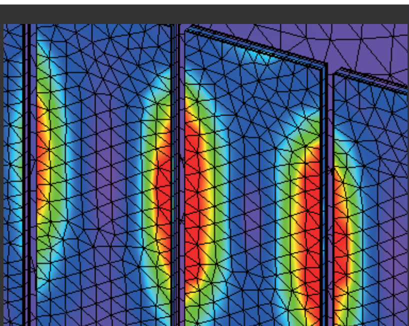
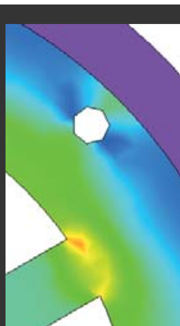
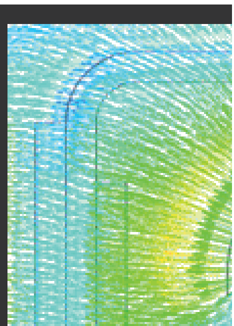
Simulation Technology for Electromechanical Design

JMAG®

JMAG Newsletter







January, 2014

Simulation Technology for Electromechanical Design

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JMAG Newsletter: Highlights of the January Issue

We are pleased to present you with the January issue of the JMAG Newsletter, the first edition for 2014.

In this issue's Implementing JMAG, we look Panasonic Corporation's Appliances Company, which takes charge of Panasonic's appliance field, including household goods and appliances, equipment and devices. We interviewed Mr. Michihiro Kurokawa and Mr. Yukihiro Okada, who are in charge of research and development for major household appliances, products for cars and industrial use items. They told us about researching into motors used for household appliances and how JMAG is used widely in roles such as product development.

Product Report described JMAG-Designer Ver. 13, which was released in December 2013. Newly added are at least 40 functions, including a high parallel solver, high precision loss modeling and multiphysics functions (Small Multiphysics) as the main items. By all means try out the latest JMAG functions. This issue also introduces JMAG-VTB 3.0, released simultaneously with Ver. 13. We describe its features and latest updates.

Solutions is a new column kicking off with an article about a vibration noise analysis. The first-ever of these columns focuses on describing motors and modeling methods.

The world is filled with a countless number of research papers and technical materials. Paper Introduction picks up papers and technical materials containing necessary opinions and handling modeling techniques about high-accuracy loss evaluation.

Partner Introduction looks at how JMAG is being used for motor design studies such as control design at Shanghai University, which has been a partner university since 2012. We provide an introduction to the latest version of Dassault Systems SIMULIA's Abaqus, whose tie-up with JMAG broadens simulation possibilities.

Event Information looks back at the JMAG Users Conference held from Wednesday, December 4 to Thursday, December 5, 2013. This is a must-see not just for those who took part, but also for others who were unable to attend.

JMAG Newsletter is naturally for those already using JMAG, as well as intended for others who have yet to use JMAG or have only recently started doing so. By all means, take this chance to introduce it to someone nearby.

This edition of the JMAG Newsletter is packed with more content than ever. We hope you enjoy it.

JSOL Corporation

Electromagnetic Engineering Department, Engineering Technology Division

Implementing JMAG

Panasonic Corporation

Taking household appliance technologies and presenting them to industry partners

―JMAG is a strategic tool helping bring about a technological revolution―

Lighter, thinner, shorter and smaller, yet highly functional. Motors promote evolution of household appliances and bring about their own evolutions. Evolution that is now starting an original approach to car and industrial-use parts. JMAG has supported research and development. Dr. Michihiro Kurokawa and Dr. Yukihiro Okada, who are in charge of research and development for major household appliances, products for cars and industrial use items at Panasonic Corporation talked to us about using JMAG in product development.

Motors are being used even more than Konosuke Matsushita predicted they would be 80 years ago

— It's a case of "Now that you mention it, you're right" but when you think about it, there are actually a lot of motors used in household appliances.

Kurokawa Just to give you a rough list of the many products using motors, there are air conditioners, washing machines, vacuum cleaners, refrigerators, fans, dishwashers, air purification systems, DVD and Blu-Ray disk players, digital cameras, faxes, hair dryers, shavers and on and on and on. They've all got motors.

Panasonic started its motor business in 1933, which was 15 years after the establishment of Matsushita Electric Industrial Co., Ltd., so 2013 marks its 80th anniversary. At that time, our founder Konosuke Matsushita made the following prediction when he established the electrical machinery division: "In the future, as cultural lifestyle evolves, each house will use at least 10 motors." Actually, use has clearly surpassed that prediction.

— Is there a wide variety of research and development of motors going on within the Motor Development Center in the Appliance Company's technology headquarters?

Panasonic Corporation
Appliances Company
Corporate Engineering Division
Motor Development Center
Element Development Group
General Manager Dr. Michihiro Kurokawa

Panasonic Corporation
Appliances Company
Corporate Engineering Division
Motor Development Center
Element Development Group
Dr. Yukihiro Okada

Kurokawa No, actually. The Motor Development Center is a research and development section for the Appliance Company's motor business division and it takes charge of research and development of motors in household-use air-conditioners, washing machines and refrigerators. It is also engaged in R&D for brushless motors and motor system products targeting automakers for use in cars, as well as specializing in brushless motors for items such as servo motors or amplifiers or production machinery use in industrial fields.

As a technical field, we take charge of magnetic circuit design, control system development and material development of things such as magnets or mold materials. We handle materials but we are also involved in production technologies, such as the production process or manufacturing equipment.

— What are your thoughts about bringing out a typically Panasonic feel to your motor business?

Kurokawa Our company's business centers on motors for household appliance use, so we have developed small and highly efficient motors. This is basically the same for motors to be used in the in-vehicle field or industrial field. In the future, there will definitely be more motors used than there are now in households as in the in-vehicle field, to give an example, as HV and EV become more popular.

In development and applicability of in-vehicle motors, ideas and cost power nurtured as a household manufacturer closely resembled ideas and cost power when approached from the car side, even though they are different. As a household appliance manufacturer we have naturally taken the approach of looking to make things lighter, thinner, shorter and smaller.

Seeking Product Competitiveness in the CAE Age through Actively Using QSD

— How are you currently using JMAG?

Kurokawa Our center mainly uses it with development of prototype models. What this means is that we do verification checks on motor products so that we can make them practically applicable in a shorter span of time.

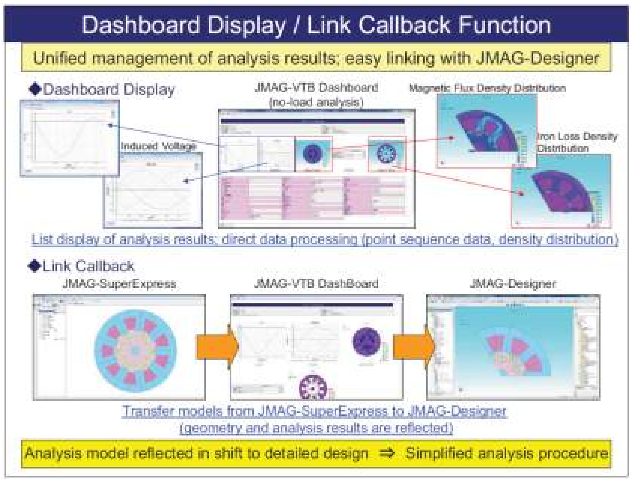
At the moment, household appliance products are currently upgraded every year normally, or two years at the most, so JMAG is indispensable for shortening the product development period. With in-vehicle parts, we adjust to automakers' minor changes, while with industrial-use items the development period is from three to five years.

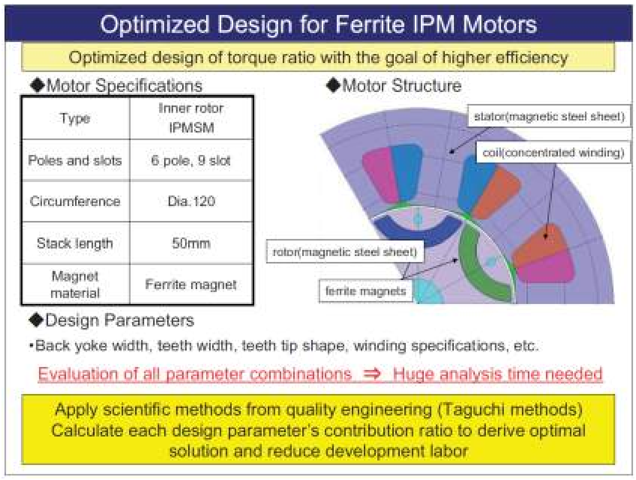
While this product upgrading is going on we are also facing challenges from competitors involved in CAE manufacturing, so we need to be able to differentiate and ultimately tie in our efforts toward being commercially competitive.

— Is JMAG's contribution to your manufacturing system good enough?

Kurokawa Of course! An extremely vital issue is the matter of friction between motors built as prototypes and control systems. For example, say you've got a motor for industrial use and you need it to provide rapid response and high-accuracy positioning. When you need to verify that amplifiers and motor controls match for conflicting matters such as stability and high-speed responses, you can't go without a JMAG simulation.

Okada Even with an electromagnetic field Finite Element Analysis (FEA) we used to do analyses using geometry defined on spreadsheet software, but now we can simply use the CAD data and analyze it as is, which drastically reduces the time needed for examining principles or verifying designs. JMAG's FEA response and analysis capabilities have improved and, on a 2D-model, we can get results in a very short time.





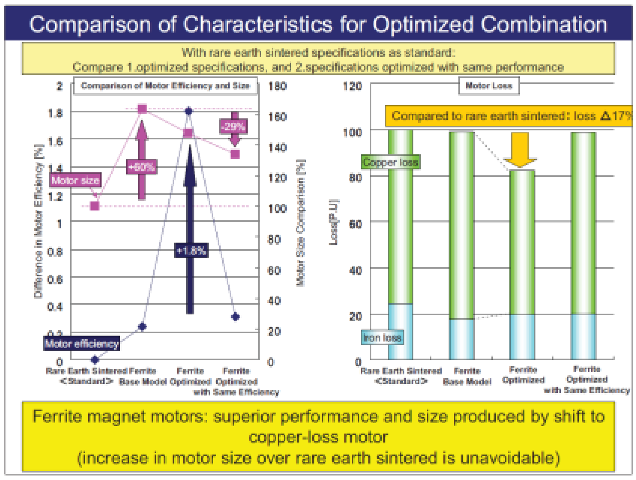
—We've heard you're using QSD with analysis. Please tell us more about that.

Okada At Panasonic, we deploy and promote the use of Quality Stabilization Design (QSD) in design process. QSD takes the global standard Taguchi Method and evolves it to add a Panasonic-style to create an optimization testing technology. We are combining QSD and CAE to use in development. For example, for development of a particular motor, we'll start an analysis prepared with anywhere from nine to 16 design parameter items until ultimately whittling that down to about two items needed for product specifications.

One of our recent topics was using JMAG-Express Powermode and QSD for optimization design and increasing efficiency in an IPM motor while using a ferrite magnet instead of a rare earth magnet. It goes without saying that ferrite magnets' residual magnetic flux is only about 1/3rd that of rare earth magnets, but we used JMAG-Express Powermode to optimize a concentrated winding magnet torque and reluctance torque ratio.

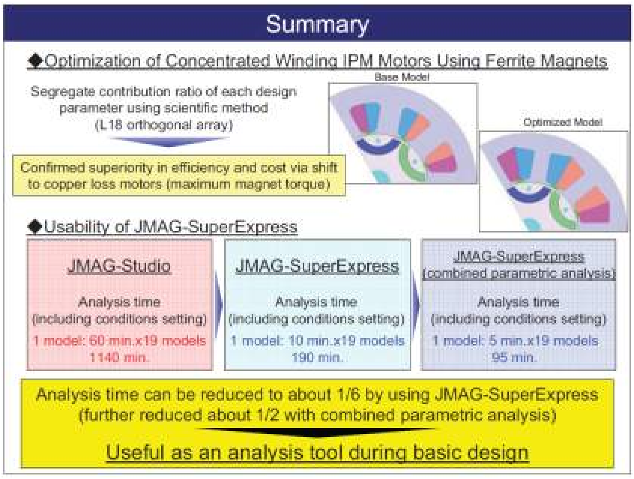
First we performed a concept design on JMAG-Express, then followed up with a basic design on JMAG-Express Powermode and went on to a detailed design in JMAG-Designer in what was a seamless analysis.

In this development case we used tests from the L18 orthogonal table as the design parameters. That is, we could perform the same test with the minimum arrangements as we could with putting everything into play. Consequently, by designing a ferrite magnet motor with well-balanced loss we could check how to come ahead on functionality and costs.



—How has JMAG been for cutting down analysis time?

Okada Comparing analysis times for 19 models, including the time needed for setting conditions, showed JMAG-Studio took 60 minutes per model for a total of 1,140 minutes; JMAG-Express Powermode took 10 minutes per model and 190 minutes overall, and then with JMAG-Express Powermode we also did a parametric analysis at 5 minutes per model for a total of 95 minutes. Just using JMAG-Express Powermode cut analysis time by 1/6th.



Anyway, it's really easy to use and intuitive. JMAG's User Friendliness

—Can you tell us how you came about implementing JMAG?

Kurokawa JMAG has, ever since it was launched, specialized in motors and is equipped with a variety of functions so we didn't think twice about using it. As far as I can recall, we first used it in about 1996 for development of a motor used in air-conditioning.

We originally used an in-house analysis software, but we heard about this software that specialized in motors, so we set it up in a laboratory at first and used it with a focus on analysis. JMAG's effectiveness was quickly recognized and in 2000 we installed it in the business division and began using it with magnetic field analyses while packed together with 3D-CAD.

—What aspects of JMAG do you value most?

Kurokawa I most commonly hear that it's easy to use. And there is plenty of support even with automation of such things as coupling with 3D-CAD and this helps tremendously.

Okada I think an overwhelming capability is the intuitive view of magnetic flux density in a magnetic field. As soon as you evaluate several sets of results, you can change designs and change materials. We're really grateful to have these intuitive types of functions.

Stress calculation or interface improvements were incorporated early and it's extraordinarily user-friendly, which I think is the reason for our continued use. We're extremely grateful that it's response is so fast, particularly concerning inquiries about analysis.

Adding JMAG's material database to our company's own database to create tremendous original development strength is another reason why it's so well-received within our company, too.

—Is your ultimate aim to be able to avoid having to use prototypes?

Kurokawa Hmm. That's a hard one. Testing and verification work naturally involves verifying designs, but there is also a variety of other verifications carried out, including those related to production conditions. I think that with existing technologies it's impossible to avoid making a prototype. If we make prototype-free production our ultimate goal, it will probably need a faster CAE environment and a different perspective.

Okada Going prototype-free is an ideal, but errors arising when assembling prototypes is an unavoidable issue. Actually, it's a fact that (making a prototype) can show whether calculation results are precise or a little bit askew.

Therefore, perhaps a better way to phrase our goal would be that we use JMAG to get closer to reality. For example, just by being able to visualize motor behavior in a PWM control makes the benefits JMAG bestows to be significant.

I think JMAG is probably the closest thing around to offering multiphysics support.

—Please tell us if you have any requests regarding JMAG functions.

Kurokawa I guess it would have to be support for multiphysics. Friction, shock, stress, fluid, light, electrons, thermal, electrical field, magnetic field, chemical reaction and so on. I don't think it's an exaggeration to say that manufacturing is already in a state where it's not possible to get as far as producing revolutionary technology without a background of analyzing the multiphysics phenomenon process. We're waiting for the emergence of a comprehensive simulation software.

I believe that JMAG is the closest to being able to do this. We talked about development of an IPM motor using a ferrite magnet. Various JMAG software couples extremely smoothly and seamlessly. These properties can form the basis for multiphysics support and I get the feeling they make it easier for multiphysics to become a reality.

Okada Say you asked: "We're making this function, what should we develop with a focus on motor properties?" I think JMAG is extremely effective for responding to this question, so it could expand its role from being a simple analysis tool to a design tool.

—What are the next targets for the Motor Development Center?

Kurokawa As with the Panasonic group business policy, we want to strengthen our business with corporate clients, doing so with the addition of in-vehicle products in addition to our household appliance field. With in-vehicle or industrial use, there are in every field numerous technical issues related to requirements for motors different to those confronting household appliances, like environmental durability, noise and miniaturization. On the other hand, you could also say there is a great deal of room left for development. This is what we're focusing on.

For example, in the in-vehicle field we could add our company's strength of audio-visual products and get real about involvement in core parts related to driving or safety, like batteries or devices, which could be given as a goal for expanding business greatly. And you would have to give better development speed to further enhance quality and customer satisfaction.

Currently, JMAG is undoubtedly an indispensable tool for solutions to new motor-related technical issues and rapid development. That's why we want to continue actively seeking functions needed for solutions.

Panasonic

Company name: Panasonic Corporation

Head office: City of Kadoma, Osaka Prefecture

Capital: 258.7 billion yen (As of March 31, 2013)

Consolidated sales: 7.3 trillion yen

(As of March, 2013)

Consolidated number of employees: 293,742

(As of March 31, 2013)

No. of affiliates: 538 (As of March 31, 2013)

President and Director Kazuhiro Tsuga

Panasonic Corporation, Appliances Company

Business Overview

Appliances Company is an internal company that takes charge of Panasonic's appliance field, including its household appliances and cold chain. The Motor Development Center is one of our device business and works centered on highly efficient brushless motors for the three fields of household, in-vehicle and industrial use.

http://panasonic.co.jp/ap/

Product Report

Introducing JMAG-Designer Ver.13

We released JMAG-Designer Ver.13 in December, 2013. We have released Version 13 (which we'll call Ver. 13 from here on). With Ver.13, we focused on functional development aimed at high speed calculation and detailed modeling, in particular. The solver features the first parallel solver made for commercial use in the electromagnetic field analysis segment. Modeling technologies include higher accuracy in loss calculation for starters, realize small multiphysics through coupling of thermal and structural analyses for electromagnetic field analyses and provided a wide array of new functions. This product report introduces the most important new functions in Ver.13.

Overview

We released JMAG-Designer Ver.13 in January, 2013. Newly added are 40 or more functions in the development of Ver.13 including high parallel solver, high precision loss modeling, multiphysics function (Small Multiphysics as its main functions (Fig. 1).

The high parallel solver newly included in Ver. 13 drastically improves the scale of electromagnetic field analyses, as well as the degree of detail that can be dealt with in a realistic time. This powerful solver enables users to avoid having to worry over how much time they'll need for analysis and enables trying out a wide variety of ideas.

With material modeling, Ver. 13 has been equipped with a material properties database that has a hysteresis group. Iron loss calculations can tap into this built-in data for analyses and, by allowing for minor loops in the details, improve the degree of accuracy in iron loss. Moreover, a higher precision loss analysis is realized taking into consideration the effect of stress due to production degradation. Analysis makes high-fidelity material modeling a reality not by envisioning a convenient ideal, but by being as close to an actual state as possible.

For phenomena modeling, we have strengthened coupling functions within JMAG to enable any user to use the software from anywhere at all as part of our pursuit of multiphysics. We will present analysis functions (small multiphysics) in the form of running magnetic field analysis including centrifugal force or thermal-magnetic field coupled analyses allowing for the effect of using a 1D heat analysis and a new coupling framework developed in our pursuit to become easier to use.

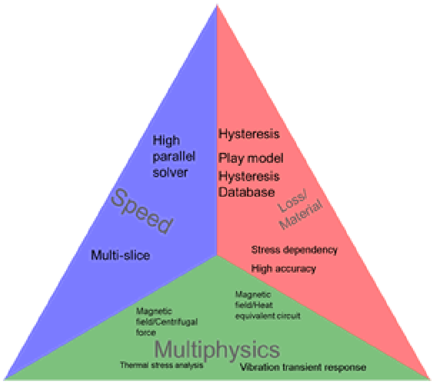


Fig. 1 Three Concepts and Functions Characterizing Ver. 13

High speed solver

One of the most important features of Ver. 13 is the accelerated solver. A new acceleration technique in Ver. 13 is the high parallel solver for large/detailed analysis and Multi-Slice function to achieve speed analysis by allowing for skew effect in 2D motor models.

High Parallel Solver (Magnetic Field Analysis)

The new high parallel solver now supports 128 parallels compared to the just 8 parallels maximum supported in a conventional SMP/DMP. This shows a comparison on an IPM motor model between the high parallel solver and the conventional SMP solver (Fig. 2). This shows solving speed is greatly enhanced without any decline in accuracy.

The high parallel solver drastically reduces analysis time and also achieves a large model analysis at high precision, which has been considered until now to be unrealistic. Analysis themes we could not venture into before are now possible, such as laminated steel sheets, coil wire/ends and detailed eddy current loss analysis for large machines.

For example, a transformer is composed of a number of parts including tank, clamp, shield and cover plate surrounding the body. Since each part becomes the generation source of eddy loss, detailed modeling is required to evaluate local overheating accurately. Until now, geometries had to be simplified to make the analysis scale smaller as analysis scale was an obstacle, which meant that loss evaluation had to be something qualitative.

The high parallel solver enables modeling of only the necessary degree of detail. It also enables you to confirm concentrations of leakage flux to the clamp, connector or shield as a magnetic bypass to the tank or eddy current causing localized heat. The high parallel solver will not only realize highly detailed analyses, it will also be able to show through the analysis detailed physical phenomena that had not been capable of being confirmed before.

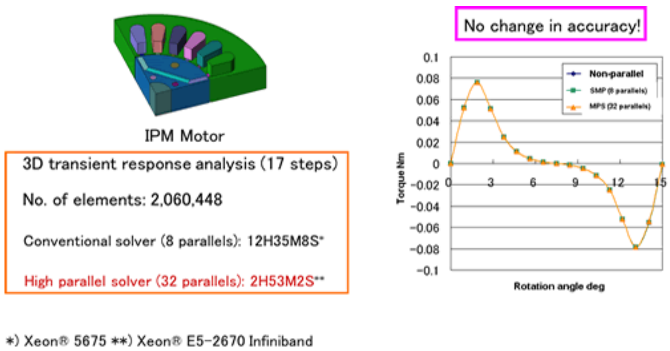


Fig. 2 Example of Acceleration using High Parallel Solver

Multi-Slicing

For skewed motors, a 3D analysis may be often necessary considering magnetic flux in the axis direction. The scale of the analysis can be massive in the 3D analysis, and calculation cost is much more expensive than 2D analysis when it comes to calculation of analysis time and disk capacity to save data.

The Multi-Slice function is a new analysis function taking into consideration skew with a 2D model. The skew effect is allowed for by specifying the skew angle and number of cross-sections of the axial direction. This function performs analysis allowing for skew by running an analysis coupled with multiple models with different relative positions of rotor and stator from a 2D model. As this is an analysis bade on a 2D analysis, the answer is obtained quicker than it would be under a 3D analysis (Fig. 3, Table 1).

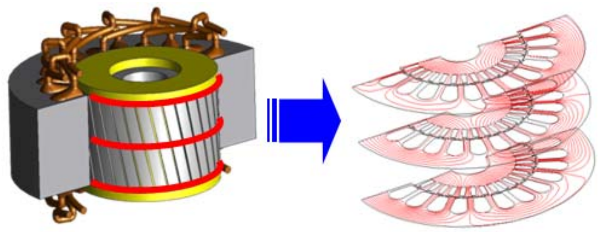


Fig. 3 Image of Analysis under Multi-Slicing

Table 2 Comparison of Multi-Slice Method and #D Analysis Calculation Time

Type	No. of Cross-Sections	No. of Ele-ments	Acceleration Rate
3D	-	634,978	1.0
2D	3	17,248	64
	5	17,248	27
	7	17,248	17

High-Precision Loss Calculation

JMAG has engaged in an effort to support higher accuracy of loss calculation for magnetic devices such as motors, depending on the various loss factors such as hysteresis loss, eddy current loss inside the laminated structure and increased iron loss due to process degradation.

In Ver.13, we have continued with this flow and raised our standard of detail to an even higher level.

Greater Precision of Stress-Dependent Iron Loss Calculations

When evaluating the iron loss value, an analysis considering the impact of stress caused by processing deformation generated in the manufacturing process may be necessary. JMAG has provided iron loss calculation functions (evaluation of iron loss based on stress scalar values) focusing on a symbol of stress, but now we know the necessity of evaluating magnetic flux density and iron loss characteristics for each principal axis direction of the stress.

