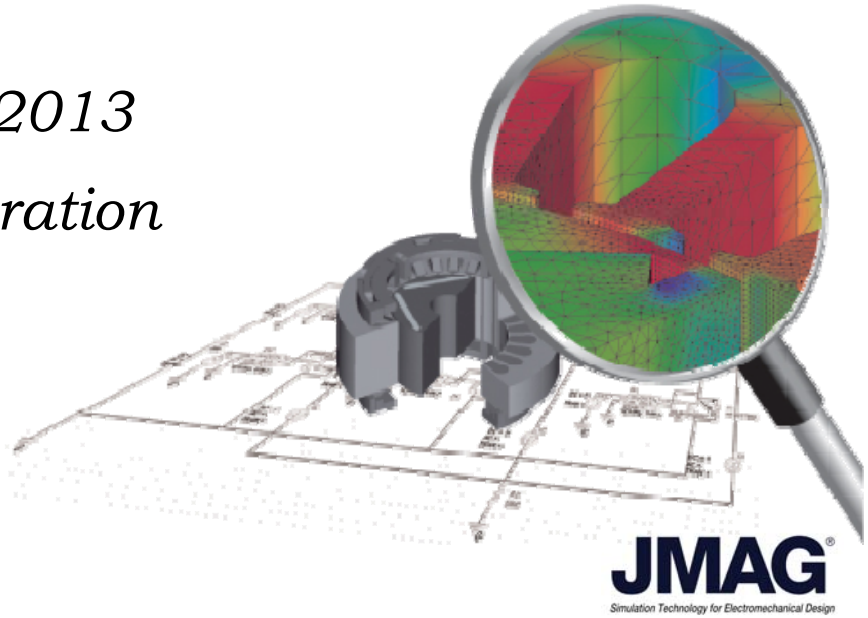
Introduction to JMAG-Designer Ver.13 New Functions

November 2013

JSOL Corporation



Ver. 13 Features

- *JMAG-Designer Ver.13 will be released in early December 2013.*
- *Main features :*
  - *Details*

    High-precision loss model, temperature/stress evaluation in magnetic field analysis
  - *High-speed*

    High parallel calculation, 2.5D calculation using the multi-slice method
  - *Open*

    I/O expansion of general purpose interface

JMAG-Designer Ver.13

- *Enhanced speed*
  - *High parallel solver*
  - *Faster heat/electric field parallel solver*
  - *Consideration of 3D effect using multi-slice method*
- *High precision loss*
  - *Laminated eddy current loss calculation*
  - *Hysteresis loss calculation*
  - *Stress tensor dependency iron loss calculation*
- *Multi-Physics*
  - *Small multi-physics*
  - *Structure transient analysis*
- *Optimization*
  - *Optimization calculation using response surface methodology (RSM)*
- *Model base development*
  - *I/O expansion of general purpose interface*
  - *LMS VL link expansion*
  - *RT model 3D correction*
- *Setting conditions*
  - *Study management*
  - *Setting of non-analysis target parts*
  - *Select/deselect model*
  - *Fraction input*
  - *Current hysteresis band control*
- *Post*
  - *Result rendering type control for each part*
  - *Vector rendering density control*
  - *Induction motor efficiency map*
  - *Selectable multiple control methods*
- *Mesh Generation*
  - *Improved thin mesh*
- *JMAG-Express*
  - *Sizing through design comparison*

Features x Applications

	All	PM	IM	SRM	Transformer
High parallel solver	x				
Faster heat/electric field parallel solver	x				
Consideration of 3D effect using multi-slice method		x	x		x
Laminated eddy current loss calculation	x				
Hysteresis loss calculation	x				
Stress tensor dependency iron loss calculation	x				
Small multi-physics	x				
Structure transient analysis	x				
Optimization calculation using response surface methodology	x				
I/O expansion of general purpose interface	x				
LMS VL link expansion	x				
RT model 3D correction		x			
Study management	x				
Setting of non-analysis target parts	x				
Select/deselect model	x				
Fraction input	x				
Current hysteresis band control				x	
Result rendering type control for each part	x				
Vector rendering density control	x				
Induction motor efficiency map			x		
Selectable multiple control methods		x			
Improved thin mesh	x				
Skin mesh generation for mesh models	x				

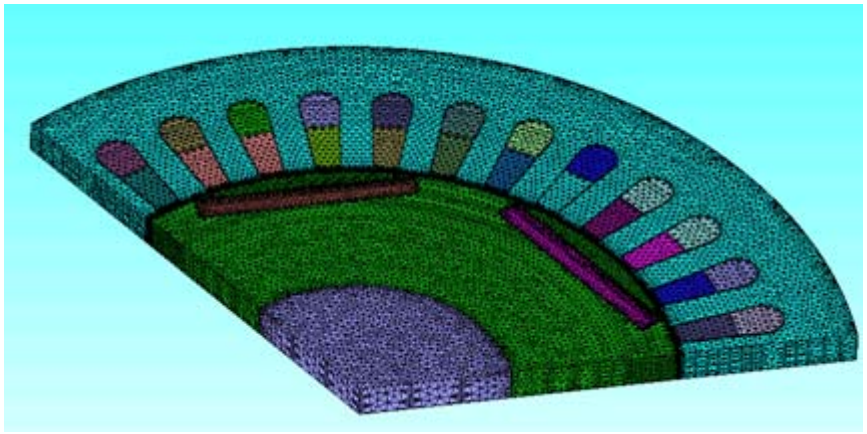
Acceleration

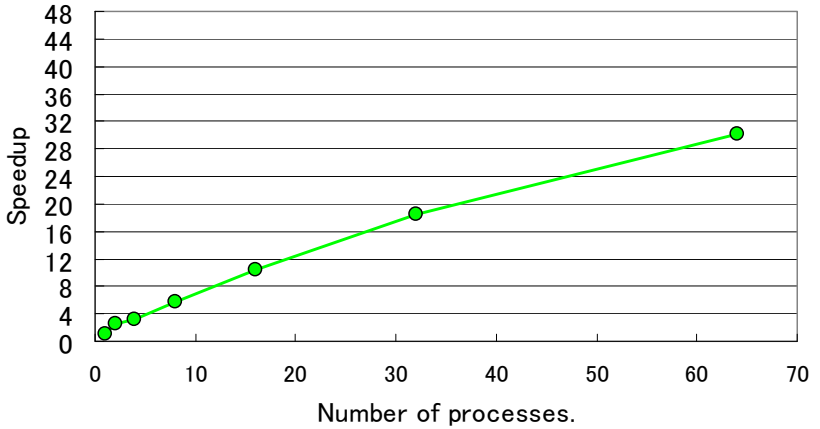
Solving large-scale, highly accurate models at high speed is an eternal theme of our work. However, it is little-known about how quickly a large-scale electromagnetic field analysis model can be solved. For instance, for IPM motors and induction motors developed as motors for drives in EV, to solve the cogging torque of IPM motor in high accuracy, a high quality mesh is required near the gap and the scale of the model will grow. Induction motors will need 3D and transient response analyses because of the skew applied to the secondary conductor and impact from eddy current flowing in the bar. The means to be taken to improve speed varies for each model.

High Parallel Solver

- *Achieved faster speed by increasing the number of parallels for magnetic field analysis*
- *Reduced 24-hour analysis calculation time to just 45 minutes and is 32 times faster in 64 parallels*

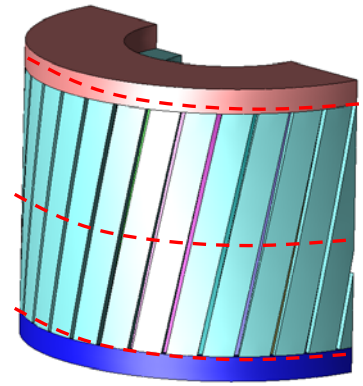
IPM Motor Model (1.08 million elements)

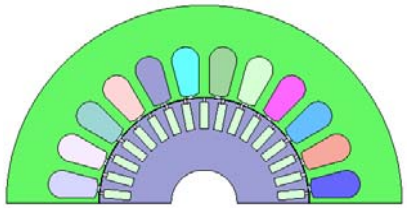


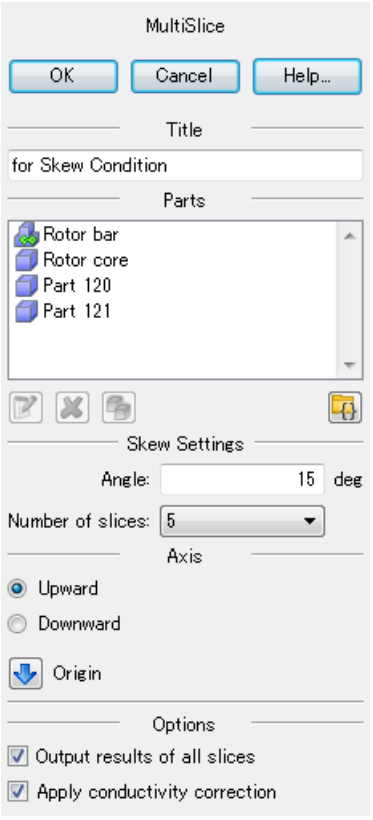


Consideration of 3D Effect using Multi-Slice Method

- *Enabled fast computation considering 3D effect using multi-slice method*
- *Enabled recalculation using multi-slice method based on existing 2D data*

