Simulation Technology for Electromechanical Design

JMAG®

JMAG Newsletter

Contents

JMAG Newsletter: Highlights of the July Issue

The temperature outside is getting hotter, but we hope you are finding ways to stay comfortable. We are pleased to present you with the July issue of the JMAG Newsletter, and apologize for the slight delay.

This month's "Implementing JMAG" features an interview with Mr. Yonemori from the Mazda Corporation, which has been the only company in the world producing commercial vehicles with rotary engines for more than 40 years, and continues to steadily move into the future by coming up with unique scenarios further automobile evolution. He was kind enough to speak to us on topics from Mazda's view of the future to the role played by JMAG at the forefront in creative areas.

The "Technical FAQ" provides answers to questions we often receive. This issue introduces useful functions for a user who is having trouble knowing how to do analysis well when faced with unfamiliar tools. Also, we redesigned our Technical FAQ webpage in March. Searches can now be done by application, such as Analysis Function, Motor, or Heater, to make it easier to find an answer to your question. If you haven't seen it yet, please feel free to use it along with JMAG's technical support.

There are almost as many papers and technical reports in the world as there are stars in the sky. In our "Paper Introduction," we introduce papers that our engineers have read and found useful. In this issue, we present literature from a variety of fields in which induction heating phenomena are being used.

The "A to Z" also focuses attention on basic material properties and various functions to make coupled thermal analysis more familiar.

Finally, new features are introduced for JMAG-Designer Ver.12.1, released in June, 2013. GUI mapping functions have been added to Ver.12.1, greatly improving its linking ability with other software. We have also taken measures for better ease-of-use for our customers, so please see the details in the "Product Report."

The JMAG Newsletter is intended for everybody, from those who are currently using the product to those who have not started yet. 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

Mazda Motor Corporation

Using Simulation to Support Automobile Evolution
—JMAG, the de facto tool that anticipates the widespread use of electrical devices—

Automobiles have been made more environmentally friendly by taking advantage of electricity from cars that consume fossil fuels. These days, cars are undergoing further evolution. A key to these is held by the category of new technologies known as electric devices, with the core part being the motor. Processes have been established to make simulation technology more versatile for more effective development. Mazda is gradually and reliably making preparations for the future by creating scenarios for the evolution of its own cars. JMAG also plays an important role in the area of cutting-edge innovation.

The Building-Block Strategy and SKYACTIV TECHNOLOGY. Mazda's View of the Future

— Mr. Yonemori, you're identified with the "Innovative Research Planning Field's Innovative Research Team and the Advanced Vehicle System Research Field's Integrated Vehicle Control Research." Could you tell us what kinds of research your section does?

Yonemori: Innovation means "to make something for the first time," and our section is truly involved with activities that create new technologies, not based on anything from the past. For example, we very freely think of ideas that may be possible in the future, like how motors could change if a combination of materials that has not been thought of until now allowed a new magnet to be invented that would produce several times the magnetic properties at a fraction of the cost, and then we investigate how overall systems would be structured as groups of technologies to support these becoming reality. I like to say, "Use your own ability to carve out your own future, and then go and get it."

Mazda Motor Corporation
Innovative Research Planning Field
Innovative Research Team
and Advanced Vehicle System Research Field
Integrated Vehicle Control Research
Senior Technical Specialist
Mr. Kei Yonemori

— In what kinds of specific fields do you deal with innovation?

Yonemori: Before I tell you about that, you need to understand the cars that Mazda is working on making now.

Mazda came up with the "Sustainable Zoom-Zoom" vision in March, 2007. This proclaims Mazda's commitment to making a sustainable future a reality in which cars, people, and the earth can continue to coexist happily. Based on that, in June, 2008, the "plan to raise the average fuel economy of Mazda vehicles sold worldwide by 30% compared with 2008 levels by 2015" was drawn up. Our strategy for making this a reality is what we call the "Building-Block Strategy."

In recent years, hybrid cars, electric cars, and other cars incorporating new electric devices have appeared on the market, and these vehicles' performance can be said to be the combined power of the electric devices and previous technologies

related to the engine, transmission, body, chassis, etc. Sometimes the media seems to rather hastily talk as though a complete shift to hybrid and electric cars is a foregone conclusion.

At Mazda, though, we expect that the proportion and role taken by the internal combustion engine in automobile powertrains will still be as big in 2020 as it has been in the past. The areas where there is a combination of internal combustion engines and electric devices will be expanded, so we don't think there is only value in electric devices. This is why we have adopted the "Building-Block Strategy," which emphasizes improvements in the "base technologies" responsible for cars' basic performance, while also incrementally combining electric devices such as regenerative braking and hybrid systems.
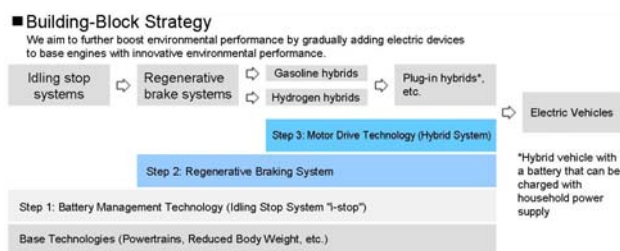

Fig. 1 Building-Block Strategy

— In other words, it's not simply a technological generation shift, but an overlaying of new technologies onto existing ones, leading to a higher level of overall functionality.

Yonemori: That's right. When you improve the efficiency of the base internal combustion engine, the balance of the electric devices added to it when making a hybrid necessarily changes. By striking the right balance, we're trying to make cars that provide both the pleasure of driving that Mazda is known for and excellent environmental performance.

Our name for all of the innovative next-generation technologies we are researching and developing to make this happen is "SKYACTIV TECHNOLOGY." Going back to the fall of 2010, when the new Demio was put on the market including the "SKYACTIV-G," the world's first mass-produced engine to reach a compression ratio of 14.0, we've gotten positive attention with our 2012 introduction of the CX-5 and Atenza with full SKYACTIV integration.

Although complete devotion to hybrid- and electric-car scenarios is becoming the norm, we've used our own strengths to show that there is still room for improvement in internal combustion engines. This is just my own opinion, but I think it can at least raise questions about development trends in the automobile industry.

JMAG: Supporting MBD, the New Current in Development

— So, these are the Building-Block Strategy, and the SKYACTIV TECHNOLOGY that are actually making it possible. But your research is located one step further into the future than that, right?

Yonemori: I can't give many specifics, but I'm mainly involved with research on wide-range drive motors for cars and functional integration systems. It's OK to move forward with investigations of various topics in a very free way because we cannot see the future shape of the things we are looking at, but we also have to have a kind of "basic premise."

In automobile development, all of the related engineers (this crosses company barriers, so the idea is that these are people who are experts in each field) pile up an unbelievable amount of debate and trial-and-error while forming the essence, or concept, of a new car model. Before building a prototype, the better ability you have to accurately preview the final product, the more

quickly and efficiently you are able to pick out any problem areas, and then fix them before they can spread any further. That's where CAE comes in and helps make it possible to some degree to get a clearer image. Recently, the development process called MBD (Model Based Development) has been implemented, and simulation is also rapidly becoming the mainstream.

MBD is one methodology for pursuing limit design for customers. Cars from recent years, for example the representative hybrids, have a nonlinear power plant with an internal combustion engine, motor, and brakes that work together in a complicated way. At times, ON/OFF operations are discontinuous, and managing torque smoothly with overall coordination is actually an extremely advanced ability. In addition, all of the many performance indices have to be met, including "high performance," "small size / lightweight," "low cost," "controllability," "extremely quiet / low vibration," and "high quality / long life / heat resistance." Because of all this, if you can become expert in getting an accurate grasp of behavior models that express the dynamic properties of different systems in advance, you can more quickly get that much closer to drawing out a machine's potential, and come that much closer to the system your customers are looking for.
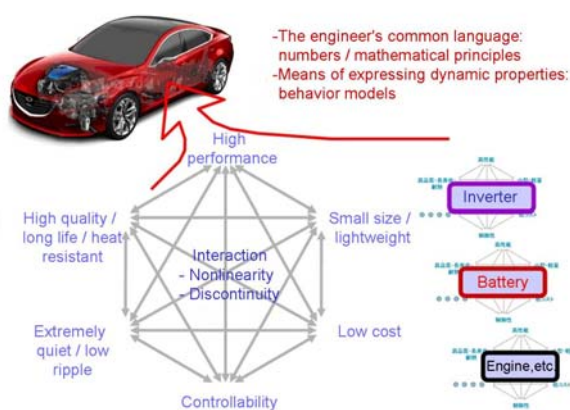
Fig. 2 Concept design
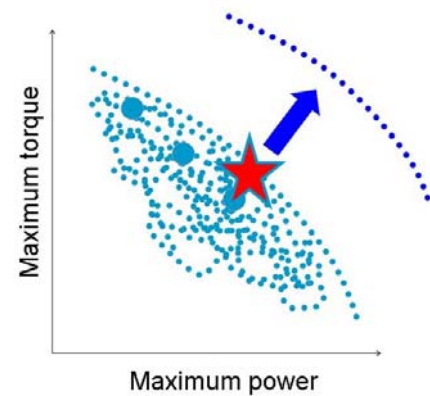
Fig. 3 Unit development

— And that is where JMAG is helpful?

Yonemori: Refined dynamics is one of the important indices for cars, but it is not enough to simply have a lot of torque with low variation. For the way torque is produced, we have many years of experience that tell us that "this kind of torque production feels better," and our research aims at making that happen. For example, people who have ridden a motorcycle will understand that the "thump thump thump" of the torque undulations in a V engine feels really exciting, while a single-cylinder engine makes a sort of gratifying "tap tap tap" sound, and each has its own particular merit. In the car world, the ideal would be to be able to know the sensory relationship between the accelerator and brake pedals and torque (acceleration / deceleration g-forces) production, or between steering angle and turning g-forces. If you can even just have complete knowledge of the internal variation components unique to the electrical field, and if it has excellent operability, then you can get to the ideal by the shortest route.

— You've proven this in reality using high-level analyses in JMAG-RT?

Yonemori: I'm preparing my own report on our use

of JMAG-RT in MBD for electric-drive vehicles.

In analysis of electric-drive vehicle motor drive systems, it is usual to narrow down to easily-calculated ideal conditions and discuss their relative merits and demerits in terms of representative properties like maximum motor performance. But this is limited to only one of the object's properties. Actual motors are affected by variations in the battery voltage and overheating of internal parts, so that even if they come from the same design drawing, each motor has its own individual character, to put it a bit strongly. Also, in JMAG itself, it is not possible to rigorously express the interactions between the operating environment, changes in efficiency, and others with the motor connected to its surrounding systems. So, with our goal of a "limit design for a dynamic system," we used JMAG-RT to build a high-speed calculation environment that can get an overall view of the interactions and trade-offs within a system all at once.
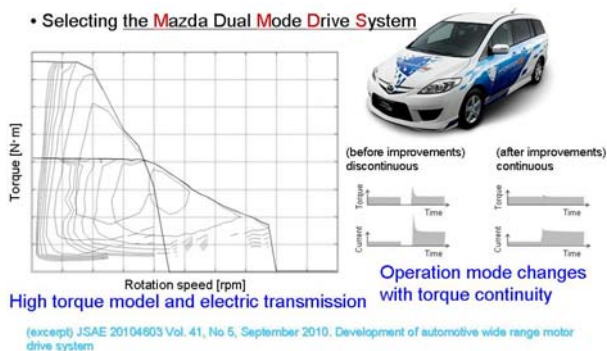

Fig. 4 MDMDS system
Kei Yonemori, Technical Research Center, Mazda Motor Corporation
"A Case Example of JMAG-RT Application in an Electrical Automotive MBD"
Excerpted from presentation materials from JMAG Users Conference 2011

— How are you using your analysis results?

Yonemori: Detailed desktop test reports for all designs are now created automatically, and we can get complete knowledge of limit-design cases in which existing technologies are used to their maximum potential with full automation. For example, with an original design whose properties we have already obtained, we will apply an algorithm from game theory to attempt to improve its properties even further, and let the computers run a huge, 24-hour nonstop trial-and-error session on it. Further, we can add in experiment-design algorithms, make clear which factors are in high correlation using the least number of studies, and run various simulations focusing on the factors with the highest contribution to motor properties. Even further, we try making use of genetic algorithms to try out mutation-like combinations that would not normally be thought of, to see if they lead to technological breakthroughs.

Our attempts to improve the dynamic limits of the system's performance include (multiple) visualizations of heat behavior inside the system, visualizations of the relationship with battery voltage reductions during full acceleration, and use of computers to find patterns of shared aspects in groups of superior designs. We're involved in a wide variety of efforts, but we actually keep a basic policy of complete automation for the calculation itself because we don't want to place too much emphasis on manpower. Even the most powerful computer in the world can't look analytically at sets of calculation results or apply good ideas from outside the model space. Our slogan for these efforts is, "Let engineers do what only humans can do, and leave large-scale operations up to the machines."

JMAG: Becoming a "Common Language" for Motor Development in the Automotive World
— Why did you decide to start using JMAG?

Yonemori: My research center implemented JMAG in 2006, and I've gradually used it more and more since then. Not only the center, but also the development and design departments use it.

We chose it because it's the de facto standard for electromagnetic field analysis simulation software in Japan. Like in MBD, the job of an engineer is not done when the calculation results are received. In fact, that's where the discussion begins. The major goal is to share those results with other departments and with development specialists at collaborating companies, and quickly improve research and development efficiency before moving on to actual machine production, where improvisation will not work.

That being the case, if people are speaking a different language, work efficiency cannot be improved. I think that its being the de facto has a profound meaning in today's development environment. For analysis of motors for electric-drive vehicles in particular, electric manufacturers also use JMAG, so it doesn't make sense to use a solution other than JMAG, and changing between tools would require work that is not directly connected to (is not necessary for) car makers' basic work.

— Have you had any problems with the support system?

Yonemori: As for Japanese permanent magnet motors, I know that the best authorized knowledge from the specialized field is already included, so I have no problems there. Also, the staff has responded very generously even to proposals for utilization from my company, so when we have had problems, I don't remember there ever being any delays since the time we implemented it. It's also very helpful that new features are developed in

response to requests from the places that are using JMAG.

Because of this, even departments within my company that would not have been expected to do so have started to use JMAG, and it is coming to play an even bigger role as a "common language."

— Thank you so much for the kind words.

Yonemori: I think there are a lot of different reasons why JMAG has become the de facto in Japan and is used as a common language among Japanese automakers. I've heard that in the beginning, a lot of hard work went into turning research results from university into a reality with this package.

In any case, I personally am willing to say that JMAG can be used as one yardstick for determining a motor's evolution or its suitability, and that JMAG-RT can be used to provide a lot of technical proposals with dynamic models. I'm not just trying to stick up for JSOL, but having a common language is really very useful.

A Tool for Making Beautiful Automotive Electric Devices

— Could you tell us a little about areas for improvement in the software?

Yonemori: If you compare CAE results and actual prototypes, you can get really excellent analysis results for each individual analysis topic. But personally, I would like to be able to get more advanced multiphysics analysis results.

First would be to "investigate from different angles" (not available up to now), which would show, by confidence interval, what kind of effect inconsistencies between design drawing data (with manufacturing tolerance) and the actual machine would have on properties such as power and torque. Secondly, JMAG is motor electromagnetic field analysis software, but it would be nice if it could coordinate more with other FEM solution tools, such as those for thermo-hydrodynamics, to expand its range. Thirdly, I wonder if it could be made possible to create direct, coordinated processes from research simulation to production simulation by passing virtual simulation data to departments in charge of production processes, where the experts in manufacturing are.

The ultimate ideal would be that, within the high-speed cycle of research and development, the experts from each field would push each other to have enthusiastic debates about refining design drawings from their own standpoints. To achieve this, designs have to be sent out in a form that is polished up the way designers want it to be, and received by the manufacturing department where later processing can be done. (This in itself is not bad as a general idea.) However, when a production line is actually created, you don't want any places where you later realize, "we should have done it this way," for example at the level of it being difficult to change a die.

— In other words, there's a need to deepen the coordination between overall design technologies and overall production technologies?

Yonemori: Automobile development already looks at what feels good to people from an engineering perspective, and now is the time to actually incorporate that into designs. Simulation of the changes that result from different materials and others, with free use of 3D CAD, is progressing on the one hand. But now we have arrived at a time when we have to think about directly connecting simulation results with actual production systems and incorporating that kind of data into overall design technologies, with JMAG being one part of that.

Specifically, I'd like to see not only motors but everything up to and including inverters fall within JMAG's application range. That's because in today's world of automobile drive, there are no more motors that don't have inverters. (Batteries fall within the realm of chemical reactions, so JMAG doesn't have to keep up with them.) I'd also like it to move more into total system control. Accounting for heat is an absolutely necessary function. There's no fixed pattern for how JMAG should deal with cooling systems or car bodies in expanding its functionality, and I'm sure it's an area of great concern for JSOL, but I just wanted to bring up my own hopes.

— Can you define once again what role you think JMAG will have in automobile development from now on?

Yonemori: I mentioned some of my own wishes, but I don't think JMAG's role as an indispensable research and development tool will change at all. Cars will continue to evolve to meet customers' wishes, and it's easy to imagine that the relative importance of different functions and parts will

constantly change within the process of forms becoming more diverse and then being narrowed down over and over. What the future holds is always fluid and fundamentally uncertain. Also, it's not like things are necessarily made more secure just be becoming more high-tech. This is exactly why the importance of getting a clear image of more visions of the future becomes more and more important, and simulation will play a larger and larger role as it becomes more advanced and more accurate.

There are many different electric devices, from the traditional rotating machines used in auto development such as starters and alternators to today's traction motors and electric superchargers, and even injectors and so on beyond rotating machines, so that even though cars have a development history of a hundred years, progress has never stopped. Just like with the internal combustion engine, innovations are being made by engineers' ceaseless hard work and imagination, and there is still room for more progress.

If today's engines are likened to "works of art" created with a master craftsman's many cutting tools, electric devices, with their short history of refinement, are more at the level of rough-hewn pieces made by cutting up a tree with a chainsaw. I realize that this is of course only my own opinion, but I haven't yet seen or produced any motor that was so beautiful it made me feel like sighing.

