15UEE504-Electrical Machine Design

Presented by
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Department of EEE
Unit – I

Introduction:

Unit-II

**DC Machines:**

Unit - III

Transformers:

Unit - IV

Induction Motors:

Unit-V

_Synchronous Machines:_

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Reference Books

WHAT IS DESIGN?

- Design is defined as a **creative physical realization of theoretical concepts**.

- Engineering Design is **application of science, technology and invention** to produce machines to perform specified tasks with optimum economy and efficiency.
Design Process?

The process of design involves following circuits,

- Electrical Circuit
- Dielectric Circuit
- Magnetic Circuit
- Mechanical parts
- Thermal Circuit
Major Considerations in Electrical Machine Design:

- Cost
- Reliability / Durability
- Specifications Of Performance
- Limits
IM : 20 TO 30 Years - Low Initial Cost
SM & Trns : Designed with Reliability and Durability

Less emphasis on Initial Cost

*Electrical Machines:*
- Static Machines - Transformers
- Rotating Machines - Generators & Motors
  Conversion in any electrical M/C takes place through magnetic field.
  Magnetic Field produced by an EM which require core and winding.
Electrical Engineering Materials

- High Conductivity Materials
- High Resistivity Materials
High Conductivity materials

- Used for making all types of windings
- All types of apparatus and devices
- Used for transmission and Distribution of electric energy
- Least possible resistivity
High Resistivity materials

- Used for making resistances
- Used for making heating devices
High Conductivity Materials:

Fundamental Requirements to be met are

- Highest possible conductivity
- Least possible temperature co-efficient of resistance
- Mechanical strength
- High tensile strength and absence of brittleness
- Rollability and Drawability
- Weldability and Solderability
- Adequate resistance to corrosion.
**High Resistivity Materials:**

- Resistivity
- Specific weight
- Density
- Resistance temperature co-efficient
- Co-efficient of thermal expansion
- Thermal conductivity
- Specific heat
- Tensile strength
COPPER

Properties:
- High electrical conductivity.
- Excellent Mechanical Properties.
- Immunity from oxidation and corrosion.
- Ductile metal.
- Can be forged, rolled, drawn, machined.
- Most electrical machines employ windings of annealed high conductivity copper.
- Hard drawn copper wire – used in electrical machines as wires.

Department of EEE
Aluminium is available in abundance on earth’s surface. 

- Softer than Copper

- **Can not be drawn into fine wires** due to low mechanical strength
- Machines have to be redesigned for larger slots to accommodate aluminium wires.
- For induction motors with power outputs up to 100 kW – **Aluminium used as bars and Squirrel cage.**

- **Super enamelled aluminium wires** - used as Stator Windings of small induction motors.

- Aluminium used as Transformer tank because of its light weight.
# 15UEE504-Electrical Machine Design

<table>
<thead>
<tr>
<th>Item</th>
<th>Copper</th>
<th>Aluminium</th>
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</thead>
<tbody>
<tr>
<td>Cost</td>
<td>1</td>
<td>$0.49p_c/p_a$</td>
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<tr>
<td>Cross-Section</td>
<td>1</td>
<td>1.62</td>
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<tr>
<td>Diameter</td>
<td>1</td>
<td>1.27</td>
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<tr>
<td>Volume</td>
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<td>2.04</td>
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<tr>
<td>Weight</td>
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<td>0.49</td>
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<tr>
<td>Breaking Strength</td>
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<td>0.64</td>
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</tbody>
</table>

*p_c* = unit price by weight of copper  
*p_a* = unit price by weight of aluminium
### Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Copper</th>
<th>Aluminium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, kg/m³</td>
<td>8900</td>
<td>2700</td>
</tr>
<tr>
<td>Melting point, °C</td>
<td>1083</td>
<td>660</td>
</tr>
<tr>
<td>Thermal Conductivity, W/m·°C</td>
<td>350</td>
<td>200</td>
</tr>
<tr>
<td>Resistivity, Ωm</td>
<td>$0.01724 \times 10^{-6}$</td>
<td>$0.0287 \times 10^{-6}$</td>
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<tr>
<td>Resistance temperature co-efficient at 20°C, -1°C</td>
<td>0.00393</td>
<td>0.0039</td>
</tr>
<tr>
<td>Co-efficient of thermal expansion at 20°C/°C</td>
<td>$16.7 \times 10^{-6}$</td>
<td>$25.5 \times 10^{-6}$</td>
</tr>
<tr>
<td>Specific heat, J/kg·°C</td>
<td>390</td>
<td></td>
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<tr>
<td>Specific strength MN/m²</td>
<td>220-250</td>
<td>920</td>
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</tbody>
</table>
IRON AND STEEL

Iron and Steel:

- Steel alloyed with chromium and aluminium is used for making starter rheostats.

- Cast iron is used in the manufacture of resistance grids to be used in the starters of large motors.
Bronze:
- Copper based alloys containing tin, cadmium, beryllium and other metals are called bronze.
- Used as high conductivity materials.
- Possess high mechanical strength as compared with copper, but have higher resistivities.
Beryllium Copper:

- Used for carrying springs, brush holders, sliding contacts and knife switch blades.
- Resistivity 3 to 6 times that of copper.
Cadmium Copper:

- Copper alloys containing 1.1 percent cadmium give wires which are stiffer, harder and of high tensile strength than hard-drawn copper.
- Used for making contact wires and commutator segments.
- It is also used for cage windings.
Brass:
- It contains 66% of copper and 34% of zinc. High mechanical strength.
- Wear resistance.
- Lower conductivity than copper.
- Easily shaped by press forming methods.
- Good weldability and solderability.
- Fairly resistance to corrosion.
- Used in the manufacture of electrical apparatus as current carrying and structural materials.
Thank You