ELECTRICAL ENGINEERING MATERIAL

[THEORY-4]

3RD SEM EEE

Prepared By *:Er. Rakesh Kumar Sethi*

NILASAILA INSTITUTE OF SCIENCE & TECHNOLOGY ,
SERGARH-756060, BALASORE (ODISHA)
(Approved by AICTE & affiliated to SCTE&VT, Odisha)

CONTENTS

CHAPTER-1(CONDUCTING MATERIAL)

Conducting material:

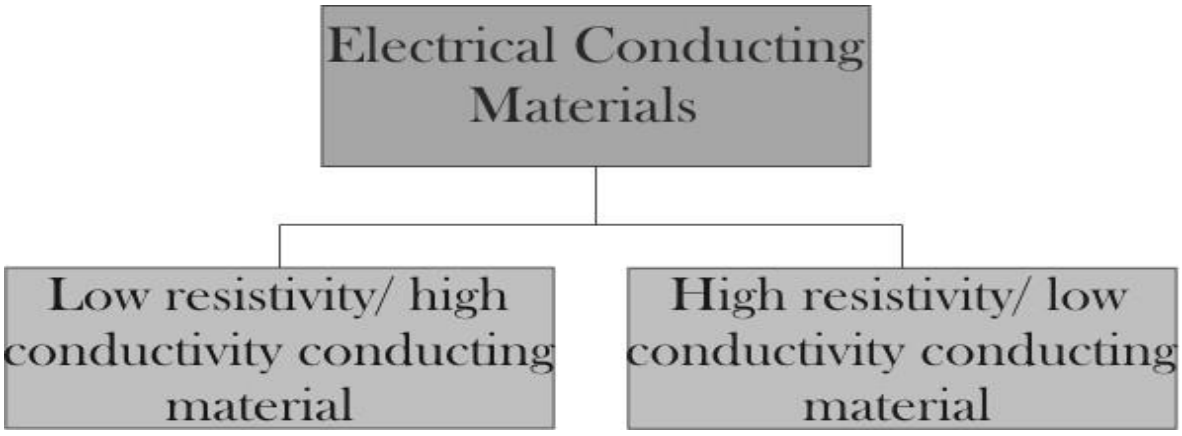
- The materials which conduct electricity due to free electrons when an electric potential difference is applied across them are known as conducting materials. .
- Conducting materials are good conductors of electricity and heat.
- Gold,silver,copper,aluminum are the examples of conducting materials

Resistivity:

- Resistivity is a measure of the resistance of a given size of a specific material to electrical conduction.
- Materials that conduct electrical current easily are called conductors and have a low resistivity.
- Those that do not conduct electricity easily are called insulators and these materials have a high resistivity.

Factors effecting the resistivity of electrical materials are –

1. Temperature.
2. Alloying.
3. Mechanical stressing.
4. Age Hardening.
5. Cold Working.



Application of low resistivity material

- A material with low resistivity means it has low resistance and thus the electrons flow smoothly through the material.
- Fore xample,Copper and Aluminum have low resistivity.Good conductors have less resistivity.

i. Copper:

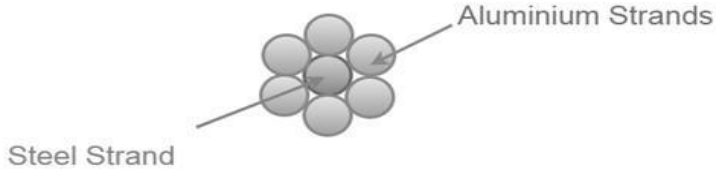
- It is most widely used metal because soft its high conductivity.
- Silver has the lowest resistivity but due to its high conducting material.
- Copper is available in two forms,that is a copper and hard drawn copper,for use as conducting material.
- Hard drawn copper is about 4% less conducting than annealed copper, but has more tensile strength and is used,in transmission and distribution lines where conductors have to be stretched.

ii. Aluminum:

- Aluminium is available in various forms such as oxides,sulphates,silicates,phosphates,etc.
- Pure aluminiumis softer than copper,so can be rolled in to thin sheets
- Use of aluminium as an electrical materi al,particularly in the aircraft industry,has considerable advantages because of the saving in weight involved.
- Electrochemical plants are enormous user so aluminium bus bars ,because electrolytic cell operators with heavy currents at low voltages and to carry these current, massive bars are required.
- Aluminium,because of its lightness,is being used more and more for such bus bars.
- Thecurrentcarryingcapacityofaluminiumbeing75% that of copper,and its density being approximately one-third that of copper,
- Aluminum busbarisonly about half the weight of copper bus bar of equal current carrying capacity.

Stranded Conductors

- Stranded conductors are very much use for transmission and distribution line.
- A stranded conductor is consists of several thin wires of small cross sectional area called stranded conductors.



Stranded Conductor

- At the center of stranded conductor,we are using steel conductor which provided the high tensile strength to conductor.
- In the outer layers of stranded conductor,we use aluminum conductors,which provide the conductivity to stranded conductor.