I think that fully drawing out the hidden potential of electromagnetic materials like iron, copper, and magnets is like eliminating "wasteful things" that interrupt airflow through streamlining or propellers on an airplane. I hope that JMAG will continue to be sharpened as a tool that will allow progress toward products with their functions refined into beautiful forms. We should work together to apply ourselves

to a "The SKY is the Limit" development spirit, and move toward a future where we can fulfill all of our customers' wishes.
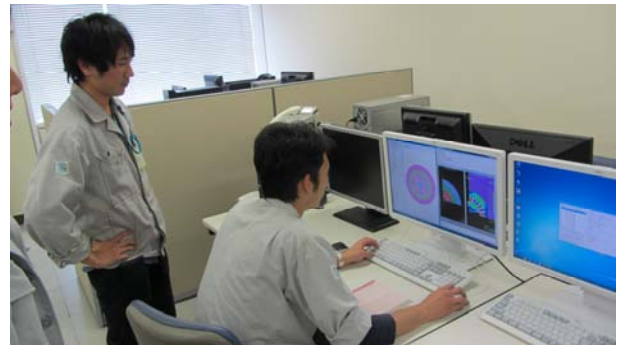
We were granted a Certificate of Appreciation

Our contribution to Mazda's construction of their CAE environment including a hybrid-motor optimization system using JMAG and others was well received, and we were granted a Certificate of Appreciation.

We always do our best to grapple with customers' requests and problems, but we sometimes worry, "is JMAG truly useful for our customers?"

For this reason, we are extremely glad to be shown a customer's estimation in tangible form such as this Certificate of Appreciation. We would like to use this space to express our gratitude. Thank you very much.
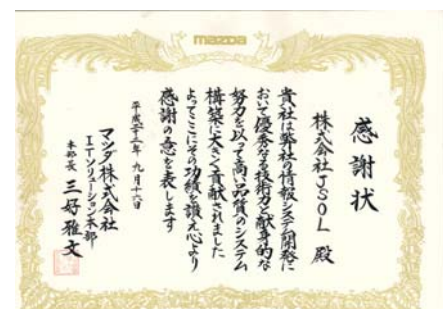
MAZDA

Company name: Mazda Motor Corporation

(Mazda Motor Corporation)

Capital: JPY 258,957,096,762

Consolidated number of employees: 37,617

Market listing: Tokyo Stock Exchange, First Section

Representative: Masamichi Kogai, Representative Director, President and CEO

Business Overview

Manufacture and sales of passenger cars and trucks.

We are the only company in the world with 40 years of experience in mass production and development of rotary-engine cars. Our brand reputation is particularly high in European countries such as Germany and England, as well as in Australia, and the Mazda 3 (Axela) was the top-selling model by car model in Australia in 2011 and 2012.

Our current company catchphrase is "Zoom-Zoom."

http://www.mazda.com/

Introducing JMAG-Designer Ver.12.1

We released JMAG-Designer Ver.12.1 in June, 2013. A wide variety of new functions have been added, including pre- and post-processing, solvers, and coupling, and the product now boasts greater stability and ease of use with better loss analysis accuracy and new tools for MBD, linking functions, and geometry editor functions.

This article introduces the most important new functions in Ver.12.1, focusing on loss analysis, MBD, and geometry creation.

Overview

This Product Report introduces fifteen functions that have been added to Ver. 12.1, with an explanation of their development background and goals, dividing Ver. 12.1's functions into seven categories.

Materials Modeling and Loss Analysis

To raise the efficiency of devices, particularly motors, to the upper limit, materials modeling and loss analysis technologies for simulation are needed beyond what has been available in the past.

Our new materials modeling and loss analysis functions share the goals of more directly handling hysteresis properties and eddy currents in laminated steel sheet to be closer to actual phenomena, and of improved accuracy in the high-frequency region of areas with high saturation and silicon sheet.

Also, it is now possible in analysis to specify areas of deterioration from warping when dealing with degradation of magnetic properties due to punching.

Advanced Iron Loss Calculation

In past versions of JMAG, loss calculation was carried out by obtaining the coefficients needed for hysteresis loss and eddy current loss calculation formulas from magnetic flux density distributions, using magnetic field analysis and loss data for each frequency in post-processing.

In Ver.12.1, a new method has been developed that provides accuracy across a wider range of frequencies and magnetic flux densities than was possible before, by directly handling the core's hysteresis properties and electric conductivity.

1. Hysteresis Loss Calculation

For hysteresis loss calculation, it is now possible to define hysteresis loops directly from the new GUI, in addition to the calculation methods that were already available (fig. 1).

The properties of materials with BH characteristics and loss data already in the materials database can be analyzed by automatically generating hysteresis loops from their DC magnetizing properties.

Even if the amplitude of the magnetic flux density is the same, loss calculation can be done reflecting differences in loss due to the location of the minor loops by directly accounting for hysteresis

properties (fig. 2). Compared with previous calculation methods, accuracy for hysteresis loss is greatly improved in high-saturation regions with superimposed direct current or with high-frequency components superimposed over a fundamental wave.
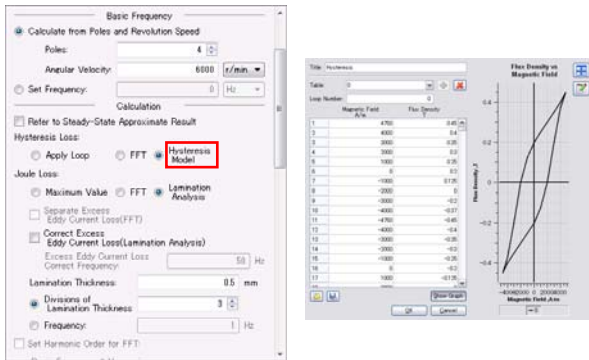

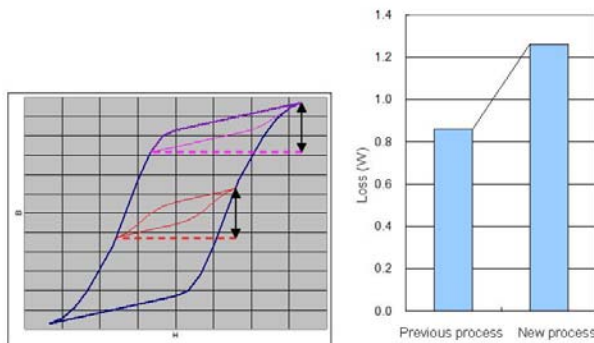Fig. 1 Specifying hysteresis loops from the GUI

Fig. 2 Difference in minor loop location with the same amplitude (left) and difference between previous and new hysteresis loss analysis methods (right)

2．Eddy Current Loss Calculation

For eddy current loss analysis, a new calculation method has been introduced that uses the lamination loss function included in Ver.12 in iron loss calculations. This method, in contrast to previous calculations that were based on loss data tables per frequency, runs analysis accounting for the thickness of each lamination of steel sheet based on the specified electric conductivity. Eddy current loss calculation accounting for laminated

construction is also made possible for 2D models by considering the results from solving Maxwell's equations in the lamination direction as corrections to 2D analyses. Accuracy for eddy current loss values, which previously had a tendency toward overestimation particularly in high-frequency regions, has been greatly improved because it is no longer necessary to apply extrapolation/interpolation processing when analysis frequencies are outside the range of a loss data table.
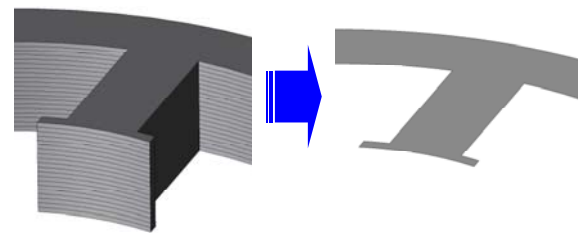
Fig. 3 Eddy current loss from lamination loss

Modeling Accounting for Degradation

JMAG provides methods for mapping stress distributions or multiplying total applied BH characteristics by a scale factor in order to model magnetization properties due to production degradation.

Newly-added analysis functions that account for processing stress allow analysis with direct specification of regions that are degraded due to processing. Degraded regions are specified by selecting the region edges for 2D models or solid faces for 3D models, and specifying the amount of deformation (fig. 4).

Changes in properties due to processing deformation are specified in a magnetic flux density - magnetization correction coefficient table for magnetic properties, and in a magnetic flux density − loss correction table for loss properties.

Increases in iron loss density adjacent to the punching region can be confirmed by comparing

the iron loss density distributions with and without processing degradation around the teeth and slots (fig. 5).

Fig. 4 Specifying the degraded region in a 2D model.

Fig. 5 Comparing iron loss density distributions with and
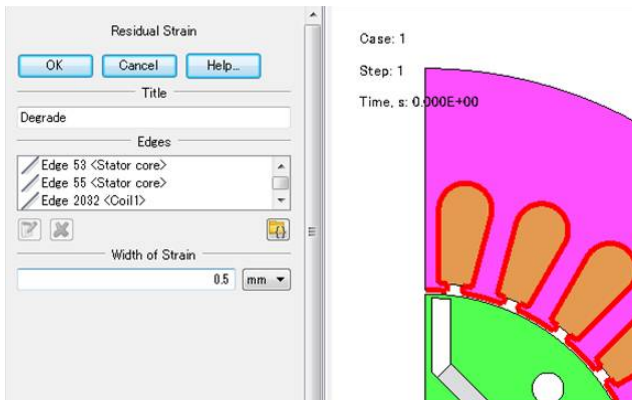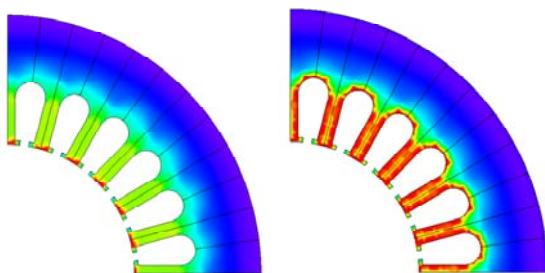
without degradation

(left: without degradation; right: with degradation in the slots)

JMAG-RT

JMAG-RT's utility has been broadened for HILS in addition to SILS/MILS. With the increase in applications that operate JMAG-RT and their further establishment in business, demand has risen for reduced RT model generation time and for more targets for using JMAG-RT. In Ver.12.1, needs for versatile control simulation have been met with reduced RT model generation time, support for parallel circuits, and improved precision for JMAG-RT Viewer, with a particular focus on work efficiency.

Reduced RT Model Generation Time

RT model generation time has been greatly reduced by focusing on symmetry in geometries and periodicity in three-phase AC in order to reduce the number of calculation cases. Further, we plan to accelerate nonlinear iterative calculation in magnetic field calculations carried out during RT model generation by providing specialized tunings for JMAG-RT. Table 1 shows a comparison of RT model generation time between Ver.12.1 and the previous version.

Table 1 Comparison of RT model generation time between old and new versions.

	V12	V12.1
IPM (10kW, 6P18S)	6.3h	3.5h
IPM(1kW, 4P6S)	1.3h	0.8h
SPM(10kW, 10P15S)	19.0h	8.9h

Support for Parallel Circuits

Up to now, motor models in JMAG-RT were provided with the assumption that their FEM coil circuits were constructed in series. When the target's circuit was parallel, circuit conversion processing was necessary for correction before and after generating an RT model.

Ver.12.1 makes it easier and cheaper, with corrective processing no longer necessary because parallel circuits can be accounted for during RT model generation (fig. 6). Circulating current is not considered in each parallel circuit, so m-series/n-parallel structures and n-parallel/m-series structures are seen as equivalent.
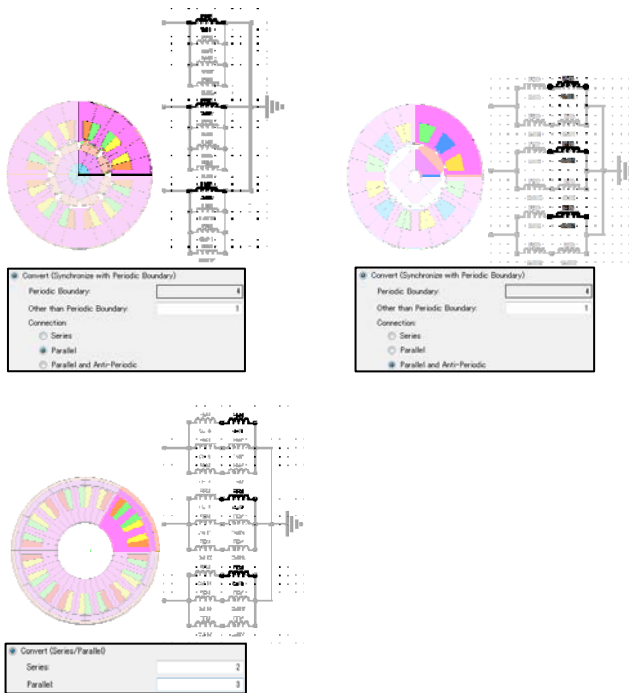
Fig. 6 RT model parallel circuit structures supported in

Ver.12.1

JMAG RT-Viewer for Spatial Harmonics Models

Spatial harmonics models not only reflect nonlinear properties of magnetization characteristics in inductance and amount of magnetic flux, but also provide precise data reflecting the spatial harmonics of slot harmonics and others. By reflecting these precise RT models in JMAG-RT Viewer, it is now possible to provide more accurate torque-rotation speed properties and efficiency maps (fig. 7).
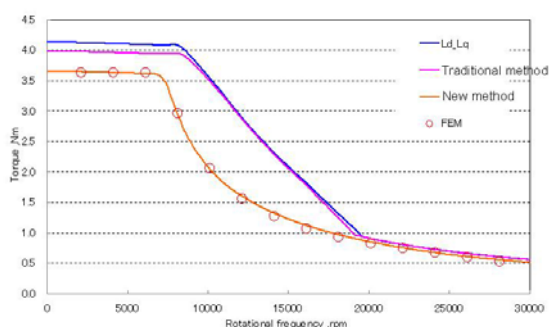

Fig. 7 Comparison of rotation speed-torque properties for

each calculation method

Model Based Design and Multi-physics

For model based design using finite element method electromagnetic field analysis (hereafter FEA), interactive data exchange of results as load conditions is necessary, in addition to creation of analysis models based on the physical phenomena from one CAD model.

Ver.12.1 accelerates model based design by improving multipurpose file output functions and including a new user interface for Abaqus CSE.

Multi-Purpose File Export Tool

This tool was first included in Ver.12, allowing JMAG analysis results together with mesh generated in JMAG to be output in Nastran format.

In Ver.12.1, in addition to the earlier functionality, mesh data created in other applications in Nastran format can be imported, and physical quantities including electromagnetic force and loss calculated in JMAG can be mapped onto mesh data as load conditions.

Further, thermal transfer coefficient distributions that are output in CSV format can be imported into JMAG thermal transfer analysis data from analysis results of other thermo-hydrodynamic software and set as thermal transfer boundary conditions. When the temperature dependency of a thermal transfer boundary condition is small, analysis results can be obtained in a short time by using JMAG's thermal transfer analysis.

GUI for Abaqus CSE

CSE in Abaqus is a function that controls coupled analysis with Abaqus and other software. Processing with input from the command line or patch files is necessary for coupled analysis using CSE.

In Ver.12.1, a JMAG GUI is included for coupled analysis with JMAG (fig. 8). This provides an easy-to-use environment for JMAG-Abaqus coupled analysis.
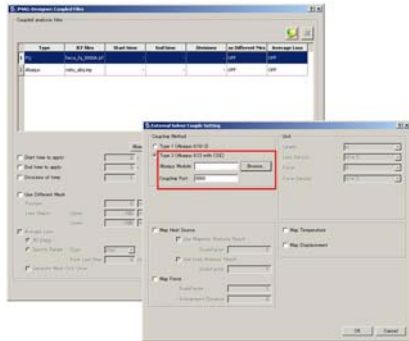

Fig. 8 GUI for Abaqus interface

Transformer Analysis

Higher and higher frequencies are being used for the drive frequency in small-scale power transformers in order to reduce their size even more. These higher frequencies lead to problems such as increased loss and localized heat generation because of skin effects and proximity effects in the windings. In order to reduce loss and localized heat generation, the use of litz wire has increased, and therefore so has the need for analysis that accounts for litz wire.

Improved Litz Wire Calculation

The number of litz wires per bundle that can be used and the solving speed in analysis within transformer studies have been greatly increased (fig. 9).

It is not unusual for the number of strands in a litz wire bundle to be more than 100, but investigation using transformer studies is made possible by the great increase in calculating ability.
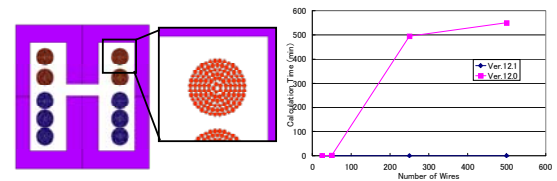
Fig. 9 Litz wire analysis (left), and solving speed comparison between versions (right)

Mesh Functions

The expanded slide mesh functions released in Ver.12 have been extended further. The application range and calculation speed for expanded slide mesh have been greatly improved over the previous version.

Improved Expanded Slide Mesh

The new expanded slide mesh functions are a combination of earlier functions and extruded mesh functions (fig. 10). Higher calculation speeds can be achieved with reduced model scale, while maintaining calculation precision. Table 2 is a comparison of number of elements and calculation time with the previous version. Expanded slide mesh functions can also be applied to full models. (Ver. 12 only supported partial models)

Expanded slide mesh   Extruded mesh + expanded slide mesh
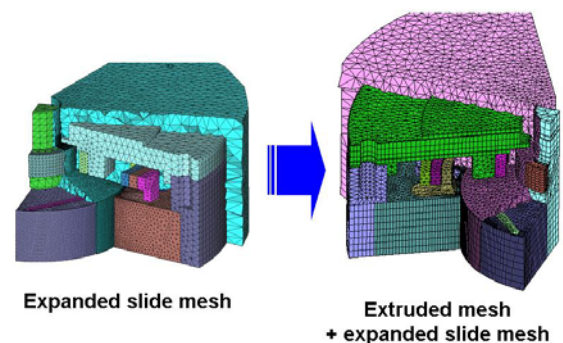
Fig. 10 Differences in mesh with the same model

Table 2 Comparison of model scale and analysis time

	Ver.12	Ver.12.1
Number of elements:	3,920,000	1,850,000
Number of nodes:	90,000	66,000
Analysis time	10h 46m	5h 33m

Pre- and Post-Processing

Pre- and post-processing functions have been added to enable users' ease-of-use, work efficiency, and detailed analysis, including: conversion of 2D models to 3D models while preserving materials and conditions; improved set functions; and optimization functions focusing on specified components with FFT processing.