The newly added stress dependency iron loss calculation function (tensor-vector value evaluation) enables a loss analysis allowing for magnetic flux density changes over time in response to each primary axis of the stress (Fig. 4, 5). In comparison to the conventional analyses, the ability to consider the impact of difference in directions of principal stress and magnetic flux density greatly enhanced the detail of iron loss analyses.

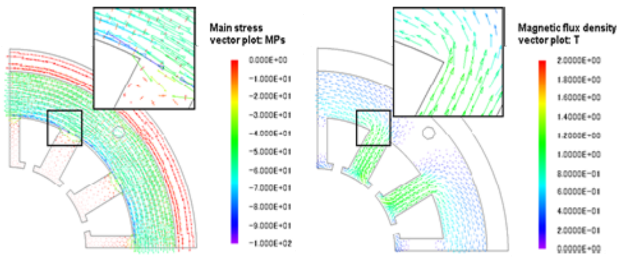


Fig. 4 Difference in Directions between Principal Stress Distribution (left)
and Magnetic Flux Density Distribution (right)

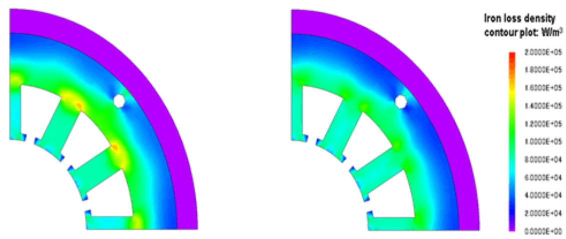


Fig. 5 Comparison of Differences in Handling Stress
(Left: Scalar, Right: Tensile)

Adding the Hysteresis Properties of a Magnetic Steel Sheet

Hysteresis properties affect not only the iron loss in magnetic devices, but also response characteristics, so there is a strong requirement for allowance to be made of this in analyses. JMAG enables analyses of detailed magnetic properties that take into account the hysteresis properties. However, since data of hysteresis properties usable in analyses is almost never found in market, obtaining it requires significant time and cost for many users.

With support from joint research facilities such as the Electrical Machinery & Apparatus Laboratory at Doshisha University, JMAG incorporated into the JMAG material database commonly used hysteresis property data of magnetic steel sheets (various types of 35A- and 50A-class magnetic steel sheets) (Fig.6).

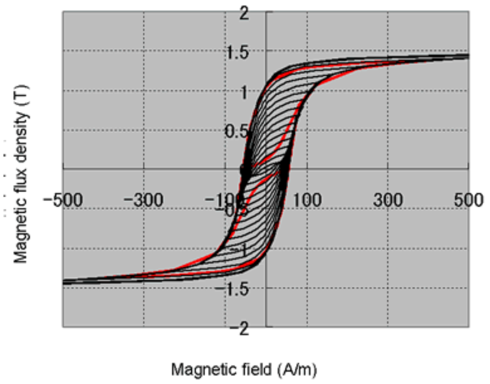


Fig. 6 Example of Hysteresis Measurement Results to be Included

Multiphysics

Complex physical phenomena in reality need to be tackled from multifaceted approaches including magnetic, thermal and structural aspects in product design. However, when these designs are performed by each division in most cases, a need to fulfill the demand for the trade-off for each request item may cause a lot of hassle when trying to obtain optimal design values. To solve this problem, a cooperated/coupled analysis simulation via CAE dealing with complex phenomena would be an effective measure, but users also tend to hesitate to use this due to prioritizing preliminary learning of each analysis step.

The Multiphysics function newly introduced for Ver. 13 allows even magnetic analysis users to easily handle an analysis taking into consideration the impact of both centrifugal force and heat (small multiphysics) in addition to the thermal stress analysis studies that enable handling of heat generation, thermal stress and thermal deformation at the same time.

We have also added a new level on the JMAG-Designer treeview for coupling analysis functions, presenting a comprehensive coupling analysis environment that's easy to use.

Vibration analyses can now also handle items such as vibration phenomena including transient changes due to having added an analysis function in the time region.

Small Multiphysics

Small multiphysics enables coupling analyses accounting for centrifugal force analysis or heat during drive time in a magnetic field analysis with the concept of multiphysics analysis functions that anybody can use easily.

1. Magnetic Field Analysis/Centrifugal Force Calculation

Centrifugal force can be calculated when concurrently running a magnetic field analysis for motors (Figure 7). Electric/magnetic circuit design such as torque and induced voltage under the specified rotational speed can be examined besides strength design to check if it has sufficient robustness to withstand the centrifugal force. Furthermore, the function to render and check physical quantity concurrently based on different phenomena such as stress/displacement distribution and magnetic flux distribution helps us to understand the phenomena in an objective manner.

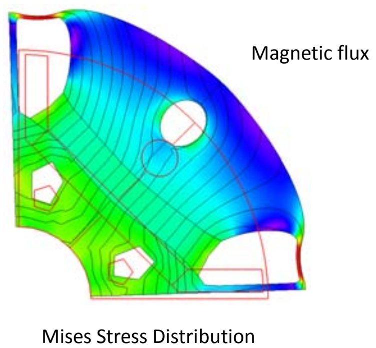


Fig. 7 Mises Stress Distribution of IPM Motor Rotor

2. Magnetic Field Analysis/ Thermal Equivalent Circuit Calculation

What is vital in a thermal analysis is heat exchange and heat release phenomena through parts which are not modeled in the magnetic field analysis, such as the bobbin and case. Detailed modeling which is often required in the magnetic field-thermal coupled analysis was a discouraging factor for users to perform an analysis.

In the newly created magnetic field-thermal coupled analysis using the heat equivalent circuit, settings in the heat equivalent circuit from the circuit editing screen for the magnetic field analysis enables an analysis taking into account the heat generation phenomena due to copper and iron losses. This shows, without using a complicated 3D thermal model and by employing a heat equivalent circuit, how increasing the coil heat generation and resistance values lowers the torque (Fig. 8). This analysis can be specified and run from a magnetic field analysis, allowing even non-experts such as electric/magnetic circuit designers to easily handle an analysis taking into consideration the heat generation.

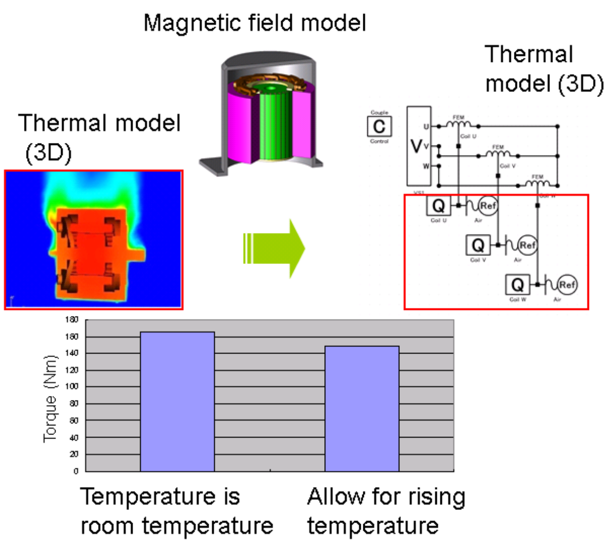


Fig. 8 Easy Evaluation of the Heat Generation Effect using Heat Equivalent Circuit

Thermal Stress Analysis Study

Heat generation phenomenon due to eddy current brings structural deformation of objects due to thermal stress, as well as has an impact on the physical property value such as electrical conductivity.

With the thermal stress analysis study, if the coefficient of thermal expansion in physical property values is defined, thermal stress distribution and thermal displacement distribution are output using temperature distribution as a load (Fig. 9). For objects like busbars that are subject to heat deformation in large currents in conductors, we provide an effective evaluation method.

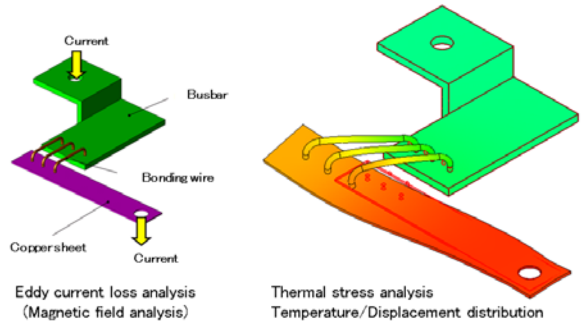


Figure 9 Temperature Distribution and Thermal Deformation caused by Eddy Current Loss as a Heat Source

New Framework for Coupled Analyses

1. Direct Execution of Coupled Analysis

A coupled analysis combines multiple analysis types such as magnetic field analysis and thermal analysis, but conventional JMAG-Designer did not support a framework for the coupled analysis and from Ver. 13 there is a new framework for coupling analysis. Preparing a new hierarchy called the analysis group in the new framework, magnetic field analysis studies and thermal analysis studies which are necessary for a coupled analysis are collectively managed within a group. This framework also supports parametric analyses during coupled analyses, greatly enhancing operability during coupled analysis.

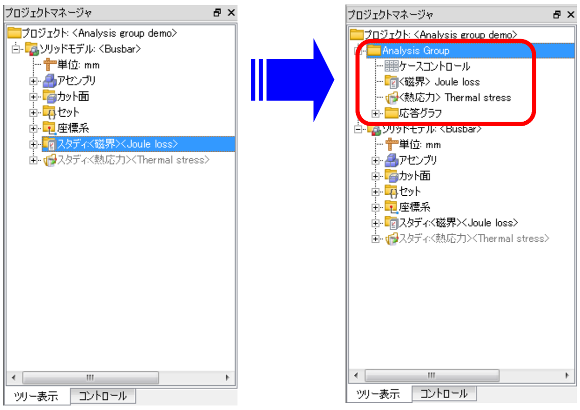


Fig. 10 Adding Analysis Group

2. Geometry data sharing between different analysis types

Target parts to be analyzed in the coupled analysis differ depending on the magnetic field analysis, thermal analysis and structural analysis. For example, in the high frequency induction heating, although heating coils are modeled for the magnetic field analysis to handle work piece’s heat generation phenomena, only work piece is handled without modeling the heating coils for thermal analysis. Nonmagnetic objects which are omitted in the magnetic field analysis will be included as targets in the structural analysis.

As requirements differ regarding part data for each analysis type like this in coupled analyses, each study is divided up into its own different solid model.

Ver.13 provides the shared solid model under new coupled analysis framework, which was divided by each analysis type in earlier versions (Fig. 11). Depending on the analysis type, parts not needed for an analysis can be directly controlled from the JMAG-Designer main window. For this reasonhis thiis a convenient function since preparing a single, detailed, solid model in advance as a CAD model will ensure there is enough for the geometry.

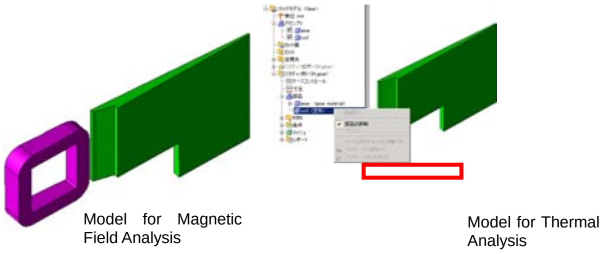


Fig. 11 Data Sharing in the Magnetic Field-Thermal Coupled Analysis (Gear Quenching)

Vibration Transient Analysis

A transient response analysis function is added to the Ver. 13 vibration analysis, a structural analysis module (DS).

However, property to the instantaneous excitation force that can damage equipment in real phenomena. Even for users who deal with the electric/mechanical system, there is an increasing demand for acquiring a real time response of stress and displacement to the transient changes based on the electromagnetic phenomena.

This newly added transient response analysis function enabled users to grasp stress and displacement variation overtime depending on the electromagnetic force generated instantly (Fig. 12).

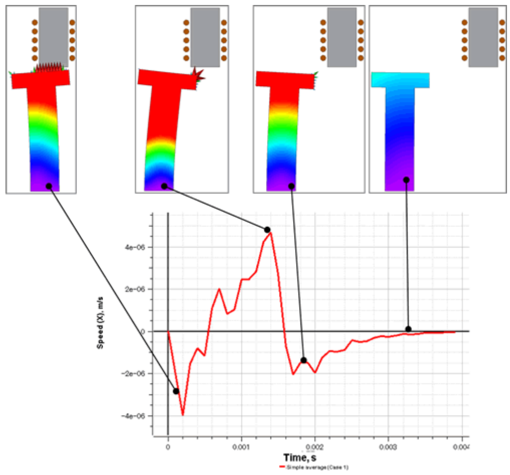


Fig. 12 Variations in Suction Core Vibration Speed due to Moving Electromagnet

Generating Mesh

Stray loss generated in large transformers or generators is often addressed as the theme of analysis because of its size. Stray loss is often caused by loss in the thin sheet structure surrounding the body and analyses must take into account the skin effect when a mesh is generated. The thin mesh function is a new mesh generation technique to meet this requirement.

Thin Shell Mesh Generation

This function is a mesh generation function that has been vastly improved to make it applicable to complicated thin sheet structures through such means as crossing thin sheets (Fig. 13). Generating a layered mesh in the direction of sheet thickness enhances the precision of mesh generation, highly accurate expression of eddy current and analysis convergence.

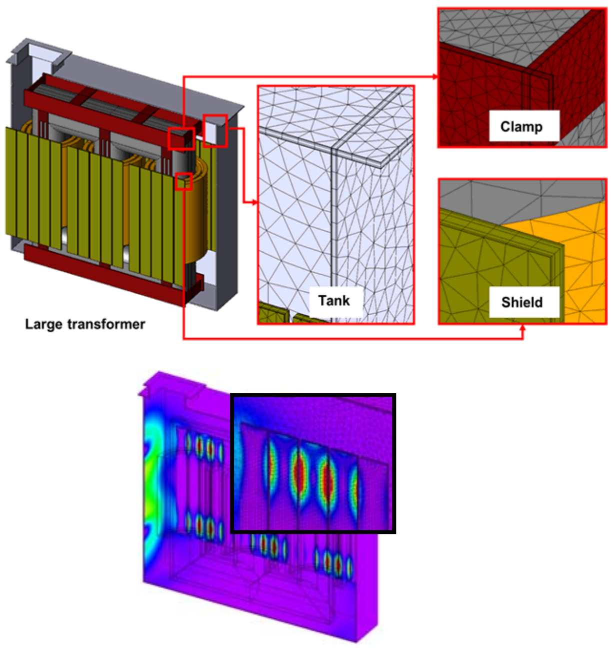


Fig. 13 Stray Loss Density Distribution in a Large Transformer

JMAG-RT/Efficiency Map

The correction function for each amplitude or phase of current is added to meet the rising demand for JMAG-RT solutions required for generating a plant model of the high precision motor.

Furthermore, JMAG-RT Viewer newly added the efficiency map function for induction machines which was also in high demand, where the temperature dependency of the efficiency map can be taken into account.

Correction of rtt file current amplitude/phase difference

JMAG-RT is a tool capable of providing a highly accurate motor plant model, but sometimes you may need to correct part of the data in the rtt file (say, when you wish to incorporate the 3D effect such as the effect of inductance from the coil end on magnetic saturation using a 2D model).

The new JMAG-RT can correct output values such as torque and magnetic flux for each current amplitude and phase within a rtt file that is generated from the PM motor model referring to the data sheet for correction (csv file) (Fig. 14).

Fig. 14 Current Amplitude/Phase Correction Dialog Box

Efficiency Map Supporting Induction Machines and Consideration of Temperature Dependency

JMAG-RT is second most heavily used application for induction machines which are used as a target of variable speed control, except for PM motors.

We have had growing number of requests for rendering efficiency maps using rtt files from induction motors and this new efficiency map function now support induction motors (Fig. 15). Efficiency maps for induction machinery not only plot contours for each operation point, they also display slide contour mapping enabling optimal efficiency.

Also considering temperature correction coefficient when an efficiency map is generated enables confirmation of the temperature dependency of the efficiency map.

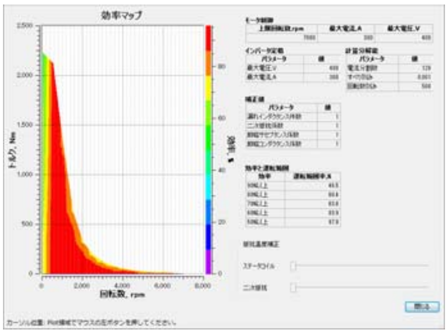
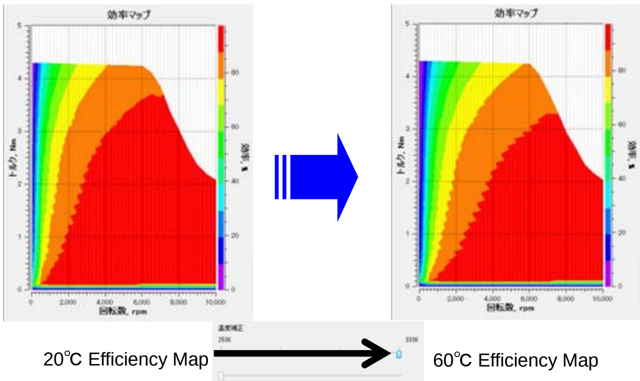


Fig. 15 Induction Motor Efficiency Map Example



20℃ Efficiency Map 60℃ Efficiency Map

Fig. 16 Efficiency Map Temperature Dependency

Optimization

Displaying sensitivity analysis results using response surface

We've made the optimization function display a response value for a design variable on the response surface. Since the response values are displayed using contour for multiple variables, it is possible to confirm the response values sensitivity to design variables, which is in the relationship of trade-off (Fig. 17).

Changing and improving the optimization algorithm enabled significant improvements in the optimum value. (*)

(*) We recommend setting one target function in Ver. 13's optimization function.

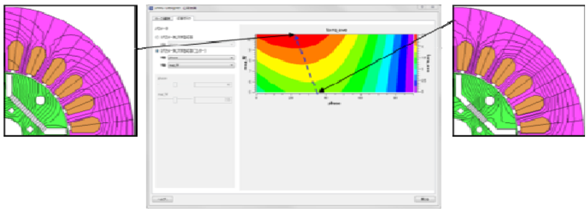


Fig. 17 Response Surface Results for Current Phase/Magnetic Width, Torque

Results Analysis

Ver.13 newly added a new function controlling display of distribution amounts to enable clearer views of results.

Controlling Result Rendering Type for Each Part

To confirm the analysis results using contour or vector, they were exported to all of the targets displayed in the earlier versions, but displaying the contours and vectors at the same time will render them overlapping and made them difficult to view.

The new results rendering function can specify contours and vectors for each part, depending on the requirements. Fig. 18 shows what happens when flux leakage generated from the coil and core becomes loss in the shield. By showing loss generation only in the shield it becomes easy to discern the cause and effect of the leakage flux and loss it generates.

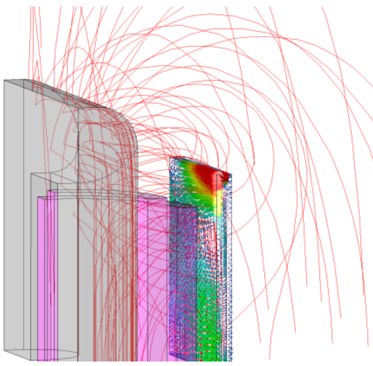


Fig. 18 Magnetic Flux Density (Vector) and Joule Loss (Contour) (Single Phase Transformer 1/8 model used)

Density Control of Vector Rendering

Vector output being rendered in the unit of element depends on the mesh density. Models comprised of detailed mesh have many vectors to display, which makes it difficult to see some of the detailed distribution.

Using the in-built vector rendering density control function has enabled display of vector distribution with less density, which makes it easier for users to see.

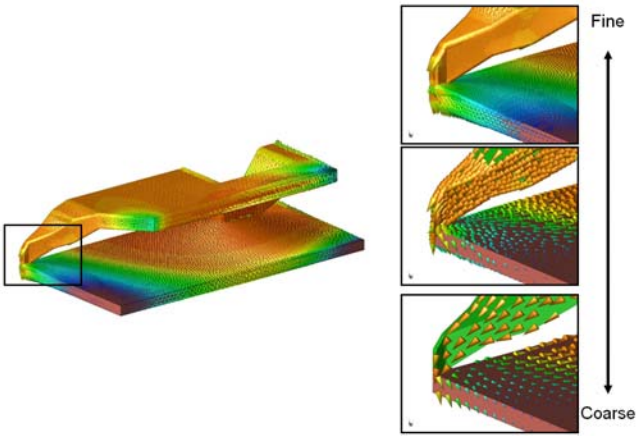


Fig. 19 Density Control of Magnetic Flux Density Vector (Magnetic Head Model)

Model-Based Development

We have tried with JMAG to realize an interface environment that seamlessly blends structural/vibration analyses and thermal liquid analyses with JMAG magnetic field analyses to make a reality of CAE creating a model-based development environment.

Ver. 13 expands types of electromagnetic force to be handled by the Multi-Purpose File Export Tool or LMS Virtual Lab interface.

Expansion of the Multi-Purpose File Export Tool

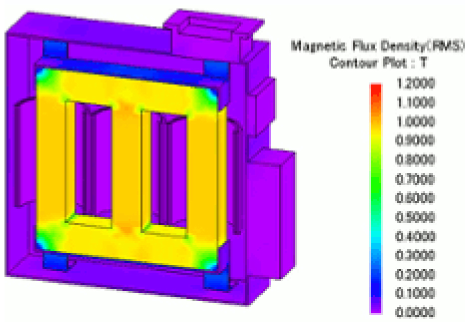
The multi-purpose export tool is a tool with the objective of taking JMAG analysis results such as electromagnetic force or loss and using them as load conditions for structural analysis or thermal analysis software other than JMAG.

File output in the Universal format is available as well as in the Nastran format. Broaden the CAE software range using JMAG's results.

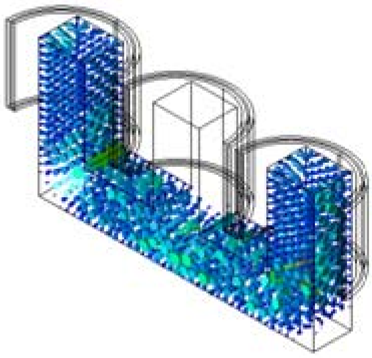
LMS-Virtual.Lab Interface expansion

LMS Virtual Lab. is a CAE software with an established reputation in the field of sound/vibration analysis. The earlier version of JMAG was able to transfer only electromagnetic force distribution generated on magnetic surfaces to LMS Virtual.Lab from analysis results obtained until now.

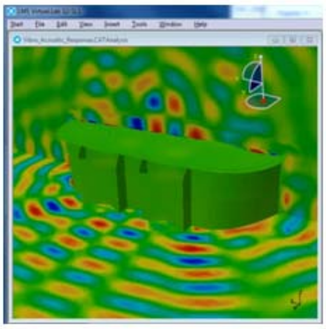
The new LMS Virtual.Lab interface is also capable of adding to this a map of the internal distribution of electromagnetic force. Furthermore, Lorentz force and magnetostrictive force can also be mapped and vibration phenomena frequently occurring within electromagnetic phenomena can also be handled widely. Showing an example of using JMAG and LMS Virtual.Lab to obtain the sound pressure distribution emanated from magnetostrictive vibration generated from the core of the power transformer (Fig. 20).



Magnetic flux density distribution



Equivalent magnetostriction force vector



Sound pressure distribution

Fig. 20 Example of Transformer Magnetostriction Vibration

In closing

The new functions described in this article will also be added to our Website and in seminars for updated versions of software to be held from January 2014.

(Takayuki Nishio)

Product Report

JMAG-VTB is Now Easier to Use

We simultaneously released JMAG-Designer Ver. 13 and JMAG-VTB Ver. 3.0 in December 2013. We improved the method of using JMAG-VTB Ver 3.0 and added a navigation function. Even analysis beginners can easily obtain analysis results using JMAG-VTB. JMAG-Designer license-holders can use it immediately, so why not give it a try? This article will describe JMAG-VTB features and latest updates to the software.

What is JMAG-VTB?

JMAG-VTB is a tool that can solve the problems of those who've thought about analysis but don't know how to analyze, those who are so busy with other work they don't have the time to spend on analysis or those confused by the idea that analysis results will differ depending on the size of the mesh used.

JMAG-VTB can run analyses with inputting just an analysis model and design parameters, so for those starting out on analyses it's a solution tool that is also easy to use. Scenarios prepared for each application enable immediate analyses (Fig. 1). Scenarios are defined in an analysis flow decided for each application and analysis objective. For example, if a power transformer designer is evaluating stray loss, they can choose a stray loss scenario. Or if an insulation breakdown evaluation is required, select the insulation evaluation scenario.

