



COURSE OF :

Design of Electrical Machines

Lecture for Third-Year Undergraduate Students

Instructor: Dr.Zeghba Oussama

Date: 2025 / 2026

CHAPTER ONE :

BASIC DESIGN CONSIDERATIONS OF ELECTRICAL MACHINES

Introduction

Electrical machine design is one of the core fields of electrical engineering. It focuses on the scientific and technical principles that allow the generation, conversion, and efficient utilization of electrical energy. It involves the analysis of electromagnetic, mechanical, and thermal components of the machine to determine dimensions, materials, and parameters that achieve the desired performance with minimum losses and maximum reliability.

Definition

► Electrical machine design is the engineering process aimed at defining the electrical, magnetic, and mechanical parameters of a machine (generator, motor, transformer, etc.) to meet specific performance requirements under defined operating conditions.

Objectives

- Achieve the required electrical performance (torque, efficiency, voltage, etc.).
- Increase efficiency and reduce energy losses.
- Minimize cost and improve reliability.
- Enhance cooling and insulation systems.
- Ensure adaptability to various operating conditions.
- Facilitate manufacturing and maintenance processes.

Types of Electrical Machines

Include motors, generators, transformers, and linear machines.

Examples: An induction motor for water pumping, a 220/380V distribution transformer
A linear motor for magnetic levitation transport systems.

Design Stages

1. Define operational requirements (power, voltage, speed, load type).
2. Perform electromagnetic analysis (flux, forces, losses).
3. Design the magnetic circuit (materials, geometry).
4. Design the electrical circuit (windings, resistance, poles).
5. Thermal and cooling analysis.
6. Validation and simulation using FEMM or ANSYS Maxwell.

Practical Examples

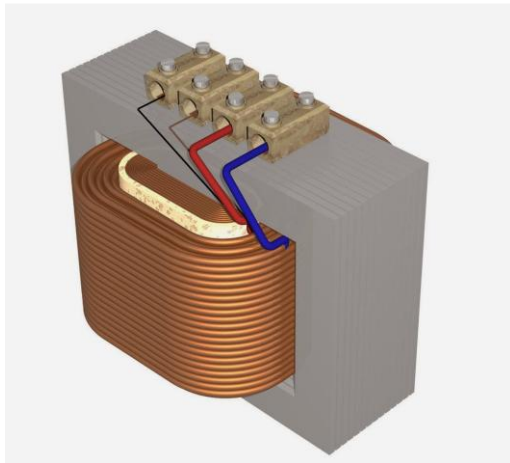
- Design of a three-phase induction motor to increase efficiency from 85% to 90%.
- Design of a power transformer with reduced core and copper losses using silicon steel.

Objectives of Machine Design

- ▶ 1. Long life, low maintenance, economical
- ▶ 2. Efficiency - Reduced losses (copper, iron, mechanical, insulating materials)
- ▶ 3. Reliability - Low cost and high quality
- ▶ 4. Safety - Thermal, insulating, and mechanical standards

Principles of Design

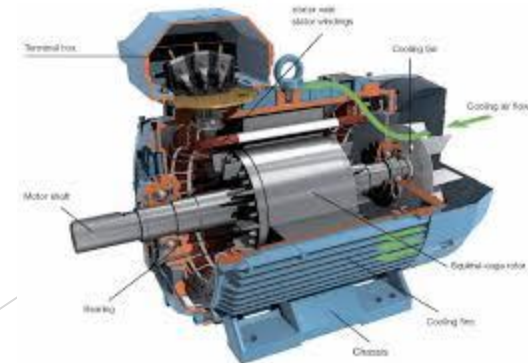
► An electric machine is an electromechanical device that comprises the stationary and moving parts combined together to generate, transform or utilize the mechanical/electrical energy.



Transformer



DC motor



induction motor

Importance of the Topic

- ▶ Good engineering design is the heart of all such applications. Engineering design is the application of science, technology and invention to produce machines to perform specified tasks with optimum economy and efficiency.

Lecture Objectives

- ▶ - Understand the basic principles of transformers and motors
- ▶ - Study design factors affecting performance
- ▶ - Learn about material selection and geometric dimensions
- ▶ - Link theoretical concepts with industrial applications

Lecture Outline

- ▶ 1. Theoretical principles
- ▶ 2. Design factors
- ▶ 3. Material selection and dimensions
- ▶ 4. Industrial applications

Introductory Conclusion

- ▶ Good design ensures efficiency and cost-effectiveness
- ▶ - Connect theory with practical applications
- ▶ - Open paths for specialization in improving machine performance

Main Stages of the Design Process

- ▶ 1. Specification - power, voltage, frequency, speed
- ▶ 2. Electromagnetic design - dimensions, windings, flux density
- ▶ 3. Mechanical design - shaft, bearings, cooling
- ▶ 4. Thermal analysis - heat dissipation, temperature rise
- ▶ 5. Modeling & simulation - MATLAB, ANSYS Maxwell, Flux 2D
- ▶ 6. Validation & testing - theory vs. experiment

A reminder of materials for electrical machines

- Generally speaking, an electrical machine is composed of three types of materials:

Conductors - magnetic - insulators

- 1) Conductors : the flow of electric currents
- 2) Magnetics : the channeling of magnetic flux
- 3) Insulators : prevent the flow of electric current in places where it is not necessary