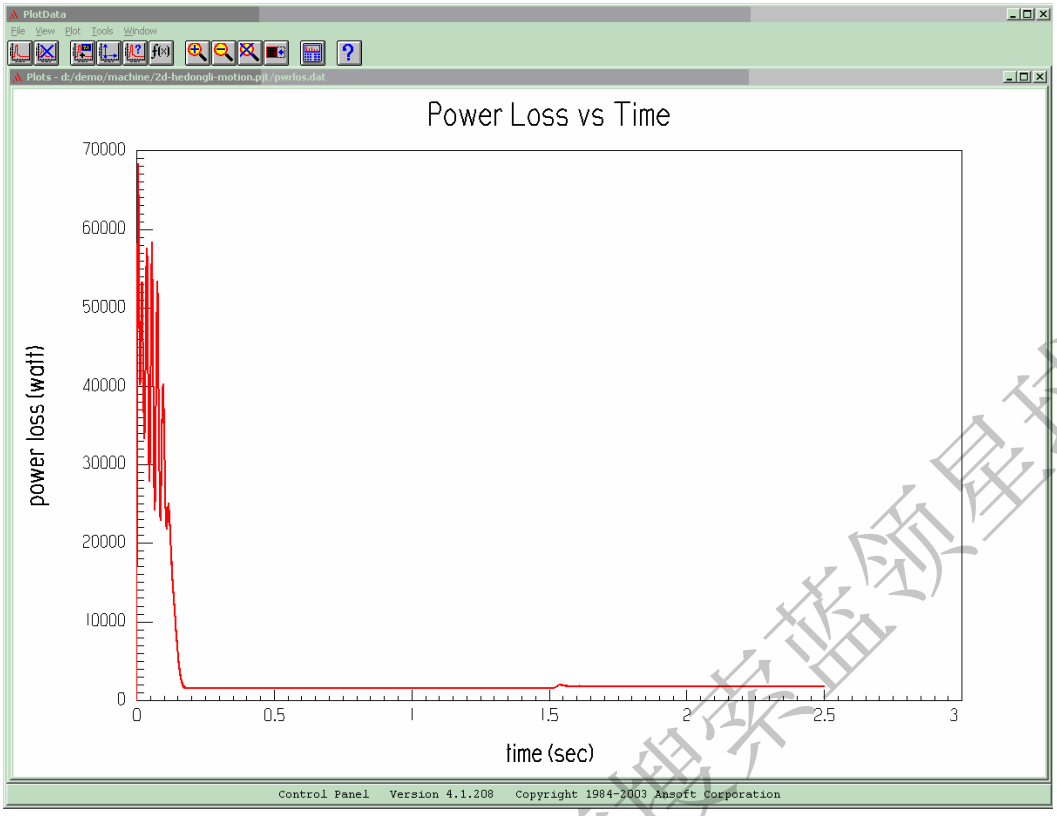
绕组相电压



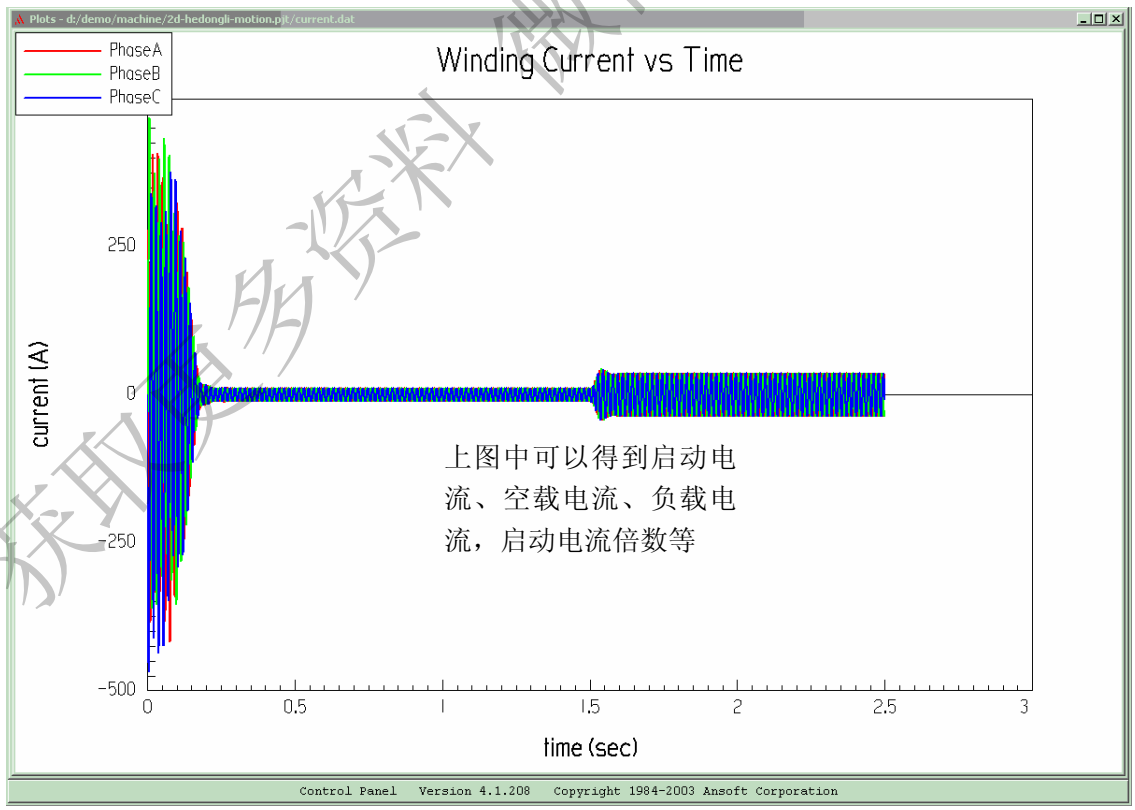
输出转矩/时间曲线



转速/时间曲线-(负载转速 3525rpm)