Settings are also simple All a user need do is enter the design parameters they normally use and it's possible to run an analysis. Selecting analysis conditions and the like is simple, even if you don't know about settings or operational procedures in JMAG-Designer. And even though JMAG-VTB has automated procedures, that doesn't mean that it's merely an automatic tool. JSOL-provided scenarios in JMAG-VTB include analysis know-how JSOL has accumulated, so users can obtain appropriate results without having any analysis expertise.

Let's have a look here at the types of analysis know-how included in the scenarios.

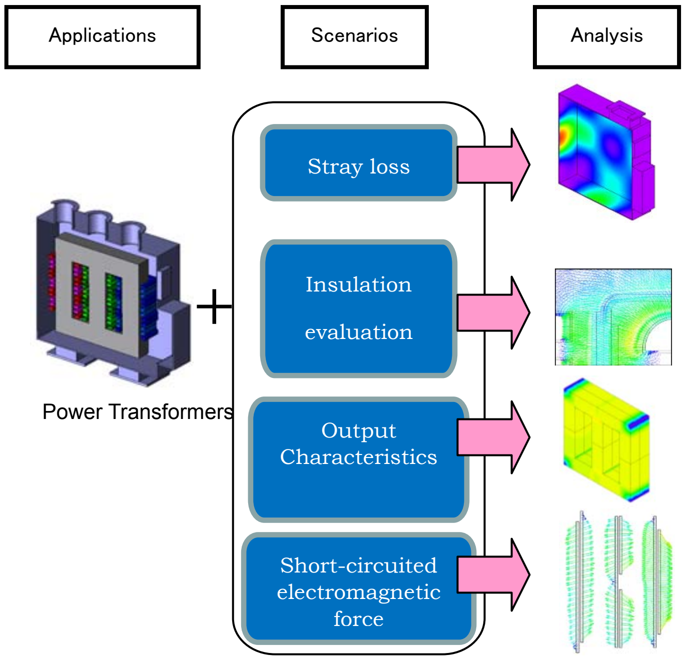


Fig. 1 Objective-oriented Scenario

This shows an example using a power transformer. Please refer to the list at the end of the article for supported.

An appropriate mesh size is decided automatically

JMAG-VTB will automatically decide the appropriate mesh for each scenario. I'll describe an example following selection of a scenario for a stray loss analysis in a power transformer. Leakage flux from the coils in a power transformer raise the fear of generating eddy current loss in the tank encasement. To accurately obtain this eddy current loss, you need to generate a mesh that will express the eddy current distribution bias toward the tank surface. Skin depth δ, which dampens the current density from the surface to 1/e, can be calculated according to Formula (1).

$$\delta = \frac{1}{\sqrt{\pi \cdot f \cdot \mu \cdot \sigma}} \quad ..(1)$$

f: frequency (Hz), μ: permeability, σ: electric conductivity

We can understand from Formula (1) that the skin depth differs depending on the analysis conditions and changing these conditions requires examination or changing for each user. And know-how is needed to decide on what is actually the right mesh thickness needed to express the eddy current. With the skin depth obtained from Formula (1) it is not possible to accurately express the eddy current distribution and that we need to thicken divisions that have already been separated. JSOL-provided scenarios not only include Formula (1), they also incorporate know-how accumulated up until now and this enables automatic generation of the right mesh.

Evaluation Methods Supporting Analysis Objectives

JMAG-VTB summarizes analysis results that should be evaluated for each scenario and outputs these on a dashboard. For example, if analyzing high-frequency induction hardening in a gear, to check whether hardening is progressing as supposed, it will confirm whether the hardening temperature has attained the maximum achieving temperature. Naturally, using JMAG-Designer will show the maximum achieving temperature distribution, but using JMAG-VTB enables obtaining the appropriate analysis results without having to know how to operate JMAG-Designer. This high-frequency induction hardening scenario displays bicolored contours setting the hardening temperature as a threshold (Fig.2).

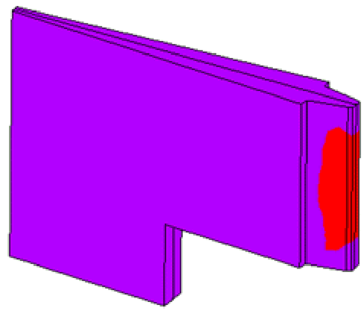


Fig. 2 Diagram showing Bicolored Contours Setting the Hardening Temperature as a Threshold

Description of JMAG-VTB Ver 3.0, the Latest Version

JMAG-VTB Ver 3.0 has been made with the goal of being easy to use and we have added a navigation function to use JMAG-VTB. Here, we'll describe the software and its new functions.

The guide function will navigate us

This function displays the guide explaining how to operate what a user is going to operate at a timing when a user actually is operating items like input settings. The guide function displays contents related to what the user is showing, enabling worry free settings.

So that JMAG-VTB can support arbitrary models, you need to be able to make settings in JMAG-VTB regarding information of the input model. A user may know from among the part names about which part is the coil, but they may not know which coil is the U-phase if there are three phases to choose from. So, it is necessary to import a model into JMAG-Designer and set which one is U-phase coil. When booting up JMAG-Designer, the guide will display simultaneously and this will enable easy settings (Fig. 3).

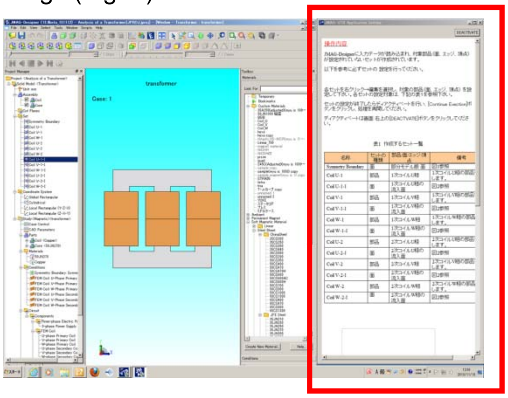


Fig. 3 Guide Function

Also Supports Arbitrary Part Numbers

JMAG-VTB Ver3.0 also supports models with a number of parts that differs to the number of parts specified when creating the scenario. Here we'll give an example using a description of a scenario for a single-phase induction motor. The scenario includes the shaft as one of the parts. An imported model can also be supported even if it does not include parts like the shaft, or there are fewer parts in the model than the scenario. And when importing a model with a large number of parts and a frame around the stator exterior, it can be supported by adding in the settings an increased number of parts. (Fig. 4)

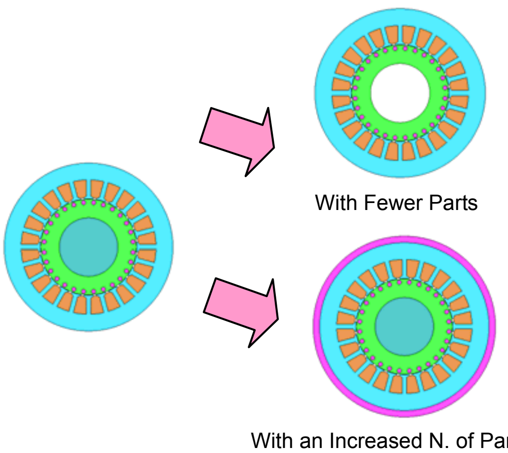


Fig. 4 Example Using Increase/Decrease of Part Numbers

(Single-phase Induction Motor)

Arbitrary coil numbers can also be supported

The number of coils, which comprise the coil part, also supports arbitrary numbers. We assume that it's common to change number of coil turns or winding pattern in response to changes being made in the analysis model geometry. FEM coil conditions and the FEM conductor conditions are specified at that time, o changing the number of turns or winding pattern may also require creating or adding new setting conditions. JMAG-VTB automatically sets the appropriate conditions in response to an arbitrary number of coils. For example, when running an induction heating analysis of something like an induction furnace, the FEM conductor condition needs to be used to allow for current distribution in the heating coil. Consequently, FEM conductor condition settings must be made for each individual coil, and a change in the number of coils means an increase or decrease in the number of conditions applying to them. Using JMAG-VTB, the FEM conductor conditions and FEM conductor components on circuits will be created automatically in conjunction with the number of coils being used (Fig. 5.) In such cases, the user need only input the number of coils and the coil placement intervals.

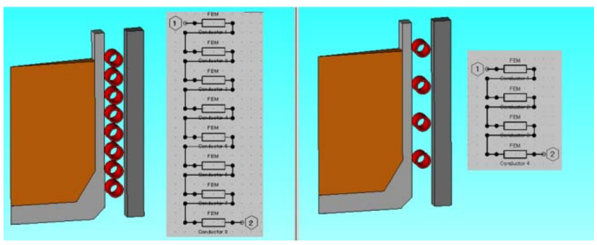


Fig. 5 Circuit Components Created in an Induction Furnace
(Left: 8 coils, Right: 4 coils)

Select the design parameters from the connection pattern

Even if you have decided on the application you would like to analyze, I guess you'd probably still like to look at making many more exchanges to the circuits that you will use. With JMAG-VTB, circuits to be used are already registered as a parameter, so it's simple to confirm results obtained after changing the circuit.

For example, in a scenario of stray loss analysis in a power transformer, you can choose from four patterns of connection (Fig. 6). Users need only to select from the parameters the connection pattern that they would like to use in the analysis and they can easily confirm the effect that changing the connection would have.

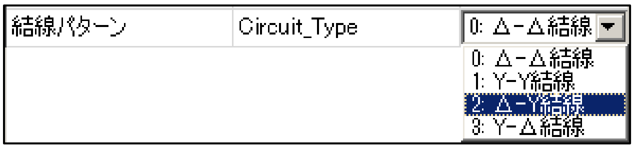


Fig. 6 Selecting a Circuit from the Design Parameters

Design parameters are easier to understand

Design parameters are selected when running an analysis and from JMAG-VTB Ver 3.0, now there is a pop-up explanation given for each design parameter (Fig. 7). This makes it much easier to understand the meaning behind each design parameter and you can enter the design parameters without having to ponder over what they actually do.

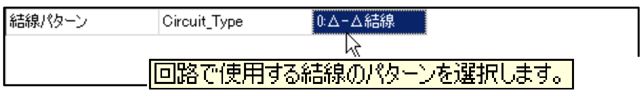


Fig. 7 Description of Design Parameters

Improved JSOL-provided Scenarios

JSOL has until now provided over 100 different scenarios, but with the latest version it has made improved versions of the scenarios it provides. Among the main applications improved with this version are for device, single-phase induction motors and non-contact power supplies using power transformers, inductors and induction heating phenomena. These scenarios can be used in their existing formats or given additional improvements by users to enable them to be used in even wider areas.

How to Use JMAG-VTB

If you have a license for JMAG-Designer's Prepost and Solver, you can use JMAG-VTB immediately without any additional cost or license. JMAG-VTB is included with the JMAG-Designer installer, so install both at the same time.

In Closing

There are functions we couldn't give a description of within the bounds of this article.

We had a hands-on seminar for JMAG-VTB for the Users Conference and gave participants a chance to actually operate the latest version. We hope using JMAG-VTB will be useful for your work

(Tetsuya Hattori)

List of Applications JMAG-VTB Supports

- IPM Motors
- SPM Motors
- Three Phase Induction Motors
- Single-Phase Induction Motors
- Switched Reluctance Motors
- Brush Motors
- Synchronous Reluctance Motors
- Stepping Motors
- DC Generators
- Linear Motors
- Linear Solenoids
- Electromagnetic Relays
- Electromagnetic Breaks
- Power Transformers
- Inductors (Reactors)
- Switching Transformers
- Sensors
- Contact-less Power Transfer
- High Frequency Hardening
- IH Cooking Equipment
- Electromagnetic Forming
- Induction Furnace
- Resistance Heating
- Printer
- Circuit Breakers
- RFID
- Magnetic heads
- Shield Rooms
- Capacitors
- Cables

Motor Design Course

Issue 2 Moving Forward with Motor Concept Design

In the September 2013 issue of this newsletter, the first of these ongoing columns, I gave an explanation about the background to starting a course on motor design. In this issue and the second column, I'll finally get around to explaining what's involved in designing motors. The theme of this column will be to provide a starting point for concept design. Although it may seem a little boastful, what I'll do is go over some of the results that we have obtained through our studies and, hopefully, these will be of use to your work.

Motor Concept Design

When starting out on a motor design, the first thing that must be done is to clearly establish the precise reason for why you are designing a motor. There is always an objective for starting a development. Clarifying this objective enables defining the directions that are to follow.

Whether designing a variation from an existing product base or working on improvements of defects, existing products are always the place to start. Even with a completely new design, it's normal to start working from existing products that have similar performance or size to the desired product. Existing products derived from a variety of examinations of results and been evaluated as competitive, so they have reliability and results, even if aspects about them remain a matter of concern. I'm not suggesting you place blind faith in existing products, but want you to know that they are important when it comes to moving ahead on new designs because that involves reassessing existing designs.

I'll put aside the picky stuff from now on and move onto some details. Fig. 1 is a simple summary of the flow of a motor's concept design

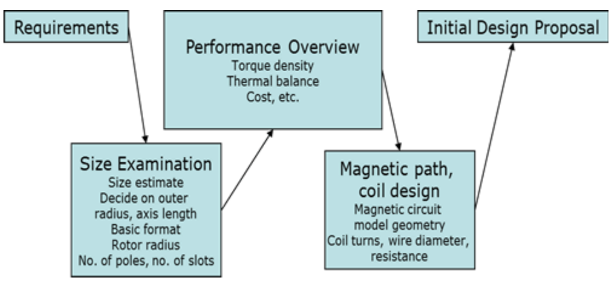


Fig. 1 Motor Design Flow

Start from your requirements, decide on rough characteristics then check performance matters based on experience values, including output, torque and thermal suitability. Finally, decide on items such as the model geometry and coil diameter of the magnetic circuit and summarize all of these as the initial design proposal. This initial design proposal will serve as the springboard toward a more detailed design.

First Decide on Size

Items, and I'm not talking about just motors here, have a proper size. From IT equipment or smartphones used in the palm of the hand through to supercomputers that occupy entire buildings, items have a size depending on their performance and capabilities. Of course, there are precious works of art whose value cannot be calculated, but the size of a device is usually determined while based on the role it has to play. Putting it another way, the density of a particular job will be decided according to the specific unit weight. With motors, the smaller the motor, the lower its output and the bigger a motor the greater its output can be.

Items weighing a lot are also large and their heat capacity and heat release area are also enlarged, enabling significant output. This is not something that needs to be re-thought, but you do need to be aware of it as you'd be surprised by how many times people don't get it right.

Looking back over existing motors, you'll learn there's a proper value for rough weight output density. I'd aim for about 0.3 to 1.0 kW/kg. If setting the output density at a low figure, you're in a position to consider you have given yourself some breathing space. For motors used continuously, like those powering factory lines running night and day or used to drive bullet trains, you must consider that maximum rating is equal to continuous rating. Phrasing it another way, you can expect to create characteristics of endurance, like a marathon runner who is always running continuously. Alternatively, raising the output density setting will eat into your breathing space. You need large output in a short time like a commuter train accelerating, but once you're cruising, you can set a higher output ratio. Continuing with the runner analogy, in this case the characteristics are more of a short-distance runner than a marathoner.

For this example, we'll use the following:

Output: 1kW, 2.5Nm/4000rpm

Input: 200V/7A

to design a motor. Applying an output density of 1kW to a motor gives you weight in the 1kg to 3.3kg range. As stated earlier, 1kg is like a high performance sprinter and 3.3kg is more like a marathon runner with endurance.

Specify the output density while allowing for the size of the output permitted by requirements and the rating time necessary for this. But, you should note that it's not worth too much worry over this at this stage, so I decided by just throwing in a number. Being typically Japanese, I went for the middle of the road and chose a design for a weight of 2kg.

If the iron of the specific gravity of the motor materials is 7.8g/cc, content of 256cc will be necessary to make 2kg. There are multiple combinations of the outer diameter and outer radius to make 256cc (See Table 1).

Table 1 Combination of the Outer Diameter and Outer Radius

Outer diameter (mm)	Stack length (mm)
40	203.7
50	130.4
60	90.5
70	66.5
80	50.9
90	40.2
100	32.6
110	26.9
120	22.6

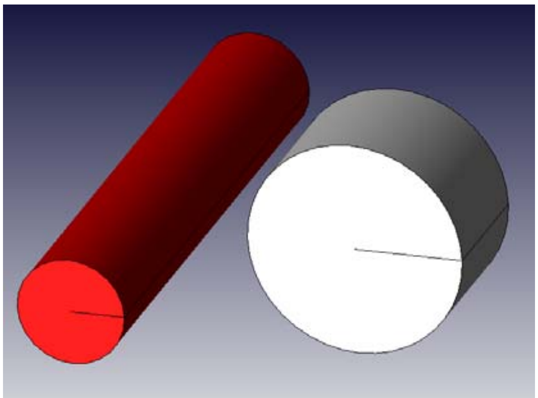


Fig. 2 Same-volume Cylinders of ϕ40/L200 and ϕ80/L50

Even though they have an identical volume, they have completel different feelings with one being long and thin and the other short an fat. Nonetheless, the weight remains the same, so it's difficult to decid on one or the other.

Select from this combination in accordance with requirements. Decisive factors will be such things as ease of incorporation into equipment, ease of positioning and ease of production. Here we'll look at the comparatively middle of the road φ80mm × L 51mm (Fig. 2)

Next, we'll decide on the rotor diameter. Setting the rotor diameter at 50% of the stator diameter gives good balance if you're dealing with the inner rotor. The larger the diameter, the greater the tendency for increased percentages. If it's the outer rotor, most gather somewhere from 70% to 90%. We will use a standard inner rotor and decide on a rotor diameter of φ40mm, which iis 50% of the stator diameter.

Next, we'll decide on the number of poles. Use the size of the magnet or number of slots as a guide for deciding on the number of poles. For each pole, an extreme-sized magnet, either small or large, will adversely affect performance and make it more difficult to create the magnet. A design with a magnet width from 10mm to 100mm works as a guide. Here, the rotor diameter has been decided on as being φ40, so the rotor circumference is 125.7mm. If there are four poles, the circumference is 31.4mm, so this is perfect as the magnet will be neither too small nor too large.

We have decided on four poles, so the number of slots should be six with a concentrated winding and either 12 or 24 with a distributed winding. Our design is comparatively voluminous, so we'll use distributed winding. Concentrated winding enables lowering the height of coil ends, but this is best utilized with small, thin motors of small volume. Each turn of the coil is short, so that also reduces copper loss. Distributed winding raises the coil end height, but has the benefit of increasing the number of slots per pole, making it easier to create a weak field control effect and reducing iron loss and magnet eddy current loss (Fig. 3).

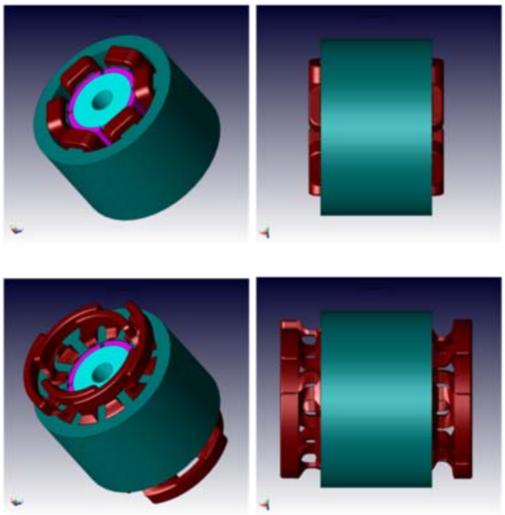


Fig. 3 Concentrated Winding (above) and Distributed Winding (below)

The slot pitch in concentrated winding is 1, so it controls the heigh of the coil end to prevent it from overlapping with the coil in anothe phase. As there are at least three slot pitches in distributed windinç the coil end becomes higher and motor length longer.

With distributed winding, the slot pitch (arc) is 5.2mm with 24 slots of 10.5mm with 12 slots. If the slot pitch falls below 10mm difficulties arise from a production capability point of view, so we'll examine a case here using 12 slots.

Deciding on the number of poles is a comparatively major judgment, but it affects only the internal area of the motor and has only limited impact on the exterior or output, thus changes can be made at the stage when you're moving forward on detailed design. Changes in concentrated or distributed winding, or in the number of slots, can be undertaken during detailed designing, so don't really need to be given a great deal of thought at this stage.

Check torque density (thrust density)

In the previous section I mentioned that required output plays a large part in determining size. At that time, you'll also find aspects important for deciding whether output should peak for a short time or endure for a long time. However, you should note there are times when it's best not to limit operation to a short time. To give an example in terms of humans, remember even Olympic athletes are incapable of sprinting 50km or lifting over 400kg. Applying the same logic to motors should limit the torque to what is capable of being drawn out from the weight. As I'm sure you're all aware, magnetic circuits are subject to a phenomena known as magnetic saturation. This has a significant association with torque (thrust force), with a limit to the force that can be output per unit of volume and attaining magnetic saturation when it achieves that value.

As torque depends in some aspects on the model geometry, I recommend evaluating through the more common thrust density. Essentially, this means there's a standard value for the force for each gap face. Areas where the motor generates torque are air gaps between the rotor and stator. Consequently, this area and force will influence the size of the torque. The gap area is determined by the stack length and rotor radius (Fig. 4).

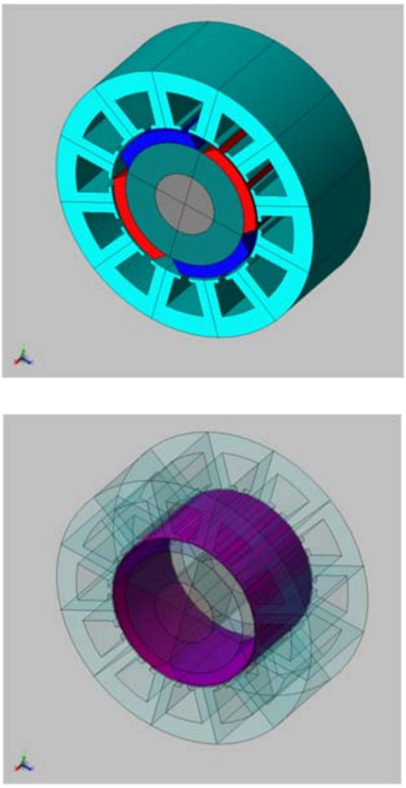


Fig. 4 Air Gap Regions in a Motor

Multiplying the targeted torque by the rotor radius will obtain the radial directional thrust force that should be generated from the gap area. By the time thrust force has developed, the contribution of the rotor radius ends and there is an exchange of force with each unit area. Imagining this situation from a mechanical engineering viewpoint, the stator and rotor moving into the air gap creates a shape like those generated through torsional shearing stress.

The rotor radius is φ 40mm and stack length 51mm, so the gap area surface is 6409mm^2. As the targeted torque is specified as 2.5N/m, there is a need to divide the rotor radius 20mm by the force 125N. The 125N/m will bear the 6409mm^2 face and the thrust force density per unit face will be 0.0195 N/mm^2.

The standard value of the thrust force density is about 0.02N/m to 0.06N/m. This shows us that our figure of 0.0195 leaves us with margin of space. Having the margin for this value means there is margin with the torque, which means it's possible to reduce the stack length or cut the rotor radius.

Our examination focused on the torque density, but at this stage there's also a necessity to estimate to a certain extent other factors such as the thermal balance between things like the heat generation amount and radiation generation amount and costs and weight of materials to be used.

Specifying the Magnetic Circuit Geometry

As size largely determines dimensions and we have planned for torque density (thrust force density), we can finally move on to determining the geometry for the motor's magnetic circuits. Key factors are to ensure sufficient surface space for the magnetic flux flowing through the motor, the teeth width in the stator, the yoke thickness and rotor's yoke thickness.

Magnetic flux within the motor circulates including leaked magnetic flux does not boil over or otherwise disappear. Consequently, it's possible to maintain in each area a circuit where magnetic flux can circulate. The gap magnetic flux becomes the basis for estimating this.

Gap magnetic flux density in the vicinity of 0.6T to 1.0T is used in most cases. A guide should be to secure enough space to ensure there are no obstacles to circulation of the magnetic flux. The stator teeth are a silicon steel plate, so you can expect saturated magnetic flux density from 1.6T to 2T. In areas where permeability is high, gap magnetic flux can pass through, so it's possible to narrow that area width.

