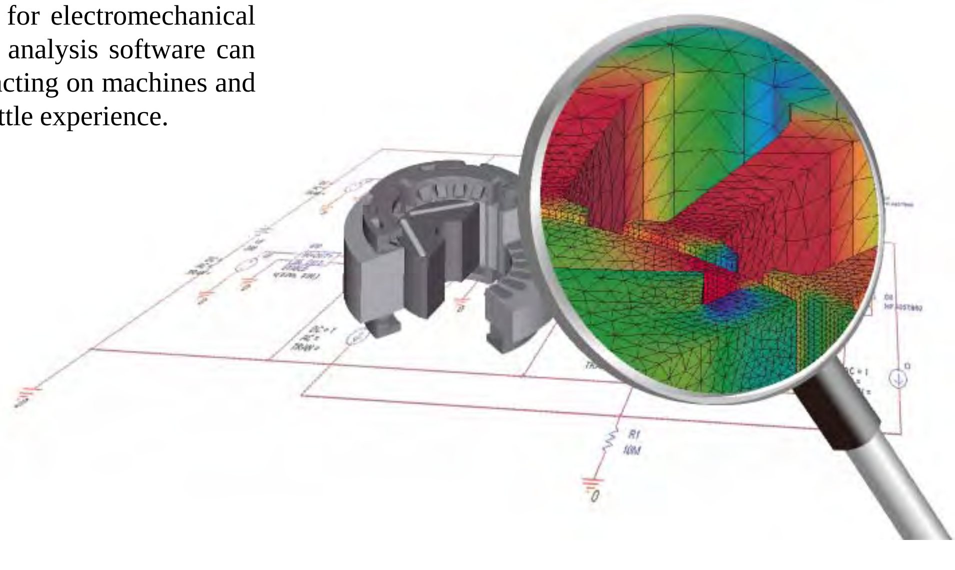
JMAG News Letter

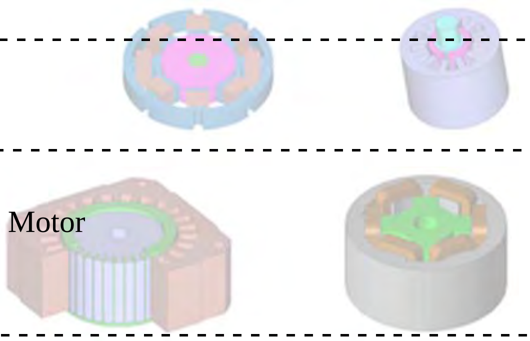
Sept. 2010

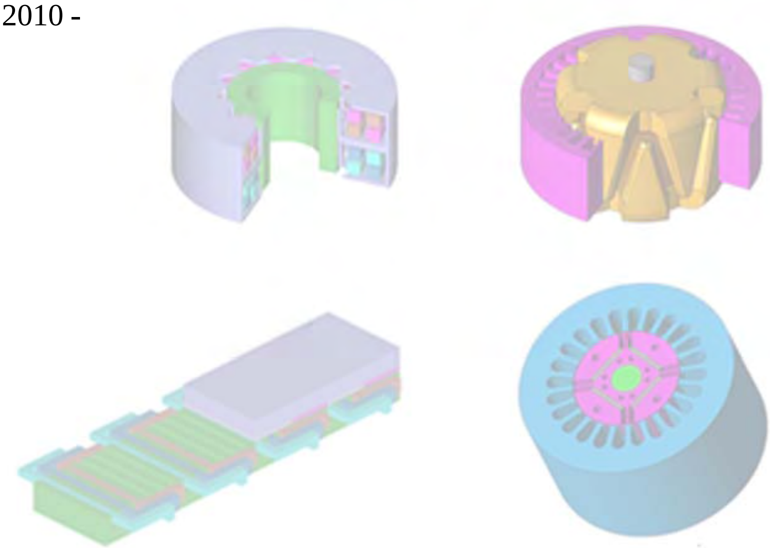
JMAG is a comprehensive software suite for electromechanical design and development. This high speed analysis software can capture the complex physical phenomena acting on machines and obtain highly accurate results easily with little experience.



www.jmag-international.com

Contents





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JMAG News Letter September Edition

This edition of the JMAG News Letter features motor design.

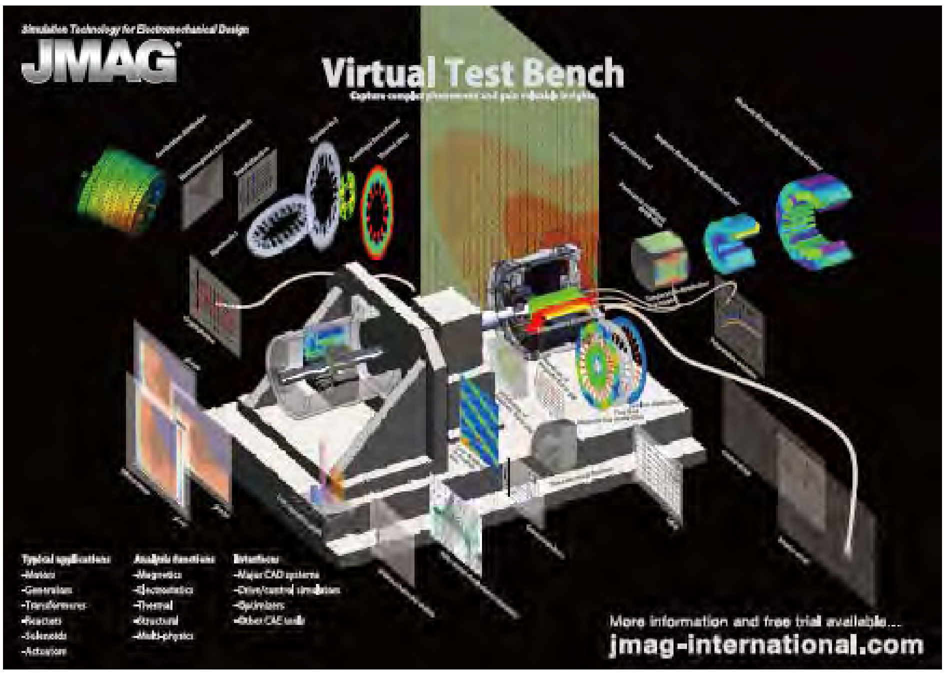
We interviewed the Meidensha Corporation which was established more than 113 years ago. The Meidensha Corporation is known for its heavy electric machine manufacturing whose technology focuses on rotating machines such as motors. In addition to initially contributing to enhancing social systems such as generators, transformers, and water disposal equipment, the Meidensha Corporation has developed products including electrical systems for industry such as elevators and drive motors for electric vehicles.

