Logic and Strategies When Analysis and Measured Results Don't Match

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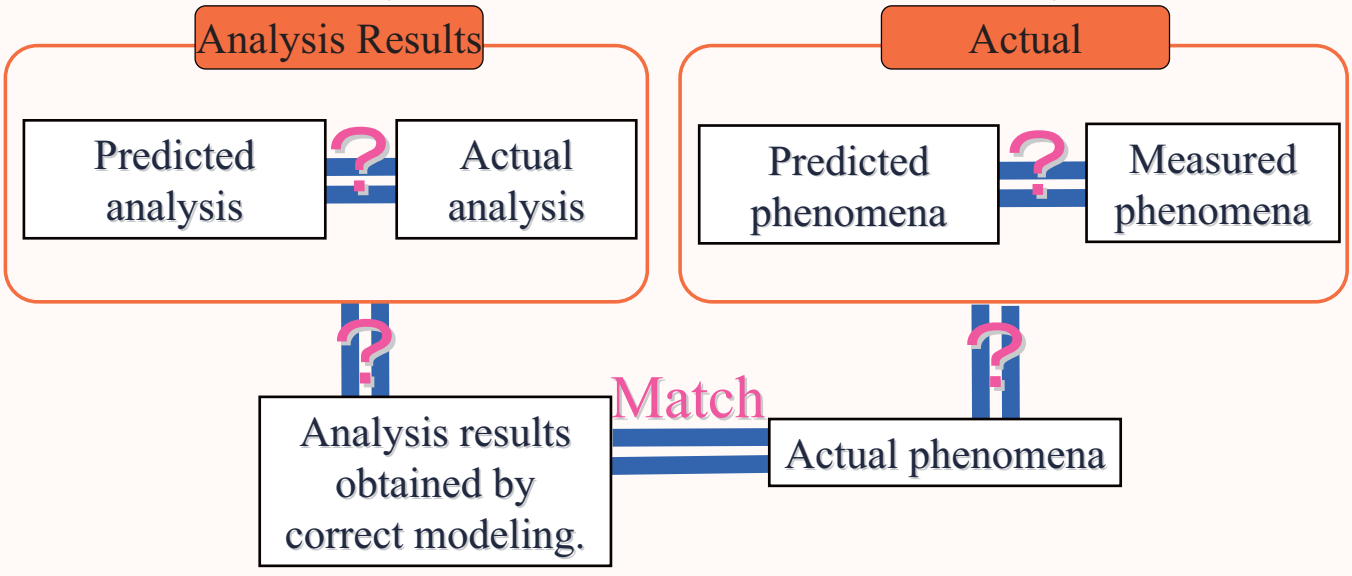
Contents

Overview

- Often the results obtained by analyzing geometry clearly modeled from the prototype does not match the results that are measured. In this situation, the way of filling in the difference between the analysis results and measured results is key.
- This seminar introduces reasons why the analysis and measured results do not match and provides examples to address these issues.

Do the Analysis and Actual Phenomena Match?

- The analysis results will match the actual phenomena if the modeling is correct.
- However, the analysis results often do not match the analysis results.



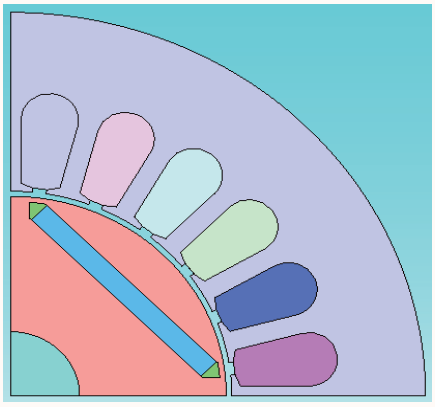
There are many reasons results don't match...

- The prototype and analysis model differ
  - The geometry, dimensions, or material properties differ from the prototype
- There is phenomena not taken into account in the analysis. (The analysis is run based on the specified settings)
  - Eddy currents, 3D effect, laminated structure of electromagnetic steel sheets
- The method of modeling is inappropriate
  - The air region is insufficient, mistakes in condition settings, misuse of analysis features
- The conditions don't match
  - The rotation speed differs. The current differs.
- Numerical errors
  - Discretization error of mesh/error of nonlinear calculations
- Problems caused by Measurement
  - The physical quantities being compared differ
  - The environment, such as temperature, differs.
  - Measurement error

