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JMAG Express软件功能介绍

艾迪捷信息科技(上海)有限公司

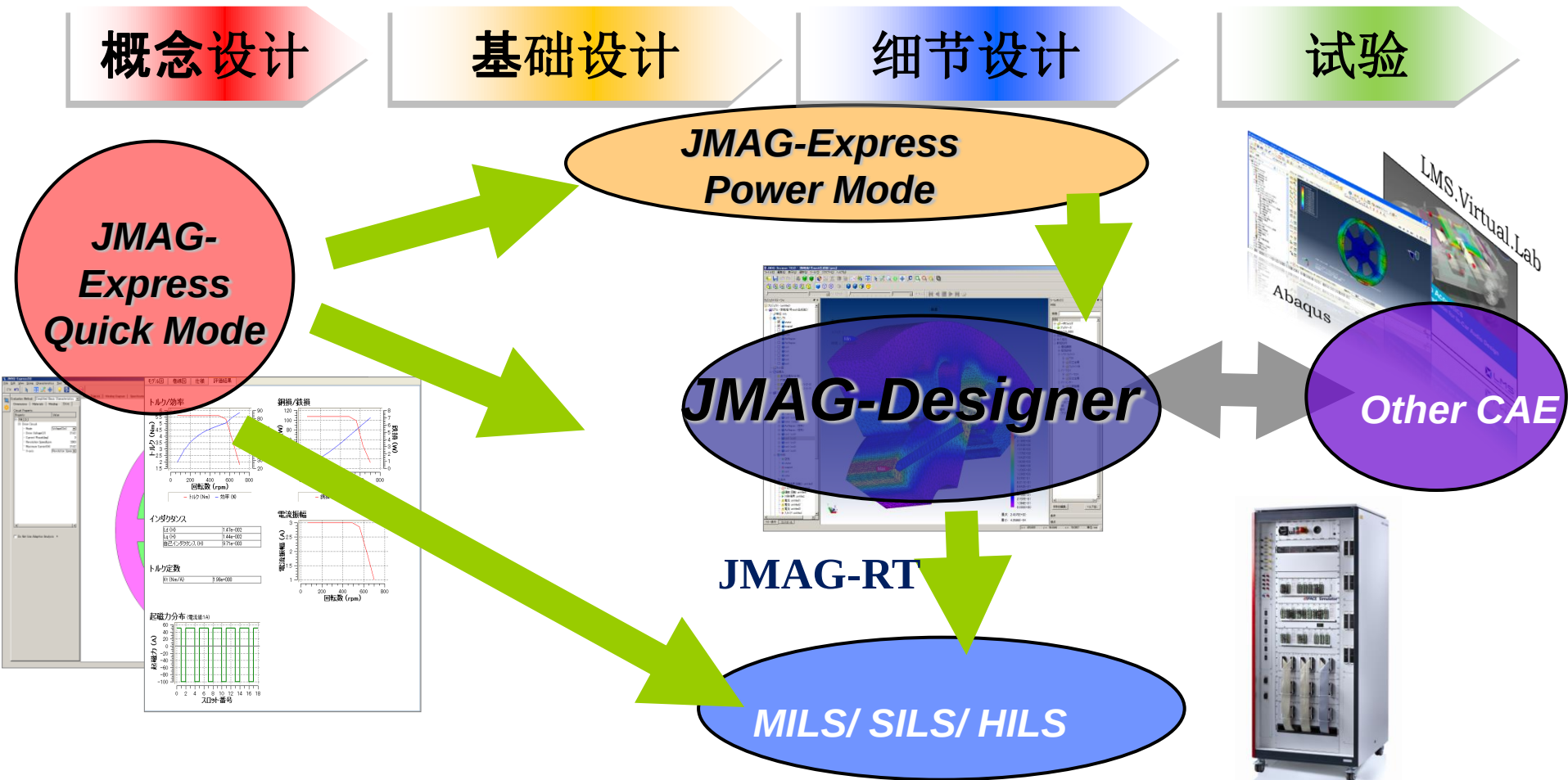
演讲人:薛波



主要内容

- JMAG的电机设计工具链
- JMAG-express概况
- Express 目前支持的电机种类以及槽型
- Express QM介绍
- Express QM自制模型案例分析
- Express Power Mode介绍

一、JMAGの电机设计工具链





三、JMAG-express特点简介

在开发电机的每一个设计环节，从最初的概念设计到最后的细节设计，JMAG都提供了丰富的工具

JMAG-express:Quick mode、Power mode两个版本

- JMAG-Express Quick Mode:
- 快捷得到分析结果
 - 采用快捷有限元计算模式，保持一定精度的情况下保证非常快的计算速度
 - 用户可以采用库里大量模版，自建模版等
 - 用户可以快捷参数化求解合理几何参数
- JMAG-Express Power Mode:不用设置的自动有限元分析
 - 可以显示各种云图分布，曲线等有限元结果
 - 可以分析各种电机性能参数
 - 计算是在后台调用JMAG Designer来完成

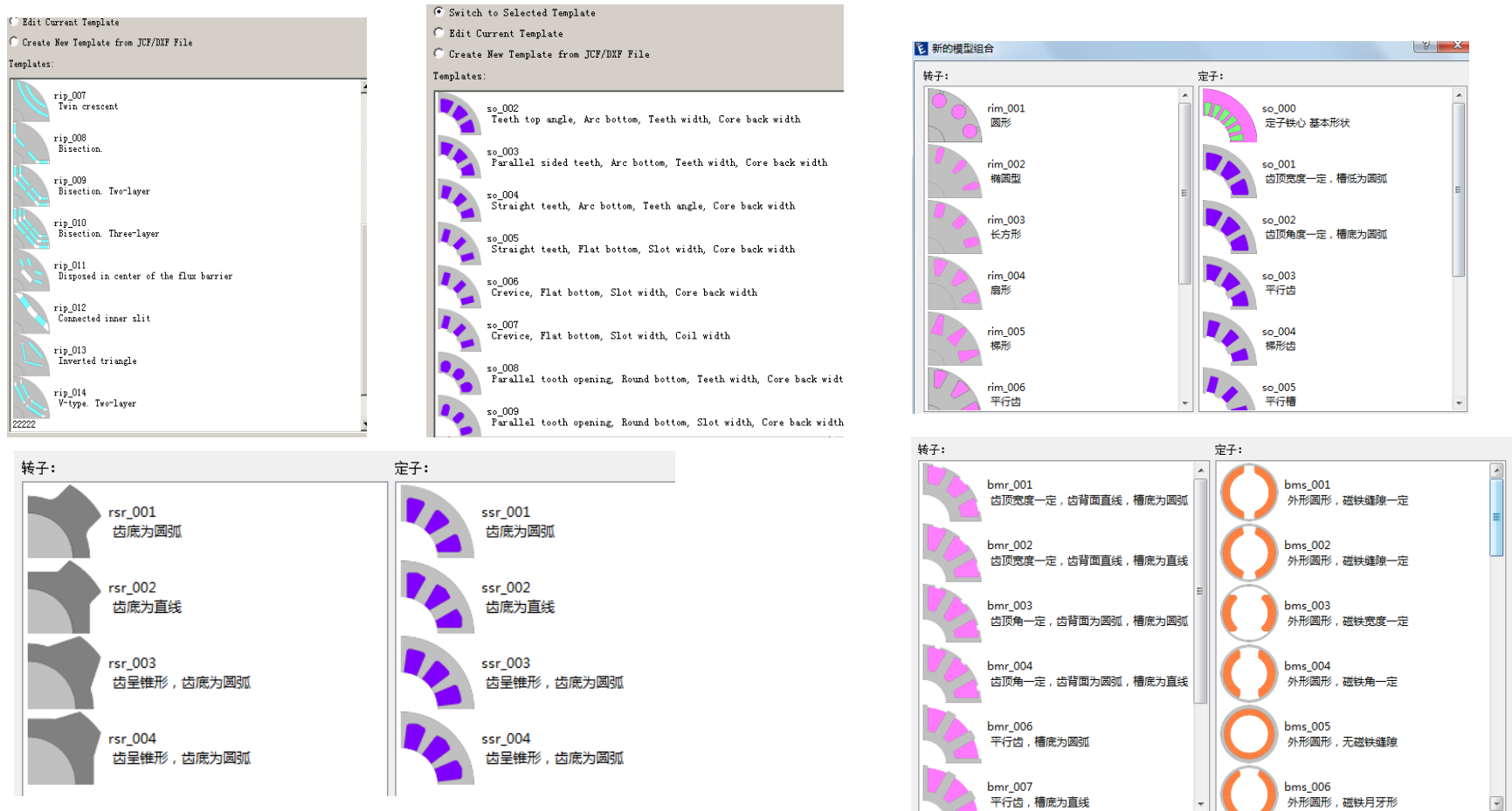


四、Express 目前支持的电机种类以及槽型

4.1 Express 目前支持的电机种类

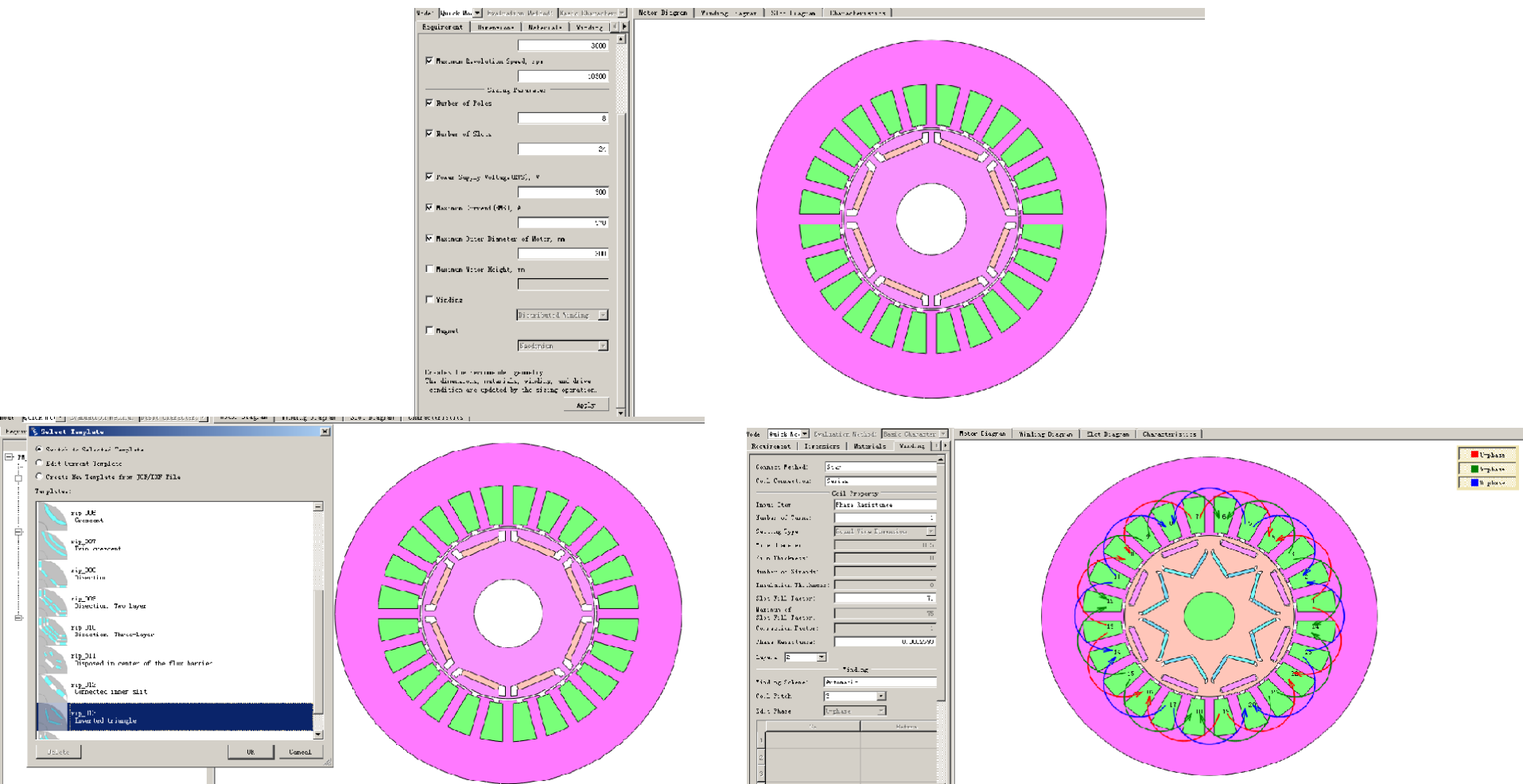
- ▷  Brushless motor(IPM)
- ▷  Brushless motor(SPM)
- ▷  Brushless motor(Outer Rotor/IPM)
- ▷  Brushless motor(Outer Rotor/SPM)
- ▷  Three phase induction motor
- ▷  Single phase induction motor
- ▷  Switched reluctance motor
- ▷  Brush motor
- ▷  Universal motor
- ▷  Externally Excited Synchronous Machine
- ▷  Wound-Field AC Synchronous Machine