- Basic,reasonofusingstrandedconductoristomaketheconductorflexible.
- Ifweuseasinglesolidconductor.Itdoesnothavesufficientflexibilityanditisdifficulttocoila solid conductor.
- Hence,itbecomesdifficulttotransportasinglesolidconductoroflonglengthoverthedistance
- Toeliminatethisdrawback,conductorisformedbyusingseveralthinwiresofsmallcross section.
- These thin wires are called strands. By making the conductor stranded, it becomes flexible. Whichmakesstrandedconductorsuitabletobecoiledeasilytotransportitoverlongdistance.

ACSR

- Aluminiumconductorsteel-reinforcedcable(ACSR)isatypeofhigh-capacity,high-strength stranded conductor typically used in overhead power lines.
- Theouterstrandsarehigh-purityaluminium,chosenforitsgoodconductivity,lowweight and low cost.

Bundle conductor

- Abundleconductor isaconductor madeupoftwoormoresub-conductorsandisusedasone phase conductor.
- Forvoltagesgreaterthan220kVitispreferabletousemorethanone conductor perphase which is known as Bundle conductor.

Advantages of Bundled Conductors

- Bundlingofconductorsleadstoreductioninlineinductance.
- Bundleconductorsabilitytoreducecoronadischarge.
- Whenpowerisbeingtransferredatveryhighvoltagesusingasingleconductor,thevoltage gradient around it is high, and there is a high chance that the corona effect will occur, especially in bad weather conditions.
- Reductionincommunicationlineinterferenceduetoreductionincorona.

Highresistivitymaterialandtheirapplication

(1) Tungsten

- Thismaterialisusedinelectronicandvacuumengineering.
- Itisalsousedinelectron,X-rayandotherkindsoftubes.
- Thetungstenfilamentismadeinstraight,coiledorcoiled-coilform.

(2) Carbon

- Carbonisusedinautomaticvoltageregulatorsformakingthepressuresensitivepile resistors.
- Itisusedinthemanufactureofweldingelectrodes,fixedandvariableresistorsforlight current and contacts of certain classes of D.C. switch gear.

Superconductingmaterialsapplications

- Powertransmissioncables.
- Transformers.
- Motorsandgenerators.
- Faultcurrentlimiters.

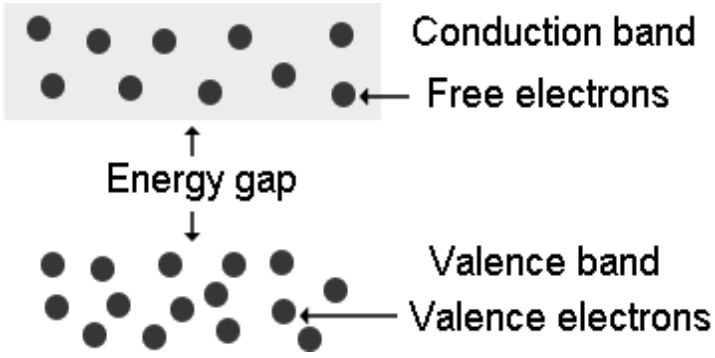
****

CHAPTER 2(SEMICONDUCTING MATERIAL)

- Semiconductorsarematerialswhichhaveaconductivitybetweenconductors(generallymetals) and nonconductors or insulators (such as most ceramics).
- Semiconductorscanbepureelements**.**

ENERGY BANDTHEORY

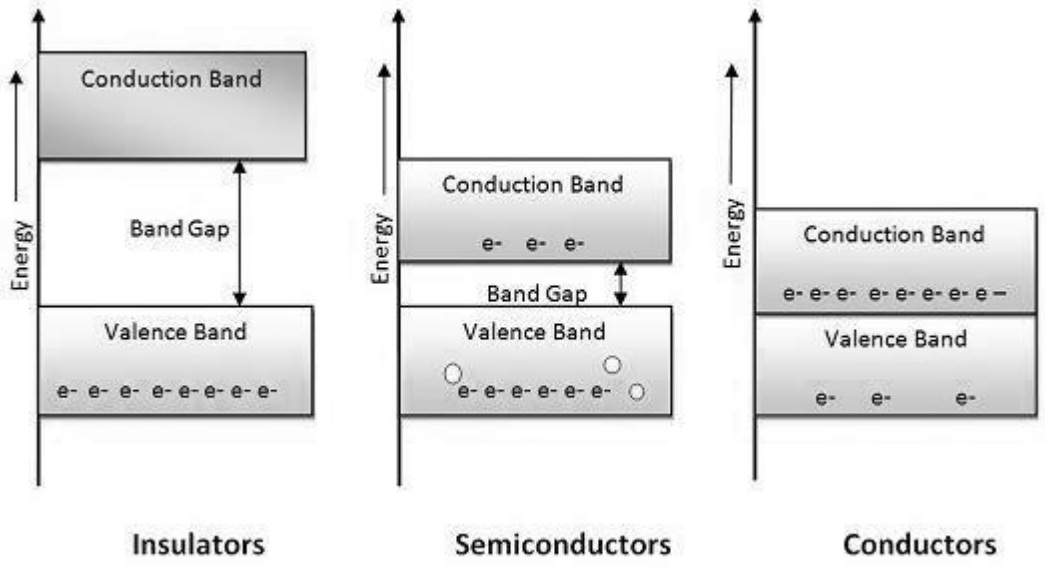
- Energyhastobesuppliedtomoveelectronsawayfromthenucleusoftheatom.
- Thevalenceelectrons havethehighestenergylevelsoftheelectronsthatarestillboundtotheir parent atoms.
- Additionalenergy isrequiredtocompletelyremoveanelectronfromtheatom,sofreeelectrons have higher energy levels than valence electrons.
- Thiscanbeillustratedwithanenergybanddiagram,whichshowstwoenergylevels,a valence band and a conduction band**.**
- Valenceelectronsarelocatedinthevalencebandandthefreeelectronsinthehigherconduction band.