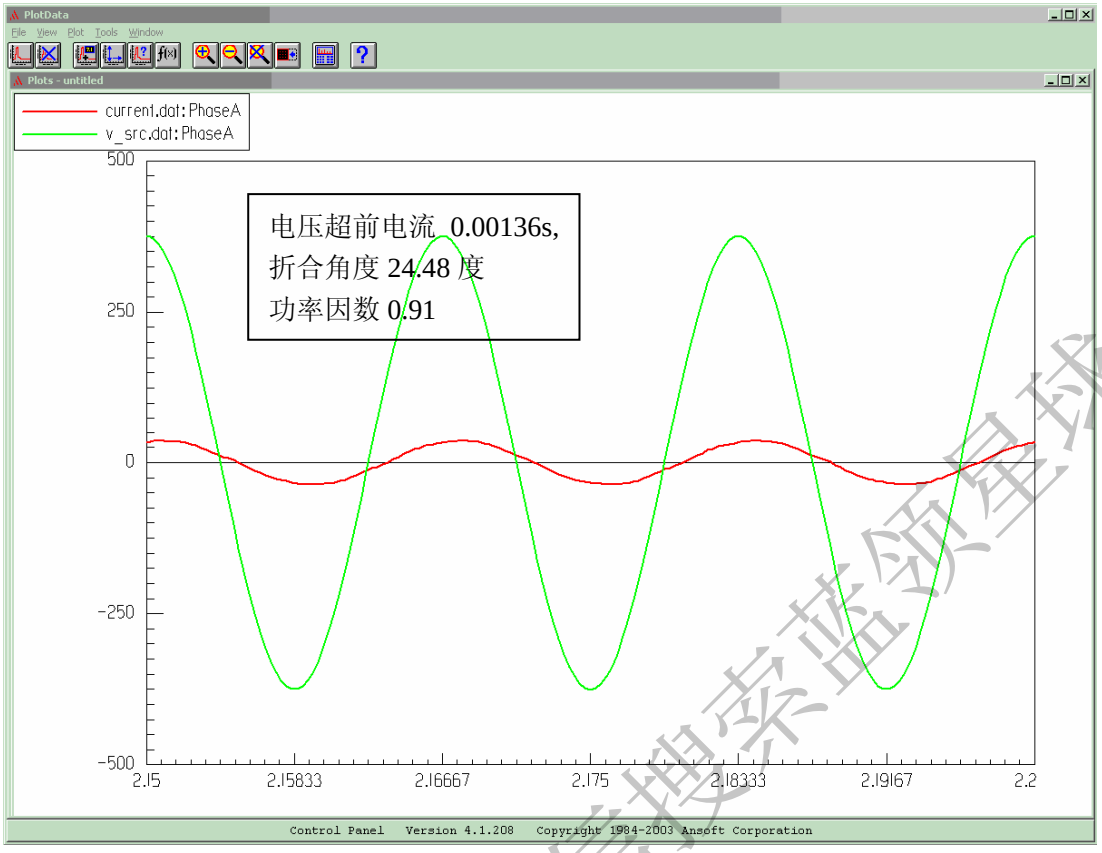


铁耗和转子铜耗随时间变化曲线

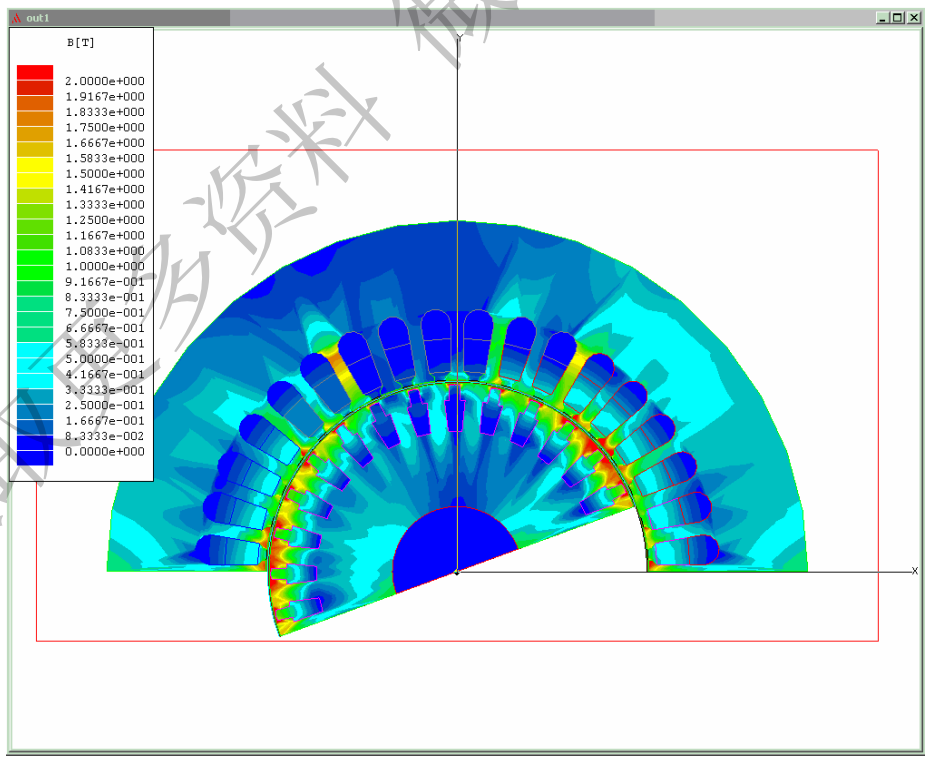