4.2 各类电机均可以自由组合定子和转子类型



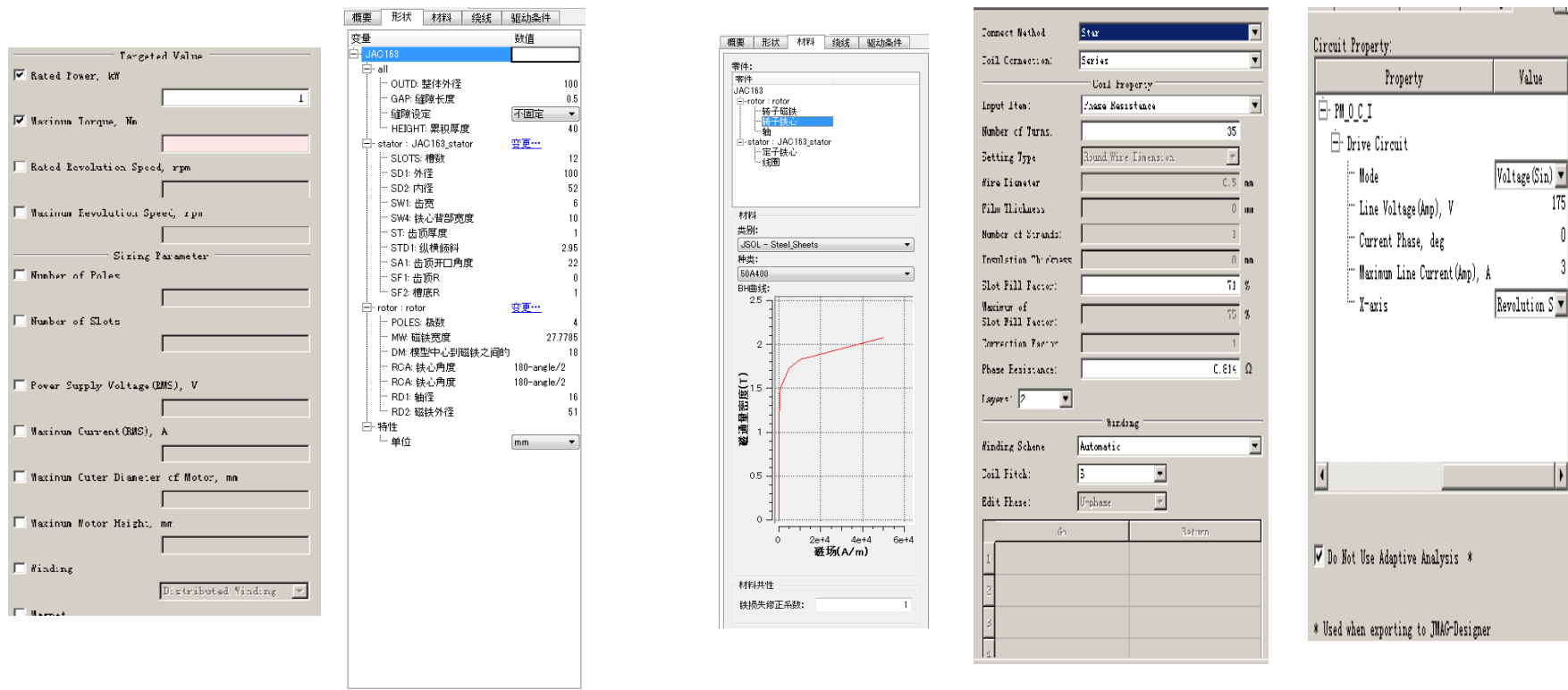
同时用户可以修改这些模版或者完全新增自己的模版

4.3 各类电机均可以自由组合定子和转子类型



4.3 Express 需要的设置

只要输入模板中提示的数值，解析模型定义过程就会完成。
完全不需要解析的相关知识与技巧



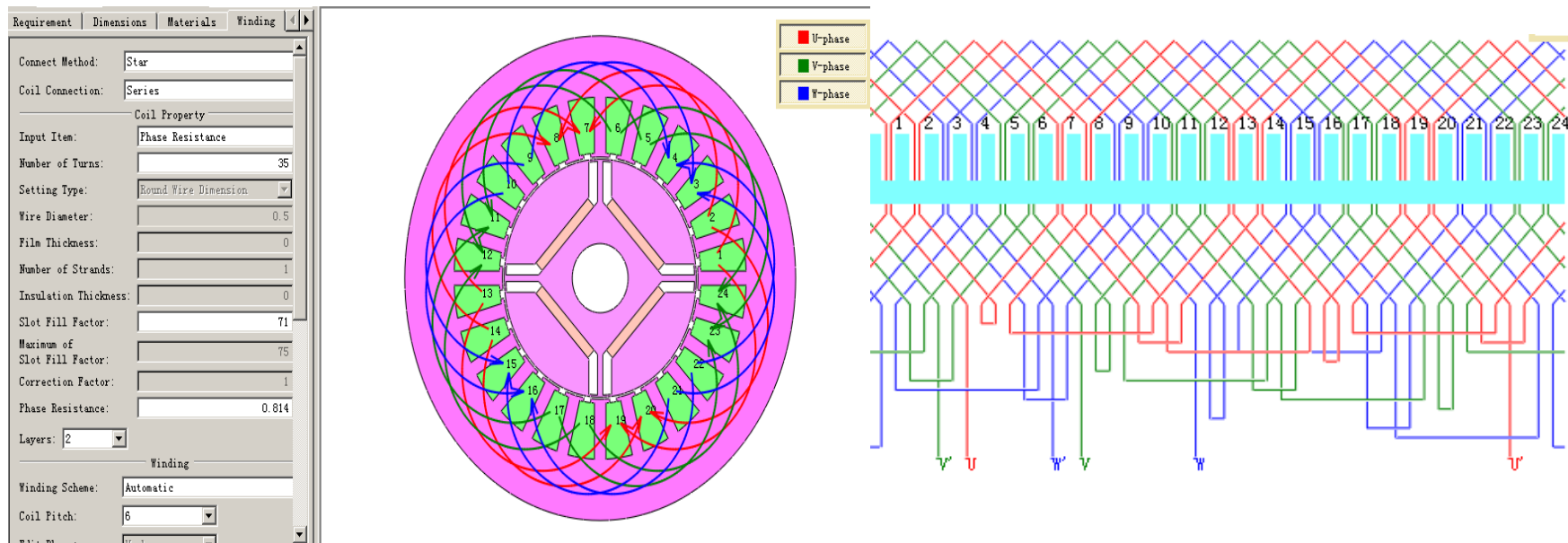
The figure displays four screenshots of the Express software interface, illustrating the configuration process for a motor model.

- Targeted Value Panel:** Shows various input fields for motor specifications, including Rated Power (kW), Maximum Torque (Nm), Rated Revolution Speed (rpm), Maximum Revolution Speed (rpm), Number of Poles, Number of Slots, Power Supply Voltage (RMS), V, Maximum Current (RMS), A, Maximum Outer Diameter of Motor, mm, Maximum Motor Height, mm, and Winding (Distributed Winding).
- Variable List Panel:** Displays a tree structure of variables for the JAC163 motor, such as OUTD (整体外径), GAP (磁隙长度), HEIGHT (叠片厚度), SLOTS (槽数), SD1 (外径), SD2 (内径), SW1 (齿宽), SW4 (铁心背部宽度), ST (齿顶厚度), STD1 (纵模材料), SA1 (齿顶开口角度), SF1 (齿顶R), SF2 (槽底R), POLES (极数), MM (磁轭宽度), DM (模型中心到磁轭之间的), RCA (铁心角度), RD1 (轴径), RD2 (磁轭外径), and Unit (mm).
- Material Properties Panel:** Shows the material selection process, including the material type (JISOL - Steel Sheets), grade (50A400), and a graph of magnetic flux density (T) versus magnetic field (A/m).
- Circuit Properties Panel:** Displays the drive circuit configuration, including the input item (Phase Resistance), number of turns (35), setting type (Round Wire Dimension), wire diameter (0.5 mm), film thickness (0 mm), number of strands (1), insulation thickness (0 mm), slot fill factor (71 %), maximum of slot fill factor (75 %), connection factor (1), phase resistance (0.814 Ω), winding scheme (Automatic), coil pitch (3), and edit phase (Up phase).

设计需求/筛选 几何形状的再定义 材料的指定 绕线的设置 驱动条件的设置



4.3 Express 需要的设置



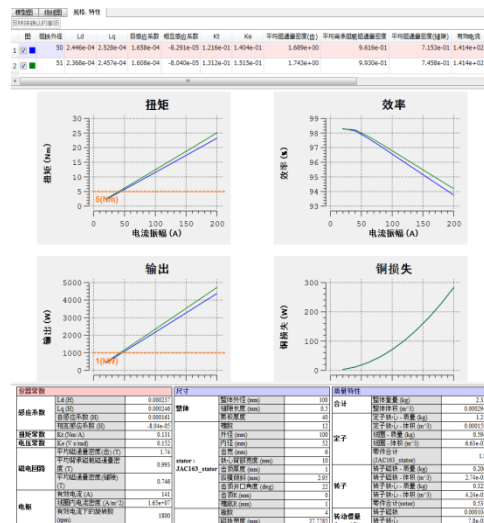
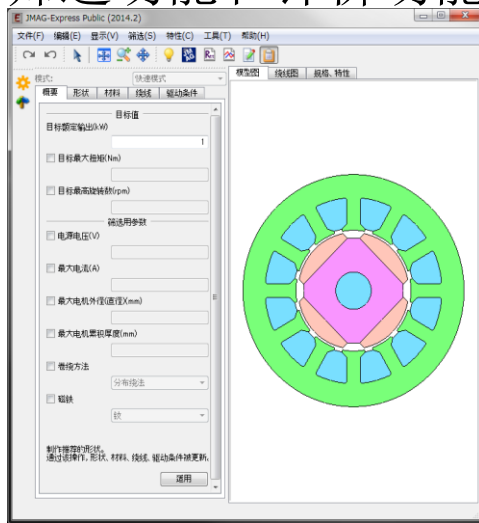
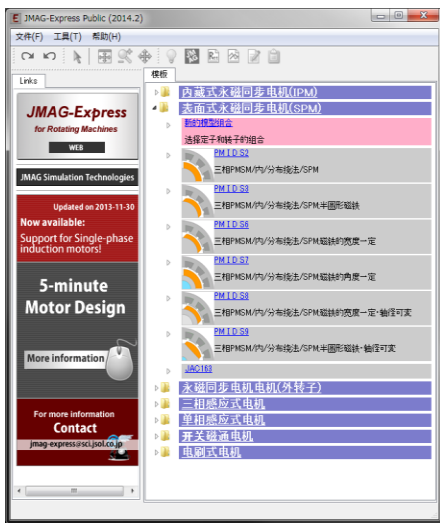
可以设置电路连接方式，串并联数，可以直接设置电阻也可以计算电阻

4.4 Express QM的主要结果特点

种类繁多的几何形状

1秒内输出结果的 筛选功能和评价功能

多种设计方案的结果比较

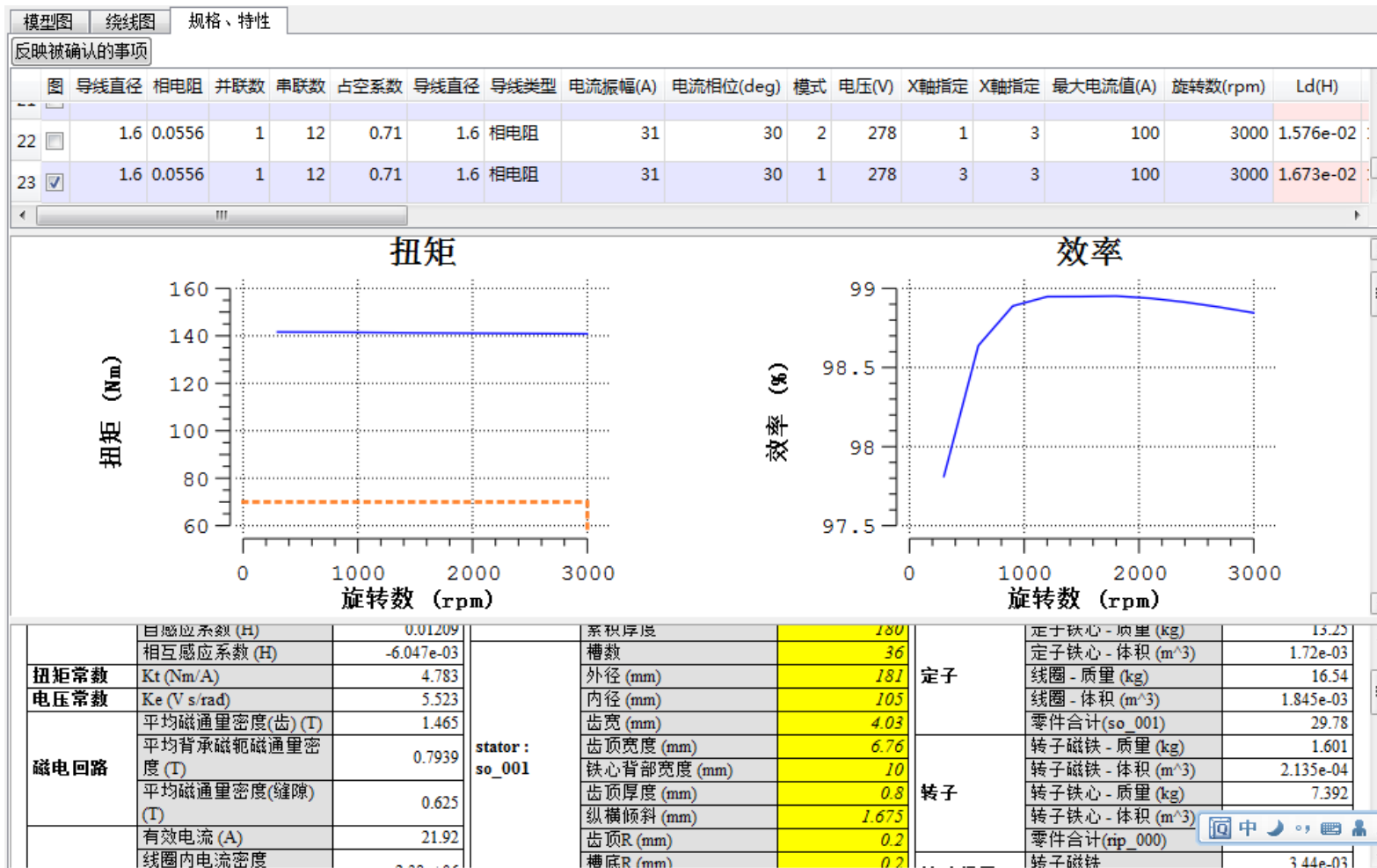


输出信息:

N-T曲线特性， 转矩/效率， 铜损/铁损， 电感， 电压， 磁动势分布，

转矩系数, 感应电压系数, 磁通量密度 (齿/后轭/缝隙)

4.4 Express QM的主要结果特点



4.5 参数化分析——未达到设计目标

仪器常数		
感应系数	Ld (H)	0.02428
	Lq (H)	0.06681
	自感应系数 (H)	0.03036
	相互感应系数 (H)	-0.01518
扭矩常数	Kt (Nm/A)	0.4326
电压常数	Ke (V s/rad)	0.4995
磁电回路	平均磁通量密度(齿) (T)	1.243
	平均背承磁轭磁通量密度 (T)	0.5231
	平均磁通量密度(缝隙) (T)	0.5072
	有效电流 (A)	2.121
电枢	线圈内电流密度 (A/m^2)	1.355e+06
	有效电流下的旋转数 (rpm)	3000

绕组	
接线方式	星形接线
串联数	8
并联数	1
绕组数	35
设定类型	相电阻
相电阻	0.814
绕组	自动
层数	2

尺寸		
整体	整体外径 (mm)	112
	缝隙长度 (mm)	0.5
	累积厚度	37.5
	槽数	24
定子 : stator_02	外径 (mm)	112
	线圈外径 (mm)	83.7
	线圈内径 (mm)	57.8
	内径 (mm)	56
	齿宽 (mm)	3.3
	槽开口部宽度 (mm)	2
转子 : ipm_rotor	极数	4
	轴径 (mm)	16
	外径 (mm)	55
	磁铁厚度 (mm)	2.5
	磁铁宽度 (mm)	21
	缝隙之间的距离 (mm)	1.5
	缝隙宽度 (mm)	2.5
	距离磁铁中心的位置 (mm)	13
	缝隙深度 (mm)	0.5

质量特性		
合计	整体重量	
	整体体积	
定子	线圈 - 质量 (kg)	
	线圈 - 体积 (m^3)	
	定子铁心 - 质量	
	定子铁心 - 体积 (m^3)	
转子	零件合计(stator)	
	转子磁铁 - 质量	
	转子磁铁 - 体积 (m^3)	
	转子铁心 - 质量	
转动惯量 (kg m^2)	转子铁心 - 体积 (m^3)	
	零件合计(ipm_ro)	
	转子磁铁	
	转子铁心	
合计		
材料		
线圈	类别	
	密度	0.000
定子铁心	类别	JSOL - Steel Sheets
	种类	50A1000
	密度	7850
	类别	JSOL - Nd-Fe-B Magnet

设置参数范围

设置范围

始值: 终值: 分隔数:

表格式

1

2

3

4

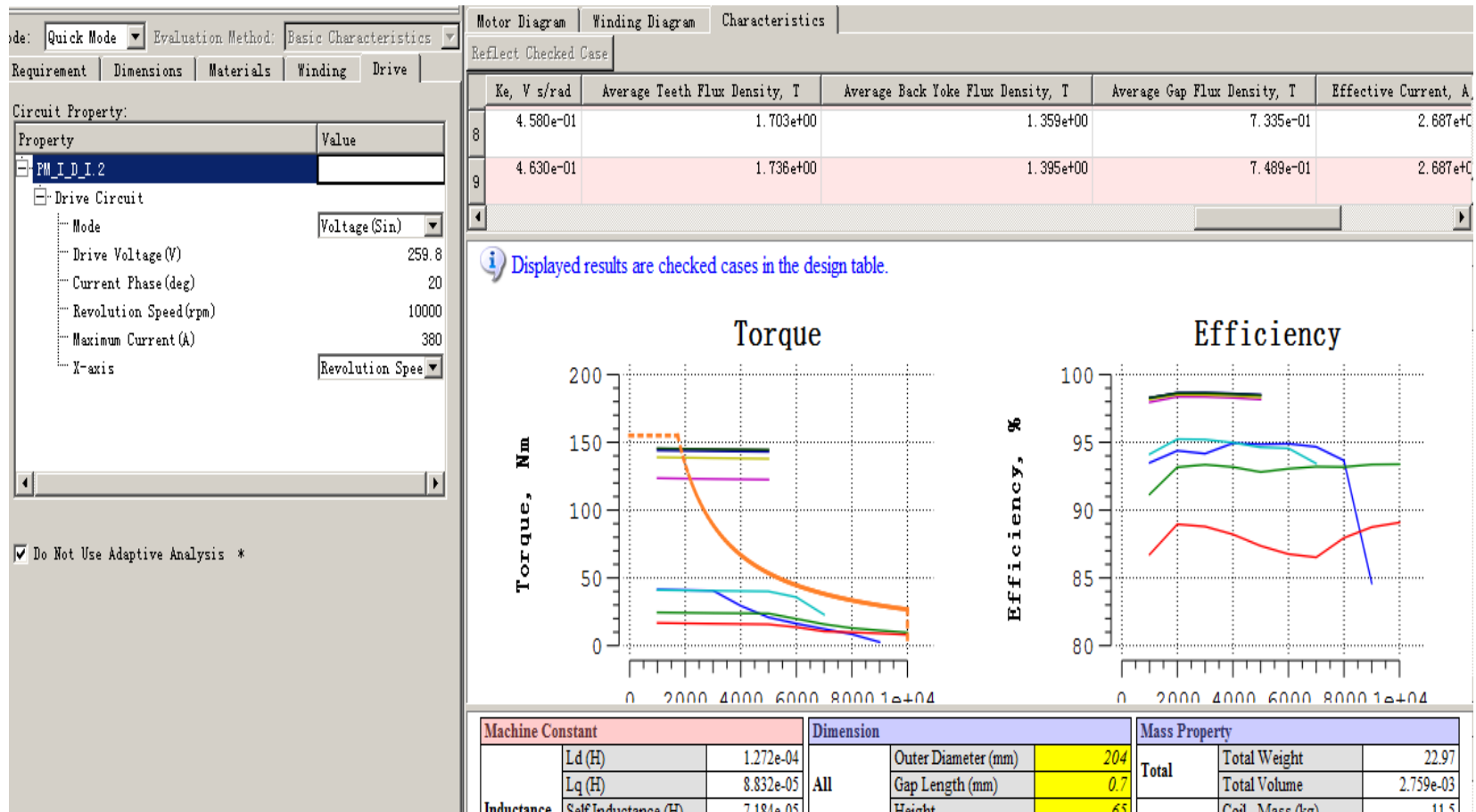
5

6

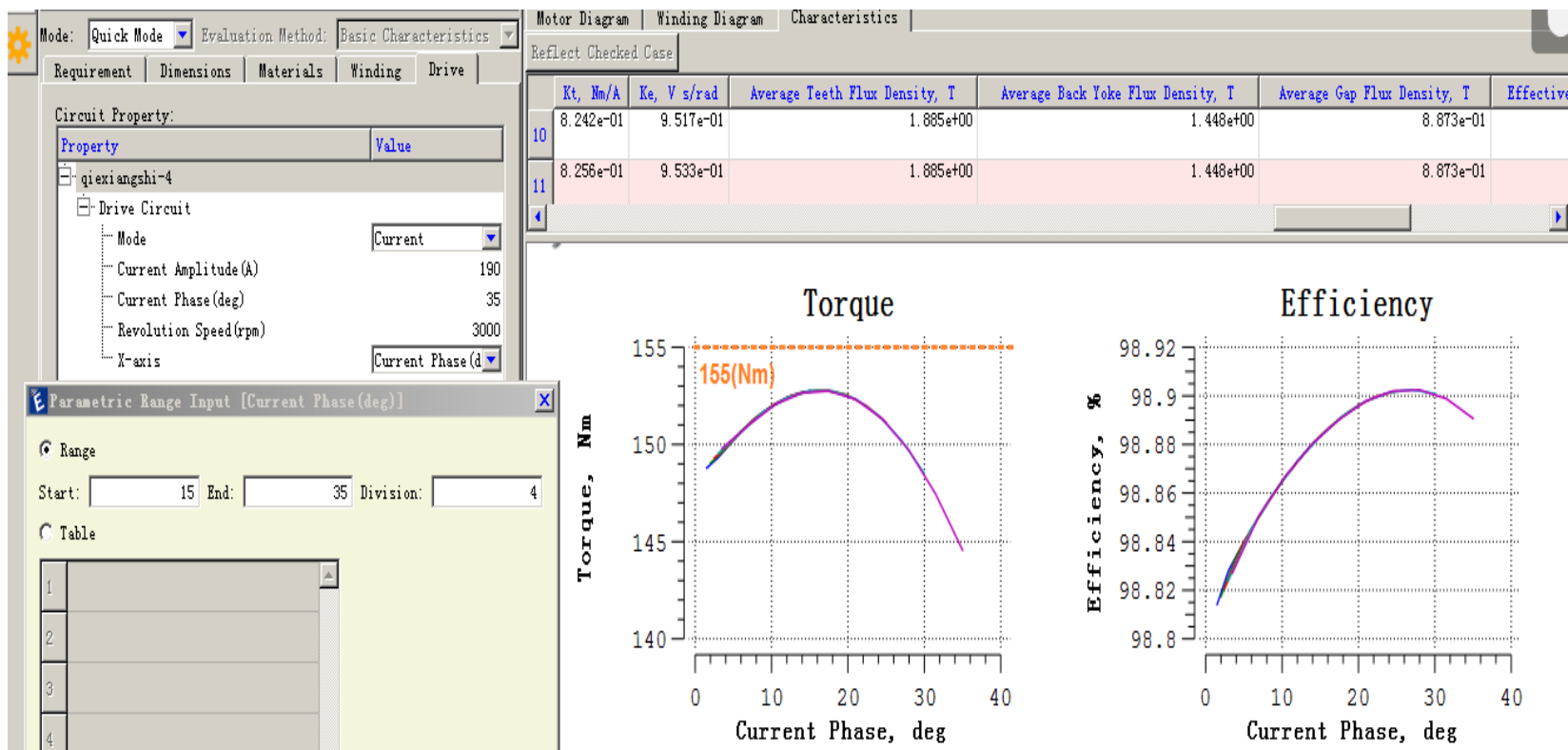
输入参数

当设计结果达不到时可对一些重要指标进行参数化分析，设定分析范围，得到对比结果（所有黄色显示的项均为可参数化计算的选项）

4.5 参数化分析——利用磁阻转矩

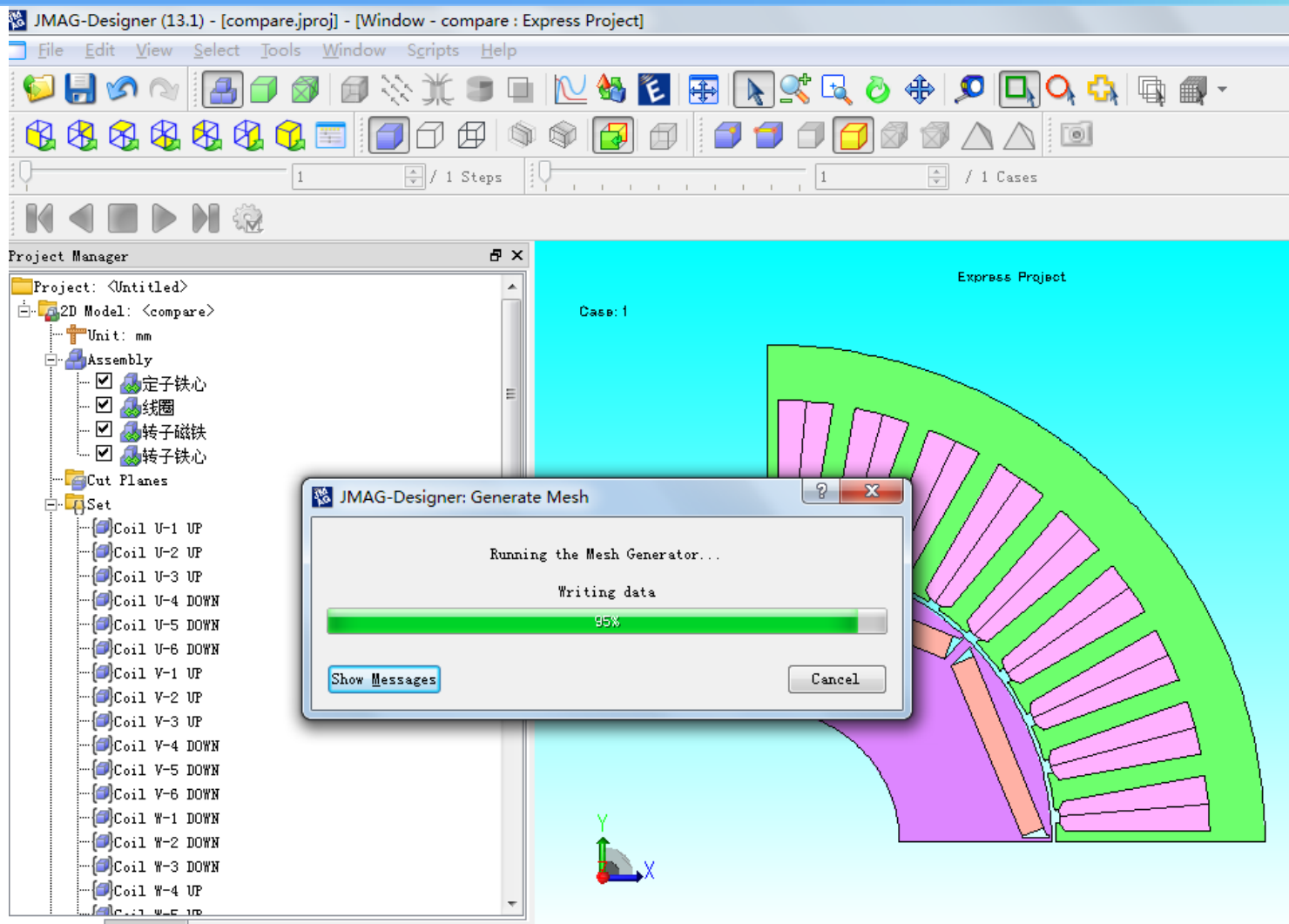


4.5 参数化分析——利用磁阻转矩



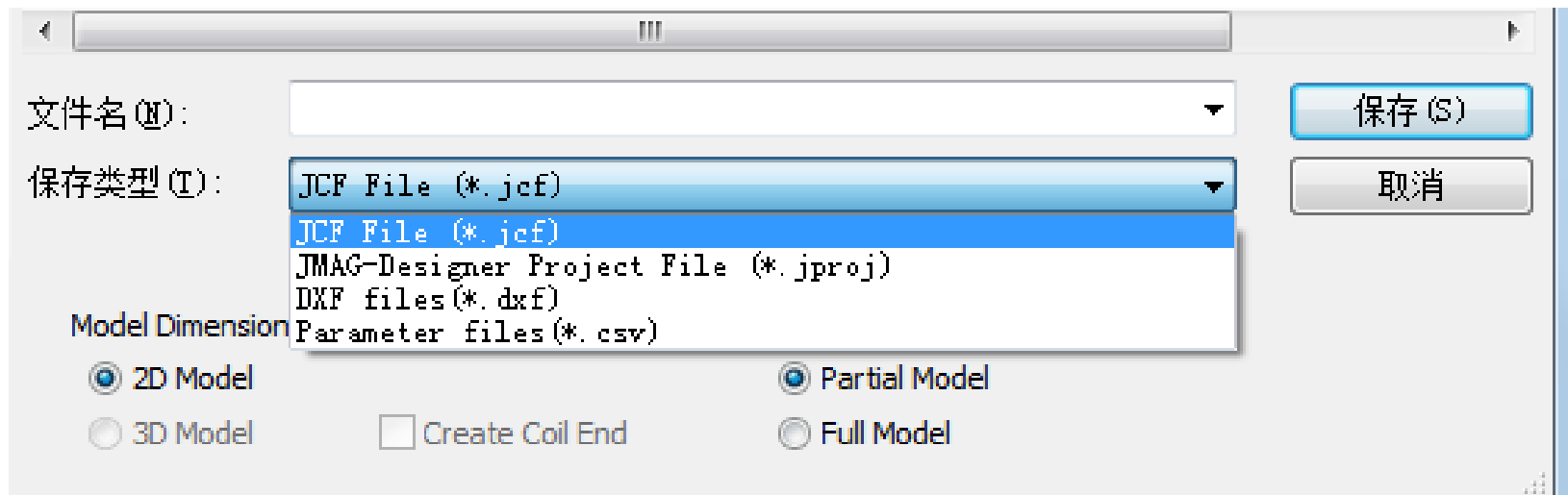
从相位扫描可以得到当初始相位在15度左右时转速3000转的情况下转矩最大
 从相位扫描可以得到当初始相位在25度左右时转速3000转的情况下效率最高