In this interview, the Meidensha Corporation discusses their implementation of JMAG, the internal activities used to increase JMAG's effectiveness, and how they plan to expand their use of JMAG in the future. This discussion brought many interesting ideas to light including ways to sustain the sharing of technological information. There experience provides valuable insight that can be used as reference in your future endeavors.

I am proud that JMAG has become one of the tools that supports the cutting-edge technology from the Meidensha Corporation. I would also like to share my deep appreciation to the Meidensha Corporation for taking time away from their busy schedules to answer our questions.

In this edition, the challenges of motor development and the increasing role of JMAG are also discussed in a three part series of Technical Reports.. The first in the series focuses on "energy conservation and higher efficiency." This report categorizes and introduces a wide range of reference material from the perspective of using JMAG. If you have any opinions or advice about the categories we have chosen, please don't hesitate to let us know. We will including any feedback we receive in the second issue of this three part series. In addition, analysis examples from JMAG's Application Catalog related to motor development are introduced. This information introduces invaluable features that you may want to try in your on analysis workflow.

In the final section of the JMAG News Letter, we provide information about acquiring the materials used and distributed at the TECHNO-FRONTIER 2010. We hope you enjoy all of the information provided in this edition of the JMAG News Letter.



Jun Sugata
Engineering Technology Division
JSOL Corporation

Implementing JMAG

Meidensha Corporation

Stimulating the Expansion and Reinforcement of the Business Domain with JMAG

The Meidensha Corporation, whose business ranges vary from heavy electric machinery to industrial electric systems, was established 113 years ago. The technology of its products is mainly founded in rotation machines. The JSOL Corporation's electromagnetic field analysis software, JMAG, has stimulated technological innovation, supporting product development by providing a tool capable of achieving higher efficiency, higher output, and establishing highly precise control technology for its products. Electromagnetic field analysis software is also at the forefront of development for new technologies that require advanced solutions for environmental conservation. Mr. Yamada, Executive Officer and General Manager of the New Product Development Group, Mr. Nomura, Senior Fellow, Mr. Watanabe, Senior Engineer of the New Product Development Planning and Management Department, and Mr. Matsuhashi, Manager of the Analytic Simulation and Advanced Control Technologies Section, discuss why they decided to implement JMAG and the benefits of using it.

Tetsuo Yamada
Executive Officer
General Manager,
New Product
Development Group

Masakatsu Nomura
Senior Fellow
New Product
Development Group

Hiromitsu Watanabe
Senior Engineer
New Product
Development Planning
And Management Dept.

Daiki Matsuhashi
Manager
Analytic Simulation
and Advanced Control
Technologies Section

- The Meidensha Corporation has manufactured and sold electrical devices such as generators, transformers, and electric distribution systems as well as contributed to the social infrastructure, such as water treatment devices and control systems for water supply and sewerage systems, various electric components for manufacturing equipment, and computer systems since it was established in 1897. What advantages does the Meidensha Corporation have?

Mr. Yamada Our technology and products are fundamentally based on "rotation" or in other words "rotating machines." The phenomena of "rotation" seems simple, but in fact it is quite profound. For example, when motors start or brake, the necessary force, rotation speed, and the type of control depend on the type of load.

A motor-driving system usually requires a motor itself and an inverter to control the speed of the motor by the current supplied. It wouldn't be a high quality system if either the motor or the inverter did not work well. The motor has to respond quickly and accurately to the control of the inverter, and the inverter has to control the motor by accurately detecting the speed and output.

Motors and inverters can also be bought separately and combined. However, the Meidensha Corporation earned the trust of its customers because we are able to produce high-performance products by developing the motor and inverter as one unit.

Our motors and inverters are comprehensively investigated at each stage of development by a team of development engineers. This allows us to resolve any problem with assembly, etc., at the earliest stage of development. We can offer products that can be used easily by our customers because we are able to examine the products based on the actual circumstances that our customers will be using them.

Motors from the Meidensha Corporation

Inverters from the Meidensha Corporation

Not Simple Simulations, But a Tool Stimulating Creativity

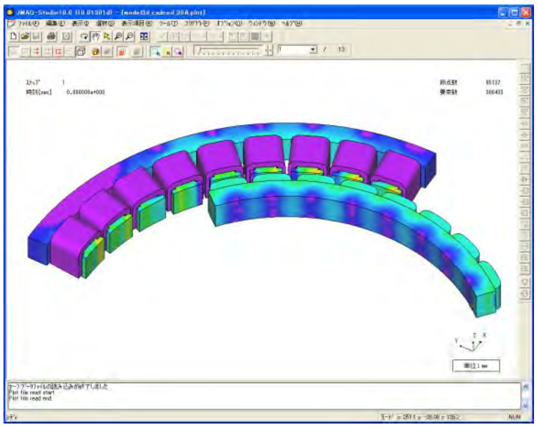
- Why did you decide to implement JMAG in the late 1990's?

Mr. Nomura JMAG provides a way for us to attain and progress our implementation of computer aided engineering (CAE). In the late 1980's, we established a CAE center and began supporting our design process with analysis software that used the finite element method[I]. At that time, it was a trial and error process using both magnetic field analysis software that we internally developed and other universal analysis software.