- Insemiconductorsthereisagapbetweenthevalenceandconductionbands.Soenergymustbe supplied for valence electrons to "jump up" to the conduction band.
- Thisreflectsthefactthatenergymustbesuppliedto removevalenceelectronsfromtheirparent atoms and become free electrons.
- Ininsulatorsthisgapismuchlarger,torepresentthesignificantlyhigherenergylevelsthatwould be needed, to "pull" electrons from their parent atoms.
- Inmetalsthevalencebandandconductionbandactuallyoverlap.
- Soinmetals,valenceelectronscanmoveeasilyintotheconductionband,producingalarge number density of free electrons.

Insulator

Anymaterialthatkeepsenergysuchaselectricity,heat,orcoldfromeasilytransferringthroughis an insulator. Wood, plastic, rubber, and glass are good insulators.



Semiconductor

- Semiconductorsarematerialswhichhaveaconductivitybetweenconductors(generallymetals) and nonconductors or insulators (such as most ceramics).
- Semiconductorscanbepureelements.

Conductor

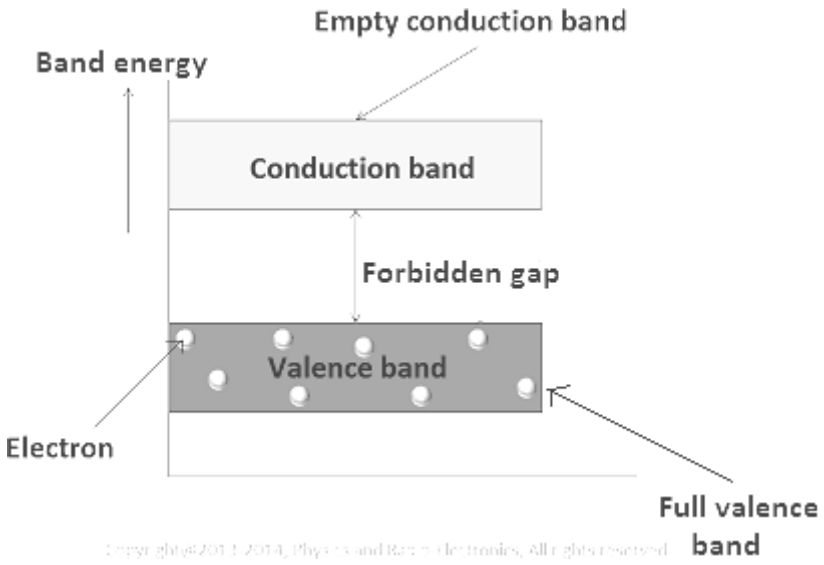
- Aconductorisamaterialwhichelectricity,heatorsoundcanflowthrough.Anelectrical conductor conducts electricity.
- Theabilitytoconductelectricityiscalledelectricalconductivity.Mostmetals,likeironand copper, are electrical conductors.
- Thesemetalsareusedtomakewirestocarryelectriccurrent.

Covalent bond

- Acovalentbond,alsocalledamolecularbond,isachemicalbondthatinvolvesthesharingof electron pairs between atoms.
- These electron pairs are known as shared pairs or bonding pairs, and the stable balance of attractiveandrepulsiveforcesbetweenatoms,whentheyshareelectrons,isknownas covalent bonding.

Forbidden energy gap

- Forbiddenenergygapisthegapbetweenvalencebandandconductionband.Inotherwords the energy required by an electron to jump from valence band to conduction band.
- Forbiddenenergygap,alsoknownasbandgapreferstotheenergydifferencebetweenthetop of valence band and the bottom of the conduction band in materials.
- Currentflowingthroughthematerialsisduetotheelectrontransferfromthevalence bandtothe conduction band



.