4.6 可以一键操作到Designer进行再次计算





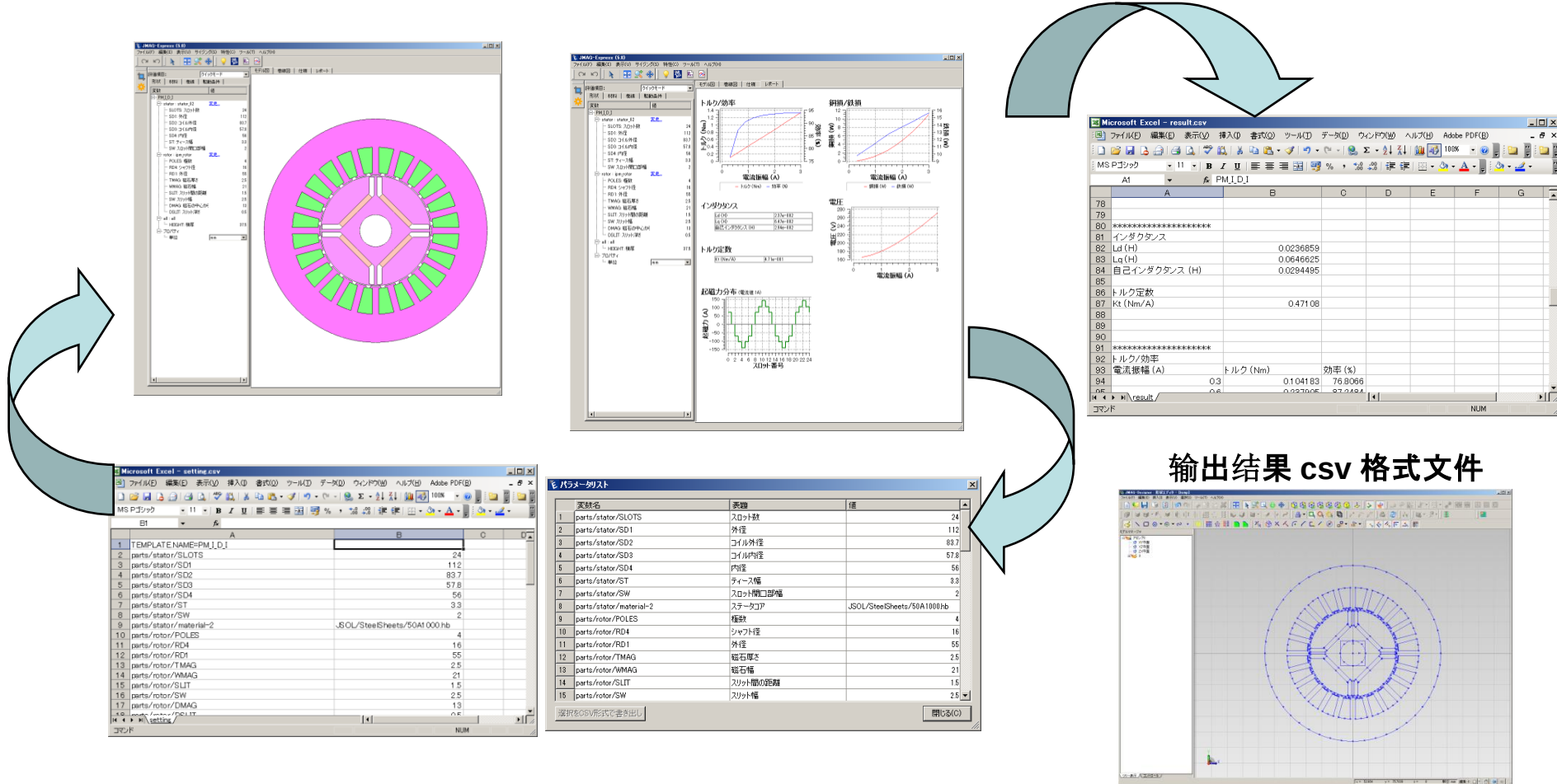
4.7 Express QM可以导出各类文件



可以导出jcf, project文件, 也可以导出dxf几何模型文件和csv表格文件

在导出project文件时可以选择是2D, 3D, 周期性模型或者全模型, 导出3D时可选择是否导出端部

4.7 Express QM可以导出各类文件

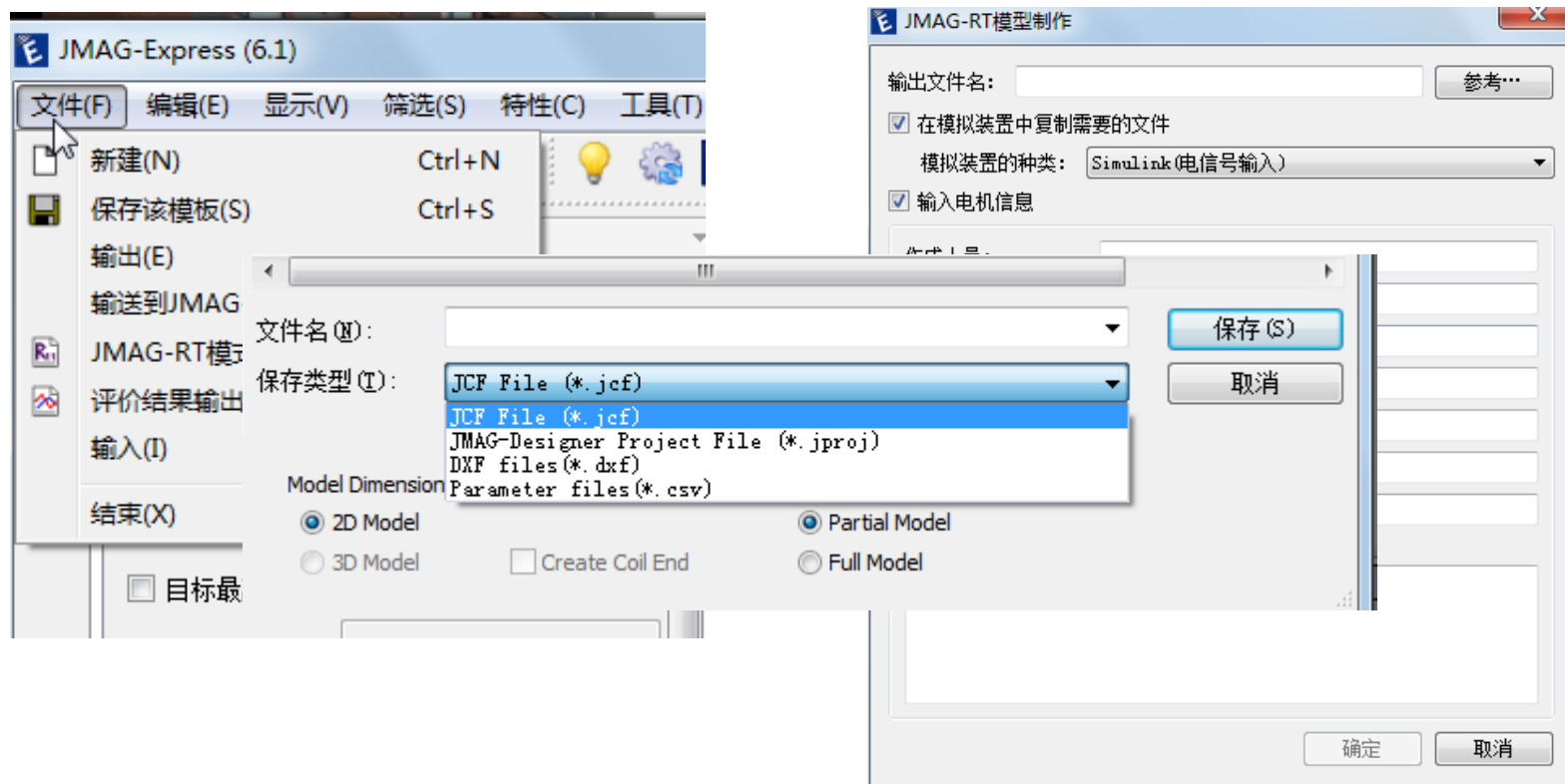


创建 csv 格式的输入文件

dxfl 几何模型



4.8 一键生成rtt文件

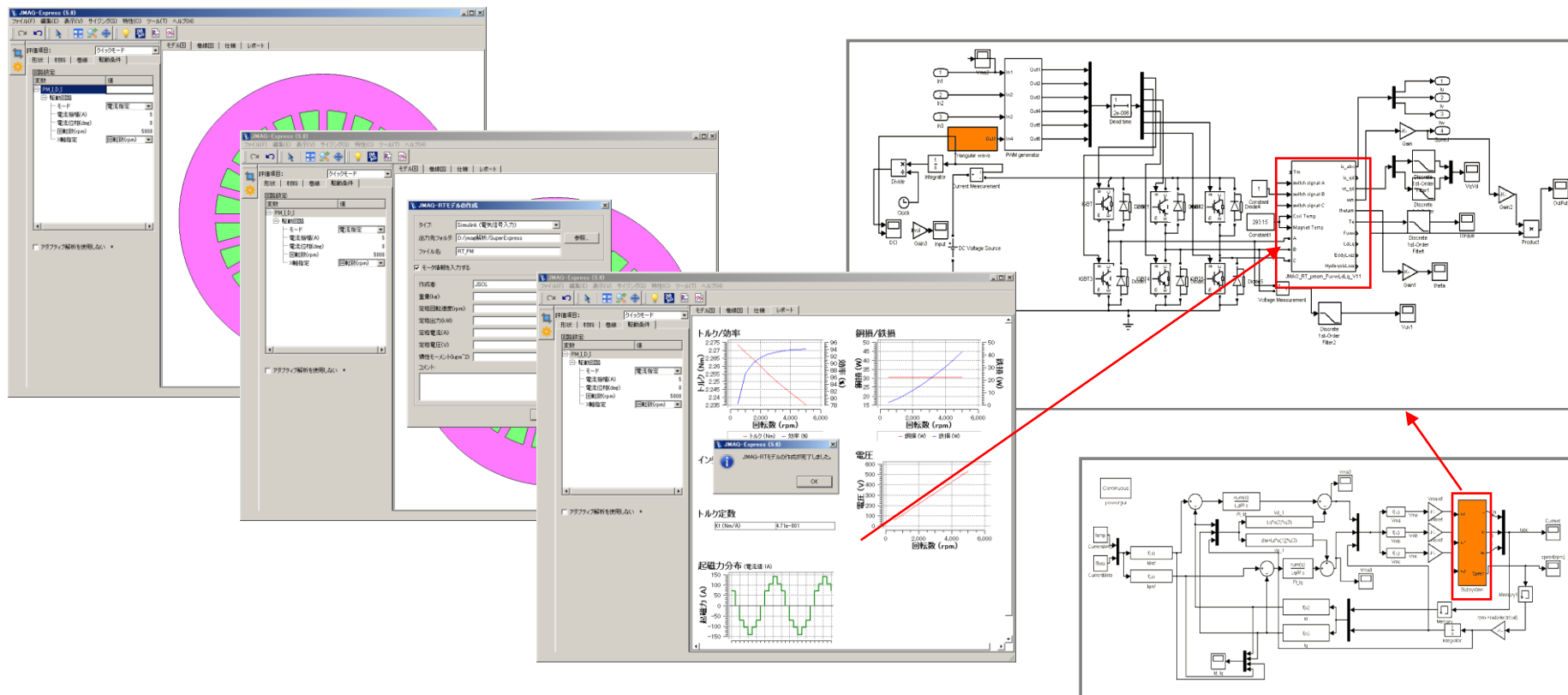


可以进行一键操作，生成rtt文件，绘制效率图，进行半实物联合仿真等

4.9 Express生成的Rtt文件跟Simulink联合仿真

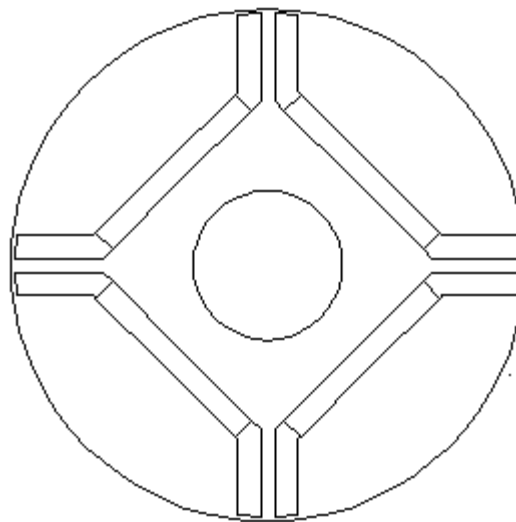
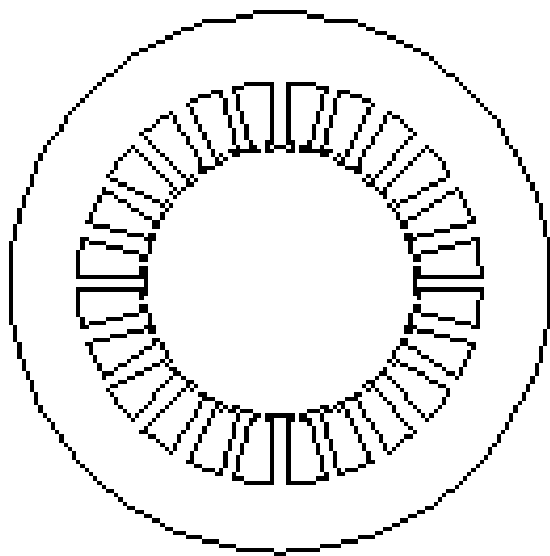
JMAG-RT 模型 (LdLq 模型)

可用于创建效率图以及跟控制联合仿真





五、 Express 自制模型案例分析



定子以及转子dxf文档，利用其生成**express**模型

5.1 定子模型创建

Parameter	Value
PM_ID_I2	
all	
OUTD: Outer Diameter	112
GAP: Gap Length	0.5
Gap Type	Free
HEIGHT: Height	37.5
stator : stator_02	
SLOTS: Number of Slots	
SD1: Outside Diameter	
SD2: Inside Diameter	
SW1: Tooth Width	
SW2: Slot Opening	
SW4: Core Back Width	
ST: Tooth Tang Depth	
ipm_rotor : ipm_rotor	
POLES: Number of Poles	4

Select Template

- ☐ Switch to Selected Template
- ☐ Edit Current Template
- ☒ Create New Template from JCF/DXF File

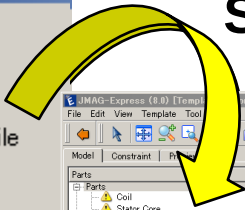
Templates:

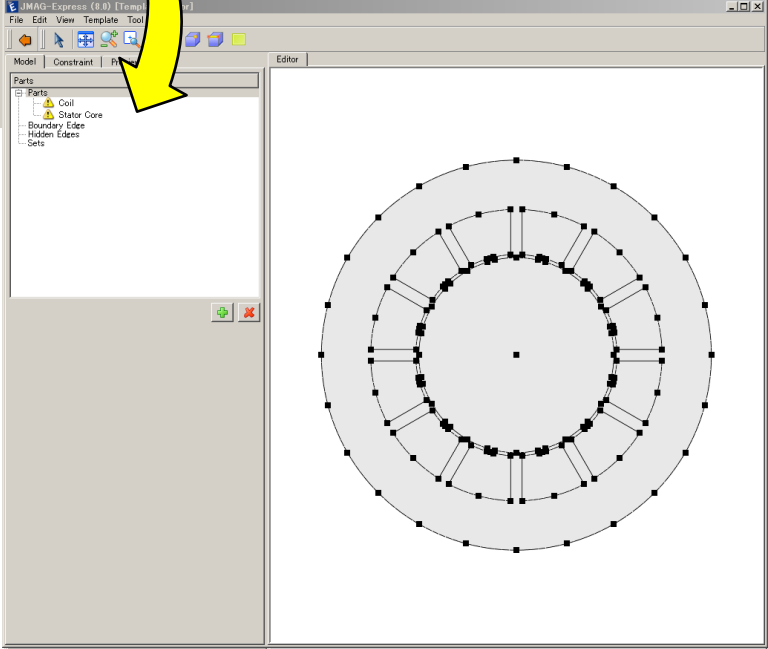
0.3

[Modify...](#)

