Electrical Engg Material

Conducting Materials (Chapter 1)

Materials which are used for conducting electricity are known as conducting material.

Conducting materials have very low values of resistivity

Resistivity

It is a measure of the resisting power of a specified material to the flow of an electric current.

According to ohms law we know

$V = I R$ where R is the resistance

R is directly proportional to its length l & inversely proportional to its cross section area a.

Thus

$$R \propto \frac{l}{a} \quad \text{or} \quad R = \rho \frac{l}{a} \text{ ohm}$$

where ρ is the co-efficient of proportionality and is known as resistivity or specific resistance.

$$\boxed{\rho = \frac{Ra}{l}}$$ unit is ohm-meter

Factors Affecting Resistivity

1. Effect of Temperature on Resistivity.
2. Effect of alloying on Resistivity
3. Effect of mechanical stressing on resistivity

1. Effect of Temperature on Resistivity

→ The most important factor which affects the value of resistivity is the temperature.

→ The resistance of the conducting material increases with temperature and decreases with decrease in temperature

→ The change in resistance of a material per ohm per degree change in temperature is called the temperature co-efficient of resistance of that material.

The resistance of a conductor changes with temperature according to the law

$$R_t = R_0 (1 + \alpha t)$$

where R_t → Resistance of the conductor at t degree

R_0 → " " zero "

α → It is the temperature co-efficient of resistance.

2. Effect of alloying on resistance

→ Another factor which affect the resistivity of material is alloying

→ By adding impurities to a metal its resistivity can be increased.

→ Alloys have higher resistivity than the pure base metal.

→ When a metal is alloyed, it also acquires high mechanical strength which are needed for certain application

→ For example

When copper is alloyed with zinc, the alloyed material is called brass (60% Cu, 40% Zn)

By alloying Cu with Zinc, its resistivity is increased and its conductivity is decreased by 4 times but the tensile strength is much more than that of Copper and brass is used to make products like :-

rods, shafts, heavy plates, plug points, socket outlets, knife switches etc where high strength and hardness are necessary.

3. Effect of mechanical stressing on resistivity :

→ Mechanical stressing increases the resistivity and decreases the conductivity, annealing (Heat treatment process) restores the electrical conductivity by regularity in crystal structure.

→ Mechanical stressing like cold working operation distorts the crystal structure of the metal, hardens the material, increases its tensile strength and increases slightly its resistivity.

Eg → The increase in tensile strength is very useful for many purpose such as overhead conductors. That is why many types of conductors are finally drawn in cold stage in which case they are identified as harddrawn.

Classification of conducting materials into low resistivity and high resistivity materials :-

Low resistivity materials

→ low resistivity materials are used in house wiring

→ used for power transmission and distribution in the winding of transformers and machines like motors and generators

→ low resistivity materials are used in all such application where power loss and voltage drop should be low.

→ low resistivity material material posses low value of resistivity

High resistivity materials

→ high resistivity material are used for making resistance element for heating devices, starters for electric motors, resistance used in precision measuring instruments, loading resistance

→ rehostat and filament of incandescent lamps.

→ high resistivity material are used in all such application where a large value of resistance is required.

→ If low resistivity materials were used for such application the length of the wire would be too large which would increase to a large extent the overall size of the equipment.

→ high resistivity material posses high value of resistivity

Properties
Low resistivity material

1. **Low temperature co-efficient**

The change of resistance with change in temperature should be low to avoid variation in voltage drop & power loss with changes in temperature.

For eg → the resistance of transmission lines which are very long will increase when exposed to hot summer sun this will cause increase in voltage drop and power loss in transmission line.

→ the windings of electrical machines and apparatus become hot when loaded. This causes temperature rise and if the conducting material of the winding has high temperature co-efficient of resistance, the voltage drop and power loss in the winding will be high.

2. **Sufficient mechanical strength**

The overhead line conductors are used for transmission and distribution of electrical power are subject to stresses due to wind and their own weight. The conducting material used for the windings of transformers, motor and generators develop mechanical forces when loaded, the coils for the windings of such equipment are made on formers, the conducting material is subject to mechanical stresses. To withstand all this mechanical stresses the conducting material should posses sufficient mechanical strength.

Properties
High resistivity material

1. **Low temperature coefficient**

The change of resistance with change in temperature should be negligible to give accuracy of measurement.

For eg → high resistivity material are often used as shunts in electrical measuring instruments, in making wire wound precision resistance and resistance boxes. For such application the material of the element should have negligible temperature co-efficient of resistance otherwise the accuracy of measurements will be reduced.

2. **High mechanical strength**

High resistivity material to be used for application where the wire must be very thin are required to have high tensile strength otherwise they may break during the drawing of the wire or during operation.

Low resistivity material

3. Ductility

Ductility is that property of a material which allows it to be drawn out into wire.
Conductors are required in different sizes and shapes i.e round wire section or rectangular wire section. Therefore the conducting material should be ductile enough to enable itself being drawn into different shapes & sizes.

4. Solderability

Conductors are often joined or jointed The joint should offer minimum contact resistance. A simple joint is to be twist the conductors with the materials to which it is to be jointed. But this gives high contact resistance. Minimum contact resistance results if the joint is soldered. All materials do not lend themselves to proper soldering. So while selecting conducting material it should be kept in view!

5. Resistance to corrosion

The conducting material should be such that it is not corroded when used in out door atmosphere.

High resistivity material

3. Ductility

High resistance material are required in the shape of very thin wires in the case of precision wire wound resistors and in the shape of thick wires in the case of the elements used in ovens, heaters, starters etc. High resistance materials to be used for such applications should be capable of being drawn into wires of different sizes and be capable of being coiled.

4. High melting point

In application like loading rheostats and starters for electrical motors the material of the resistance element should be able to hold or withstand high temperature for a long time without melting.

element the amount of heat radiation will reduce

5. No tendency for oxidation

Materials used as high resistance elements in heating appliances should be able to withstand high temperature for a long time without oxidation. This is because if an oxide layer is formed on the heating

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