PARAMETER	INTRINSICSEMICONDUCTOR	EXTRINSICSEMICONDUCTOR
Formofsemiconductor	Pureformofsemiconductor.	Impureformofsemiconductor.
Conductivity	Itexhibitspoorconductivity.	Itpossessescomparativelybetter conductivity than intrinsic semiconductor.
Bandgap	The band gap between conductionandvalencebandis small.	Theenergygapishigherthan intrinsic semiconductor.
Fermilevel	Itispresentinthemiddleof forbidden energy gap.	The presence of fermi level variesaccordingtothetypeof extrinsicsemiconductor.

Dependency	Theconductionrelieson temperature.	Theconductiondependsonthe concentrationofdopedimpurity and temperature.
Carrierconcentration	Equal amount of electron and holesarepresentinconduction and valence band.	The majority presence of electronsandholesdependson the type of extrinsic semiconductor.
Type	Itisnotclassified.	Itisclassifiedasptypeandn type semiconductor.

N-TYPEMATERIAL

- AnN-typesemiconductoris atypeofmaterialusedinelectronics.Itismadebyaddinganimpurityto a pure semiconductor such as silicon or germanium.
- Theimpuritiesusedmaybephosphorus,arsenic,antimony,bismuthorsomeotherchemical element. They are called donor impurities.

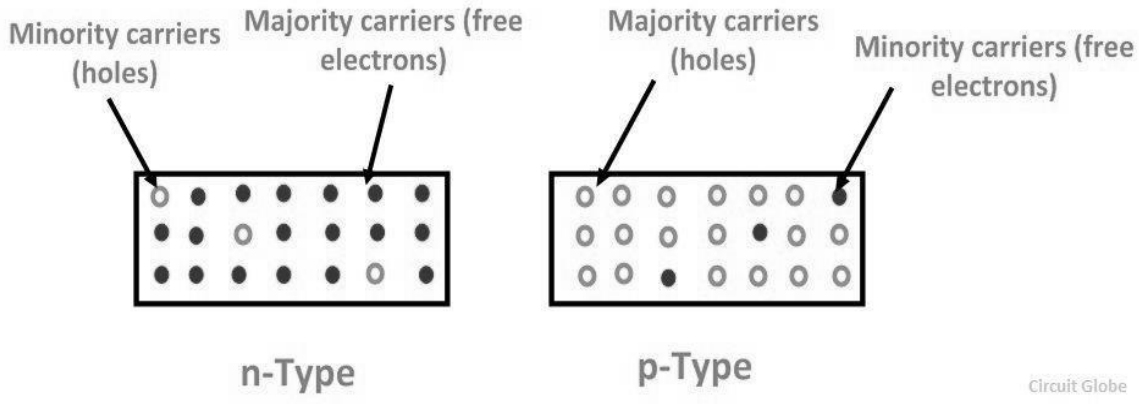
P-TYPEMATERIAL

- Ap-typesemiconductorisatypeofsemiconductor.Whenthetrivalentimpurityisaddedtoan intrinsic or pure semiconductorthen it is said to be an p-type semiconductor.
- TrivalentimpuritiessuchasBoron(B),Gallium(Ga),Indium(In),Aluminium(Al)etcarecalled acceptor impurity.

BASISOFDIFFERENCE	PTYPE SEMICONDUCTOR	NTYPE SEMICONDUCTOR
GroupofDopingElement	InPtypesemiconductorIIIgroup element is added as doping element.	InntypesemiconductorVgroup element is added as doping element
MajorityCarriers	Holesaremajoritycarriers	Electronsaremajoritycarriers
MinorityCarriers	Electronsareminoritycarriers	Holesareminoritycarriers
Fermilevel	Itliesbetwwnenergybandand valency band	Itliesbetweenenergybandand conductor band
MovementofMajoritycarriers	Majoritycarriersmovefromhigher to lower potential	Majoritycarriersmovefromlower to higher potential.
Typeofimpurityadded	Trivalentimpurityladded	Pentavalentimpurityadded.

Majority and Minority Carriers

- Inann-typesemiconductor,theelectronsarethe majoritycarrierswhereas,theholesarethe minority carriers.
- Inthep-typesemiconductormaterial,theholesarethemajoritycarriers,whereas,theelectronsare the minority carriers as shown in the figures below.



- WhenasmallamountofPentavalentimpurityisaddedtoapuresemiconductor.
- itprovidesalargenumberoffreeelectronsinthecrystalformingthen-typesemiconductor.
- Someofthecovalentbondsbreakevenattheroomtemperature,releasingasmallnumberof electron-hole pairs.
- Thus, an n-type semiconductor contains a large number of free electrons and a few numbers of holes.ThismeanstheelectronprovidedbyPentavalentimpurityaddedandashareofelectron-hole pairs.
- Therefore,inn-typesemiconductor,themostofthecurrentconductionisduetothefreeelectrons available in the semiconductor.
- Similarly,inthep-typesemiconductor,theholesareinthemajorityascomparedtoelectrons,andthe conduction takes place because of the very few electrons which are present in the minority.