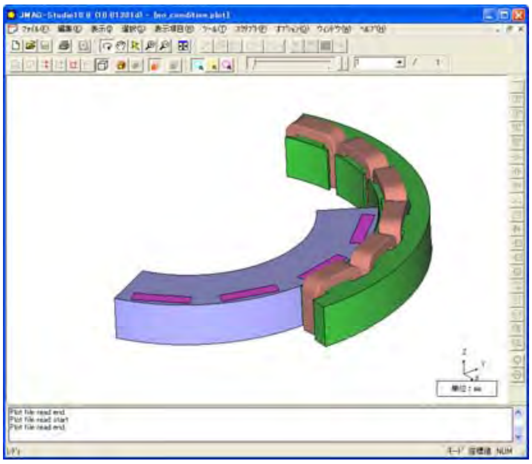
In the field of industry, the development of permanent magnet (PM) motors, or a type of motor that uses permanent magnets on the rotor, was a huge turning point. Three dimensional magnetic field analysis was required in the 1990's when the technological development of PM motors gained momentum. We needed a tool that could accurately calculate the torque because the torque ripple[II] directly affects the ride of elevators using PM motors. However, there is a problem that the path of eddy currents which exists in the magnet cannot be evaluated by means of a two-dimensional analysis. Therefore, a tool with three-dimensional magnetic field analysis is necessary.

We tried several magnetic field analysis tools when we stumbled upon JMAG. JMAG was an easy-to-use software suite that satisfied our need for three dimensional simulations that could analyze the transient phenomena of rotating motors and the eddy currents that existed. Personally, I was astonished by the analysis of the eddy currents in the permanent magnets of PM motors. We could enhance our techniques during design processes by verification of the simulation with measurement.

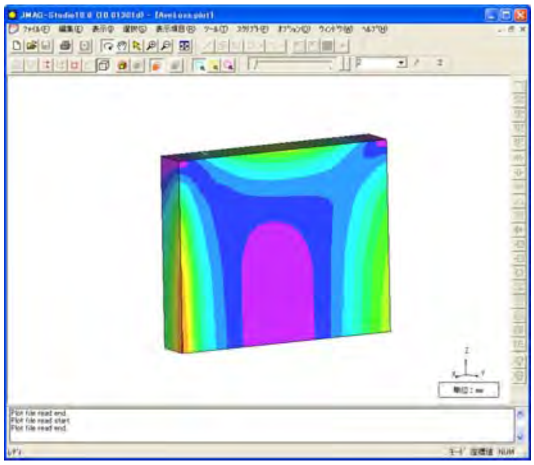
Mr. Matsuhashi When we originally implemented JMAG we needed an analysis specialist because JMAG operated on a workstation, but today, JMAG, which now runs on personal computers, is much more user friendly allowing us to use it in many different departments. We have been able to increase the level of our prototypes and reduce the number of prototypes as JMAG has become more accessible to designers as well as engineers. We had to examine the technology and quality of our products, build and rebuild prototypes at various stages of product development, which is not limited to PM motors. We strive for a front-loading type of development process using analysis software to guarantee only a single prototype is required at each stage of development. Obviously, our ultimate goal is to have a development process that doesn't require any prototype, but that will still take some time to achieve. However, JMAG has contributed vastly in reducing the number of prototypes and virtually eliminated the need to totally overhaul a prototype or start the development process from scratch.



Magnetic Field Density Contour Plot of a SPM Motor



IPM Motor Model



Eddy Current Loss Distribution of a Permanent Magnet

I Finite element method refers to an analysis method performed by separating a large object into virtual elements that have a finite size, and then analyzing the object as the sum of the elements.

II Torque ripple refers to the ripple in the torque (force) when a motor rotates. The torque ripple causes noise and vibrations and worsens the control.

Increasing the Effectiveness by Sharing Analysis Results

- What types of innovation are required to get everyone accustomed to JMAG and increase the effectiveness of implementation?

Mr. Nomura JMAG was not used throughout our company immediately. I feel there are certain skills required to become accustomed to JMAG. The Analytic Simulation and Advanced Control Technologies Section has established a system for analysis technologies accepted by all the engineers in our company. The results from the analysis and the experimentation were compared for consistency and error, and if an error occurred the reason was clearly identified. Associated divisions started, adopted, and utilized the data shared as technological assets by gathering all of the valid data. Even today, we reinforce our competitive edge by creating a knowledge base that actively discloses information valuable to each division via a database server.

Mr. Watanabe Proving the validity of not only JMAG, but CAE, to the entire company was also a key factor. The effectiveness of JMAG was even compared to other third-party software now and again at technical report and quality management meetings as well as internal exhibitions that our President attended. JMAG was promoted from the top down throughout the company after receiving praise for cost effectiveness from the President of the Meidensha Corporation. As an engineer himself, he understood immediately the importance of using JMAG so that only a single prototype would be required. This allowed us to expand the use of JMAG.

Internal Exhibition at the Meidensha Corporation

Creating an Environment for Each Engineer to Discover the Value of JMAG

Mr. Matsuhashi Each engineer also needs to experience the value of JMAG so that it can be effectively implemented.

I was also amazed when the eddy currents produced were visualized in the analysis results obtained by JMAG. I have re-evaluated the development process in the past which allowed me to fully comprehend the potential I was seeing.

A design engineer with hands on experience using JMAG told me that he was able to gain confidence in his decisions by comparing the simulation images of the eddy current loss in a permanent magnet obtained by JMAG with the results of the actual eddy currents.

My colleagues and I, as well as many of our engineers, had the same experience which was also instrumental in expanding the use of JMAG in the Meidensha Corporation. There is no key person that has been specially assigned as an analysis specialist. We value the ability to work with one another to discover new ways of using the analysis based on other analysis that we have performed without hesitation. This provides an environment where the engineers exchange technical ideas horizontally to one another, rather than only learning the fundamental operations.

Of course, this type of collaboration would not be possible if JMAG was not so easy to use. As JMAG-Studio and JMAG-Designer have advanced, the interface has become even more accessible to a wide range of engineers. Even the workstation version of JMAG utilized a graphical user interface and mouse operations.

