UNIVERSIDAD PONTIFICIA ICAI ICADE COMILLAS MADRID
ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA

Diffusion of Electromagnetic Fields into Continuous Media

with application to

Conducting Hysteretic Magnetic Materials, and Electromagnetic Launchers

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Programa: Doctorado en Ingeniería Industrial e Informática **Créditos:** 2
Lugar: ETS de Ingeniería ICAI, Alberto Aguilera, 25.
Fecha: 13, 15, 18, 20, y 22 de septiembre **Horario:** 10:00 a 14:00

Presentation

The course deals with the diffusion of electromagnetic fields in conducting nonlinear magnetic media and in conducting parts of special electric machines. This diffusion is described by nonlinear partial differential equations and it has qualitative aspects that do not appear for linear diffusion equations. This makes the matter of significant theoretical interest. At the same time this analysis is important in many industrial applications as: *magnetic components in power electronics, electromagnetic shielding, nondestructive testing, induction heating, design of energy conversion devices, electric machines, magnetic materials in biomedical implantable sensors and actuators, etc.*

Particular attention will be related to the magnetic hysteresis, a ubiquitous phenomenon encountered in many different areas of natural science, engineering and economics. It will be focused on the Preisach Model of hysteresis and on the recent developments on the vector hysteresis models.
An overview on the principle of operation of the electromagnetic launchers will be provided. These special electric machines cover a very wide spectrum of applications, and they exhibit and require a very high level of technology. Solid and plasma armature based electromagnetic launchers will be touched.
Finally, some considerations on wave-like solutions into conducting nonlinear magnetic media are presented, and it is opened a discussion on the development of new magnetic materials.

Related topics

- *Magnetic hysteresis*
- *Analysis of eddy currents*
- *Partial differential equations*
- *Nonlinear science*
- *Analytic and numerical techniques*
- *Measurement techniques*

Aim

The main purpose of the course is to make the student more confident with the evaluation of the current distributions into conductors, a very instrumental analysis in many cases of applied electromagnetism. Because of the presence of nonlinear terms this matter is, in general, very complex, but it is hoped this course can be stimulating for the student and can suggest new interest and reflections.

Course program

The course is organized in the following sections:

1. Introduction (… “it all began with the Maxwell’s equations”), constitutive equations of simple materials, the diffusion equation;
2. Magnetic hysteresis, general concepts, the approach of the macro and micromagnetism;
3. The Preisach model of hysteresis;
4. Measuring the B(H) relation, measuring techniques and analysis of the results;
5. The parallelogram model of hysteresis as a simplified approach to the evaluation of the losses;
6. Recent developments on the vector hysteresis models;
7. Some analytic techniques for dealing with the nonlinear diffusion equation: the case of the abrupt magnetic transition, the case of the flat-power hysteresis loop, the linear problem optimization, the decomposition of the nonlinear term by a complete set of functions;
8. Electromagnetic shields, how to measure the shielding effectiveness?
9. Introduction to the electromagnetic launchers, principle of operation, solid and plasma armature launchers, some cases of study;
10. The governing equations of the field in the rails and in the armature, short notices on experiments and measurement techniques;
11. Wave-like solution into conducting nonlinear magnetic media, a theoretical study.
12. Practical/Simulation/Laboratory sessions will be organized according to the student's interests.