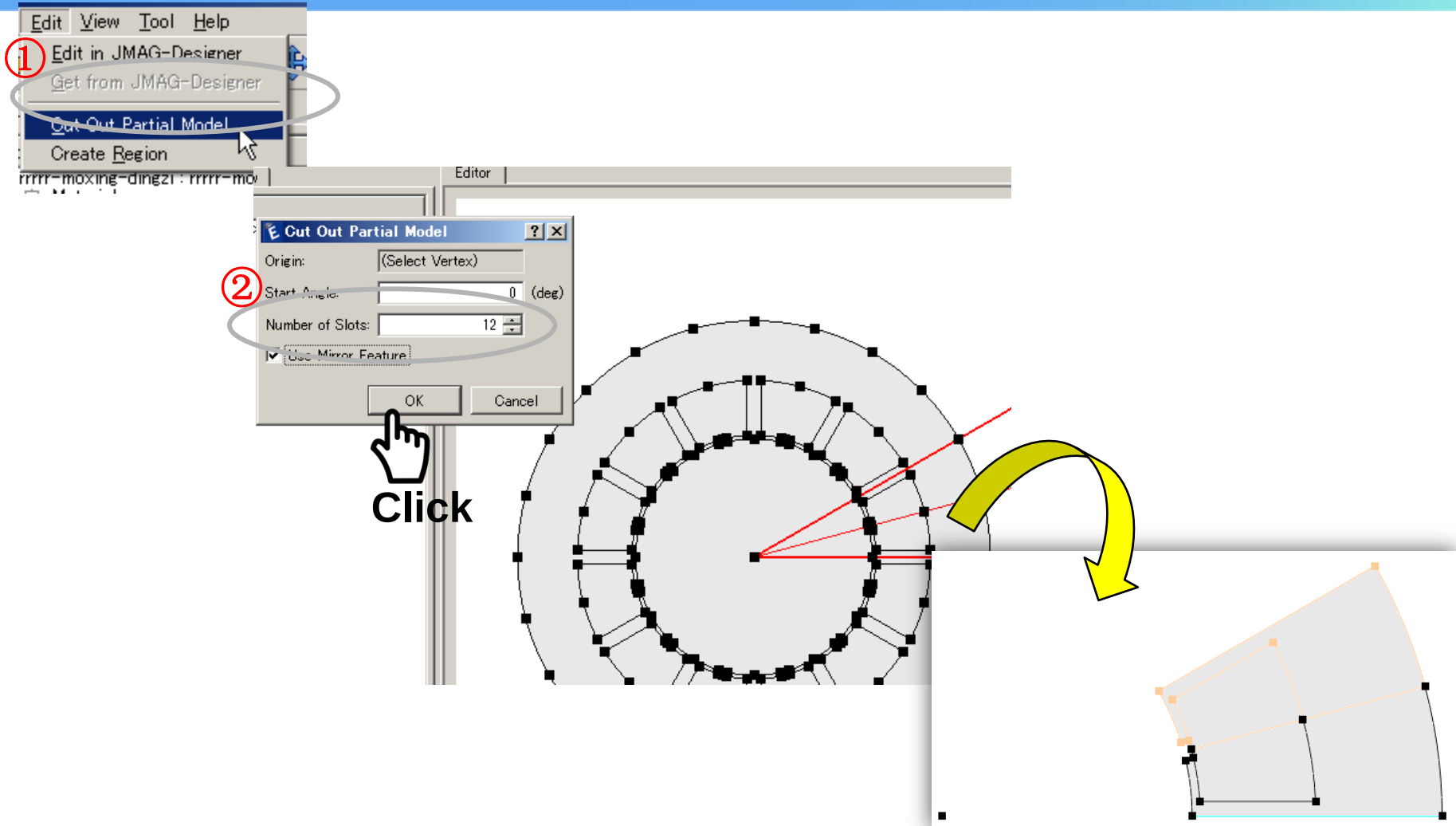
Click

Select dxf file of stator

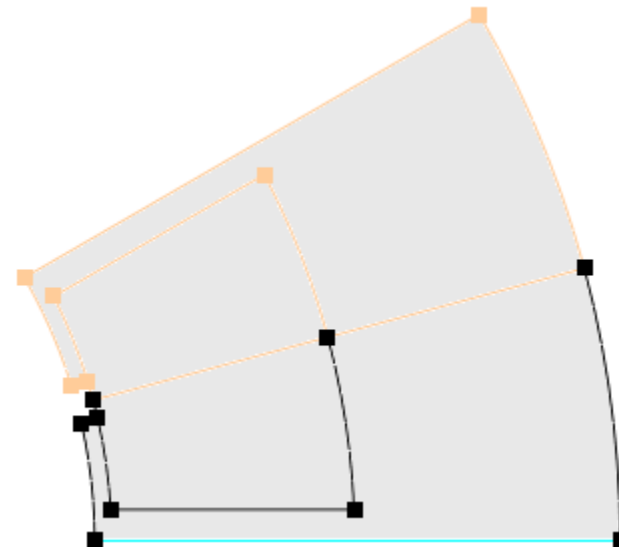
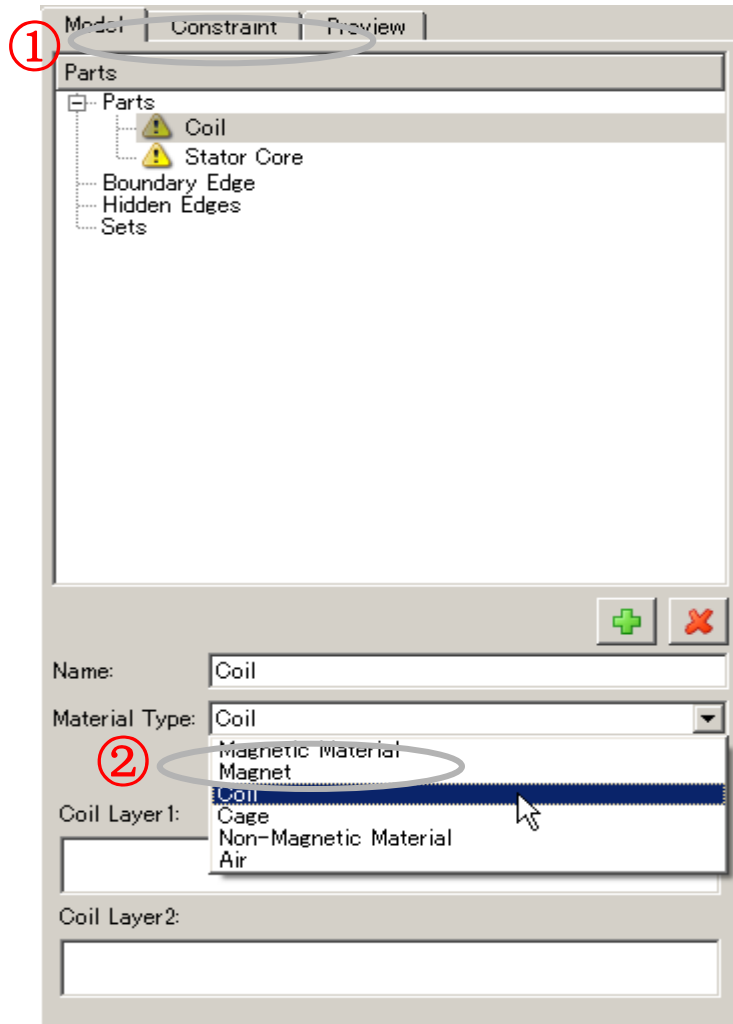




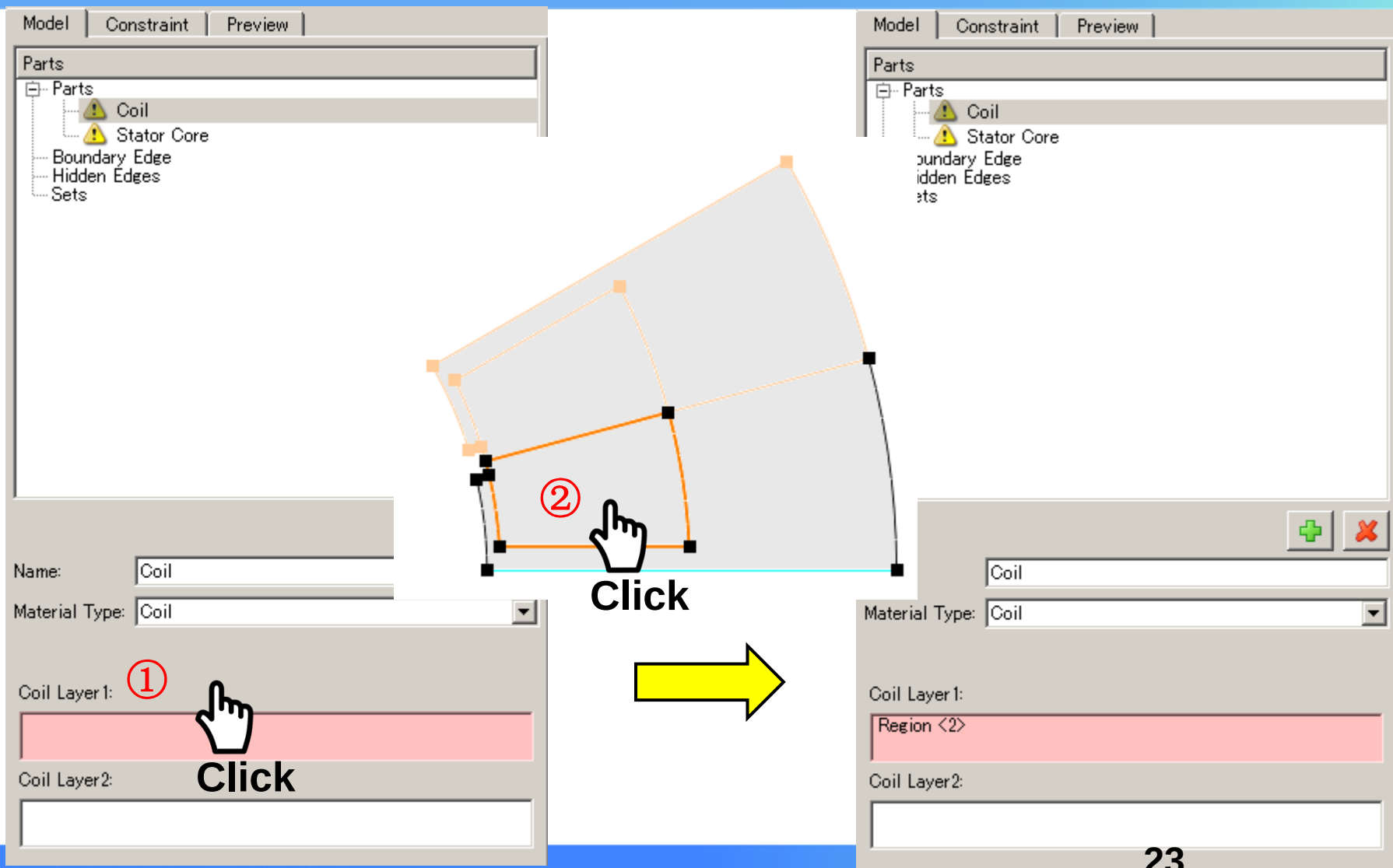
5.2 切割部分模型



5.3 设置线圈材料



5.4 设置线圈上下层



Model | Constraint | Preview

Parts

- Parts
 - Coil
 - Stator Core
- Boundary Edge
- Hidden Edges
- Sets

Name: Coil

Material Type: Coil

Coil Layer1: **1** Click

Coil Layer2:

Model | Constraint | Preview

Parts

- Parts
 - Coil
 - Stator Core
- Boundary Edge
- Hidden Edges
- Sets

Coil

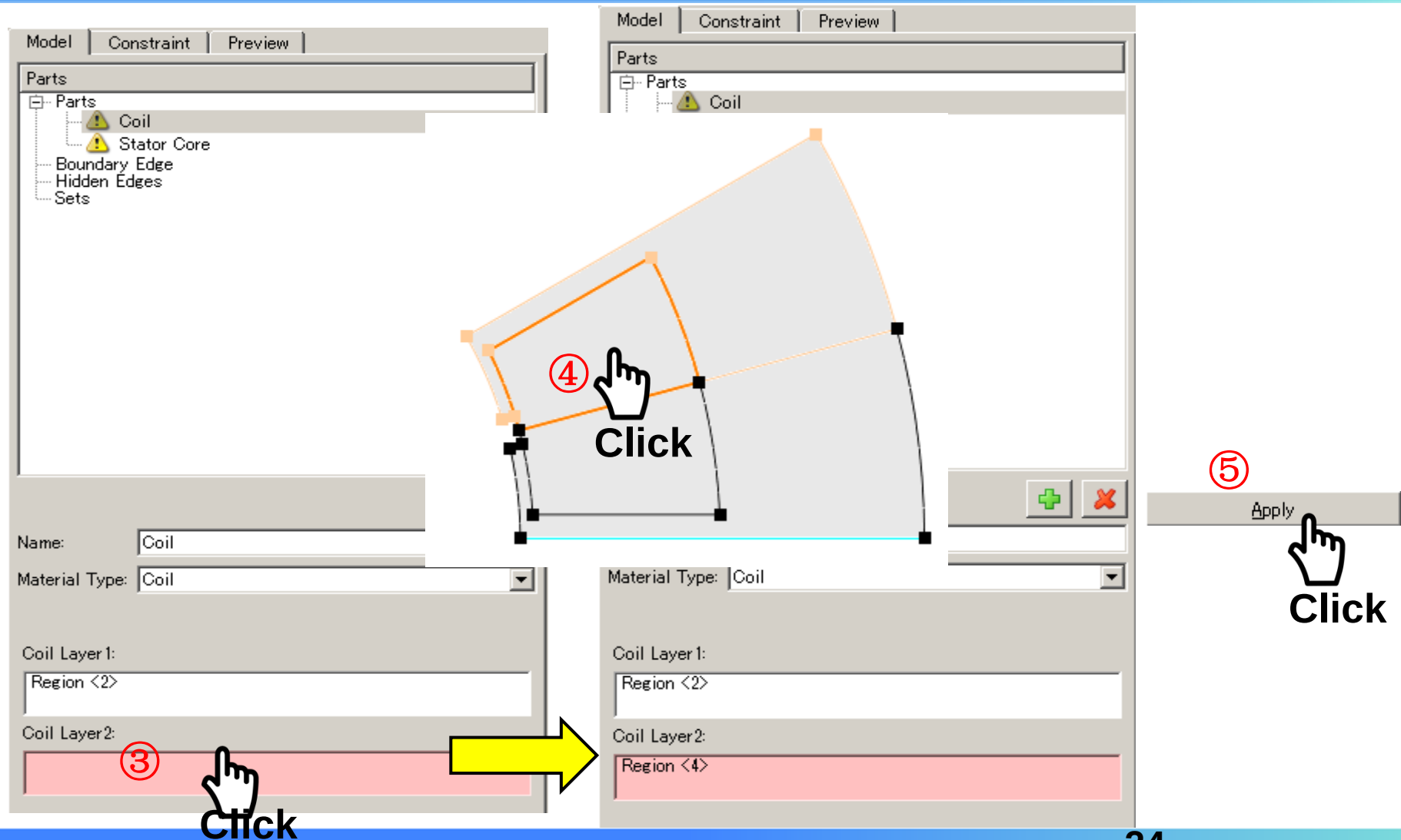
Material Type: Coil

Coil Layer1: Region <2>

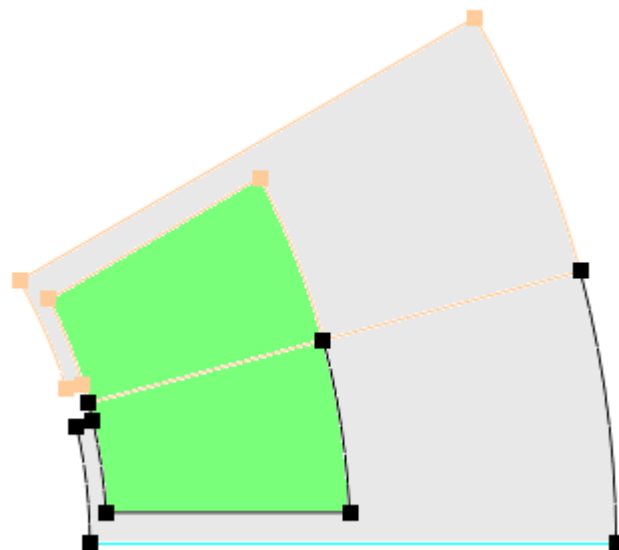
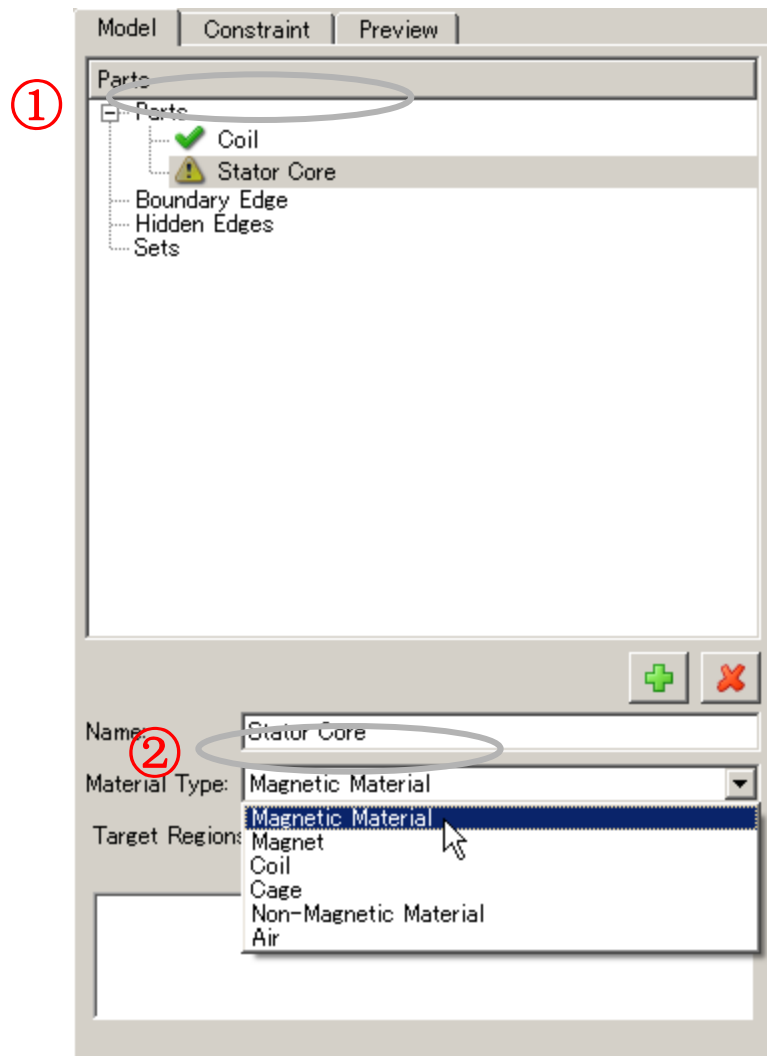
Coil Layer2:

23

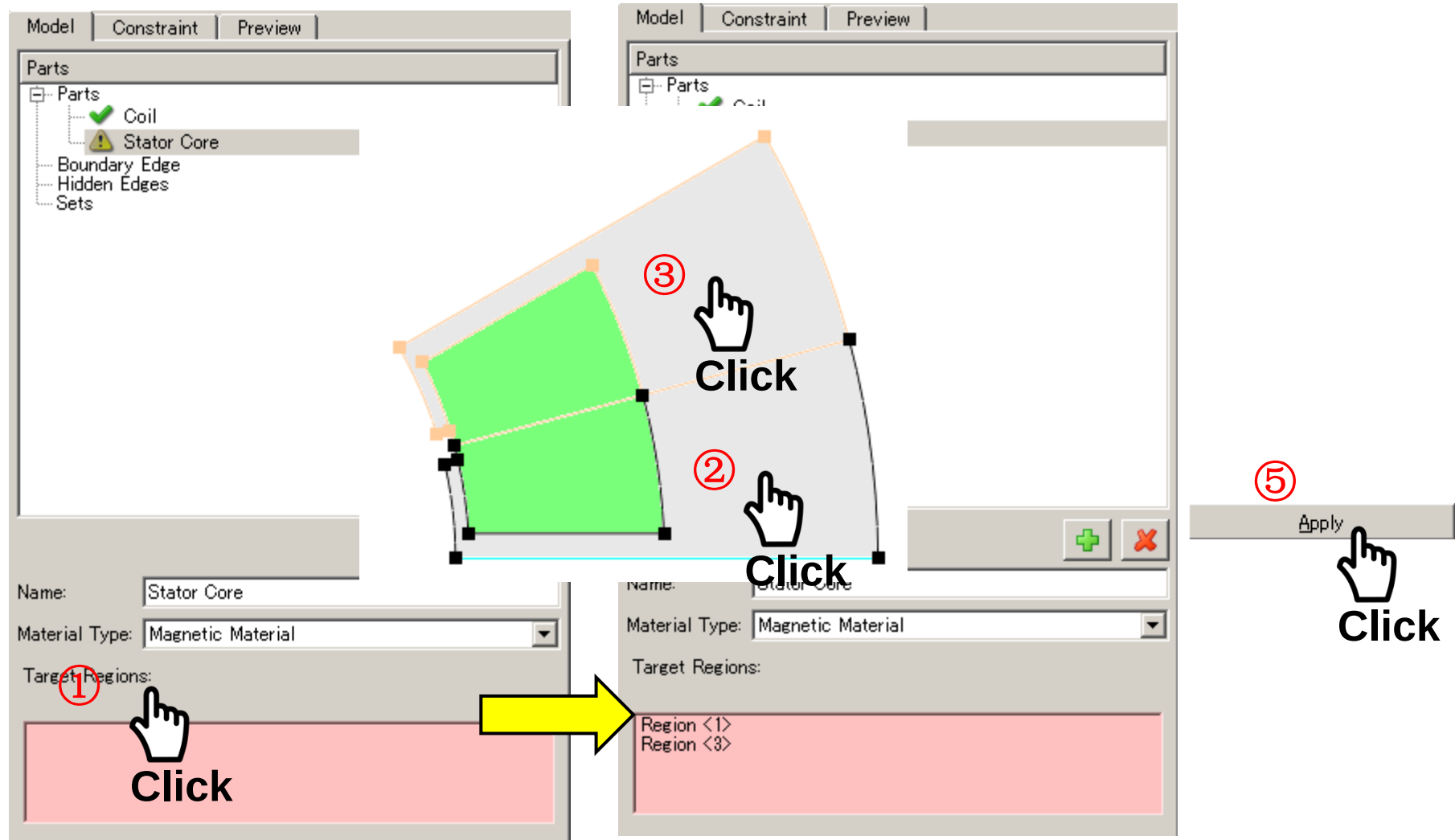
5.4 设置线圈上下层



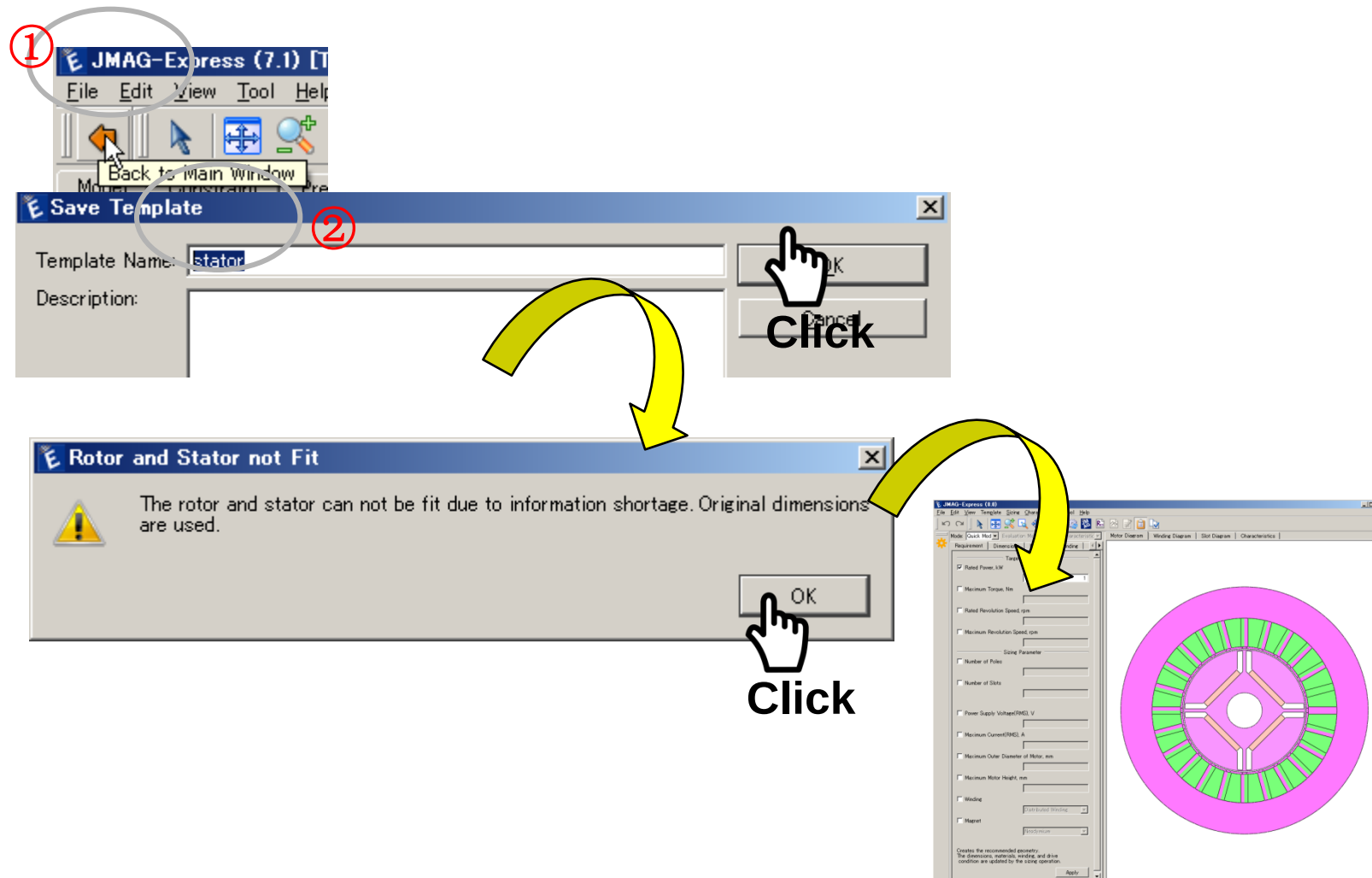
5.5 设置定子铁芯材料



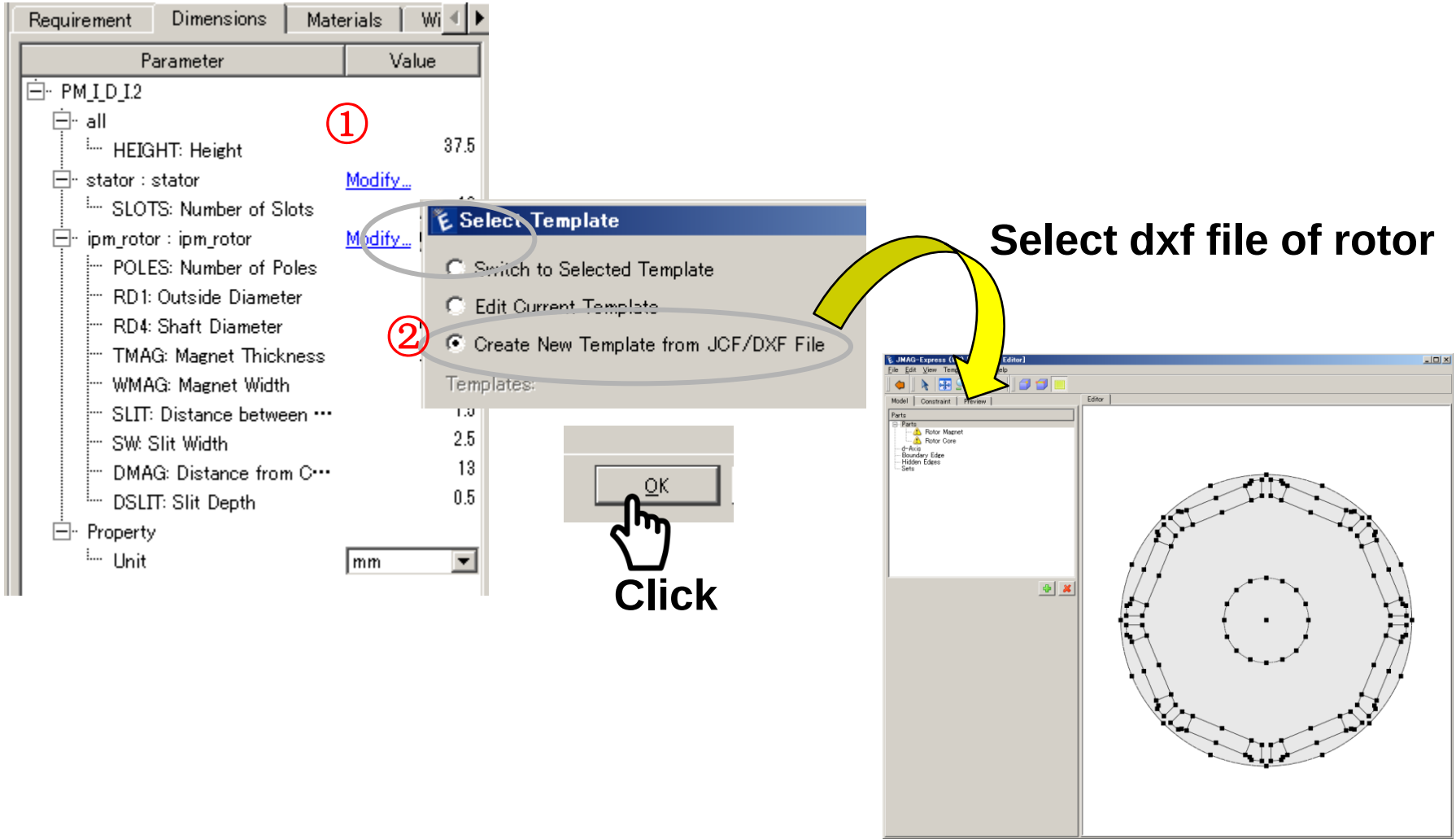
5.5 设置定子铁芯材料



5.6 回到主界面



5.6 打开转子dxf 文件



Requirement Dimensions Materials Wi

Parameter	Value
PM_ID_I2	
all	
HEIGHT: Height	37.5
stator : stator	
SLOTS: Number of Slots	48
ipm_rotor : ipm_rotor	
POLES: Number of Poles	4
RD1: Outside Diameter	100
RD4: Shaft Diameter	30
TMAG: Magnet Thickness	1.0
WMAG: Magnet Width	2.5
SLIT: Distance between ...	13
SW: Slit Width	0.5
DMAG: Distance from C...	
DSLIT: Slit Depth	
Property	
Unit	mm

①

Modify...

②

Select Template

- Switch to Selected Template
- Edit Current Template
- Create New Template from JCF/DXF File

Templates:

OK

Click

Select dxf file of rotor

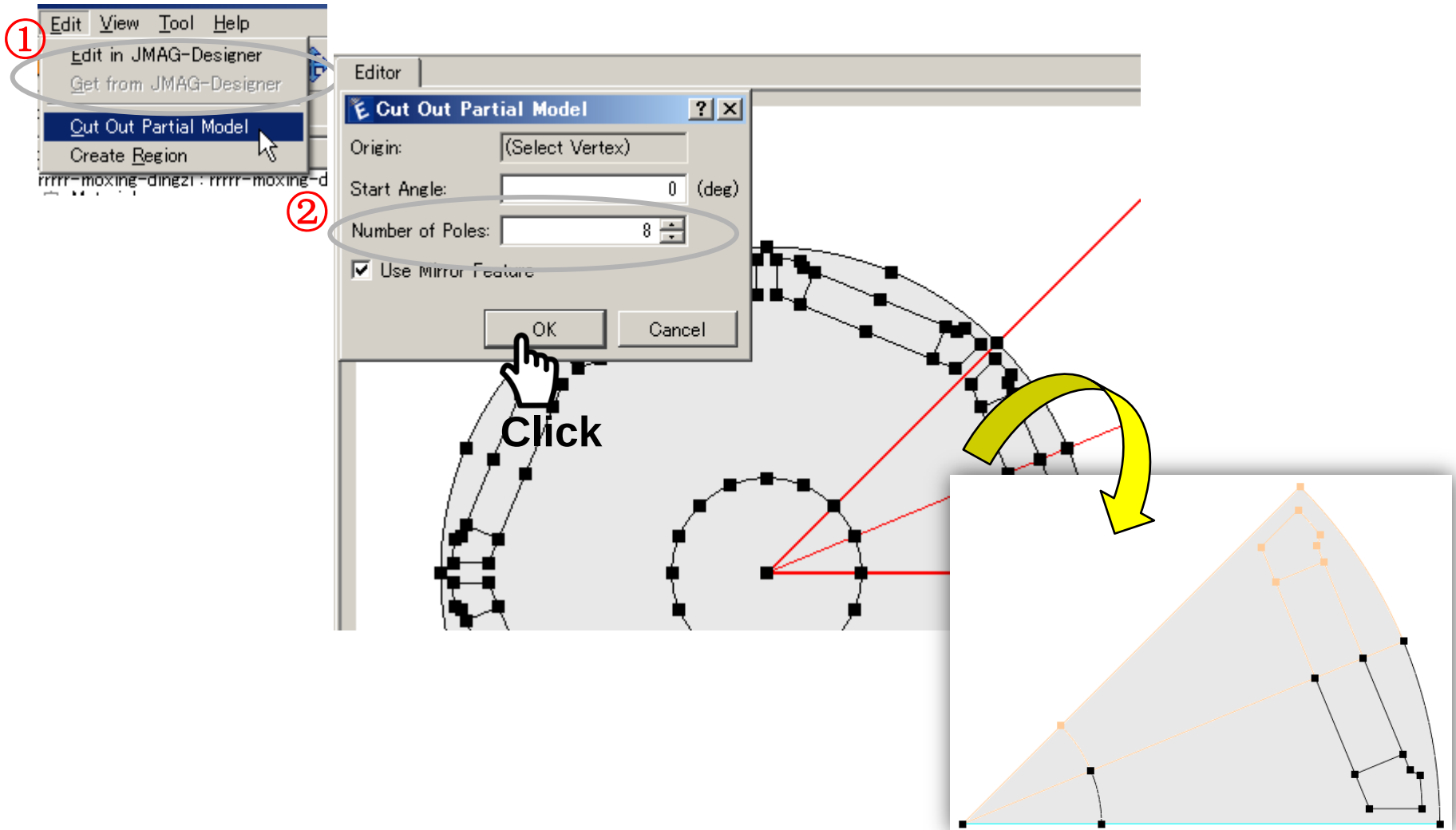
JMAG-Express

Model Constraint Preview Editor

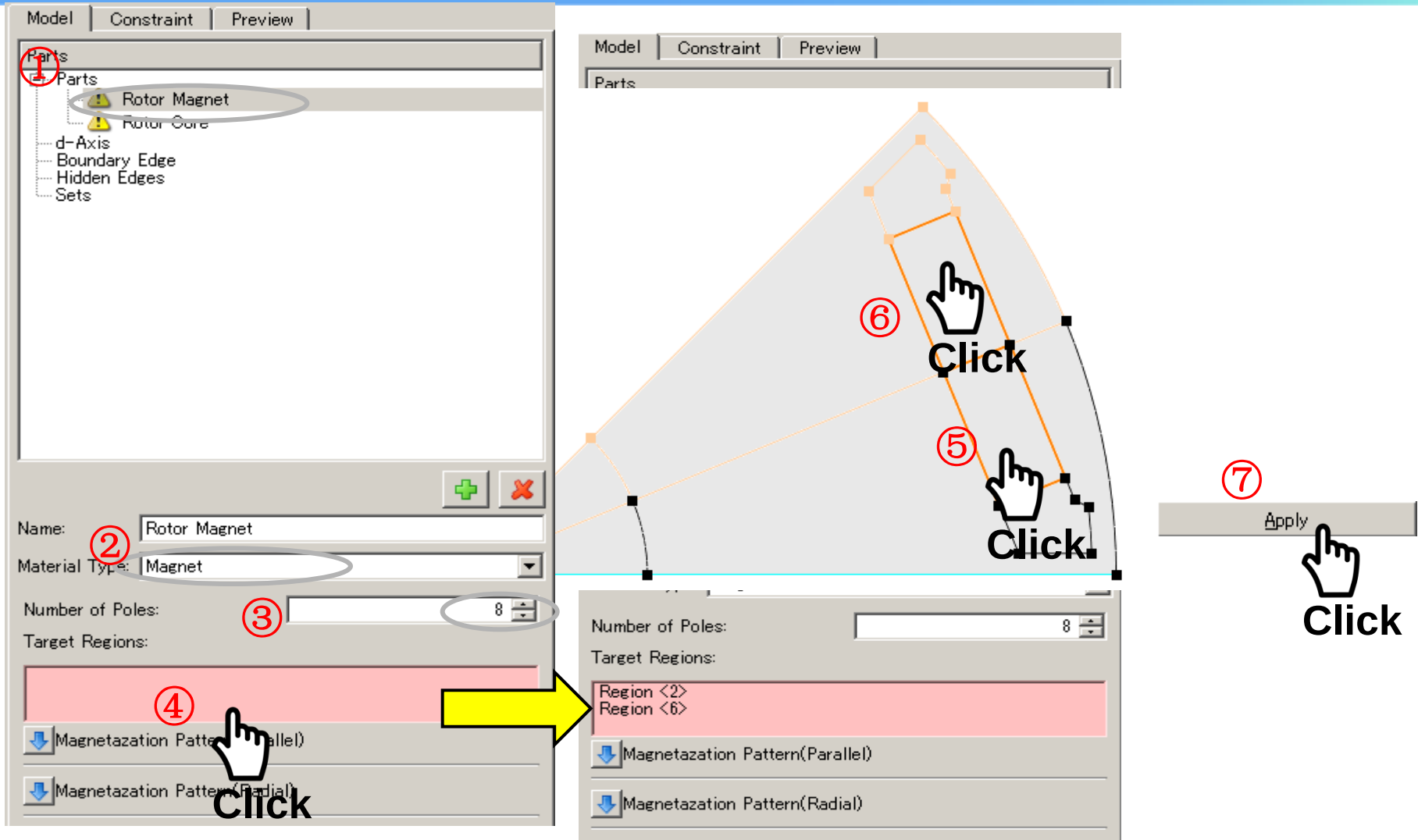
Parts

- Rotor Magnet
- Rotor Core
- d-Hub
- Boundary Edge
- Hidden Edge
- Set

5.7 切割转子部分模型



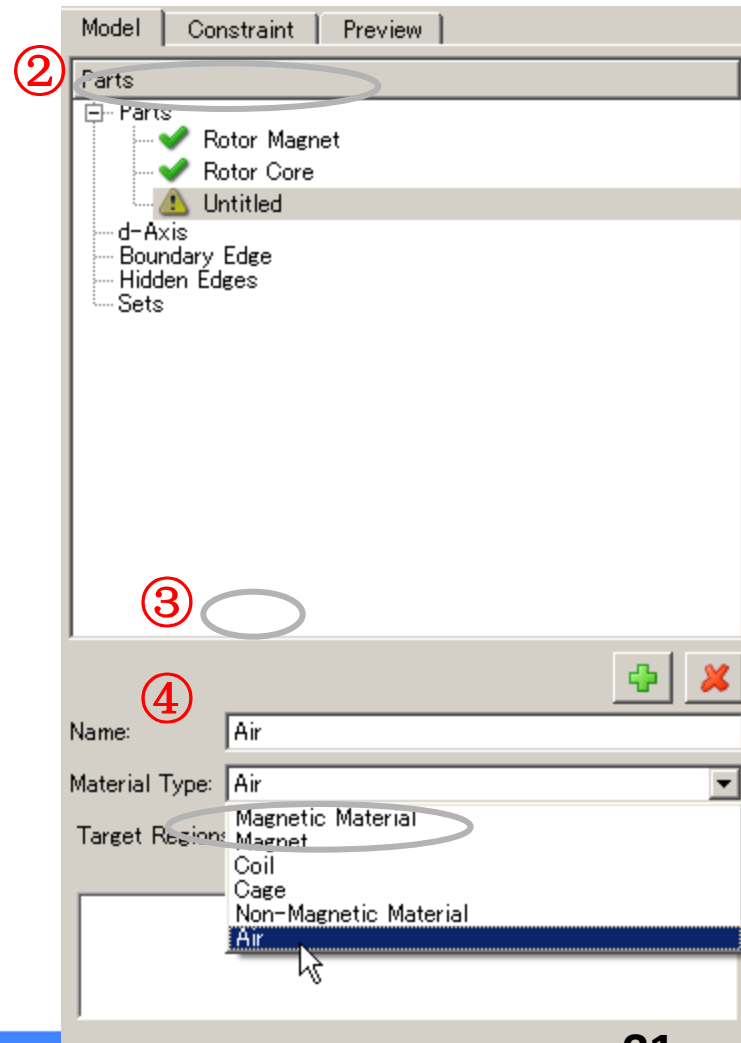
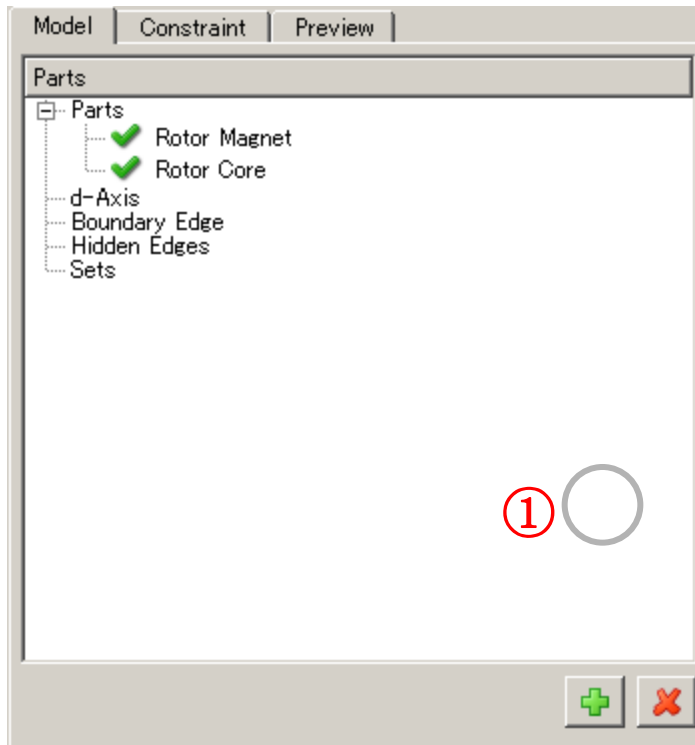
5.8 设置磁钢材料



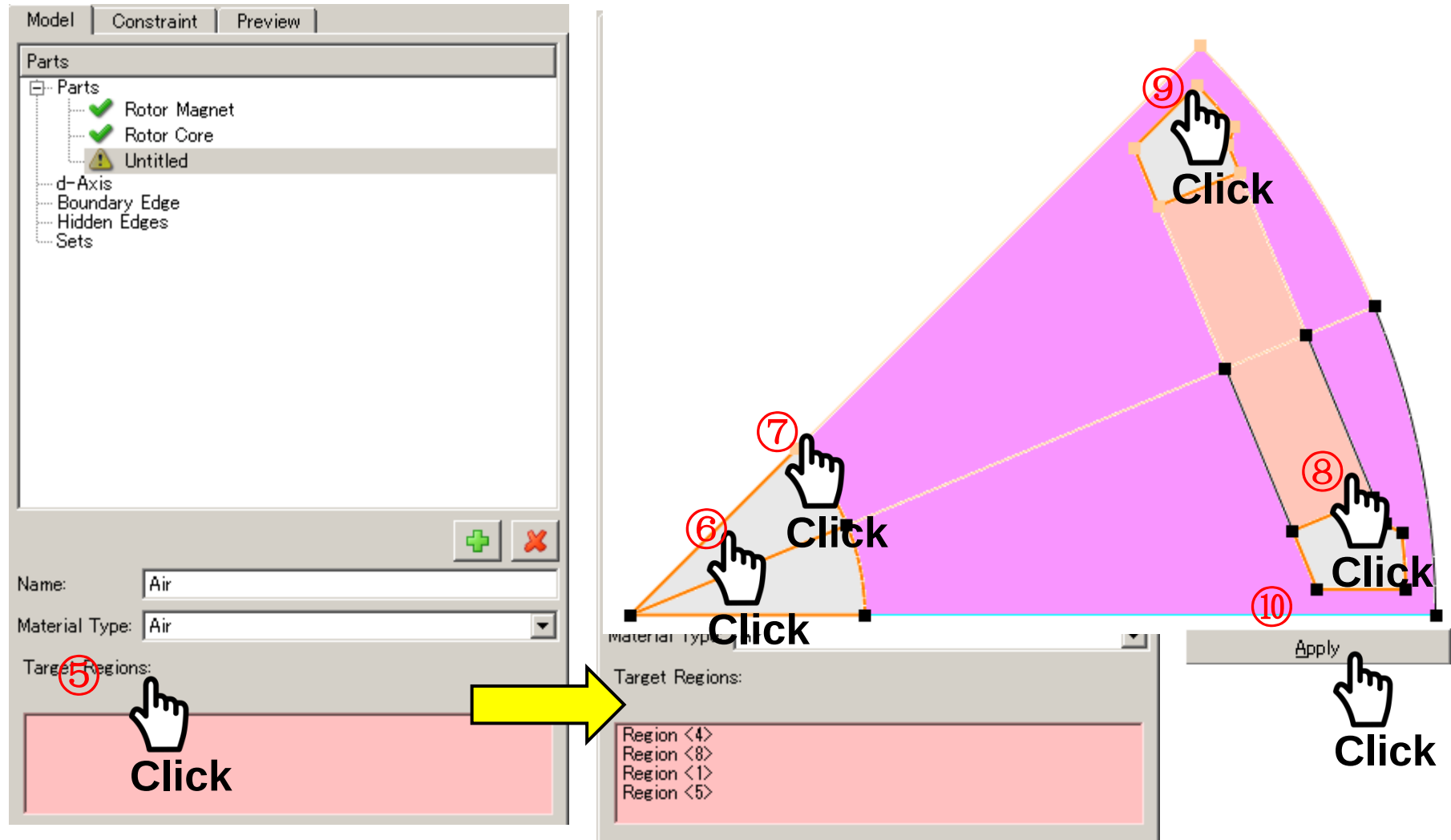
The screenshot illustrates the steps to configure the magnetic material for a rotor magnet in the IDAJ software. The interface is divided into several panels:

- Parts Tree:** Shows the hierarchy of the model. The 'Rotor Magnet' part is selected, indicated by a red circle 1.
- Properties Panel:**
 - Name:** Rotor Magnet
 - Material Type:** Magnet (indicated by red circle 2)
 - Number of Poles:** 8 (indicated by red circle 3)
 - Target Regions:** A list of regions to be magnetized. The 'Magnetization Pattern (Parallel)' option is selected (indicated by red circle 4 and a yellow arrow pointing to the 3D model).
- 3D Model:** A 3D view of the rotor magnet assembly. The magnet region is highlighted in orange. The 'Click' label with a hand icon and red circle 5 points to the magnet region. The 'Click' label with a hand icon and red circle 6 points to the pole region.
- Apply Button:** A button labeled 'Apply' (indicated by red circle 7) is used to confirm the settings.