Expanding Simulation Functions for New Environmentally Friendly Technology

- Isn't a drive motor and inverter built by the Meidensha Corporation used in the “i-MiEV" electric vehicle from Mitsubishi Motors?

Mr. Yamada Yes. Mitsubishi Motors started purchasing our motors and inverters in 2008 for their electric vehicle drives because they are small and light, have less noise, and are highly durable.

By optimizing the design using JMAG simulations, these PM motors realized a smaller and lighter design, which also results in higher efficiency, higher output, and lower losses. The inverter controlling the current flowing in the motor supports a smooth and powerful driving experience by providing highly accurate drive control technology.

Originally, the Meidensha Corporation researched the application of PM motors for elevators in addition to researching applications for electric vehicles collaboratively with large electronic manufactures and universities. Our motor technology is used in electric vehicles that can reach the speeds of F1 racers. The outstanding drivability of the i-MiEV was achieved by further innovations based on motor/inverter technology accumulated from our previous research. The simulation technology provided by JMAG was in the background of this technological development.

- How will the Meidensha Corporation expand their business in the future and what role will JMAG play?

Mr. Yamada The Meidensha Corporation created a medium-term management plan, "POWER 5," which is a five year plan starting from fiscal 2009. In this medium-term plan, we are striving to expand our business in 5 areas that contribute to a low-carbon society, such as motors and inverters for electric vehicles. Each of these business areas relates to rotating machine technology in some way, such as motors. The direction of technology in the future points to continuous technological development for rotating machines. In addition, innovation of products contributing to environmental conservation is also indispensable.

In the future, design methods accounting for the biodegradability of products, which is the last stage of their life cycle, will be necessary to meet the challenges in reducing the total environmental burden. PM motors, for example, will probably need to be innovatively designed so that the permanent magnets of the rotor can be recycled easily. Heavy electric equipment and industrial electric systems, just like appliances, require recycling control methods founded in product liability.

Mr. Watanabe Product development has to be environmentally friendly as well as consumer friendly, not simply by quantitatively understating the environmental burden of the products, but by establishing a product life cycle management system. Therefore, it is necessary to know the performance of products at an early stage of development or even at the stage of concept. And it means that simulation becomes more and more important.

I have realistic expectations that the calculation speed will continue increasing and the range of analysis will expand to thermo-fluid analysis. However, stepping back for a wider perspective, I would love to see functions to calculate the CO_2 emissions of a product at the analysis stage and increase the percentage of materials used in products that can be recycled.

JMAG is evaluated highly as one of the major leaders in magnetic field analysis software since its release in 1983. And for this reason, I expect JMAG to continue being a software that engineers can rely on.

Motor and Inverter for the i-MieV

MEIDEN

MEIDENSHA CORPORATION

Corporate Name	MEIDENSHA CORPORATION (Kabushiki Kaisha Meidensha)
Founded	June 1, 1897
Capital	¥17, 070 million (as of March 31, 2009)
Consolidated Number of Employees	7,133 (as of March 31, 2009)
Consolidated Sales	¥198,797 million (as of March 31, 2009)
President	Junzo Inamura

Business Overview

The Meidensha Corporation was established as a heavy electric machine manufacturer in 1897. In addition to business in social infrastructure, such as generators, transformers, control equipment, and water processing equipment, the Meidensha Corporation is founded in industrial systems, such as drive equipment for elevators and electric vehicles and industrial computers, as well as maintenance of the various equipment. Their consolidated sales are ¥198,797 million as of March 2009. The Meidensha Group is a global manufacturing and sales group that has 23 companies domestically in Japan and 15 companies internationally which are localized in Asia. Presently, they are focusing on various components for electric vehicles and the use of natural energy, such as solar power and wind generators.

http://www.meidensha.co.jp/

Motor Development Using JMAG

Supporting Excelled Motor Development

- Challenges of Motor Development and the Increasing Role of JMAG -

This series of technical reports discusses the challenges of motor development and the increasing role of JMAG. In the first edition of this series, we focus on "energy conservation and higher efficiency."

● Overview

There are an infinite number of motors that surround us in our daily lives. These motors are used widely in various machines from appliances such as washing machines and air conditioners to large products like automobiles and elevators in addition to portable devices such as cellar phones and video games. Reports have indicated that approximately 60% of the power used in Japan is consumed by electric motors.

The amount of work endured and knowledge gained from the trail and error of motor designers should not be forgotten in a society that has learned to take motors for granted. JMAG has been a tool that motor designers continue to use to address the challenges that they face each day.

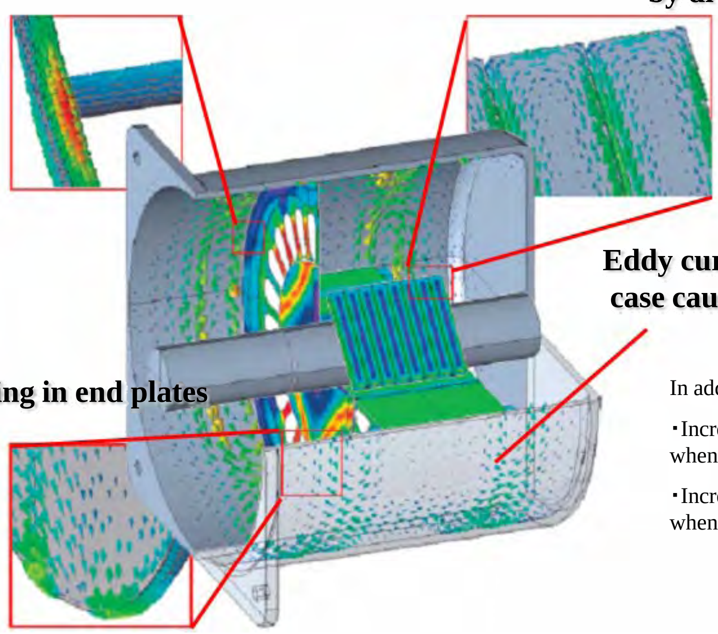
This report introduces the types of challenges in motor development JMAG is used to overcome and why so many have selected JMAG as their tool of choice.

