Universidade Federal de Santa Catarina
Departamento de Engenharia Elétrica
Materiais Elétricos - Laboratório

Levantamento da Curva de Magnetização de Indutores

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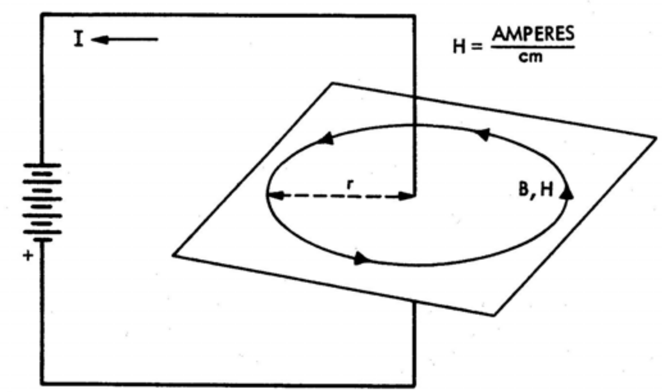
Clóvis Antônio Petry, professor.

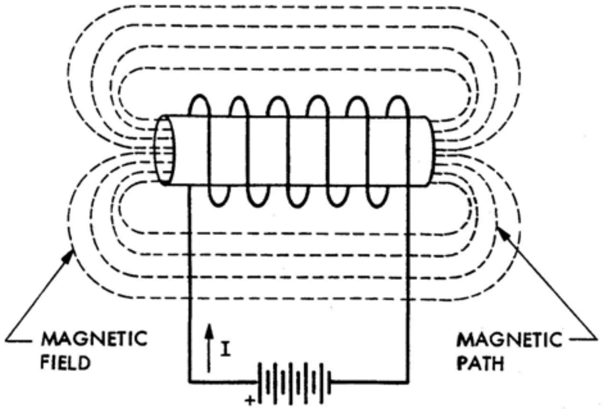
Florianópolis, maio de 2006.

Propriedades Magnéticas



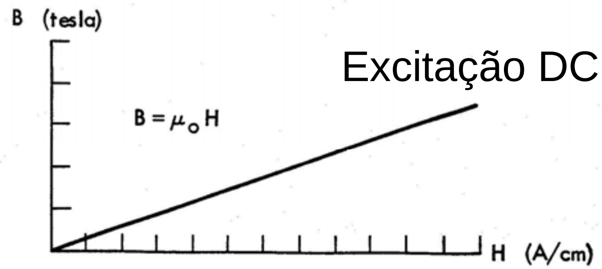
Magnetic field.

$$H = \frac{2I}{10r}$$



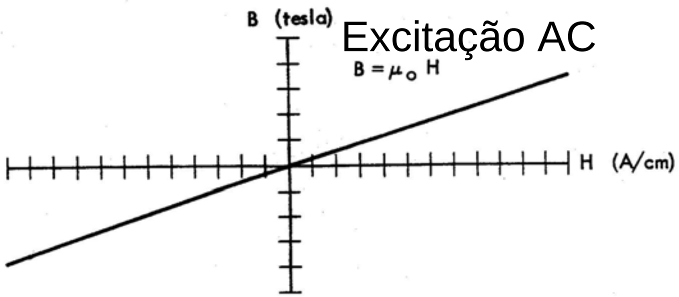
Air coil with an intensified magnetic field.

Excitação DC



Relationship between *B* and *H*.

Excitação AC

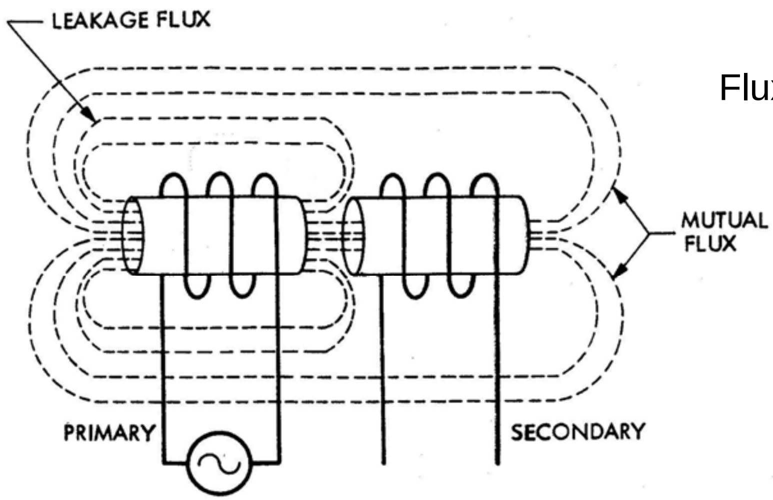


Relationship between *B* and *H* with ac excitation.