Conversion from 2D Models to 3D Models

This is a function for simple creation of 3D models by using extrusion operations on already-existing 2D models. Materials and conditions are preserved, so analysis can be done immediately after conversion to a 3D model (fig. 11). It is convenient when, after 2D analysis, you want to run detailed analysis considering 3D effects. For example, models created in JMAG-Express can be easily expanded into 3D models.

Fig. 11 Conversion into a 3D model by extrusion and preservation of materials and conditions

Improved Set Functions

Analysis templates are a very convenient functionality for taking the settings, conditions, and results processing from one analysis model and applying them to other analysis models. Until now, if an analysis template was applied to a CAD model without set information, the problem arose that the analysis template's information was lost.

With new set functions, when an analysis template is applied to a CAD model without set information, an empty set is created in the CAD model. This greatly reduces the work of resetting set information because the user can easily see what kind of solid/surface/edge information should be set for the empty set.

FFT Data for Optimization

For analysis using optimization, it is necessary to record output values for target functions in response graphs. In Ver.12, users' output table values could be recorded as response graphs, but table values processed using FFT after analysis were not supported.

Measures dealing with certain frequencies, for example reducing noise in the audible range, are needed in actual design. Optimization calculation, such as to control only specific frequencies in a waveform processed with FFT, is necessary in carrying out analysis for this purpose.

With new response graph functions, FFT results can be used in optimization calculations by recording table values processed with FFT as response values. Fig. 12 shows results from an example with target functions set to maximize the first-order component and minimize the 3rd-order component of a motor's induced voltage. With the flux-barrier shape as a design variable, the induced voltage and the 3rd-order component of the magnetic flux density are displayed with the geometry for each case.
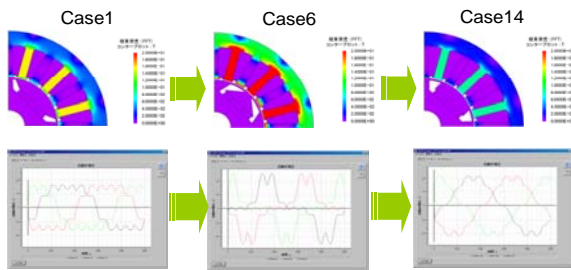
Fig. 12 Comparison of distribution of 3rd-order component of magnetic flux density (above), and induced voltage (below) for each case

Flux-Line Drawing for 3D Models

In addition to previously-available functions for drawing flux lines from a coordinate point specified on a model, it is now possible draw 3D flux lines passing through a specified cross-section (fig. 13). By drawing vector fields such as magnetic flux density and current density as continuous flow lines, the analysis target's physical phenomena can be obtained objectively as electromagnetic circuits or electric circuits.
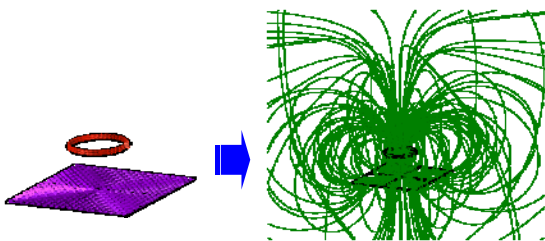

Fig. 13 Current density distribution (left) and flux line distribution (right) of a ring coil and conductor sheet model

Geometry Editor

As mentioned at the beginning of this article, geometry creation functions in Ver.12.1 have been developed with the goals of high stability and ease-of-use.

For optimization calculations and parametric analyses combining multiple design variables, a high degree of robustness in constraint conditions is desirable for the various geometries that arise in the calculation process. New constraint functions have improved robustness to meet these demands.

Also, the Geometry Editor employs functions to improve ease-of-use at various points. The Geometry Editor now allows you to check interference, display previews during constraint setting, set features together for assembly models, and select targets according to setting targets of basic shapes/constraints/regions.

Improved Robustness for Constraint Functions

Improved algorithms have led to a great improvement in robustness for constraint functions. Angle constraints have been particularly strengthened for better robustness.

Also, other constraint condition functions now make it possible to confirm constraints in advance via a preview. Constraints can be confirmed before conditions are finalized in order to see whether the constraints are set as intended, or whether there is any unintended motion (fig. 15). Also, the various constraints that are set are displayed hierarchized by type in the Model Manager (fig. 16). Constraint conditions that are needed as design variables can be located easily.
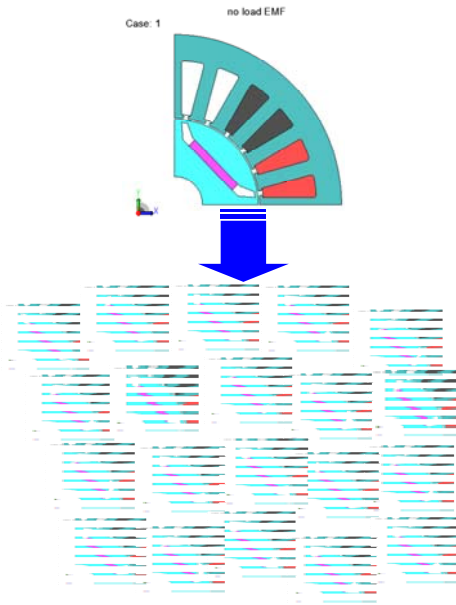
Fig. 14 Improved robustness for constraint functions

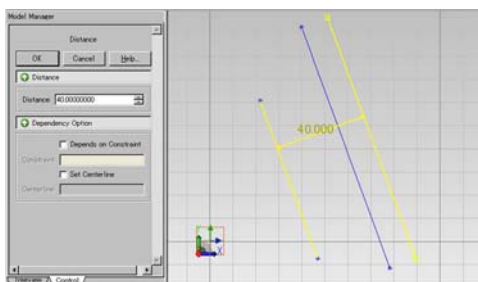Flux barrier geometries for each case during optimization

calculation

Fig. 15 Preview display during constraint setting
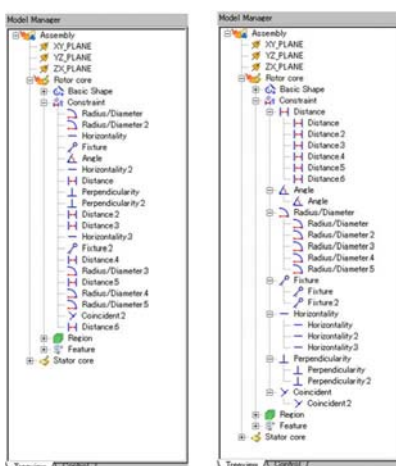
Fig. 16 Constraint condition hierarchy (left)

(right shows the constraint conditions list

from the previous version)

Improved Geometry Editor

Several points of improvement in the Geometry Editor's operability when creating model geometries are presented here.

A highly-requested feature for confirming measurements in the Geometry Editor is now available. The need to go back and fix mistakes is reduced because measurements can be checked at each point while creating a geometry without changing to the main Designer screen. Functions for checking interference between regions and solids have also been added. These also reduce the need to go back to fix mistakes, by checking whether there is interference during model creation.

Geometry editing functions have also been strengthened. Direct editing of assemblies constructed from multiple parts is possible. Up to now operations were necessary for each part when setting features for geometry models, but in Ver.12.1, features can be set to assemblies directly. Fig. 18 shows an example of direct application of an extrude cut to an assembly to change it to a 1/2 model, using a full model of an electromagnetic relay.

Further, it is possible to select either basic shapes, constraints, or regions for editing operations by applying a select filter function to operation targets (fig. 19). For example, if you only want to reapply constraints and you click to select the constraint filter, the operation target will always be constraint only, and basic shape or region will not be not erroneously selected. This means that not only is selection easy, but also mistakes due to operation can be avoided with this function.
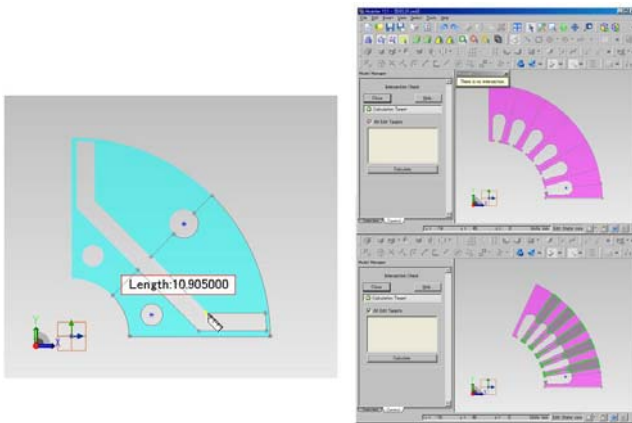
Fig. 17 Confirming measurements (left), and checking region
interference (right) with the Geometry Editor

Fig. 18 Extrude cut on an assembly
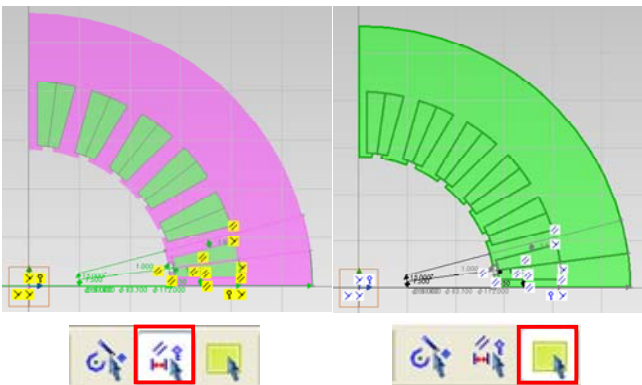
Fig. 19 Selecting a setting target using select filter (constraint
selection (left), region selection (right))

If there are any points on which you are unclear regarding the new functions, or if you would like more information, please feel free to contact our support staff.

(Takayuki Nishio)

In Conclusion

The functions of Ver.12.1 introduced in this issue are also published in the New Features materials found at the webpage below, so please take a look.

http://www.jmag-international.com/products/swf/jmag-designer_ver121_en.swf

Is FEA Effective in Motor Development? Issue 3 FEA for Understanding Detailed Phenomena

This issue is aimed at those designing or using motors, to let you know the effectiveness of utilizing simulation. We hope you will find this useful as a reference for designing better motors.

Overview

This series has explained the issue of "Why is finite element method electromagnetic field analysis (hereafter FEA) effective in motor analysis?" Issue 1 discussed the use of FEA at the concept design and initial design stages for motors, and showed that use of FEA at the initial design stage allows high-speed investigation of design proposals with many degrees of freedom, which is difficult to calculate by hand. Issue 2 explained that, at the detailed design stage, FEA can be used for trial-and-error to economize on detailed designs. This final issue discusses the significance of FEA for detailed understanding of the phenomena that occur inside a motor.

Actual measurement tells you about performance and quality, but it does not tell you what the issues are

Prototypes are produced in order to evaluate whether developed products that have passed through concept design and detailed de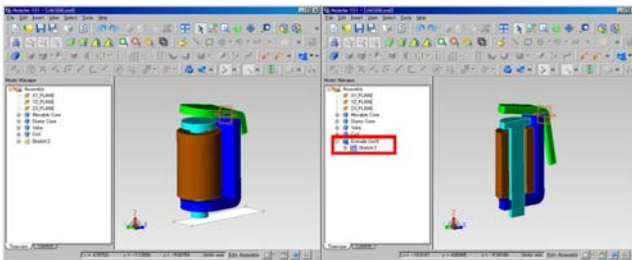sign can display performance as expected from their design, and their performance is measured using measuring devices or test benches. For example, the quality of a design can be evaluated by using measurement with a motor test bench to see if its output is as intended. These results come out clear and in black and white, but do not tell you the reason why the desired performance was not achieved, or what needs to be improved (fig. 1). Hints can be found through careful analysis of measurement results, but there are many design elements (causal elements), so it is not easy to find the cause.
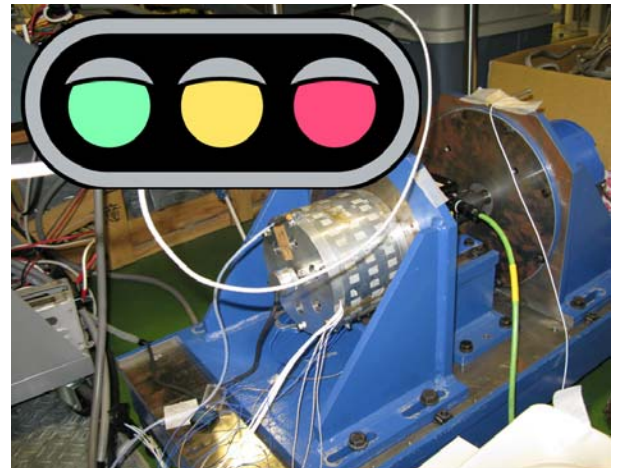
Fig. 1 Actual measurement can tell you about quality and provide hints, but...

Measurement is not easy

Measurement itself is not easy. For example, reduced loss and improved efficiency are constant goals for motors, and ever more reductions in loss are desirable in development. However, motors have become more efficient compared to earlier times, with amounts of loss that are normal today representing a large part of the work to be done, so more attention is being paid to areas where loss reduction can only be achieved by very close

examination. It is as though most of a great feast has been finished, and it is now a matter of scraping up what is left around the edges.

Let's take iron loss measurement as an example. In theory, iron loss is separated into hysteresis loss and eddy current loss, but these cannot directly be measured separately, so they are separated by using theoretical formulas on measurement results. Traditionally, measurements using Epstein's method have been used to measure the loss in a laminated core. JMAG's iron loss tool also obtains iron loss using this data during practical calculation, and this method is thought to provide a certain degree of accuracy even now.

However, with reductions in motor size, operation in high frequency and high magnetic flux density regions that were not used previously is increasing in order to promote higher performance, and iron loss in these operation regions is getting more attention. Superimposed direct current has a large effect on loss in these regions, but Epstein's method is not adequate for loss measurement with high frequency and high magnetic flux density because it cannot account for superimposed direct current. Because of this, analysis using these results does not have sufficient accuracy, so something needs to be done to improve accuracy. Further, measurement itself is becoming more difficult because high-output and high-fidelity power supplies are necessary to measure loss with high frequency and high magnetic flux density (fig. 2).
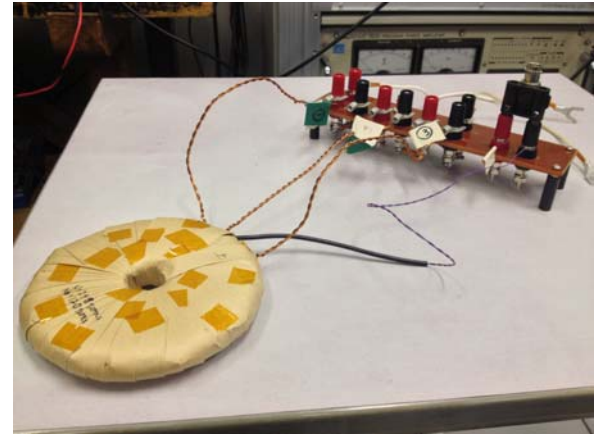
Fig. 2 Loss measurement of a ring core

Using FEA to bolster understanding and analysis of real phenomena

This is where FEA shows its effectiveness. FEA theoretically allows complex phenomena to be analyzed by modeling various physical phenomena. In reality, it is extremely difficult to "model all physical phenomena," but modeling with attention to the physical phenomena that are thought to make large contributions and the phenomena that are being focused on makes it possible to estimate how much influence these have.

Returning to the example given above, in order to find iron loss, which is difficult to measure, faithfully modeling material behavior and running analysis, such as using FEA to trace materials' hysteresis loops or directly analyze eddy current behavior, can be a great help in confirming and understanding their behavior. By comparing these analysis results with measurement results and interpolating them with each other, phenomena that could not previously be understood can now be understood, which should provide hints as to what can be done in response to the problem (fig. 3).
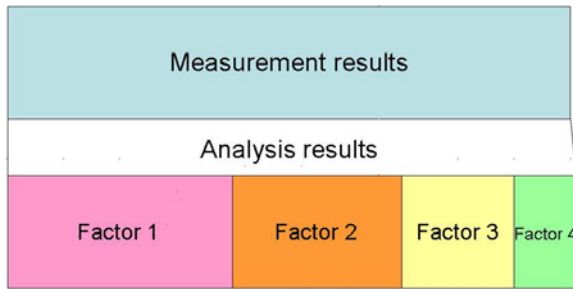
Fig. 3 Analysis results can help in factor analysis

If evaluation of all physical phenomena is done in advance and development is carried out ideally exactly as designed, problems should not be discovered at the prototype evaluation stage, but sometimes events occur that are unexpected and whose cause it is difficult to know. In these situations, the correct approach is to compare measurement results with expectations from analysis, make use of all available information, and find a way to learn the cause and create a response plan.

JMAG loss analysis functions to improve model fidelity in line with theory, in order to come closer to real phenomena

In order to realize "FEA for understanding detailed phenomena," this section introduces the recently released JMAG-Designer's new functions for improving material loss analysis accuracy for laminated steel sheet.

Material properties modeling and iron loss eddy current components

In order to accurately analyze eddy currents in laminated steel sheet using FEA, ideally one would model the steel sheets one by one before analysis. However, this is not practical because it would mean an enormous calculation scale in reality. The

function that solves this problem with practical calculation is "Eddy Current Loss Calculation for Laminated Steel Sheet." This analysis function itself was released in JMAG-Designer Ver.12.0, so many readers are probably already aware of it, but I would like to introduce it once again.