This technical report, the first edition of this series, focuses on the challenges of motor development from the perspective of energy conservation and higher efficiency.

● Challenges of Motor Development: Conserving Energy and Gaining Higher Efficiency

More highly efficient motors are expected to contribute largely to environmental conservation in a time when conserving energy and preventing global warming have become key. Understanding the cause and areas loss is produced is vital to achieving higher efficiency. Today's consumers are also looking for even smaller and lighter products. The ongoing demand for miniaturization while keeping the existing output requires reinforced designs that also account for the thermal design.

This section examines the causes of loss as well as the thermal design.



http://www.jmag-international.com/solutions/motordesign.html

(1) Loss

Losses Caused by Harmonic Components

Even though loss can be expressed in a single word, it stems from a wide variety of causes. The copper loss of coils[1] and the iron loss of cores[2][3] are the most prominent examples. However, losses that once could be ignored now need to be examined comprehensively to meet stringent requirements for higher efficiency. The eddy currents that occur in magnets is a classic example. Motors utilizing permanent magnets had been implemented widely to gain higher efficiency because magnet torque produced by the coercive force could be utilized in addition to the reluctance torque produced by the current. However, in actual drive system using controllers and inverters, the losses increase drastically from currents that contain many spatial harmonic components and carrier by-products of PWM[4][5]. Thermal demagnetization can become a problem triggering variations in torque if the eddy current loss in magnets increases because of the carrier by-products.

Separating magnets into sections is known to have some effect on limiting eddy currents, but research has revealed that these losses can also be reduced by modifying the geometry on the surface of the rotor and stator teeth to optimize the magnetic flux pathways[6][7][8][9]. This research focuses on observing the condition of the flux lines to define the magnetic pathways and examine possible countermeasures. Motors are often examined to include the type of control and stability by creating efficiency maps used for computer aided engineering (CAE) tools[10][11][12][13][14].

Loss Caused by Magnetic Flux Leakage

Stray load loss is a type of loss that is starting to grab the attention of designers[15][16][17]. Designs that anticipate flux leakage are increasing as motors continue to be miniaturized while increasing output, but the flux leakage in motors produce eddy currents in surrounding metal such as the cases. Especially in high rotation drives, overheating can become a problem because the amount of heat that is produced rises. Eddy currents need to be considered, especially for motors that have stators with thin back yokes.

The magnetic flux leakage may also produce eddy currents in laminated steel sheets. Laminated steel sheets are a material that reduces the eddy currents that are produced in the direction of lamination by layering these steel sheets. However, if magnetic flux is produced in the axial direction by the leakage flux, losses can occur from the eddy currents that are produced in the lamination plane because insulation is not used in the direction of the lamination plane. The same caution needs to be used for end plates attached to rotors[18].

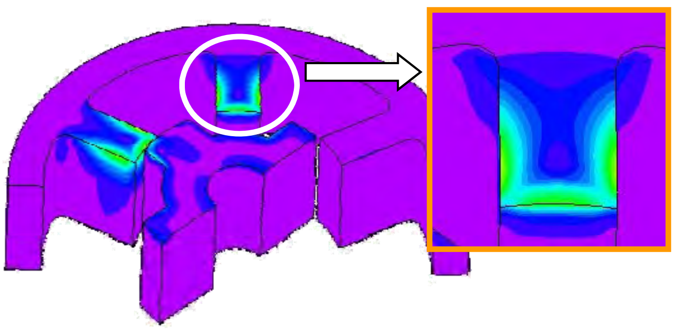
Loss Caused by the Manufacturing Process

Characteristic degradation caused by shrink fitting and press fitting result in loss that cannot be ignored. The compression stress moves in the stator when shrink fitting or swaging is used and the permeability and loss vary by the added stress because of the joint strength between the frame and stator core[19]. Case studies have shown a loss reduction of 13%[20] by changing the geometry of the stator to focus stress in areas with minimal magnetic flux which illustrates the need to investigate shrink fitting and press fitting as measures for achieving higher efficiency.

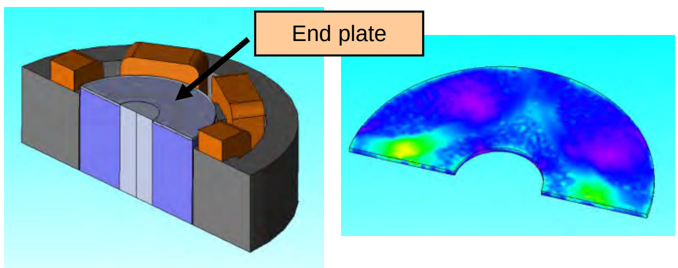
(2) Thermal Design

The loss can never be completely eliminated even as more efficient motors are developed using the methods described above. As indicated earlier, designs most often include drives operating as close to the upper limit of the thermal design as possible because miniaturized higher output motors are required. The loss increases as the output increases and the temperature for each part of the motor rises. At high temperatures, there is a danger of thermal destruction caused by irreversible demagnetization in magnets that have a high temperature dependency[21] resulting in a vicious circle of higher resistance and increased loss in coils. The heat needs to be managed by finding the right balance between higher output and heat[22][23][24].

First, the heat sources need to be identified to manage the heat that is produced. The heat can be managed using the same approach as reducing loss because the heat sources are equivalent to the areas producing the loss. Countermeasures including ways to handle and disperse heat as well as the cooling method can be considered by identifying the heat sources[25][26][27].



Eddy current distribution produced in laminated steel sheets



Joule Loss in an end plate caused by leakage flux

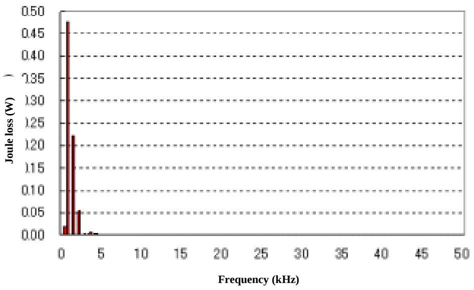
● Contribution of JMAG

The areas and cause of losses that are difficult to measure using actual experiments on prototypes can be identified using JMAG. This section introduces the reasons why JMAG is selected by designers. The actual methods for performing analyses are presented in our Application Catalog (hereinafter referred to as JAC: http://www.jmag-international.com/catalog/).