Applications OF Rectifier

1. Becauseofitspropertyofrectification,itcanbeutilizedasapartofthepowersupplycircuitry.
2. Itcanbeutilizedinpowersupplyunitswithswitching-modetechnique.
3. Duringthedetectionoftheamplitudeforthemodulatedradiosignalsrectifiersareused.
4. Inordertosupplythevoltageinapolarizedmannerforthepurposeofwieldingrectifiersareused.

Applications Photovoltaic

- (PV)cellisthetechnicaltermforsolarcell,whichisusedtoconvertsunlightdirectlyintoelectricity....
- NowadaysPVtechnologyisbeingusedtopowerhomesandcommercialbuildings,andeveninlarge power stations of several utility companies.

Application of solar cells.

- Solarcellsareveryusefulinpoweringspacevehiclessuchassatellitesandtelescopes.
- Theyprovideaveryeconomicalandreliablewayofpoweringobjectswhichwouldotherwiseneed expensive and cumbersome fuel sources.

Application of transistor

- Transistorsarealsousedtoswitchelectronicsignals..
- Mosttypesoftransistorsarepackagedindividuallybutcanalsobeincludedinanintegratedcircuit.

Photoconductive cell

- Whenaphotoconductivematerialisconnectedaspartofacircuit,itfunctionsasaresistorwhose resistance depends on the light intensity. ..
- .Themostcommonapplicationofphotoresistorsisasphotodetectors,i.e.devicesthatmeasurelight intensity.

****

CHAPTER-3(INSULATING MATERIAL)

Definition:

- Thematerialwhichdoesnotallowtheelectricitytopassthroughthemisknownasanelectrical insulating material.
- Thechargeof theinsulatingmaterialdoesnotmovefreely, orin otherwords, itprovidesthehigh resistivepathtotheelectriccurrentthroughwhichitisnearlyimpossiblefortheelectriccurrentto conduct through it.
- Itisusedintheoverheadtransmissionline**.**

The insulating materials would have the following properties.

1. Thematerialmusthavehighmechanicalstrengthsothatitcarriesthetensionandweightofthe conductors.
2. Theymusthavehighdielectricstrength.
3. Thematerialishighlyresistiveforpreventingtheflowofleakagecurrentfromtheconductortoearth.
4. Thematerialisnon-porousandfreefromimpurities.
5. Theelectricalandchemicalpropertyofthematerialshouldnotbeaffectedbythetemperature.

Mechanical Properties of Insulating Materials
1. Tension and Compression:

- Theconductorsoftransmissionanddistributionsystemsofoverheadlinesaresupportedbymeansof insulators to avoid leakage of current through the supports to the earth.
- Whenatensileloadexistsonit,itshouldbeabletowithstandandshouldnotgivewaymechanically.

2. Resistance to Abrasion:

1. insulatorusedbetweenthecommutatorsegmentswhicharesubjectedtoabrasiveactionduring the running of the motor.
2. Theinsulationqualitiesshouldbesuchthatitshouldwithstandthis

Viscosity:

- Inliquidinsulators,viscosityplaysanimportantrole.
- Itaffectsthemanufacturingprocess.
- Lowviscosityliquidsaremoremobile.
- Liquidinsulationsshouldnotcontainimpuritiesasitwillalsoaffecttheviscosityandthe performance

Electrical Insulating Material

- Thematerialwhichdoesnotallowtheelectricitytopassthroughthemisknownasanelectrical insulating material.
- Thechargeof the insulatingmaterialdoesnotmovefreely,anditprovidesthehighresistive pathto theelectriccurrentthroughwhichitisnearlyimpossiblefortheelectriccurrenttoconductthroughit.
- Itisusedintheoverhead transmissionlinebetweenthetowerandconductorforpreventingtheflow of electric current from the conductor to earth.

Properties of an Electrical Insulating Material

- Thematerialmusthavehighmechanicalstrengthsothatitcarriesthetensionandweightofthe conductors.
- Theymusthavehighdielectricstrength.
- Thematerialishighlyresistiveforpreventingtheflowofleakagecurrentfromtheconductortoearth.
- Thematerialisnon-porousandfreefromimpurities.
- Theelectricalandchemicalpropertyofthematerialshouldnotbeaffectedbythetemperature.

Insulating material characteristics

- Largeinsulatingresistance.
- Highdialecticstrength.
- Uniformviscosity
- itkeepstheelectriclossesaslowaspossibleandelectricstressesuniformunderhighvoltage difference.
- Leastthermalexpansion.
- Whenexposedtoarcingshouldbenon-ignitable.
- Shouldberesistancetooilsorliquids,gasfumes,acids.
- Shouldhavenodeterioratingeffectonthematerial,incontactwithit

Classification According to Substances and Materials:

(i) Solids(Inorganic and Organic):

Mica,wood,slate,glass,porcelain,rubber,cotton,silk,rayon,paperandcellulosematerialsetc.

