Making JMAG analysis handy by CATIA models

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Abstract :
A lot of permanent magnets and electromagnets are used for the actuator and the sensor, etc. now. In SMC Corporation who is the air pressure equipment maker, a permanent magnet and the electromagnet are built into products such as the solenoid valves, cylinders and card motor.
Recently, the magnetic field analysis software came to calculate a complex model at short time. Therefore, it has come to be used for the product development.
In this paper, it is described to analyze the magnetic field handily by using three dimension model of CAD;CATIA for an analytical model of JMAG.

Making JMAG Analysis Handy With CATIA Models

Hisashi Yajima* (SMC)

A lot of permanent magnets and electromagnets are currently being used for things like actuators and sensors. At the SMC Corporation, an air pressure equipment manufacturer, permanent magnets and electromagnets are built into products such as solenoid valves, cylinders and card motors.

Recently, magnetic field analysis software has been able to calculate complex models in a short period of time, so it has come to be used for product development.

In this presentation, I will describe how to analyze a magnetic field simply by using a three dimensional model of CAD (CATIA Ver5) as a JMAG analytical model.

(Keywords, Magnetic field analysis, JMAG, CAD, CATIA)

1. Introduction

Permanent magnets and electromagnets are currently being used in things like actuators and sensors, and at the SMC Corporation, an air pressure equipment manufacturer, permanent magnets and electromagnets are built into products such as solenoid valves, cylinders, and card motors. Electromagnetic analysis using techniques such as FEM, which has been actively researched since the 1980's, has gotten to where it can calculate more complex models that are closer to actual machines in a short period of time, thanks to developments in computer functions and software. Accordingly, at development and design centers they have begun to use FEMs like CAE with the objective of lower development time and prototype costs.

In this paper I will talk about the following issues regarding magnetic field analysis using JMAG-Designer (JSOL Corporation), an electromagnetic field analysis software.

(1) Electromagnetic field analysis at development and design centers
(2) Simplification of JMAG analysis using CATIA models
(3) JMAG's handy features

2. Electromagnetic field analysis at development and design centers

Fig. 1 displays the steps of product design at a design and development center. When designing a product at a development and design center, they study the dimensions and material qualities of each part and decide on them in order to fulfill the required specifications of the product. These are decided either

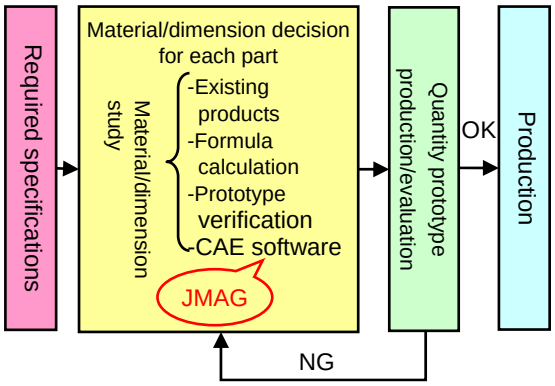


Fig. 1 Product design steps

based on existing products or studies of desktop calculations based on mathematical formula (They actually use spreadsheet software or independent programs). There are also times when they make decisions for new products while verifying prototypes. Then they manufacture and evaluate the prototype, and if it meets the specifications then it moves on to the next production preparation stage. However, in the event that the prototype does not meet the required specifications, setbacks occur such as studying the materials and dimensions again, so a lot of time and expense are wasted.

When studying the material quality and dimensions for each part, CAE software like JMAG is used. If a person can obtain a precise result in a shorter amount of time, then they can get rid of the prototype verification and setbacks, thereby shortening development time and reducing expenses by a wide margin.