上图中可以得到启动电流、空载电流、负载电流，启动电流倍数等

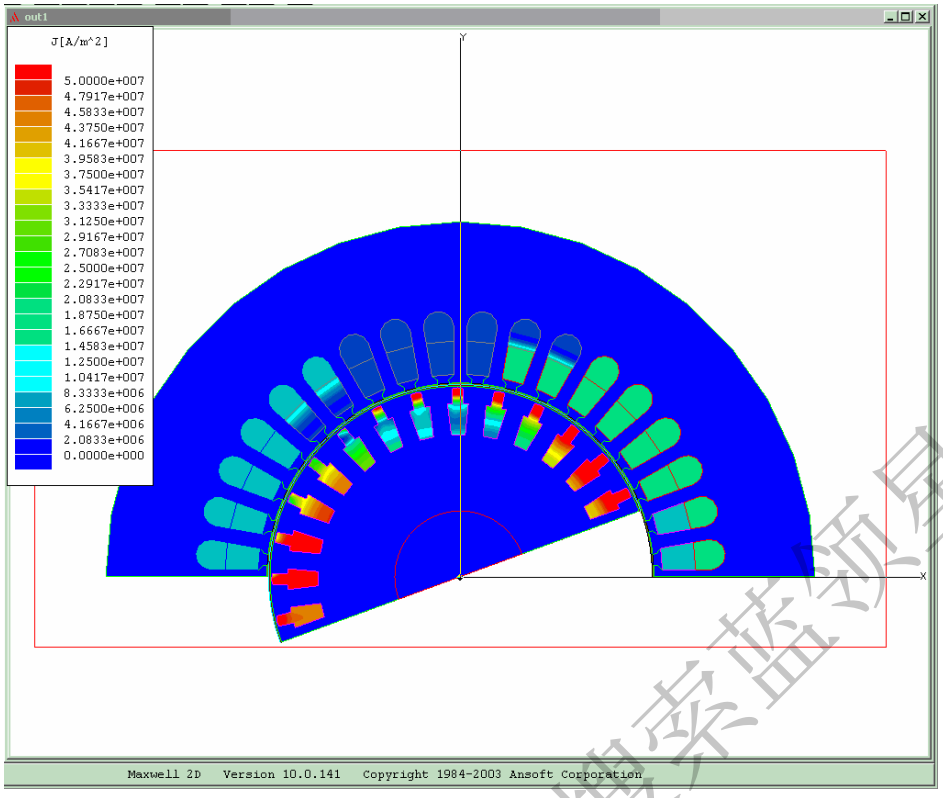
相电流/时间曲线



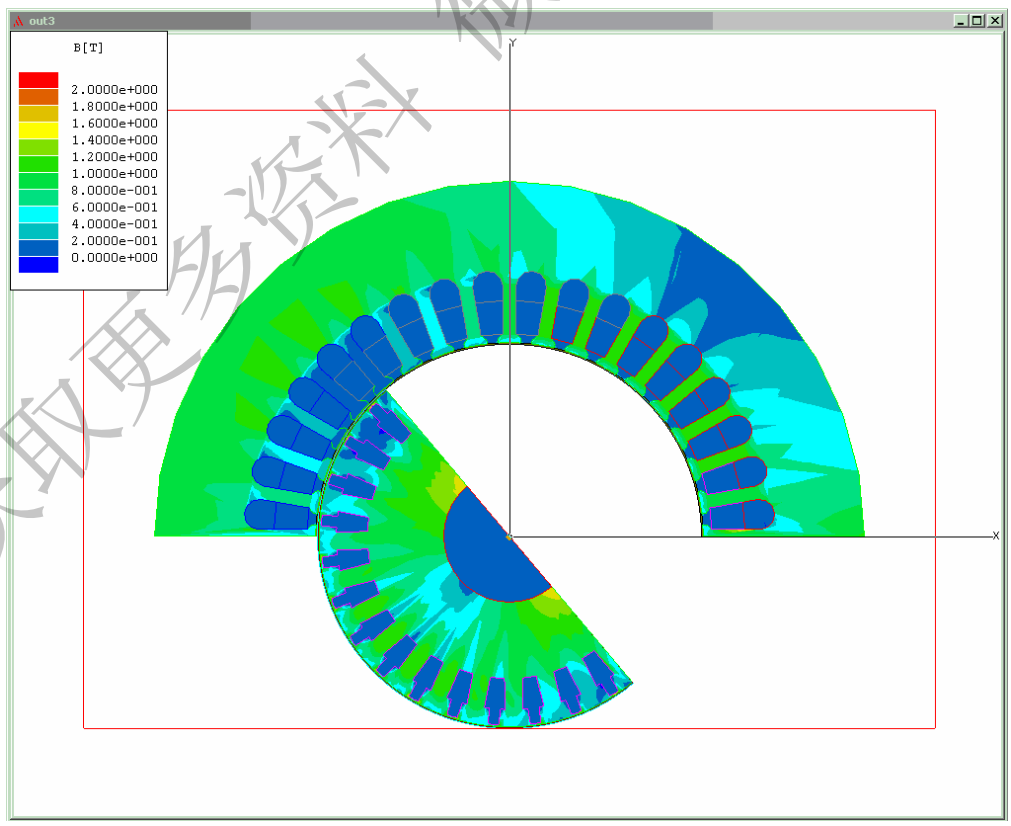