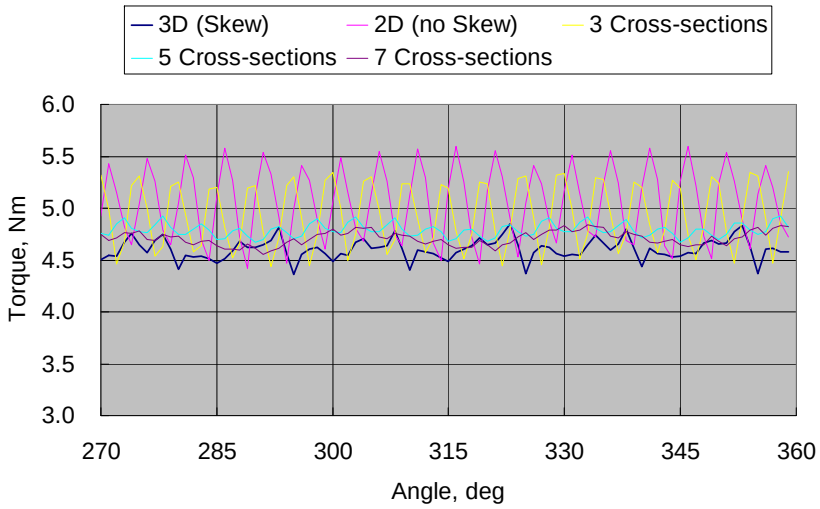


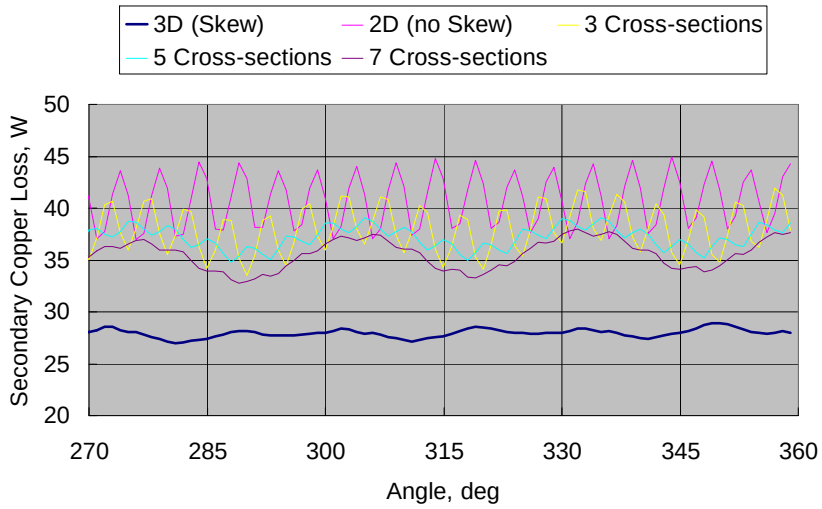


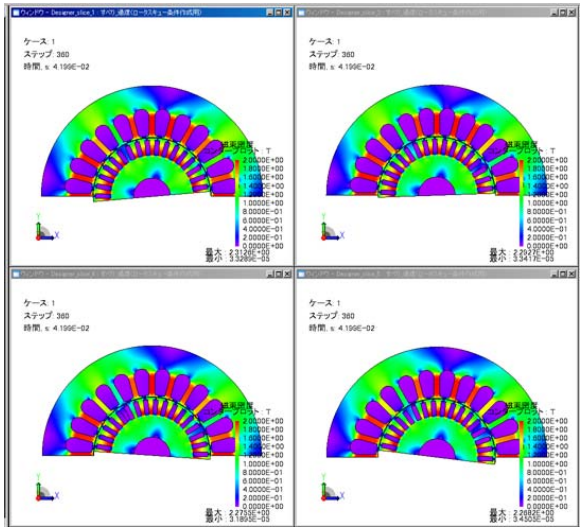


	No. of elements /nodes	*Calculation time 360 step*	*Acceleration magnification*
3D	*634,978/ 160,548*	*10d3h37m (14617m)*	*1.0*
3 Cross-sections	*17,248/ 9,629*	*228m*	*64*
5 Cross-sections	*-*	*529m*	*27*
7 Cross-section	*-*	*852m*	*17*

Torque and Joule loss on rotor bar







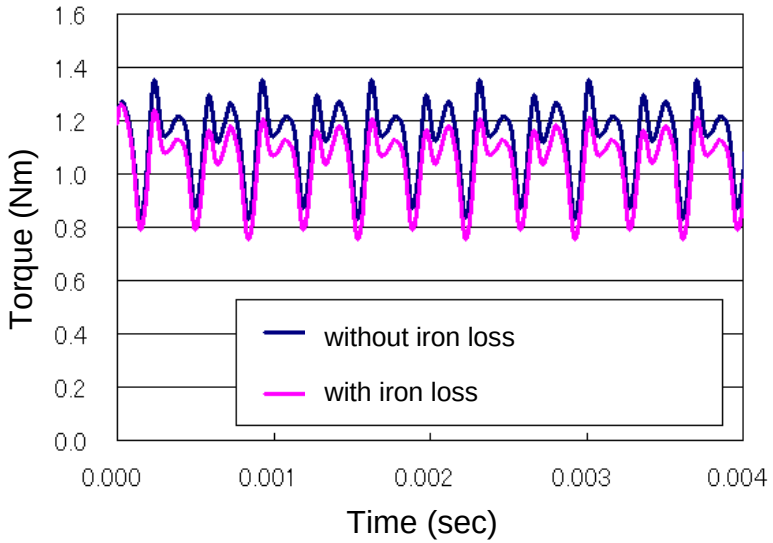
High Precision Loss

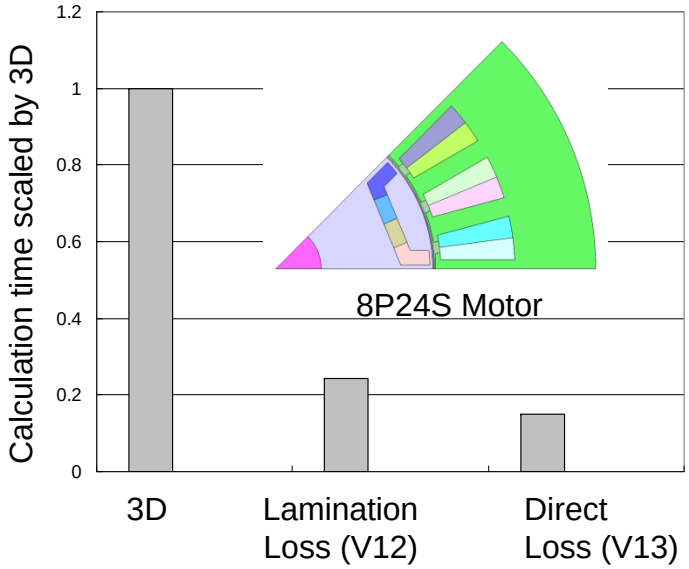
Electrical devices like large generators, EV/HEV drive motors, large transformers or high frequency transformers increasingly require improved efficiency, even of 1% improvement. To meet that requirement, we need to pinpoint loss factors and take necessary measures against them.

Loss factors differ for each type of equipment. For instance, detailed evaluation of iron loss when driving with an adjustable speed drive at a fast speed is a key when dealing with the above-mentioned drive motors. You may have to evaluate iron loss accounting for minor loops under conditions where the operating environment changes from time to time with a PWM drive. As loss properties vary according to the stress applied during processing, it is necessary to take this impact into account.

Direct Calculation of Iron Loss

- *Highly accurate iron loss calculation for various drive conditions*
- *Usable only by switching options*
- *Ten times faster than existing versions*



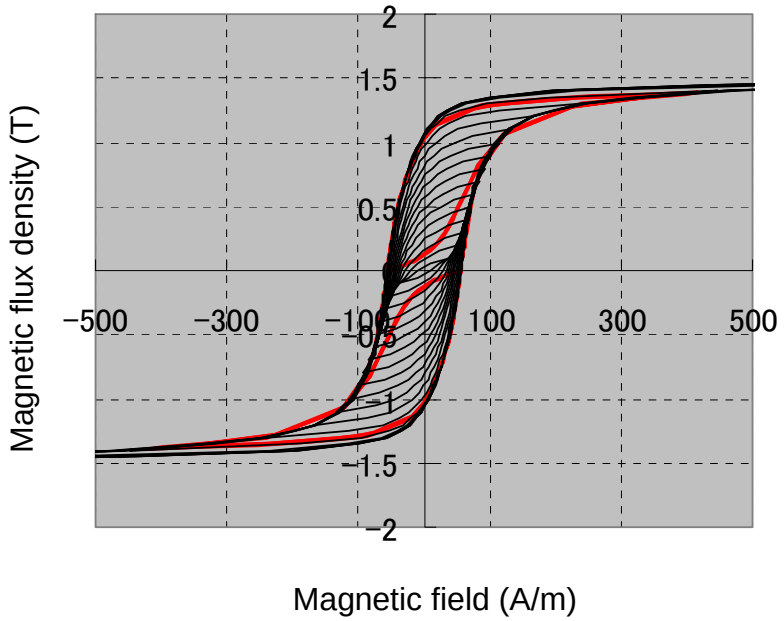


Greater Precision of Iron Loss Calculations in Stress Dependency

- Possible to take into detailed consideration the impact of stress
  - Impact of compressive stress and tensile stress
  - Impact when magnetic flux density and stress have different directions

Hysteresis Properties Included in Material Database

- *Possible to use symmetric loop data needed for directly calculating iron loss*
- *Covering representative magnetic steel sheets*



Trajectory of measured axisymmetric loop group and the hysterone minor loop that uses that loop group.

Listed data
35H210、50H470、35H360、
50H470、50H1300、35H230、
35H250、35H270、35H440、
50H230、50H250、50H270、
50H290、50H310、50H350、
50H400、50H600、50H700、
50H800、50H1000

Multi-Physics

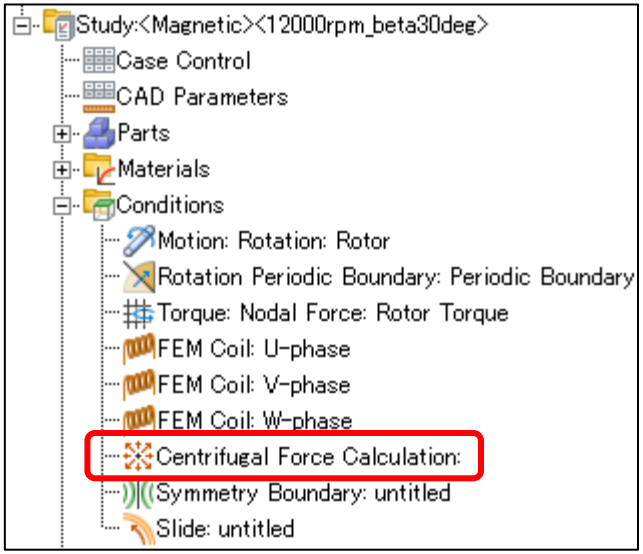
Real phenomena is multi-physics. Analysis combining multidisciplinary regions is moving closer to reality, but just combining functions may only make things more difficult than they need to be.
Small multi-physics is about complicated phenomena being solved quickly and easily, while retaining its essence.