3. Simplification using CATIA models

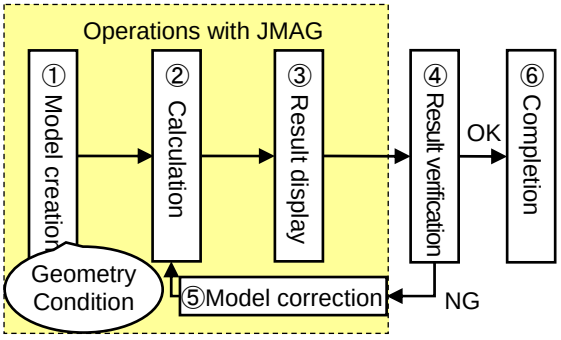
I have assembled the problems with using CAE software below:

(1) It requires learning the software's specific operations.
(2) Not understanding the conditions or usage method for precise calculations.
(3) Creating and correcting the analysis model take time.
(4) Calculations take time.

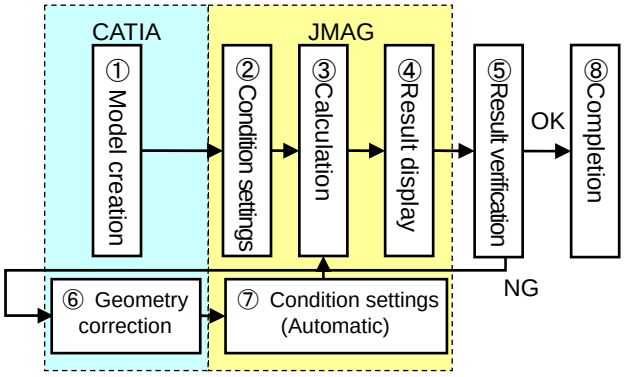
Points (1) and (2) above become problems when introducing CAE, but by becoming familiar with it and building up experience they can be resolved. For point (4), by making the analysis model as small as possible and using multiple computers that have a fast computation rate, this problem can be solved to a certain extent, as well. For point (3): analysis model creation and correction, which occurs during calculations, I would like to introduce a case study in which it is possible to use a model produced in a CAD software called CATIA Ver. 5 (Made by IBM, referred to below as CATIA) and carry it out simply in JMAG-Designer (JSOL Corporation, referred to below as JMAG).

Fig. 2 displays the steps of magnetic field analysis using JMAG. First, make an analysis model. At this step, set the geometry, dimensions, material conditions, and analysis conditions. After that run the calculations with a computer, display the results, and study them. If you are not satisfied with the results, correct the analysis model and run the calculations again. Normally you can use the model geometry creation tools built into JMAG for the model geometry. Producing a complicated actual machine model requires time to become familiar with the software, and because you create the geometry from scratch it takes time to create a model. In order to reduce the time required to create a model you can load a 3D model made in CATIA, but when you correct the geometry you have to load the 3D model from CATIA and set the conditions. In actual designs there are several design variables (Like dimensions, etc.), in addition to processing several dozen analysis models, so carrying out the condition settings for each case requires an extremely large amount of time for the worker and becomes a burden.

This is where I would like to introduce CAPRI, which couples the analysis model geometry between CATIA and JMAG. As shown in fig. 2 (b), by using CAPRI the geometry that you edited in CATIA appears in JMAG, and you can run the analysis without doing the condition settings every time (With CAPRI you just do the settings when installing JMAG, so you are not actually aware of it when you are using it.). By using these functions, you can greatly reduce the working time used toward