This function one-dimensionally obtains eddy currents (skin currents) in the lamination direction of laminated steel sheet from time variations in the magnetic flux density and the material's permeability, electric conductivity, and lamination thickness, making it possible to obtain eddy current loss from 2D analysis results. For 2D analysis, the concept is like 2D + 1D (fig. 4).
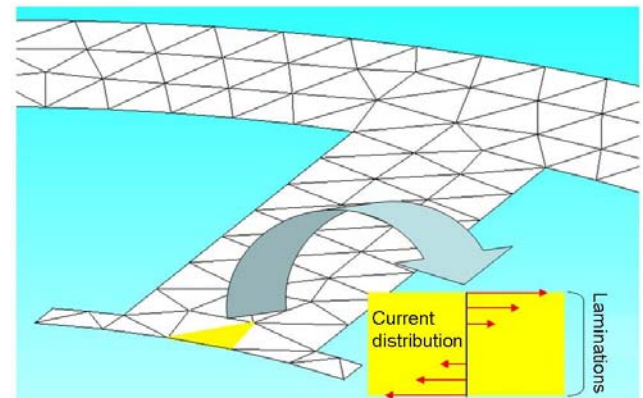
Fig. 4 Concept of modeling in Eddy Current Loss Calculation for Laminated Steel Sheet

This method makes it possible to reduce calculation time to a manageable amount of time because it does not generate mesh in the lamination direction. It can also be applied to 3D analysis models. It has the disadvantages that in reality it ignores existing currents that are turned back in the lamination direction and that it is necessary to make a distinction with in-plane eddy currents, but it makes it possible to estimate the eddy current component of the iron loss in transient analysis, which was not possible with earlier iron loss analysis tools.

One of the problems raised in measurement (Epstein's method) is that high frequency and high magnetic flux density measurement is very difficult. As mentioned earlier, a high-quality, large-current power supply at high frequency is needed to carry out measurements in these regions. However, because it is difficult to get this kind of power supply, high-frequency loss outside the measurement range is obtained using extrapolation from low-frequency measurement results as a quadratic function of the frequency. Because of this, the higher the frequency is, the stronger the tendency toward overestimation, which causes error to be produced.

Eddy current loss can be obtained with high precision using the Eddy Current Loss Calculation for Laminated Steel Sheet function because eddy current loss is solved almost directly, making extrapolation unnecessary, and because it is possible to account for the phenomenon of the skin depth becoming thinner with increasing frequency. Loss can be understood with precision by comparing this function and measurement results, helping to solve the problem.

Material properties modeling and iron loss hysteresis components

I will introduce functions for improving analysis accuracy for hysteresis loss here, like I have for eddy currents. The policy for modeling the phenomena is, of course, to try to grasp hysteresis precisely.

Recently, motors with PWM drive have increased, but with PWM drive, the current waveform supplied to the motor has time harmonics superimposed by switching in addition to the fundamental wave. Accordingly, when seen on a micro level, its shape oscillates due to time harmonics in areas with DC offset caused by the fundamental wave. Because of this, the operating state of the magnetic circuit also has circulating minor hysteresis loops caused by superimposed DC.

Measurements made with Epstein's method cannot evaluate the effects of superimposed direct current because they measure loss by adding an alternating magnetic field around the zero point. The effect is small even with offset from superimposed DC so long as the operating state has relatively low saturation, but hysteresis loops become dramatically larger when saturation regions of silicon steel sheet are used (fig. 5). This means that the hysteresis loss is different for cases with and without superimposed DC.
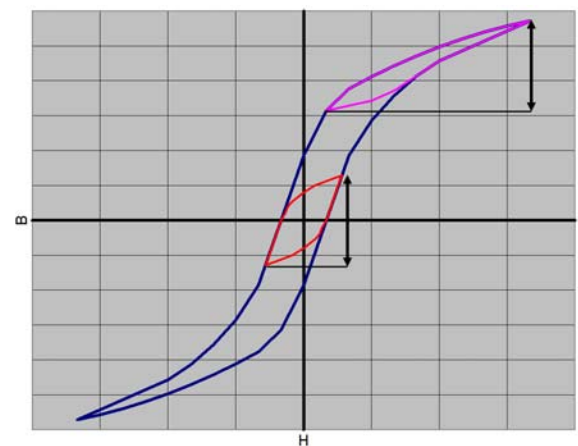
Fig. 5 Hysteresis loss

Recently, operating magnetic flux densies have been made higher in order to advance the miniaturization of electric motors, and it is often thought that a certain amount of magnetic saturation is inevitable so that, combined with the effects of PWM drive, the danger of hysteresis loss becoming larger than expected has become greater.

Functions have been implemented as of JMAG-Designer Ver.12.1 for carrying out magnetic field analysis accounting for hysteresis minor loops.

Previously this was done using user subroutines, but it can now be set from the user interface. Regarding the issue of creating materials' hysteresis loops, a function is available, only for silicon steel sheet with iron loss properties, for automatic creation of hysteresis loops using that material's data. This is in addition to the method of users defining their own loops as point sequences.

Geometry modeling and magnet eddy current loss evaluation

Magnet temperature issues due to eddy current loss in magnets and reduced performance that comes with them are big problems for permanent magnet motors. The magnets are often incorporated into the rotor, so it is technically difficult to take temperature measurements of loss occurring in the magnetic substance while it is rotating.

In order to estimate this loss using analysis, it would be ideal to run a 3D analysis and an analysis with simulation of the eddy currents flowing in the magnets, but this is not practical because the calculation scale of 3D analysis is too large. As I explained in Issue 2, by using 2D analysis results and 3D analysis of the rotor only with magnetic flux boundary conditions applied, it is possible to calculate loss in the magnets with high precision in a reasonable calculation time (fig. 6).
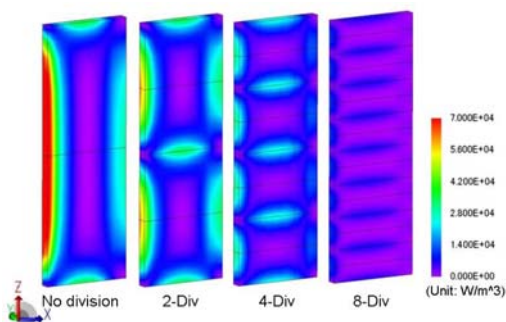
Fig. 6 Heat generation distribution

from magnet eddy current loss

Functions for geometry modeling and stray load loss calculation

Like magnet eddy current loss, stray load loss is another area where some overlooked tidbits may be picked up. For example, eddy current loss produced in a motor case by leakage flux and coil ends is one possibility. These losses are relatively small, and measuring them individually is very difficult.

For this reason, it is important to confirm in advance that they are quantitatively small by calculating the losses using analysis. When loss is found to be larger than design values after the fact, a check must be done to see whether stray load loss is being produced in unexpected places.

Stray load loss is produced in motor cases, etc., so it is necessary for analysis to model all of the parts from which the motor is constructed, which requires 3D analysis. JMAG includes the following three functions to support the pursuit of stray load loss while both preserving calculation accuracy and controlling calculation scale in 3D analysis.

・Extended slide mesh

・Extruded mesh

・Coil end creation functions

With extended slide mesh functions, it is now possible to use slide mesh in geometries in which the motor cover is overhanging, which was not possible with previous cylindrical meshes. This makes it possible to obtain eddy currents with a higher degree of stability than when using patch mesh (fig. 6).

When extruded mesh is used to confirm a geometry such as a motor that has an identical cross-section at any point along its length, it uses 2D and extrusion to make a 3D mesh for that part, so the number of divisions in the radial and axial directions can be set appropriately. This allows a

3D model to preserve calculation accuracy while avoiding increases in the number of elements (fig. 7).
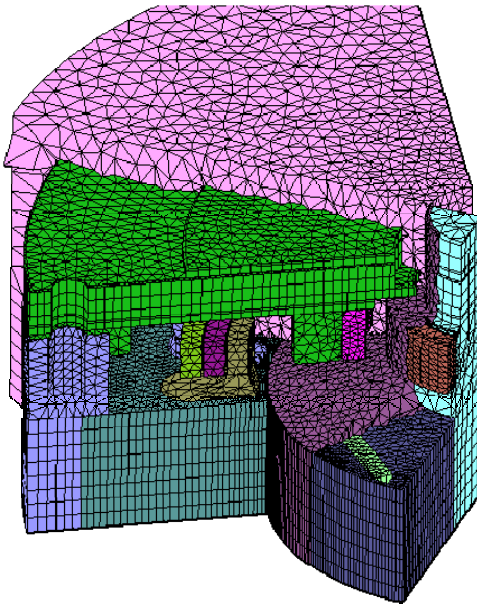
Fig. 7 Combination of expanded slide mesh and extruded mesh

Coil end creation functions allow the simple creation of coil end solids that are difficult to create as geometries in CAD. In order to consider stray load loss, the effects of the magnetic field created by the coil ends must be evaluated, so modeling functions are necessary for the coil ends (fig. 8).
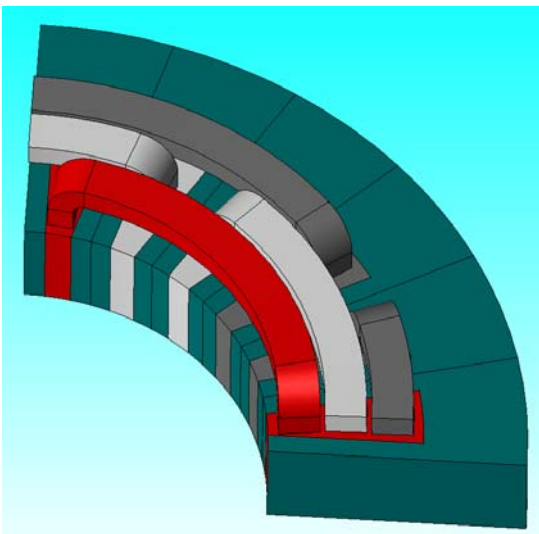
Fig. 8 Geometry created using a coil end template

These analysis functions make it easy to evaluate stray load loss.

Ways to increase calculation speed for detailed analysis

It is unavoidable that the scale of calculations for these high-precision calculations will grow large. For this reason, solvers that can process large-scale models with high speed are indispensable. In addition to a reevaluation of calculation methods, efforts have been made to extract better performance from hardware in order to achieve higher solver speeds in JMAG. It is well known that SMP and DMP are now common ways of increasing calculation speed with parallel processing by multiple CPUs or cores, but it is now also possible to use GPUs (Graphic Processing Units) intended for image processing to accelerate calculation.

These developments in modeling and calculation technologies have increased analysis precision, so analysis of measurement data is more powerfully supported.

Detailed analysis functions other than for loss

I have mainly focused here on functions for accurate loss calculation, but JMAG can also be used for detailed calculations other than for loss. For example, development is ongoing for consideration of degradation of magnetic properties due to stress by combination with structural analysis, and simpler linking with other applications for thermal fluid analysis, making it easier to do investigations that straddle multiple physical domains.

In Conclusion

Over these three issues, I have explained the effectiveness of FEA in motor development. JMAG is constantly striving for improved functionality and increased performance, but we will never be able to completely keep up with our users' ever-increasing demands. Still, we are continuing with our development so that we will not be left too far behind, and it is our greatest wish to provide a tool that will be even a little useful for all of you. 🇯

(Yoshiyuki Sakashita)

Issue 4 Applications for Induction Heating Phenomena

This report introduces papers on induction heating phenomena used in various fields. Taken from the latest papers published by the IEEE, these provide an overview of the kinds of products and technologies induction heating is used in according to the problems or phenomena that need to be analyzed. I have included 18 example applications in the hope that, whatever issues you are dealing with, you may be able to see how similar issues are dealt with in other fields.

Overview

Induction heating analysis tends to have large calculation loads, but with improved performance in calculating machines in recent years, environments are now made so that it can be done right at design facilities. However, induction heating is used in many different fields, and involves many different issues. In this report, I will give an overview of papers on a wide variety of uses for these phenomena, organized by the issue being covered. I have tried to pull these together so that you may find hints from other fields for issues you need to solve, and I hope you will find it useful. These are taken from a survey of papers published in "IEEE Transactions on Magnetics" in recent years, with a focus on electromagnetic phenomena.

Induction Heating Phenomena

I will first give a brief introduction to induction heating phenomena. When alternating current flows in a coil and a magnetized object moves at high speed, nearby conductors produce eddy currents. If the heat generated by these eddy currents is noticeably larger than the heat given off, a temperature rise is seen, which is induction heating phenomena. In general, there are two ways of working with heating phenomena. The phenomena being treated differ greatly depending on whether you are doing heat reduction design to control the heat that is generated, or you are actively making use of the heat generated in objects. This report focuses on the latter, making active use of generated heat. Compared to traditional heating methods using hot gas, induction heating methods making active use of heat generation have many benefits, including allowing localized heating and rapid heating, and being easier to incorporate into production lines. However, they also have their problems, such as that induction heating equipment can be very expensive, and coil design and current conditions need to be controlled to ensure uniform heating. The following sections will present relevant literature and fields for various issues.

Applications by Issue
Issue: "Uniform thermal distribution"

In induction heating using heating coils, eddy currents are produced in the surface facing a heating coil, causing the temperature to rise. Because of how this is done, it is necessary to properly investigate the heating coil's shape and the current conditions if you want the temperature to rise uniformly. A look at trends in the literature shows that uniformity is used as an objective

function in optimization methods.

It has been shown that a more uniform thermal distribution can be provided by induction cookers by changing the coil design from single-coil to seven-coil [1]. With a single-coil system, the heating in the surface facing the coil becomes localized, leading to fast aging of the pan, but this can be improved with multicoils design. The influence of proximity effects among coils have also been discussed [2].

Coils for heating nonmagnetic strips while moving them can either come in solenoid or transverse form. Optimization calculations have been carried out for uniform heating of strips of different widths using a multi-coil system with the latter coil shape [3]. A case has been reported of using UVW 3-phase heating coils to heat aluminum sheets uniformly while moving them. In this example, distributions of eddy current, magnetic force, and power density along the position of the strip are studied in order to evaluate the heating uniformity [4].

Issue: "Localized heating"

These heating methods can be seen as taking advantage of the ability of induction heating phenomena to produce heat in a limited area only. Loss produced in the work piece is concentrated in the parts facing the coil. This is because, when the amount of generated heat is increased with more current, the temperature can be rapidly raised in just the target area before the heat spreads out.

A 3D analysis example is given using an inductor for tube induction welding. The analysis of the tube uses a new strategy in displaying the movement of a metal strip [5].

To cause solder paste reflow in a printed circuit board (PCB), either hot air convection or infrared ovens have been relied on in the past. However, heat stress can result when the entire package is heated, and

unexpected defects may occur. Localized heating using induction heating has been tried for this purpose [18].

An example using induction heating for shrink fits has also been reported. Shrink fits are joints in which two or more parts need to be fit together, so the dimensions of the outer metal part are increased by induction heating, another metal part is inserted there, and the whole system is consequently cooled. A complex analysis of these phenomena is performed by a fully adaptive higher-order finite element method with thermoelastic displacements in addition to coupled magnetic field and temperature field analysis [6].

A thermo-inductive technique for detecting defects in metallic pieces has also been written about. Eddy currents concentrate in areas with flaws, so a method has been demonstrated to measure areas of temperature rise using an infrared camera [7].

Issue: "Higher heating efficiency"

Use of an inductor transfers magnetic flux through the air, so energy is lost in that space. This makes it necessary to find suitable electromagnetic means of increasing efficiency. In particular, non-magnetic materials do not transfer flux as easily as magnetic materials, so problems tend to arise.

Various methods are being tried in induction cookers, including improving the coupling between the inductor and pot using a ferrite core, and placing an aluminum foil to shield the electronics from magnetic flux. In a report focusing on efficiency in planar inductors for induction cookers, comparisons are made of analyses run with variations such as materials, number of turns, current frequency, type of cable, and placement of the ferrite core [8].

A concept is proposed of forcing a billet to rotate at high speed in a dc magnetic field to induce heating in order to increase heating efficiency in a nonmagnetic work piece such as aluminum. This method is interesting

in that it uses dc current and magnets rather than using ac current [9].

Issue: "Finding the circuit constant of induction coils"

When thinking about how to supply the current needed for induction heating, the focus shifts from controlling current conditions to the coil's circuit constant. Examples have been seen of obtaining circuit constants in induction cookers, etc. [8].

Methods of heating aluminum sheet material while moving it are being investigated. 2-D analysis is carried out to reduce solution time, but computational accuracy can be improved by accounting for the end-turn leakage inductance [4].

Issue: "Reducing stray field"

Devices built so that the magnetic circuit is surrounded by magnetic materials account for a minority of induction heaters. However, if it is not surrounded, magnetic flux disperses into the surrounding region. Shielding for controlling stray field is found in several different fields.

A system for high-temperature levitation melting induction heating has been reported. Heating coils are positioned so that magnetic flux will not leak into the surrounding region [10].

Issue: "Finding and controlling electromagnetic force distributions"

Lorentz force from generated eddy currents cannot be ignored when a large amount of electric power is applied in order to heat a target object to a high temperature, because the magnetic flux density also increases. Just as there is a field of study for restraining and regulating the Lorentz force distribution, there is a field for actively making use of Lorentz force to convey electricity-conducting liquids.

A study was reported relating to a pump for high-temperature molten metal. This uses a mechanism to move metal by applying a twisted rotating magnetic field to liquid metal from outside. Reverse flow can occur if the Lorentz force produced in a cross-section is nonuniform, so the study pays particular attention to uniformity of electromagnetic force [11].

In relation to the forces generated when 3-phase alternating current is applied to thin steel plate being conveyed, another report gives a comparison of the attractive force caused by magnetization and the repelling force caused by Lorentz force. The frequency determines the relationship between both of their magnitudes [12].

Issue: "Conveying electrically conductive liquids"

If a liquid is electrically conductive, it can be adjusted to flow in the desired direction by producing Lorentz force.