额定状态电压电流波形



起动 0.018s 时磁密分布图

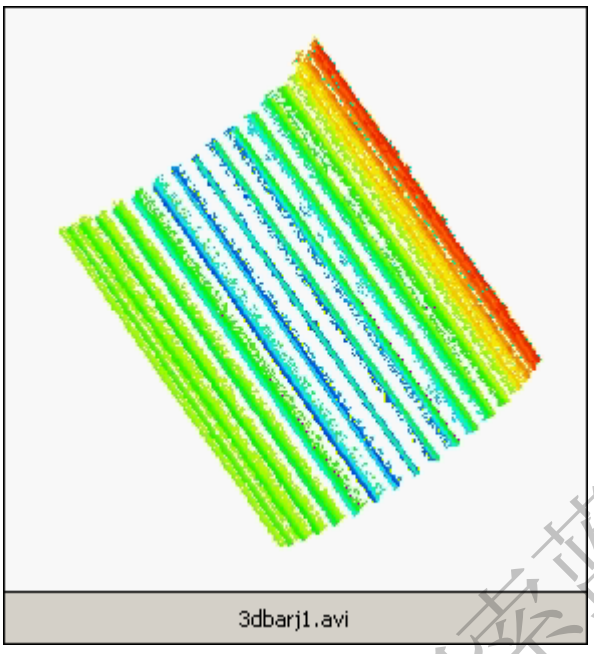