Small Multi-Physics

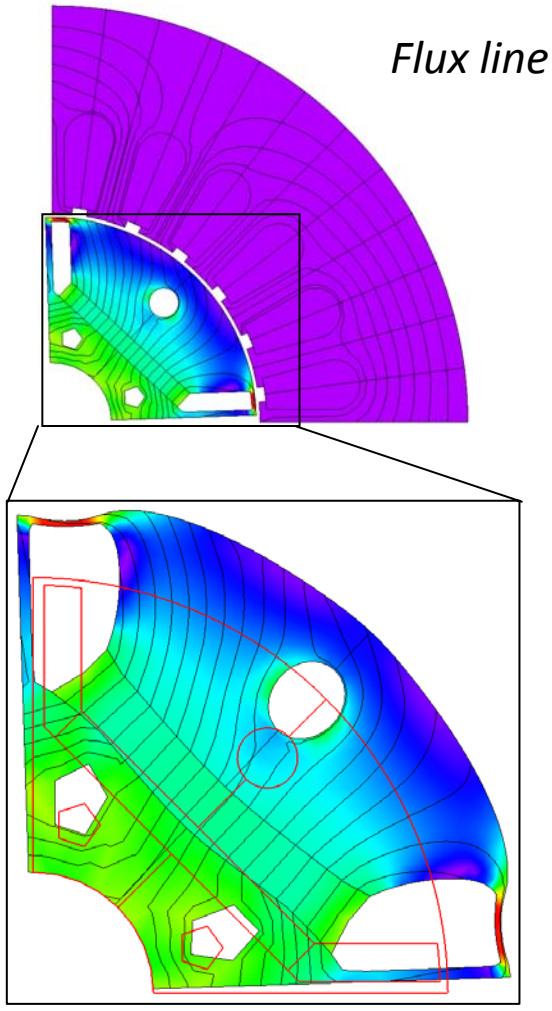
- *Quickly and easily get a grasp of complex physical phenomena*
- *Calculate multiple physics results with a single analysis*
  - *Centrifugal force calculations during magnetic field analysis*
  - *Temperature calculations during magnetic field analysis (coupling with the heat equivalent circuit)*
  - *Thermal stress displacement calculations during thermal analysis*
- *Provide a comprehensive coupled analysis framework*

Electromagnetic and Mechanical Analysis

- *Centrifugal force calculations during magnetic field analysis*

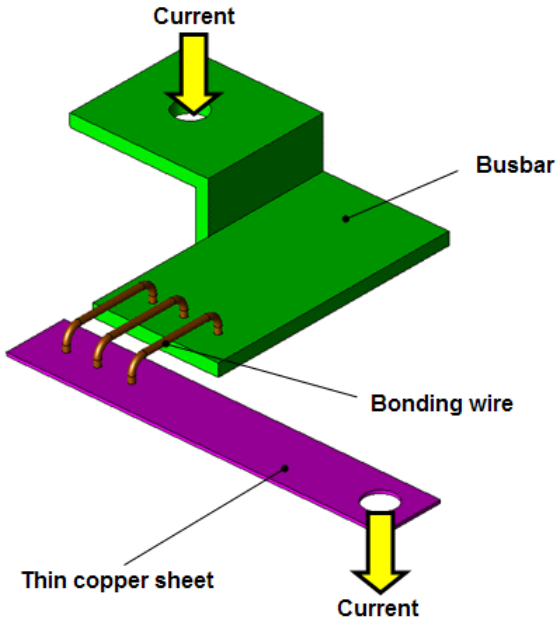


Flux line

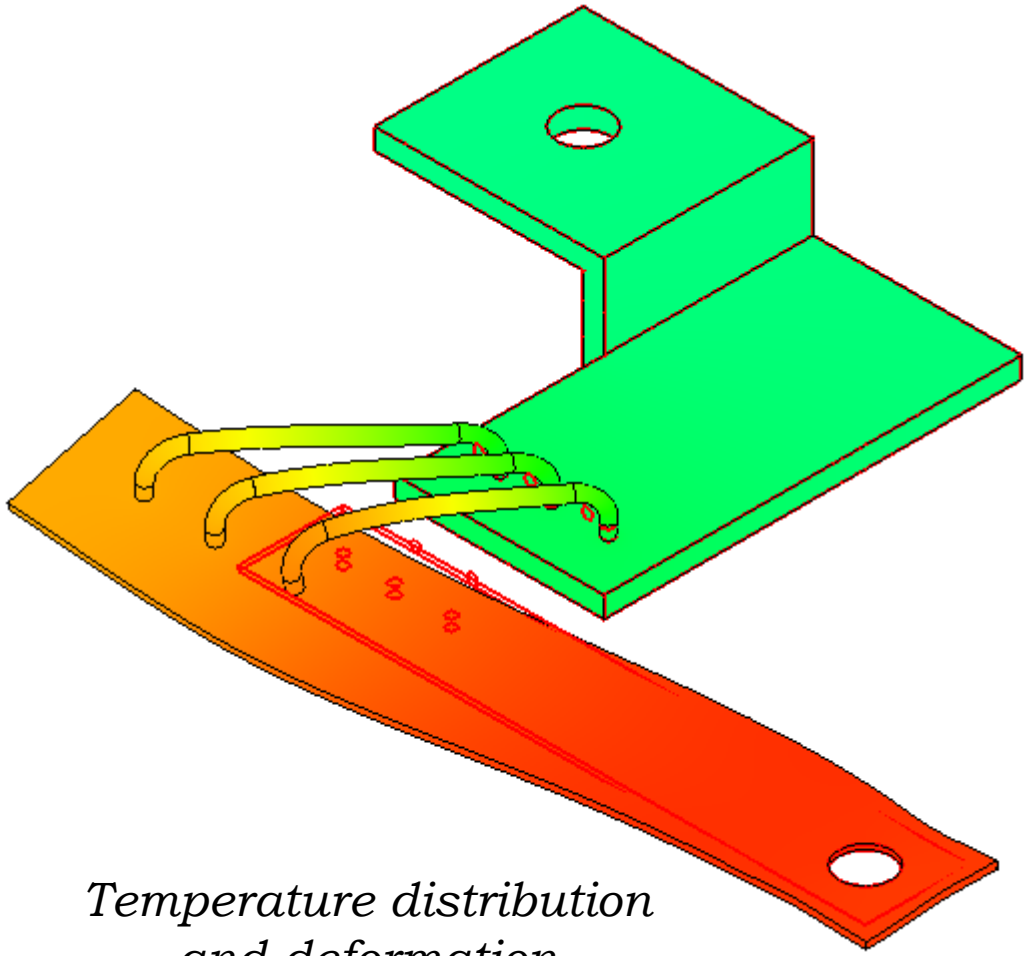


Mises stress

- Loss, Temperature and Thermal Stress

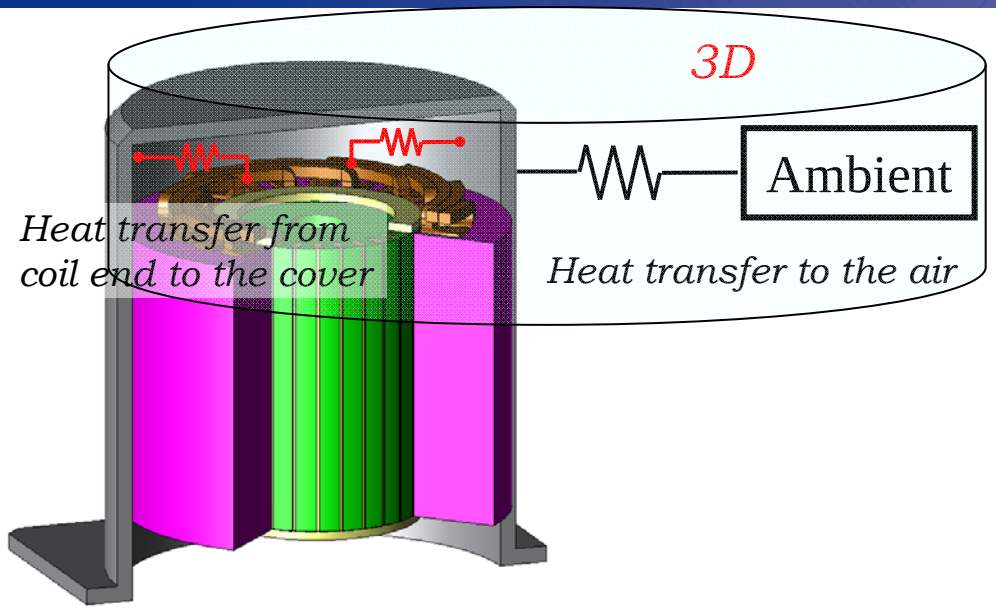


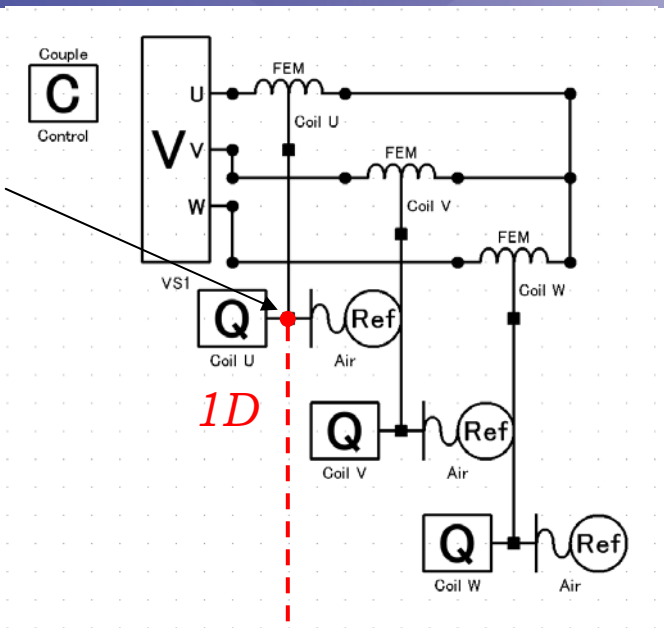
Joule loss analysis

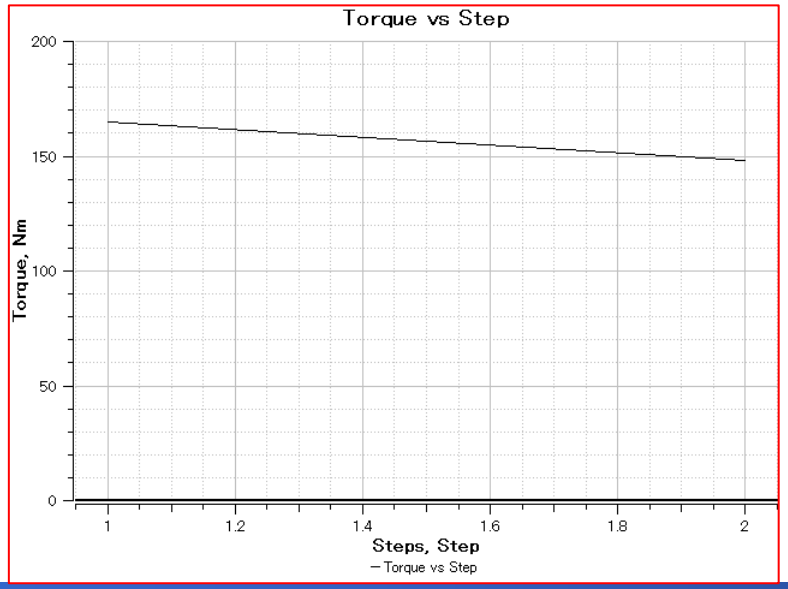


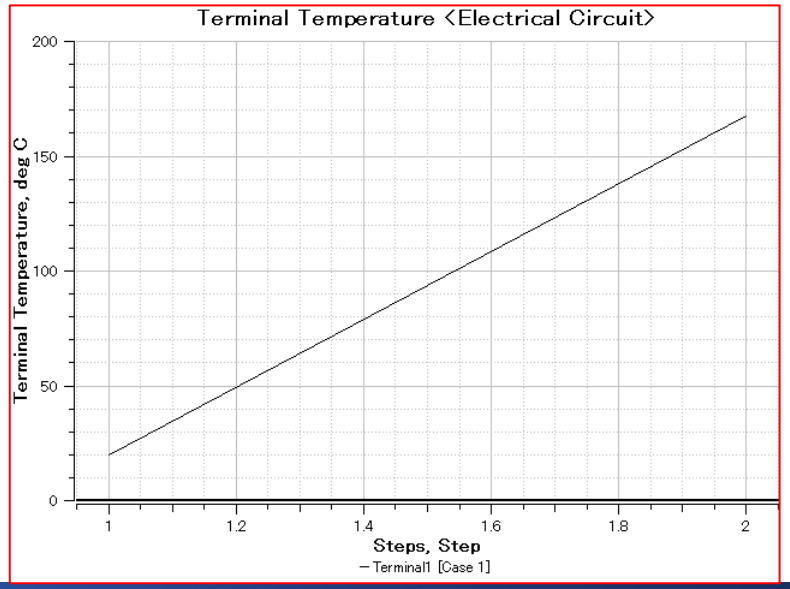
Temperature distribution and deformation