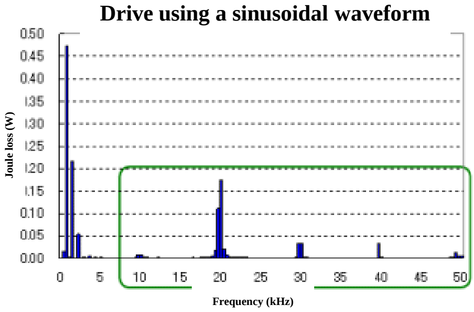
(1) Material Modeling Combining Convenience and Flexibility

Highly accurate modeling is required to obtain highly accurate analysis results. Material modeling is one of the most vital elements to obtaining loss[15][16]. JMAG contains material data for over 700 materials from 12 different manufacturers. The material characteristics can be modeled without specifying any complex settings by simply dragging and dropping the desired material from a list of materials to the model. Iron loss analyses accounting for stress dependency can be performed with ease using the wide range of materials registered in JMAG's material database that includes the magnetic flux density and stress dependency of iron loss.

Each of the material settings can also be specified by the user. The settings can be specified as desired so that even the measured data of iron loss can only be used for an analysis utilizing the material database in JMAG as a base.

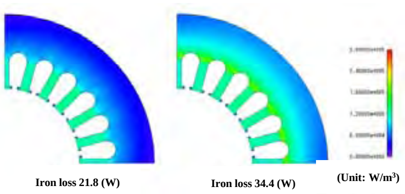


Drive using a sinusoidal waveform



PWM inverter drive

Joule loss frequency components of a rotor core



Iron loss density distribution
(left: not accounting for stress; right: accounting for stress)

(2) Calculation Features for Obtaining Various Loss

The eddy currents and hysteresis loss which cause the iron loss can be obtained separately using the iron loss calculation features in JMAG (iron loss condition/iron loss study)[JAC069][JAC106]. Highly accurate results are obtained using calculations that account for the nonlinear properties of materials. Especially in eddy current calculations[JAC022], the surface layers of a model can be comprehensively analyzed using mesh simulating the skin effect which accounts for the skin depth. The efficiency can be examined using the loss that is obtained[JAC058][JAC103]. In addition, loss accounting for the carrier harmonics in the actual drive, such as inverters, can be obtained using features to link to circuit/control simulators[30][31][32][JAC090][JAC059]. The link to the circuit/control simulator is not only used to analyze the current waveform during drive, but also examine the control system on the circuit side. Some case studies have even shown a reduction in loss by optimizing the excitation timing in SR motors[33].

In JMAG, the stress distribution obtained using a structural analysis can be set as a condition for the magnetic field analysis. A magnetic field analysis which takes into account the stress dependency of the permeability and loss can be performed by obtaining the stress distribution produced by shrink fitting and press fitting first in a structural analysis[JAC87][JAC142].

Furthermore, the loss obtained in a magnetic field analysis can be specified as a condition in a thermal analysis[JAC018] Therefore, the rising temperature of the motor during drive can be investigated in addition to identifying the heat sources. The effects of thermal demagnetization of magnets caused by rising temperatures can also be investigated[JAC120].

(3) Visualizing Results in Versatile Post-processing

The quality of analysis is determined by its ability to extract valuable information from the results. JMAG offers versatile post-processing that supports the evaluation of analysis results from a wide-range of perspectives. The flow of eddy currents can be comprehensively displayed in the model using a multiple cut plane feature and the magnetic flux versus time can be displayed for particular points on a model using the probe feature. The magnetic flux pathways can also be displayed three dimensionally using flux lines. The graph feature can even be used to extract the loss versus time or the frequency components using FFT with ease.

Conclusion

This Technical Report has discussed the challenges of motor development as well as energy conservation, looked at ways of achieving higher efficiency, and introduced how JMAG is being used.

The next technical report will focus on attaining lower vibration and lower noise as well as reducing cost.

Reference Material

● Loss Caused by Harmonic Components

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[9] Patel. B. Reddy、T. M. Jahns「Modeling of Stator Teeth-Tip Iron Losses in Fractional-Slot Concentrated Winding Surface PM Machines」、IEEE ECCE 2009 p.1903-1910

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● Loss Caused by Leakage Flux

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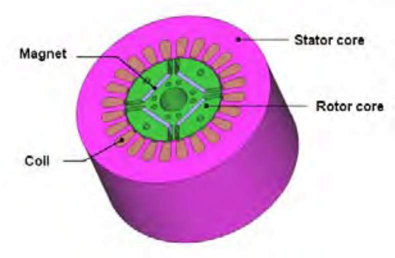
[JAC069] Iron Loss Analysis of an IPM Motor
[JAC106] Iron Loss Analysis of a Brush Motor
[JAC022] Analysis of the Eddy Current in the Magnet of an IPM Motor
[JAC058] Efficiency Analysis of an IPM Motor
[JAC103] Efficiency Analysis of a Permanent Magnet Synchronous Motor
[JAC090] Iron Loss Analysis of an IPM Motor Considering PWM Carrier Harmonics
[JAC059] Iron Loss Analysis of an IPM Motor Accounting for a PWM –Direct Link-
[JAC087] Iron Loss Analysis of an IPM Motor Including the Effect of Shrink Fitting
[JAC142] Press Fit Analysis of a Divided Core
[JAC018] Thermal Analysis of an IPM Motor
[JAC120] Thermal Demagnetization Analysis of an SPM Motor

JMAG Application Catalog

The Application Notes guide users inexperienced in analysis software or experienced users that want to explore new fields of simulations through a smooth simulation process.
In this issue of the JMAG News Letter, two of our newest examples are highlighted; "Sound Pressure Analysis of a Transformer," and "Thermal Analysis of a Choke Coil."