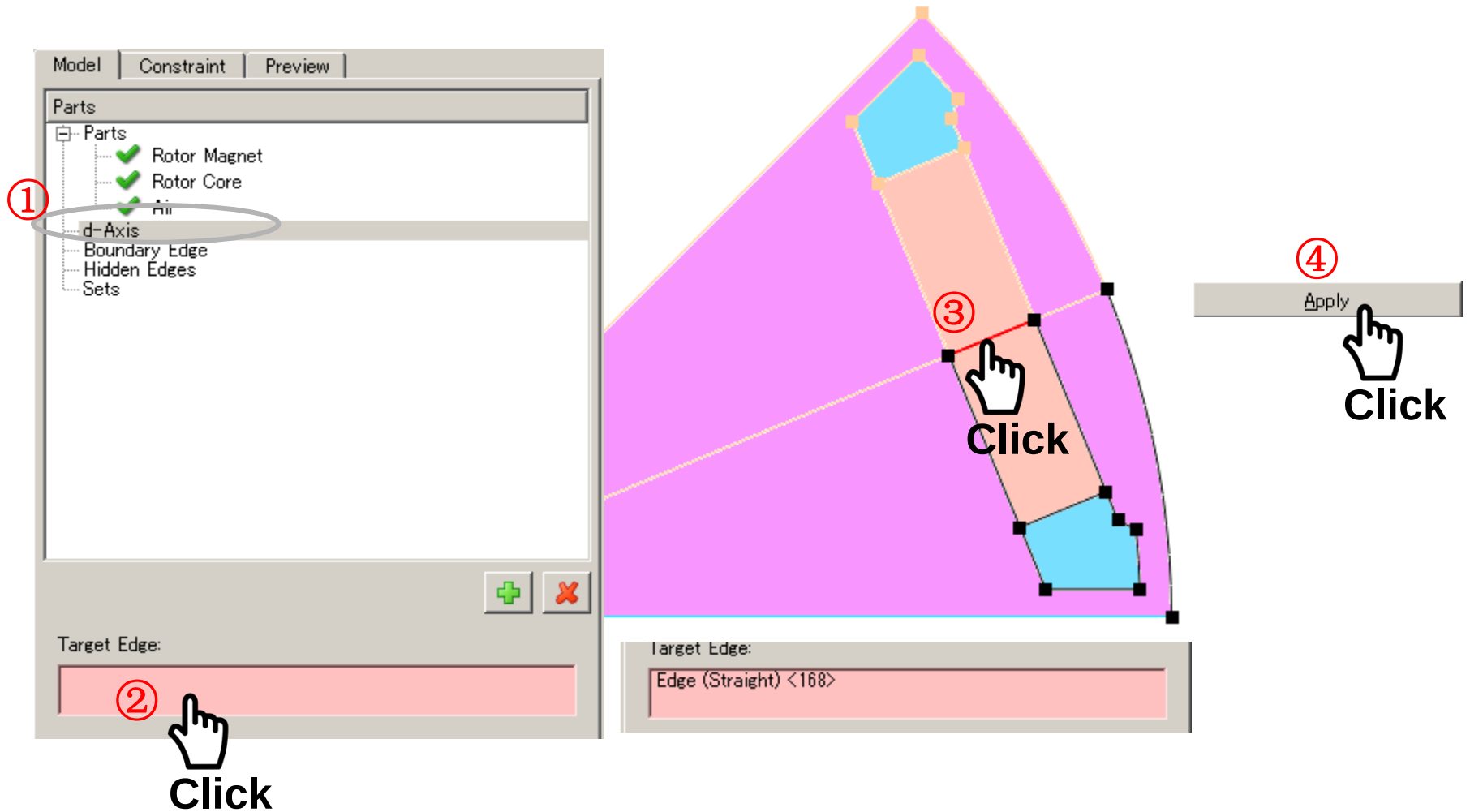
5.9 设置空气材料属性



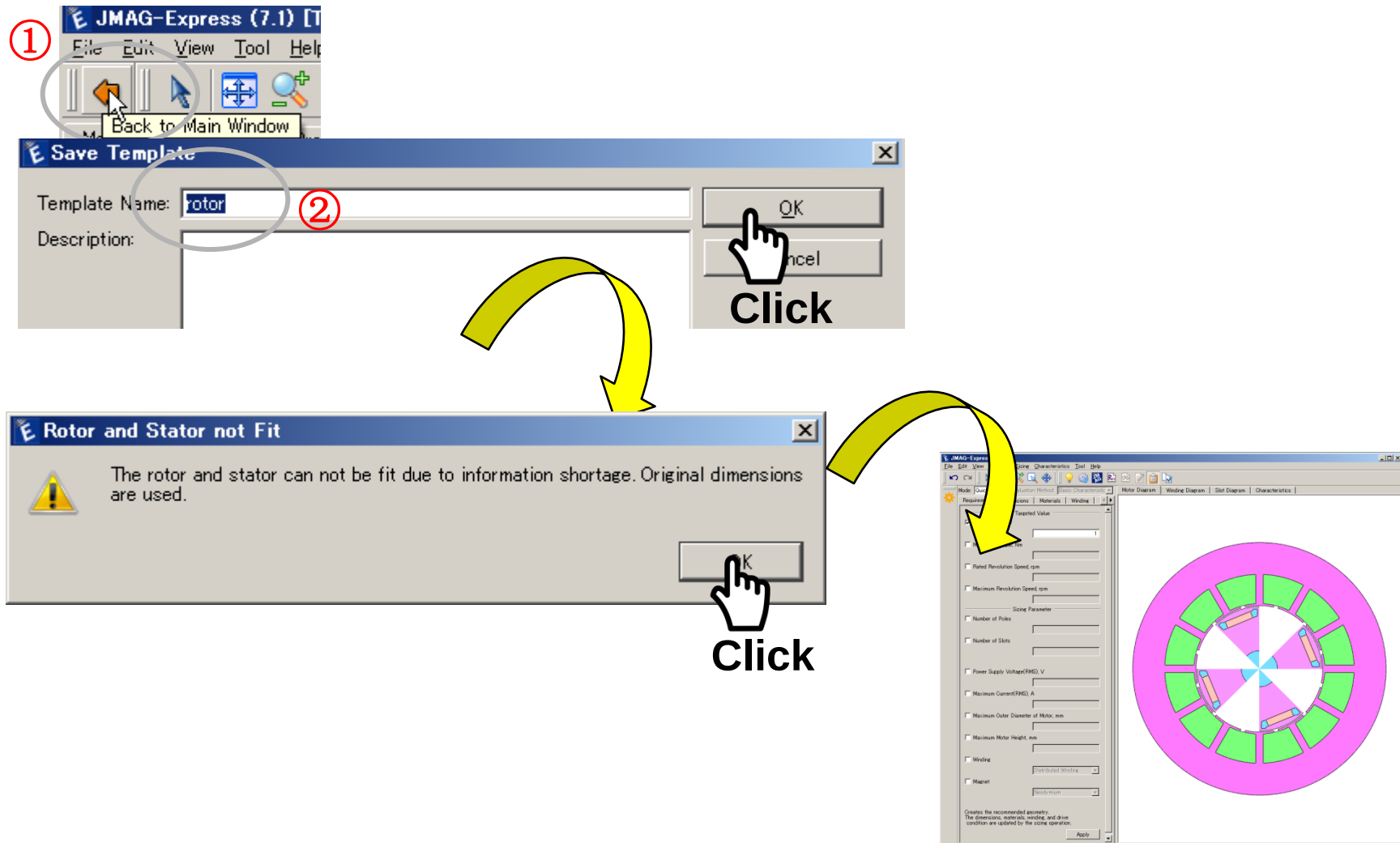
5.9 设置空气材料属性



5.10 设置d轴边界



5.11 主界面



5.11 主界面

①

Requirement | **Dimensions** | Materials | Winding

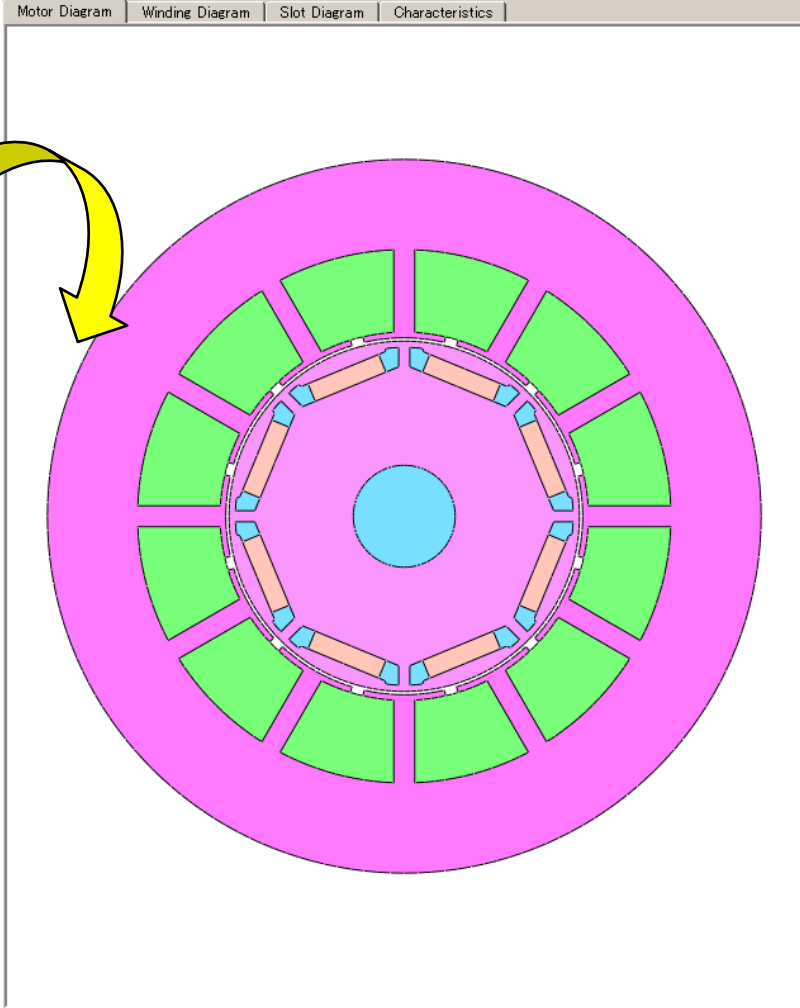
Parameter	Value
PM_ID_I2	
Unit	mm
all	
OUTD: Outer Diameter	112
HEIGHT: Height	37.5
stator : stator	
SLOTS: Number of Slots	12
ipm_rotor : Rotor	
POLES: Number of Poles	8

②

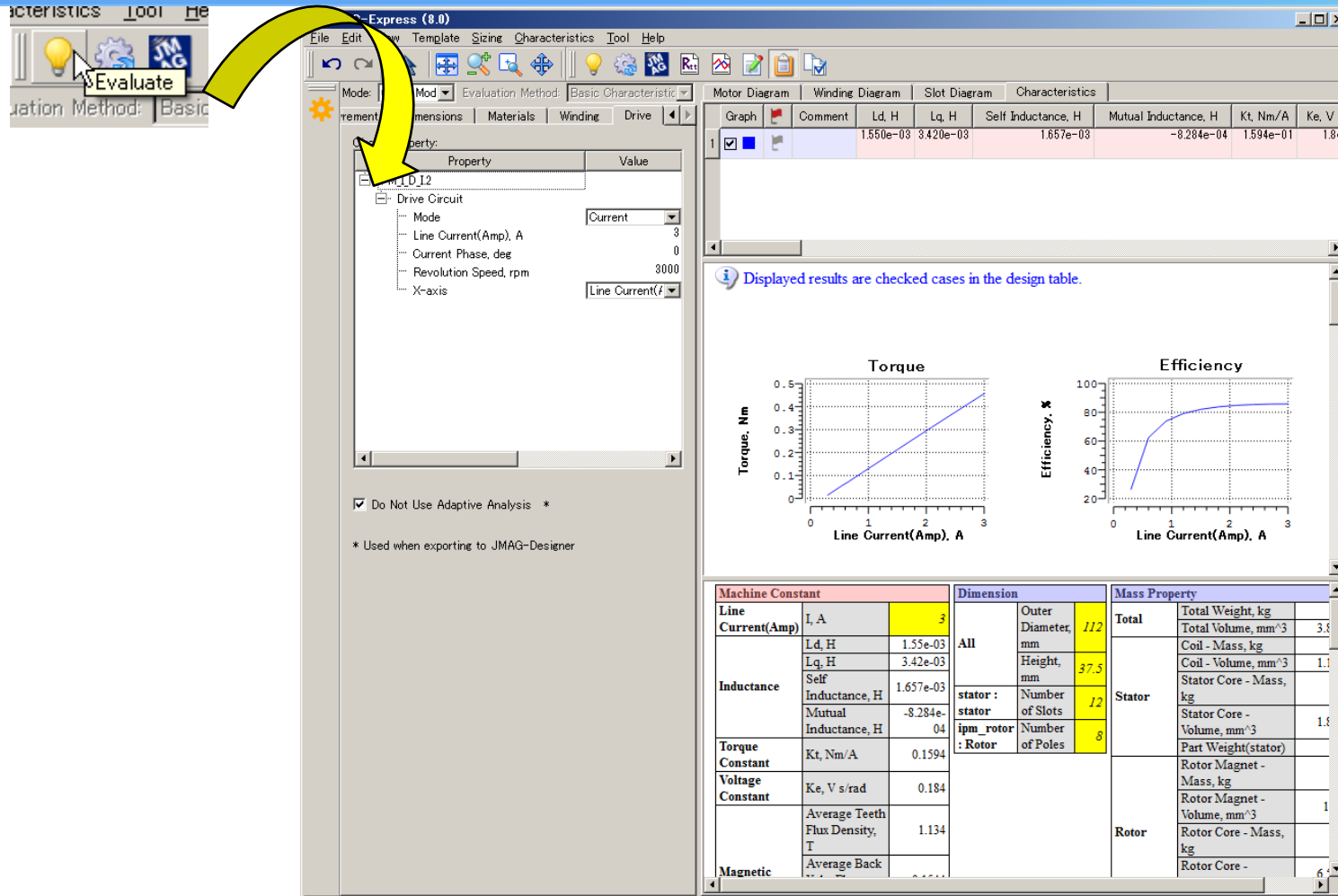
Modify

Modify

Motor Diagram | Winding Diagram | Slot Diagram | Characteristics



5.12 评估分析结果



设置电机的材料，线圈绕组以及驱动方式

5.13 模型参数

JMAG-Designer (x64) (16.0beta) - Untitled[PM_I_D_S2.2-moxing.jproj] - [Window - PM_I_D_S2_0 : Express Project]

File Edit View Select Tools Window Scripts Help

1 / 33 Steps 5 / 5 Cases

Project Manager

- Filter:
- Rotor Magnet
- Coordinate System
 - Global Rectangular
 - Cylindrical
 - Local Rectangular (Y-Z-X)
 - Local Rectangular (Z-X-Y)
- Study: <Magnetic> <Express Project>
 - Case Control
 - CAD Parameters
 - Radius@P1:Radius/Diameter@...
 - Parts
 - Coil: <Copper>
 - Stator Core: <50A1000>
 - Rotor Magnet: <NdFeB_Br=1...>
 - Rotor Core: <50A1000>
 - Materials
 - Copper
 - 50A1000
 - NdFeB_Br=1.0(T)(reversible)
 - Conditions
 - FEM Coil: U-Phase Coil
 - FEM Coil: V-Phase Coil
 - FEM Coil: W-Phase Coil
 - Motion Rotation: untitled1

Treeview Control

Case: 5
Step: 1
Time: s: 0.0000

Express Project

JMAG-Designer: All Cases Messages

Case	Step	Time	Power	Torque	Message
3	2812	1619	0	2	Open report... G:/2016年会资料/PM_I_D_S2.2-moxing.ifiles/PM_I_D_S2_0'2/Express Project'2/Case2
4	2830	1628	0	2	Open report... G:/2016年会资料/PM_I_D_S2.2-moxing.ifiles/PM_I_D_S2_0'2/Express Project'2/Case3
5	2850	1638	0	2	Open report... G:/2016年会资料/PM_I_D_S2.2-moxing.ifiles/PM_I_D_S2_0'2/Express Project'2/Case4

Case 1
Warning: The slide circumferential division is changed
Warning: The area of the electromagnetic power and the torque condition is extended

Case 2
Warning: The slide circumferential division is changed
Warning: The area of the electromagnetic power and the torque condition is extended

Case 3
Warning: The slide circumferential division is changed
Warning: The area of the electromagnetic power and the torque condition is extended

Case 4
Warning: The slide circumferential division is changed
Warning: The area of the electromagnetic power and the torque condition is extended

Case 5
Warning: The slide circumferential division is changed
Warning: The area of the electromagnetic power and the torque condition is extended

Export Close

x = 11.7539 y = -14.4246 z = 0.0183706 Unit: mm

15:34
2016/11/21

5.14 Express QM总结

Express QM在确保准确度的基础上，可以进行非常快捷，非常强大的电机设计工作，用户不用学习软件操作，都可以很好的完成前期的概念设计部分。

同时也为后期的Designer有限元分析完成了前期的几何，材料，绕组关联， 电路驱动设置等前期工作，可在Designer里直接进行更加精确细致的计算



六、Express Power Mode介绍

-----有限元分析模式

- Express Power Mode特点
- Power Mode永磁电机基本特性计算
- Power Mode永磁电机谐波损耗以及转矩分离计算
- Power Mode永磁电机永磁体分段涡流计算
- Power Mode感应电机计算内容
- Power Mode开关磁阻电机计算内容
- Power Mode 操作
- 可在 JMAG-Designer中一键操作确认结果
- 基本特性计算
- 考虑 PWM波的铁耗计算
- 考虑 PWM的永磁体分段涡流计算
- 转矩分离计算
- Power Mode 相关说明

6.1 Power Mode 相关说明

用户是否可以自定义计算事项

- Power Mode中不行
- 但是用户可以通过 JMAG-VTB设置计算流程，实现自定义计算

用户是否可以自定义计算模版

- 在Quick Mode当中就可以直接创建用户自己的模版，在Power Mode中可以直接使用

想要知道更多计算的流程设置.

- 用户可以参考所有的JMAG application note



6.2 Power Mode总结

前期参数设置如选择模版，几何参数，材料，绕组等设置皆同 Quick Mode

可选择和设置计算种类多，基本涵盖所有普通计算需求

后台调用JMAG-Designer有限元计算，但不需要到Designer里进行设置，且需要的结果自动返回显示，既准确又方便快捷

THANK YOU



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