Electromagnetic and Thermal Analysis



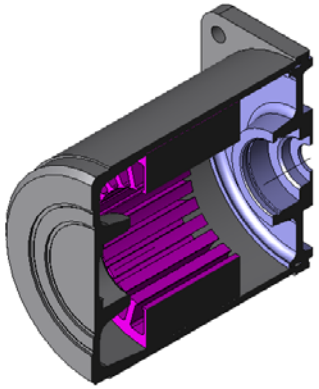


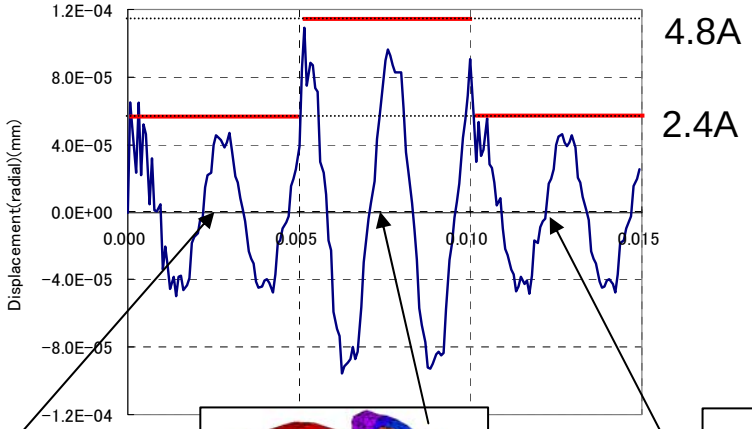




Structural Transient Analysis

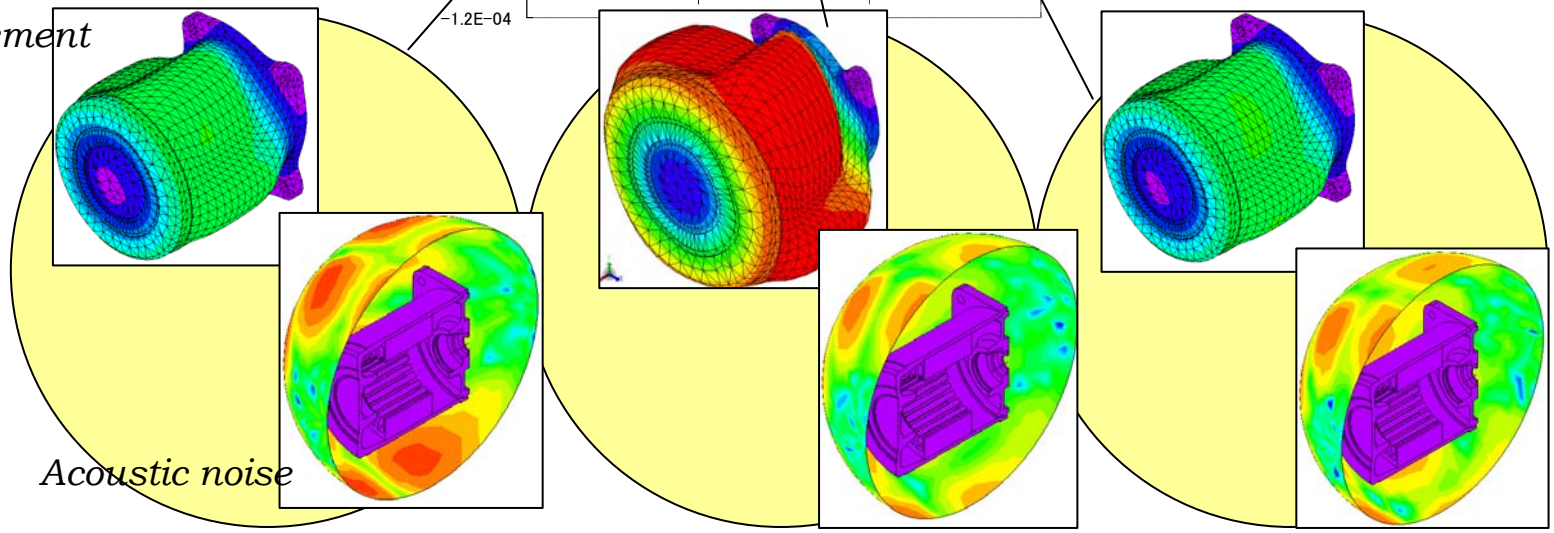
- *Possible to evaluate transient phenomena such as when a motor's drive starts*





Displacement

Acoustic noise

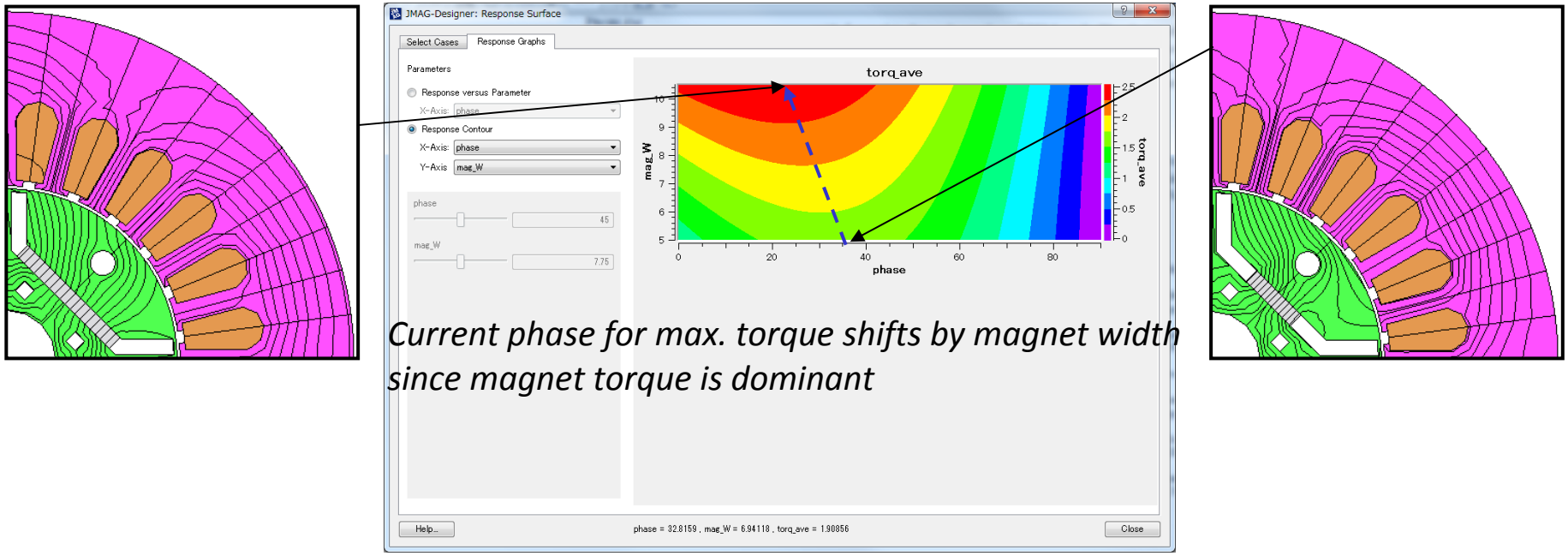


Optimization

Optimization is more than merely seeking the extreme value in solution space with multimodality. Narrowing down design parameters and scope while gaining sensitivity through a parametric analysis from an engineering viewpoint.
This can be achieved efficiently and semi-automatically.
Using this feature, you can acquire a group of design proposals instead of a single design proposal.

Optimization through Response Surface Methodology (RSM)

- *Using RSM enables simple and speedy improved solutions*
- *Enabled visualization of how response graphs are created based on the target function, for example, the maximization of average torque*
- *Possible to set the response data for a PM motor's Ld and Lq and maximize reluctance torque*



Current phase for max. torque shifts by magnet width since magnet torque is dominant

Model-based Development

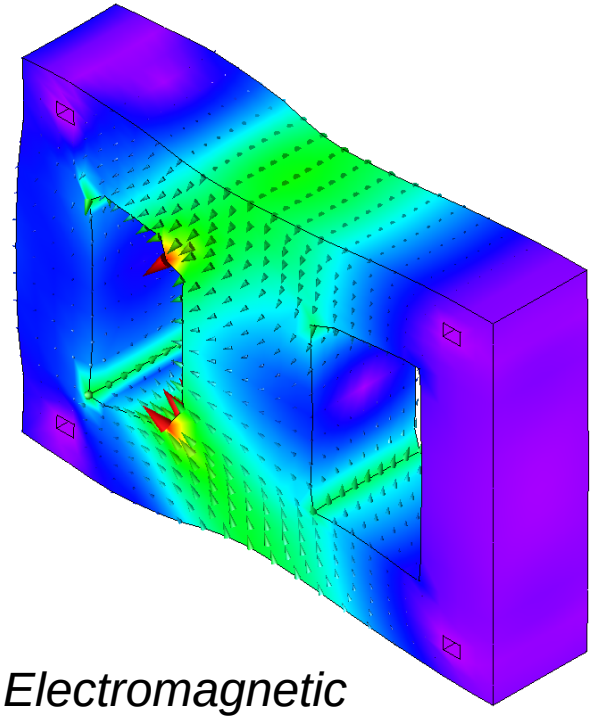
We perform model-based development in a variety of areas from electrical models, mechanical models, motor models and ECU models.
JMAG not only provides high-precision electrical models and motor models, it also presents an environment easily connected to other systems.