The stator yoke area aims to flow the magnetic flux that has come from the stator teeth into the adjacent pole, so it's possible to broadly guess the number of teeth.

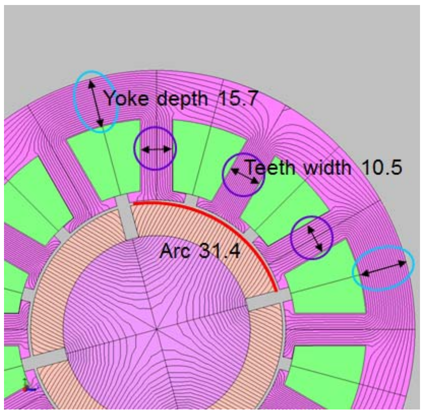


Fig. 5 Deciding the Stator Dimensions

The arc of the magnetic pole is 31.4mm. As the magnetic flux emitted from this magnet is drawn from three stator teeth, width of 10.5mm, as 1/3rd of 31.4mm, is needed. Magnetix flux arising from the teeth divides to the left and right of the stator yoke and goes on to the adjacent pole, which shows why we need a thickness of 15.7mm, or half of the 31.4mm.

However, the residual flux density of the magnet is about 1T even in neodymium sintering and allowing for things like magnetic resistance in the gap, it's possible to forecast operating points of about 0.6T to 0.7T. As the stator teeth are silicon steel plates, it's fine to easily expect 1.4T and double that in magnetix flux. Consequently, set the teeth width at half, that is 5mm, and the stator yoke thickness at 8mm (Fig. 5).

Similar thought patterns apply to the rotor yoke (Fig. 6). Magnetic flux flowing from the magnet is washed into the adjacent magnet, showing why we need 15.7mm, or half of the arc's 31.4mm. Saturation magnetic density from 1.6T to 2T such as often used in carbon steel in SPM can also be expected and the stator teeth can similarly be half at 8mm.

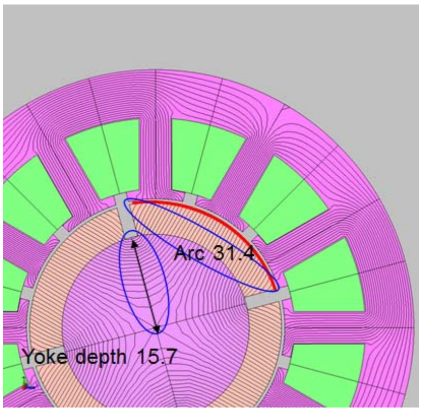


Fig. 6 Deciding Rotor Dimensions

Deciding the Number of Coil Winds

Torque is generated from the build-up of magnetic flux and current, thus the work of deciding on the number of coil winds is equivalent to deciding on the weight of a magnet. Placing magnets with a variety of force enables fewer current ampereturns. On the other hand, even with only a small amount of magnet, increasing the size of the current ampereturns enables obtaining of torque. Current ampereturns are current multiplied by the number of turns. If you have a current of 100A and 1 turn and current of 1A and 100 turns, the strength of the electromagnet face will be the same. The relationship between torque, flux linkage and current is:

Torque (N,m) = Number of Pole Pairs x Flux Linkage (Wb) x Phase Current (A)

Therefore, maximum torque of 2.5N/m with pole pairs 2 and 7A the maximum phase current tells us we need flux linkage of 1.79Wb. As the gap area has been decided in advance, the magnet strength (magnetic flux amount) and number of coil turns needs to be adjusted. Table 2 collates the combination between the number of coil turns and gap magnetic flux to reach 1.79Wb.

Table 2 Combining Coil Turns and Gap Magnetic Flux to make 1.79Wb

Turns (turn/phase)	Gap Magnetic Flux mWb	Gap Magnetic Flux Density T
40	4.464	0.697
60	2.976	0.464
80	2.232	0.348
100	1.786	0.279
120	1.488	0.232
140	1.276	0.199

Where simply placing rare earth magnets such as happens with SPM, the gap magnetic flux density will be about 0.6T. Increasing the magnets and arranging them in formations such as a V enables increasing the magnetic flux density. Increased magnetic flux density means greater cogging torque, which leads to an increase in iron loss. Air gaps are also subject to armature magnetic flux passing through, so filling these with magnets raises the danger of causing magnetic saturation. Rare earth magnets are also expensive, so there is the additional risk of increasing costs.

Reducing magnets enables lowering of the gap magnetic flux, but we also know this increases the number of coil turns. Increasing the number of coil turns in a coil turning around the same slot face can only be achieved by thinning each coil. Increasing the number of turns will lengthen the coil. For example, doubling the number of turns will have the cross-section face and double the length and resistance and copper loss will increase fourfold. Here we'll use a comparatively large number of magnets and move ahead at 60 turns.

The guide value for the area between the coil cross-section face and current where current passes through is 10A/mm^2. That means we need to ensure at least 0.7mm^2 can be obtained so 7A of current can pass through, with φ1.0 as the guide. The number of turns has been determined as 60, so the necessary slot surface will be 42mm^2, which is 0.7 x 60. However, it's not possible to insert coils so that there are no gaps left in the slot. Using a standard value of 40% to 60% for the lamination factor and then deciding 50% will work shows we need a surface of 84mm^2. As the trapezoidal inside the slot from the stator geometry decided earlier has a top of 5.4mm, base of 11.7mm and height of 11.6mm, we need a surface of 99.18mm^2, which allows us to confirm that we essentially capable of doing 60 turns within the slot (Fig. 7).

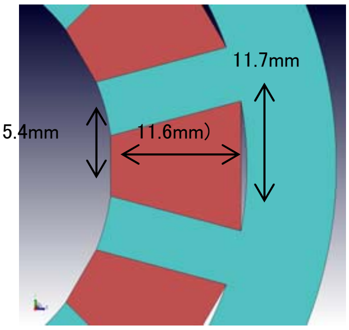


Fig. 7 Slot Area

As the number of coil turns is 60 turns, diameter is φ1.0 (0.7mm^2) and items such as the stator geometry have been decided, it's possible to confirm the coil resistance value. Obtain the initial coil turn length. Axial direction length is 91mm, comprising the outer radius 51mm and one side of the coil end height 40mm. The height of the circumferential arc is the gap radius 40mm and slot depth 20mm divided by the number of poles to work out at 47.1mm. Thus, the length of 1 turn is:

$$\left((51+40)+47.1\right)\times 2 = 276.2(mm)$$

according to this calculation. This calculation shows that with 60 turns and two poles, the length of each phase will be 33.1mm.

$$276.2 \times 60 \times 2/1000 = 33.1(\mathrm{m})$$

This requires winding an extraordinarily long copper wire. The bobbin area is 0.7mm^2 and copper resistance rate 1.68e-8ohm m, which tells us the resistance value is 0.79ohm per phase.

$$33.1 \times (1.68\mathrm{e}-8)/(7\mathrm{e}-7) = 0.79(\mathrm{ohm})$$

The current passes through at a maximum of 7A, which tells us that copper loss generated at each phase is 39W.

Copper Machines and Iron Machines

There are times when investigating this balance between the magnet magnetic flux and coil turns is referred to as "deciding the load." Magnetic load refers to the gap magnetic density and electrical load is the accumulation of coil turns and current, so the magnetic load significant shows the electrical load for each unit length in the gap area. The motor's output is determined by the accumulation of the electrical and magnetic loads, so deciding these loads is fundamental for the motor's design. Copper machines use copper wire as a magnetomotive force source within motors to increase electrical load and iron motors use magnetics or an iron core with these attributes used to determine the motors characteristics.

Settling the Initial Design Proposal

If you've reached this far, you can now summarize an initial design proposal. Elements obtained are shown in Table 2.

The first hurdle to overcome will be to find out whether this initial design proposal will be able to satisfy all requirements. Check matters such as whether there is sufficient output, or that volume and weight requirements have been met. However, don't forget that this is nothing more than an initial design proposal, so there's no need to think too much about precision as long as you're in the right area. Use this design proposal as a springboard, start examining from the finer areas and gradually improve on the degree of completeness in the design. It's a designer's job to go over and over and over their designs, so good luck and work hard at it.

Don't forget to pay attention when examining results that they are not too far away from requirements. In most cases, there will be an error somewhere within the initial design process, so be prepared to re-check the examination process. Only in cases where it becomes impossible after repeated efforts to overcome an inabilty to meet requirements, talk with the planner to check whether the requirements themselves are the problem. However, there are many cases where the planner is at fault, which means it's highly unlikely that they are going to be particularly conducive to changes. In such cases, throw everything you have at settling the issues at hand. I'm sure the results you come up with will prove to be the best solution.

Table 3 Elements Decided in the Initial Examination

Parameters	Specifications
Format	Inner Rotor SPM
Number of Poles	4
Number of Slots	12
Outer stator diameter	ϕ80 mm
Rotor radius	ϕ40 mm
Stack length	51 mm
Coil turns	60 turns/pole
Coil resistance	0.77 ohm/phase
Coil wire diameter	ϕ1.0 mm
Peak Current	7 A peak
Core	50A400
Magnet	Neodymium sintered
Weight	2 kg
Maximum torque	2.5 N/m
Maximum rotation speed	4000 rpm
Output	1kW

Detailed Examination Next Issue

As mentioned in the previous issue, examinations through to now can all be undertaken easily using the JMAG-Express design tool. It's a tool where geometries can be changed easily, analysis results obtained immediately and trial and error conducted allowing for balance between the dimensions in each part applied in the initial examination phase, so please give it a try.

In the next issue, we will use JMAG-Express Public to evaluate the initial design proposal we wrote about in this issue. Together with design paraments, I also have other things planned, such as disclosing information or holding seminars, which I hope you'll find beneficial, so please look forward to these

(Yoshiyuki Sakashita)

Motor Design Course

Column: Copper Machines and Iron Machines

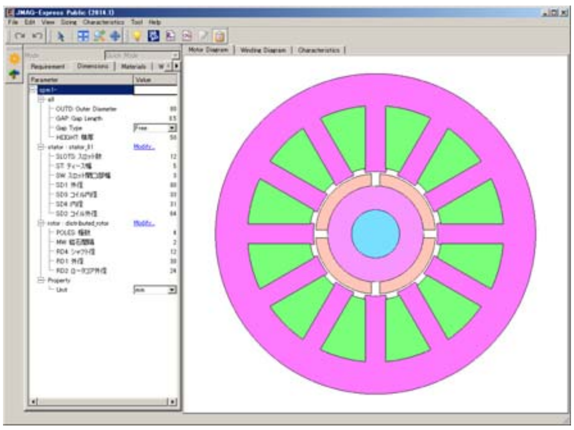
The Motor Design Course focused on motor design, but issues that could not be covered in that are explained in this column, used in JMAG to produce simple verification results and allow for deeper thinking about solutions.

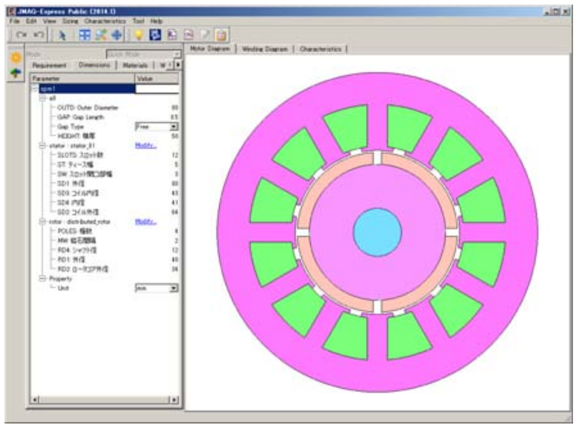
In this issue, I'd like to talk about electrical and magnetic loads and copper and iron machinery. Those on the frontlines of motor design use terms like electrical load or magnetic load all the time, but they aren't really concepts that stick clearly in my mind. But thinking about the principles behind motor motion and assuming magnetic flux increases with accumulation of coil turns, I had this vague idea that they probably have something to do with a relationship between magnetic flux and coil magnetic flux. Browsing through a textbook, magnetic loading is defined as being "gap magnetic flux density" and electrical loading as "ampere-turn for each circumferential direction unit length in the armature gap," which I confirmed to about the size I had first imagined it to be.(Reference: Designing Electrical Devices 2nd Edition, The Institute of Electrical Engineers of Japan)

When designing a motor, heightening both magnetic and electrical loading will enhance performance but, as I'm sure you're well aware, there is the impact of magnetic saturation to be taken into account, so it shouldn't be forgotten that there are limited to raising magnetic loading (which equals gap magnetic flux density) and it shouldn't be increased recklessly. Even with electrical loading, when it becomes a matter of simply increasing ampere turns then conditions become extremely stringent in terms of heat and volume and weight are increased, so this cannot be recklessly raised, either. Consequently, the matter of maintaining load balance is what motor design is all about. Up until now, I haven't paid a great deal off attention to the matter of load, but it is vital for regular motor design. Paying attention to load when it comes to design is a not new concept. Indeed, it means nothing more than reaffirming that you should continue as always to focus on things such as gaps, magnetic flux density in magnetic circuits and coil current destiny when designing.

Using a similar turn of phrase, there are copper machines and iron machines. Large electrical load machinery is called copper machinery and machinery where the gap magnetic flux density is high and magnetic load significant is called iron machinery. When it comes to PM motors, coil magnetic flux is dominant for copper machines. Reducing magnets can keep magnet costs controlled and gap magnetic flux density during low or no-load will be lower, reducing iron loss. Alternatively, when the number of turns is relatively large, the coil will become thinner the greater the number of coil turns if the slot size remains the same and this will increase copper loss. On the other hand, magnetic flux is dominant for iron machines. By cutting down the coil turns to generate the same torque, copper loss at a large torque can be reduced. However, this requires the use of large amounts of magnets, so it increases costs (magnet weight unit costs vary greatly within motor materials). But there is the disadvantage that even with no load, the motor interior has high magnetic flux density so even with a light load the iron loss will be fairly high.

This concept is a little difficult to understand just in words, am going to show you in this column the results obtained from a simple experiment in JMAG-Public. An SPM motor with an outer radius φ80 (mm) and stack length 50 (mm). Compare results between a medium rotor radius of φ40 (mm), a copper machine with a lower rotor radius of φ30 (mm) and an iron machine with a higher radius of φ50 (mm). Changing the rotor radius also changes the magnet amount, so adjust the number of coil turns so the torque doesn't change from 7(A). The result is that although the torque constant remains steady, balance changes with total magnetic flux created by the magnets, coil inductance, copper loss and iron loss.





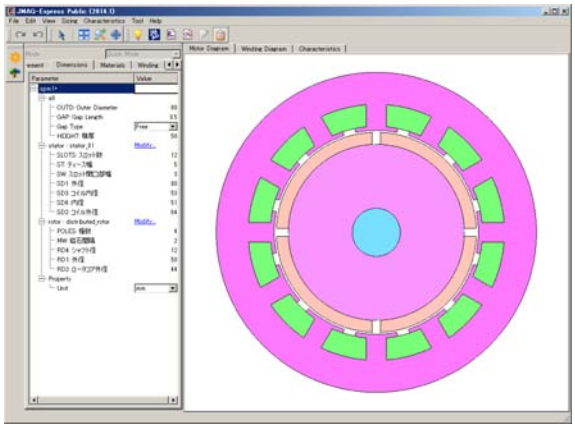


Fig. 1 Motor geometry Copper machinery_φ30 (top) and iron machinery _φ50 (bottom) and Initial design proposal_φ40 (middle)

Experiment results are shown in Table 1. As expected, copper machines held down iron loss, but conversely copper loss increased. This was because lower total magnetic flux numbers were recovered by the number of turns, whose increase thinned the wire radius and raised resistance by about 40%. Inductance has also increased due to the raised number of turns. The torque constant is steady, so induced voltage is the same but it is possible to predict that the increased inductance raises the number of rotations and makes it harder to turn.

As expected with iron machinery, iron loss increased, but copper loss also increased against expectations. This was because the narrowing of the slot area was accompanied by an increase in the rotor radius and reduction in the number of turns, but despite this the coil needed to become slightly thinner.

Table 1 Design parameters and motor constant

	Copper Machine	Standard	Iron Machine
Rotor Radius	30	40	50
No. of Turns	89	65	53
Wire Diameter	0.77	0.80	0.69
Lamination Factor	34.8	34.6	35.0
Phase Resistance	1.287	0.935	1.102
Inductance (mH)	7.18	3.52	2.09
Torque (N·m)	2.77	2.77	2.74
Gap Flux Linkage (Wb)	2.69	3.59	4.51
Iron Loss (W)	14.95	20.84	24.72
Copper Loss (W)	93.94	68.75	81.03

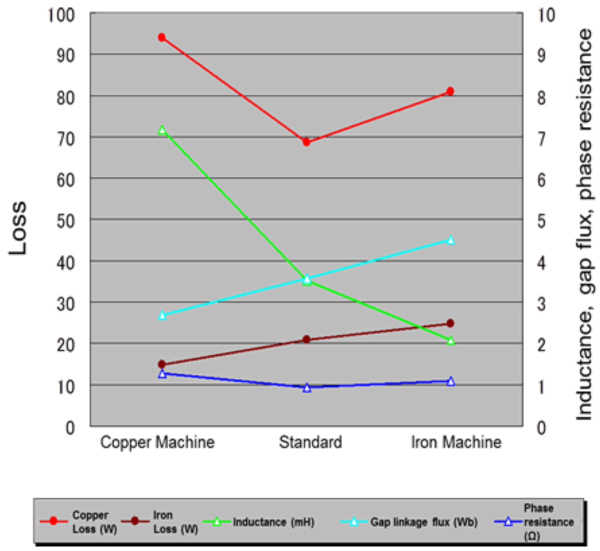


Fig. 2 Motor parameter sensitivity

Iron and copper loss were taken at 7(A)/6000 (rpm). I changed all sorts of things, but ultimately I got a typical result that showed my initial design proposal was well-balanced. However, getting this right is more than just a matter of increasing or decreasing magnets. Searching around the area of the parameters used in the initial design proposal suggest the optimum is around here. Naturally, driving points while raising torque or relative benefits of each type with increased rotational speed may vary. I learned that it is important for the design to know what operation state to focus on. Motor design is exceedingly (and enjoyably) tough as there are all sorts of ideas involved.

If there is a topic you would like us to cover in this column, we will try to deal with it. If you have a theme or opinion regarding content, please contact the JMAG Newsletter Editorial Department.

E-mail:info@jmag-international.com

Solutions

Starting With Vibration Noise Analyses Vol. 1 (Motor Edition 1)

Vibration noise has become an unavoidable issue when dealing with electrical equipment in recent years and it seems magnetic circuit designers are somewhat distant from vibration sound analyses. In this series, I would like to give a description of initiatives toward a vibration noise analysis where electromagnetic force obtained from JMAG acts as the vibratory source. I'd like to focus on motors for the first entry in this column and describe modeling methods to get a grasp on an analysis of resonance from electromagnetic force and eigenfrequency. It would be wonderful if motor designers not involved in electromagnetic vibration took it on or joined with machinery designers to devise methods to counteract vibration noise.

Overview

As demands for motors to become smaller and denser, there has been a trend for vibration and noise to increase. This is particularly evident with electromagnetic vibration where electromagnetic force is the vibratory force. There are growing requirements for reduced vibration and noise. Using simulation enables understanding the cause of vibrations and allows the prediction of vibration noise and devising of countermeasures against it.

In this edition, I'd like to describe modeling methods to gain a grasp of resonance from electromagnetic force and eigenfrequency, which is one of the initiatives made using JMAG regarding vibration noise analysis in motors. I'll also describe modeling and electromagnetic force evaluation to estimate vibration and noise in electromagnetic calculations. And, when it comes to the eigenfrequency calculation, I will touch on modeling of magnetic steel sheet (stator core), rotor and coil, as well as contact modeling between stator core and frame and frame and cover. I will describe modeling using JMAG's structural analysis function, as well as coupling with other software.

Motor Specifications and Analysis Assumptions

Vibration sound analysis modeling methods vary according to motor specifications, so I'll kick off by showing the motor geometry we'll use for this article (Fig. 1, Table 1).

Now I'll explain the analysis assumptions. For this article, we're going to look at noise in the several kHz band as it's the noise most grating on the ears. For motors in the several kHz band that we're going to look at, the band has an eigenfrequency in the lower order of the stator core. With the rotor core, however, the eigenfrequency is in a high frequency region of at least 5kHz in the lower order. We won't be allowing for the impact of rotor bias as the electromagnetic force generated in the rotor has only a negligible effect on the housing or upper and lower parts of the cover. Consequently, I'd like to look at modeling methods to gain a grasp of resonance effects from electromagnetic force and eigenfrequency generated in the stator core.

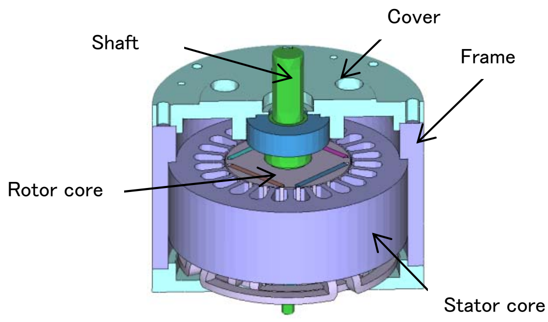


Fig. 1 Motor geometry

Table 1 Motor specifications

Number of Poles	4
Number of Slots	24
Outer stator diameter (mm)	150
Inner stator diameter (mm)	80
Gap length (mm)	1
Stack length (mm)	50

Vibration Noise Analysis using JMAG

JMAG is not merely software with electromagnetic field analysis functions that performs highly accurate calculations, it also has structural analysis functions, so is capable of carrying out all calculations related to vibration noise in electrical equipment. Doing all the calculations in JMAG smoothens transfer of electromagnetic force and enables unified operation methods, making it extremely beneficial for conducting vibration structural analyses, which even electromagnetic circuit designers are unaccustomed to. The flow of the vibration noise analysis is as outlined below (Fig. 2).

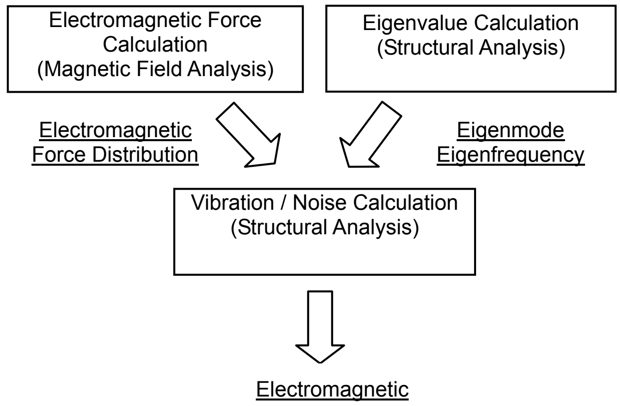


Fig. 2 Analysis Flow

Electromagnetic force calculation for the vibration noise analysis

Electromagnetic Force Calculation Modeling

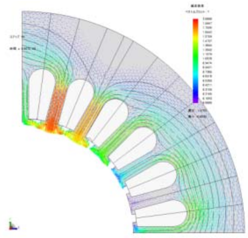
In electromagnetic force calculations, you need to create an electromagnetic field analysis model that will obtain accurate electromagnetic force at the frequency of the vibration or noise that you want to evaluate. What that means is that it's important to have the time intervals and mesh divisions to express electromagnetic force variations at the frequency the several kHz band that you wish to evaluate. Generally, you should be wary that models analyzing induced voltage waveforms or torque in design workplaces aren't really good enough for the jobs they're being required to perform.

When it comes to time intervals, I recommend you have at least eight divisions in every period of a frequency you want to evaluate. Of course, you can divide more than that, but I recommend you divide fewer times and then compare the results you attain with those from eight divisions to check on the effect of dividing.

For mesh divisions, JMAG has a rotation periodic mesh function that automatically recognizes the geometry and generates a mesh allowing for periodicity and symmetry. Using this function will generate a high quality mesh and enable obtaining of highly accurate electromagnetic force.