Iron Loss Analysis of an IPM Motor

For saving energy and improving efficiency in motor, it is important to decrease iron loss. The iron loss generates heat by consuming electricity inside the magnetic material, causing the temperature rise in the motor. So the iron loss in the motor needs to be evaluated and reduced.
This note presents the use of magnetic field analysis to evaluated the iron loss of a stator core and rotor core with a sinusoidal current at the rotation speed of 1800 rpm and the current amplitude of 4.0 A.



Magnetic Flux Density Distribution

Figure 1 shows the magnetic flux density distributions of the stator core and rotor core. Figure 2 shows the magnetic flux density waveform of the r-component at the measuring points (1) and (2).
At the measuring point (1), the magnetic flux density is higher and changes substantially. On the other hand, at the measuring point (2), the magnetic flux density is higher but it does not change much. These differences of magnetic flux density affect the iron loss.

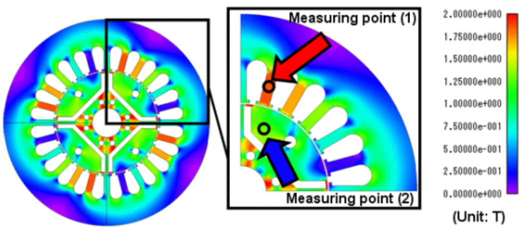


Figure 1 Magnetic Flux Density Distribution(0.0166667(sec))

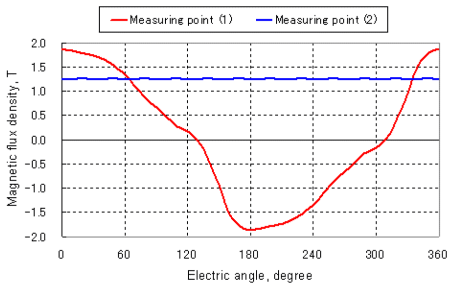


Figure 2 Magnetic Flux Density Waveform(r component)

Joule Loss Density Distribution / Hysteresis Loss Density Distribution / Iron Loss Density Distribution

Figure 3, Figure 4, and Figure 5 show the Joule loss density distribution, hysteresis loss density distribution, and iron loss density distribution of the stator core and rotor core, respectively. Table 1 lists the losses of the stator core and rotor core. As shown in the magnetic flux density waveform, the Joule loss density is higher at the part where the magnetic flux density changes substantially compared with the part where the magnetic flux density does not change much. The hysteresis loss shows the similar result. Both Joule loss and hysteresis loss are higher in the stator than in the rotor according to Table 1.

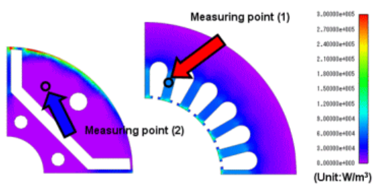


Figure 3 Joule Loss Density Distribution
(left: rotor core, left: stator core)

Figure 4
Hysteresis Loss Density Distribution
(left: rotor core, left: stator core)

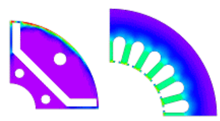


Figure 5
Iron Loss Density Distribution
(left: rotor core, left: stator core)

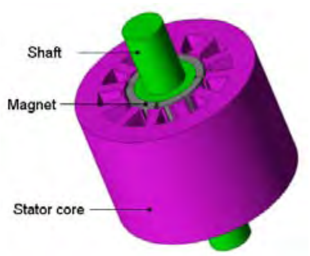
Table 1 Iron Losses

	Rotor core	stator core	Total
Joule loss (W)	1.2	7.5	8.6
Hysteresis loss (W)	0.3	9.9	10.2
Iron loss (W)	1.5	17.4	18.9

Thermal Demagnetization Analysis of an SPM Motor

Demagnetization may occur in an SPM motor during rotation because of the rising temperature caused by the eddy currents, or the reverse magnetic field produced by the coil in the permanent magnet. The need to evaluate the demagnetization using a magnet field analysis is becoming more important because demagnetization reduces the performance of an SPM motor.

The mechanical characteristics need to be evaluated accounting for demagnetization caused by rising temperatures while the motor is driven, because the demagnetization is irreversible even after the temperature decreases once the operating point of the magnet exceeds the knee point . This example presents the use of a magnetic field analysis to evaluate the torque waveform and demagnetization of an SPM motor while changing the temperature of the permanent magnet.



Torque Waveform

The torque waveform when the temperature of the magnet is varied from 60 degrees Celsius to 140 degrees Celsius and then back to 60 degrees Celsius for one electrical period (180 degrees of mechanical angle) is indicated in Fig. 1.

The average torque is reduced by the thermal demagnetization when the magnet is at a temperature of 140 degrees Celsius, as indicated in Fig. 1. The irreversible demagnetization that occurred at 140 degrees Celsius is apparent when the temperature of the SPM motor is returned to 60 degrees Celsius with an average torque that has decreased 16%.

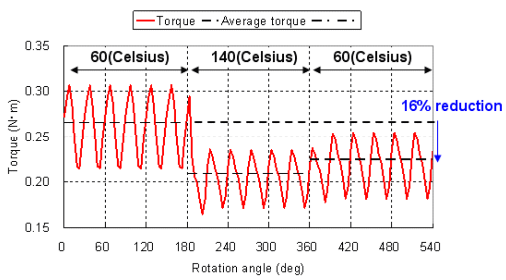


Fig. 1. Torque waveform

Demagnetizing Ratio Distribution

The demagnetizing ratio distribution*1 for each temperature with reference to the magnetization before the temperature rises is indicated in Fig. 2.
The entire magnet is demagnetized at 140 degrees Celsius when compared to the magnetization before the temperature rises. The ends of the magnet are dramatically demagnetized almost 70%, as indicated in Fig. 2. Even when the magnet is returned to 60 degrees Celsius, there is a large range of demagnetization.

*1The demagnetizing ratio is the amount of demagnetization with reference to magnetization that is specified.