Strategy: Example (1) Discrepancies in Motor Loss

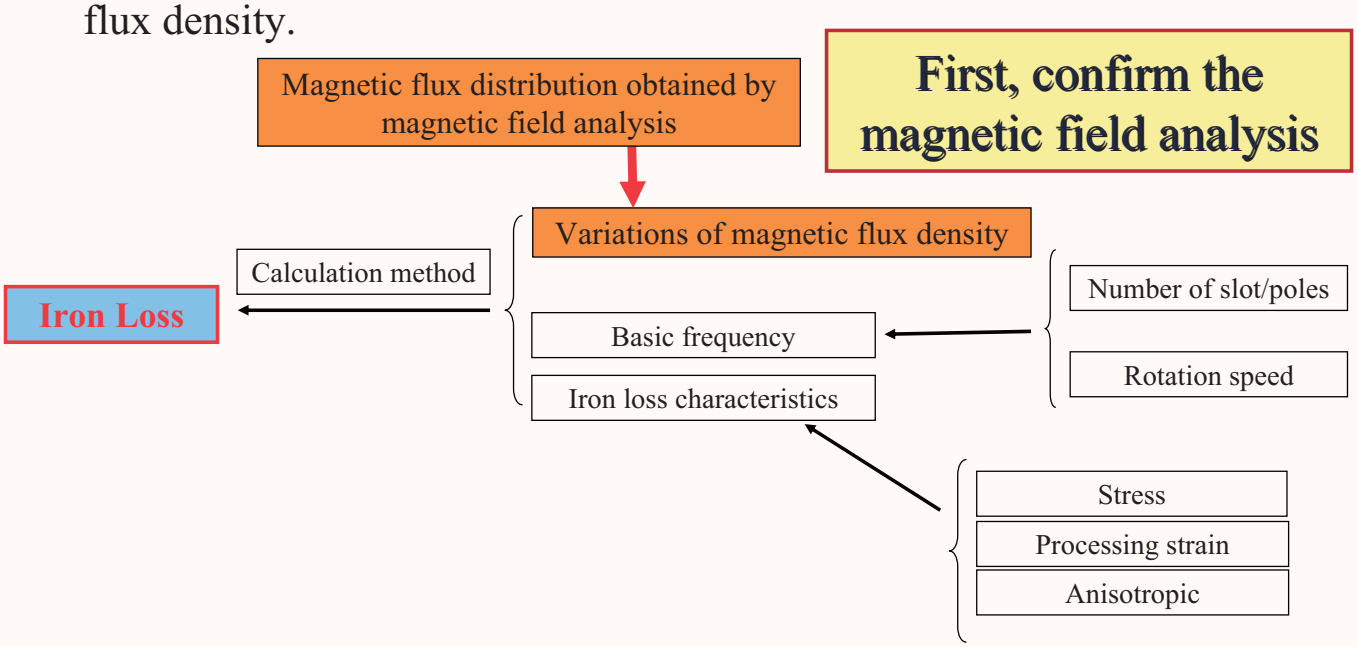
(Prediction)

- 2D analysis of an IPM motor
- Excited by sinusoidal current
- Iron loss obtained using the Iron Loss Calculation tool.



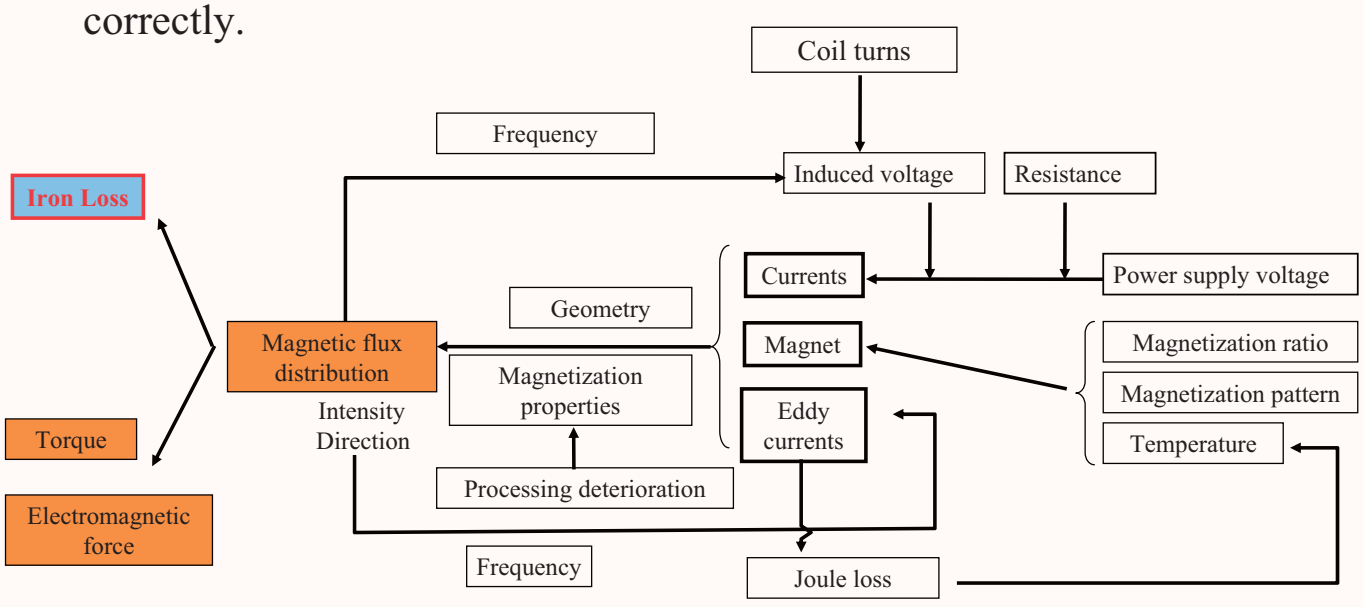
Correlation Diagram of Iron Loss Calculations

