ABSTRACT

At CERN, the circulating beam current measurement is provided by two types of transformers, the Direct Current Current Transformers (DCCT) and the Fast Beam Current Transformers (FBCT). Each type of transformer requires different magnetic characteristics regarding parameters such as permeability, coercivity and shape of the magnetization curve. Each transformer is built based on toroidal cores of a magnetic material which gives these characteristics. For example, DCCTs consist of three cores, two for the measurement of the DC component and one for the AC component. In order to study the effect of changes in these parameters on the current transformers, several interesting raw materials based on their as-cast properties were selected with the annealing process used to tune their properties for the individual needs of each transformer. First annealing tests show that the magnetization curve, and therefore the permeability, of the material can be modified, opening the possibility for building and studying a variety of transformer cores.

CURRENT TRANSFORMERS AT CERN

- Magnetic cores made out of wound soft magnetic material
- DCCTs: three magnetic cores
- FBCTs: one magnetic core

What is inside?

What do we need?

B-H curve adapted for each transformer
- DCCT: coercivity around 3 A/m
- High permeability
- Controlled power losses
- Low Barkhausen Noise

PARAMETERS UNDER STUDY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Why?</th>
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<tbody>
<tr>
<td>Ribbon thickness</td>
<td>Affects Eddy currents</td>
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<tr>
<td>Power losses</td>
<td>Heats up the core</td>
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<tr>
<td>Shape of B-H curve</td>
<td>Influences response</td>
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<tr>
<td>Barkhausen Effect</td>
<td>Influences resolution</td>
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</tbody>
</table>

MATERIALS

- Materials that comply with the required characteristics are soft ferromagnetic alloys [3]:
  - Permalloys (80% Ni + 20% Fe)
  - Alloys of 80% Fe and/or Co + 20% B, Si, C

Tuning of B-H curve:
- thermal treatment with or without magnetic field
- Thermal treatment under crystallization temperature to maintain structure

Material Selection:
- Iron-based amorphous alloys: less BN
- Cobalt-based alloys: good permeability

TESTS

- Barkhausen Noise (BN):
  - BN was measured and compared with a triangular pulse wave
- B-H curve and permeability:
  - B-H curves were measured at 200 Hz
  - Permeability was calculated from the inductance value measured with an impedance analyser
- Annealing and insulation:
  - Annealing: under vacuum at 250°C during one hour
  - Sol-gel method was tested as insulation

CONCLUSIONS & OUTLOOK

- Iron-based alloys: low permeability, high coercivity → Not the best option
- Cobalt-based alloys: good characteristics
- Further study on insulation required
- Study annealing process: with/without magnetic field, time, temperature, etc.

REFERENCES & ACKNOWLEDGMENTS

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