SETHU INSTITUTE OF TECHNOLOGY

15UEE504-Electrical Machine Design

Presented by

C.Shiva

Assistant Professor/EEE

Department of EEE

15UEE504-Electrical Machine Design

Unit – I

***Introduction*:**

Major considerations in Electrical Machine Design - Electrical Engineering Materials – Space factor – Choice of Specific Electrical and Magnetic loadings – Thermal considerations - Heat flow – Temperature rise - Rating of machines – Standard specifications.

15UEE504-Electrical Machine Design

Unit-II

DC Machines:

Output Equations – Main Dimensions -Magnetic circuit calculations – Carter's Coefficient - Net length of Iron –Real & Apparent flux densities – Unbalanced Magnetic Pull- Selection of number of poles – Design of Armature – Design of Field winding - Design of commutator and brushes – performance prediction using design values.

15UEE504-Electrical Machine Design

Unit - III

Transformers:

Output Equations – Main Dimensions - KVA output for single and three phase transformers – Window space factor - Overall dimensions – Operating characteristics – Regulation – No load current – Temperature rise in Transformers – Design of Tank - Methods of cooling of Transformers.

15UEE504-Electrical Machine Design

Unit - IV

Induction Motors:

Output equation of Induction motor – Main dimensions –Length of air gap- Rules for selecting rotor slots of squirrel cage machines – Design of rotor bars & slots – Design of end rings – Design of wound rotor -– Magnetic leakage calculations – Leakage reactance of polyphase machines- Magnetizing current - Short circuit current –Operating characteristics.

15UEE504-Electrical Machine Design

Unit-V

Synchronous Machines:

Output equations – choice of loadings – Design of salient pole machines – Short circuit ratio – shape of pole face – Armature design – Armature parameters – Estimation of air gap length – Design of rotor –Design of damper winding – Determination of full load field mmf – Design of field winding – Design of turbo alternators – Rotor design.

15UEE504-Electrical Machine Design

Text Books

1. Sawhney A.K, “A Course in Electrical Machine Design ”, Dhanpat Rai& Sons, Sixth edition
2010.
2. Sen S.K., “ Principles of Electrical Machine Designs with Computer Programmers ”, Oxford
and IBH Publishing Co. Pvt. Ltd, 2006.

15UEE504-Electrical Machine Design

Reference Books

1. Shanmugasundaram A., Gangadharan and Palani R, “Electrical Machine Design Data
Book ”, New Age International Pvt. Ltd., 2007.
2. Upadhyay K.G., “ Design of Electrical Machines”, New Age International Pvt. Ltd., 2008
3. Agarwal R.K., “Principles of Electrical Machine Design ”, S.K.Kayaria& Sons , 2007
4. Eclayton A. and NNHancock, , “The performance and Design of Direct current Machines ”,
CBS & Distributors Pvt.Ltd, 2004.

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

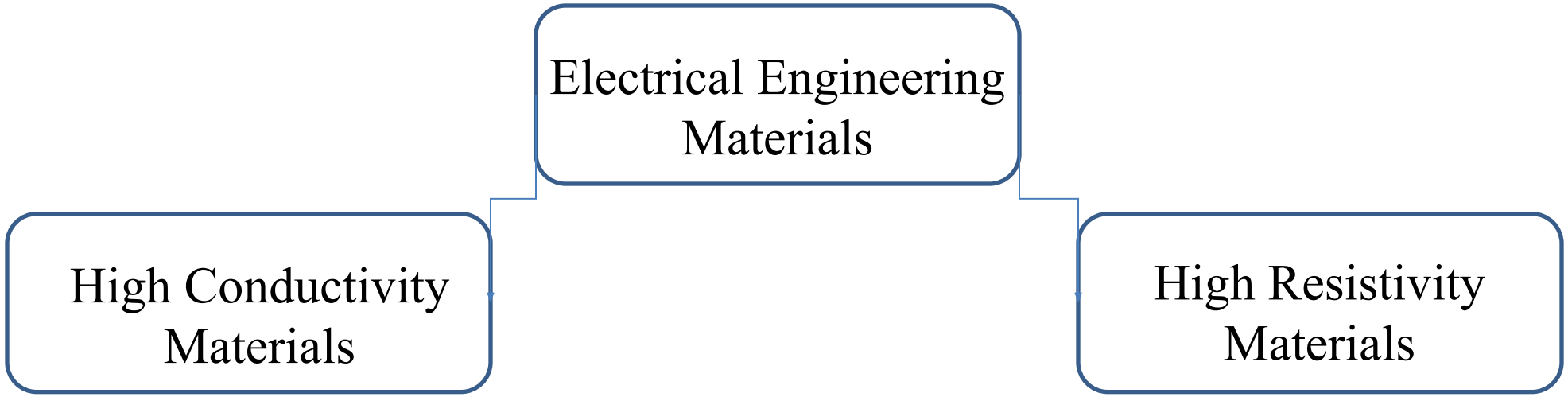
Electrical Machines:

- Static Machines - Transformers
- Rotating Machines- Generators & Motors

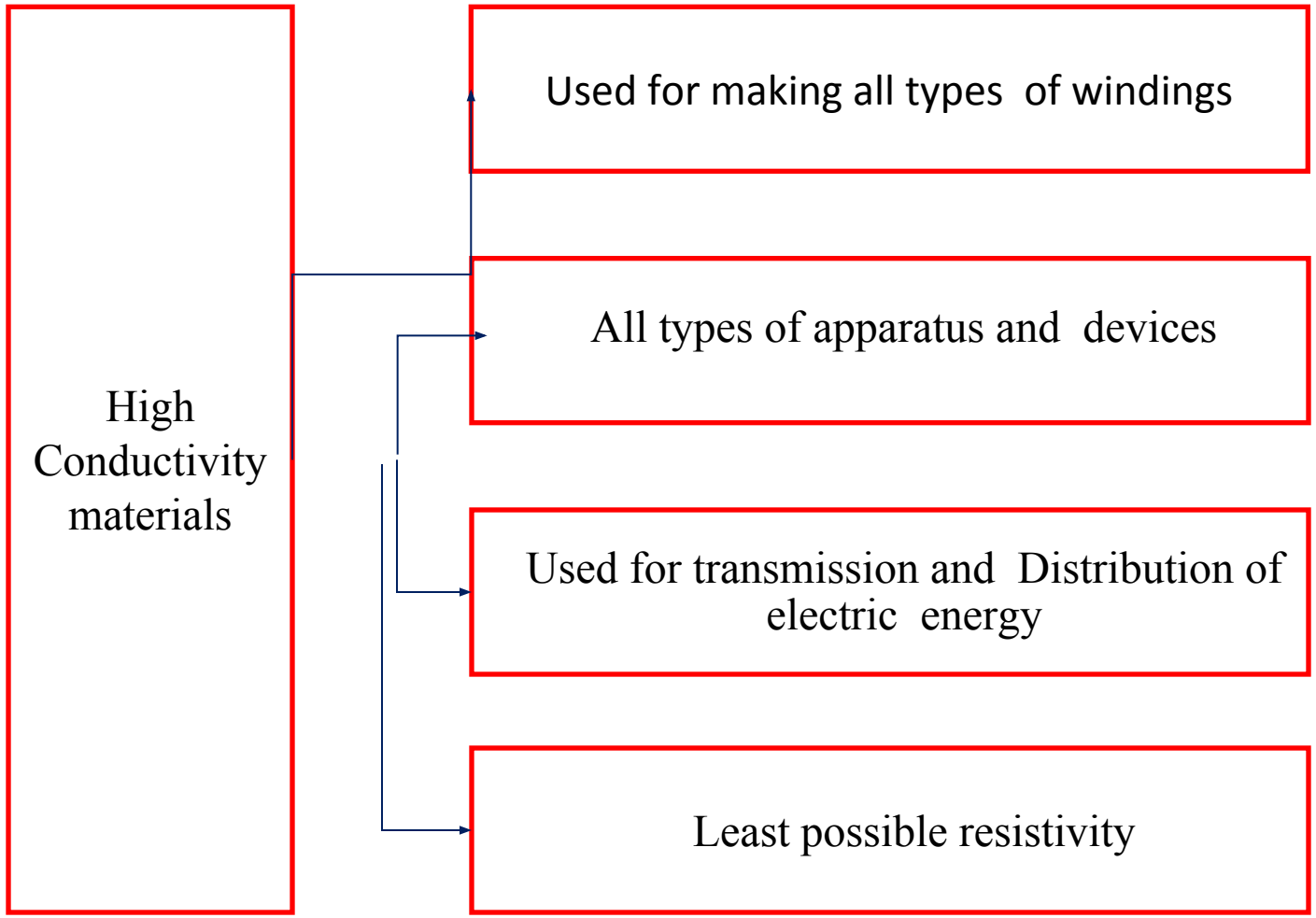
Conversion in any electrical M/C takes place through magnetic field.