I/O Expansion of General Purpose Interfaces

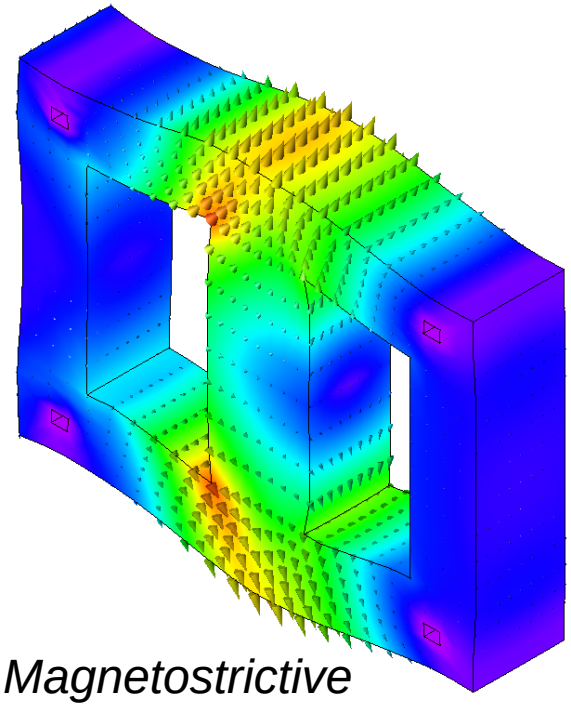
- *Enabled output of universal files in addition to Nastran and csv*

Expanded LMS VL Interface

- *Possible to hand over results to LV, including force working within objects*
- *Supports magnetrostriction and Lorentz force*



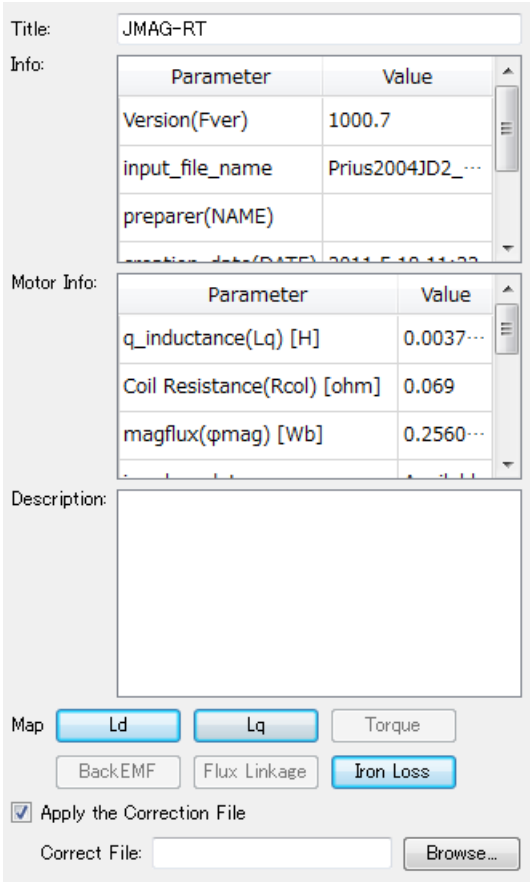
Electromagnetic vibrations



Magnetostrictive vibration

3D Correction of RT Model

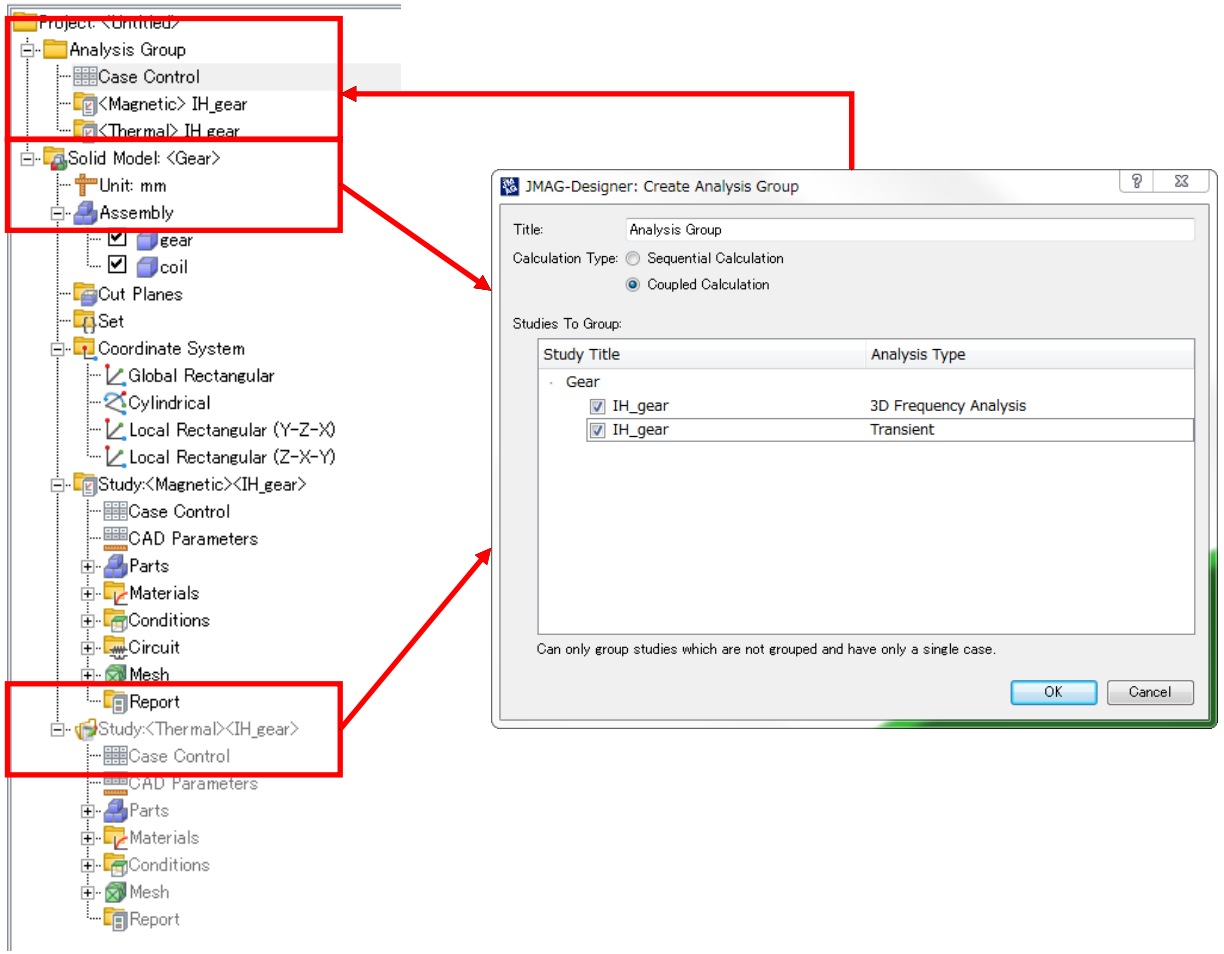
- *Possible to add 3D effects to an RT model generated in a 2D analysis*
- *All RT model types can be corrected*



Setting Conditions

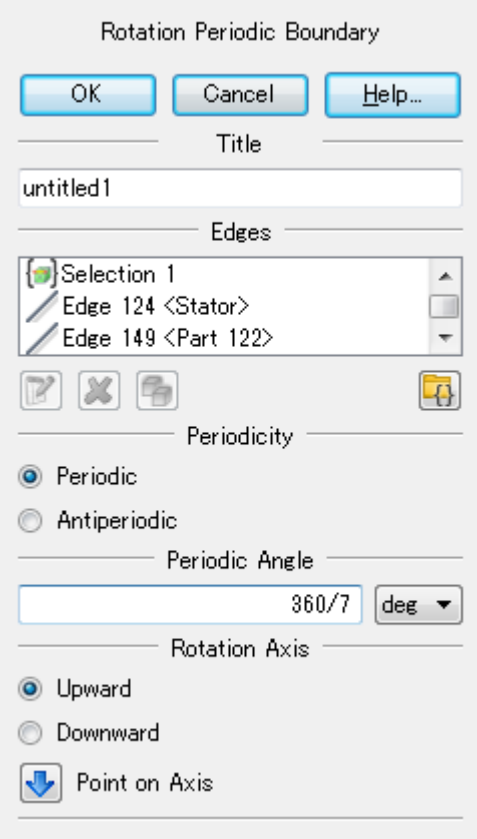
'Analysis Group' Enables Management of Multiple Analysis Types of Studies

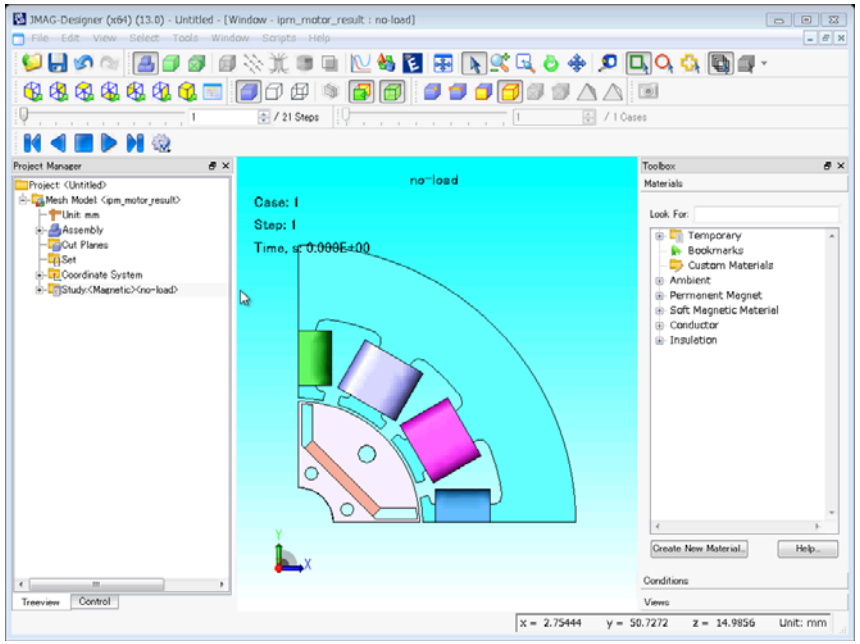
- *Enabled simple running of coupled analyses from the product tree*
- *Visualize associations between studies*



Settings for Non-Analysis Parts

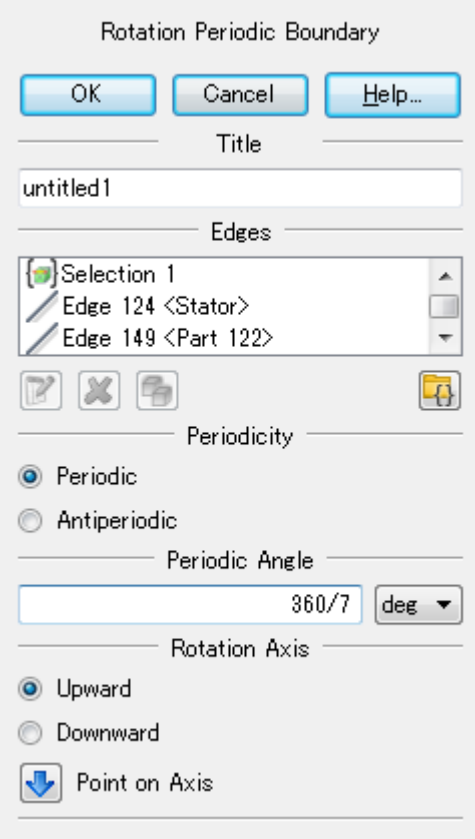
- *You can specify parts that won't be analyzed*
  - *For example, of the parts used in a magnetic field analysis, you can conduct a structural analysis specifying only the stator core*