- The magnetic field analysis needs to obtain highly accurate results because the iron loss is calculated from the variations of the magnetic flux density.



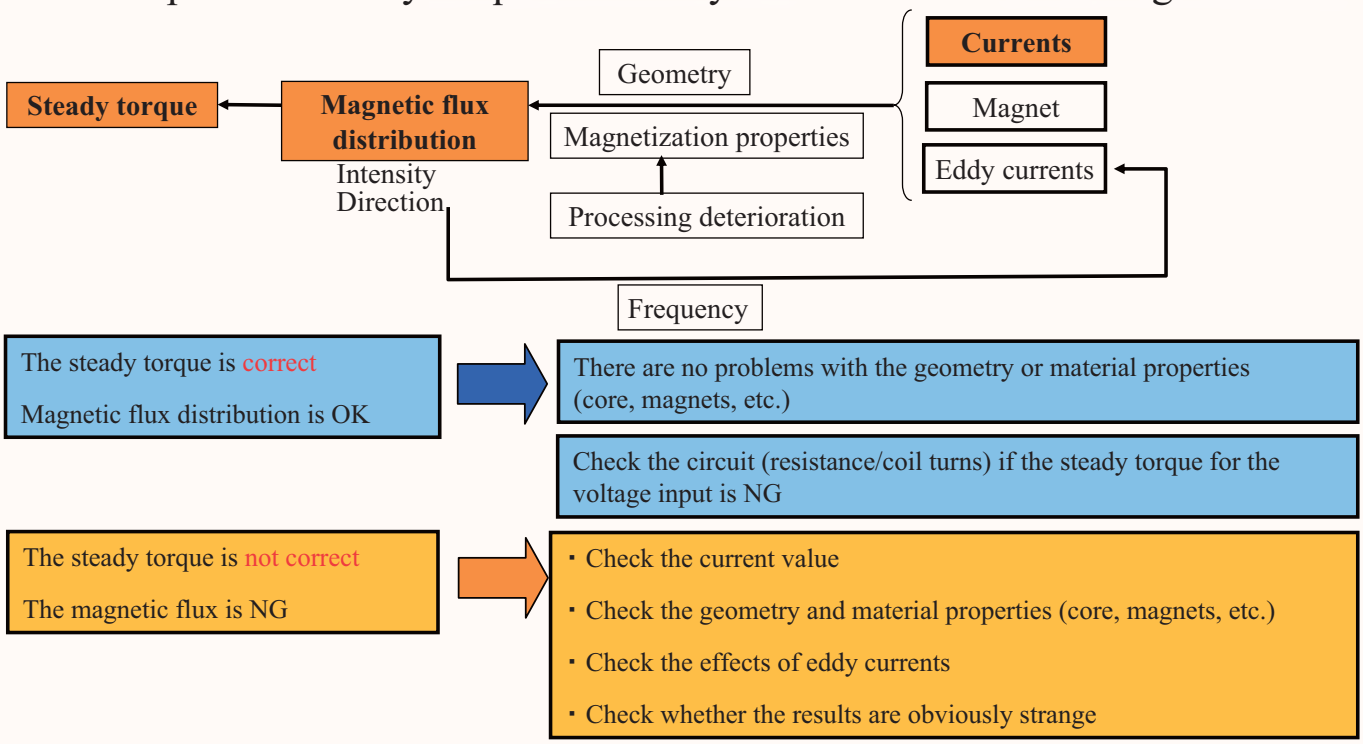
Correlation Diagram of the Magnetic Field Analysis

- Whether the steady torque matches the measured results is confirmed first to examine if the magnetic flux distribution has been obtained correctly.



Confirming Magnetic Flux Distribution

- Compare the steady torque excited by current rather than voltage



The steady torque is correct

Magnetic flux distribution is OK

→ There are no problems with the geometry or material properties (core, magnets, etc.)