One paper presents a system to move molten metal by generating a rotating magnetic field in it [11]. Another gives a report of a triply coupled magnetic field/temperature field/field of flow analysis of inductively heated incompressible flow of electrically conductive liquid in ceramic pipe [13]. There is also a report of contactless purification of metal by levitation melting using the Lorentz force generated in it [10].

Issue: "Material modeling"

For induction heating analysis, accounting for temperature dependency in the material being heated is important from the standpoint of accuracy. A particular problem is that it is difficult to obtain magnetic properties taking account of temperature dependence in magnetic materials. Simplified methods are also needed for analyzing composite materials with complex structure.

It has been reported that it is important in terms of accuracy to take account of the temperature dependence of the B-H curve when doing analyses of

billet heaters that are used, for example, for the shaft of a car. I think this can serve as a useful reference for the temperature dependence of carbon steel [14].

Induction heating is being used for heat treatment of carbon fiber reinforced polymer (CFRP) composites, which have high mechanical and chemical resistance per unit weight. Issues regarding how to model multilayer CFRP composites and ways to handle anisotropy in electrical properties for analysis have been published [15].

Issue: "Accurate control"

Compared to gas heating methods, induction heating allows simple adjustment of the amount of heat by simply controlling the current. I found an example of control of position with attention to regulation. Traditionally, position has been controlled by pneumatic elements, but a possibility of producing thermoelastic dilatation using induction heating with the goal of more precise regulation has been suggested [16].

Issue: "Contactless application"

Compared to electric heating and gas heating, induction heating allows higher temperatures to be reached in the target object without any contact. Active applications are being investigated in fields where as little mixture with other substances as possible is necessary.

A case has been reported of refining metal to a high degree of purity without contact through levitation melting [10]. There is also a method of heating magnetic fluids with induction heating as a form of magnetic induction hyperthermia treatments to cancers. The report points out that the induction heating depends on the relation between the magnetic core size and the coating layer thickness [17]. When tension is applied to thin steel plate that is being conveyed by the contacting pinch rollers used to prevent it from slackening by its own weight, surface cracks and exfoliation of coating can occur. The use of a linear induction motor to apply electromagnetic force to steel sheet without contact has been tried as a way to avoid this problem [12].

In Conclusion

These examples are not all necessarily based in industry, but they help to reaffirm the wide range of uses and studies that can be achieved with induction heating phenomena. While each of them deals with its own issues, common points can be seen when looking at the phenomena involved.

(Hiroshi Hashimoto)

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Fully Mastering JMAG

Common Questions for JMAG

Traditionally, JMAG has been used mainly by technicians specializing in electrical systems, but in recent years there have been more opportunities for mechanical designers and others to use it for electromagnetic designs outside of their own field. There are probably quite a few among those who have made the transition to this unfamiliar tool who worry about how they should use it to perform better analyses.

This section of the Newsletter deals with questions that we receive most often in order to help people who are having similar kinds of problems, and make JMAG a more user-friendly tool.

The questions here cover a wide range of topics, such as "Operation Methods", "Analysis Techniques", "Results Evaluation" and "Troubleshooting". Each question is identified with labels, so please take a look at the topics that interest you.

OPERATION METHODS (FAQ-885)

Q1. Scripts that are recorded using the Automatic Script function are sometimes difficult to understand for me. How can I easily edit it?

A1. Editing the recorded scripts with a little ingenuity makes it possible to perceive the contents of the code a great deal.

As you mentioned, most of the script coding recorded using the Automatic Script function are redundant and hard to understand. Indexes are often substituted for the command arguments, leading to make the command objects hard to be distinguished.

In order to make the recorded script descriptions understandable, it is recommended to apply rules mentioned below.

Rule 1: Insert comments dutifully.

Rule 2: Define new objects to divide the long script in single line into multiple short scripts.

Rule 3: Replace the indexes with specific names for the arguments.

For example, the procedure to change the number of turns 35 to 50 of U-phase coil in the circuit FEM coil is recorded by the Automatic Script function shown as below.

```
Set app = designer
Call app.SetCurrentStudy(1)
Callapp.GetModel(0).GetStudy(1).GetCircuit().GetSubCircuit("StarConnection1").GetComponent("U-phase coil").SetValue("Turn", 50)
```

According to the above mentioned rule, this script can be revised the one as below.

Rule 1: Insert comments dutifully.

Applying rule 1: Change the value for Number of Turns to 50 under Study > Circuit > Components > FEM Coil > U-phase coil.

Rule 3: Replace the indexes with specific names for the arguments.

Applying rule 3: Index 1 is replaced with the study name "2D_PM_motor_load".

Set study = model.GetStudy("2D_PM_motor_load")

Rule 2: Define new objects to divide the long script in single line into multiple short scripts.

Applying rule 2: The long script in single line is divided into multiple short scripts as below.

```
Set study = model.GetStudy("2D_PM_motor_load")
Set circuit = study.GetCircuit()
Set subcircuit = circuit.GetSubCircuit("Star Connection1")
Set component = subcircuit. GetComponent("U-phase coil")
Call component.SetValue("Turn", 50)
```

【Other resources】

Many people are highly concerned with topics relating to scripts, so it has been frequently talked about as a theme. Some seminar materials are put on the JMAG website. Please visit the site below mentioned.

http://www.jmag-international.com/support/en/seminar/pdf/uc2011_30_eng.pdf (user verification required)

Operation Streamlining Session in JMAG Users Conference 2011　JMAG-Designer Script Course (Practice Version)

ANALYSIS TECHNIQUES (FAQ-38)

Q2. Please tell me how to how to calculate motor efficiency.

A2. Efficiency is expressed using the proportion of output power and input power.

Motor efficiency can be expressed using the proportion of output power from the motor and input power to the motor.

In further details, motor output is calculated as the product of generated torque and rotation speed, and motor input is obtained as the sum of its output and loss, respectively. Then, motor loss is assumed that it is sum of copper loss, iron loss, mechanical loss, and wind loss, so how to calculate the motor efficiency is described as the formulas below.

Motor efficiency = output / input

Output = torque * rotation speed

Input = output + loss

Loss = copper loss + iron loss + mechanical loss and wind loss

Loss 1:　Modeling the motor windings using the FEM coil and applying voltage as input make it possible to account for copper loss in magnetic field analysis.

Loss 2:　Iron loss is not accounted for during the magnetic field analysis using JMAG-Designer. It can be obtained using

the iron loss calculation tool as post-processing after completing the magnetic field analysis.

Loss 3:   Mechanical loss and wind loss are also not accounted for during the magnetic field analysis using JMAG-Designer as well. In order to include mechanical loss and wind loss into the loss, it needs to be calculated from the results of structural analysis or actual measurements.

Q3. I am going to use the Parallel Computing functions to shorten the analysis time. I presume that these functions provide two, four, and eight parallel processing. Is the same number of analysis licenses as the degree of parallelism required?

A3. The required number of analysis licenses for parallel computing is half of the degree of parallelism.

One solver license for the analysis type to be carried out is necessary. In addition to that, the required number of parallel licenses is half of the number of parallelism degree. For example, when running a 3D transient response analysis in four parallel processing, one license for transient response analysis and two for parallel computing are needed, respectively. The license name for parallel computing is "SMP".

Beside the Parallel Computing functions, in JMAG-Designer using the GPU (Graphics Processing Unit) leads to the shorter calculation time. The required number of SMP licenses when running analyses using GPU is as listed below.

For 1 GPU board, 2 SMP licenses are required.

For 2 GPU boards, 3 SMP licenses are required.

For 4 GPU boards, 5 SMP licenses are required.

【Other resources】

- Refer to the following online help for more information on shared memory multiprocessing (SMP).

JMAG-Designer Online Help > Functions of Analysis > Magnetic Field Analysis > Study Properties > Solver Calculation > Parallel Computing (SMP)

- Refer to the following help for more information on graphics processing unit (GPU).

Home > Functions of Analysis > Magnetic Field Analysis > Study Properties > Solver Calculation > Use GPU

Q4. What kind of settings should I make when obtaining the magnetic flux amount that passes through a certain cross-section?

A4. "Calculation" that is a post-process function for analysis results is available.

In JMAG-Designer v12.0 or later, calculation functions for parts, faces, and edges have been newly added. For example, calculating "the magnetic flux amount (surface integral of magnetic flux density) that flows through the specified arbitrary face" after completing magnetic field analysis is now possible, leading to compare with magnetic equivalent circuit is much

easier.

Please make sure to make a model with selectable faces that are being evaluated before running an analysis.

The steps are as mentioned below (fig.1).

1. Carry out the calculation for magnetic field analysis.

2. Right-click Calculation under Study >Results in Project Manager, and select "Add Surface Calculation".

3. Enter "Magnetic flux amount" in the Title field in the Calculation properties dialog box.

4. Select the face to be evaluated.

5. Select "Magnetic Flux Density" for Result Type.

7. Select "Surface Integral" for Calculation.
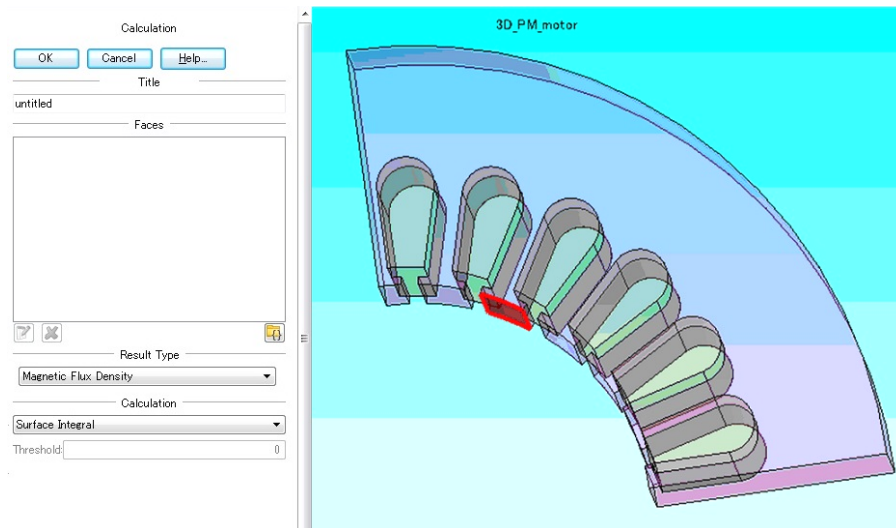
8. Click "OK".

Fig. 1 Surface integral of the magnetic flux density.

9. "Magnetic Flux Density: Magnetic flux amount" is added under Calculation.

10. Right-click "Magnetic Flux Density: Magnetic flux amount" and select "Show" > "Magnetic Flux Amount".

11. Results graph of "Magnetic Flux Amount" appears (fig.2).
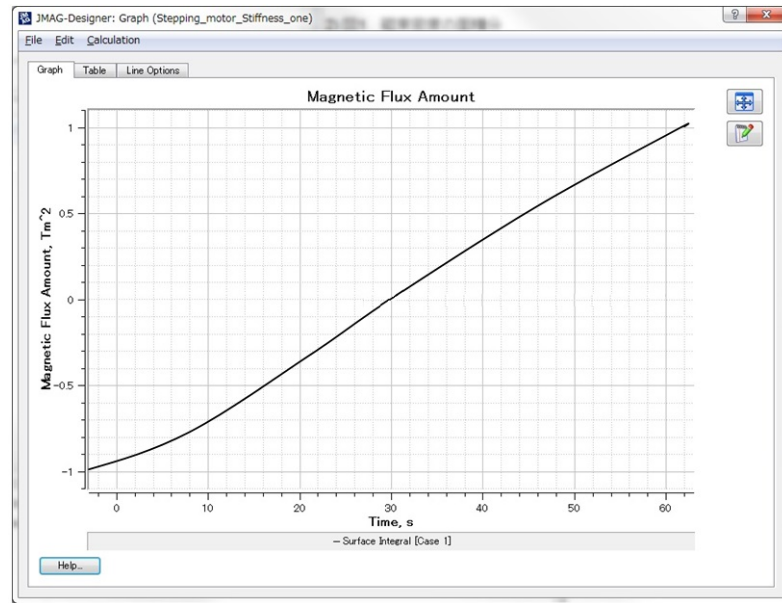
Fig. 2 Magnetic flux amount results

【Other resources】

Refer to the following online help for more information on

CONTENTS tab > Result Display > Tables > Adding Calculation for Parts, Faces, and Edges > Adding Calculation for

Parts, Faces, and Edges

■ Troubleshooting ■

Q5. An error message "RT_simulink was not found" appeared when I executed a calculation with MATLAB/Simulink using a JMAG-RT model. Could you suggest any countermeasure for this case?

A5. This error occurs when dll for S-Function that is used in the JMAG-RT model is not found.

Please check if the file mentioned below is included in the [Current folder] in MATLAB/Simulink when an error message "RT_simulink was not found" appeared.

1. If you are working on MATLAB /Simulink for 32-bit version,

RT_simulink.dll

2. If you are working on MATLAB /Simulink for 64-bit version,

RT_simulink.mexw64

When you found no such files, please find the above mentioned file in the folder mentioned below, and copy it to the [Current folder] in MATLAB/Simulink.

- If your computer's operating system is Japanese,

JMAG-Designer Installation folder¥JMAG_RT¥Simulink¥ja

- If your computer's operating system is any language other than Japanese,

JMAG-Designer Installation folder¥JMAG_RT¥Simulink¥en

Technical FAQ on the Web

We have technical FAQ on our homepage, so come take a look if you have any questions:

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 also update the FAQ on our homepage regularly, so we hope that you can use them along with the Newsletter to help streamline your analysis operations. Please don't hesitate to use JMAG technical support if you have any questions when using JMAG. Let's fully master JMAG-Designer.

(Ming Gao)

Issue 9 Understanding Thermal from A to Z

Has everyone mastered JMAG?

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 introduce "Things that we should know" in JMAG, as well as some advantageous applications.

Overview

There are many people who have the impression that induction heating analysis, thermal demagnetization analysis, and thermal stress analysis are very difficult, aren't there?

JMAG thermal analysis handles simple heat conduction phenomena. For this reason, material properties or conditions to be set are less compared with those for magnetic field analysis, so just understanding the meaning of that makes it possible to run an analysis easily. Coupled analyses between thermal and magnetic field, thermal and structural, and thermal and electric field are deceptively difficult, but they are nothing more than extensions of thermal analysis. Consequently, they are not terribly difficult if you can get a firm grasp of the mechanism of thermal analysis.

In this issue of AtoZ, I will focus on material properties and various conditions that form the basis of thermal analysis and explain what they are so that you can feel thermal analysis and coupled analysis with heat more familiar.

Material Properties

In thermal analysis, material properties need to be specified are only three items, specific heat [J/kg/deg C], thermal conductivity [W/m/deg C], and density [Kg/m^3]. Specific Heat and Thermal Conductivity is set in the Thermal Properties tab of the Material Editor dialog box, and Density is set in the Mechanical Properties tab. (figures 1 and 2) All these material properties can be defined as the table value for Temperature Dependent and nonlinear properties can be taken into account. (fig.3) Temperature Dependency under Density is set to express a phase transformation such as density variations from metal's crystal structure changes in high temperature.

In a coupled analysis between thermal and magnetic field, a model used in a magnetic field analysis is often used also in a thermal analysis as it is. Magnetic field analysis models, however, includes parts such as air regions that are not necessary in a heat conduction analysis, so they must be deleted. In such cases, just clearing the [Include This Material to Analysis] checkbox in the Material properties dialog box of the part makes it possible to delete the part. (fig.4) The part seems to be still exits in the model, but it is exempt from calculation, leading to the shorter calculation time.
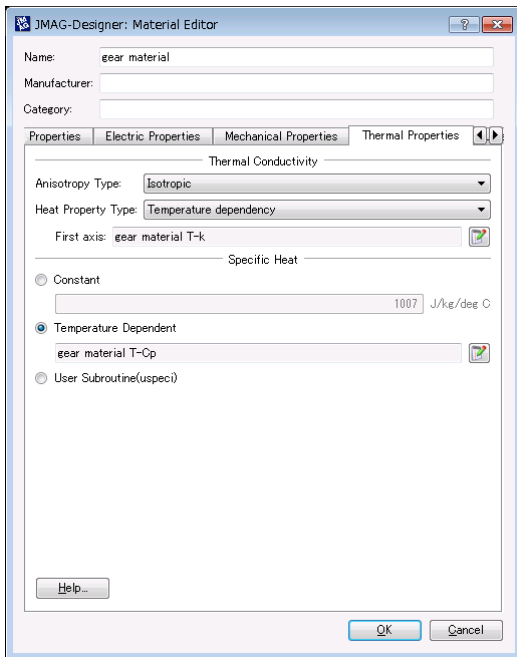
Fig. 1 Thermal Properties tab of the Material Editor dialog box