起动 0.018s 时电密分布图

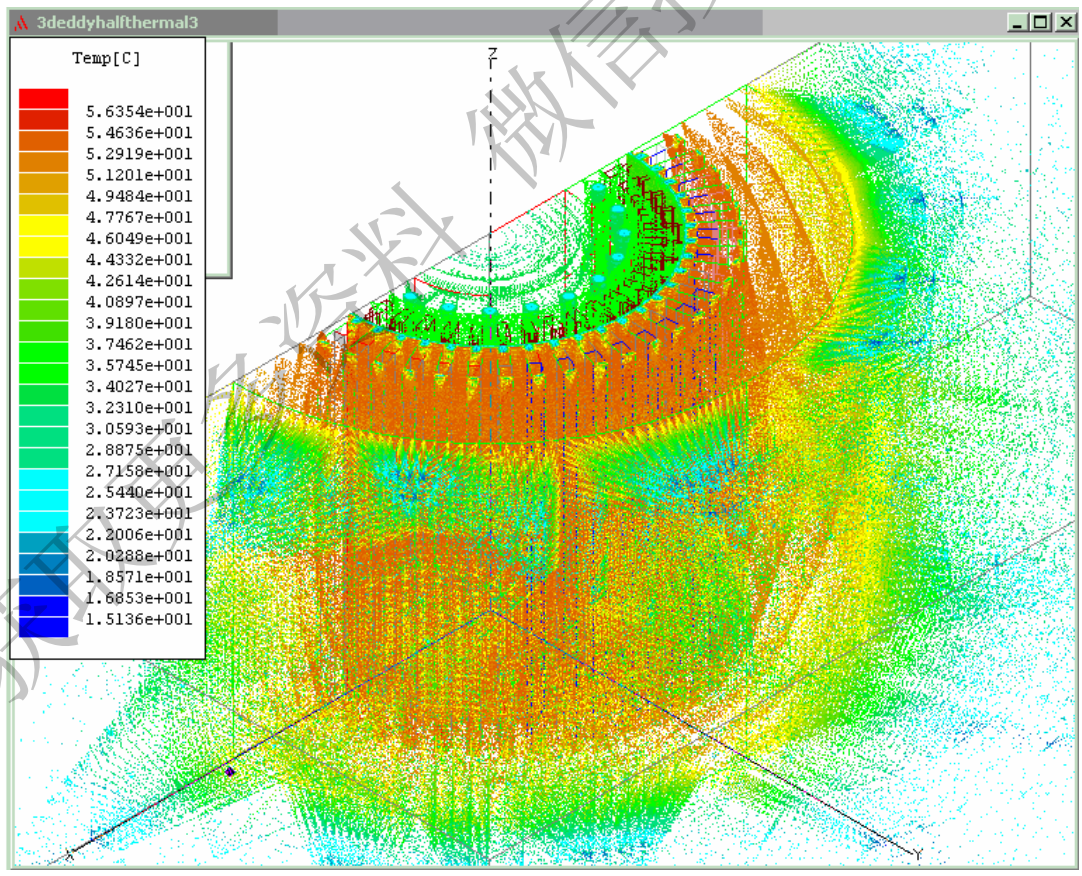


起动 1s 空载时磁密分布图

三维分析结果



负载时导条电流密度随相位变化



三维温度场分布