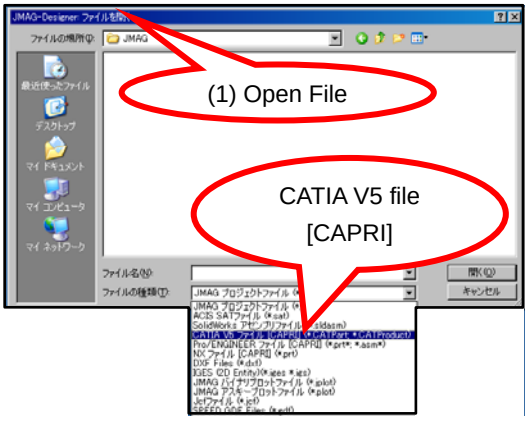


(a) When only operating with JMAG



(b) When coupling with CATIA

Fig. 2 The steps of magnetic field analysis using JMAG



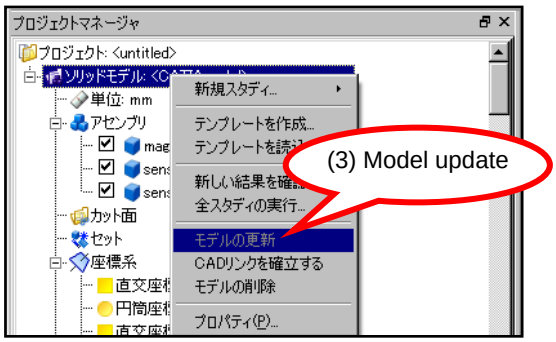


Fig. 3 CATIA and JMAG coupling screen
(The screen is JMAG-Designer Ver10.5)

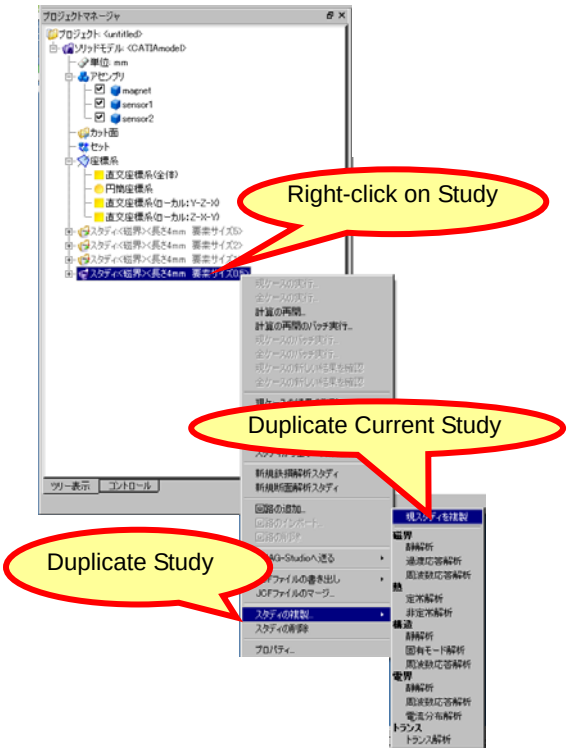


Fig. 4 Study duplication method
(Screen is JMAG-Designer Ver. 10.5)

creating and correcting the analysis model, which occurs with every analysis, and you do not have to become familiar with the model geometry creation method that is specific to JMAG.

Fig. 3 displays the PC screen when analyzing while correcting geometry that is coupled between CATIA and JMAG. The process is carried out with the steps below:

(1) Select "CATIA V5 File [CAPRI]" from "Open File"
····· Model coupling

(2) Change CATIA's geometry and save
····· Model geometry change

(3) Select "Update Model" in JMAG
····· Analysis model correction

(4) Select "Run Study" in JMAG
····· Running the calculation

4. JMAG's handy features

In the previous section I showed the fact that it is possible to reduce man-hours by coupling with CAD (CATIA) when creating and correcting an analysis model, but there are other convenient functions in JMAG, as well. I will introduce them below:

(1) Copying conditions that require analysis results

In the previous version of JMAG (JMAG-Studio), the user had to input conditions (I have listed the conditions that require analysis results below) such as flux density