(ii) Liquids(Oils and Varnishes):

Linseedoil,refinedhydrocarbonmineraloils,spiritandsyntheticvarnishesetc.

(iii) Gases:

Dryair,carbondioxide,nitrogenetc.

Insulating materials, on the basis of theirphysical and chemical structure may be classified in variouscategories as follows:

Fibrous materials:

- Theyarederivedfromanimaloriginorfromcellulose,whichisthe majorsolidconstituentof vegetable plants.
- Themajorityofmaterialsarefromcellulose.
- Thisincludespaper,wood,card-board,cotton,juteandsilk.

Impregnated fibrous material:

Thefibrousmaterialsareimpregnatedwithsuitableimpregnatedoil,varnish,andepoxy-resinto improve its thermal, chemical and hygroscopic properties.

Non-resinous materials:

- Solidinsulationswhicharedirectlyavailableinnatureandareorganicbasedcomeunderthisclass.
- Thesematerialsaremineralwaxes,asphalts,bitumenandchlorinatednaphthalene.

Insulating liquids:

- Insulatingliquidfulfilotherimportantrequirementsliketheyoffergoodheatdissipationmedia,
- theyusedforextinguishingarcsincertainapplicationslikecircuitbreakers.
- Theyincludevegetableoils,fluorinatedliquids,mineralinsulatingoilsandsyntheticliquids.

Insulating Gas

Adielectricgas,orinsulatinggas,isadielectricmaterialingaseousstate...Dielectricgasesareusedas electrical insulators in high voltage application

Properties of insulating Gases

- Utmostdielectricstrength.
- Fineheattransfer.
- Incombustible.

- Chemicalidlenessagainsttheconstructionmaterialused.
- Inertness.
- Environmentallynonpoisonous.
- Smalltemperatureofcondensation.
- Highthermalconstancy.
- Acquirableatlowcost

Application of Insulating Gases

- ItisusedinTransformer,
- Radarwaveguides
- CircuitBreakers,
- Switchgears,
- HighVoltageSwitching,Coolants.
- Theyareusuallyusedinhighvoltageapplication

Q.Why glass is used as a insulating material?

- Ithasahighertensilestrengthcomparedtoporcelaininsulator.
- Asitistransparentinnaturetheisnotheatedupinsunlightasporcelain.
- Theimpuritiesandairbubblescanbeeasilydetectedinsidethe glassinsulator bodybecauseofits transparency.

****

CHAPTER–4(DIELECTRIC MATERIAL)

Adielectricmaterialisasubstancethatisapoorconductorofelectricity,butanefficientsupporterof electrostatic field.

Dielectric constant of permittivity

- Thedielectricconstant(k)ofamaterialistheratioofitspermittivityε tothepermittivityofvacuum εo,sok=ε/εo.
- Thedielectricconstantisthereforealsoknownastherelativepermittivityofthematerial.
- thedielectricconstantisjustaratiooftwosimilarquantities,itisdimensionless**.**

Dielectric loss

- Dielectricloss,lossofenergythatgoesintoheatingadielectricmaterialinavaryingelectricfield
- .Forexample,acapacitorincorporatedinanalternating-currentcircuitisalternatelychargedand discharged each half cycle.

Dielectric polarization

- Dielectricpolarizationisdescribethebehaviorofa materialwhenanexternalelectricfieldisapplied on it.

- Asimplepicturecanbemadeusingacapacitorasanexample.Thefigurebelowshowsanexample of a dielectric material in between two conducting parallel plates

Dielectric breakdown

- dielectricbreakdownoccurswhencurrentflowsthroughanelectricalinsulator.
- Thevoltageatwhichtheinsulatorbecomeselectricallyconductiveiscalleditsbreakdownvoltage.

Applications of dielectrics are

- Theseareusedforenergystorageincapacitors.
- Toenhancetheperformanceofasemiconductordevice,highpermittivitydielectricmaterialsareused.
- DielectricsareusedinLiquidCrystalDisplays.
- CeramicdielectricisusedinDielectricResonatorOscillator.
- BariumStrontiumTitanatethinfilmsaredielectricwhichareusedinmicrowavetunabledevices providing high tunability and low leakage current.
- Paryleneisusedinindustrialcoatingsactsasabarrierbetweenthesubstrateandtheexternal environment.
- Inelectricaltransformers,mineraloilsareusedasaliquiddielectricandtheyassistinthecooling process.
- Castoroilisusedinhigh-voltagecapacitorstoincreaseitscapacitancevalue.
- Electrets,aspeciallyprocesseddielectricmaterialactsaselectrostaticequivalenttomagnets.

****

CHAPTER-5(MAGNETIC MATERIAL)

Magnetic materials are thosematerialsthat can beeitherattracted or repelled when placed in an external magnetic field and can be magnetized themselves. example-iron

Onthebasisoforientation,themagneticmaterialsareclassifiedintofourcategories

(a) Diamagnetic

(b) Paramagnetic

(c) Ferromagnetic

(d) Anti–ferromagnetic

1. **.Diamagnetic materials**

- Thesematerialsaremagnetizedwhenplacedinamagneticfield.
- Magneticdipolesinthesesubstancestendtoaligninoppositiontotheappliedfield.
- Theyproduce an internal magnetic field that opposes the applied field and the substance tendsto repel the external field around it.

