Measurement and analysis of amplitude magnetic permeability and magnetic losses of Silicon steel sheet

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Background

Silicon steel sheet is one of the most widely used magnetic materials and has the advantages of high magnetic permeability, low magnetic loss, small magnetostrictive effect and easy processing. It is the core material of a variety of motors and transformers . The permeability is an important indicator of the performance of silicon steel, which represents the ability of a silicon steel film to lead the flux. The non-linearity of the permeability of the magnetic materials affects the magnetization of the material and even affects the stability and controllability of the motor . Electromagnetic loss is also an important parameter for the application of magnetic materials. Therefore, the measurement and analysis of the permeability and electromagnetic loss of silicon steel sheet are the basis of designing various motors, which is of great significance to improve the working efficiency of the motor.

Objectives

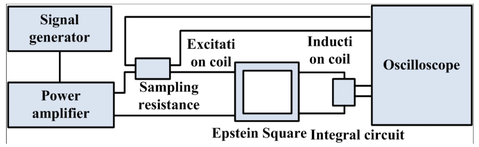
- The amplitude of magnetic permeability and electromagnetic losses of Silicon steel sheet are important parameters of designing all kinds of motors.
- It is necessary to analyze the relationships between magnetic permeability and electromagnetic loss of silicon steel sheet and frequency before designing the most efficient motors .

Conclusion

- Silicon steel sheet in the same magnetic field, with the magnetic field frequency increasing, the amplitude of magnetic permeability fluctuates downward trend.
- At the same magnetic field frequency, as the magnetic induction intensity increases, the amplitude of the magnetic permeability and the real and imaginary part of the complex magnetic permeability increase and then decrease.
- Under the same magnetic induction intensity, the real part of the amplitude of magnetic permeability and the complex magnetic permeability decreases with the increase of the magnetic field frequency, and the imaginary part of the complex magnetic permeability decreases firstly and then decreases.
- Under the condition of low frequency magnetic field, the electromagnetic loss mainly comes from the hysteresis loss. Under the high frequency magnetic field, the electromagnetic loss mainly comes from the eddy current loss.

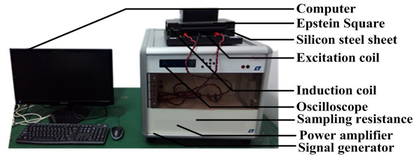
Methods

Measurement Schematic



The whole system consists of function signal generator, power amplifier, Epstein box, silicon steel sheet (length 300mm, width 30mm, thickness 1mm), sampling resistance, integral amplifier circuit, oscilloscope and so on. Excitation circuit in the Epstein side of the excitation coil access to a sampling resistor and the voltage of the sampling resistor reflects the magnetic field of the silicon steel. The integral amplifier circuit is accessed to the Epstein side of the induction coil and the induction coil voltage reflects magnetic induction intensity of the silicon steel sheet.

Experimental Procedures



Different magnetic hysteresis loops are measured using AMH-1M-S dynamic testing system under different conditions:

Hysteresis curves of the same saturation magnetic field under different frequencies;

Hysteresis loops of same magnetic field frequency under different magnetic induction;

Hysteresis loops of different frequencies at the same magnetic induction.

Samples

Sample Dimensions

- Layer length:300mm
- Single-layer thickness:0.5mm
- Single-layer width:30mm
- Density:7.73g/cm3
- Material: Fe-Si N.O.

Epstein frame

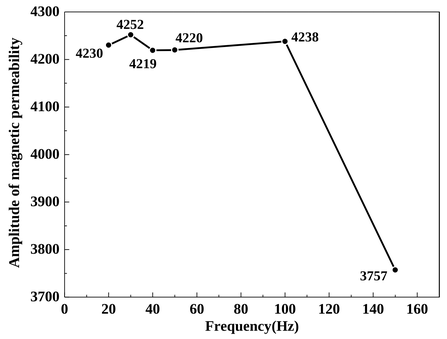
The test method requires the placing of the test samples so that they are lapped upon one another at 90 degrees to one another to form a double lap joint. This configuration uses four stacks to form a closed magnetic circuit.

A The test samples should be 30 mm wide and have a length in the range from 280 mm to 320 mm. The number of pieces required for accurate testing depends on the thickness of the test samples.

The Epstein frame is designed for the measurement of magnetic characteristics of electrical sheet steels in a 30 mm wide test sample, which is in agreement with IEC 60404-2 international test standards.

Results

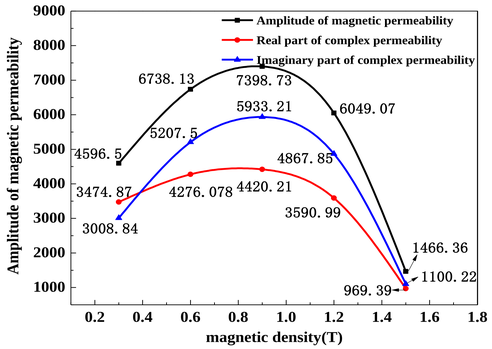
The amplitude of the magnetic permeability of Silicon steel sheet



Magnetic field frequency is in the range of 20 ~ 100Hz, magnetic effect of silicon steel sheet is good. When the magnetic field frequency is above 100Hz, the magnetic permeability drops rapidly.

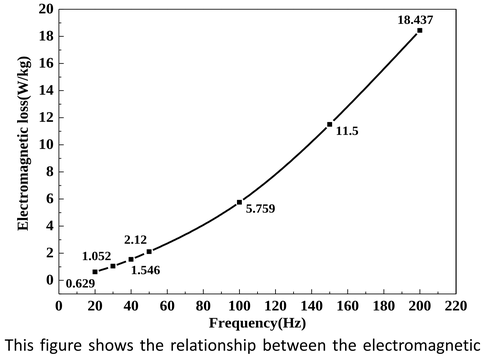
With the increase of frequency, the change of magnetic field is accelerated, and more magnetic domain rotation and magnetic domain wall movement are promoted to accelerate the transition of reversible magnetic domain to irreversible magnetic domain.

The figure shows the relationship between the amplitude of the magnetic permeability and frequency. It can be seen that the amplitude of magnetic permeability decreases with the increasing of frequency when the intensity of the excitation magnetic field is constant.

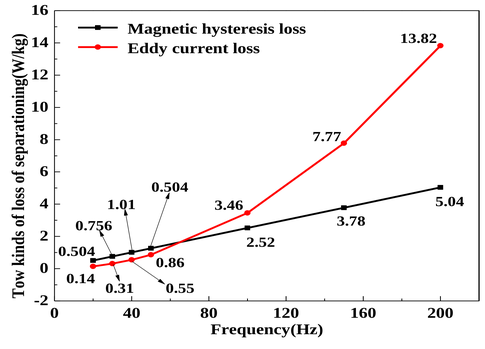


The figure shows the relationship between the amplitude of magnetic permeability and magnetic induction, the real parts of the complex magnetic permeability and magnetic induction, the imaginary parts of the complex magnetic permeability and magnetic induction.

Magnetic losses of Silicon steel sheet



This figure shows the relationship between the electromagnetic loss and the frequency. The imaginary part of the complex magnetic permeability characterizes the electromagnetic loss of the magnetic material. We can see that the effect of frequency on electromagnetic loss is the main factor. With the magnetic field frequency increases, electromagnetic loss increases.



This figure shows relationship between hysteresis loss, eddy current loss and frequency using the separation method of electromagnetic loss. It can be seen from the figure that the hysteresis loss increases linearly with the increase of the magnetic field frequency. With the increase of the magnetic field frequency, the eddy current loss increases rapidly.