→ Check the circuit (resistance/coil turns) if the steady torque for the voltage input is NG

The steady torque is not correct

The magnetic flux is NG

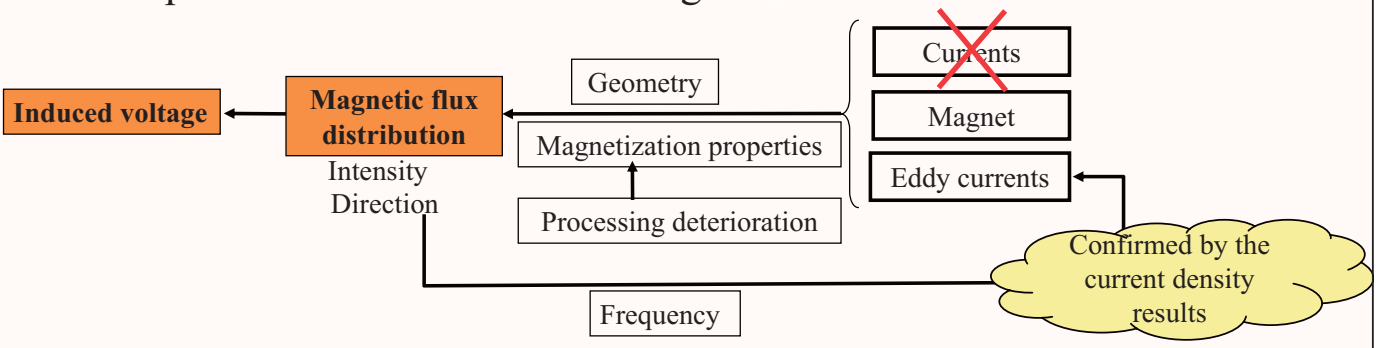
→
- Check the current value
- Check the geometry and material properties (core, magnets, etc.)
- Check the effects of eddy currents
- Check whether the results are obviously strange

Checking Whether the Results are Obviously Strange

- Confirming the magnetic flux density
  - The magnetic flux density saturates at approximately 2.2 T. Confirm that the saturation is not unusually large, such as 20 T, or unusually small, such as 0.001 T.
  - Confirm the flow of the magnetic flux density. Is the magnetic flux concentrated in the core as predicted? Is the magnetic flux density choppy or swirling?
- Confirming the Current Density
  - 2E+7 A/m^2 is normally the upper limit of current density. Are the results for the current density appropriate?
  - Confirm the flow of current density. Is the current suddenly eliminated? Is the current density smooth?

Confirming the Current Value

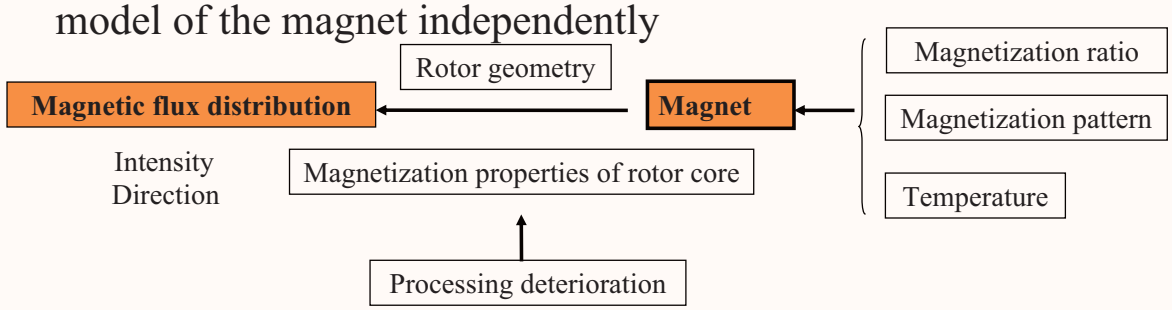
- Compare the no load induced voltage without a current.



The induced voltage is correct The current value is NG	Check whether the settings for the current are correct Check whether the current is flowing as intended
The induced voltage is incorrect The current value is OK or NG	・Check the geometry and material properties (core, magnets, etc.) ・Check the effects of eddy currents