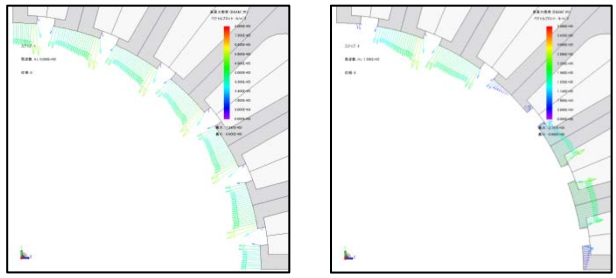
Confirming the Electromagnetic Force Mode

JMAG not only finds out about space distribution of electromagnetic force generated in places such as between the teeth of the stator, it can also confirm the electromagnetic force mode, which is the space distribution for each time harmonic component in electromagnetic force. Separate the DC components with large electromagnetic force and the harmonic component, which is decided by the number of poles and slots before checking. For example, with four poles and 24 slots, confirm the mode number from the electromagnetic force vectors of the DC components, the 4th-, 12th- and 24th-order components which are decided by the number of poles and slots (Fig. 3). When the electromagnetic force mode and eigenmode are the same it generates a large amount of vibration, so confirming the electromagnetic force mode is extremely important in terms of accurately discerning the vibratory force.

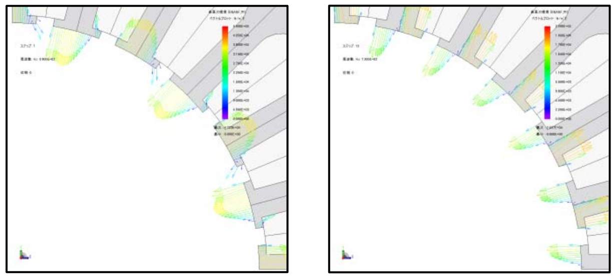


Magnetic field analysis result

Confirm FFT processing of electromagnetic force distribution



Electromagnetic force (DC component), electromagnetic force (4th order component)



Electromagnetic force (12th order component), electromagnetic force (24th order component)

Fig. 3 Confirming the Electromagnetic Force Mode

Calculating the eigenmode value for a vibration noise analysis

Eigenmode analysis steps

Obtain an eigenfrequency and eigenmode in an eigenmode calculation. Motors are made up of many different parts, so decide on the modeling method from the aspect of individual parts. Once you have decided on a modeling method based on individual parts, assemble parts individually and then model them in a unified form (Fig. 4). Assembling individual parts and comparing the actually measured eigenfrequency and eigenmode with the analysis results to always confirm the suitability of the modeling method.

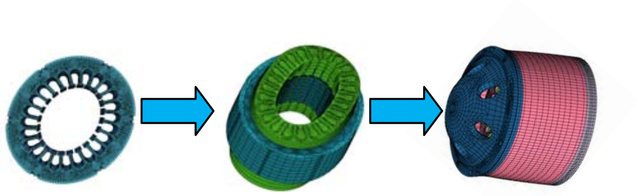


Fig. 4 Steps in an Eigenfrequency Analysis

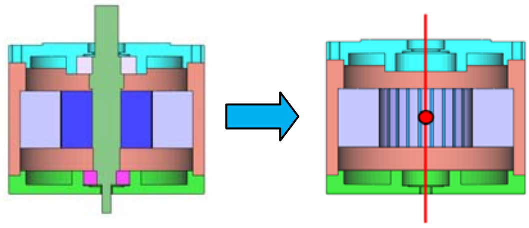


Fig. 5 Modeling the Rotor Area

Magnetic steel sheet modeling

The stator core in particular needs to be examined among all individual parts. As the magnetic steel sheet in the stator core is laminated, modeling it with fidelity would require a model with an enormous number of elements. Anisotropic material properties can be set in JMAG, so softening the stiffness in the lamination thickness direction enables modeling of the lamination core in a single homogenized lump. Setting the Young's modulus of the lamination thickness direction at 20% to 50% of the Young's modulus in the in-plane direction enables modeling of a magnetic steel sheet as an anisotropic material. Modeling methods will differ if the magnetic steel sheets are welded or stuck together with adhesive. If the sheets are welded only on the exterior of the core, have a relatively low Young's modulus of around 30% and if all places are fixed into place as with an adhesive core, then make the setting around 50%.

Modeling the Rotor Area

This shows how to model the rotor area comprising the rotor core, magnet and shaft. It is believed that the rotor area eigenfrequency has only minimal impact on vibration noise, the object of this edition. However, the effect of the rotor's mass has an impact on the stator and stator exterior frame. The rotor core, then, is modeled on the mass point and shaft on beam elements to keep down the model size (Fig. 5).

Coil Modeling

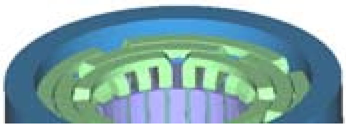
This shows coil modeling methods. Here are the results of how much of an effect coil modeling methods can have on stator core deformation by creating the three type of models shown below (Fig. 6). They are all made up of a stator core, frame and coil.

1) Modeling of all finite elements, including the coil end region

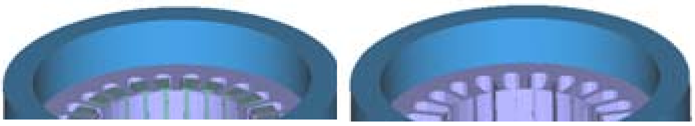
2) No modeling of coil end, modeling of finite elements including only coils in the slots. In the coil end region, the mass point is modeled.

3) The coil is not modeled with finite elements, but all mass points are modeled.

The total mass of the coils in models 1) through 3) is set so that they are all the same. Comparing the eigenfrequency when the frame is distorted into an ellipse shows it to be 1) 2143Hz, 2) 2118 Hz and 3) 2064Hz, to be almost unchanged. If the mass is the same as the coil, this result shows that different modeling methods for coils have only negligible effect on stator core or frame distortion. Arrange the coil mass with the actual machinery and model with mass distribution appropriate for actual machinery to ensure there is no effect on stator core distortion. Here we will use 1) Simplified model where the coil end is a ring, in which the coil distortion can be confirmed.



1) Model



2) Model 3) Model

Fig. 6 Examination of Coil Modeling Method

In models 1) through 3), the region differs in which coils are modelled with finite elements. The regions modeled using finite elements are: 1) All 2) Only coils within the slot, or 3) None.

Stator Core and Frame Contact Modeling

This shows contact modeling with the stator core and frame. The method of contact modeling the core and frame may need changes depending on the interference, but there are many methods, such as joining them with springs. In this case, the frame is a simple ring shape with sufficient uniform pressure applied, so assuming it will not slide in the θ allows for sharing nodes between the stator core and frame (Fig. 7). Compare with the eigenfrequency of the actual machinery and adjust the material characteristics of the part. Young's modulus may need to be increased slightly due to the effect of the fit and the effect of the internal pressure in both the frame and stator core.

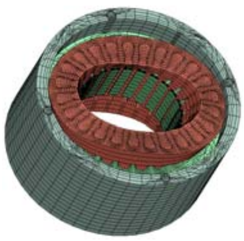


Fig. 7 Model of the Stator Core, Coil and Frame

Contact Modeling of the Frame and Cover

This shows contact modeling with the frame and cover fixed in place with a screw. As the screw area in the space between the frame and cover is completely fixed, the model has only the screw area as a shared node point (Fig. 8). As the effect of friction in contact planes outside of this screw area is so negligible there are no constraints and it is free.

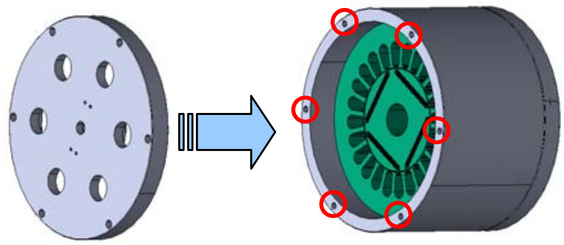


Fig. 8 Contact Modeling of the Frame and Cover

The screw area circled red is the only shared nodal that is merged and others are free.

Vibration Noise Analysis

In a vibration/sound calculation, use electromagnetic force obtained from a magnetic field analysis and eigenmode obtained from an eigenmode calculation to calculate the vibration and the sound pressure on the face specified for evaluation. With many permanent magnet motors there is little electromagnetic force due to magnetic flux in the lamination direction and the generated magnetic field has periodicity in the rotating direction so conduct a 2D, partial model magnetic field analysis. Modeling methods, meanwhile, differ significantly with vibration analyses in such ways as modeling the motor exterior frame in a full model. Using electromagnetic force conditions from JMAG's structural model analysis function can be applied for mapping electromagnetic force in a vibration analysis where modeling methods are different.

The result of the acceleration properties of the surface actually measured can be confirmed as having a resonance frequency of just over 3000Hz (Fig. 9). This shows the eigenmode of the resonance frequency confirmed through an analysis. We learned the cover shakes at about

2700Hz (Fig. 10). In this way we also learned that it's possible to find out in an eigenmode analysis the same finding achieved through actual measurements that frequency increases with acceleration. We hope this helps you to understand how to consider mechanical vibration countermeasures using analyses.

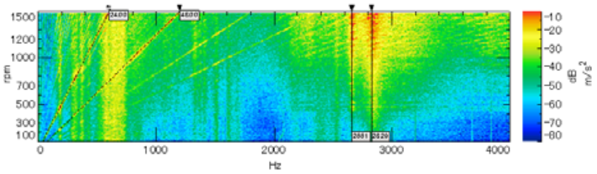


Fig. 9 Frequency-No. of Rotations-Acceleration Properties

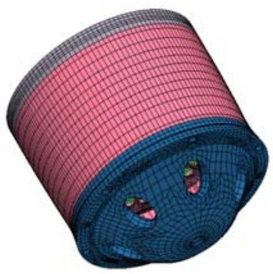


Fig. 10 Eigenmode in Resonance Frequency (2679Hz)

Coupling with Other Software

We have described coupling using JMAG's structural analysis function, but if you already use other structural analysis software, it is also impossible to import electromagnetic force analysis results obtained from JMAG to conduct a vibration noise analysis.

Outputting electromagnetic force distribution in a file

When using another structural analysis software like Nastran, OptiStruct (from Altair) or ANSYS Mechanical (from ANSYS), output an electromagnetic force distribution file using JMAG's multi-purpose export tool function. Using this tool will output the electromagnetic force distribution in a Nastran, .csv or unv. file format.

With this tool, as with a structural analysis in JMAG, it becomes possible to output results obtained from a 2D partial model analysis in a 3D full model (Fig. 11). This shows a case study of a vibration analysis in Altair's OptiStruct using an electromagnetic force Nastran file output from JMAG (Fig. 12).

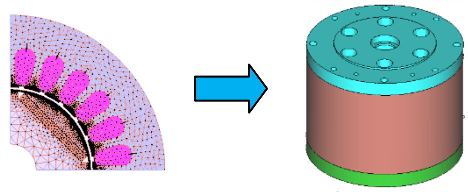


Fig. 11 Mapping Electromagnetic Force

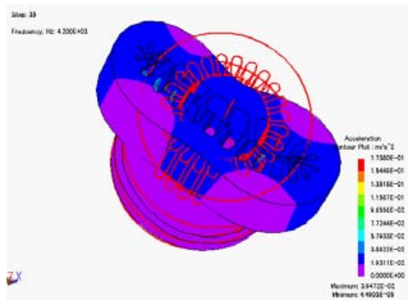


Fig. 12 Vibration Analysis Results from Altair's OptiStruct

Coupling with LMS Virtual.Lab from LMS

Use JMAG-Designer's exclusive output tool to prepare for a vibration sound calculation using LMS Virtual.Lab from LMS. This tool will output electromagnetic force in a time sequence and is mapped in an analysis model in LMS VirtualLab. For that reason, even if the geometry changes such as through adding places where electromagnetic force is not generated for reasons such as the addition of reinforcing ribs on structural models, there is no need to return to JMAG-Designer for re-mapping. This shows the results of an acoustic analysis using LMS Virtual.Lab (Fig. 13).

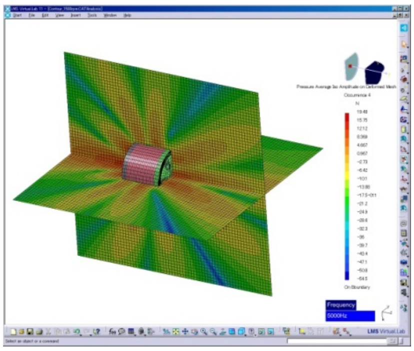


Fig. 13 Results of an Acoustic Analysis using LMS Virtual.Lab from LMS

Coupling with SIMULIA's Abaqus

When performing a vibration calculation using SIMULIA's Abaqus, it is possible to directly map electromagnetic force calculated by JMAG with an Abaqus input file.

This shows the results of acceleration distribution calculated in SIMULIA's Abaqus (Fig. 14).

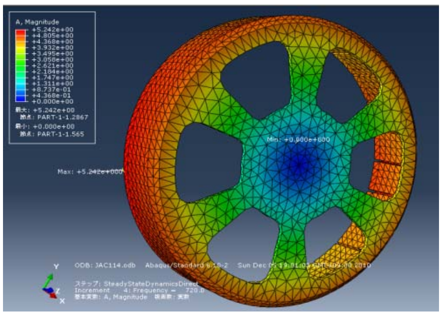


Fig. 14 Acceleration Results in SIMULIA's Abaqus

In Closing

This article refers only to a single case, but it was a description of modeling methods to gain an idea of how a motor's electromagnetic force and eigenfrequency create a resonance phenomenon. Electromagnetic force naturally needs countermeasures, being the vibratory force, but steps also need to be taken mechanically against vibration and these can be examined using JMAG. JMAG's structural analysis function enables geometry creation or condition specification using the same operations as for a magnetic field analysis. When examining a structural analysis as an extension of a magnetic field analysis, there is no need to learn any new operational procedures. Of course it's also possible to couple with other software formats that specialize in structural analyses and we plan to make it even more powerful moving forward.

For those who are currently using JMAG only for magnetic field analyses, why not give it a try with structural analyses? Our next edition is planned to be a look at modeling methods for evaluating harmonic frequency from PWM carrier frequency.

(Tetsuya Hattori)

Paper Introduction

Issue 6 Lesson on Advanced Iron Loss Analysis

In this series, I would like to introduce various papers that present ways of using JMAG while performing electromagnetic field simulation. In this 6th edition, I will describe nine papers that focus on the impact of iron loss and enlighten about the necessary knowledge and modeling technologies for advanced iron loss evaluation.

Overview

Mr. Kazuyuki Narita from JSOL is in charge of introducing the papers covered in this issue. The September 2013 edition of the JMAG Newsletter described initiatives related to JMAG loss analysis. The artiucle talked about how advanced evaluation of iron loss in electromagnetic field simulation required taking a variety of steps to counter the effects of iron loss and then introduced many initiatives from JMAG. In the July 2013 next-generation seminar that we held loss analysis was also an issue brought up, as were numerous countermeasures against loss. This article will introduce papers that describe the various causes of the different types of losses.

Images in this text are all self-created and have not been taken from papers or edited.

Various Factors that Affect Loss

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[1] Kaido. "Kaitenki ni okeru Tesson Kyodo ni tsuite (Iron loss behavior in rotating machinery)," Electrical Engineering Rotating Machiner Research Materials, RM-00-119, 2000.

Magnetic objects like magnetic steel sheets or ferrite, in which loss occurs, are affected by a number of factors that outnumber the ideal of having no impact. That is what makes evaluation of loss in electromagnetc field simulation difficult. This paper looks at the five major causes of iron loss in rotating machinery (magnetic flux distribution, rotational fields, stress strain, time harmonics and spatial harmonics) and broadly summarizes their mechanisms and effects. It also touches how to model electromagnetic steel sheet in the equivalent magnetic circuits to understand magnetic steel sheet properties and evaluate rotating machine performance.

I introduce this book first because it contains a large variety of causes and presents them in an easily understandable manner.

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Factors in the Production Process

To produce rotating machines or transformers, magnetic steel sheets are punched out of a press and laminated. After lamination, the magnetic steel sheets are caulked, welded or bolted to fix them into place. Finally, the lamintated iron core is pressed into a frame and undergoes a process called hardening. Magnetic steel sheets are exposed to all sorts of effects during this production process. I would like to describe here for you a paper that touches on these factors within the production process.

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[2] Kaido, Mogi, Fujikura, Yamasaki: "Punching Deterioration Mechanism of Magnetic Properties of Cores", IEEJ Trans. FM, vol.128, no.8, 2008

Pressing magnetic steel sheets during the production process is known to have an effect on the magnetic properties of the magnetic steel sheets and iron loss properties. But the mechanism of those effects is less well-known. This paper tries to clarify the mechanism of the impact on properties that punching has on magnetic steel sheets by observing a cross-section of a magnetic area's structure taken from a magnetic steel sheet. This paper tries to clarify the mechanism of the impact on properties that punching has on magnetic steel sheets by observing a cross-section of a magnetic area's structure taken from a magnetic steel sheet. The breadth of the regions subjected to plastic deformation appear to variate due to factors such as clearance, plate thicknes or Si content. The breadth of the regions subjected to plastic deformation appear to variate due to factors such as clearance, plate thicknes or Si content.

It is also a good reference due to the rich amount of data it contains regarding coercive force through punching, B-H curves and hysteresis loss degradation. We will show you how we have done this, using examples.

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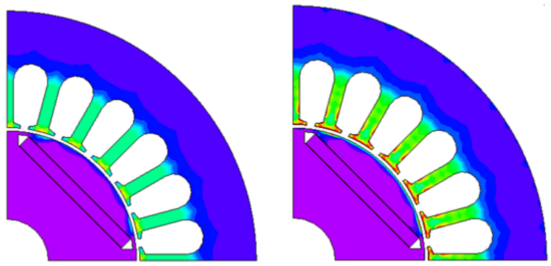
[3] Kashiwara, Fujimura, Okamura, Imamura, Yashiki. "Denjikoban no Uchinuki ni yoru Jiki Tokusei Rekkaryo ni Oyobasu Uchiunuki Joken no Eikyo no Kaiseki (Analysis of the Impact of Punching Conditions on Degradation of Magnetic Properties due to Punching of Magnetic Steel Sheets)," The Institute of Electrical Engineers of Japan (IEEJ) Magnetics Technical Meeting. MAG-08-74, 2008.

A modeling method is to measure the properties in a thin magnetic steel sheet punched out as a test and use those properties in a magnetic field analysis of the impact of the punching process on regions (This is also in the paper mentioned in [2], but generally a punched item 2-to-3 times thicker than the insulation is called a region) and give those material properties. Even if understanding that punching casuses degradation in properties, how do you know what punching process influence should you model in an analysis? This is a practical method, but the test piece must be punched under exactly the same conditions as for actual machinery and the impacted region width needs to be estimated, both of which can be problem areas.

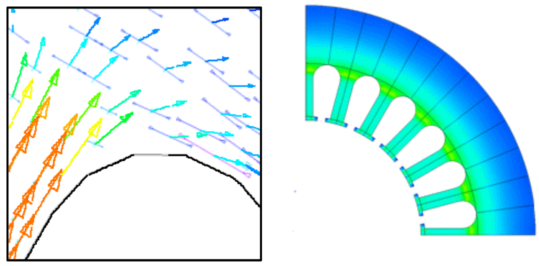
This paper describes a method for modeling a combination of a deformation analysis (Abaqus from SIMULIA) and an electromagnetic field analysis (JMAG) to determine the impact of the punching process. Firstly, conduct the deformation analysis to obtain the warping or remnant stress distribution caused by punching the magnetic steel sheet. Then use a table to allow for the impact of this warping and remnant stress distribution on magnetic properties and loss and map these as a distribution amoun in the material properties for an electromagnetic field analysis. Performing these steps will, in principle, enable modeling of the impact of the punching process. It is also valid because it enables understanding of the property degradation mechanism by changing the punching conditions through a deformation analysis.

This paper essentially examines only a single magnetic steel sheet, but it could be expanded to practial application in items such as rotating machinery by eflecting the warping or remnant stress distribution material properties to an electromagnetic field analysis using the homogenization method.



(a) No punching (b) Punching

Fig. 1 Impact of Punching on Loss



(a) Relationship between Stress and Magnetic Flux (b) Loss Distribution allowing for Stress

Fig. 2 Impact Stress has on Loss

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[4] Nakano, Fujino, Tani, Daikoku, Tsude, Yamaguchi, Arita, Yoshioka. "Tesshin Naibu no Ouryoku Bunpu wo Koryo shita Koseido Tesson Kaiseki Hoho (Method of Advanced Analysis of Iron Loss Allowing for Stress Distribution in the Inner Core," IEEJ Journal, vol.129, No.11, pp.1060-1067, 2009.

To fix in place a laminated core in a rotating machine, use press fitting or hardening of the core in the case. This will ensure the core undergoes some stress and change these to magnetic properties or loss. Normally, you would use principal stress (compressive or tensile) to allow for the influence of stress, but when the stress and magnetic fluzx are in different directions, the expression is insufficient.

This paper isolates the magnetic flux density from the core parts in an electromagnetic field analysis in the principal stress in a structural analysis to allow for the angle formed by stress and magnetic flux. As a result, it shows that conventional methods not allowing for direction and treating stress as having a major impact and the methods used here obtain the results closest to those obtained from actual measurements.

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[5] Miyagi, Aoki, Nakano, Takahashi: “Effect of Compressive Stress in Thickness Direction on Iron Losses of Nonoriented Electrical Steel Sheet”, IEEE Transactions on Magnetics, vol.46, No.6, pp2040-2043, 2010

In rotating machines or transformers, magnetic steel sheets can be caulked, welded, or fixed into place with bolts above and below a clamped or framed laminated core. In these cases, stress is placed on the lamination thickness direction of the core. Apart from our paper there are many other examples of papers describing changing properties if the stress is exerted through something like pressing toward the core's in-plane direction, but few report on the property changes stress brings about in a lamination thickness direction.

Our paper will show that even by exerting a comparatively minor compressed stress of 0.5MPa in the lamination thickness direction can increase hysteresis loss by as much as a maximum of 12%. We will also show how this increases abnormal eddy current loss.

Our paper contains one of the few documented measurement data of lamination thickness direction stress, which makes it an important contribution.

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Magnetomotive Force Waveform Factors

The most commonly used iron loss evaluation methods are either Steinmetz's empirical law or another method based on that. Steinmetz's empirical law has a coefficient that expresses hysteresis loss and eddy current loss, but this is calculated from loss values obtained through Epstein's law or applying sinusoidal alternating flux in a single plate test method. But magnetic flux in actual rotating machines or transformers fluctuates in a much more complicated manner. For example, with a rotating machine, slot structures include items such as spatial harmonics or carrier time harmonics caused by PWM power conversions. When a transformer comes in contact with the rectification circuit, the core moves into a state of direct current bias magnetism. This paper gives an example of knowledge and modeling technologies regarding loss that does not come from sinusoidal alternating flux.

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[6] Kaido, Yabumoto, Lee, Miyata: "Minor-loop Magnetic Properties of Non-oriented Electrical Steel Sheets" The Papers of Joint Technical Meeting on Static Apparatus and Rotating Machinery, IEE Japan SA-05-35、RM-05-35、2005

As stated above, hwen core magnetic flux density incudes harmonics or in direct current bias magnetism, it is possible to render a minor loop trajectory on the B-H curve. Measuring minor loop properties is an onerous task, so the data on them is important.

This paper is a vital reference as it displays numerous types of hysteresis loop properties. A must-read, in particular, is data about how even though the fluctuation quantity of magnetic flux density (AC components) stays the same, the iron loss greatly increases depending on the amount of direct current bias magnetism (DC components) (iron loss grows threefold with 1.2T of direct current bias magnetism).

In recent years, it seems increasingly likely that hysteresis modeling will be possible on even OTC software, but whether solutions it provides are correct and how it came about getting those results and what sort of hysteresis properties exist still need to be understood. This paper helps understand hysteresis properties.

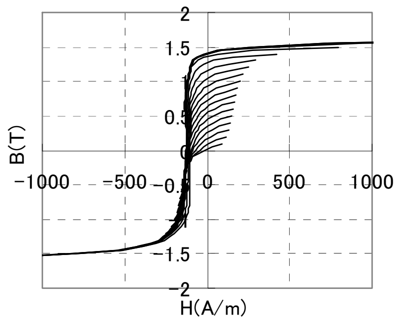

Fig. 3 Hysteresis Properties in 50A1300 (Lower curve)

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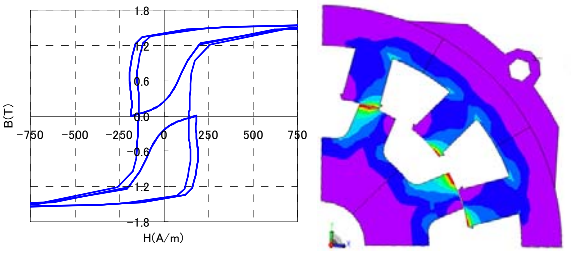
[7] Matsuo, Shimode, Terada, Shimasaki : "Application of Stop and Play Models to the Representation of Magnetic Characteristics of Silicon Steel Sheet", IEEE Transactions on Magnetics, vol.39, No.3, pp.1361-1364, 2003

In an electromagnetic field analyses, play modeling has recently been under the spotlight as a form of practically modeling magnetic hysteresis. The authors have continued research into play modeling, including methods of applying it to electromagnetic field analyses, methods to identify necessary functions for the play model from the measured data and expanding interest to AC hysteresis.