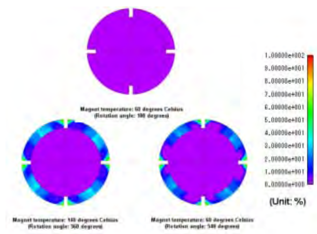


Fig. 2. Demagnetizing ratio distribution

Operating Point

The element selected to display the operating point is indicated in Fig. 3, and the operating point for each temperature is indicated in Fig. 4. The irreversible demagnetization is apparent because the operating point has exceeded the knee point for element A after the temperature rises. The operating point does not return to the original B-H curve after the temperature is reduced to 60 degrees Celsius. The size of the reverse magnetic field imposed upon each element is also illustrated on the horizontal axis.

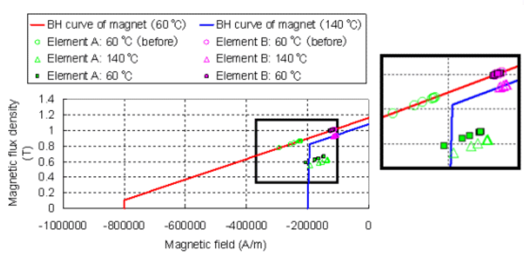


Fig. 4. Operating point

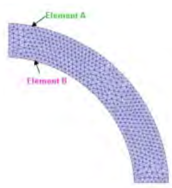


Fig. 3. Selected element

Over 120 analysis examples for JMAG are available on our website at: http://www.jmag-international.com/catalog/index.html

Exhibition Report

TECHNO-FRONTIER 2010 MOTORTECH JAPAN/POWER SUPPLY JAPAN 2010

The JSOL Corporation presented and demonstrated JMAG at the MOTORTECH JAPAN and POWER SUPPLY JAPAN exhibitions held at the TECHNO-FRONTIER 2010. More than 1,500 people turned out for the exhibition which ended as a great success.

The latest version of JMAG-Designer released on the same day as the exhibition was announced and the motor simulation technology leading the industry was introduced by JSOL.

We would like to take this opportunity to offer those that were unable to attend the exhibition the materials that were distributed at MOTORTECH JAPAN via the JMAG website.

Overview of MOTORTECH JAPAN Exhibition

● Presentations

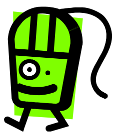
- Motor Design Using JMAG
- Demands for Motor Performance
- Achieving Higher Design Efficiency Using JMAG
- JMAG – Simple to be Precise
- Providing Highly Accurate Motor Models
  -Revolutionizing the Supply Chain-
- Solutions for Everyone Working with Motors
- Noise issues of Motor Drives
- Demands for Optimized Design
  -Simulations for Optimizing Designs-

● Exhibition Overview

- JMAG-Designer Takes Off !
- Motor Design Using JMAG-Designer
- Examining a Multitude of Designs Using Parametric Analysis
- Demands for Motor Performance
  -More Comprehensive Analysis-
- Would You Like to Make a Digital Motor Catalog?
- High-speed JMAG Solver
  –If Its Not Fast, Its Not Worth Using-
- Leading-edge Automatic Mesh Generation Technology in JMAG
- Using JMAG-RT
- Addressing the Heat of Motors Using JMAG-Designer
- Conduction Noise Analysis of a Motor Driven by an Inverter
- Enhanced Support System

For the materials distributed at MOTORTECH JAPAN 2010, see:

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



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Panels & Flyers

Presentations

Overview of Presentations at the MOTORTECH JAPAN 2010 Exhibition

Motor Design Using JMAG

The latest version of JMAG, the analysis tool proven for motor design and development, will be released in July. This presentation introduces some of the functions recommended for motor design.

Demands for Motor Performance

The highly advanced motors of today require limit state design. Capturing and evaluating the inner workings of motors is vital to satisfy the stricter demands of designs. An evaluation and analysis environment driven by CAE can step up to these demands.

Achieving Higher Design Efficiency Using JMAG

Time is valuable to each one of us. For this reason, JMAG continues to strive to increase the speed analysis. More comprehensive models as well as a multitude of cases can be analyzed quickly by utilizing the high-speed linear solver, the multiple core/cluster parallel solver, and distributed processing. This presentation demonstrates the raw power of JMAG.

JMAG – Simple to be Precise

Since its release in 1983, JMAG has been utilized for a large number motor development projects around the world. JMAG combines many years of experience in the field of motors in an easy to use package. This presentation introduces how simple highly accurate analyses can be to perform.

Providing Highly Accurate Motor Models – Revolutionizing the Supply Chain -

The complexity of motors and application directed motors being designed today cannot be expressed on a paper request or specifications. The detailed specifications of a motor can be defined using JMAG-RT by confirm the motor to be used. Wouldn't you as a motor manufacturer or motor procurer like to investigate the motors you supply or purchase in advance?

Solutions for Everyone Working with Motors

This presentation introduces the vast range of ways JMAG can be used for a multitude of applications. JMAG is ideal for the design and development of unique products by allowing users the potential for new discoveries.

Noise Issues of Motor Drives

Issues of electromagnetic noise in motor drives is more apparent as switching devices increase in speed. The analysis solutions provided by JMAG+EMC Studio can support users in overcoming these problems.

Demands of Optimized Design – Simulations for Optimizing Designs -

The physical phenomena acting on motors is very complex. Designers are constantly struggling with the trade offs of motor characteristics such as the magnetic circuit, strength, output, and temperature. The latest simulation technology provides new avenues to solutions by allowing designers to take one step closer to the physical phenomena that occurs. This presentation introduces optimization design using JMAG.

Overview of the POWE SUPPLY JAPAN 2010 Exhibition

● **Exhibition Outline**

- Transformer design features in JMAG
- Reliable transformer design

JMAG-Designer Ver.10 implements a specialized interface to analyze transformers and reactors. If you would like a catalog for JMAG-Designer or analysis examples of a power or switching transformer, please contact us using the contact information to the right.

（Contact）
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