A.11: Development of M(H) tracer for characterization of permanent magnets

High-energy permanent magnets are crucial components for biasing of of microwave ferrite circulator, which require large and stable magnetic fields for operation below resonance at high power. Demagnetization curve (normal and intrinsic) of permanent magnets are the important for tuning of ferrite circulator. We have designed and developed a Pulse-Type Hysteresis Loop Tracer (5 Tesla) for characterization of high energy permanent magnets (NdFeB and Sm-Co based magnets) and Hard ferrite magnets, which are used for biasing of ferrite circulator. This article presents indigenous development of Pulse-Type MH system, magnetic characterization of NdFeB magnets and anisotropic strontium ferrite magnet disks.

A magnetic hysteresis loop tracer using a pulsed high magnetic field of 50 kOe for rare earth based permanent magnets is developed. The high pulsed magnetic field is generated by discharging a large capacitance charge (6 mF) with a voltage of 1.5 kV into magnetizing fixture (an air solenoid) with the inner diameter of 75 mm and length of 175 mm. A schematic diagram of the MH loop tracer is shown in Fig. A.11.1.

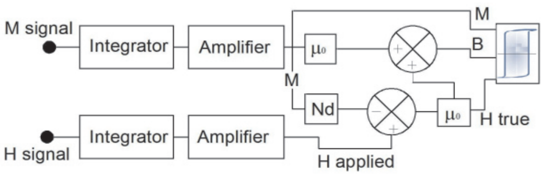

Fig. A.11.1: Schematic diagram of pulsed MH tracer

A capacitor bank is charged by constant current using series resonant topology with switching frequency of 25 kHz, producing linear voltage build up across capacitor bank. When the capacitor bank gets fully charged up to 1.5 kV, the voltage control circuit resets charging and triggers SCR. The stored energy will thus be discharged into solenoidal magnetizing fixture. The maximum magnetic field of 50 kOe for positive half and 45 kOe for negative half is achieved.

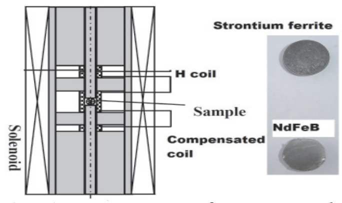

Fig.A.11.2: Arrangement of sensor coils in solenoid

Permanent magnet disc of 25 mm diameter is placed at the center of the solenoid, magnetic moment (M) detected by means of a compensated coil. The field (H) is detected by means of a separate axial coil. Placement of discs of strontium and Nd-Fe-B magnets and arrangement of sensor coils in the solenoid is shown in Fig. A.11.2. The detected signals are proportional to the derivative of the applied field dH/dt and the polarization dJ/dt. The sensor coil constants are experimentally determined by measuring a magnetic moment by means of changing polarity of DC current in search coil with calibrated turn-area product, placed at the center of the sensing coil, and measuring the mutual inductance between them. These signals are electronically integrated, amplified and then supplied to a 14 bit M3i.4142, 250MS/s data acquisition card. The pulsed field system is shown in Fig.A.11.3.

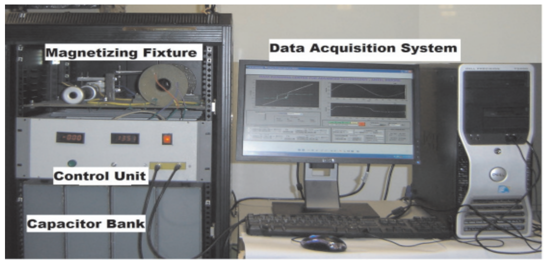

Fig. A.11.3: Pulsed Magnetic Hysteresis loop tracer

LabVIEW based data acquisition is used to trace M-H, B-H & demagnetization curves - normal & intrinsic, which is shown in Fig. A.11.4.

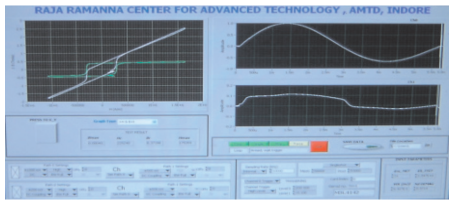

Fig. A.11.4: Lab view based system displaying M-H and B-H curves

The calibration of the hysteresis loop tracer is carried out by using a standard Ni sample with the purity 99.9%. Measured saturation magnetization showed good agreement with the known values. The hysteresis loops of NdFeB and Strontium ferrite magnet disks are obtained with this system. Measured normal and intrinsic corecivities together with energy product is shown in Table A.11.1.

Table A.11.1: Measured magnetic parameters

Permanent Magnet	Coercivity		Remanence B_r (G)	Energy Product MGO(kJ/m^3)
	Intrinsic H_{cM} (Oe)	Normal H_{cB} (Oe)		
Strontium Ferrite	3437	3162	3796	3.43 (27.44)
Nd-Fe-B	33600	9460	11200	28.11 (224.88)

These values are used in composite magnetic circuit for tuning of ferrite circulator. An accurate magnet state has been obtained which are found useful for indigenous development of circulators at RRCAT.

Reported by:
P. Pareek (ppareek@rrcat.gov.in)and R.S. Shinde