

## Improving Flux Models Thanks to Better Magnetic Material Measurement.

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When using Flux for the design of an electromagnetic device, the definition of materials and the setting of the correct material in the specific regions is a compulsory step.

Recently, there has been an increasing number of requests for more accurate knowledge of materials properties. There are many reasons for this, we mention the main ones here:

- 1) The increase of the cost of raw materials (especially rare earth based magnets).
- 2) The request for more efficient electric machines (especially rotating machines).
- 3) The discovery of new materials and grades.

In Flux, the user is able to define the model and choose from a variety of properties depending on the type of model: electric, thermal, magnetic soft and magnetic hard. We will focus here on the last two.

### ● Hard magnetic materials

These are defined in Flux by the magnetic remanent or residual flux density (Br) and by the recoil permeability ( $\mu_{rec}$ ), which is approximately equivalent to the slope of the BH curve of the magnet in the 2nd quadrant. The combination of these two parameters are used to define the coercive force of the permanent magnet, unless the material has a non linear behavior in the 2nd quadrant.

**Non linear behavior:** With Flux it is possible to set non linear behavior using similar functionalities for BH setting for soft materials. It can be used for specific materials such as Alnico alloy or used to define deviation from linearity in ferrite or rare earth based magnets (rare earth based and ferrite magnets exhibit a linear and reversible behavior in the 2nd quadrant of the BH loop).

As the price of rare earth materials continues to climb, Alnico alloys could become more popular in the near future, especially in devices that do not need to produce high power density.

**Temperature behavior:** magnetic properties of all permanent magnets are temperature dependent, which means that the characterization at temperatures other than room temperature is required. It is rather common to perform the computation of a modeled device setting the properties of the permanent magnet at the values obtained at the highest temperature (i.e. at the minimum Br).

This is useful in checking the minimum performance; however this does not hold true for all cases. For example in ferrite, Hc has a positive gradient up to ca. 200 °C, which means that Hc decreases as the temperature decreases.: consequently in the ferrite devices working at low temperatures., The performance should be checked if the value of the magnetic strength field in the permanent magnet at low temperature is still lower than the Hc value, to avoid undesired and irreversible demagnetization of the magnet.

**Special magnetization shapes in final device:** to get specific performances, for example noise reduction, in some devices sinusoidal or even more exotic magnetization waveforms may be required. This condition can be set in Flux using the "spatial parameter" functionalities, available after version 10.2.

Spatial parameters can be very useful in defining a more realistic magnetization pattern in the device, for example, it



Fig. 1: Measurement equipment for soft magnetic materials characterization up to 1000 Hz.

is very difficult to simulate a non perfect radial magnetization by magnetizing fixtures (figure 2).

### ● Soft magnetic materials

In Flux the soft magnetic materials properties are initially defined by setting the B vs. H curve in 1st quadrant. (as soft magnetic materials are used as a "flux conveyor").

**Common properties of a soft magnetic material:** it is rather easy to get the BH curve for a normal soft magnetic material, for example, FeSi with specific losses and thickness. This information may be obtained from the material supplier or from a supplier publication.

**Uncommon properties of a soft magnetic material:** if the material is not a normal grade, a complete properties table is not usually given by the supplier., Specific losses,( example:50 Hz at magnetic induction of 1 or 1,5 Tesla) may be given. However a complete BH loop in the 1st quadrant and magnetic losses coefficients are not usually given.

In Flux it is possible to include the magnetic losses in the computation, by Bertotti formula in the post processor or by the LS module using the Loss Surface model. Hysteresis and Eddy Current losses may be computed; excess losses are in general very low and they can be neglected.

To get the magnetic losses coefficients, measurements at different induction and at different frequencies must be

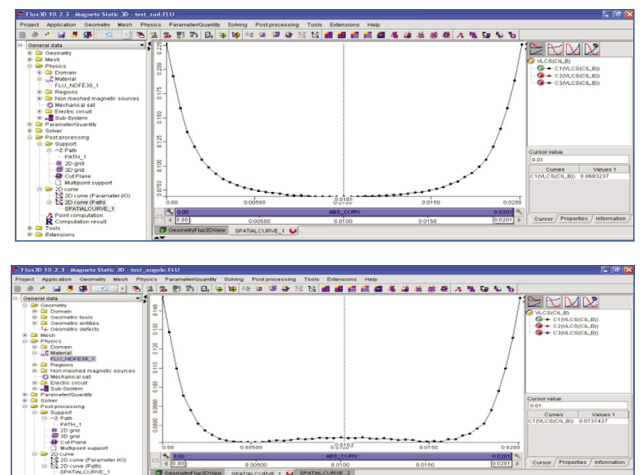


Fig. 2: Use of spatial parameter in Flux for setting the real magnetization shape of magnets .