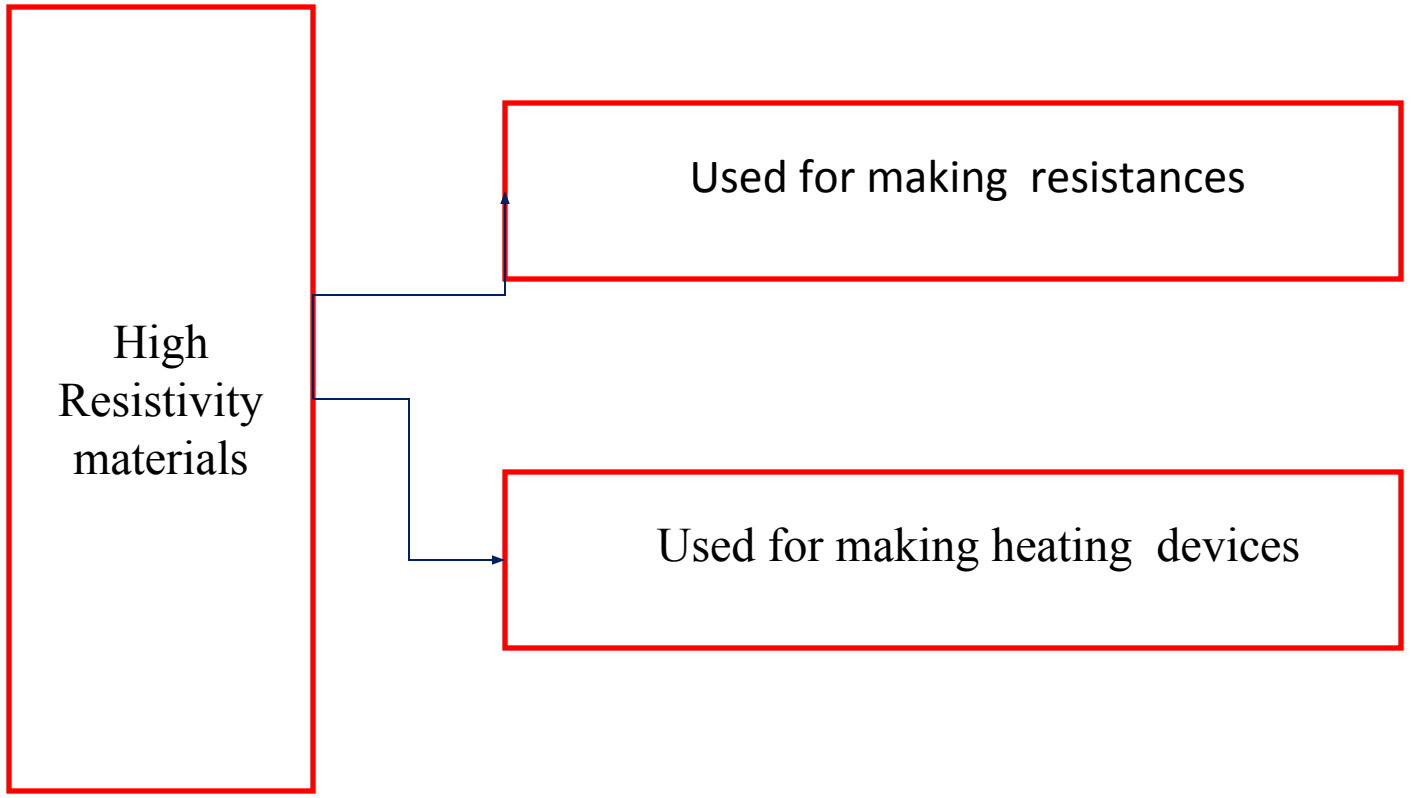
Magnetic Field produced by an EM which require core and winding.

Electrical Engineering Materials



15UEE504-Electrical Machine Design




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.

ALUMINIUM

- 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 upto 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.

Item	Copper	Aluminium
Cost	1	$0.49*p_c/p_a$
Cross-Section	1	1.62
Diameter	1	1.27
Volume	1	2.04
Weight	1	0.49
Breaking Strength	1	0.64
*p_c = unit price by weight of copper p_a = unit price by weight of aluminium		

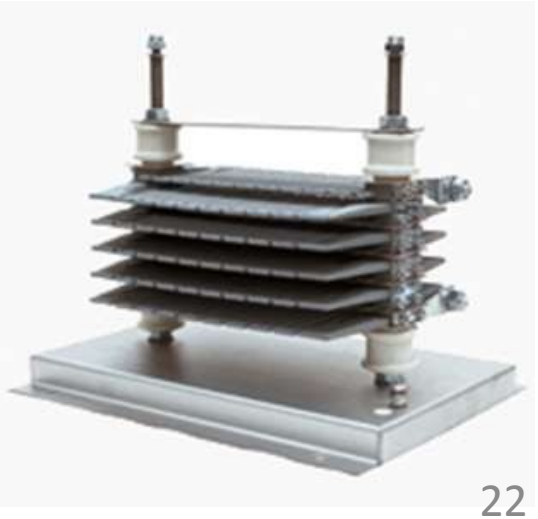
15UEE504-Electrical Machine Design

Characteristics	Copper	Aluminium
Density,kg/m^3	8900	2700
Melting point, ◦C	1083	660
Thermal Conductivity W/m-◦C	350	200
Restitvity,Ωm	0.01724×10^{-6}	0.0287×10^{-6}
Resistance temperature co-efficient at 20˚C,-1˚C	0.00393	0.0039
Co-efficient of thermal expansion at 20˚C/˚C	16.7×10^{-6}	25.5×10^{-6}
Specific heat,J/kg-˚C	390	
Specific strength MN/m^2	220-250	920

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.



ALLOYS OF COPPER

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