Permeabilidade

$$\mu_0 = \frac{B}{H}$$

Transformador Simples

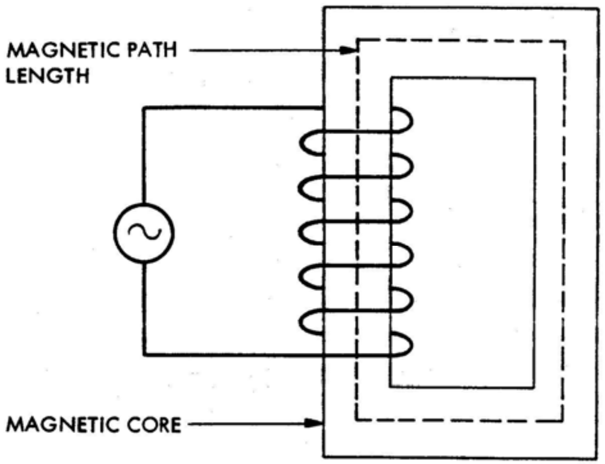


The simplest type of transformer.

Fluxo não confinado

$\mu_{ar,vacuo,\ papel......} \approx 1$ [G/Oe]

Núcleo Magnético

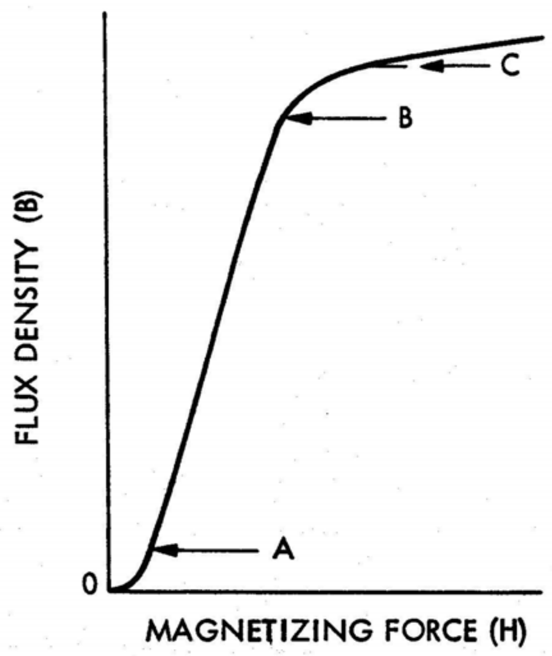


Introduction of a magnetic core.

$\mu_{Mat.\ Ferromag.} \approx nx10^2 ... nx10^3 ...$ [G/Oe]

Fluxo confinado: MPL

Curva de Magnetização de núcleos magnéticos



Magnetization curve.

Observações:

• A densidade de fluxo varia lentamente até o ponto **A**;

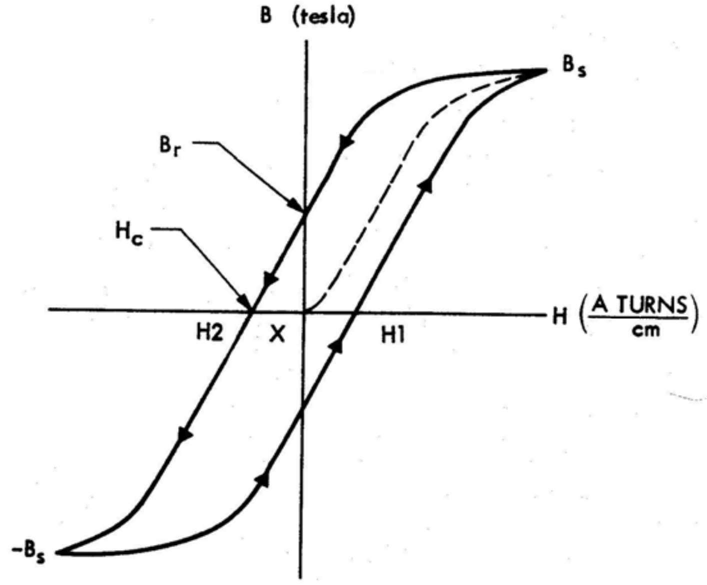
• Do ponto **A** ao ponto **B** a densidade de fluxo varia rapidamente;

• No ponto C o material está saturado, e a relação B/H tem comportamento semelhante ao núcleo de ar.

