Hysteresis loop for a ferromagnetic material

Group 12

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Aim:

i) To study the magnetization (M) of a ferromagnetic material due to an applied magnetic field B and to plot the hysteresis (M vs. B) curve.
ii) To calculate the retentivity and coercivity the material.

Apparatus:

Two solenoid coils, S and C, ferromagnetic specimen rod, reversible key (R), ammeter, magnetometer, battery, rheostat and transformer.

Procedure:

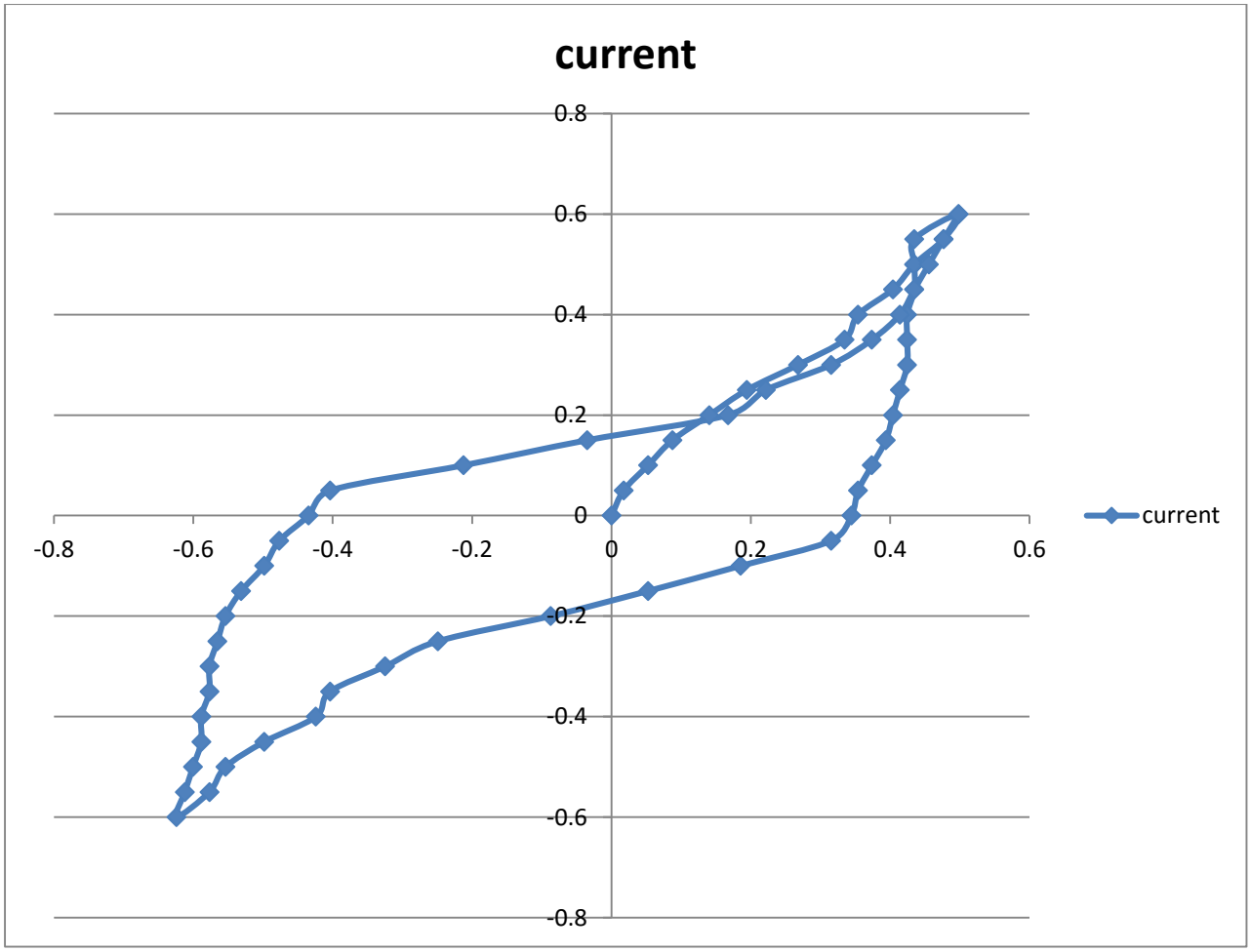
1. The connections were appropriately made as per the circuit diagram.
2. The magnetic needle was aligned in such a manner that 0-0 are aligned along the needle.
3. Some arbitrary current was passed and the compensating coil was moved such that the field due the solenoid is cancelled out by the compensating coil at the needle position.
4. The ferromagnetic material was demagnetized by placing it in a coil carrying alternating current and by increasing the current slowly.
5. After this the material was put inside the solenoid and the current was turned on.
6. If the needle showed any deflection then that meant that the material had not been demagnetized properly.
7. The current was increased in step of 0.05A and the deflection angle was noted.
8. The current was varied from 0 to maximum and then to 0 and the reversing key was reversed to reverse the direction of magnetic field.
9. The variation of current was followed as step 7.
10. The graph of tan of the angle Vs current was plotted.

