

ELECTRIC MACHINE DESIGN

ENEE 306

Lecture : 3
Tutorial : 0
Practical : 3

Year : III
Part : I

Course Objectives:

The objective of this course is to provide fundamental knowledge of electrical conducting, magnetic, and insulating materials used in various electric machines, as well as the principles of heating, cooling, and overall performance optimization. It emphasizes on design of transformers, stators, and rotors of induction and DC machines. By the end of the course, students will be able to apply these concepts to analyze, design, and evaluate the performance of different electric machines.

1 Materials Used in Electrical Equipment (5 hours)

- 1.1 Review of electrical conducting materials
 - 1.1.1 Various characteristics and comparison between conducting materials
 - 1.1.2 Materials of high conductivity and high resistivity
- 1.2 Magnetic materials
 - 1.2.1 Classification, characteristics and application of magnetic materials
 - 1.2.2 Materials for steady flux (Solid core materials), materials for pulsating fluxes (Laminated core material sheet)
 - 1.2.3 Special purpose alloys, hot rolled and cold rolled steel sheets, sintered powder core
 - 1.2.4 Magnetic materials used in transformers, DC machines and AC machines
- 1.3 Insulating materials
 - 1.3.1 Classification, characteristics, application
 - 1.3.2 Insulating materials for transformers, DC machines and AC machines, ceramics

2 Heating and Cooling of Machines (7 hours)

- 2.1 Review of heat transfer: Conduction, convection and radiation
- 2.2 Internal temperature (Hot spots and their calculations)
- 2.3 Temperature gradients in iron core
- 2.4 Temperature gradients in conductors placed in slots
- 2.5 Ventilation of electrical machine
 - 2.5.1 Types of enclosures, methods of cooling, schemes of ventilation
 - 2.5.2 Cooling of totally enclosed machines, cooling circuits, cooling systems

- 2.6 Temperature rise, heating time constant, final steady temperature rise, cooling time constant
- 2.7 Rating of electric machine based on temperature rise
- 2.8 Calculation of temperature rise in armature, field coils and commutators

3 Transformer Design (14 hours)

- 3.1 Types of transformer: Power transformer, distribution transformer, core type and shell type
- 3.2 Design approach
 - 3.2.1 Output equations (Single and three phase), volt per turn
 - 3.2.2 Choice and sizing of core: Square core, stepped and cruciform core
 - 3.2.3 Choice of flux density
 - 3.2.4 Design of winding and choice of current density
 - 3.2.5 Design of insulation
 - 3.2.6 Design of window and window space factor
 - 3.2.7 Design of yoke and limb
- 3.3 Calculation of operating characteristics from design data
 - 3.3.1 Resistance of winding, leakage reactance of winding in core type transformer, iron loss, copper loss, efficiency, regulation
- 3.4 Design of cooling system
 - 3.4.1 Temperature rise in plain walled tank, design of tank and tubes

4 Three Phase Induction Motor Design (10 hours)

- 4.1 Three phase induction motor
 - 4.1.1 Construction, core material
 - 4.1.2 Types of three phase stator winding: Mush winding, lap winding and wave winding
- 4.2 Design approach
 - 4.2.1 Output equation, choice of magnetic and electric loading
 - 4.2.2 Choice of stator winding, stator slots and insulation, stator teeth, stator core and stator stamping dimension
 - 4.2.3 Air gap length, rotor design (Squirrel cage and slip ring type)
 - 4.2.4 Leakage inductance, evaluation of equivalent circuit parameters and operating characteristics from design data

5 DC Machine Design (9 hours)

- 5.1 Armature winding
 - 5.1.1 Lap and wave winding
- 5.2 Design approach
 - 5.2.1 Output equation, choice of average gap density, choice of ampere conductors per meter
 - 5.2.2 Choice of number of poles in DC machine, pole proportions

- 5.2.3 Selection of length of air gap
- 5.2.4 Choice of armature windings, number of armature conductors, number of coils, number of armature slots, armature conductor selection
- 5.2.5 Design of commutator, design of brushes, design of field windings and compensating winding

Practical

(45 hours)

1. Detailed design of core type power transformer: Orthographic drawing of transformer including winding, tank and tubes
2. Detailed design of core type distribution transformer: Orthographic drawing of transformer including winding, tank and tubes
3. Detailed design of three phase induction motor: Drawing of three phase stator winding (Mush winding, lap winding and wave winding)
4. Detailed design of DC armature winding: Drawing of lap and wave winding used in DC machine armature

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	5	8
2	7	9
3	14	19
4	10	14
5	9	10
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Sawhney, A. K. (2015). A course in electrical machine design. Delhi: Dhanpat Rai & Sons.
2. Deshpande, M. V. (2009). Design and testing of electrical machines. Delhi: PHI Learning Private Limited.
3. Say, M. G. (1957). The performance and design of A.C. machines (Latest Edition). London: Sir Isaac Pitman & Sons.
4. Say, M. G., Taylor, E. O. (1986). Performance and design of D.C. machines (Latest Edition). London: Pitman Publishing.
5. Agarwal, R. K. (2014). Principles of electrical machine design. S. Delhi: K. Kataria & Sons.