MEASURING ELECTROMAGNET POLARITY USING MAGNETIC REMANENCE

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TURN THE MAGNET ON AND OFF AGAIN, THEN CHECK THE POLARITY SAFELY

ABSTRACT

- We motivate the measurement of magnet polarity in a manner that is electrically safe, by measuring the magnetic remanence of iron yokes of normal conducting electromagnets.
- This has been used to confirm the polarities of iron-dominated dipole and quadrupole electromagnets at the Linac Extension Area at the Advanced Photon Source.

MOTIVATION

- Installation and commissioning of accelerator systems, a common quality assurance task is ensuring that magnets are connected to power supplies with the correct polarity [1-4].
- Powered electromagnets present both electrical and magnetic hazards to personnel approaching them [5].
- Different ways of mitigating these hazards, electrically insulating shielding or shielding to keep people out of magnetic field.
- Another way is to switch off the magnet power supply, and Lock-Out-Tag-Out (LOTO) the source of hazardous energy.

METHOD

- Magnet polarity checker Magnaprobe MKII. The north pole is red, south pole is blue.

Figure 1: Probe.

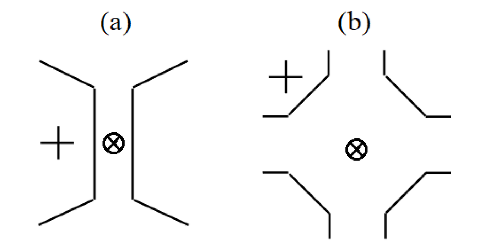

Figure 2: Polarity convention.

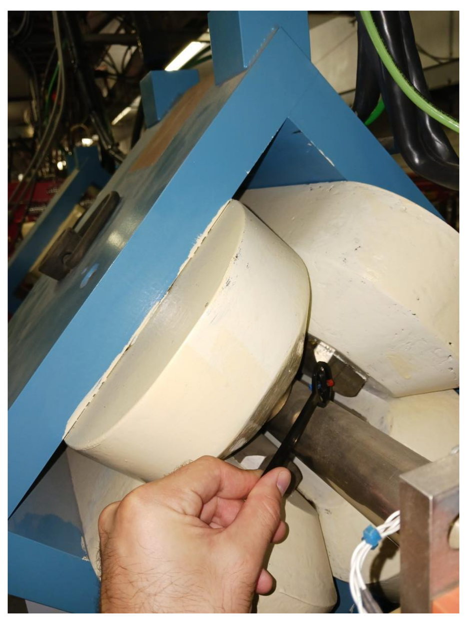

Figure 1: Measurement

- Procedure steps:

1. Accelerator enclosure secured.
2. Accelerator magnets energised at its nominal current setpoint for 10 minutes using its connected power supply. This puts the magnet on its hysteresis curve.
3. Accelerator magnets de-energised, leaving only the remnant field in the magnet.
4. LOTO accelerator magnets, and verify zero energy state by Zero Voltage Verification (ZVV). At this point, all LOTO requirements should be complete to enable authorised access to the accelerator enclosure.
5. Lower the accelerator access control system level to authorised access.
6. Enter the accelerator enclosure and approach the unpowered electromagnet which is LOTOed.
7. Measure the polarity of the remnant field (without any electrical hazard) using a permanent magnet probe.

RESULTS

- Magnet types Q_1 correspond to upright quadrupole, and B_2 to skew dipole (vertically deflecting).
- Deliberately included a couple of quadrupoles from the PTB line, so that we could associate a known focussing or defocussing polarity with the existing, operational lattice of the accelerator beamline.
- Booster bypass (BB and LA) had the correct polarity, while newly installed magnets in the LEA beamline did not all have the correct polarity.
- Used this information to correct the polarity of magnets in the LEA beamline.

Table 1: Initial Measurements.

Magnet	Type	Polarity meas.	Correct?
PTB:Q8	Q_1	Blue	Yes
PTB:Q9	Q_1	Red	Yes
BB:QE1	Q_1	Blue	Yes
BB:QE2	Q_1	Red	Yes
BB:Q1	Q_1	Blue	Yes
BB:BM:1-1	B_2	Blue	Yes
BB:BM:1-2	B_2	Blue	Yes
BB:BM:1-3	B_2	Blue	Yes
BB:BD:1	B_2	Red	Yes
BD:Q1	Q_1	Red	Yes
BB:Q2	Q_1	Red	Yes
BB:Q3	Q_1	Blue	Yes
BB:Q4	Q_1	Red	Yes
BB:BM:2-1	B_2	Red	Yes
BB:BM:2-2	B_2	Red	Yes
BB:BM:2-3	B_2	Red	Yes
BB:Q5	Q_1	Blue	Yes
BB:Q6	Q_1	Red	Yes
LA:Q1	Q_1	Blue	Yes
LA:Q2	Q_1	Red	Yes
LEA:Q1	Q_1	Blue	Yes
LEA:Q2	Q_1	Red	Yes
LEA:Q3	Q_1	Red	No
LEA:Q4	Q_1	Red	No
LEA:Q5	Q_1	Blue	No
LEA:Q6	Q_1	Red	No
LEA:Q7	Q_1	Red	Yes
LEA:BD	B_2	Red	Yes

Table 2: After Correcting Polarity.

Magnet	Type	Polarity meas.	Correct?
LEA:Q1	Q_1	Blue	Yes
LEA:Q2	Q_1	Red	Yes
LEA:Q3	Q_1	Blue	Yes
LEA:Q4	Q_1	Blue	Yes
LEA:Q5	Q_1	Red	Yes
LEA:Q6	Q_1	Blue	Yes
LEA:Q7	Q_1	Red	Yes
LEA:BD	B_2	Red	Yes

DISCUSSION

- Safe, quick: a few seconds at most per magnet. It took longer to record the result.
- Alternatives such as such as little power supply may introduce new measurement errors: supply has to be connected with the correct polarity.
- Future work: a quadrupole with horizontal and vertical corrector trims
- Why this poster format?
  - Why *not* try something new [6]?

SUMMARY

- Step-by-step procedure to test the polarity of magnets installed with their associated power supply off.
- By exciting the magnet briefly, we propose putting the magnet on its hysteresis curve, and observing the polarity of the excitation using the remnant magnetic field.
- A measurement procedure that can be performed by someone approaching the magnet without electrical hazards.

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