Curva de Histerese

- Obtida submetendo o material a ciclos completos de magnetização e desmagnetização

- Representa a perda de energia no núcleo



Hysteresis loop.

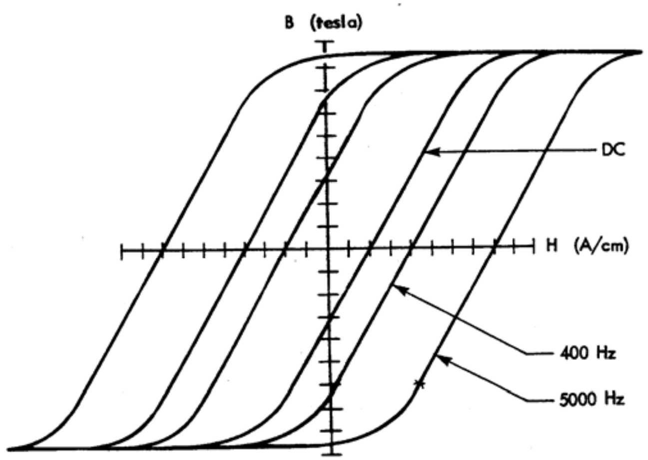


Figure 1.14. *B-H* loop operating at various frequencies.

Características dos Materiais

Muitos materiais possuem características próximas ao loop B/H quadrado ideal.

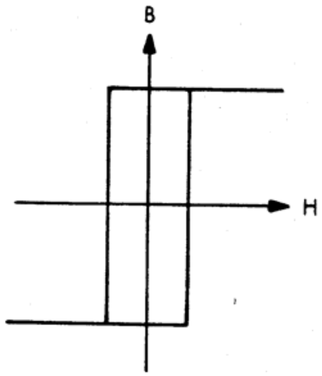


Figure 1.23. Ideal square *B-H* loop.

Table 1.1. Magnetic core material characteristics

TRADE NAMES	COMPOSITION	* SATURATED FLUX DENSITY, tesla	DC COERCIVE FORCE, AMP-TURN / cm	SQUARENESS RATIO	** MATERIAL DENSITY, g / cm^3	CURIE TEMP. ^0C	WEIGHT FACTOR
Supermendur Permendur	49% Co 49% Fe 2% V	1.9–2.2	0.18–0.44	0.90–1.0	8.15	930	1.066
Magnesil Silectron Microsil Supersil	3% Si 97% Fe	1.5–1.8	0.5–0.75	0.85–0.75	7.63	750	1.00
Deltamax Orthonol 49 Sq Mu	50% Ni 50% Fe	1.4–1.6	0.125–0.25	0.94–1.0	8.24	500	1.079
Allegheny 4750 48 Alloy Carpenter 49	48% Ni 52% Fe	1.15–1.4	0.062–0.187	0.80–0.92	8.19	480	1.073
4-79 Permalloy Sp Permalloy 80 Sq Mu 79	79% Ni 17% Fe	0.66–0.82	0.025–0.82	0.80–1.0	8.73	460	1.144
Supermalloy	78% Ni 17% Fe 5% Mo	0.65–0.82	0.0037–0.01	0.40–0.70	8.76	400	1.148
Metglas: 2605SC	81% Fe 3.5% Si 13.5% B 2% C	1.5–1.6	.03–.08	.9–.98	7.32	370	.96
2714A	66% Co 4% Fe 15% Si 14% B 1% Ni	.5–.65	.008–.015	.9–.98	7.59	205	.995
Ferrites F N27 3C8	Mn Zn	0.45–0.50	0.25	0.30–0.5	4.8	250	0.629