  Ex:Gold,water,mercuryandevenanimals

2. **Paramagnetic materials**

- In these materials the magnetic dipoles in the Magnetic Materials tend to align along the applied magnetic field and thus reinforcing the applied magnetic field.
- Suchsubstancesareattractedbyamagnetifitappliesasufficientlystrongfield.
- Itmust benotedthatsuchmaterials arestillfeeblemagnetizedandthemagnetizationdisappears as soon as the external field is removed.
- Ex:Liquidoxygen,sodium,platinum,saltsofironandnickel. 3
  .ferromagnetic materials
- Mostoftheferromagneticmaterialsaremetals.
- CommonexamplesofferromagneticsubstancesareIron,Cobalt,Nickel,etc.
- Inaddition,metallicalloysandrareearthmagnetsarealsoclassifiedasferromagneticmaterials.
- Magnetiteisaferromagneticmaterialwhichisformedbytheoxidationofironintoanoxide.

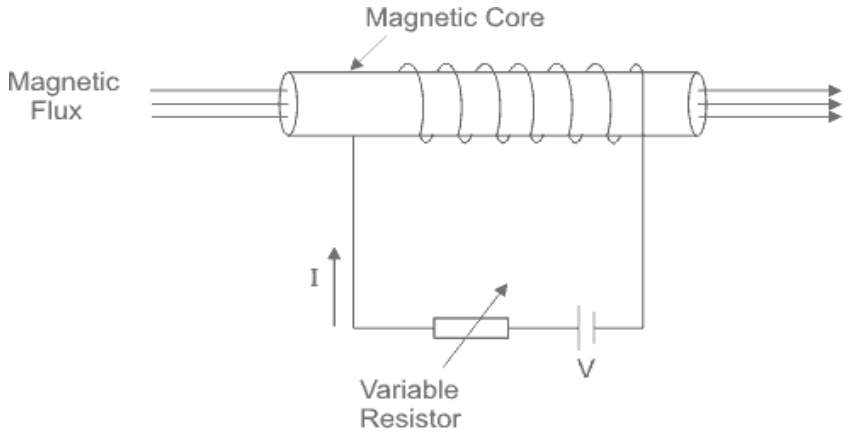
Magnetization curve and Hysteris

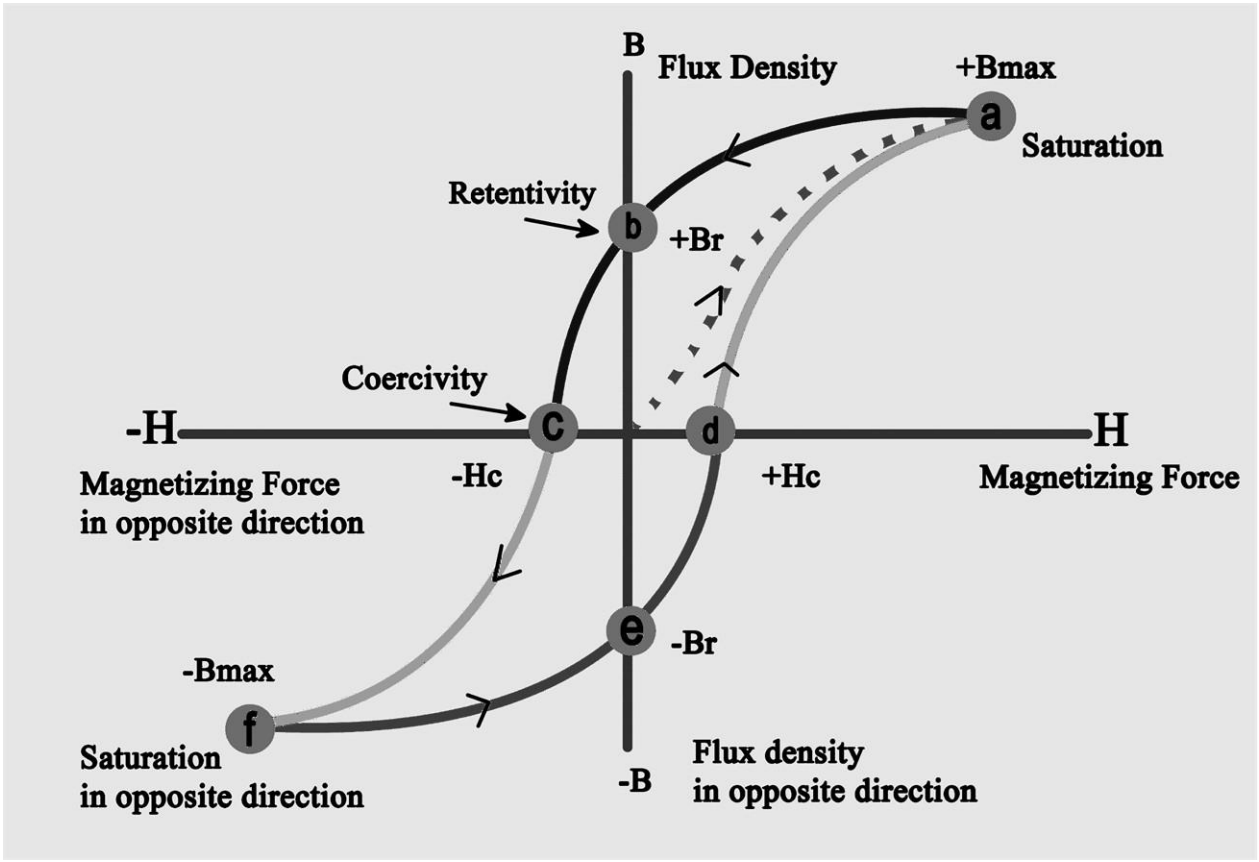
- Hysterisinferromagneticmaterials-BHcurve.
- Hysteresisispresentinferromagneticmaterial
- .Whenamagneticfieldisapplied,theferromagneticmaterialwillbecomemagnetic.
- HysteresisloopisafourquadrantB-Hgraphfromwherethehysteresisloss,coerciveforceand retentively of s magnetic material are obtained.
- Ifamagneticmaterialtouseasacorearoundwhichinsulatedwireiswound.
- Thecoilsisconnectedtothesupply(DC)through variableresistortovarythecurrentI.
- CurrentIisdirectlyproportionaltothevalueofmagnetizingforce(H) as