Confirming the geometry and material properties

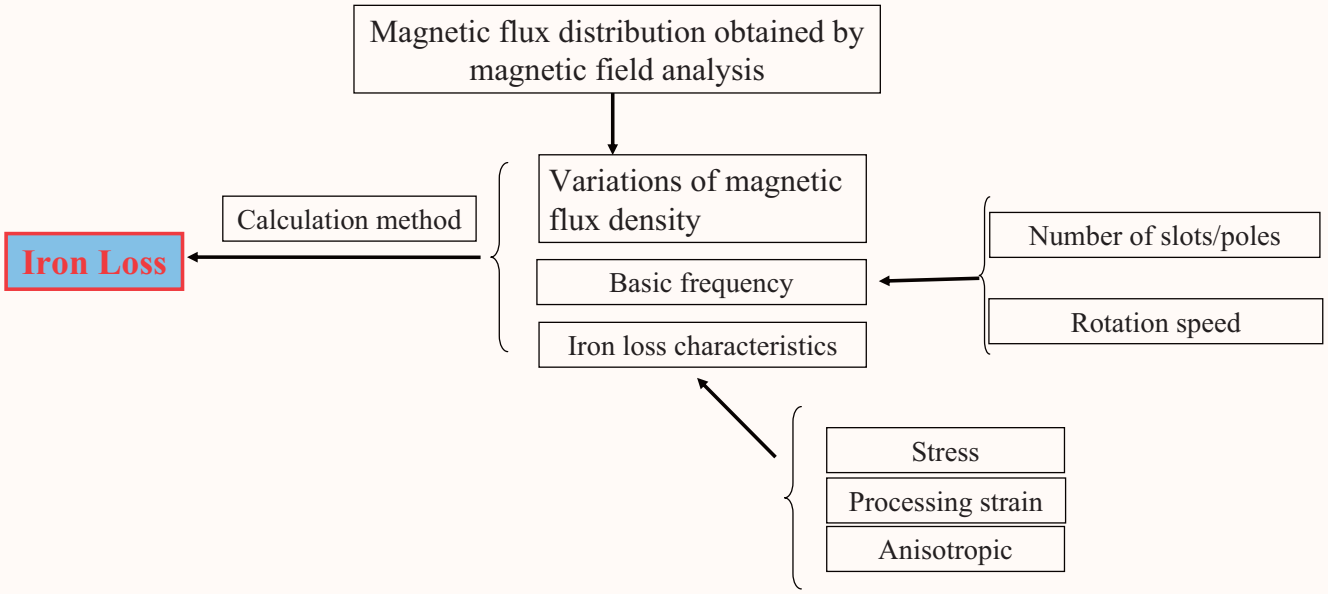
- Compare the magnetic flux density on the surface of the magnet using a model of the magnet independently



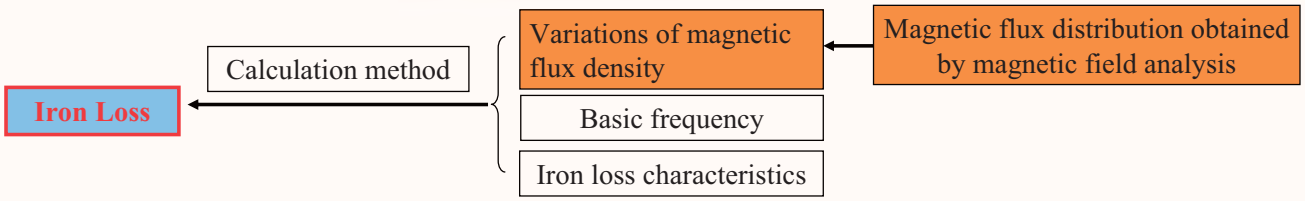
The surface magnetic flux density is correct The properties of the rotor core and magnets are OK	・Check the stator geometry and gap width ・Check the magnetization properties of the stator core Check the 3D effect (effects of the ends, skew, overhang)
The surface magnetic flux density is incorrect The properties of the rotor core and magnets are NG	・Check the magnets (magnetization properties, orientation, magnetization ratio, demagnetization, geometry) ・Check the properties of the rotor core and geometry

Confirming the Iron Loss Calculation Settings

- The settings for the iron loss calculation are confirmed if the results for the magnetic field analysis are correct.



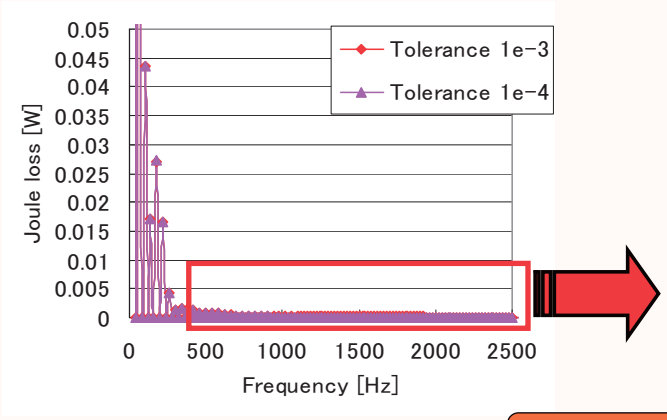
Confirming the Required Magnetic Field Analysis Accuracy for the Iron Loss Calculation