This paper includes an early paper by one of thie authors about the possibilities of practical application of play modeling in electromagnetic field analysis. This work is reccomended for those interested in play modeling.



(a) Hysteresis Loop (b) Loss distribution

Fig. 4 Lay Modeling an SR Motor Loss Analysis

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[8] Bottauscio, Chiampi, Chiarabaglio: "Advanced Model of Laminated Magnetic Cores for Two-Dimensional Field Analysis", IEEE Transactions on Magnetics, vol.36, No.3, pp.561-573, 2000

As magnetic steel sheets have nonlinear magnetic properties, flux variations in the sheet are rapid and when the surface skin effect is strong, permeability is distributed in a complicated manner in the direction of the plate thickness. If that distribution includes harmonics or direct current bias magnetism it will have different conditions to those of the sunsoidal alternating magnetic flux. Consequently, it becomes difficult to predict the eddy current loss due based on Steinmetz's empirical law with assumptions about sinusoidal waveform alternating magnetic flux.

To precisely calculate eddy current loss under the complicated manner stated above requires a 3D transient response analysis modeling the sheet's thickness direction. But 3D transient response analyses are large and take a lot of time for calculations, both of which are problems.

To counter this, use a 2D analysis or magnetic density boundary condition obtained from a treated 2D analysis and conduct a 1D analysis to understand the eddy current distribution in what is a complicated and difficult proposal. Due to making an allowance for non-linear magnetic properties, it becomes possible to evaluate with high precision eddy current distribution when magnetic flux variations are complicated and the authors could report of successfully applying the application to items such as rotating machines. This paper presents a case study from the initial stage. This paper also describes the Preisach method to model hysteresis (Mathematically equivalent to the play model described in [7]

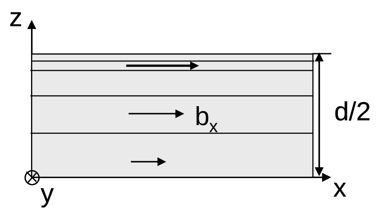

Fig. 5 1D Analysis of the Magnetic Steel Plate Thickness Direction

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[9] Narita, Sakashita, Yamada, Akatsu: "Iron Loss Calculation of PM Motor by Coupling Analysis between Magnetic Field Simulator and Control Simulator(Second Report)," ICEMS2009, 2009

I'm sorry to boast, but this is a paper I co-wrote. Permanent magnet synchronous motors (PMSM) or variable speed induction motors as their power adjusted by the PWM inverter, but when doing so the PWM carrier generates time harmonics in the rotating machine and these harmonics cause an increase in iron loss. This paper obtains current including a PWM carrier in an operating state and calculates iron loss in an electromagnetic field analysis by incorporating PMSM behavior models created in an electromagnetic field analysis into the control and circuit system simulator. The result was that the tendencies in iron loss depending on the variations in items like carrier frequency or DC voltage matched well with the tendencies of actual measurements.

This kind of method can be used for optimal designing for the entire drive system losses including controllers and inverters.

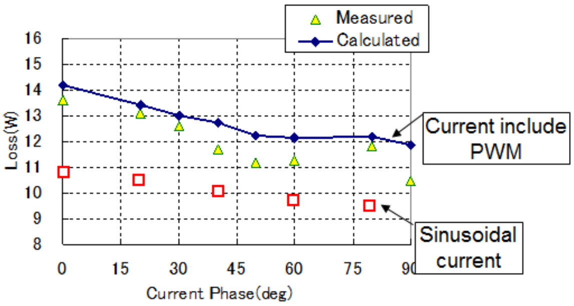

Fig. 6 Impact on Harmonics Loss

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Conclusion

I described the impact and causes of iron loss and informed about the necessary knowledge and modeling technologies for advanced iron loss evaluation.

(Katsuyuki Narita)

Fully Mastering JMAG

Common Questions for JMAG

JMAG is used across a broad spectrum spanning from advanced research and development through to product production design and in educational fields. There may be many among those reading this JMAG Newsletter who still feel they haven't learned how to master it or perhaps feel a bit lost about how to set it up. When you come up against obstacles to using JMAG, of course there's always Technical Support, but don't forget there are also FAQs on our website that you can use to solve problems by yourself. In this issue, we will select from those FAQs five questions that have been asked a lot recently. We have divided the questions into three categories of "Operation Methods," "Analysis Technologies" and "Troubleshooting," so please pick the category in which you are most interested.

OPERATION METHODS（FAQ-930）

Q1. Can parallels be drawn easily in the Geometry Editor?

A1. Yes. This is a function newly added to JMAG-Designer from Ver.12.0 onward.

Before JMAG-Designer Ver. 11.0, users had to enter distance constraint settings to draw parallels from the line in the Geometry Editor that was to serve as the base. From JMAG-Designer Ver. 12.0 onward, the addition of the [Parallel] function to the Geometry Editor has eliminated the line-drawing process and simplified geometry creation. Here, we'll call the existing line A and the line we're going to create will be B. When making A and B parallel, select A, then click the [Parallel] button and a settings window will appear on the left of the screen. The line, B, which we will be creating, can be seen in the preview. Click [OK] in the settings window to complete the operation.

[Other resources]

Click on Online Help, below, for more detailed information.

JMAG-Designer Help > Creating Geometry > Creating 2D Geometry with Geometry Editor >Creating Parallel Lines

OPERATION METHODS（FAQ-801）

Q2. There are two types of section graphs. What is the difference between these two?

A2. The differences lie in the physical quantities that can be graphed and the methods of graphing.

[Section]

Interpolate the value for each element, and draw a graph on the specified line.

Input the value for each element, and draw a graph on the specified line.

Set the output item in [Study Properties].

To depend on the mesh density, the number of points will increase where the mesh is fine and the number will decrease where the mesh is coarse.

[Air Region Section]

Calculate the magnetic flux density / magnetic field of the non-magnetic material.

Specify the number of divisions on the specified line then draw a graph with the adjusted number of points.

It is possible to draw a section line with a high degree of separation even within space with coarse mesh and the outer circle of an analysed space.

When using the [Generate Mesh Every Analytic Step] function, it is possible to display the magnetic flux density distribution of the air region where the mesh is not outputted.

If the mesh is generated for the air region, both the section and air region section can be displayed, but since the air region section can achieve more specific results, use the air region section.

[Other resources]

See the following Help items for more detailed information about sections that can be output with each analysis.

JMAG-Designer Help > Output Results> Display Results and Output Items>List of Output Items

Analysis Technologies（FAQ-582）

Q3. What is the difference between the Surface Impedance Boundary Condition (SIBC) set in parts and the skin mesh?

A3. If the skin depth is extremely thin compared to the thickness of the conductor, then consider using the SIBC Method.

When allowing eddy current flowing through the conductor surface, you will need to use a skin depth mesh, but when this skin is extremely thin, then consider using the SIBC Method. If you apply a skin mesh when the frequency is high and the surface skin is extremely thin compared to the conductor, it can result in a skin depth mesh size extremely thin compared to the conductor internal mesh size. When there is an extreme difference between the surface and interior size, many flat skin depth meshes are made and there is a risk that calculation accuracy or convergence will worsen. In such cases, consider applying the SIBC method.

Conductors using the SIBC method establish boundary conditions that express bias in conductor surface eddy current and analyze the impact on the conductor exterior. Using the SIBC method means it is not possible to solve the field inside a conductor, so avoid using this method if seeking to analyze inside a conductor.

Current distribution while using the SIBC method involves calculating the conductor surface as the surface current distribution. When confirming the contour and vector, display the shell and select [Surface Current]. The shell element can be confirmed by making all parts in the assembly of the solid model invisible, right-clicking mesh under study and then [View] →[Show All Shell]. Note that analysis results cannot be confirmed without displaying the shell or current distribution.

TROUBLESHOOTING (FAQ-931)

Q4. I can't get very far with my remote system calculations I have executed. How can I confirm the settings?

A4. There are six points that can be confirmed, as outlined below.

1) Check your version of the remote system.

If the remote system version is different with each computer there is a possibility the calculation will not start. If you are using an old version or they differ depending on the equipment being used, update all computers to the latest version. Versions can be checked by opening the following files in a text editor. remote.conf in the Install\conf folder.

E.g.: C:\Program Files\JMAG-RemoteSystem\conf

Open in a text editor and confirm the following code exists:

remote_version=3.0.16

2) Check the ports in your firewall settings.

In a remote system, Port 8888 (TCP) and Port 7777 (UDP) between the management server and CPU node need to be open.

First, go to the management window (http://(management server address):8888/html/index.html), open the "About the CPU node" =>Add/Delete and all CPU nodes will be displayed. If a CPU node does not appear, check firewall settings. If Port 8888 (TCP) and Port 7777 (UDP) are not open, open them according to the instructions "9-4 Opening Ports" in the Installation Manual, which details firewall settings.

Start>All Programs>JMAG-Designer** >License> Installation Manual

Is the pathway you need to take to check the settings.

3)Check the status of the CPU node.

The CPU node status needs to be "IDLE." Check the computer is on "IDLE." The status indicates the current condition of the computer. If the computer is not being used, it's "IDLE," while if it's calculating it's status is "BUSY," while if the status of the computer is unknown for some reason or another it will display "INVALID." If "INVALID" is displayed, check 4).

4) Check the installation directory has been specified.

Calculation is executed using JMAG installed in the directory specified by the settings screen (http://(CPU node address):8888/html/setup.html). Check that the JMAG Install Directory of the settings screen is the JMAG-Designer’s installation folder to be used.

5) Check the CPU group.

If the CPU nodes on the client computer are directly specified, they can't be run remotely. Check in advance that the

CPU node is registered in a CPU group specified under "CPU Group Name," such as JMAG-Scheduler, in places including the Run Analysis dialog box.

If it is not registered, go to the managment window "About the CPU Node"=>"Register CPU Group" and add the CPU node to that group.

6) Check java.exe.

If multiple remote systems are opened in one computer, there is a possiblity that the calculation will not run smoothly. Confirm there is no problem in any of the areas from 1) to 5), above, and if a calculation is still not possible, check that there are not mutliple remote systems open. In a Windows OS Task Manager, check java.exe. If several systems are open, in the Windows OS Task Manager, stop all java.exe momentarily with [End Processes], Next, in the Windows Control Panel, double-click on "JMAG-Remote System" from Service in Component Service to begin the service. The problem may be solved by booting the remote system. Note that this action requires Administrator authority.

[Other sources etc.]

For more details, check the installation manual included within the JMAG folder installed in \Program Files.

TROUBLESHOOTING (FAQ-932)

Q5. We have customized our JMAG-Express rotor geometry, but the symmetry of the geometry collapses.

A5. You can solve this by using the [Mirror Copy] function.

Case

Created a rotor geometry in JMAG-Designer at 1/4 size in a circumferential direction with symmetry.

Imported the model into JMAG-Express and changed the geometry.

While doing so, changing one dimension skewed another area and the geometry that should have had symmetry no longer had it. Parts with symmetry include a magnet with the same symmetry at a 45 degree angle, and the same CAD parameters.

Use the Mirror Copy function to check the geometry. Use the following procedures to do so.

1. Open a geometry model template (.jcf file) in JMAG-Express.
   [Edit Geometry Template] will display at the same time.
2. Select [Edit] > [Edit in JMAG-Designer] from the menu bar.
   Geometry Editor is displayed anew.

Even if you correct the model in JMAG-Express, there are times when the symmetry of the geometry will collapse.

If that's the case, change it according to the following procedures.

1. On the [Geometry Editor] screen, change the model with periodicity further to make it a half geometry.
2. On the [Geometry Editor] screen, use the Mirror Copy function and select [axisymmetrical] and [area], push [OK] and mirror copy the work.
3. Select [Obtain from JMAG-Designer] in [Edit] in the menu bar in the geometry template editor window and import the geometry into JMAG-Express.
4. From [File] in the menu bar, select [Save Template] and save the template.

Technical FAQ on the Web

We have technical FAQ on our homepage, so check it and contact us if you have any inquiries.

URL: http://www.jmag-international.com/support/en/faq/index.html (user verification required)

The technical FAQ is a collection of actual questions from our clients, so you might discover some new ways to use JMAG if you go through them. We regularly update our website FAQ. Use this together with the JMAG Newsletter to make your analysis work more effective. Please don't hesitate to use JMAG technical support if you have any questions when using JMAG. We hope you will fully master JMAG!

(Eri Zese)

Fully Mastering JMAG

Issue 11 Electric Field Analysis from A to Z

JMAG continues to evolve with each passing day. There may be functions in JMAG that even those who have already been using it will learn for the first time. There are also some useful procedures that are not well known yet. Why don't we aim at making operations more efficient by becoming familiar with new functions that we don't know about?

In this series, I would like to give a description of "Things we should know" about JMAG, as well as some advantageous applications.

Overview

If you asked many JMAG users how to go about conducting an electric field analysis in JMAG, it's fair to say they wouldn't be able to offer a precise answer immediately. People use JMAG for evaluation of magnetic phenomena, but there are only limited numbers of products that need to make allowances for electric field analyses to it's rare for those involved in magnetic field analyses to reach out to electric field analysis, too. Although the names of electric field analysis and magnetic field analysis have a close resemblance, they're handling different phenomena and are evaluated in a divergent manner.

This issue of A to Z will focus on how to handle particular types of phenomena using JMAG's electric field analysis, as well as introduce material properties and various types of conditions so we can get you acquainted with electric field analysis.

Analysis model and type of analysis

Only 3D geometries can be handled. JMAG's electric field analysis handles three types of analyses: static, frequency response and current distribution. Right click the JMAG-Designer Project Manager, select the type of analysis for the electric field analysis and create the applicable study.

In a static analysis, by giving an input electric potential/electric charge to a static unchanging over time, it enables obtaining the surrounding electric potential/electric charge distribution (Fig. 1).

In a frequency response analysis, the analysis subject is given an electric potential difference with sinusoidal variations, which enables obtaining the electric potential distribution, electric field distribution and current density distribution generated inside the target.

In a current distribution analysis, giving the subject -- a steady state current field with no gushing or absorption -- electric potential/electric charge enables obtaining the current distribution from the subject. Only conductor areas where current flows (or areas in liquids with conductivity) are modeled in current distribution analyses and modeling insulators like air is unnecessary. Allowance is not made for magnetic flux generated by the current flow.

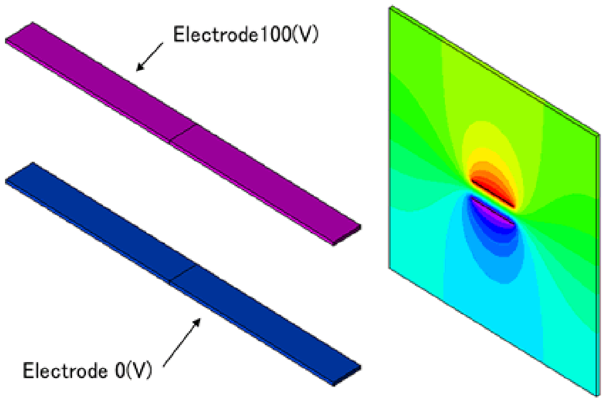


Fig. 1 Positive and Negative Poles and Electric Potential Contour Plot Settings (Static Electric Field Analysis)

Material Properties

Material properties used in the electric field analysis are electrical properties only. Specify the two types of electrical properties, electric conductivity [S/m] and relative permittivity. Static analyses handle relative permittivity only. Frequency response analyses use both electric conductivity and relative permittivity. Current distribution analyses handle electric conductivity only and calculates current flow when an electric field generates.

Boundary Conditions

Regardless of the analysis type in an electromagnetic field analysis, the electric potential forming the standard must be set. For boundary conditions other than for electric potential, decide on selections depending on the type of analysis.

Electric Potential Boundary

Can be used with all analysis types. Sets the electric potential for the place that is specified. Electric potential that will become a standard is necessary in electric field analyses, so specify at least one place. Settings are possible for all parts, part surfaces, edges and vertex.

Current Boundary/Current Density Boundary

Can only be used in a current distribution analysis. Specify the inflow and outflow from a specified place. Part faces can be specified. This report describes two divergent examples of current paths. It is possible to confirm that as the current flows from the left the upper current path is long and that most of the current flows on the lower current path (Fig. 2).

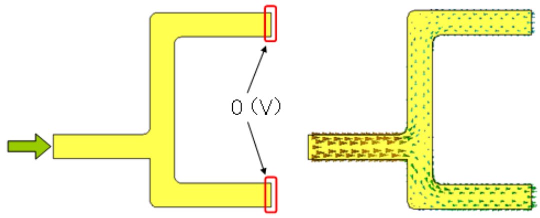


Fig. 2 Divergent Current Path Model (left) and Current Density Vector Diagram (Right)

Electric Field Boundary

Useable in static and frequency response analyses. Allows specifying of the electric field in a specified face. In a frequency response analysis, you can also set the phase of an electric field. Part faces can be specified. It is possible to obtain the electric potential distribution to satisfy the specified electric field.

Natural Boundary

Can be used with all analysis types. The specified face will be the face in the direction the current flows in. The part face can be specified. This is used frequently in partial models (Fig. 3).

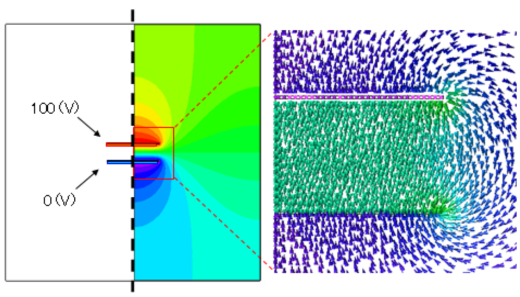


Fig. 3 The Central Line Forming the Natural Boundary and Electric Potential Contour Settings (Left) and Enlargement of

Center Vicinity Electric Field Vector Settings (Right)

Symmetry Boundary

Can be used with all analysis types. The specified face will be the one in which the current can be expelled vertically. A uniform electric potential is set for the boundary. An electric potential phase can also be specified together with its amplitude in a frequency response analysis. The part face can be specified. Usable when creating a partial model. Here is a one-quarter model with a central boundary between electrodes fixed at 50 (V) (Fig. 4). Note the electric field distribution is different from that of an example of a natural boundary with upper and lower symmetry (Fig. 3). When there is distribution of electric potential on the boundary surface, avoid using a partial model with a symmetrical boundary.

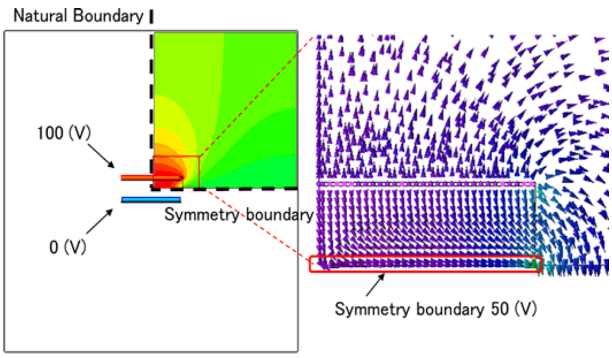


Fig. 4 Natural Boundary, Symmetrical Boundary and Electric Potential Contour Settings (left) and Enlargement of Center Vicinity Electric Field Vector Settings (Right)

Periodic Boundary (Rotation) and Periodic Boundary (Translation)

Can be used with all analysis types. Specify the model cross-section and periodic angle when the analysis target is a partial model. Narrowing the analysis scope cuts calculation time and the memory needed for calculation.

Charge conditions

Giving a charge to a particular part or surface can generate an electric field.

Surface Charge

Can only be used in a static analysis. Setting a charge for a specified face generates an electrical field.

Volume Charge

Can only be used in a static analysis. Setting a charge for a specified part generates a surrounding electrical field.

Output

This function calculates the physical amount of a particular scope from an electric field distribution obtained from the results of an electric field analysis.

Surface Charge

Can be used with all analysis types. Obtains an electromagnetic force generated in a specified face.

Electromagnetic Force

Can be used with all analysis types. Obtains a charge generated in a specified part.

Current

Can only be used in a current distribution analysis. Calculates the current amount passed through a specified face.

Modeling

It's possible to allocate special attributes to certain parts and conduct an analysis of these.

Perfect Conductor

Useable in static and frequency response analyses. Calculation occurs on the assumption that specified parts will have the same electric potential as the entire object. This shows an example of a perfect conductor, the long, thin object in the center of the item giving 100(v) to the right end and 0(V) to the left end (Fig. 5). It's possible to confirm the electric potential is uniform inside the conductor (Fig. 6).

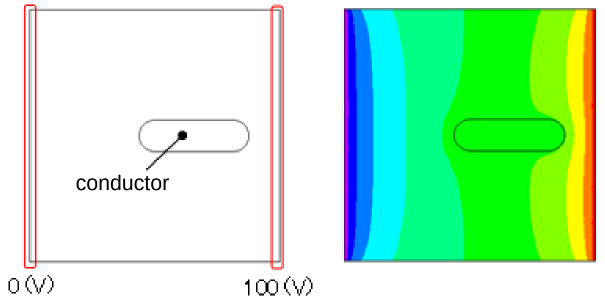


Fig. 5 Analysis Model (left) and
Electric Potential Contour Settings (right)

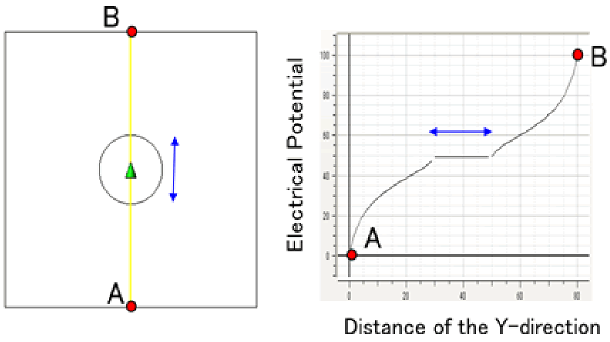


Fig. 6 Section Graph Positioning (left) and
Electric Potential Graph Cross-section (right)

Insulation

Can only be used in a current distribution analysis. A specified face becomes an insulator and current no longer passes through it.

In Closing

In this edition I have talked about the conditions used in an electric field analysis and described the meaning of its functions and how to use them. We hope you will have a look.

(Hiroshi Hashimoto)

JMAG University Partner Introduction

Shanghai University
Expectations of JMAG's highly accurate, detailed analyses of loss, control and vibration

In the electrical engineering faculty of Shanghai University, research is moving forward in a wide range of activities including material modeling, electrical circuit design, multiphysics and control design using HILS. We have been in a partnership with Shanghai University since 2012. In this issue we will talk about the partnership between JMAG and Shanghai University.

Shanghai University School of Mechatronic Engineering and Automation

Shanghai University was established in 1958 and is a city-run university and an important base with more than 50,000 students. The main campus is located in the Baoshan district of Shanghai.

The university has a faculty called the School of Mechatronic Engineering and Automation where research is carried out in electronics and controls. Established in 1990, the university started with electronic and automation and now there are also control theory and electrical engineering courses. Currently, the school is divided into two courses, one for control engineering and the other for electrical engineering.

As the head of the school, I am involved in joint research with companies both within and outside of China and our connections with local major corporations such as the Shanghai Electric Group and the Baosteel Group Corporation are strong. Overseas, the university is actively engaged in joint research with companies from the United States, Britain, France and Japan.

Surong Huang
Electrical Engineering
Professor
Shanghai University

In this issue we talk with Prof. Huang from the School's Electrical Engineering Faculty about how JMAG is being used. Dr. Huang began teaching at Shanghai University in 1977 and he has also done research in the United States at WEMPEC in the University of Wisconsin, also a JMAG-partner university.