*tesla = 10^4 Gauss
** $g / cm^3 = 0.036\ lb / in^3$

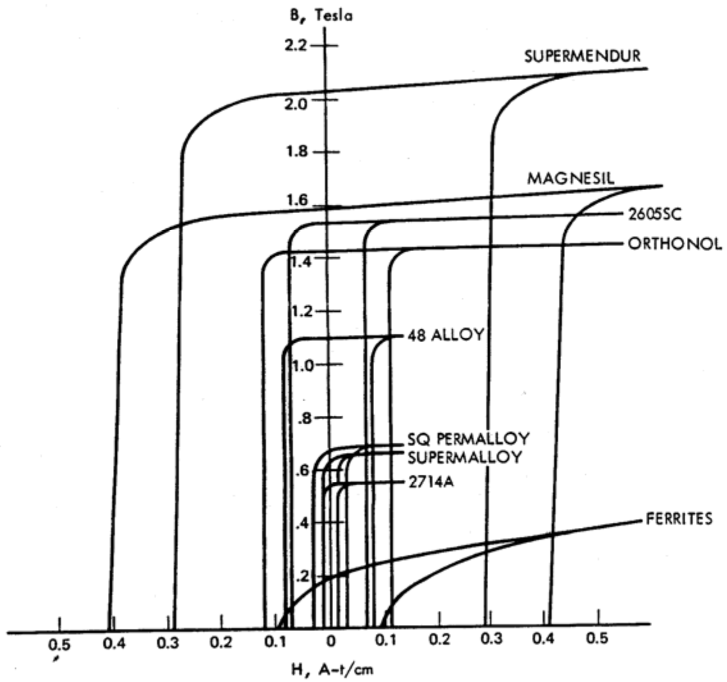


Figure 1.24. The typical dc *B-H* loops of magnetic materials. (*Courtesy of Magnetics Inc.*)

Teoria da Saturação do Núcleo

Material desmagnetizado

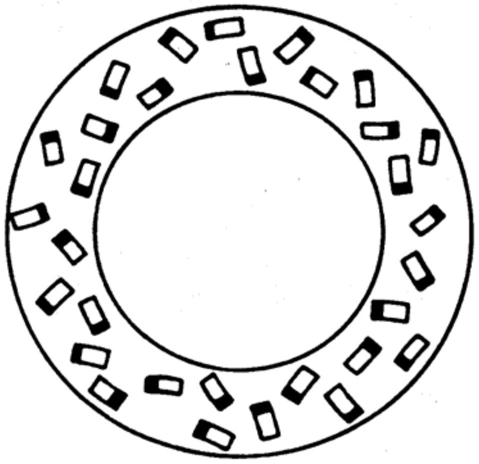


Figure 1.42. Unmagnetized material.

Considera-se: material magnético é constituído de inúmeras moléculas magnéticas individuais

Material Magnetizado

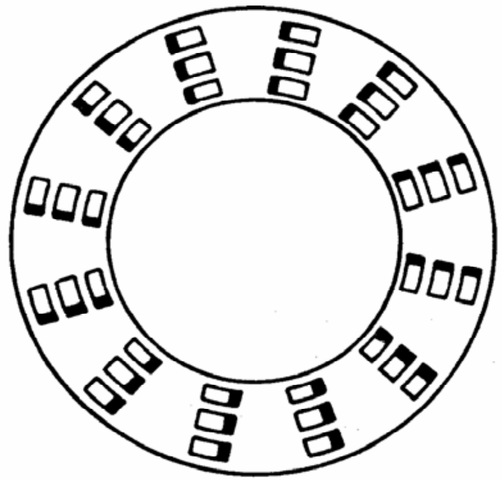


Figure 1.43. Magnetized material.

***<u>Saturação</u>*: Ocorre quando todas as partículas estão alinhadas**

O grau de magnetização depende do grau de alinhamento das moléculas.