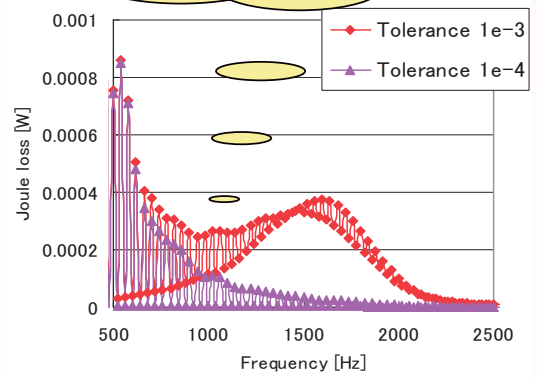
- Are the magnetic flux density variations at the calculation frequency obtained?
  - If the variations of the magnetic flux density are not obtained at the frequency to calculate:
    - (Countermeasure) Use a smaller time interval for the magnetic field analysis
    - (Countermeasure) Decrease the nonlinear tolerance
  - If the variations of magnetic flux density are not obtained at a higher frequency than the frequency to calculate:
    - (Countermeasure) Ignore the unnecessary iron loss of harmonics
- Are there current harmonic components when using PWM, etc.?
  - (Countermeasure) Confirm the effects of the harmonics by running a magnetic field analysis using a current waveform accounting for PWM.

Reasons the Analysis Does Not Match the Measured Results

- The iron loss is overestimated because the accuracy of the magnetic field analysis results in a high-frequency region are low.



The iron loss should not increase in high-frequency regions when excited by sinusoidal current



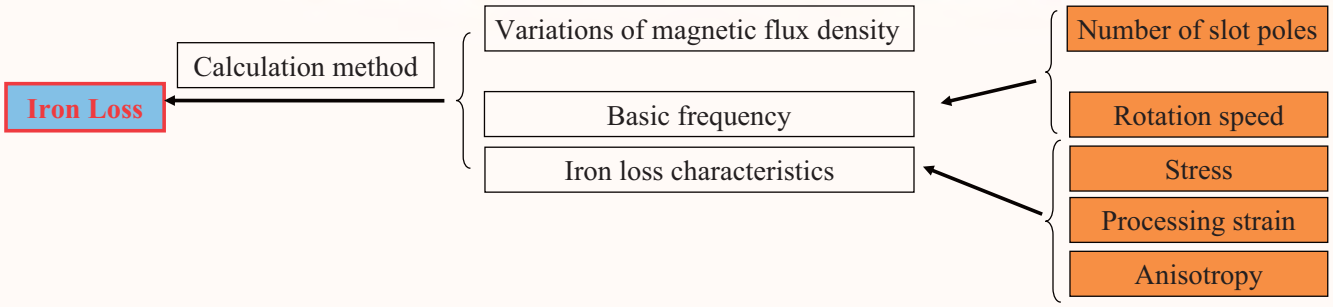
The accuracy is improved by setting the nonlinear tolerance to 1e-4

Because the high-frequency region is not required when using a sinusoidal current:

(Countermeasure) Ignore the results in high-frequency regions.

(Countermeasure) Do not calculate the iron loss in the high-frequency region.

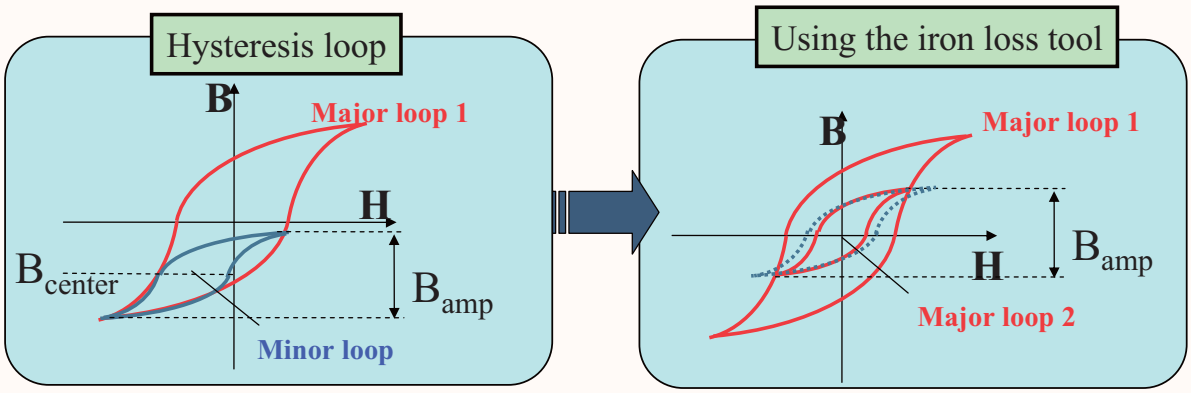
Confirming the Iron Loss Calculation Settings