Fig. 2 Mechanical Properties tab

of the Material Editor dialog box
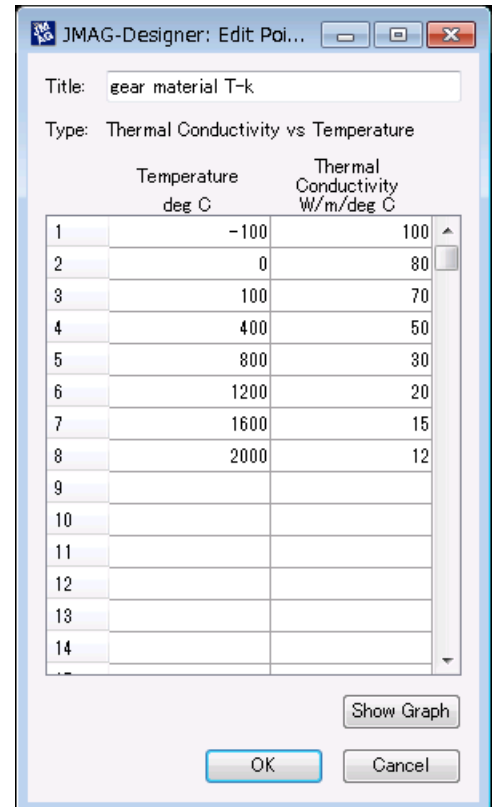
Fig. 3 Temperature dependency table of thermal conductivity.
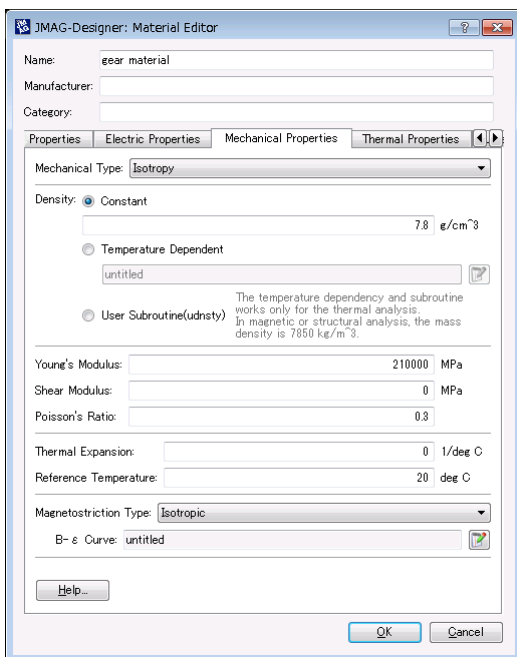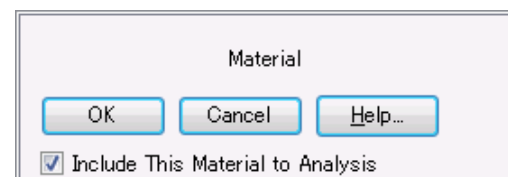

Fig. 4 Material properties screen

Boundary Conditions

Thermal analyses are characterized by their many boundary conditions that can be set compared with other analyses. (fig.5)

Below are descriptions of the meanings and their particular characteristics of boundary conditions unique to thermal analyses.
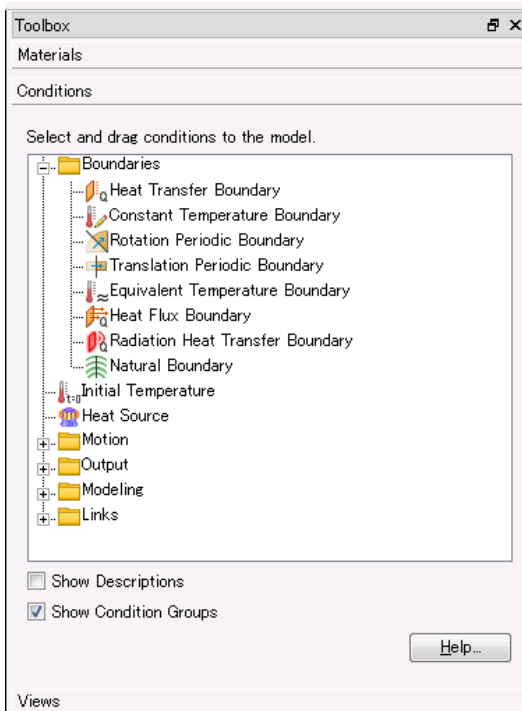
Fig. 5 Boundary conditions list of thermal analysis

Natural Boundary

Natural boundary is one of the boundary conditions that is equivalent to Neumann boundary in Finite Element Method (FEM) analysis and means "heat insulation" in thermal analysis. Heat does not conduct thorough the natural boundary face. In JMAG, natural boundary is virtually set if no boundary condition is set to the part surface. Natural boundary or periodic boundary need to be set to the cross-section when handling a partial model to reduce the analysis region.

Heat Transfer Boundary

Heat value that enters and leaves from the part surface can be controlled by setting heat transfer coefficient [W/m^2/deg C]. Specifying the heat transfer boundary makes it possible to simulate the leakage in the heat value beyond the boundary face etc. without precisely modeling the outer air or liquid beyond the boundary face.

Reference temperature needs to be set in addition to the coefficient for heat transfer boundary

conditions. "Reference temperature" here means the outer ambient temperature beyond the boundary face. The user can arbitrarily specify the value for the temperature and the temperature obtained from the thermal circuit mentioned below can be referred to.

Radiation Heat Transfer Boundary

This condition is set when handling heat radiation effects (heat radiation energy exchange between object surfaces). Heat radiation effects are obvious when the object has a high temperature, but it is not so remarkable under low temperature. For this reason, radiation heat transfer boundary condition is generally not set in analysis under low temperature.

Setting the radiation heat transfer boundary leads to higher calculation costs such as computer memory size and calculation time according to the specified face area. Therefore, it is necessary to study the effects carefully and keep the face to be specified to the minimum.

The following section explains two topics, the meaning of setting parameters and handling of the specified face in order to achieve deeper understanding of radiation heat transfer boundary.

Setting parameters for radiation heat transfer boundary

Heat value density (heat flux) that is radiated and imbibed from the face that the radiation heat transfer boundary condition is set is defined by formula (1).

$$I = \varepsilon\sigma F\{(T+273.15)^4 - (T_0+273.15)^4\} \quad \text{.............. (1)}$$

In this formula, where I is heat flux [W/m^2], where ε is radiant parameter, where σ is Stefan-Boltzmann coefficient (constant), where F is

configuration factor, where T is temperature [deg C] obtained from analysis, and where T_0 is reference temperature [deg C], respectively. The parameters that the user can specify are radiant parameter and reference temperature. 0 to 1 is usually set for radiant parameter. In JMAG, setting the radiant parameter value for the temperature in the table makes it possible to add temperature dependency to the radiant parameter. Configuration factor is automatically calculated internally based on the positional relationship of the parts.

Handling the specified face of radiation heat transfer boundary

Heat radiation energy is exchanged via specified face of the radiation heat transfer boundary. Targets of the heat radiation energy exchange are every direction unless shielding material exists. If heat radiation energy is emitted from a radiation heat transfer boundary's specified face and another radiation heat transfer boundary's specified face is set in its translational direction, heat radiation energy is exchanged between these faces. In case a shielding material exists in the heat radiation energy's translational direction or case neither shielding materials exists nor any other radiation heat transfer boundary's specified face is set, heat radiation energy exchange does not occur but only radiation or imbibition arise. For the case just the heat is radiated from the heat source surface, it is recommended to apply heat transfer boundary conditions after converting the heat radiation to temperature dependency heat transfer coefficient in order to reduce the calculation costs. In the direction that heat radiation energy exchange arises, T_0 corresponds to the temperature on the opposite specified face. On the other hand, T_0 corresponds to the temperature that is previously set by the user in the direction heat radiation energy exchange

does not arise. In the real phenomena, heat sometimes reaches to the back of the shielding material from multiple reflections, but multiple reflections are not taken into account in JMAG.

Conditions

Heat generation and initial temperature are the conditions that are unique to thermal analysis. The meanings of these conditions are as their name and the setting itself is not difficult, but are extremely important conditions when carrying out a coupled analysis with any analysis other than thermal analysis.

The following section explains the meanings of these conditions involving coupled analysis.

Heat generation

Heat source is defined in this condition. You can set the value in total amount [W] or density [W/m^3]. For steady state analysis, it is specified by constant value, and for transient state analysis, different heat sources per analysis time can be set in the table.

Loss that is obtained from magnetic field analysis or electric field analysis can also be set for heat source. Loss distribution is automatically imported as heat source distribution just by specifying the results file from magnetic field analysis or electric field analysis. Heat source can be handled in both distributions amount and total amount in the part. When distribution amount is set for heat source type, the loss distribution obtained from magnetic field analysis or electric field analysis is directly reflected as the heat source distribution of thermal analysis. Heat source distribution is compensated even when meshes are different between magnetic field analysis and thermal analysis. On the other hand, when total amount is set for heat source type, heat value is applied to the entire part as total amount, so heat source distribution in the part is

uniform. When any FEM coil condition or current condition that coil is treated as a block in magnetic field analysis is set, the current distribution can become biased, sometimes leading to a biased joule loss distribution as well. In reality, however, loss arises in every single wire, so the heat source distribution is uniform. In such case, setting total amount for heat source type makes it possible to run an analysis that is realistic.

Initial temperature

The temperature just at the 0 second in analysis time is specified for this condition. This parameter must be set for transient state analysis.

Different temperatures in part, face or vertex can be set for initial temperature. Also, if you have a table file called "temp file" that includes node ID and temperature information and is formatted in the type unique to JMAG, it can be imported as initial temperature. A "temp file" can also be created using Multi-Purpose File Export tool that has been improved in JMAG-Designer Ver.12.1. A "temp file" based on the mesh information of the thermal analysis input data can be exported using Multi-Purpose File Export tool if you have a csv file that includes the coordinate and temperature information and an input data for thermal analysis in JMAG thermal analysis (saved as jcf file).

Heat equivalent circuit

Handling the parts and local thermal phenomenon as lumped constants and analyzing the overall thermal phenomenon in one dimension using an equivalent circuit is often conducted as a simple and high-speed analysis method even today. (fig.6)
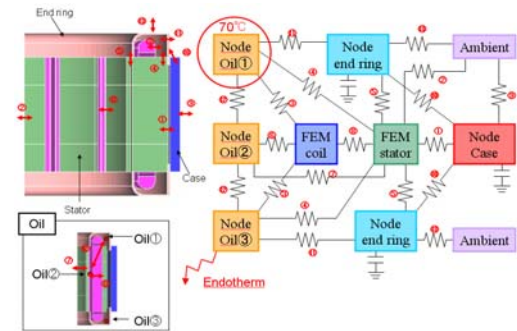
Fig. 6 Heat equivalent circuit

Heat equivalent circuits can be handled also in JMAG, and it is possible to calculate by coupling a detailed thermal analysis using the Finite Element Method (FEM) and a simple analysis using a heat equivalent circuit

Typical heat equivalent circuit component is explained below.

Thermal resistor component

This is a component that simulates the state of being difficult to transfer of heat between terminals. (fig.7). This component corresponds to a resistance in an electric circuit and is one of the frequently used one in heat equivalent circuits.

Heat value Q that transfers between terminals is defined by the formula (2).

$$Q=1/R*(T2-T1) \dots \dots \dots (2)$$

In this formula, where Q is heat value [W], where R is thermal resistance [deg C/W], and where T1 and T2 are terminal temperature [deg C], respectively. Thermal resistor can be defined not only as constant value but as table value for temperature dependency.

Fig. 7 Thermal resistor component

Fig. 8 Heat transfer boundary component and equivalent temperature boundary component

Heat transfer boundary component, equivalent temperature boundary component

These are connection components that connect a heat equivalent circuit and a finite element model. (fig.8) The temperature can be referred to between the heat equivalent circuit and finite element model to each other via these connection components. No special setting para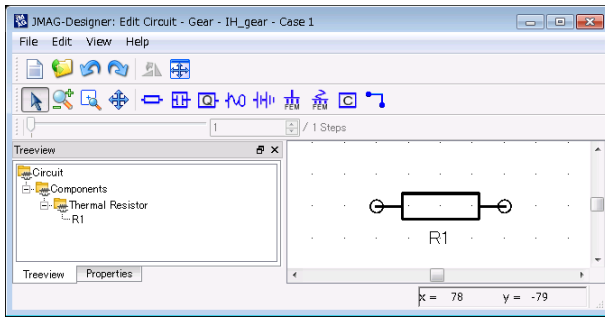meters are set and just selecting the item from the pull-down menu to set which heat transfer boundary condition and which equivalent temperature boundary condition refer to the terminal temperature of the boundary component.

For example, these components are used when connecting the two finite element models that are located apart from each other. (fig.9) For example, air or liquid that are usually needs to be modeled exist between these separated finite element models, so it is assumed that a thermal analysis considering the flow as liquid is required. Such complicated calculation, however, takes an extremely long time and is not easy. In such case, if heat value transfer between these two models is known experientially, simulating the heat value transfer using a heat equivalent circuit and analyzing approximately is more efficient.

Fig. 9 Connecting the finite element models using a heat equivalent circuit

Output

This section explains the post-process conditions to use the results from thermal analysis not as distribution amount but as average value or total value. Of course, JMAG-Designer's post feature is equipped with the function to calculate the average value or total value of distribution amount, but previously setting this kind of post-process conditions makes it possible to streamline the post-process. When referring to the results from the thermal analysis in a coupled analysis, a certain representative value instead of distribution amount would be sometimes suitable and this post-process condition is vital in such case.

Average temperature

This is a condition for calculating the average temperature in the specified region. This condition is set to specify the reference temperature for the

FEM coil or resistance component that temperature dependency resistance is set when coupling with a magnetic field analysis.

Heat flow amount

This is a condition for calculating the heat value that pass through the specified face. Using the JMAG-Designer's post feature makes it possible to obtain the same results by calculating surface integral for the results of the heat flux in the specified face.

In Closing

In this issue, I have introduced the meaning of the features and how to use it concerning the especially significant conditions that are frequently set in thermal analysis. I have more and more conditions that I would like to introduce, so please let me introduce them in the next issue. Be sure not to miss it.

(Masahiko Miwa)

Event Information

JMAG Takes On the Problem of Loss

JMAG is taking on the problem of loss. This issue introduces the "5th Seminar on Advanced Computational Electromagnetics," which will be held in July.

5th Seminar on Advanced Computational Electromagnetics:
-Toward Putting High-Precision Loss Analysis into Practice-
Conference Outline

Host : JSOL Corporation

Date : Tuesday July 23, 2012 13:30-20:00 (including reception)

Venue : TRUST CITY CONFERENCE MARUNOUCHI (in front of Nihonbashi exit of Tokyo Station)

Capacity : 200 persons (may be increased) -

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

Purpose of the Seminar

Environmental problems and energy problems worldwide in recent years have made energy-saving demands on electric devices increasingly severe. At the same time, while efforts toward higher efficiency and lower loss are becoming more extreme, the situation has become so that even a one-percent reduction in loss is nearly impossible to achieve while maintaining costs.

So what is needed to break out of this situation? One thing is to make use of the full potential of material properties.

This is easier said than done. While it is necessary to combine the wisdom from four connected fields to make full use of material properties, we have realized that we are lacking in three of these fields. Because of this, we would like to provide our users with the best analysis functions we have developed while receiving guidance from experts from these different fields.

The first field is material behavior. For example, it is necessary to correctly grasp the effects on behavior, temperature dependency, frequency dependency, and loss due to processing strain, including minor loops, for the magnetic properties of magnetic steel sheet. Precise equipment and technique is needed for this. For this field, we have invited Professor Fujiwara from Doshisha University.

The second field is application technology. It is necessary to understand electric devices such as motors and transformers, and to use the right processing on the right materials and arrange them in the right way. Further, it is also important to understand, for example, the phenomena in a motor controlled by an inverter. This requires knowledge and experience in both electric device design and controls. We have invited Professor Akatsu from Shibaura Institute of Technology for an overview of the future of motor development, Mr. Kometani from Mitsubishi Electric Corporation for the field of analysis of large-scale rotating machines, and Mr. Yamagiwa from Daikin Industries, Ltd. for the field of analysis of mid-sized rotating machines.

The third field is materials development. Thanks to attempts to make full use of materials in product design, design needs have become clear down to the detailed particulars. To make these a reality, technologies for measuring and

analyzing materials accurately and for materials development are needed. We have invited Mr. Toda from JFE Steel Corporation in the field of materials.

Finally, we at JMAG develop analysis technologies to serve as an intermediary for all of you in the three-way relationship between measurement, application, and materials. With our theme of "Advanced Computational Electromagnetics," we invite people working at the vanguard in all different fields for a review of the latest contemporary technologies and a kick-off toward the next step. Please join us if possible.

Program

13:40	**A direction of the future motor development and requests for the motor analysis technique:** Prof. Kan Akatsu, Associate Professor, Faculty of Engineering, Electric Engineering, Shibaura Institute of Technology This presentation estimates a direction of the motor future development and the required motor analysis techniques matched with the development are pointed out. The background of this estimation is based on a request of the shorter development term due to the necessity of the consumption energy reduction, the rare metal crisis and the technical progress in the developing countries. Adding that the developing machine type becomes various, not only PMSM but also IM, Syn.RM and SRM, the multi physics analysis including the stress analysis, vibration analysis and so on is also required. From these trends, the presentation shows the road map of the motor development, the future analysis techniques are requested based on the recent analysis techniques.
14:20	**Advances in materials measurement and modeling technology (working title):** Prof. Kouji Fujiwara, Department of Electrical Engineering, Faculty of Science and Engineering, Doshisha University
15:00	**The Subjects of Large-scale Loss Analysis:** Dr. Haruyuki Kometani, Advanced Technology R&D Center Electromagnetic Systems Dept., Mitsubishi Electric Corporation The examples of the large-scale loss analysis in large-sized rotating machines are shown, such as the analysis of eddy current loss generated in the end region of large generators. And constructions of the analysis system which is needed when analyzing are shown. Moreover, the problems for putting large-scale analysis in practical use are shown.
16:00	**The present conditions and problem of the loss analysis in the PM motor:** Mr. Akio Yamagiwa, Chief Researcher, Environmental Technology Laboratory, Daikin Industries, LTD. In IPMSM model suggested in the Institute of Electrical Engineers of Japan and PMASynRM which was studied by Li-EAD project of NEDO, We compare the experiment with the result of the loss analysis using JMAG and introduce the present level of the loss analysis. In addition, We will introduce the problem of loss analysis becoming necessary for practical use in future.
16:40	**Recent Development and Application Technology of Non-oriented Electrical Steel Sheets:** Mr. Hiroaki Toda, Senior Researcher, Steel Research laboratory, Electrical Steel Research Dept., JFE Steel Corporation Recently, there has been a growing need for improving motor efficiency in response to environmental problems such as global warming and energy problems. This leads to a strong demand for further improvement of non-oriented electrical steel sheets. In this presentation, a newly developed high flux density non-oriented electrical steel (JNP Core) and its evaluation results of the characteristics in induction motor are reported after the introduction of conventional electrical steel sheets. Motor cores are often subjected to compressive stress by heat shrinking etc. It is well-known that material iron loss deteriorates largely by compressive stress. It is effective to reduce material magnetostriction in order to suppress the deterioration of iron loss due to compressive stress. Therefore, 6.5% Si steel sheets shows the lowest deterioration ratio of iron loss under compressive stress because the magnetostriction is almost zero. Furthermore, Si-gradient steel that has 6.5% Si content in the surface layer also exhibits a low deterioration ratio of iron loss under compressive stress.