JMAG was introduced in Prof. Huang’s laboratory in 2012. We have already been using commercial software and in-house production tools for research in motor development. However, in conducting more specific material modeling, coupled analysis, and cooperation control, JMAG was introduced as a tool that will provide the mechanics and technical support we need. In this issue, we will introduce the research theme in Prof, Huang’s laboratory, and their use of JMAG.

Measurement of control design / motor design / In building simulation technology

In the laboratory, Dr. Huang undertakes both the assessment and simulation of the latest designs in motor systems and verification of his findings. He has taken on a wide variety of research themes including power electronics and control and not just themes related to motor design, such as magnetic design or mechanical and thermal design. He also researches the latest on motor systems (Fig. 1). We have also been using simulations for a long time and use commercial software as well as develop analysis programs for research use. In the laboratory, team conducts simulations and measurements for various themes. There is also an array of experiment equipment available with which to conduct activities such as measure materials or establish HILS simulation environments.

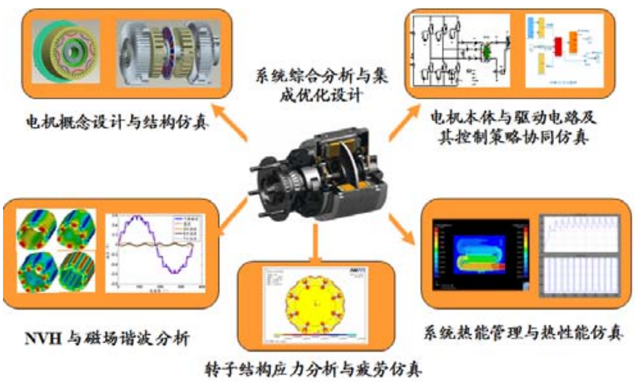


Fig. 1 Optimal motor designs allowing for magnetics, NVH, stress, control and heat

We are currently using JMAG in research themes, with examples including:

- * Motor magnetic circuit design (primarily loss evaluation);
- * Multiphysics evaluation into such areas as thermals and structure; and,
- * Control design using HILS.

among others.

Loss Evaluation Initiatives

Research laboratories are focusing their attention on motor loss evaluation to increase motor design efficiency. We are working together with a materials manufacturer and tackling the issue through both measurements and analysis, looking at items such as evaluation of stress dependency in iron loss (Fig.2). We are paying particular focus on measuring and analyzing the following items:

- Loss caused by time or space harmonic components
- Temperature and stress dependency
- Impact of rotational fields

JMAG has a rich array of functions for iron loss analysis, which raises analysis modeling accuracy and we plan to compare analysis results with actual measurements.

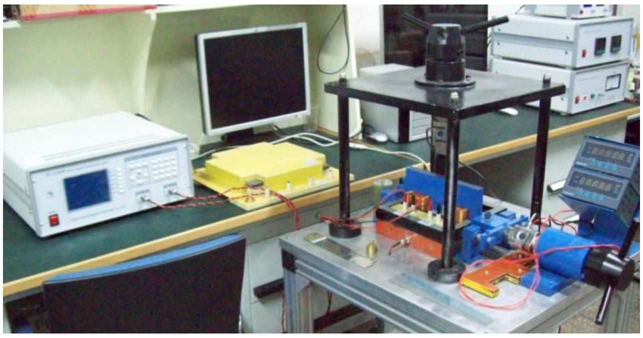


Fig. 2 Measuring device for magnetic properties allowing for stress dependency

Vibration Evaluation Initiatives

Joint research with an automaker is being carried out in a research lab with work ongoing on designing a drive motor. An important issue in this project is reducing vibration.

Up until now, the research lab would have used structural analysis programs made within the university. However, to be able to conduct a detailed evaluation of resonance phenomena resulting from excitation force generated by electromagnetic force, we needed an analysis software like JMAG, which is capable of detailed mapping of eletromagnetic distribution. JMAG is easy to use, being a single passage enabling coupling of electromagnetic field and structural analyses through to even evaluation of sound pressure, so we continue analyzing so it can be used in research laboratories. (Figs. 3, 4 and 5)

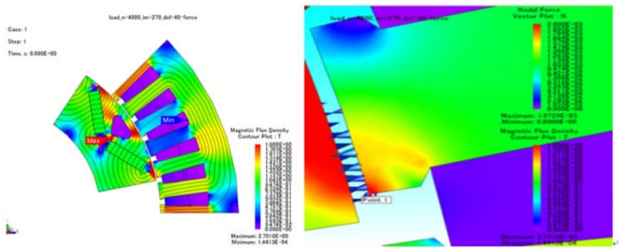


Fig. 3 Evaluating electromagnetic force at the motor stator end

Fig. 4 Device for measuring sound pressure

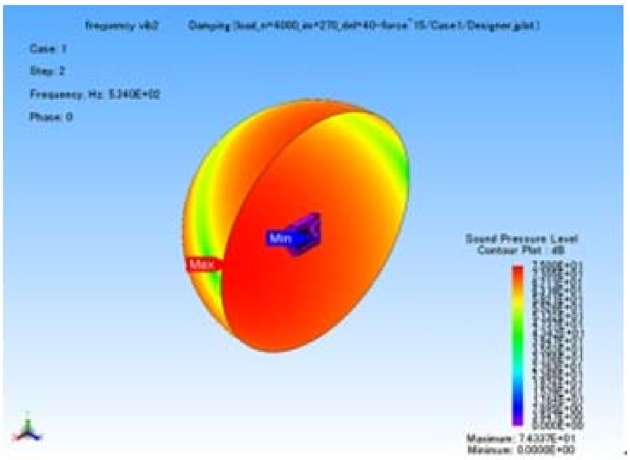


Fig. 5 JMAG calculation of sound pressure

Analysis Case Study

Huang, Surong, et al. "Magnet Motor for Electric Vehicle Based on JMAG," IDAJ-China Users Conference Papers, 2012

Control Design Evaluation Initiatives

We have a long history of involvement in control design and have utilized HILS technologies since times well in the past. In our research laboratories, by adding motor characteristics in an electromagnetic field analysis to a motor model in FPGA we have been able to gain a detailed evaluation of motor behavior without having had to create a prototype (Fig. 6). We're actually creating motor models allowing for motors with nonlinear characteristics or cross-coupling and we have the capability of simulations with responsiveness of 1 microsecond on FPGA. HILS technology is used in sensorless controls or tolerance evaluations during breakdowns.

These systems have up until now been developed in laboratories, but with each new motor, the FPGA I referred to earlier needed to be equipped with a motor model and required a certain amount of production time. Using JMAG simplifies generation of motor models and enables us to focus on control design.

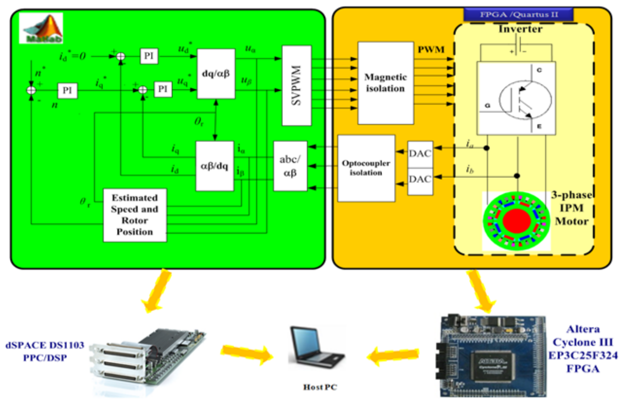


Fig. 6 HILS incorporating a detailed motor model

A JMAG Seminar that Company Engineers can also Attend

Shanghai University is emphasizing education and not just research, so it conducts training and seminars in analysis technologies not for students alone, but also mixing in corporate engineers as well. Shanghai University has conducted training and seminars since forming its partnership with JMAG.

For two days at the end of July 2013, the university conducted a seminar introducing the latest analysis technologies and utilizing JMAG to do so. Many students from the university and other Chinese companies took part, making it a meaningful event (Fig. 7).

Fig. 7 A JMAG seminar at Shanghai University

We expect JMAG will continue being used for research and teaching in laboratories.

(Interview by Hiroyuki Sano)

上海大学
Shanghai University

University name :
Shanghai University

Address:
99 Shangda Road, Baoshan District, Shanghai, China

University URL:
http://en.shu.edu.cn/

JMAG Product Partner Introduction

Dassault Systèmes Simulia

New Release of Abaqus and Coupling with JSOL Expands Simulation Possibilities

Dassault Systèmes is the world-leader in developing 3D software applications that transform the way products are designed, produced, and supported. The company is delivering on a long-term strategy to provide the most powerful realistic simulation and design optimization technology available through their SIMULIA applications for realistic simulation and optimization including; integrated structural analysis in CATIA and SolidWorks and advanced structural analysis, multiphysics simulation, process integration and automation, durability analysis, design exploration and optimization through Abaqus, fe-safe, Isight, and Tosca technologies.

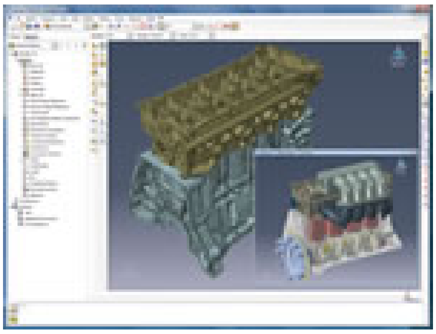
Abaqus is well known for providing proven and robust capabilities for linear, nonlinear and multiphysics simulation that are used to solve a vast array of engineering problems in a wide range of industries including aerospace, automotive, consumer packaged goods, energy and life sciences. In the automotive industry, for example, engineers are able to simulate vehicle loads, dynamic vibration, multibody systems, impact/crash, nonlinear static, thermal coupling, and acoustic-structural coupling using a common model data structure and integrated solver technology. Its unmatched integration of implicit and explicit FEA capabilities enables you to use the results of one simulation directly in a subsequent analysis to capture the effects of prior history, such as manufacturing processes on product performance.

Mr. Brad Heers
SIMULIA Product Experience Technical Expert, Transportation and Mobility, Dassault Systèmes Simulia

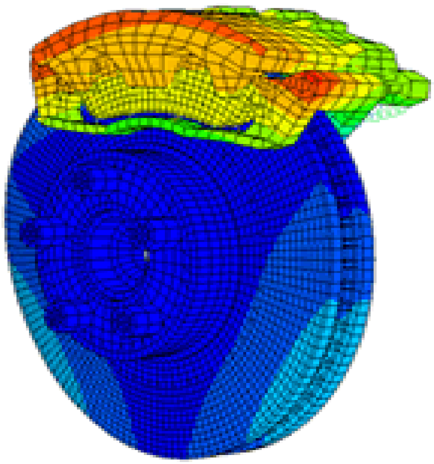
User programmable features, scripting and GUI customization features allow proven methods to be captured and deployed enabling more design alternatives to be analyzed in less time.

The Abaqus suite consists of three core products - Abaqus/Standard, Abaqus/Explicit and Abaqus/CAE. Each of these packages offers additional optional modules that address specialized capabilities some customers may need.

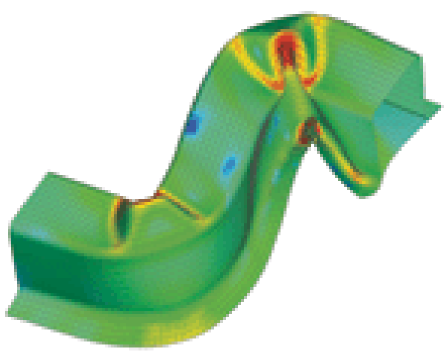
Abaqus/CAE provides a complete modeling and visualization environment for Abaqus analysis products. Through its feature-based parametric modeling capability, open access to CAD models, and advanced meshing and visualization features, Abaqus/CAE is the premiere model building, results visualization, and process automation solution for Abaqus analyses.



Abaqus/Standard provides Abaqus analysis technology to solve traditional implicit finite element analyses, such as static, dynamics, thermal, all powered with the widest range of contact and nonlinear material options. Abaqus/Standard also has optional add-on and interface products with address design sensitivity analysis, offshore engineering, and integration with third party software, e.g., plastic injection molding analysis.

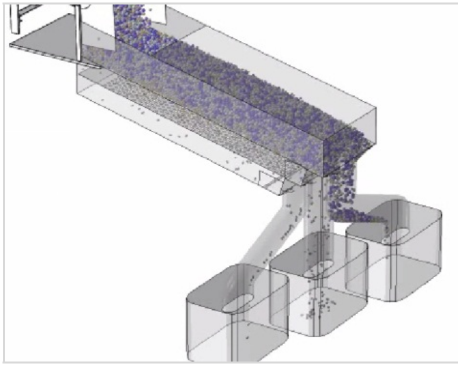


Abaqus/Explicit provides Abaqus analysis technology focused on transient dynamics and quasi-static analyses using an explicit approach appropriate in many applications such as drop test, crushing and many manufacturing processes.



Latest Release Provides New Capabilities

Abaqus 6.13 provides powerful new capabilities and enhancements that will improve your productivity, efficiency and performance based decision making. The latest releases delivers breakthrough capabilities for performance, electromagnetic Analysis, heat transfer and much more.



The release introduces a new particle method that allows users to perform an analysis using the Discrete Element Method (DEM). This enables the modeling of particulate material behavior in pharmaceutical, chemical, food, ceramic, metallurgical, mining, and other industries and is well-suited for particle mixing applications. These particles interact generally with each other and with all other parts of a model. Additionally in 6.13 steady-state flow problems can now be solved directly, eliminating the need to approximate steady state conditions using a long duration transient flow simulation. This enhancement substantially improves overall computational performance in common steady-state CFD simulations.

Why Abaqus FEA and Multiphysics Simulation

- Sophisticated, Abaqus-specific pre- and post-processing
- Robust and industry proven FEA and Multiphysics solvers

  - Complete linear & nonlinear, multibody analyses
  - Multiphysics: CFD, Smooth Particle Hydrodynamics, DEM

- Complex materials
  - Rubbers, plastics, powder metals, human tissue, soil, composites
- Sophisticated contact, fracture & failure
  - Crack, impact, and crash events
- High-performance solvers
  - Utilize 128 cores or more for extremely large models and rapid turnaround
- User Defined Subroutines
- Powerful model prep and results interpretation
  - Automation tools for customization of standard workflows

Partnering to Extend Simulation Possibilities

Dassault Systèmes also has a strong software alliance program that enables their partners to integrate their simulation technologies with Abaqus and other SIMULIA applications. This alliance program has resulted in SIMULIA and JSOL working together to provide capabilities to couple JMAG with Abaqus.

Examples of coupled simulation include the following:

Thermal and structural analyses of electric machines by using heat generation calculated in JMAG from Joule heating and hysteresis loss as the heat source for an Abaqus thermal simulation.

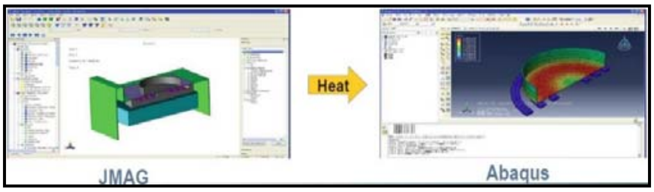
Benefits of Coupling Abaqus and JMAG

・Structural and electromagnetic simulation using the highest-class solutions

・Continue tapping into the investments made into CAE until now

Coupling Simulation Example:

Thermal and structural analysis of electric machinery run based on joule heat and hysteresis loss calculated in JMAG as the heat source for an Abaqus heat simulation.



Vibration analysis by mapping electromagnetic forces from a JMAG simulation onto point loads (*CLOAD) in an Abaqus.

Mapping a static stress distribution from Abaqus onto a JMAG mesh to account for the stress dependency of material properties.

Two-way coupling between JMAG and Abaqus for induction heating and metal forming applications using the cosimulation framework (CSE) of Abaqus. Examples of this coupling approach have been presented at the JMAG User Conference as well as the SIMULIA Community Conference. The partnership is providing opportunities to enhance the capabilities that will provide significant benefits in efficiency and capabilities for JMAG and Abaqus users.

The value comes from coupling Abaqus and JMAG

Use best-in-class solutions to simulate structural and electromagnetic behavior Leverage their current CAE investments to.

Abaqus is used by manufacturers, researchers, teachers and students to solve challenging engineering problems. A simple search on the internet related to Abaqus will yield a wealth of information.

Our global user community is passionate about sharing their experience and knowledge. You can join the SIMULIA Learning Community, attend a Regional User Meeting or our international community conference to interact with the community and SIMULIA professionals. We also host live webinars throughout the year. Below are a few links where you can gather useful information about Abaqus, including downloading Abaqus Student Edition for free from the SIMULIA Learning Community. If you have immediate requirements for more information simply fill out this contact form and we will respond to you promptly: http://simulia.custhelp.com/cgi-bin/abaqus.cfg/php/enduser/doc_serve.php?2=emailreq_inforeq_3ds

For additional information and to download Abaqus Student Edition for free follow these links:

- Download Abaqus Student Edition for Free by joining the SIMULIA Learning Community: http://www.3ds.com/products-services/simulia/academics/simulia-learning-community/
- Watch Abaqus and Isight update presentation from 2013 SIMULIA Community Conference: http://www.youtube.com/watch?v=hgK87xujUbs
- Review the latest updates in Abaqus 6.13: http://www.3ds.com/products-services/simulia/portfolio/abaqus/latest-release/
- Register to attend the 2014 SIMULIA Community Conference: http://www.3ds.com/events/simulia-community-conference/overview/

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http://www.3ds.com/simulia

Event Information

Report on the JMAG Users Conference

The JMAG Users Conference is not just for JSOL to pass on information, but is planned to also provide customers with a chance to communicate among themselves. We have prepared a wealth of contents again this year, enabling all participants to spend a worthwhile time regardless of their proficiency with JMAG, so it's accessible to everyone those using the software for the first time through to veteran JMAG users.

JMAG Users Conference in Japan

Conference Outline

Host: JSOL Corporation

Date: Wednesday, Dec. 4 to Thursday, Dec. 5, 2013

Venue: Tokyo Conference Center (Shinagawa, Tokyo)

http://www.jmag-international.com/jp/conference2013/

Keynote Presentation

JMAG Development Plan

(December 4 10:00 – 11:00)

Development planning of JMAG
Dr. Takashi Yamada
JSOL Corp.

Keynote Speech

(December 4 11:00 – 12:00)

Consideration to Cores and the Materials in Numerical Analysis for design and analysis of motors
Prof. Chikara Kaido
Kitakyushu National College of Technology

Motor 1

(December 4 13:00 – 15:00)

The study of calculation accuracy improvement for magnetic loss of motor
Mr. Kohichi Tanimoto
DENSO CORPORATION

Numerical Validation of Magnetic Measurement method of Motor Core using JMAG-Designer
Mr. Takao Imagawa
Hitachi, Ltd.

Magnet temperature analysis and prototype verification in permanent magnet synchronous motor
Mr. Ken Takeda
AISIN AW Co., LTD.

Newly introduced non-oriented electrical steel sheets to JMAG material database and the influence of magnetic properties of non-oriented electrical steels on switched reluctance motor's characteristics
Mr. Hiroaki Toda
JFE Steel Corporation

Large Scale Analyses and Vibration Analysis

- Large Transformer -

（December 4 13:00 – 15:00）

Coil Vibration as a Noise Source Generated by Transformer Load Current
Mr. Kiyoshi Wakimoto
MEIDENSHA CORPORATION

Magnetic Field Analysis of Large Transformers in Direct Current Bias Magnetism
Mr. Kenichi Tanaka
Fuji Electric Co., Ltd.

The coupling of JMAG with Virtual.Lab Acoustics in view of efficiently predicting Transformer (Acoustic) Noise.
Mr. De Langhe Koen
LMS, A SIEMENS BUSINESS
CAE DIVISION

JMAG's Searching Quest for Large Scale, Faster Electromagnetic Analysis - HPC Solver Introduction -
Kazuki Semba
JSOL Corp.

Induction Heating

（December 4 13:00 – 14:30）

Actuality and Scope on Simulation of Heat Treatment
Dr. Ju Dong-ying
Saitama Institute of Technology

High-Frequency Induction Heating Simulation using a Coupling of JMAG and COSMAP
Mr. Yohei Awata
Denki Kogyo Company

Crankshaft optimization of induction heat treatment using computer aided engineering (The second report)
Ms. Akiko Inami
Fuji Heavy Industries LTD.

Thermal Countermeasures

（December 4 16:40 – 17:40）

JMAG-Designer Case Studies and Issues for Magnetic Separators
Mr. Takashi Watanabe
Nippon Magnetics, Inc.

Case Studies Using JMAG in Electric Motor Development
Ms. Miho Shimada
KYB Corporation

Motor 2

（December 4 16:40 – 17:40）

Numerical analysis of the two-phase fluid and heat flow in the permanent magnetic synchronous motor
Dr. Toshinobu Tanimura
Komatsu Ltd.

An Initiative to Reduce Vibration in an Electric Vehicle Motor
Mr. Tsutomu Tanimoto
NISSAN MOTOR CO., LTD.

Induction Heating

（December 4 16:40 – 17:40）

Computer simulation of induction heating contains thermal deformation in large ring metal parts
Mr. Takashi Horino
NETUREN CO. LTD.

Abaqus – JMAG Cosimulation of Induction Heating and Induction Forming Processes
Mr. Kazuhiro Maeda
Dassault Systemes Simulia Corp.

Morning

(December 5 9:00 – 9:30)

System Design and Component Design (Saber-JMAG's Coupling to Revolutionize the Design Process): What Benefits does Model-Based Development have for Motor Designers?
Mr. Kurt Muller
Synopsys, Inc.

Mr. Alan Courtay
Synopsys, Inc.

Useful Tips for JMAG-Designer
Mr.Masayuki Kawai
JSOL Corp.

Coupling JMAG with a Structural Analysis and CFD Software
Mr.Yusaku Suzuki
JSOL Corp.

JMAG-RT

(December 5 9:30 – 10:30)

An Example of Motor Control ECU Software Verification from HILS using JMAG-RT
Mr. Tomohiro Morita
Fuji Heavy Industries Ltd.

A Model-Based Development Process of Automobile Using JMAG-RT and PSIM
Mr. Minoru Miyakoshi
Mazda Motor Corporation

Mr. Hirotaka Toda
Mazda Motor Corporation

Mr. Hisayuki Kabashima
Mazda Motor Corporation

Large Generator

(December 5 9:30 – 10:30)

Stress analysis of stator coil-end portion of turbine generator
Mr. Kohei Kuroda
Fuji Electric Co., Ltd.

A Tubular Hydro-Generator through Bolts Failure Analysis
Dongfang Electrical Machinery Co. Ltd
Research & Development Center
Engineer, Mr. Li Jianfu

High Frequency Transformer, Reactor

(December 5 9:30 – 10:30)

A Transient Core Loss Calculation Algorithm for Soft Magnetic Composite Material
Mr. Masaki Wasekura
Toyota Motor Corporation

Enhancing Precision in Superimposed Direct Current Characteristics Computations using a Powder Soft Magnetic Core
Mr. Kinji Kanagawa
MITSUBISHI MATERIALS Corporation

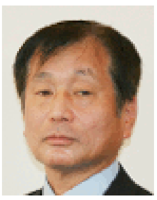
JMAG-RT Seminar

(December 5 10:35 – 12:05)

High-precision HILS Solution for EV/HEV Control Development
Mr. Koji Fukusumi
dSPACE Japan K.K

The Comparison of the real motor and motor HILS using spatial harmonics model
Mr. Kazumichi Kaneko
A&D Company, Limited

Application and Development Environment of Virtual Motor Torque Ripple Reduction Control
Mr. Yoshihiko Ozaki
DSP Technology Co., Ltd.



Motor 3

(December 5 14:40 – 16:40)

Magnetic Field Analysis of a Claw Pole Rotating Machine
Mr. Toshiyuki Yoshizawa
Mitsubishi Electric Corporation

Comparative Study of Field-Excitation Flux-Switching Motor Against PMSM for ISG Application
Pohang University of Science and Technology (POSTECH)
Electrical Engineering
Mr. Kwanghee Nam

Study on Self-Excitation Wound-Field Motor with Field Poles Excited by Space Harmonics
Mr. Masahiro Aoyama
Shizuoka University
Suzuki Motor Corporation

Loss Analysis

(December 5 14:40 – 16:40)

Role of Electrical Machines in Electrification
Mr. Ayman M. EL-Refaie
General Electric Global Research Center

The Effect of Stress in Iron Loss Analysis Evaluation: Verification through the Steel Sheet Processing Method
Mr. Motomichi Ohto
Yasukawa Electric Corporation

Analysis of Magnet Segmentation for an Electrical Machine used in Hybrid-Cars and Comparison with Calorimetric Measurement
Mr.David Bauer
Robert Bosch GmbH

Development of High power & High efficiency Motor for EV using magnetic field analysis
Mr. Takeshi Ikemi
NISSAN MOTOR CO., LTD.