- Is the basic frequency set correctly?
  - (Countermeasure) Confirm the rotation speed, number of slots, etc. are set correctly.
- Are the iron loss characteristics being used appropriate?
  - (Countermeasure) Confirm the following:
    - The frequency range taken into account for the iron loss characteristics
    - Whether there is stress or processing strain
    - Whether anisotropic materials are taken into account if they are used
    - The effects of the minor loops' positions

Regarding the Minor Loop

- The hysteresis loop of the minor loop is substituted with the loss of the major loop 2 equaling B_{amp}.
- The results obtained using the Iron Loss Calculation tool are underestimated if the loss (= area of the loop) of the actual minor loop and minor loop 2 differ when the position of the minor loop (B_{center}) has a high magnetic flux density.



Confirming the Measured Iron loss

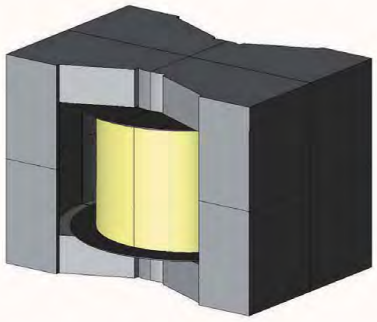
Confirm the measured iron loss if the magnetic field analysis and iron loss calculation are correct.

- Are the analysis conditions and measuring environment the same?
  - Could the environment, such as temperature, vary.
  - Are there any differences in the conditions, such as the rotation speed?
- Has the iron loss been correctly obtained?
  - Has the machine loss or copper loss been correctly obtained?
  - Has the iron loss of the inverter been isolated?
  - Is the function squared when confirming the frequency of iron loss?
- Are there any other losses (residual loss)?
  - Is there any residual loss due to flux leakage?
  - Is there any magnet eddy current loss?
  - Is there any eddy current loss due to insulation breakdown?

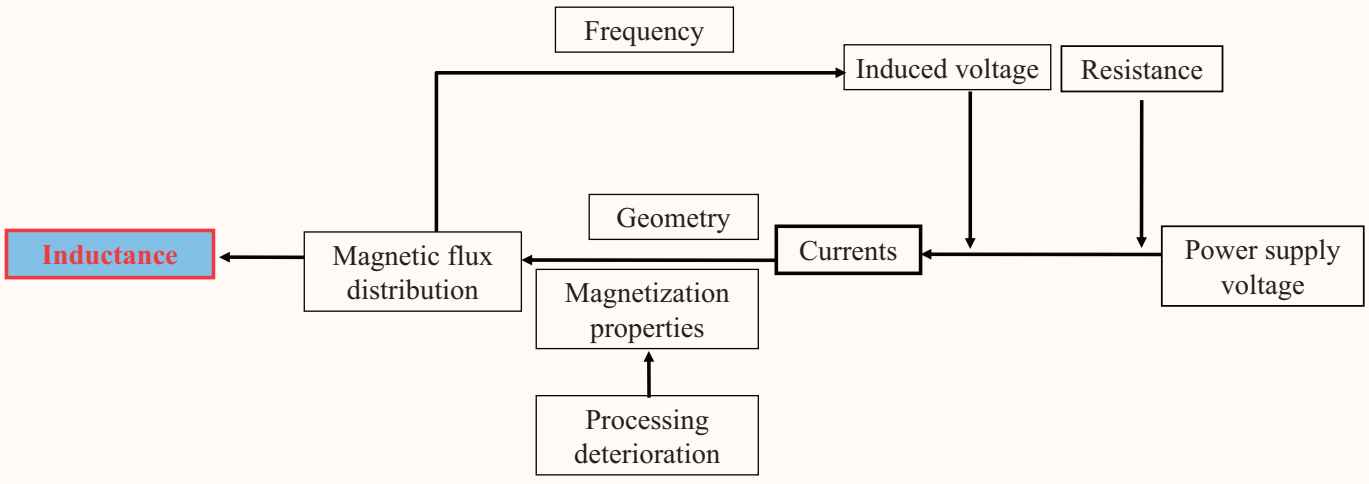
Strategy: Example (2) Discrepancies in Inductance

(Prediction)