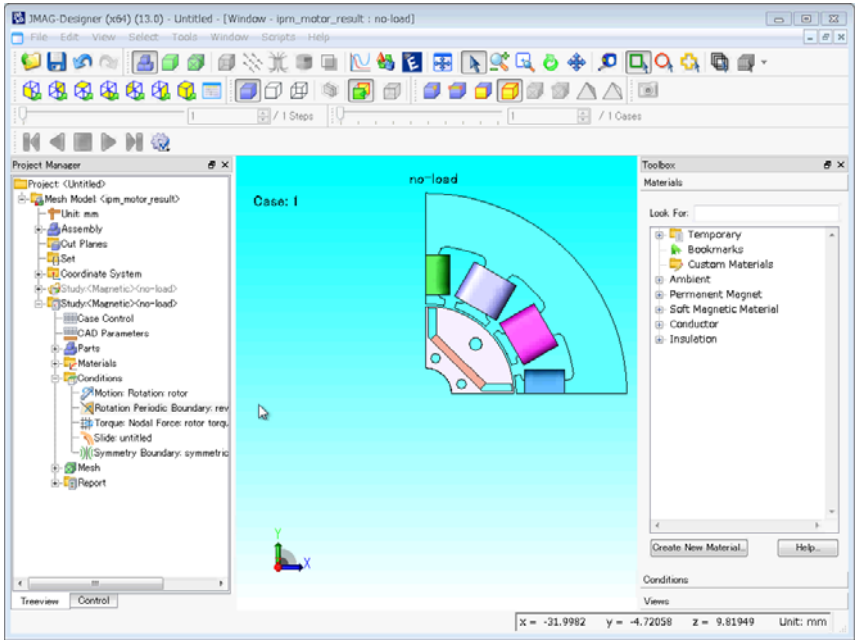




Fraction Input

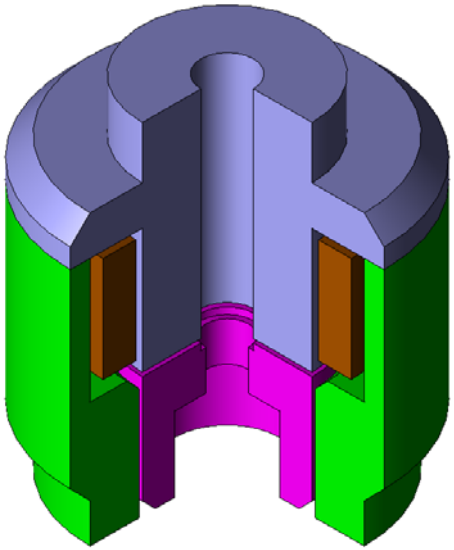
- *Enabled input of fractions in areas like periodic angles*
  - *For example, input a periodic angle of "360/7" for a 1/7th model*

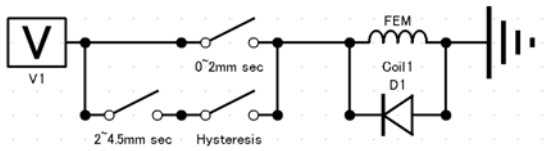


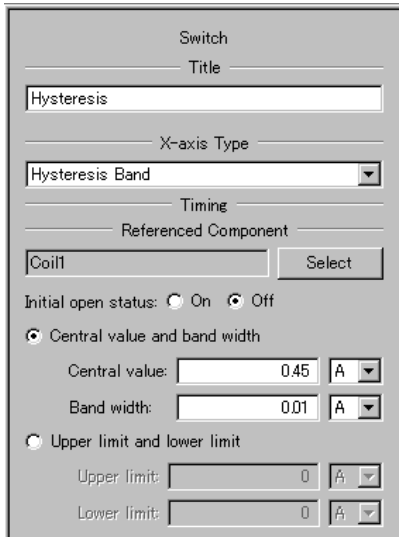


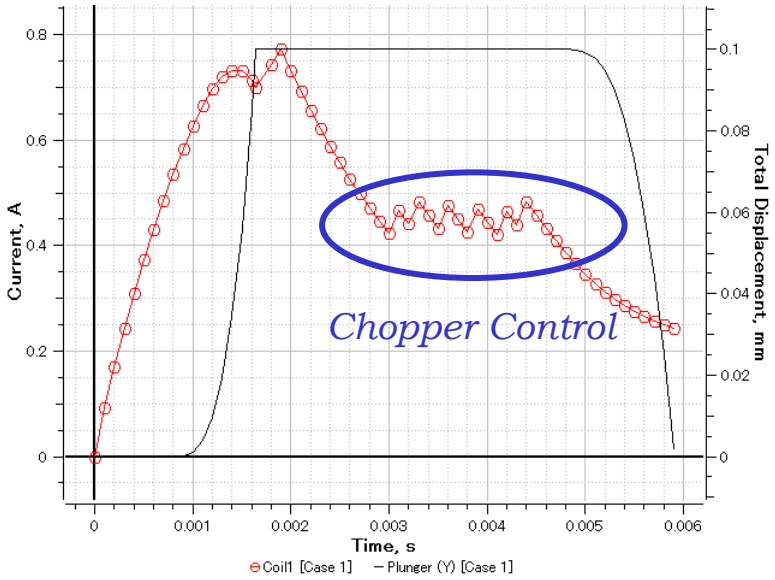
Current Hysteresis Band Control

- *Enabled hysteresis band control specifying current upper and lower limits*
- *Conduct analyses with controlled Relay or SRM current without having to use another circuit simulator*







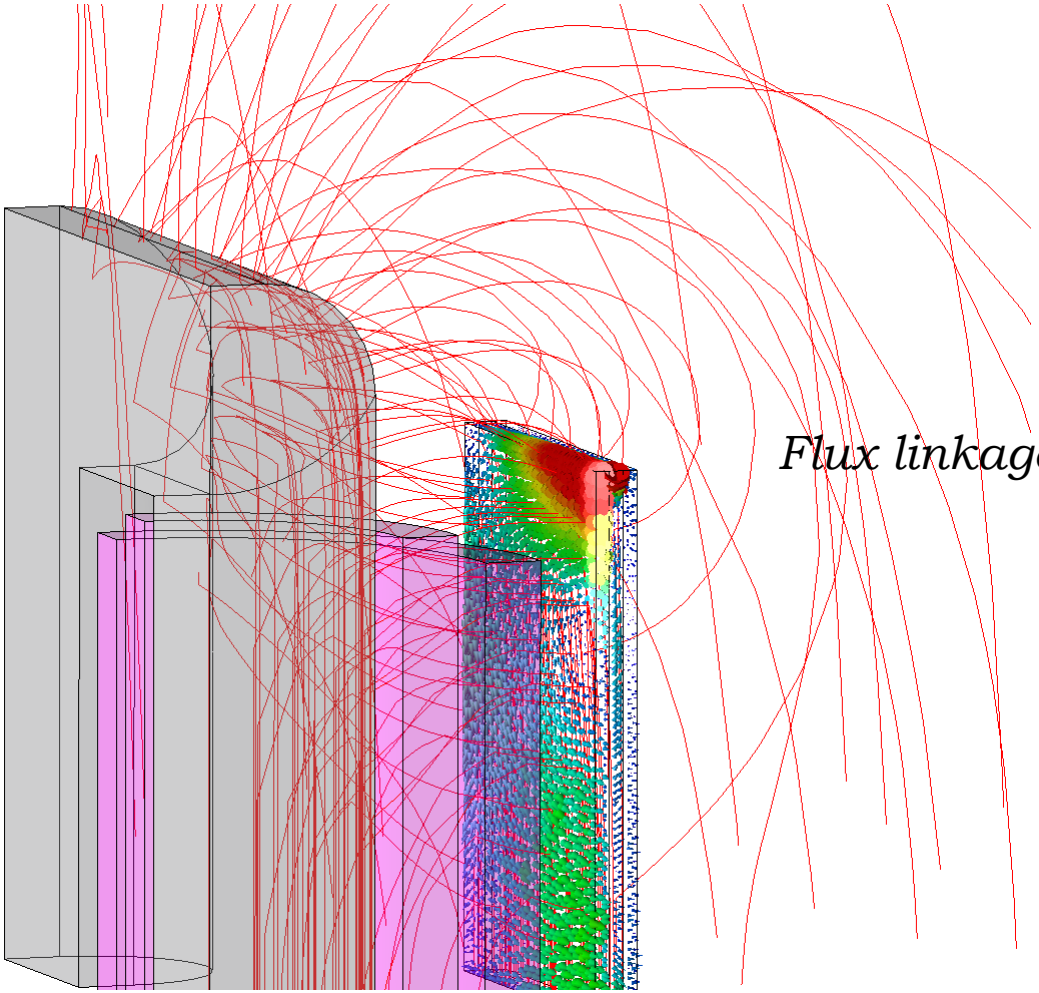


Post

To conduct a detailed results analysis, it's important to be able to see the results you're looking for in a visual format you're seeking.
Going into specifics, the analysis will provide various kinds of magnified views used to separate targets for each part depending on whether they are to be evaluated from a viewpoint of strength and flow; to gain a grasp of a complete view by pruning down to appropriate results from a large model; and, to understand properties by changing not only the properties of electrical devices but also drive conditions.

Control Result Rendering Type for Each Part

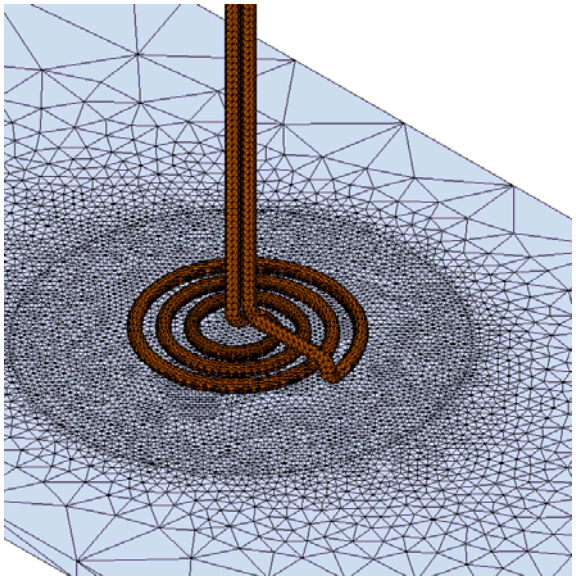
- *Possible to specify the type of result rendered for each part (contour, vector, no rendering)*



