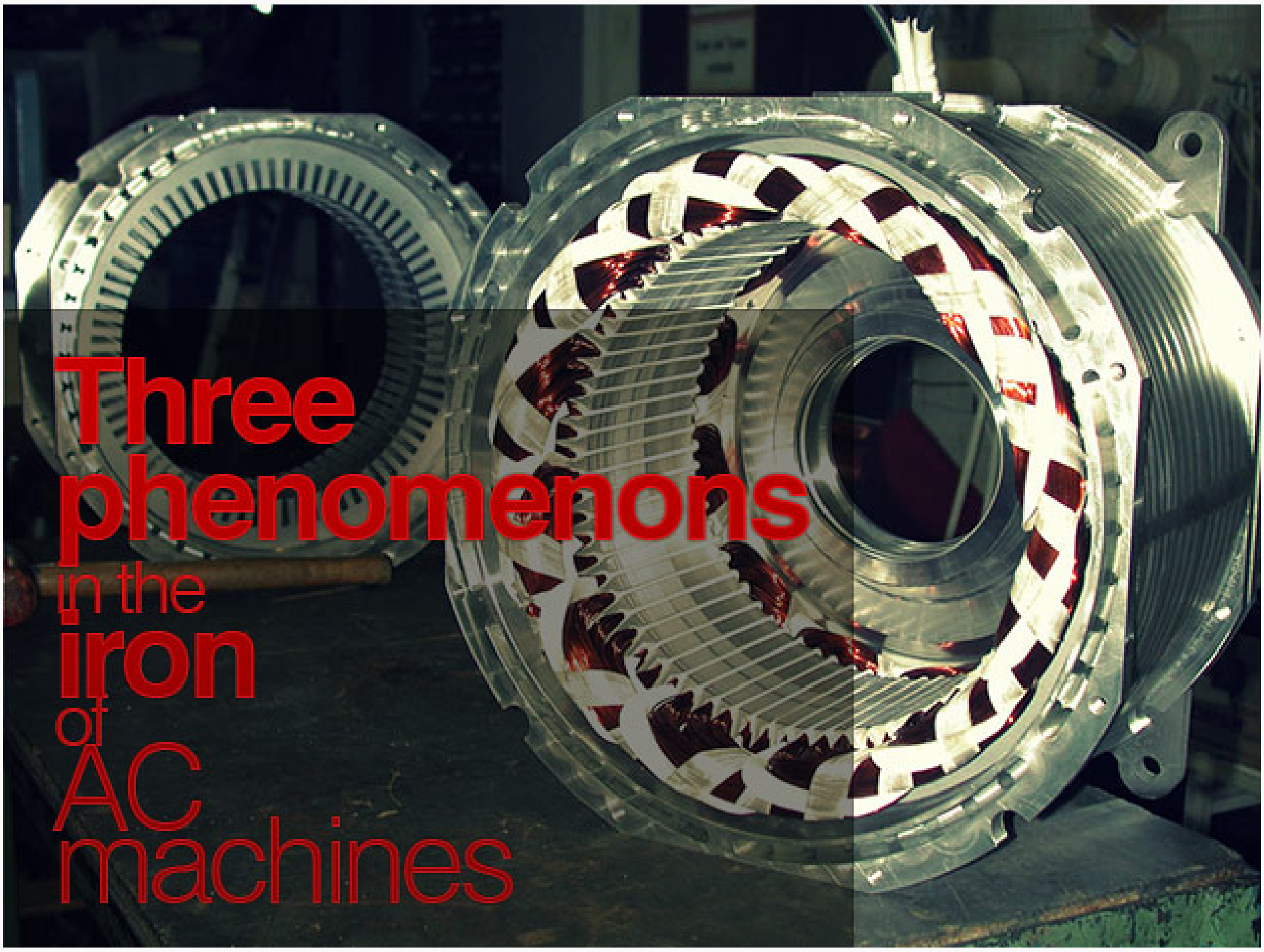
Three phenomenons in the iron of AC machines

Edvard



Three phenomenons in the iron of AC machines

Magnetic Circuits

Most of our practical ***AC machines*** (*motors, generators ad transformers*) depend heavily on the magnetic field for operation. The core iron of the machine provides a path for the magnet field.

There are a number of phenomena in the iron that are of interest as the terms keep coming up in following article.

1. Eddy Currents

Eddy currents are electrical currents that flow in the ***core iron of an AC machine***. To generate voltages in takes a magnetic field, conductors and some change between them.

In an AC machine the magnetic field is always in phase with the current, it is continuously changing.

The iron is a conductor and voltages will be induced into the iron and current will flow. ***The induced voltages are low but the currents can be high.*** The current flow will heat the iron.

If steps are not taken in machine construction cores would get extremely hot and the power loss would be huge. The core of a practical AC machine is made of thinsheets of metal. The sheets break up the circulating path and the eddy currents are minimized.

2. Hysteresis

Hysteresis is a phenomenon that occurs in core iron. ***It takes a certain amount of energy to magnetize iron.***

The magnetic dipoles of the iron must be aligned. The external magnetic field acts on the dipoles and forces then to align. In an ac corethe dipoles are continuously being realigned so there is a continuous energy loss in the core.

This loss shows up ***as heat in the core***. Hysteresis losses are minimized by the use of steel that is easy to magnetize.

Hysteresis and eddy currents always occur together. Like Bert and Ernie or beach and beer they are inseparable. Both are a result of the changing magnetic field in the core and both cause heating in the core. In the terminology of AC machines together they make up the core losses. Part of the power input into any AC machine shows up as heat in the core and is an inefficiency of the machine.

