FINITE ELEMENT MODELING (FEM) OF ELECTROMAGNETIC SYSTEMS

Instructor: Sergey Gandzha

Tenured Professor, PhD in Electrical Engineering, Doctor of Technical Sciences, Head of the Department "The Foundations of Electrical Engineering"

E-mail: gandzhasa@susu,ru

Phone: +79120810902

Course Description

The course presents mathematical models of electromagnetic fields for electromechanical devices. It is divided into two parts. The first part of the course is an introduction to FEM (finite element modeling). Then, students are given the opportunity to run the simulations of electromagnetic fields or heating conditions in ANSYS MAXWELL (RMxprt mode, 2D design, 3D design). Students accomplish their tasks using the static and transient modes; post-processor mode is used to illustrate the simulation results. At the end of the course, students are expected to write and orally present the final paper on one of the problems discussed throughout the course.

Learning Outcomes:

Upon completion of the course, students will be able to digitally simulate the performance of electromechanical systems and to make calculations using the appropriate software. They will be able to work with ANSYS MAXWELL solutions for design of electromagnetic and electromechanical devices and to use finite element modeling.

Scope and types of instructional activities, the contents of the discipline

The course is worth 3 ECTS (108 hours which include 16 hours of lectures, 16 hours of supervised practical classes (workshops, WS), 76 hours of self-study work).

Contents of the discipline, the types of instructional activities and workload

Section number	Name of sections, topics of the discipline	Workload according to the type of instructional activities (hours)			
		total	L	WS	LC
1	Basic definitions. Electric field. Magnetic field. Electromagnetic systems.	2	2		
2	Maxwell's equations	2	2		
3	Permanent magnets	2	2		
4	FEM calculations of a permanent magnet	2	2		

5	Finite element modeling of electromagnetic systems for electromechanical devices	2	2		
6	Finite element modeling of heating conditions in electromechanical devices	2	2		
7	Case study: Calculations and measurements for the magnet system with coils and permanent magnet	2	2		
8	Case study: Thermal calculations for systems with coils and permanent magnets	2	2		
9	Lab Practice: Calculations for magnet systems with permanent magnet			8	
10	Lab Practice: Thermal calculations for systems with coils and permanent magnets			8	
Total		32	16	16	

Contents of the sections, topics of the discipline

Section number	Name of sections	Contents of sections
1	Basic definitions. Electric field. Magnetic field Electromagnetic systems.	Concept of the matter. Electric field parameters (electric field strength, polarization density, vector of an electric displacement, power energy parameters, Coulomb's law) Magnetic field parameters (B-field, H-field, magnetization (M-field), Faraday's law of induction, energy of magnetic field)
2	Maxwell’s equations	Displacement current, Maxwell’ equations (integral form for a volume), Maxwell’s equations (differential form for a point)
3	Permanent magnets	Permanent magnet (definition), magnetizing, induction of saturation BS, residual induction Br, coercive force Hc, magnetic permeability, maximum magnet energy
4	FEM-based calculation of the permanent magnet	Method of permanent magnet system calculation with B=f(H)
5	Finite element modeling of electromagnetic systems for electromechanical devices	Lab practice with ANSYS Electronics Desktop Projects. Magnetic field calculations.
6	Finite element modeling of heating conditions in electromechanical devices	Lab practice with ANSYS Icepak.

7	Case study: Calculations and measurements for the magnet system with coils and permanent magnet	Case Study: ANSYS Maxwell 2D Design and Maxwell 3D Design
8	Case study: Thermal calculations for systems with coils and permanent magnets	Case Study: ANSYS Icepak Heating calculations

Contents of workshops

Number of WS	Section number	Title and summary of the lesson	Workload (hours)
1	9	Lab Practice: Calculations for magnet systems with permanent magnet	8
2	10	Lab Practice: Thermal calculations for systems with coils and permanent magnets	8

Recommended Readings

The Help option in Maxwell program for electromagnetic calculations.
The Help option in Ansys Icepak program for heating calculations.

Software: Ansys Electronicks Desktop, Ansys Icepack.