Observations:

angle 1	angle 2	average angle	tan of angle	current
0	0	0	0	0
1	1	1	0.017446214	0.05
3	3	3	0.052381162	0.1
5	5	5	0.087444085	0.15
8	8	8	0.140468653	0.2
11	11	11	0.194279305	0.25
15	15	15	0.267806947	0.3
19	18	18.5	0.334413314	0.35
20	19	19.5	0.353924411	0.4
23	21	22	0.403799811	0.45
24	23	23.5	0.434565156	0.5
25	26	25.5	0.476698605	0.55
26	27	26.5	0.498288882	0.6
24	23	23.5	0.434565156	0.55
24	23	23.5	0.434565156	0.5
24	23	23.5	0.434565156	0.45
23	23	23	0.424234664	0.4
23	23	23	0.424234664	0.35
23	23	23	0.424234664	0.3
22	23	22.5	0.413980343	0.25
22	22	22	0.403799811	0.2
22	21	21.5	0.393690741	0.15
21	20	20.5	0.373677952	0.1
20	19	19.5	0.353924411	0.05
19	19	19	0.344139579	0
17	18	17.5	0.315128563	-0.05
10	11	10.5	0.18524295	-0.1
2	4	3	0.052381162	-0.15
-6	-4	-5	-0.087444085	-0.2
-15	-13	-14	-0.249196433	-0.25
-19	-17	-18	-0.324743626	-0.3
-23	-21	-22	-0.403799811	-0.35
-24	-22	-23	-0.424234664	-0.4
-28	-25	-26.5	-0.498288882	-0.45
-30	-28	-29	-0.553973664	-0.5
-31	-29	-30	-0.5769964	-0.55
-33	-31	-32	-0.624475728	-0.6
-32	-31	-31.5	-0.612417475	-0.55
-31	-31	-31	-0.600487362	-0.5
-31	-30	-30.5	-0.588681571	-0.45
-31	-30	-30.5	-0.588681571	-0.4
-30	-30	-30	-0.5769964	-0.35
-30	-30	-30	-0.5769964	-0.3

-30	-29	-29.5	-0.565428259	-0.25
-29	-29	-29	-0.553973664	-0.2
-28	-28	-28	-0.531391686	-0.15
-27	-26	-26.5	-0.498288882	-0.1
-26	-25	-25.5	-0.476698605	-0.05
-24	-23	-23.5	-0.434565156	0
-22	-22	-22	-0.403799811	0.05
-12	-12	-12	-0.21244559	0.1
-2	-2	-2	-0.034903052	0.15
10	9	9.5	0.1672562	0.2
13	12	12.5	0.221578629	0.25
18	17	17.5	0.315128563	0.3
21	20	20.5	0.373677952	0.35
23	22	22.5	0.413980343	0.4
24	23	23.5	0.434565156	0.45
25	24	24.5	0.455464482	0.5
26	25	25.5	0.476698605	0.55
27	26	26.5	0.498288882	0.6

Graph:



Calculations:

L=46cm
r=40cm
N(number of turns)=1080
Diameter=3.18mm
A(α)=[πd^2]/4
=7.94*10^(-6) m^2

M_0 =[4π/(μ_0α2l)][(r^2 – l^2/4)^2]/r*B_E tan θ
=1.5*10^5 A/m

B_0 = μ_0nI
=1.1*10^(-3) T

Error:
Error in M
Log (M)=2log(4*π(r^2-(l^2)/4)+log B + log(tanθ) – log (α) – log (l) – log (2*μ) – log(r)
After differentiating error
M= ±1.26*10^3
Error in B
Log (B)= log μ + log (n) + log (I)
After differentiating error
B= ±0.054*10^(-3)

Precautions:

1. Strictly follow the current variation sequence. Do not change or back-track—this will lead to incorrect results.
2. To get strictly zero current you will have to switch off the battery.

Result:

Retentivity = 1.5*10^5 ± 0.0126*10^5 A/m

Coercivity = 1.1*10^(-3)±0.054*10^(-3) T