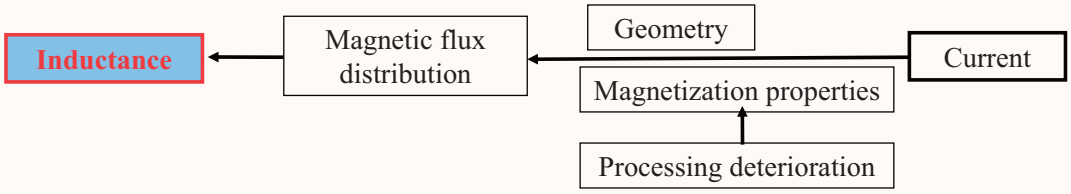
- 3D analysis of a choke coil
- Calculating inductance from the current and interlinkage magnetic flux



Correlation Diagram of the Inductance Calculation



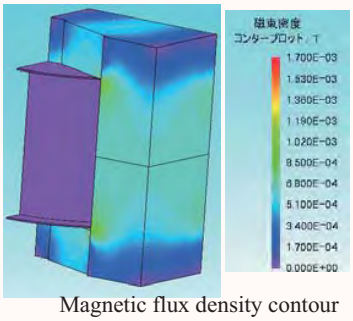
Confirming the Geometry and Magnetization Properties



- Inductance (L) represents the relationship between the current and flux linkage (Φ; flux acting on the coil)
- The inductance only depends on the geometry and magnetization properties if the current has been determined.
  - Confirm the geometry: Confirm whether the dimensions or unit of measurement differ
  - Confirm the magnetization properties: Confirm the operating points and whether the magnetization properties around the operating points differ

Reasons the Analysis Does Not Match the Measured Results

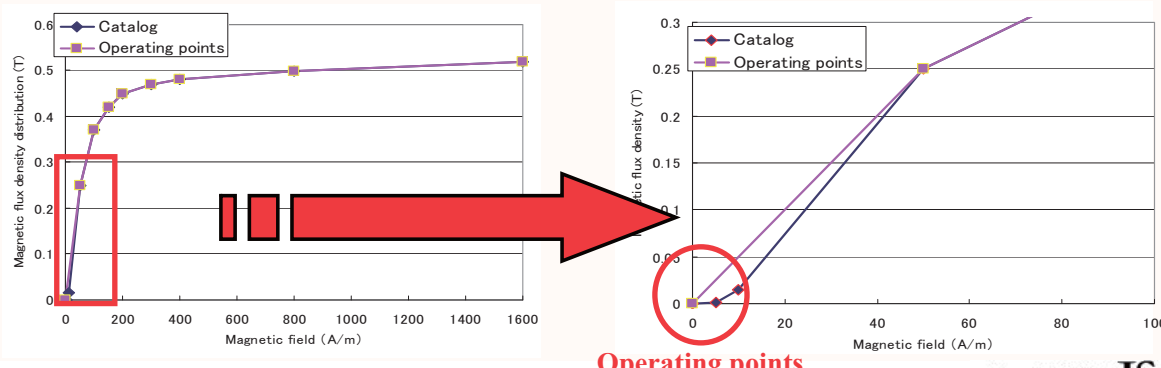
- The inductance differs largely because a the magnetization properties point sequence for the operating points is not specified.



Magnetic flux density contour

Inductance Results

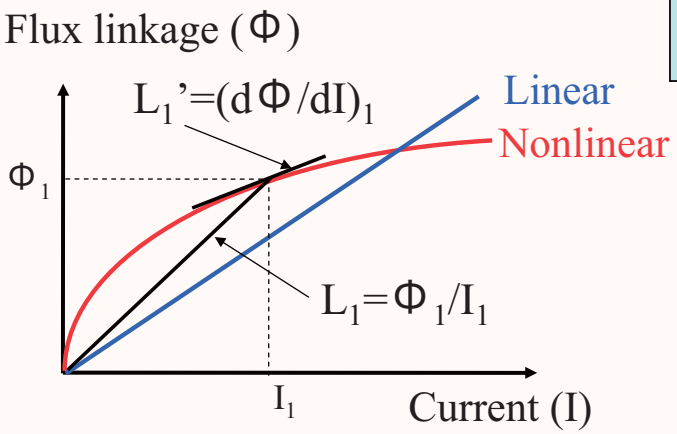
	Catalog	Operating points
Current (mA)	1	1
Inductance (mH)	1.96	3.97



Confirming the Actual Inductance

- There are two definitions of inductance. The inductance that is measured and the inductance obtained by an analysis need to be the same.

- Tied to the origin (hereinafter L): L=Φ/I
- Taken from the slop (hereinafter L'): L'=dΦ/dI



Linear: L=L'
Nonlinear: L≠L'

Conclusion

- There is always a reason that the analysis results do not match the actual measurements.
- Finding the cause is sometimes difficult, but can be flushed out with patience.
- Please contact the JMAG Support team if you can't figure out how to handle any problems you encounter.

Contact

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