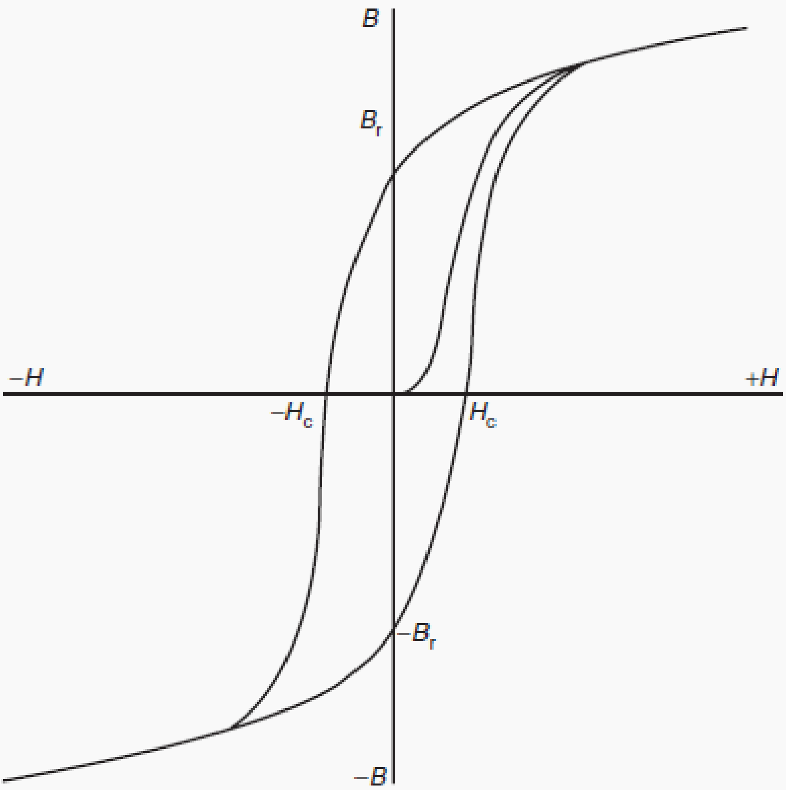


Fig. 3.2 Magnetization and hysteresis curves

3. Magnetic Saturation

Most electrical machines depend on a ***magnetic circuit***. This circuit is invariable made of iron with properties that make it easy to change the magnitude and direction of the field in the core.

One of the limiting characteristics of a magnetic circuit is the ***saturation of the iron with the magnetic field***.

The magnetic field is generated by ***passing current through a coil*** that somehow wrapped around an iron core. As the current in the coil increases, the magnetic field in the core increases. Initially this is a fairly proportional relationship. Double the current and you double the field.

However, the core eventually becomes saturated with the magnetic field and it becomes harder and harder to increase the field strength so it takes more and more current.

The relationship between ***field strength*** and current changes from one where relative small changes in magnetic field cause large changes in magnetic field to one where it takes large changes in current to get small changes in magnetic field.

Most electrical equipment is designed to run below the saturation region and moving into the saturation region has negative consequences. Most of our machines (***transformers, generators & motors***) are alternating current machines and depend on induced voltages in the windings for their operation.

The induced voltages are dependant on the rate of change ofthe magnetic field in the core. The relationship between the magnetic field and induced voltage is captured in ***Faraday's Law***:

Where:

e – induced voltage
N – the number of turns in the coil
Φ - magnetic field
t – time

In an AC machine the flux voltage and frequency are all related. If the system voltage increases at a given frequency the magnetic field strength in the machines must increase. If the frequency (*related to the rate of change of flux*) drops the magnetic field must increase to maintain a fixed voltage.

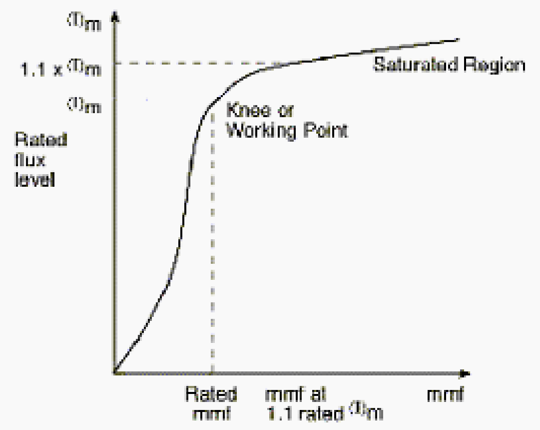


Figure 1 - Typical Saturation Curve

Most machines are designed to run with the magnetic field strength just below saturation. An increase of field in the neighbor hood of 10% will cause the core to go into saturation. A saturated core requires large amounts of magnetizing current. Large currents will cause large ***I^2R heating in the windings***.

$$e = -N\frac{d\Phi}{dt}$$

In an AC machine the core is heated by the continuously changing magnetic field. The continuous changing field produces eddy currents and hysteresis losses in the core. Eddy currents are electrical currents produced in the core iron itself. They heat the iron by electrical heating. Hysteresis losses are losses internal to the iron and are related to the forces required to change the direction and magnitude of the field in the core.

They are magnetic heating effects. In a situation where the magnitude of the magnetic field increases so will the heating effects of eddy currents and hysteresis.

Reference: *Science and Reactor Fundamentals and Electrical CNSC Technical Training Group*

Source: http://electrical-engineering-portal.com/three-phenomenons-in-the-iron-of-an-ac-machines