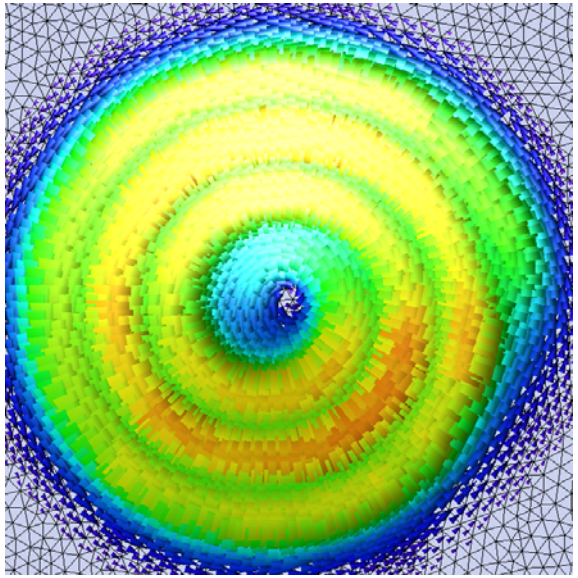
Flux linkage causes the Joule loss

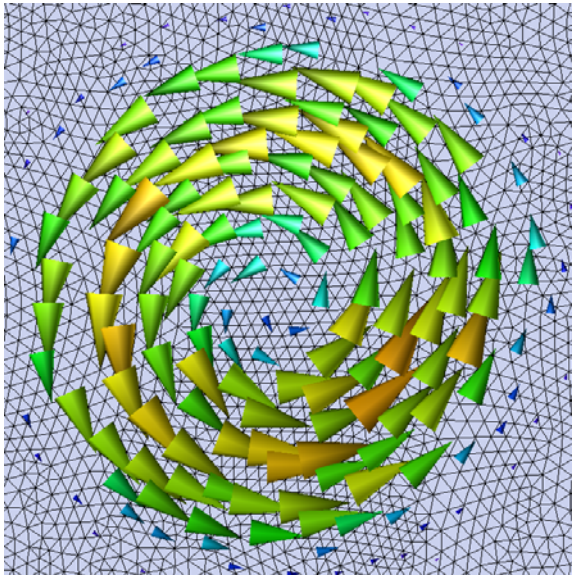
Vector Rendering Density Control

- *Accelerated vector rendering for large, detailed models*



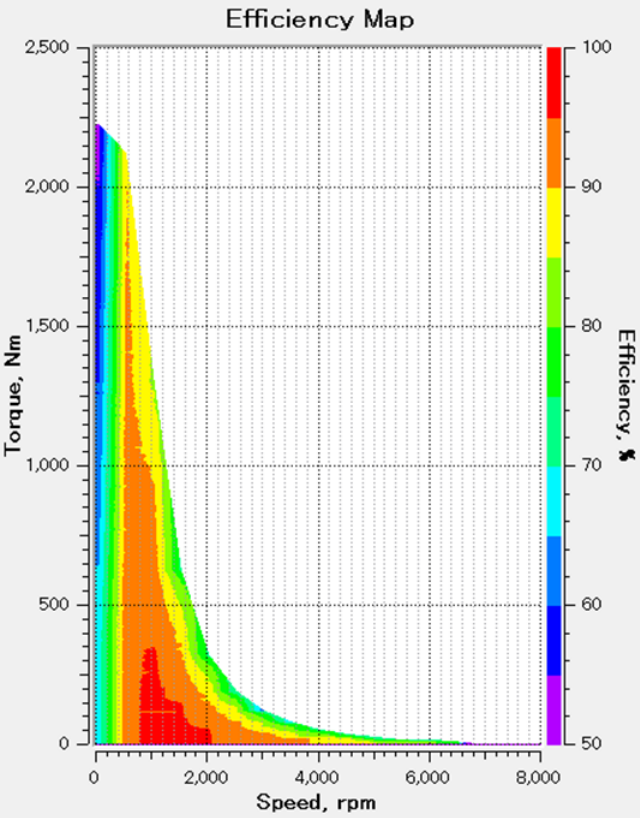
Tuning up/down the resolution

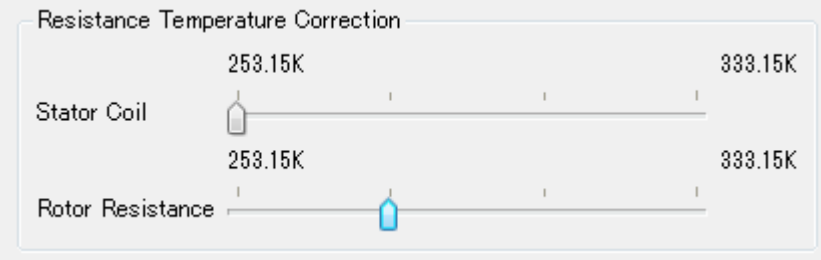




Induction Motor Efficiency Maps

- *Enabled rapid rendering of induction motor efficiency maps*
- *Automatic search of optimal currents and slip frequencies for each load and number of rotations*
- *Enabled temperature status specification and immediate re-rendering*



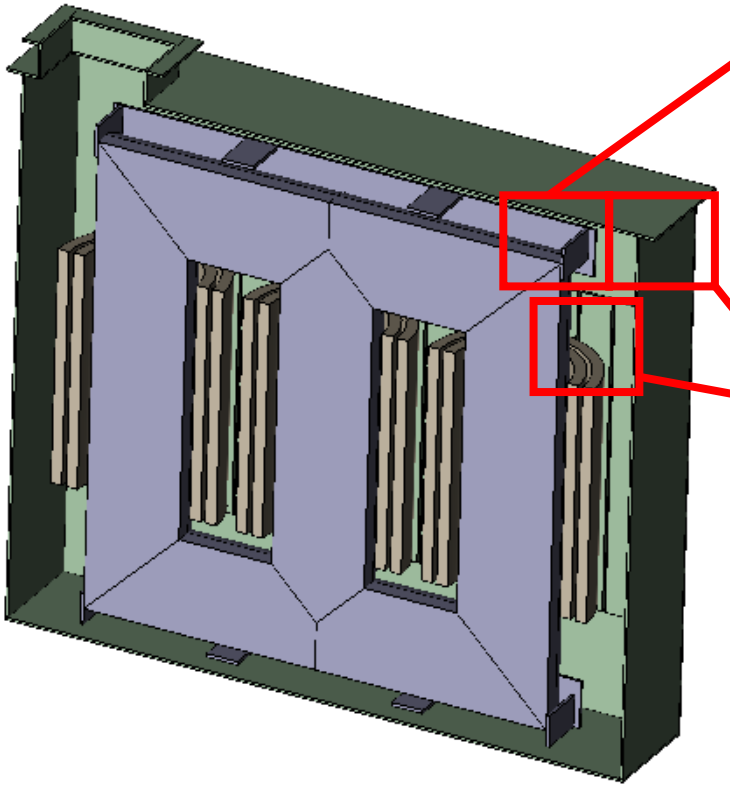


Mesh

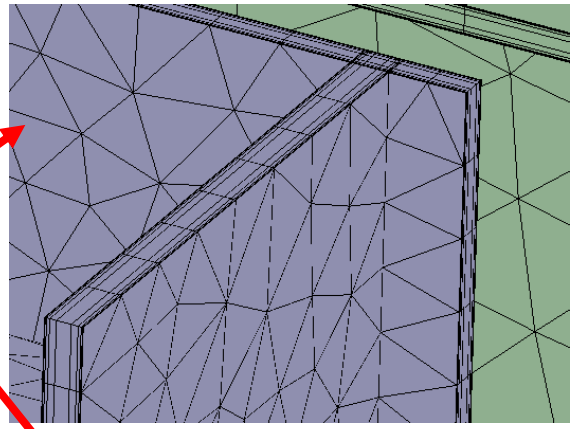
Mesh generation being made more robust for increasingly complicated CAD has become more suitable for specific applications and evaluation objectives.
Our function development seeks to satisfy demand for greater rates of successful mesh generation, production of higher quality elements and appropriate density for speedy calculations.

Thin Shell Mesh

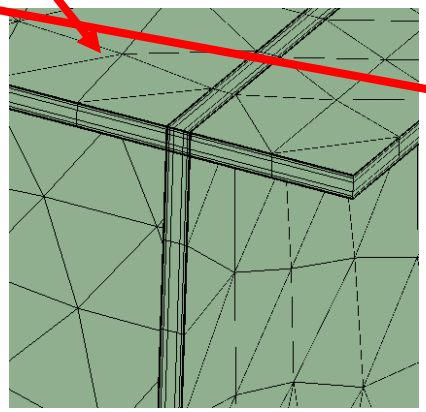
- *It's possible to generate a high quality mesh to evaluate eddy current in thin sheet items such as housing for large transformers*



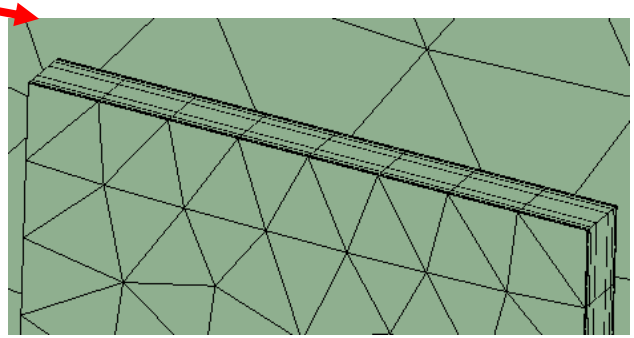
Power transformer



Clamp



Tank



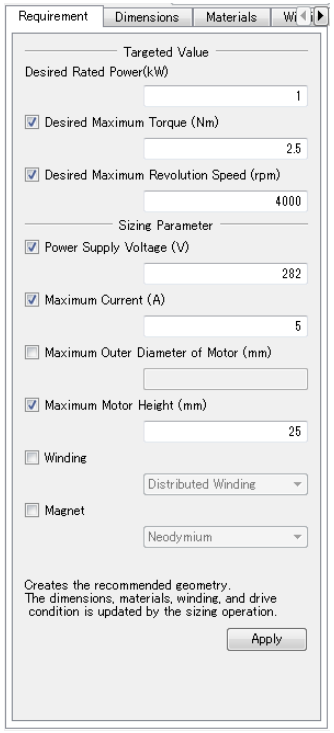
Plate

JMAG-Express for Motor Design

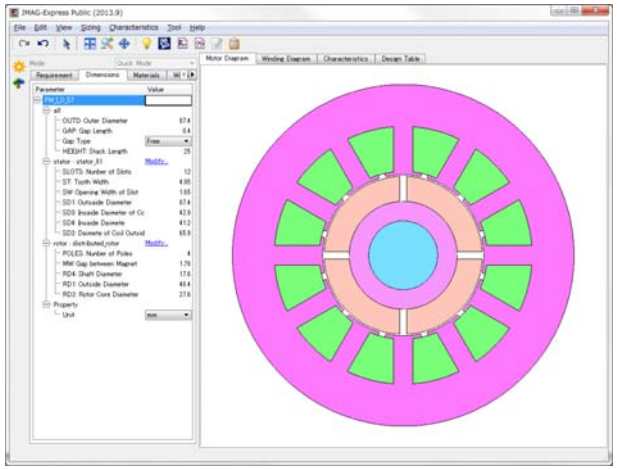
Sizing and Winding Design

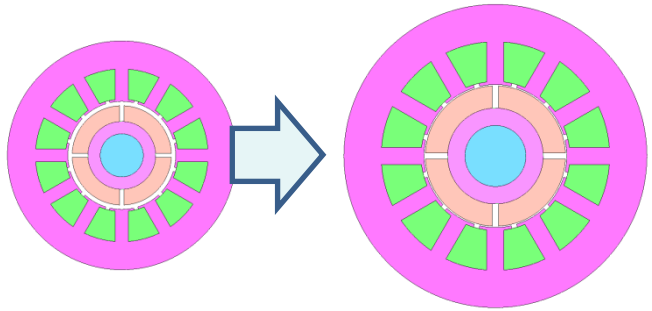
Requirement → Sizing → Winding Design → Torque Evaluation → Design Comparison

