Ferromagnetic hysteresis with PC interface system

LEP 4.3.07

Related topics

Induction, magnetic flux, coil, magnetic field strength, magnetic field of coils, remanence, coercive field strength

Principle and task

A magnetic field is generated in a ring-shaped iron core by a continuous adjustable direct current applied to two coils. The field strength *H* and the flux density *B* are measured and the hysteresis recorded.

Equipment

Coil, 600 turns	06514.01	2
Iron core, U-shaped, solid	06491.00	1
Iron core, solid	06490.00	1
Iron core, U-shaped, laminated	06501.00	1
Iron core, short, laminated	06500.00	1
Commutator switch	06034.03	1
Power supply, univ., anal. disp.	13501.93	1
Rheostat, 10 Ohm, 5.7 A	06110.02	1
Teslameter, digital	13610.93	1
Hall probe, tangent., prot. cap	13610.02	1
Barrel base -PASS-	02006.55	1
Right angle clamp -PASS-	02040.55	1
Support rod, l 150 mm	02020.15	1
COBRA-interface 2	12100.93	1
PC COBRA data cable RS232, 2 m	12100.01	1
Software COBRA, electric values,	14293.61	1
Basic Softw. f. PHYWE Windows prog.	14099.61	1
Connecting cord, 750 mm, red	07362.01	5
Connecting cord, 750 mm, blue	07362.04	5

Problems

Record the hysteresis curve for a massive iron core and for a laminated one.

Set-up and procedure

The experimental set-up is shown in Fig. 1. Connect the computer, the COBRA interface and the Teslameter to a common electric mains power supply. Connect the variable transformator to an electric socket which is as far as possible from the above-mentioned one and, if possible, which uses another phase. In addition, position the coil set-up far from the computer and from the COBRA device to avoid errors during the transfer of data due to interference by the strong magnetic fields. Connect the voltage *U* which is measured across the resistor to the analogue input 3 of COBRA and the recorder output port of the Teslameter to the analogue input port 4. Attach the Hall probe unter the yoke in such a manner that the sensor is located directly adjacent to the borehole for the positioning pin. The magnetic field of the coils should be reversed with the commutator switch only at a voltage of 0 V as otherwise voltage spikes are generated which can affect data transfer.

Execution

– Load and start the "Disp_COM1" or "Disp_Com2" program

– Select the ⟨xy⟩ mode

– Range settings: "U3/V" → ⟨100⟩
"U4/V" → ⟨ 1⟩

Fig. 1: Experimental set-up for recording the hysteresis.

– ⟨Delta t/s⟩: 0.50
  This is the sampling rate for a 486-PC. A Pentium PC can operate at a higher rate e.q. 0.2…0.3 sec.
– Press the second button from the left hand side on top of the diagramme.
  Y axis settings: Maximum: 1.000
  Minimum: –1.000
  Units/division: 0.100
– Press the forth button from the left hand side on top of the diagramme.
  X axis settings: Maximum: 15.000
  Minimum: –15.000
  Units/division: 2.000
– Set the rheostat to 10 Ω.
– Set the measuring range on the Teslameter to 2000 mT.
– Set the Teslameter to Direct Field and adjust the zero point in air using the rotary type switch above the probe jack.
– If residual magnetism is present in the iron core, demagnetise the core as follows:

  Set the commutator switch in such a manner that an opposing field is generated. Briefly increase the voltage far enough for the flux density to assume a zero value; repeat a number of times.
– Set current limiter on the power supply to 5 A.
– After pressing the ⟨Start⟩ button, start the measurement procedure by clicking the ⟨Reset⟩ key.
– Increase the voltage slowly and uniformly from zero upwards and decrease it to zero again.
– Using the commutator switch reverse the polarity of the voltage.
– Again increase and then decrease the voltage slowly and uniformly.
– Once again reverse the polarity of the voltage with the commutator switch and increase the voltage.
– Stop the measurement procedure and press the ⟨Stop⟩ button.
– Reset the voltage to 0 V.

Theory and evaluation
Since the COBRA interface can only measure voltages, the current measurement is performed with the aid of a 10 Ω rheostat.

$$I = U/10\,\Omega \qquad (1)$$

Furthermore, the field strength is calculated with the formula

$$H = I \cdot n/L$$

where H = field strength
n = number of turns in the coil (600 turns)
L = average field line lengh in the core.
(solid core: L = 232 mm
laminated core: L = 244 mm)

The following correlation between the field strength and the measured voltage results:

$$H = (n/\,(L \cdot 10\Omega)\,) \cdot U$$

The factor n/ (L · 10Ω) changes due to the different dimensions of the two iron cores as follows:

Solid iron core: (n/ (L · 10Ω) = 258.62 in 1/(m · Ω)
Laminated iron core: (n/ (L · 10Ω) = 245.90 in 1/(m · Ω)

A comparison of Figs. 2 and 3 shows that the remanence and coercive field strength are substantially greater in a solid iron core than in a laminated one.

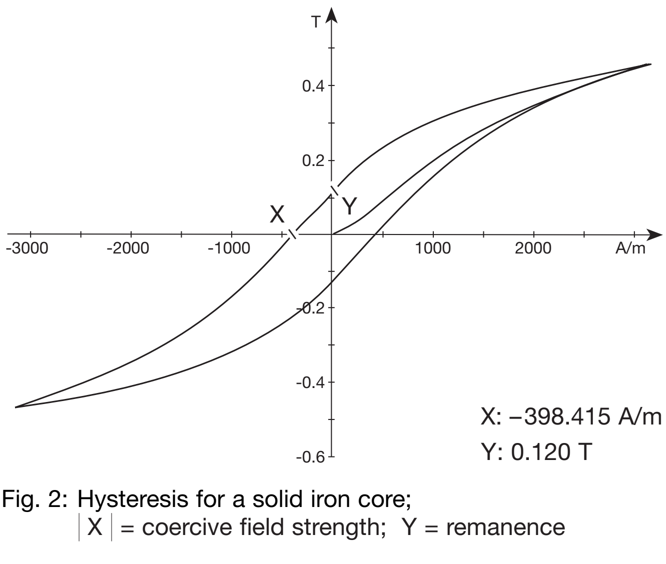

Fig. 2: Hysteresis for a solid iron core;
|X| = coercive field strength; Y = remanence

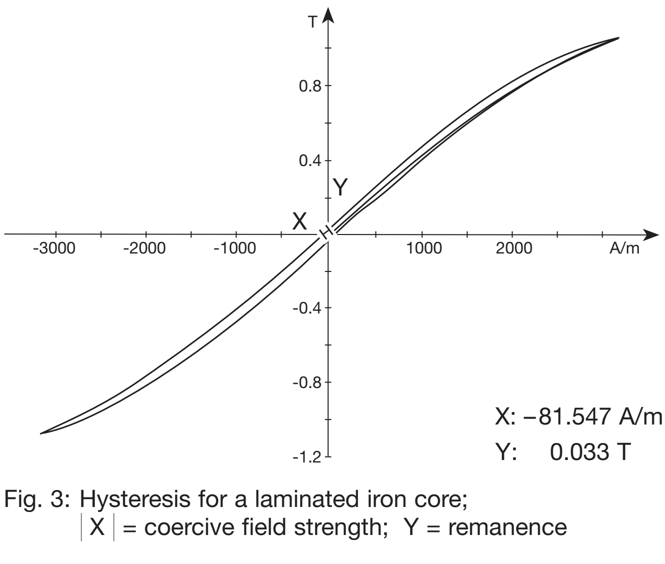

Fig. 3: Hysteresis for a laminated iron core;
|X| = coercive field strength; Y = remanence