## Improving Flux Models Thanks to Better Magnetic Material Measurement. (continued)

performed by a magnetic wattmeter. These measurements should be performed as close as possible to the rotation frequency of the magnetic field in the final device (usually between 20 Hz and 800 Hz).

**Magnetic stress after tooling:** the influence on magnetic properties of mechanical stresses due to the finishing work of tooling, cutting and packing, to achieve the final product should be included in the material that will be used in the device, if possible. For this reason the laminations of a rotating machine should be measured directly packed into the final stator, using the specific soldering or fixing methods. This way, definitive magnetic stress and electric insulation between laminations will be included in the magnetic losses measurements.

**Sample shape:** there are some usual shapes according to standards, such as the laminated ones used for Epstein yoke and single sheet tester. It is important to reduce the mass of the sample to get measurements at high induction and higher frequency, as the use of single sheet or single strip sensors has become more frequent.

**Coercimeter:** for electromagnetic devices where a closed magnetic loop is not present, a coercimeter characterization can be performed. Any sample shape can be measured by this method, achieving good accuracy, but only coercive force  $H_c$  will be obtained. Either way, the coercive force level of a sample can be compared to the expected  $H_c$  value to obtain the quality level for permeability and hysteresis losses.

Coercimeter can be useful to measure details of linear actuators, for example in proportional electromagnets where some specific details in the magnetic circuit may be found. In such details magnetic flux is bypassed through a

magnetic ring. However magnetic stresses may arise after mechanical tooling or soldering of these parts (figure 3).

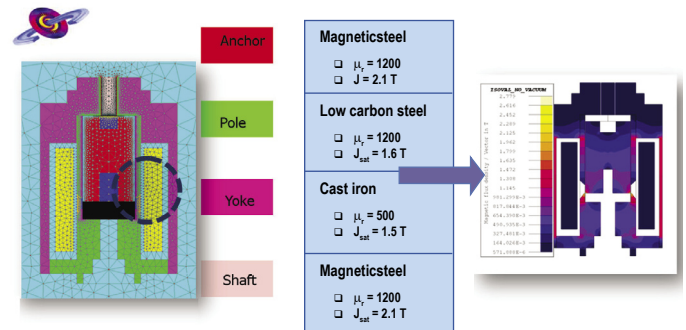


Fig. 3: Special tooling can determine local magnetic properties modification in soft magnetic materials.

### Conclusion

In conclusion, it is clear that some magnetic characterizations may be useful to get more accurate modeling of a finite element electromagnetic device. This will be more evident in the near future, due to materials sudden and unexpected material price increases, efficiency requests, and special device and material grade innovation.

## CEDRAT's Distributors Days - June 2011.

Karoline Ballini - CEDRAT.

This past June we held our annual CEDRAT distributor's meeting. It was a great opportunity for our distributors to exchange information and discuss ideas during the 3-day meeting. They discussed CEDRAT software developments, study cases and methodology, collaborative European Projects and Market Trend. The last day concluded with a training session and demonstration of CEDRAT's new optimization tool: GOT-It.

Among the participants were a large number of our European distributors: applied magnetics from Switzerland, INDIELEC from Spain, MACCON from Germany, Motor Design Ltd from UK, SPIN from Italy, and also Motor Design Solutions from Turkey. MAGSOFT from USA, and SoftWave from China were present.

Our next Rendez-vous: the Flux Conference in Marseille France on October 19<sup>th</sup> and 20<sup>th</sup> 2011!



## 2011 Flux Conference: Let's meet Flux users!

Karoline Ballini - CEDRAT.



This year our Flux Conference will be held in Marseille, France on October 19<sup>th</sup> and 20<sup>th</sup> 2011. It is our great pleasure to welcome you to this lovely place -the city of sun and cicadas. For more than 15 years Flux Conference goers (from Flux beginners to Flux experts) have gathered to talk about Flux, and CAE Methods in Electrical Engineering. The Flux Conference is a great opportunity to learn from other users and to assimilate Methodology. CEDRAT specialists will be on hand to demonstrate tips and tricks, especially during workshop sessions. Our users' meeting also provides CEDRAT with the ability to gather information from customers and learn about their needs for future developments. Discussion time between Flux users and CEDRAT teams is always a highlight.

This year, European Flux users are presenting an enriched program, complete with CEDRAT applications and models presentations. You may have already discovered some of them in this current issue of CEDRAT News. An exclusive for Flux conference participants: CEDRAT will launch its new Optimization Tool: GOT-It!

This is a unique opportunity to learn more about this new tool and how it complements the latest Flux version. Pre-conference training sessions include:

**"Be more efficient with Flux!"** (Including Flux 10.4 New Features presentation and PyFlux Scripting)

**"GOT-It: CEDRAT's New Optimization Tool"**

You can find more information on our website: <http://flux-conference.cedrat.com>.

We look forward to seeing you in October in Marseille!