Requirement



Sizing function

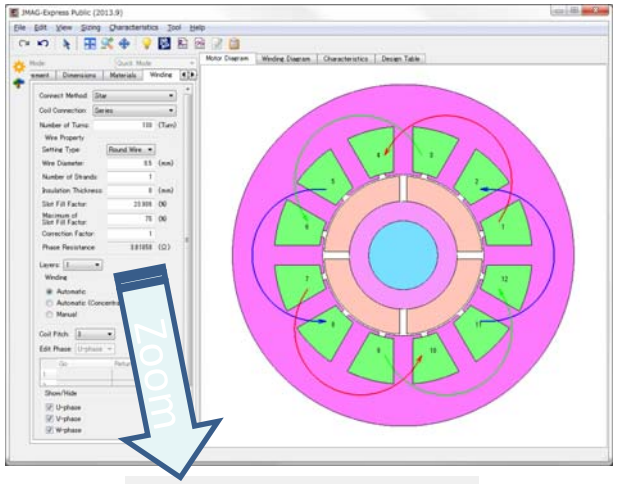




OUTD: Outer Diameter	53
GAP: Gap Length	1

OUTD: Outer Diameter	87.4
GAP: Gap Length	0.4

Winding design

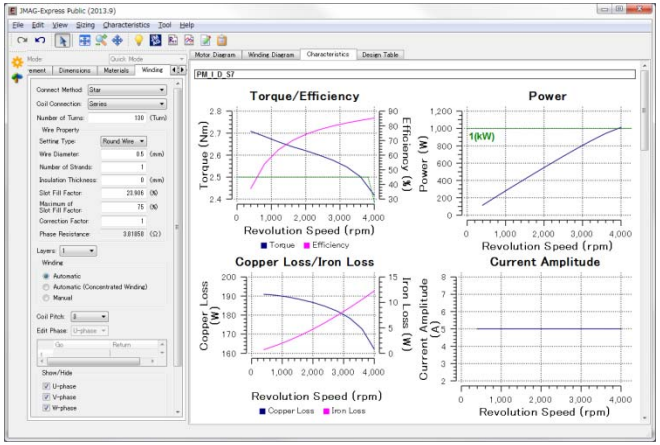


Connect Method:	Star	
Coil Connection:	Series	
Number of Turns:	130	(Turn)
Wire Property		
Setting Type:	Round Wire Din	
Wire Diameter:	0.5	(mm)
Number of Strands:	1	
Insulation Thickness:	0	(mm)
Slot Fill Factor:	23.906	(%)
Maximum of Slot Fill Factor:	75	(%)
Correction Factor:	1	
Phase Resistance:	3.81858	(Ω)
Layers:	1	

Torque evaluation and Design comparison

Requirement → Sizing → Winding Design → Torque Evaluation → Design Comparison

Torque evaluation



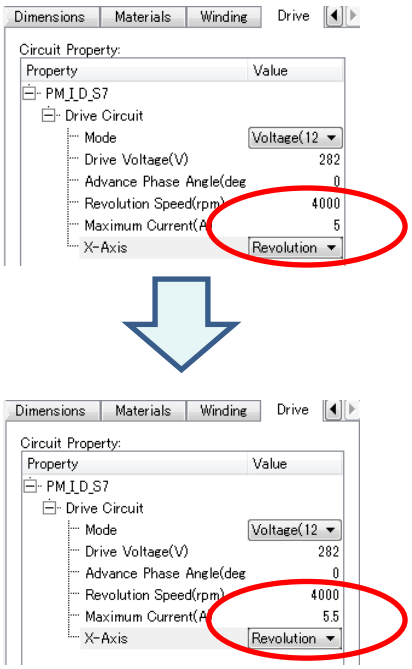
Inductance				
Ld (H)	0.00520131	Lq (H)	0.00439433	Self Inductance (H)	0.00319855
Mutual Inductance (H)	-0.00159927				

Torque Constant	
Kt (Nm/A)	0.470787

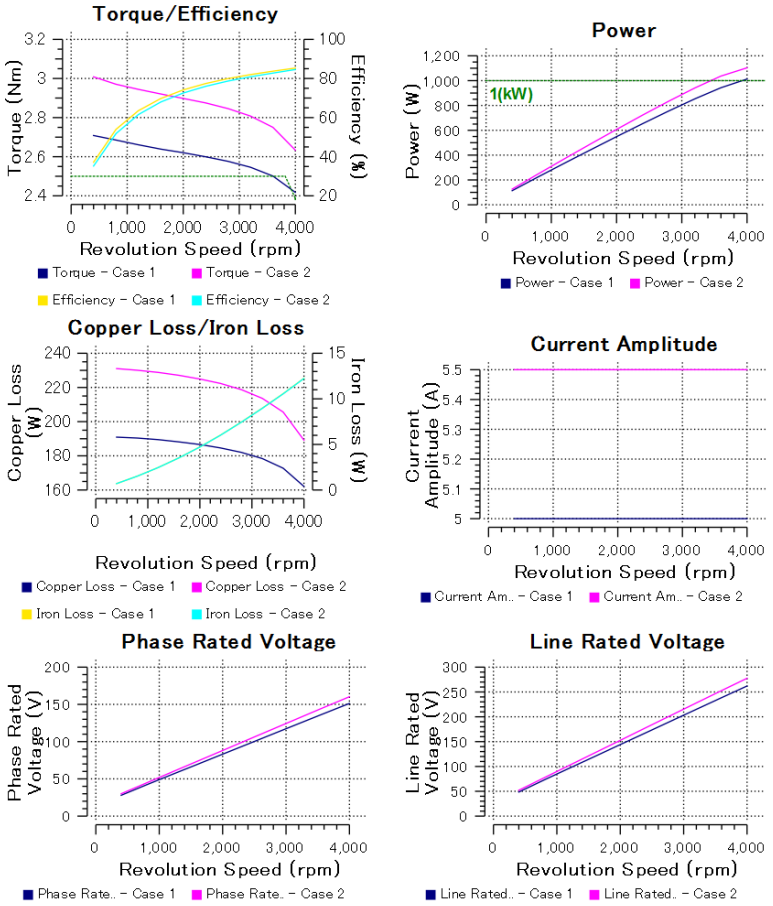
Voltage Constant	
Ke (V s/rad)	0.470787

Magnetic Circuit					
Rated Current (A)	5	Average Teeth Flux Density (T)	1.56635	Average Gap Flux Density (T)	0.610694

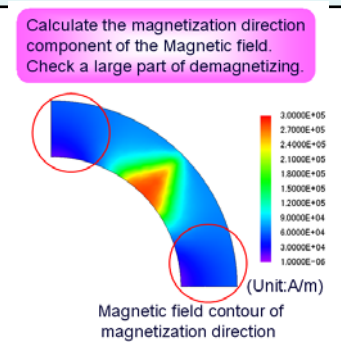
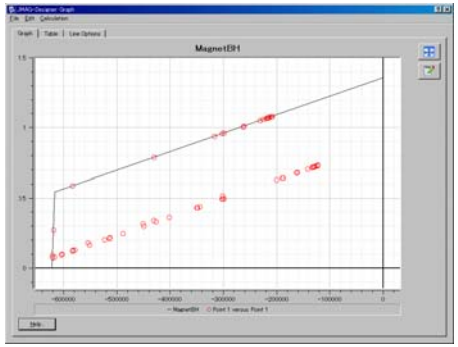
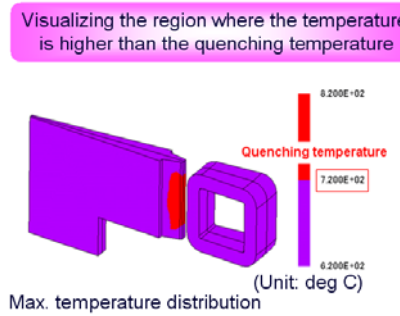
Changing current



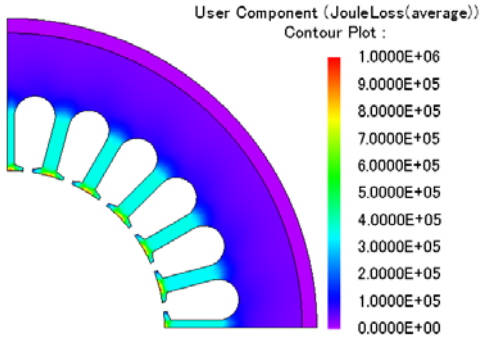
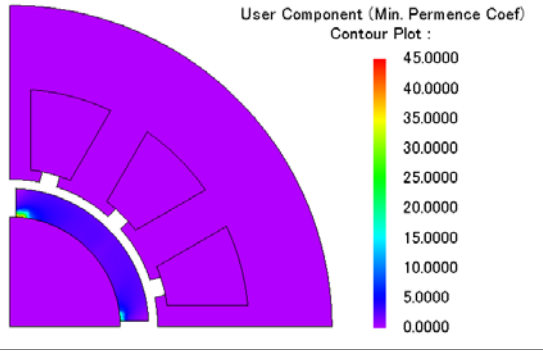
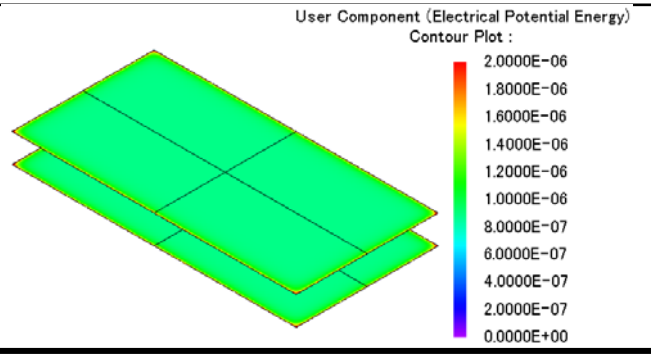
Design comparison



User component # 1

Use case	Expression	Image
Magnetic Field Strength (Initial magnetization)	(Hx*M0x+Hy*M0y+Hz*M0z)/M0abs	 Magnetic field contour of magnetization direction
Magnetic Flux Density (Initial magnetization)	(Bx*M0x+By*M0y+Bz*M0z)/M0abs	
Max temperature	his_max(Tabs)	 Max. temperature distribution during induction heating

User component #2

Use case	Expression	Image
Average of Joule Loss Average of Joule Loss (time dependency) Average of Hysteresis Loss (time dependency)	his_ave(Wj) his_ave(Wj_iron_t) his_ave(Wh_iron_t)	
Min permeance coefficient	his_min(Pc)	
Electrical Potential Energy	Qsabs*phiabs/2	

List of New and Improved Functions

- *Skin Mesh Production for Mesh Models*
- *Improved geometry creation function/Enhanced processing speed*
- *Enhanced mesh generation robustness*
- *Optimized RT model production*
- *Linux solver*
- *Use multiple RT models*
- *Supported scripts for all tools*
- *Improved user components*
- *Scheduler displays monitoring of running programs*
- *Folder management of user materials*
- *Obtain region IDs from script*
- *Export viewpoints*
- *Automatic production of data point sequences*

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