17:20	**Taking on JMAG:** Dr. Takashi Yamada, JSOL Corporation Precise estimates of loss using electromagnetic field analysis are indispensible to achieve smaller size and higher efficiency in electric and electronic devices. Since we at JSOL released the first version of JMAG over 30 years ago, we have made many technological developments to support customer needs. For loss analysis for motors in particular, we have been at the forefront in taking on new technological developments, by providing iron loss calculation tools based on Steinmetz' empirical formula, including an iron loss materials database, providing magnetic field and loss calculation functions accounting for stress dependency, etc., and many of our users have made use of these functions. At the same time, we have provided useful techniques to our users with proposals for loss analysis methods accounting for circuits and controls, demonstrating their utility in studies with actual machine models. However, the loss analysis that has been used up to now will not be sufficient for demands for high performance in the motors that will be used in the future, and a number of issues have garnered closer attention. For example, issues like, "I'd like to improve iron loss calculation accuracy by considering hysteresis," "Can I balance energy input and output with these tools?" and "Accounting for skew in an induction motor will take too much calculation time..." Right now at JSOL, development is proceeding in an attempt to take on these problems of high-precision loss analysis in areas such as including a hysteresis materials database, development of high speed calculation functions for eddy current loss and hysteresis loss in rotating machines, and high speed calculation of motors with rotor skew. This seminar will present a part of these technological developments, as well as showing a road map for development of high precision loss calculation. We humbly ask that you share your opinions regarding our company's efforts.

JMAG's Development History Regarding Iron Loss
## For improved efficiency in electric devices

Loss analysis has been one of the most important issues in electromagnetic field analysis for ten to fifteen years. Its importance has grown further in recent years. It seems simple to talk about loss analysis, but in fact there are many different ways of seeing it, such as analysis methods, materials modeling, comparison with measurements, etc., and approaches vary according to the problem. The problems and the desired degree of precision have changed over the years, as analysis of more detailed phenomena with high precision is now needed for improved efficiency in electric devices. Technological development that meets high demands is not accomplished overnight, but rather requires many years of achievement plus research and development. This section will explain how JMAG has taken on the theme of loss analysis.

Early attention to the importance of materials data and implementation of functionality

The 2nd Seminar on Advanced Electromagnetic Simulation was held in 2000 in Yokohama. Its title was "Materials Modeling in Electromagnetic Simulation." The importance of and issues in materials modeling were presented by materials manufacturers, university professors, and electric and automobile manufacturers. This is where JMAG's present development direction comes from.

In the same year, JMAG began to include materials data. JMAG was the first software to include properties for all different materials manufacturers. Most likely nobody would disagree with the importance of materials data, but this was the first time that this was included as a function in collaboration with materials manufacturers.
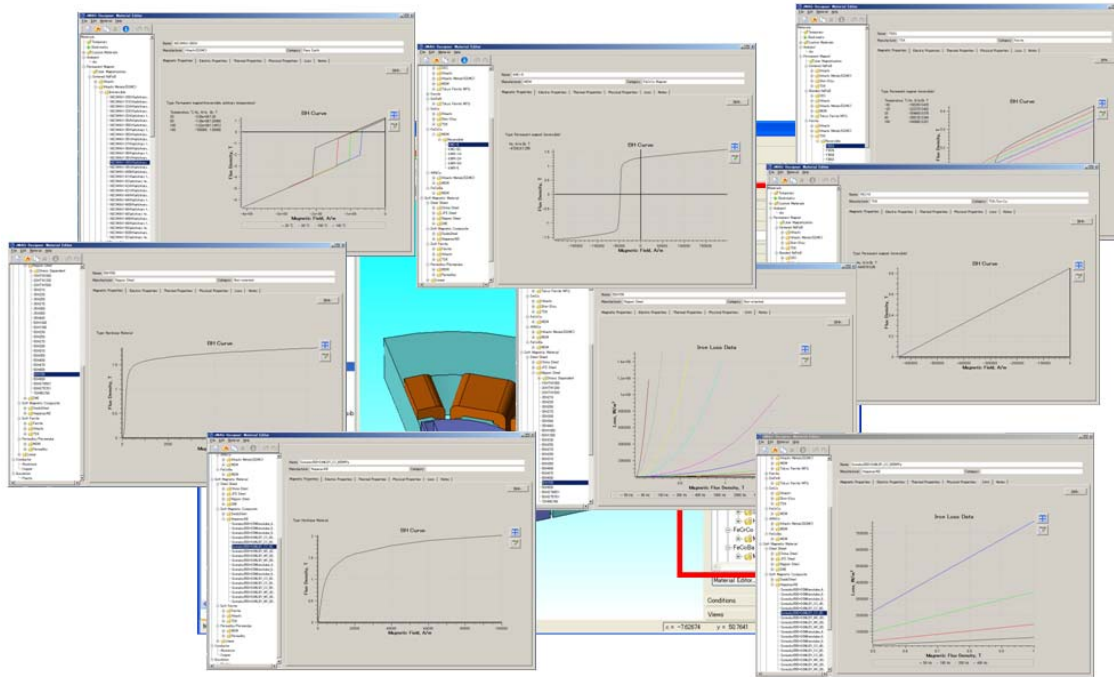
Making detailed loss analysis easy to do

Iron loss analysis becomes more usable with the inclusion of loss data in JMAG, leading to our customers' more detailed demands being met. This means that in response to these demands, JMAG not only "can do analysis," but provides usability that "can do it easily." Consideration of the stress dependency of loss properties is one example. JMAG makes it possible to see minute effects by calculating stresses that were analyzed with structural analysis, and also makes it easy to see them by inputting stress values for different parts. Also, for the first time it became practical to analyze high-frequency iron loss by accurately obtaining high-frequency current in a short time using detailed motor models with JMAG-RT. Skin effects and proximity effects due to high-frequency current in the wires are important for loss analysis of switching transformers. It is understood that analysis can be done by modeling the wires, and JMAG automates this modeling. This is how JMAG was able to provide functions to carry out detailed loss analysis easily.
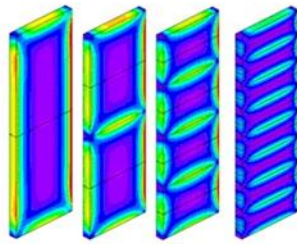
Magnet eddy current loss
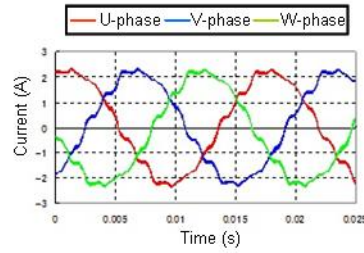
Harmonic loss
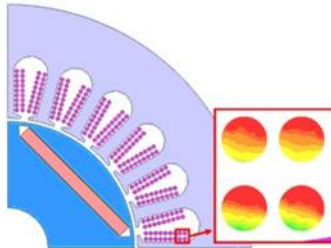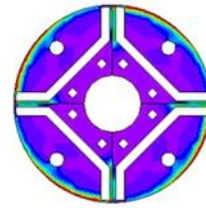
Winding AC loss
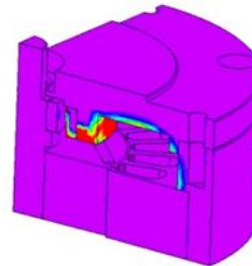
Stray loss

Reliable analysis methods behind numerical studies and measurement comparison

A high degree of precision in analysis is desirable for making motors more efficient and reducing loss. Also, as phenomena such as the effects of high-frequency iron loss become more complex, it becomes more difficult to study analysis precision. JMAG not only provides analysis functions, but also carries out studies on actual machines and works with modeling accuracy. It also tackles mesh creation techniques needed for high-precision analysis of eddy current loss in magnets. The result of this was a reducing down into a variety of functions, including mesh creation functions, analysis functions, and precision motor models for control simulation.
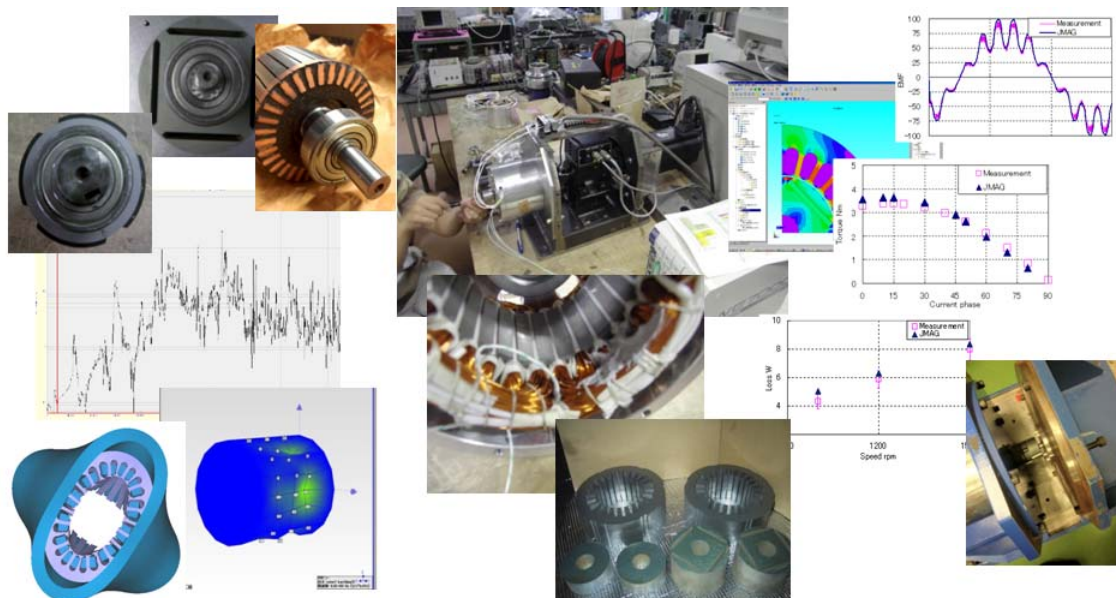
Toward more precise loss analysis

Improvements in motor efficiency are still progressing. At the same time, the required precision for loss analysis is increasing remarkably. New technologies for the effects of processing stress, more detailed materials data, and ways of measuring these need to be implemented. The latest loss analysis techniques will be presented at the 5th Seminar on Advanced Computational Electromagnetics. Please join us if possible.

Time Line of JMAG's Efforts Regarding Iron Loss

Year	Event
2000	Iron loss analysis tool included
	Materials database included
	2nd Seminar on Advanced Electromagnetic Simulation held "Materials Modeling in Electromagnetic Simulation"
2003	Magnetic field and loss analysis functions for stress dependency included
2004	Evaluation of high-frequency iron loss using control-circuit coupling functions becomes possible (JMAG-RT)
2007	High-precision mesh modeling for magnet eddy current analysis Mimura, et. al., "Influence of Mesh Division on Eddy Current Analysis in Permanent Magnet," SA-07-26, RM-07-26, 2007 [1] Mimura, et. al., "Influence of Mesh Division on Eddy Current Analysis in Permanent Magnet (part 2)," SA-07-78, RM-07-94, 2007 [2]
	Coil current loss analysis functions for switching transformers included
2008	Loss analysis considering controls and circuits, accuracy studies in actual machines IEEJ Transactions on Industry Applications Vol. 131 (2011) No. 11 P 1309-1315 "Coupled Analysis Technique Involving Magnetic-Field-Control/Circuit Simulation and Loss Estimation for Permanent Magnet Synchronous Machine," Katsuyuki Narita, Takashi Yamada, Yoshiyuki Sakashita, Kan Akatsu
2010	High speed analysis functions for magnet eddy current loss included
	Iron loss information included in JMAG-RT models

Author: Tomomi Igarashi

Event Information

Report on the JMAG Europe Users Conference

JMAG Users Conferences are held in countries around the world. The first Users Conference of 2013 was held in Europe. This was the fourth time it was held, and a large number of users took part again this year. This is a report on how it went.

JMAG Users Conference in Germany and JMAG Technical Day
Conference Outline

Host   : Powersys Solutions

Dates : Wednesday April 10 - Thursday April 11, 2013

Venue : Steigenberger Airport Hotel: Frankfurt, Germany

URL   : http://www.powersys-solutions.com/JMAG_UC/

Seminar Program (Day 2)

09:00	**2 training sessions in parallel** ・Basic Training (including Introduction to JMAG V12) ・Intermediate/Advanced training (including Introduction to JMAG V12)
13:45	**Round Table** The roundtable discussion is an opportunity for the participants to get together and share feedback about their use of FEA software**.**
16:25	**One-to-One Meeting**

Presentation Program (Day 2)

09:45	**Investigation of Proximity Losses in a Permanent Magnet Machine for electric vehicles** David Bauer, Robert Bosch GmbH*, Germany.*
11:00	**Development of electric motors in automotive applications using JMAG Software** Mohamed Hadjali, Nidec *mo*tors & actuators*, Germany.*
11:40	**Enhanced Simulation Quality for Electric Drives in Hardware-in-the-Loop Applications** Bjoern Bobe & Matthias Deter, dSPACE GmbH*, Germany.*
14:00	**Axial flux machine simulation with JMAG** Dr.-Ing. Bogdan Funieru for Institute for Electrical Energy Conversion, Technische Universität Darmstadt, Germany.
14:40	**Optimizing the Acoustic Performance of a Switched Reluctance Motor using a combined multi-physics & FEA simulation approach** Ben Meek, Koen De Lange, Koen Vansant, Fabio Santos, Herman Van Der Auwerar, Jan Anthonis, LMS International N.V*, Belgium.*
16:00	**Calculation of electromagnetic forces in claw-pole alternators for acoustic simulation** Antoine Tan-Kim, VALEO EEM*, France.*
16:40	**Linking Saber and JMAG for an integrated System Simulation Approach for Motor Drive Applications** Andre Jennert, Synopsys Inc.*, Germany.*

The JMAG Group's European member, Powersys, held a JMAG Europe Users Conference. It was held over two days, with the first being a technical day, followed by user presentations on the second.

Technical training was held on the first day for JMAG users and those considering using JMAG. In the morning, new functions and basic functions were introduced according to users' level of proficiency, and we received many questions regarding new solutions such as JMAG-Express and JMAG-VTB. In the afternoon, we had a discussion about user requests for JMAG and other topics. It was the first time we had tried this in Europe, but it turned out to be a good forum for technical exchange with active opinion sharing between participants. We were also able to receive a lot of helpful input regarding our own development.

The second day was very well attended, with more than 50 participants. We received user presentations from Robert Bosch, Nidec Motors & Actuators, Valeo EEM, Darmstadt University, and technical partners, and had a lively discussion with ideas exchanged on a variety of topics. Many participants told us that "the presentations and poster exhibitions were helpful," so we believe they went away satisfied. We also unveiled JMAG Designer Ver.12.1, released in June, a little early for Europe.

We not only provided information from JSOL by introducing functions and uses, but also received many opinions and requests for JMAG on both days, including from people who were running JMAG on their own computers at the venue and coming up with questions, which reinforced for us how much is hoped for from JMAG in Europe.

Author: Tomomi Igarashi

Exhibitions and Events for July through September, 2013

JMAG will hold exhibitions at events both in Japan and overseas. Please stop by our booth and take a look at JMAG's activity at an event near you. We would like to take this opportunity to introduce events and exhibitions for July through September, 2013.

Thermotec 2013
Conference Outline

Host   : Japan Industrial Furnace Manufacturers Association

Dates : Wednesday July 3 - Friday July 5, 2013

Venue : Tokyo Big Sight (Ariake, Tokyo)

URL   : http://thermotec-expo.com/en/

JMAG will hold an exhibition at Thermotec, which is Asia's most influential exhibition for industrial furnaces, thermal technology, equipment and materials, held every four years. We will give a demonstration of induction heating simulation at our booth. JMAG can accurately handle magnetic fields and heat motion for high-frequency induction hardening, electromagnetic design of conduction paths, and surface hardening, and provide valuable feedback for heating design, so please give it a try.

JMAAB Open Conference 2013
Conference Outline

Host   : MathWorks Japan

Date   : Thursday July 4, 2013

Venue : Tokyo Conference Center - Shinagawa (Shinagawa, Tokyo)

URL   : http://www.mathworks.co.jp/company/events/conferences/jmaab-open-conference   (Only Japanese)

The JMAAB Open Conference is a conference of the JMAAB (Japan MATLAB Automobile Advisory Board), which uses MATLAB, offering presentations to support various efforts in model based development in the automobile world. JMAG's booth will offer a chance to try using JMAG-RT, which can be combined with MATLAB/Simulink (from MathWorks). Come see the JMAG-RT technology, which can share models between system designs and plant designs.

TECHNO-FRONTIER 2013
Conference Outline

Host   : Japan Management Association

Dates   : Wednesday July 17 - Friday July 19, 2013

Venue   : Tokyo Big Sight (Ariake, Tokyo)

URL   : http://www.jma.or.jp/TF/en/index.html

TECHNO-FRONTIER is the largest trade show in Asia where development designers and production engineers gather from a wide variety of fields, including motor technologies, EMC and noise reduction. JMAG's booth will include presentations for various analysis targets and business uses. We will also give demonstrations of our new products

released in June, including JMAG-Designer Ver.12.1 and JMAG-Express. We hope that visitors to TECHNO-FRONTIER will stop by the JMAG booth at 3C-201.

Our own Mr. Yamada will give a presentation entitled "Trends in Motor Analysis Technologies and Toward Application of Model Based Control" at the motor technology seminar on July 19, so please come and see it.

NI Week 2013
Conference Outline

Host　　: National Instruments Corporation

Dates　: Sunday August 5 - Thursday August 8, 2013

Venue　: Austin Convention Center (Texas, USA)

URL　　: http://www.ni.com/niweek/

NI Week is a yearly conference held by National Instruments Corporation, and sees around 3600 engineers from countries around the world gathered under one big conference roof. JMAG's booth will present linked analysis with JMAG-RT and National Instruments' Motor HILS. Please come and see our demonstration of JMAG-RT for precision plant models.