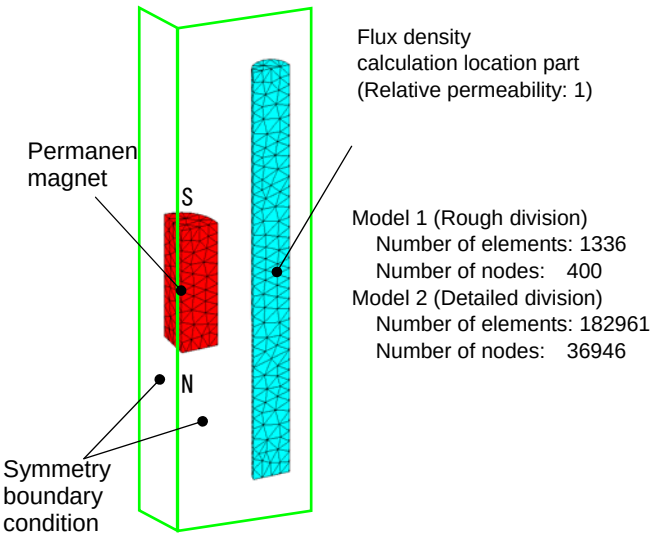
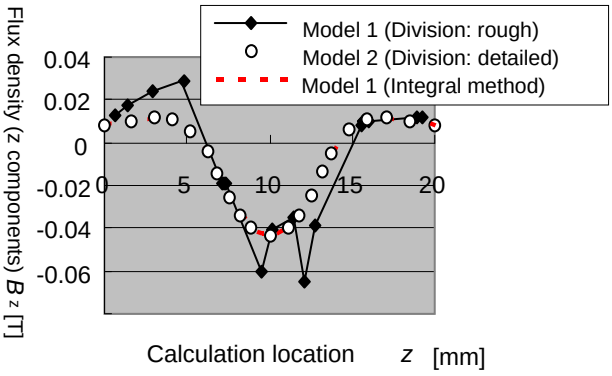


Fig. 5 Analysis model of the magnetic proximity sensor (1/4 model)



and electromagnetic force based on the vector potential calculated in fig. 2 ② for each time, and display the results.

It is not a special function or anything, but with JMAG-Designer, when the user copies and corrects a study (analysis model) that he used before, both the analysis conditions and conditions that require analysis results carry over from the original model (See fig. 4). Consequently, if the user duplicates the study, changes the materials and analysis conditions, and recalculates, there is no need to set up those kinds of conditions again. Additionally, with the model that was coupled with CATIA that I introduced in section 3, if you correct the model geometry in CATIA and run "Update Model," both the analysis conditions and the conditions that display the calculation results are set up in advance in the same way, so you can run the calculations without setting them up again.

(2) Calculating flux density in the air

In developing an electromagnetic sensor, there are times when we calculate the flux density of a detection

component's position in the air. In magnetic field analysis using FEM, the flux density is calculated for every element. Because of that, in order to display magnetic density in the air with good precision, we had to carry out detailed element breakdowns, even in air regions that exert hardly any influence on the magnetic circuit.

In the traditional JMAG (JMAG-Studio), we used the integral method from the vector potential that was calculated with FEM, and a tool that calculated flux density at an arbitrary point had been prepared. With JMAG-Designer, that tool has been equipped as a standard feature, which makes it easier to use. In the Project Manager in JMAG, if you select "Air Region" under "Analysis Results" > "Section" and use the integration method, then it calculates the flux density.

Below, I have shown an analysis case example regarding a magnetic proximity sensor that detects the piston position of the air pressure cylinder (the auto-switch). The permanent magnet is attached to the movable piston, and it detects the piston's position with the stationary magnetic resistance effect component (MR component). Using JMAG, we calculate the flux density made by the permanent magnet in the MR component's location (Axial direction component). The analysis model appears in fig. 5. This analysis model is a 1/4 model that uses the symmetry boundary condition. In model 1, the element breakdown of the detection component's position is rough. In model 2, we set up a part of relative permeability 1 in the detection component's location, and made the element breakdown more detailed. The calculation result appears in fig. 6. In model 1 (◆), with a rough element breakdown of the calculation location, the element is big, and we have not been able to calculate the detection component location's flux density. In model 2 (○), with the more detailed element breakdown, we were able to calculate it, but there were too many elements, which took time to calculate. The influence from element breakdowns such as element size and location was also large. In the calculation results from the integral method (dotted line), regardless of whether the element breakdown of the calculation location is rough, it is consistent with the calculation result where the element breakdown was detailed. There is not much influence from the element breakdown either, so it is easy to compare calculation results when changing the geometry.

5. Afterward

In this paper, I showed the places where electromagnetic field analysis is used in development and design centers, and also stated how coupling CATIA Ver5 with JMAG and using CATIA's 3D model with JMAG's analysis model allows a person to carry out magnetic field analysis easily without becoming familiar with JMAG's specific model creation.

I hope that the functions introduced here will be of help to JMAG users, and will allow everyone to carry out more useful magnetic field analysis.