Air GAP

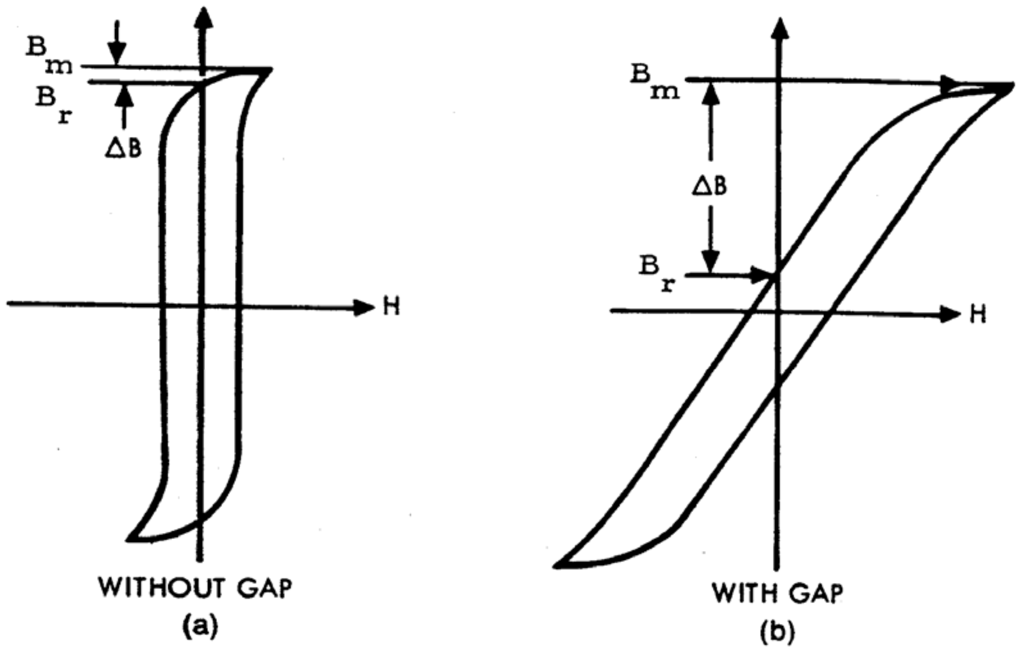


Figure 1.44. Air gap increases the effective length of the magnetic path.

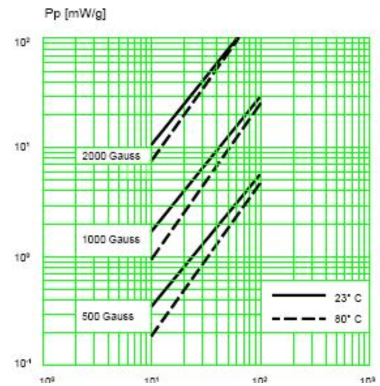
Exemplo

Material : Núcleo Ferrite IP12-R

Fabricante: Thornton Eletrônica Ltda

MATERIAL : _IP 12R_

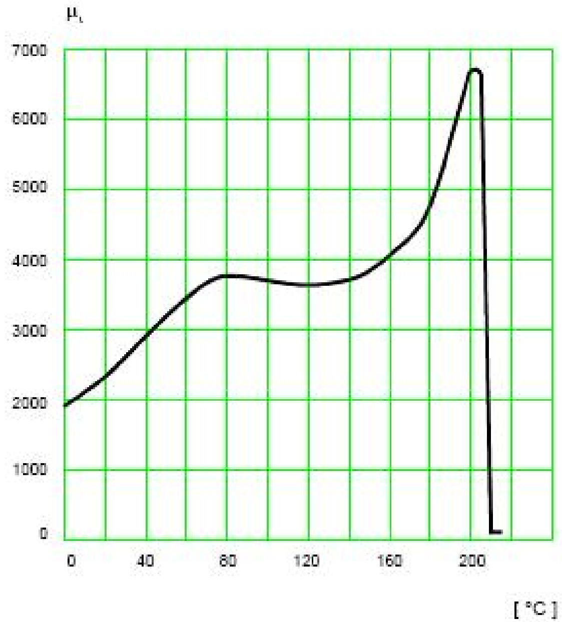
SIMB.	CONDIÇÕES	VALOR	UNIDADE
μ_i	23° C	2100 ± 25%	
B	15 Oe , 23° C	5100	Gauss
P_P	2000 Gauss 20 Khz , 80° C	20	mW / g
T_c		≥ 210	°C
ρ		4800	Kg / m³



$$B = \frac{V_{RMS}.10^8}{4.N.f.A_e}[Gauss]$$

$$H = \frac{1{,}41.0{,}4.\pi.N.I_{RMS}}{L_e}[Oe]$$

Tipico B x H



μι x Temperatura