Development of the Highly Functional Integrated Magnetic Transformer for Power Electronics
Dr. Tatsuya Hosotani
Murata Manufacturing Co., Ltd.

High Frequency Transformer, Reactor 2
(December 5 14:40 – 16:10)

Comparison of Actual Measurements of a Reactor Natural Frequency and JMAG Simulation (Refined Modeling of Elements)
Mr. Kouhei Ueda
TABUCHI ELECTRIC CO., LTD.

Easy Simulation Method of the Inductor Devices
Mr. Hidenori Uematsu
Panasonic Corporation Automotive & Industrial Systems Company

JMAG Development Planning
(December 5 16:40 – 17:35)

JMAG Development Planning 2
Dr. Takashi Yamada
JSOL Corp.

Workshops and Seminars

Participants in workshops used this as an opportunity to discuss freely about the future direction of analysis technology, make requests regarding JMAG functions. Actual JMAG developers explained the functions in seminars, which provided a deep understanding of JMAG. In the hands-on seminars, participants got a chance to take on new fields while actually using equipment devoted to these.

- First day: Wednesday, December 4, 2013, Afternoon session

(W-01) So much can be done JMAG's Induction Heating Analysis
Induction heating uses in the production process high-frequency heat treatment or localized heating. The question for JMAG is how well it can use these for solutions in a format as close to reality as possible. We will tweak JMAG's functions and review how to move forward.
(W-02) High Precision Material Modeling
We introduced case studies about the high-precision loss analysis function recently included on JMAG-Designer and discussed how to put this function to work.
(W-04) Using JMAG for High-Precision, High-Speed Calculation
High speed and high precision usually trade off against one another. But with JMAG, specializing in analysis objectives to develop functions has enabled us to achieve high precision at high speed. We showed this, using examples.
(W-06) General Electromagnetic Field Analysis Software JMAG-Designer Hands-on Seminar
We enabled future users to use JMAG-Designer as much as they wanted to get a feel for it.
(W-07) Large Transformers Latest Analysis Information

We exchanged opinions based on results of a questionnaire taken in advance about large transformer analysis requirements and initiatives we should take for the future. JSOL presented proposals for the next step.
（G-01）Inside JMAG - Pursing Inside JMAG – Solver and Mesh Edition
Based on a theme of “making a JMAG just for myself,” we discuss what would be an ideal JMAG solver and mesh. Our discussions continued on how to make our discussions a reality.

- Second day: Thursday December 5, 2013, Morning session

(W-05) Here's How to Use JMAG's Geometry Modeling Function
We worked on strengthening JMAG's modeling functions. We discussed how to make models so they get as close as possible to actual geometries.
(W-08) Structural/Vibration Analysis Modeling
We reviewed development, centering on an introduction of new functions, and exchanged opinions on solutions for modeling initiatives for structural and vibration analysis.
(W-09) Parametric Analysis, Optimization Putting to Practical Use
On the day we discussed where JMAG’s optimization function should be positioned and explained our approach to optimization calculation. We also gave an actual demonstration of JMAG's parametric analysis and discussed it while viewing screenshots.
(W-10) A Multi-Purpose File Export Tool connecting electric and machinery models
We described out Multi-Purpose File Export Tool with a rich array of functions. We also exchanged valuable opinions about strengthening the future.
(W-11) Design an Induction Motor, an IPM Motor with JMAG-Express
Using the motor design process, we allowed for getting a feel for the validity of JMAG-Express quick mode and discussed how to make this a tool that is easier to use.
(W-12) Hands-on Seminar for JMAG-VTB, an analysis automator platform
We ran JMAG-VTB and gave an introduction focusing on its customization functions. JMAG-VTB could be experienced while asking about required solutions.
(W-13) Heat Analyses in Rotating Machines and Transformers
We provided an opportunity to experience actual JMAG procedures and find out their basic underlying idea and what functions it has for forecasting temperature increases based on copper loss generated in coils and iron loss generated in the core. We moved onto an actual analysis to show how easy it actually is to use JMAG

- Second day: Thursday December 5, 2013, Afternoon session

(W-14) Proposal for Small Multiphysics
Consideration of multiphysics makes operation costs an issue as it requires production of multiple models and linking all sorts of different software. JMAG has improved its interface with multiphysics in mind and can drastically reduce operation costs. We made a proposal for how complicated multiphysics can be made simple and what approach to take to create small multiphysics.
(W-15) Getting even more use out of JMAG-RT models
We have continued improving JMAG-RT models to get as many motor designers and control and system as possible to use it. We discussed under the theme of what initiatives to take regarding issues confronting us and their solutions.
(W-16) Reusing Analysis Data
We discussed what function is required to re-use analysis data efficiently. We also discussed search functions for analysis results.
(W-17) JMAG Recommended in-House Training
JSOL proposed a number of cases and discussion went forward on issues that might occur when in-house training and internal deployment were carried out and countermeasures for such problems.
(W-18) Analysis of Direct Acting Type Motors and Solenoid Valves
We held a seminar to introduce functions related to direct action motors and solenoid valves. We showed how JMAG can analyze, using rapid response solenoid valves and linear motors as materials

(W-19) Using JMAG Results Analysis and Analysis Functions
In addition to the existing contour and vector plots, magnetic flux lines and section graphs, we've added to results processing features including response graph, difference calculation and distribution amount FFT. We showed concrete details about how to put these advanced functions to use.
(W-20) Seminar for High-Frequency Transformer and Non-Contact Power Supply System
This seminar introduced functions for high-frequency transformers and non-contact power supplies. In addition, we also introduced evaluation factors in respective product characteristics and showed actual analysis case studies.
（G-01）Inside JMAG - Pursing Inside JMAG – Post Function Edition
Based on a theme of "making a JMAG just for myself," we discussed ideal post functions. Our discussions continued on how to make our discussions a reality.

Exhibition Zone

We set up a JMAG booth to give an early glimpse at the exhibition zone into the latest JMAG-Designer release, Ver.13.0. We hope those who were among the first to try it out enjoyed the experience.

A variety of JMAG's technical partners also set up booths, starting with materials makers who provide materials databases and including hardware and software vendors, domestic and overseas measuring equipment manufacturers and prototype and design consultation companies. We thank them all very much.

The JMAG Users Conference conveys through its partner companies a variety of worthwhile information about electronic machinery development.

Were those who attended the Users Conference able to enjoy it to the fullest? I hope that the people who attended, as well as those who were unable to attend, were able to see what a meaningful experience the Users Conference was.

Our entire staff is looking forward to seeing everyone at next year's Users Conference! J

(Tomomi Igarashi)

Event Information

Exhibitions and Events for January through March, 2014

JMAG will hold exhibitions at events both in Japan and overseas. Please stop by our booth and take a look at JMAG's activities. We would like to take this opportunity to introduce events and exhibitions for January through March, 2014.

Cocktail during the BLDC AND IPM Machine Design Course by AMT

Will have booth.

Conference Outline

Host: Advanced MotorTech LLC.

Dates: Thursday, January 16, 2014

Venue: Hilton Doubletree Hotel -- San Francisco Airport (San Francisco, United States)

URL: http://www.advancedmotortech.com/training.html

Advanced MotorTech LLC. hosted “Cocktail during the BLDC AND IPM Machine Design Course by AMT” and we will open a booth. We will give descriptions of JMAG-Designer Ver. 13.0, using case studies.

(Tomomi Igarashi)

Event Information

JMAG Recommended Seminar Introduction

In this edition, we will describe the JMAG-Designer Ver. 13 Upgrade Seminar, the Electromagnetic Field Analysis Basic Course. These will present new functions and ways of using various functions to help you do more efficient analysis, so please join one if you can. Please join us if possible.

JMAG-Designer Ver. 13 Upgrade Seminar

Conference Outline

Host: JSOL Corporation

Dates: Wednesday, January 29, 2014（Tokyo）

Thursday, January 30 2014 (Osaka)

Friday, January 31, 2014 (Nagoya)

Venues: JSOL seminar rooms in Tokyo, Nagoya and Osaka

URL: http://www.jmag-international.com/jp/seminar/v-up/v-up130.html

These seminars will present JMAG-Designer Ver. 13, released in December, 2013. We will also include demonstrations of newly strengthened functionalities for users to try, in addition to the new functions.

We thank those who took part and hope they got a feel for actually using JMAG-Designer Ver.13.

(Tomomi Igarashi)

Electromagnetic Field Analysis Basic Course

Conference Outline

Host: JSOL Corporation

Dates: Monday, February 24, 2014

Venues: JSOL seminar room, Tokyo

URL: http://www.jmag-international.com/jp/seminar/ op/basic_analysis.html

JMAG is an electromagnetic field analysis software our company developes. Thanks to the support of many corporate and university users since 1983, it has become a product development and design support tool used in electric and electronic components and power electronics components such as motors, actuators, circuit components, and antennas.

This seminar will give an easily understandable explanation of matters likely to be needed for development so that you can get a grasp of analysis, electromagnetics and electrical engineering using JMAG intuitively.

For those starting out in electromagnetic field analysis or with little experience in electromagnetic design, this seminar may be ideal. What happens at the seminar is sure to contribute to your product development.

(Tomomi Igarashi)

Event Information

Report on the JMAG Users Conferences in China and South Korea

JMAG Users Conferences are hosted all over the world. Users conferences were held in China and South Korea during November of the current fiscal year, with many users taking part. Following is a report on events.

JMAG Users Conference in Korea

Conference Outline

Host: EMDYNE Inc.

Dates: Friday, November 1, 2013

Venues: Jeongja Opera House (Seoul, South Korea)

URL: http://www.emdyne.co.kr/jmag_user_meeting.htm

Program

10:00 - 11:00	JMAG: Recent development and road map JSOL Corp.
11:00 - 11:30	Field Switched Flux Motor Design Prof. Nam Kwang Hee, POSTECH
11:30 - 12:00	PM motor, Press fit, Iron loss analysis Mr. Kim Ji-Hyun, POSCO
12:30 - 12:30	High speed IM for Machinery Mr. Choi Jae-Hak, UST @ KERI
13:30 - 14:00	Script to design motor Mr. Woo Dong-Kyun, Seoul National University
14:00 - 14:30	Optimization for PM motor to reduce external force Prof. Jung Sang Yong, Sungkyunkwan University
14:30 - 15:00	Co-simulation Abaqus-JMAG Mr. Park Noh-Hwan, V-Eng
15:20 - 15:50	PM for Compress Mr. Cho Seong Kook, HallaVisteon Climate
15:50 - 16:50	TBA / Motor Loss Analysis JSOL Corp.

EMDYNE, our agent, hosted the first JMAG Users Conference to be held in South Korea. Although this was the first conference held, EMDYNE has been a JMAG user for a long time, dating back to 2004, and about 80 people attended the event in total.

Regarding the application, there were seven presentations in all, centering on rotation machines and presented by industry, partner companies and universities. JSOL presented two lectures, one of which to introduce new features and the other to unveil the latest loss analysis.

Events continued from early in the morning through to the end of the day, but participants furiously taking notes left an impression. A Q&A session following the presentation was lively and I could gain a feel for how serious people were about electromagnetic field analysis.

(Yusaku Suzuki)

JMAG Users Conference in China

Conference Outline

Host: IDAJ-China Co., LTD.

Dates: Wednesday, November 13, 2013

Venue: China (Beijing)

URL: http://www.idaj.cn/news/show/id/3301

IDAJ, our technological partner based in Beijing, China, held a JMAG Users Conference on November 13, 2013. Over 40 people took part in the third conference to be held in the country and it was a resounding success. Major automaker FAW did not confine itself to presenting case studies this year on vibration analysis alone: it also presented on large generators and large transformers. The afternoon was filled with lively discussions among participants, centering on individual technological topics.

Many participants are involved in motor analysis and they expressed great expectations in JMAG-Express as a motor design tool. I also noticed many conference participants continued speaking about motor design after the JMAG-Express seminar had finished.

(Hiroyuki Sano)

Event Information

Event Report

Attendees report on events held from September to November, 2013. We hope you will attend our next event.

Altair Technology Conference

JMAG was involved in the following presentations and booth displays.

Conference Outline

Host: Altair Engineering, Inc.

Location, Dates:

South Korea (Seoul): Friday, September 6, 2013. Hotel Conrad Seoul

China (Beijing): Monday, September 9 to Wednesday, September 11, 2013. Beijing International Exhibition Center

Britain (Warwickshire): Tuesday, September 10, 2013. Heritage Motor Centre

Taiwain (Taipei): Friday, September 13, 2013. GIS MOTC Convention Center

United States (California): Tuesday, October 1, 2013 to Thursday, October 3, 2013. Hyatt Regency Orange County

URL: http://www.altairatc.com/Default.aspx

Altair Technology Conference is Altair's user conference and is held in 10 countries around the world. JMAG gave presentations and opened a booth in Japan, South Korea, China and the United States and opened a booth in Britain and Taiwan.

We will continue to give presentations and set up booths at events overseas so that JMAG will be used in various places and various ways around the world.

(Tomomi Igarashi)

IEEE Energy Conversion Congress and Exposition 2013（ECCE 2013）

We set up a booth.

Conference Outline

Host: IEEE

Dates: Sunday, September 15, 2013 to Thursday, September 19, 2013

Venue: Colorado Convention Center (Colorado, United States)

URL: http://www.ecce2013.org/

The ECCE was very rich with its technical content as usual. There were over 500 oral sessions distributed through 4 days and the exhibitor section was also open. In between there were some partner presentations in the exhibit area as well.

There were over 200 attendances including many from overseas. Many of the presentations were academic researches which showed the latest progress in the electromagnetics and indicated the trends of electric machinery. We introduced JMAG features with demonstrations, and had various contacts from universities and industrial companies.

（Dheeraj Bobba）

A basic structural analysis course for electrical designers

Gave a presentation about JMAG.

Conference Outline

Host: JSOL Corporation

Dates: Thursday, September 26, 2013 (Tokyo)

Monday, October 28, 2013 (Nagoya)

Friday, October 25, 2014 (Osaka)

Venues: JSOL seminar rooms in Tokyo, Nagoya and Osaka

URL: http://www.jmag-international.com/jp/seminar/op/structural_analysis.html

We started the entitled seminar from September as one of our new basic seminars to include hand-on material.

Seven people attended the first seminar. The seminar was an introductory course on structural analyses and given in a classroom lecture format over two hours with the remaining time assigned to practical instruction given by actually using JMAG to run a structural analysis.

Among the answers to a questionnaire handed out were, “I gained an idea of analysis by actually using JMAG in a structural analysis,” and “It was a little too easy and I’d like you to teach us something that we can put to work in our daily duties.”

As this was a seminar targeting electrical designers without experience in structural analyses it was probably a little too easy for those who are already using structural analyses in their work. I won’t change the original objective, but will tweak the contents of the lecture to give participants greater satisfaction.

(Takayuki Nishio)

Coil Winding Chicago

We set up a booth.

Conference Outline

Host: CWIEME LTD

Dates: Tuesday, October 8, 2013 to Thursday, October 10, 2013

Venue: Donald E. Stephens Convention Center (Chicago, United States)

URL: http://www.coilwindingexpo.com/chicago/

The number of exhibitors at the show was smaller than last year but there was definitely an increased interest in general at the show and the number of people that stopped by our booth. There were numerous material manufacturing companies as well as companies that automate stacking laminations and windings. Overall atmosphere was active with many live demos on the automation of simple coil windings to complex winding patterns on stators and rotors.

（Dheeraj Bobba）

Saber Product Seminar

Gave a presentation about JMAG.

Conference Outline

Host: Synopsis (Japan)

Date: Thursday, October 17, 2013

Venue: Midland Square Convention Room (Japan, Nagoya)

URL: http://www.synopsys.co.jp/events/seminar/saber/

We took part in the Saber product seminar held by the Japanese joint venture company of Synopsis Inc.

This was the first seminar to introduce Saber in Japan and customers came from all over the country. In a Saber developer's lecture, we gave a demonstration of linking with JMAG-RT, which is one of Saber RD's new functions.

During a break period following the presentations we found many attendees were going through their JMAG=RT materials and I felt we had been able to spark awareness of the importance of highly accurate motor models.

We look forward to the day when many Saber users decide to use JMAG-RT for their high-precision motor models. J

(Hiroshi Tani)

MATLAB EXPO 2013

We set up a booth.

Conference Outline

Host: MathWorks Japan

Date: Tuesday, October 29, 2013

Venue: Hotel Grand Pacific LE DAIBA (Tokyo, Odaiba)

URL: http://www.matlabexpo.com/jp/

JMAG took part in the MATLAB EXPO again this year.

Overall, compared to the first time we set up a booth in 2004, I gained the impression that the amount of material being exhibited has been pared down to the essentials. Exhibits were divided into broad categories that included image processing, signal processing, motor controls and control verifications showed how MATLAB can be used to a broad degree in any of these fields.

About 30 people visited the JMAG booth. Nearly all of these had no direct experience in working with JMAG, but had heard about its reputation internally. Considering that only electronics manufacturers approached our booth in 2004, JMAG was virtually unknown.

This time, there was interest not just in the JMAG booth, but our motor control-contracted HILS partners also promoted JMAG, giving me a feeling that the world has changed a lot. J

(Takayuki Nishio)

LMS European Vehicle Conference

We set up a booth.

Conference Outline

Host: LMS International

Dates: Tuesday, October 29, 2013 to Wednesday, October 30, 2013

Venue: Kempinski Hotel Airport Munich (Germany, Munich)

URL: http://www.lmsintl.com/2013-european-vehicle-conference

Once again, LMS International hosted the LMS European Vehicle conference. The main topics were NVH & Acoustics, Model-Based System Engineering, Driving Dynamics & Durability. Over 30 presentations have been given as well as workshops in order to make the attendees understand what are the challenges of tomorrow and how simulation could help them to efficiently work.

In the audience, there was a majority of French and German people but also engineers from overall in Europe coming sometimes from very different department: EM Design, Control Design, Energy Management in a car, Actuators...

Most of the people who visited JMAG booth showed interest into NVH analysis with JMAG; some of them were not involved directly in Electromagnetics studies but were open to getting information about JMAG's link with other software and tools in order to forward it to their dedicated colleagues.

Another huge topic was the multi-physics applications and a third redundant topic was the principle and the use of the RT model.

（Corinne Rocherieux）

Design Workshop Seminars for Potential Motor Designers

Conducted live Webinar.

Conference Outline

Host: JSOL Corporation

Dates: Wednesday, October 30, 2013

Venue: Online

URL: http://www.jmag-international.com/jp/seminar/op/motor_design_web.html

Up until the previous seminar, participants had traveled into our offices, but we took into consideration that doing so had been difficult for many who may have wanted to attend and we needed to reduce volume, so we enabled people to experience the design process in JMAG-Express over the Web.

Participants send messages or questions during the seminar and deepened their knowledge. We will continue conducting webinars, so hope people have expectations toward these.

(Yusaku Suzuki)

SMMA 2013 Fall Technical Conference

We set up a booth.

Conference Outline

Host: SMMA

Dates: Tuesday, November 5, 2013 to Thursday, November 7, 2013

Venue: Marriott Tampa Airport Hotel (Florida, United States)

URL: http://www.smma.org/

SMMA (The Motor and Motion Association) held a forum attended by about 120 companies from various technological fields associated with motor development. This conference was a follow-up to a management conference held in the spring, but had an emphasis on technological matters with over 120 people in attendance. Design technicians spoke on a wide variety of themes based on development site case studies and including topics based on design technologies, including heat/sound countermeasures speeches, SILS and other evaluation technologies. JMAG setting up a booth attracted considerable interest for JMAG-RT from its basic property analysis characteristics to coupling analyses.

Lively exchanges of opinion occurred at the conference and technicians mixed well with no consideration of corporate boundaries.

(Tetsuo Ogawa)

Synopsys Automotive Solutions Seminar

We set up a booth.

Conference Outline

Host: Synopsys

Dates: Thursday, November 14, 2013

Venue: The Westin Southfield Detroit Hotel (Southfield, United States)

URL: http://www.synopsys.com/COMPANY/Pages/automotive-solutions-seminar.aspx?elq_mid=5125&elq_cid=516964

Synopsis held this solution-introduction seminar targeted at the auto industry in Detroit and we took part. Synopsys gave a demonstration of its virtual evaluation environment, which it developed to enhance the reliability of vehicle systems as they become more complicated through matters like ECU and drive mechanisms. The seminar focused on improving the accuracy of models used under its environment for detailed evaluation, with JMAG-RT introduced as one of the pillars of such. JMAG's presence was accompanied by setting up a boot and complete automobile manufactures and component suppliers alike showed interest in JMAG-RT's solution performance.

(Tetsuo Ogawa)

IDAJ CAE Solution Conference 2013
modeFRONTIER Conference Day、GT-SUITE Conference Day

We set up a booth.

Conference Outline

Host: IDAJ Corporation

Dates: Thursday, Nov. 7, 2013 to Friday, November 8, 2013

Venue: Yokohama Bay Hotel Tokyu (Japan, Yokohama)

URL: http://www.idaj.co.jp/icsc2013/01_modeFRONTIER/

We exhibited in modeFRONTIER Conference Day, hosted by IDAJ Corporation. Many case studies where modeFRONTIER had been used were described, including a link between JMAG and modeFRONTIER.

In the latest version of modeFRONTIER, the JMAG node linking the program with JMAG has been improved, making it even closer for optimization use by JMAG users and, I strongly feel, aiding in efficient design.

Many participants dropped by the JMAG booth and we told them of case studies coupling with JMAG.

(Tetsuya Hattori)

LMS Conference Japan 2013

We set up a booth.

Conference Outline

Host: LMS Japan

Date: Wednesday, November 13, 2013

Venue: Tokyo Conference Center (Shinagawa, Tokyo)

URL: http://www.lmsjapan.com/lmsconferences2013

Over 250 people took part in the first LMS Conference held in Japan since the Siemens Group took over the company. Presentations were largely about vibration and sound and the standard was exceptional.

JSOL opened a booth and exchanged information with lots of people. We naturally received many questions about coupling between LMS Virtual.Lab and JMAG. We expect there will be many case studies involving linking of LMS Conference and JMAG appearing at this conference.

(Hiroshi Tani)

MATLAB･JMAG･RTSim Motor Control Solution Seminar 2013
-- Virtual Motors and Controllers that can be Coupled in JMAG and MATLAB --

Gave a presentation about JMAG.

Conference Outline

Host: Hodaka Denshi K.K.

Supporters: MathWorks Japan, DSP Technology, JSOL Corporation

Date: Tuesday, November 26, 2013

Venue: Grand Park Tower (Tokyo, Shibaura)

URL: http://www.hodaka.co.jp/motorseminar/2013_11.php

Hodaka Denshi held a seminar again this year at the Grand Park Plaza and our company presented and set up a booth as one of its vendors.

About 40 people attended the seminar and listened intently until the end. Our presentation we received numerous questions about how to create data (rtt files) for JMAG-RT from actual measurement data and there was, I feel, considerable interest in JMAG-RT's solutions.

Over one-third of all in attendance were JMAG users, which was a pleasant surprise.

(Takayuki Nishio)

Otsuka Corporation CAE Summit in Chubu

Described examples of JMAG functions and use centering on the Otsuka Corporation package *JMAG99*.

Conference Outline

Host: Otsuka Corporation

Dates: Friday, December 6, 2013

Venue: 13th floor, Chubu Branch, Otsuka Corporation (Aichi, Nagoya)

URL: http://event.otsuka-shokai.co.jp/13/c1206cae/

Described examples of JMAG functions and use centering on the Otsuka Corporation package JMAG99.

JMAG prepared tools for multifaceted evaluation while coupled with analysis results obtained from other software for vibration and heat analysis, including JMAG-VTB and Abaqus equipped with workflow which enable technicians not accustomed with analysis to perform high-level analyses.

(Tomomi Igarashi)

This edition features a report centered on exhibitions and seminars in Japan and the United states. JMAG does not only provide technical support, it also presents a product enabling even greater in terms of high-speed and high-efficiency.

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Simulation Technology for Electromechanical Design