ECCE 2013
Conference Outline

Host　　: IEEE

Dates　: Sunday September 15 - Thursday September 19, 2013

Venue　: Colorado Convention Center (Colorado, USA)

URL　　: http://www.ecce2013.org/

Like last year, JMAG's USA distributor Powersys Solutions, will give an exhibition at ECCE 2013, a conference held by IEEE. Presentations of JMAG's newest functions as well as demonstrations of JMAG-Express and JMAG-RT Viewer, will be given at our booth.

As you can see, we will take part in a lot of activities in Japan, notably TECHNO-FRONTIER in July. People will have a chance to try out the new features of JMAG-Designer Ver.12.1 at all of these events. We are also planning exhibitions and seminars in countries around the world, not limited to Europe. Please have a look at the information on our website. We look forward to seeing you there.

(Tomomi Igarashi)

Event Report

Attendees report on events held from April to June, 2013. We hope you will attend an event soon.

Virtual Testing and Validation of Controller Software
Conference Outline

Host   : dSPACE Inc.

Dates   : Tuesday April 9 - Thursday April 11, 2013

Venues   : April 9, Hotel Arista (Illinois, USA);

　　　　April 11, DoubleTree (Michigan, USA)

URL   : http://www.dspace.com/en/inc/home/company/events/dspace_events/seminar_vet_il.cfm

A seminar was held to present virtualization techniques in design and study processes of control systems using tools such as HILS by dSPACE, with many participants attending, particularly testing technicians and system designers from automobile-related industries.

At the seminar, demonstrations were given of dSPACE system products with application examples included, and we presented applications and operation examples of JMAG and JMAG-RT motor models in the HILS environment. The large number of inquiries we received from testing technicians about how to use JMAG-RT motor models to further improve precision in a virtual testing environment indicated a high amount of interest.

(Tetsuo Ogawa)

Electric Motor & Power Electronics Model Development, Real-Time Simulation and Controller Implementation using National Instruments and JMAG.
Conference Outline

Host   : National Instruments Corporation

Date   : Thursday April 10, 2013

Venue : National Instruments Livonia office (Livonia, USA)

URL   : http://sine.ni.com/nievents/app/offering/p/offeringId/1450357/site/nic/country/us/lang/en

We held a seminar at National Instruments' Livonia office on the implementation of Real Time Simulation technologies using JMAG-RT in NI's LabVIEW and VeriStand Hardware In Loop Simulation (HILS) environments.

The seminar included actual demonstrations using the HILS environment of topics ranging from the detailed functions of the above HILS environments to the effectiveness of analysis functions such as current-torque patterns, which can now be handled using analysis only with JMAG-RT. Around 30 people took part, including consultants, controls design technicians, and engineers from Detroit automobile manufacturers, showing the high interest surrounding precision motor models in HILS systems.

(Tetsuo Ogawa)

Automotive Testing Conference 2013
Conference Outline

Host : National Instruments Corporation

Date : Wednesday April 17, 2013

Venue : National Instruments South Korea office (Seoul, South Korea)

URL : http://korea.ni.com/events/automotive2013 (Korean language only)

We took part in a conference held by NI about testing methods in automobile development. It was very well attended, with around 300 participants.

A joint presentation by engineers from NI in South Korea and JMAG's South Korea distributor about collaboration between NI's MotorHIL and JMAG-RT showed how JMAG-RT can generate high-precision motor models for MotorHIL. There was a JMAG booth in the conference hall, and we were able to have contact with many participating engineers and have meaningful discussions about the attention that precision motor models are receiving in South Korea.

(Koji Tani)

Maplesoft Network Event: The Importance of System-Level Modeling in your Toolchain
Conference Outline

Host : Maple Inc.

Date : Wednesday April 17, 2013

Venue : Cobo Centre (Detroit, USA)

URL : http://www.maplesoft.com/company/publications/articles/view.aspx?SID=145913

A seminar to introduce a simulation environment based on MapleSim as a system-level design tool in automotive design was held at the SAE Congress, and was attended by engineers from the automobile world.

JMAG presented examples of linking functions using precision motor models from JMAG-RT as a part of the Maplesoft toolchain. We received a lot of questions from participants who are already using system-level simulation about the implementation of JMAG-RT models to improve its accuracy, which gave us the impression that system-level simulation is spreading, and that demands for high-precision motor models are rising in the places where it is being used.

(Tetsuo Ogawa)

LMS Korea Seminar with JMAG
Conference Outline

Hosts : LMS Korea, EMDYNE

Date : Wednesday April 24, 2013

Venue : LMS Seminar Room (Seoul, South Korea)

A joint seminar was held in South Korea by our technical partner LMS with JMAG. These have been held in France, Germany, and the United States, and we plan to hold them in the United Kingdom and other parts of Europe in the future.

JSOL and engineers from our South Korea distributor EMDYNE presented electromagnetic field analysis, as well as linked analysis using JMAG and Virtual.Lab, at the seminar. After that, LMS gave an introduction to LMS's CAE solutions including AMESIM, focusing on linking. Around 30 people took part from automotive and electrical industries. Most participants were mechanical engineers who are customers of LMS, so they were very interested in the unfamiliar topic of electromagnetic field analysis. There was a lot of discussion, making it a very active seminar.

(Takashi Yamada)

Advanced MotorTech Training Course, BLDC and IPM Machine Design
Conference Outline

Host   : Advanced MotorTech LLC.

Date   : Thursday April 25, 2013

Venue : Embassy Suite Hotel (Michigan, USA)

URL   : http://www.advancedmotortech.com/pdf/IPM_BLDC8b.pdf

   Dr. Keith W. Klontz, a motor design consultant working mainly in the United States, held a seminar on motor design, which was attended by motor designers from a wide variety of fields ranging from industrial motors to automobile motors to motors for medical applications.

   Practical explanations incorporating Dr. Klontz's know-how went on over three days at the seminar, from the principles of BLDC and IPM motor performance to design methods. There was also an explanation of the effectiveness of JMAG as an analysis and design tool for these machines, and an introduction of JMAG's new features and analysis examples. Participants who are already involved in electromagnetic field simulation were particularly interested in JMAG's unique features such as its high-speed solvers and linking to controls using JMAG-RT.

(Tetsuo Ogawa)

SMMA 2013 Spring Management Conference
Conference Outline

Host   : SMMA

Dates : Wednesday May 8 - Friday May 10, 2013

Venue : The Villas of Grand Cypress (Florida, USA)

URL   : http://www.smma.org/2013-spring-management-conference.htm

   SMMA (The Motor & Motion Association) is a forum on various technical fields from materials for motors and controls to motor development, attended by 120 companies and organizations.

   This conference is held with the goals of opinion exchange and sharing of motor technologies and market trends by SMMA member firms, with around 100 of the United States' major motor-related companies attending for ardent discussions ranging from materials problems to market analysis. JMAG was also brought up in tutorials on motor development technology held at the conference in connection to the effectiveness of analysis tools in motor design, and we felt that expectations are rising for it as electromagnetic analysis software in the motor design field.

(Tetsuo Ogawa)

LMS French Vehicle Users Conference 2013
Conference Outline

Host   : LMS International

Date   : Tuesday May 14, 2013

Venue : Novotel Saint Quentin Golf National (Paris, France)

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

   The LMS French Vehicle Users Conference is an NVH and System/Control simulation conference held every year by

LMS, aimed at the automobile industry. It is held in North America and other parts of Europe as well as in France. The keynote speech and panel discussions were held on the first day, and new functions or users' case studies were presented in different sessions on the second day.

JMAG handles linking with Virtual.Lab for detailed vibration and noise simulation in electric devices. The JMAG Group's France distributor, Powersys, gave an exhibition and presentation. The theme of the presentation was the simulation of vibration and noise due to electromagnetic force in an SR motor, against the background of the increasing problem of availability of rare earths. From the sharing of opinions both in the Q&A after the presentation and at the booth, it was clear that expectations are rising for JMAG-Virtual.Lab linking to contribute as a solution to the increased need for electromagnetic noise analysis, not only for traction motors but also electric devices such as servo motors, actuators, and sensors. We will present more functions and examples in the future in order to answer to these expectations.

(Koji Kiryu)

32nd Annual WEMPEC Review Meeting
Conference Outline

Host : Dassault Systemes SIMULIA

Dates : Wednesday May 22 - Thursday May 23, 2013

Venue : University of Wisconsin (Wisconsin, USA)

WEMPEC (Wisconsin Electric Machines and Power Electronics Consortium) held its Annual Review Meeting at the University of Wisconsin, Madison.

WEMPEC brings together more than 80 core firms in various fields from automobiles, aircraft, industrial equipment, medical equipment, etc., from inside and outside the United States, in one big center of research for the field. Around 300 people attended this year's meeting and took part in technology sharing and lively interaction surrounding their research findings. JMAG is used at the university as a major research tool, and a great deal of research carried out with JMAG was presented, from electromagnetic field analysis to controls analysis.

(Tetsuo Ogawa)

2013 SIMULIA Community Conference
Conference Outline

Host : Dassault Systemes SIMULIA

Dates : Wednesday May 22 - Friday May 24, 2013

Venue : Hilton Vienna Stadtpark (Vienna, Austria)

URL : http://www.3ds.com/company/events/scc-2013/overview/

The SIMULIA Community Conference (hereafter SCC) is a regular meeting for people involved with SIMULIA (users, partners, employees), held alternately in North America and Europe every year. It is separate from the SIMULIA Users Conference, and is held as a RUM (Regional Users Meeting) in each region (more than 10 locations).

The theme of this year's SCC was increased automobile fuel efficiency, and JSOL took part as a panelist in the meeting, attended by around 50 people. We also gave a presentation of JMAG's features as a partner product. Around 60 people attended, a dramatic increase over last year and the year before, which demonstrated the increased interest in and need for electromagnetic field analysis. We also received many kind words about JMAG's ease-of-use and speed from

participants who visited our booth after the presentations.

JMAG was introduced as an important partner in partner meetings and panel sessions as well as the general sessions in the morning and afternoon.

(Koji Kiryu)

2013 Automotive Engineering Exposition Conference Outline

Host : Society of Automotive Engineers of Japan, Inc.

Dates : Wednesday May 22 - Friday May 24, 2013

Venue : Pacifico Yokohama (Yokohama, Japan)

URL : http://expo.jsae.or.jp/english/

Synopsys kindly allowed us to hold a seminar on JMAG-RT precision motor models at their booth in the 2013 Automotive Engineering Exposition.

Visitors seemed interested that linking of JMAG-RT and Synopsys' Saber has become possible, and so many came that even the standing room was filling up for the seminar in the end. This was the first time in around 10 years that I had taken part in the Automotive Engineering Exposition. The last time there were not nearly so many people and the exhibition hall seemed a lot less crowded, and when I think of scenes like people bringing their children on car simulators, it seems like a different world from today's bustle and crowding. There was a great deal of activity, with large increases in both the number of exhibitors and the number of attendees from before. I also felt the changing times because of a much more noticeable presence from overseas, especially China and other Asian countries.

(Takayuki Nishio)

Coil Winding Berlin
 - The World's largest International Coil Winding, Insulation & Electrical Manufacturing Exhibition -
Conference Outline

Host : CWIEME

Dates : Tuesday June 4 - Thursday June 6, 2013

Venue : Messe Berlin (Berlin, Germany)

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

A JMAG booth was exhibited at CWIEME Berlin 2013, held in Berlin, Germany. This is the world's largest exhibition in the field, with many different structural elements on display, including windings, laminated steel sheet, magnets, and insulating paper that make up electric motors, transformers, and electric devices. Solutions for motor designers and solutions for large-scale transformers, particularly using JMAG-Express, were introduced in presentations at the JMAG booth. We noticed a difference from trends toward higher efficiency focused on permanent magnet motors in the Japanese

market when we received a relatively large number of inquiries about induction motors, showing more of a desire for low cost than efficiency.

(Takayuki Nishio)

ITEC 2013
Conference Outline

Host : IEEE

Dates : Sunday June 16 - Wednesday June 19, 2012

Venue : Adoba Hotel Dearborn (Michigan, USA)

URL : http://itec-conf.com/

The theme of this conference was electrification technologies for various forms of transportation, focusing on cars but also including airplanes and ships, with around 200 participants attending from inside and outside the United States mostly from the automotive and aviation industries. A broad range of topics were discussed in addition to development technologies for hybrid and electric vehicles, including basic operating technologies such as energy supply, indicating the spread of technologies aimed at broadening the development of electrification technologies for forms of transportation.

Many manufacturers of cars, airplanes, and related devices came to the JMAG exhibition booth for technical discussions, showing that demand is rising for analysis technologies suitable for this field.

(Tetsuo Ogawa)

LMS European Vehicle Conference
Conference Outline

Host : LMS International

Dates : Wednesday June 19 - Thursday June 20, 2013

Venue : Kempinski Hotel Airport Munich (Munich, Germany)

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

LMS European Vehicle Conference is an NVH and System/Control simulation conference held every year, aimed at the European automobile industry. The keynote speech and panel discussions were held on the first day, and new functions or examples from users were presented in separate sessions (Virtual.Lab, Imagine.Lab, Test.Lab) on the second day.

JMAG handles linking with Virtual.Lab for detailed vibration and noise simulation in electric devices. The JMAG Group's Europe distributor, Powersys, gave an exhibition and presentation. The theme of the presentation was the simulation of vibration and noise due to electromagnetic force in an SR motor, against the background of the increasing problem of availability of rare earths. From the sharing of opinions both in the Q&A after the presentation and at the booth, it was clear that expectations are rising for JMAG-Virtual.Lab linking to contribute as a solution to the increased need for electromagnetic noise analysis, not only for traction motors but also electric devices such as servo motors, actuators, and sensors. We will present more functions and examples in the future in order to answer to these expectations.

(Koji Kiryu)

Real-Time conference 2013
The sixth International Conference on Real-Time Simulation Technologies
Conference Outline

Host   : OPAL-RT

Dates : Tuesday, June 25 - Thursday, June 27, 2013

Venue : Hotel particulier Eurosites (Paris, France)

URL   : http://www.opal-rt.com/realtime2013/

Our European distributor Powersys was one of the major sponsors of the Real Time 2013 conference. At Powersys booth JMAG had been promoted to all attendees who participated to the event.

Technical training and tutorials were proposed this year at the Conference with the opportunity to attend a variety of technical demonstrations and training organized by the experts at OPAL-RT.

(POWERSYS)

This issue has focused largely on reporting exhibitions and seminars held in the United States and Europe. JMAG will continue to strive to not only provide technological support, but also to play a part in our customers' global strategy.

Author: Tomomi Igarashi

Simulation Technology for Electromechanical Design **JMAG**®

5th Seminar on Advanced Computational Electromagnetics

Free Attendance

- Toward Putting High-Precision Loss Analysis into Practice -

Environmental problems and energy problems facing Japan in recent years have made energy-saving demands on electric devices increasingly severe. In particular, continuous improvements are expected in efficiency for motors, which are said to account for more than half of all energy consumption. In these circumstances, high efficiency is becoming not just an added value, but rather an essential feature.

In order to improve motor efficiency, vigorous research and development has been ongoing since at least 20 years ago, focused on mid-sized machines in HEVs and air-conditioners, to say nothing of the many years of hard work on large motors. Thanks to these efforts, motor and motor drive technologies have made great strides.

Computer techniques for electromagnetic field analysis technologies used in motor design have been incorporated in this forward process, and electromagnetic field analysis has become an essential technology for advanced motor development. In particular, loss analysis for the evaluation and explication of loss, and finally the minimization of loss, has contributed greatly to motor efficiency.

At this point, however, analysis technologies themselves have become an issue.

As motors evolve and further loss reductions are demanded, the need for greater precision has also increased, and current analysis technologies have become inadequate in some cases. New analysis technologies are needed.

In response to this, new methods for combination with material measurement have been developed and are proving useful in the field of analysis technology research.

For this seminar, we have invited top members from various fields to give presentations and indicate demands for loss analysis in motor development in the future, as well as to explain cutting-edge loss analysis and evaluation methods currently under development. We also hope these explanations will be a starting point for discussion of the future direction of the field and thus help to show where it is heading.

There is a limit to the number of attendees,
so please register as soon as possible.
*Non-JMAG-users are also welcome to attend.

July, 23 2013
13:30 - 20:00
TRUST CITY CONFERENCE MARUNOUCHI in Tokyo
1-8-1 Marunouchi, Chiyoda-ku, Tokyo MARUNOUCHI TRUST TOWER NORTH 3F

Program

This seminar will be held in Japanese. All written materials will be in Japanese.

Time	Program
13:30 - 13:40	**Opening ceremony**
13:40 - 14:20	**A direction of the future motor development and requests for the motor analysis technique.** Prof. Kan Akatsu, Associate Professor, Faculty of Engineering, Electric Engineering, Shibaura Institute of Technology
14:20 - 15:00	**Advances in materials measurement and modeling technology** (working title) Prof. Kouji Fujiwara, Department of Electorical Engineering, Faculty of Science and Engineering, Doshisha University
15:00 - 15:40	**The Subjects of Large-scale Loss Analysis** Dr. Haruyuki Kometani, Advanced Technology R&D Center Electromagnetic Systems Dept., Mitsubishi Electric Corporation
15:40 - 16:00	**Break**
16:00 - 16:40	**The present conditions and problem of the loss analysis in the PM motor** Mr. Akio Yamagiwa, Chief Researcher, Environmental Technology Laboratory, Daikin Industries, LTD.
16:40 - 17:20	**Recent Development and Application Technology of Non-oriented Electrical Steel Sheets** Mr. Hiroaki Toda, Senior Researcher, Steel Research laboratory, Electrical Steel Research Dept., JFE Steel Corporation
17:20 - 18:00	**Taking on JMAG** Dr.Takashi Yamada, JSOL Corporation
18:00 - 20:00	**Social gathering**

Registration:
http://www.jmag-international.com/seminar/op/new_mag.html

Contact · Organizer: JSOL Corporation E-mail: event@jmag-international.com

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