$$H = \frac{NI}{l}$$

Where,N=no.ofturnofcoilandlistheeffectivelengthofthecoil.

- magneticfluxdensityofthiscoreisBwhichisdirectlyproportionaltomagnetizingforceH.





- Hysteresisofamagneticmaterialisapropertybyvirtueofwhichthefluxdensity(B)ofthis material lags behind the magnetizing force (H)
- Coerciveforceisdefinedasthenegativevalueofmagnetizingforce(-H)thatreducesresidual flux density of a material to zero'

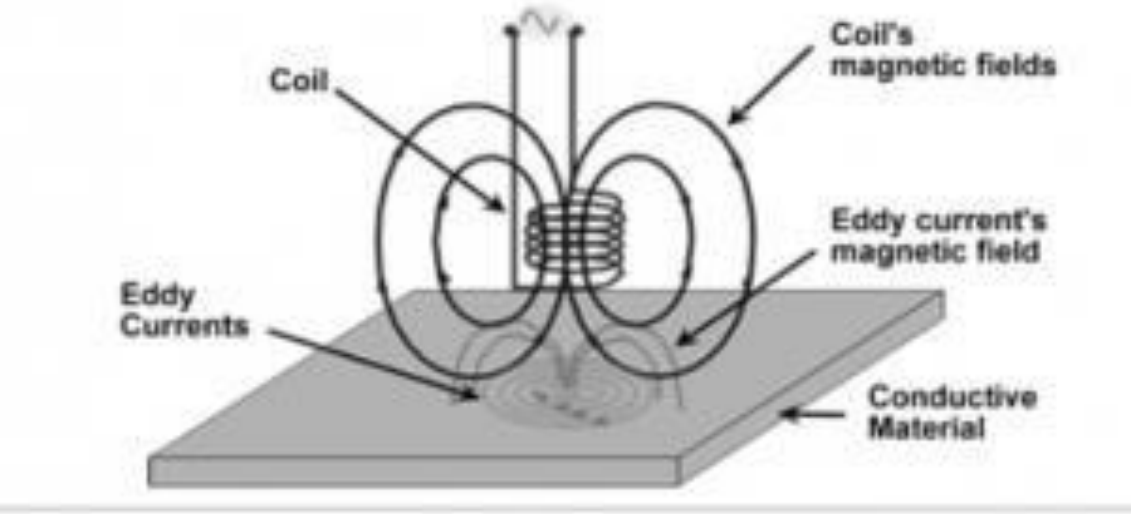
- Residualfluxdensityisthecertainvalueof magneticfluxperunitareathatremainsinthe magnetic material without presence of magnetizing force (i.e. H = 0).
- Retentivitydefinedasthedegreetowhichamagneticmaterialgainsitsmagnetismafter magnetizing force (H) is reduced to zero.

The advantages of hysteresis loop are given below.

- Smallerhysteresisloopareasymbolizeslesshysteresisloss.
- Hysteresisloopprovidesthevalueofretentivityandcoercivityofamaterial.Thusthewayto choose perfect material to make permanent magnet, core of machines becomes easier.
- FromB-Hgraph,residualmagnetismcanbedeterminedandthuschoosingofmaterialfor electromagnets is easy.

Eddy Current

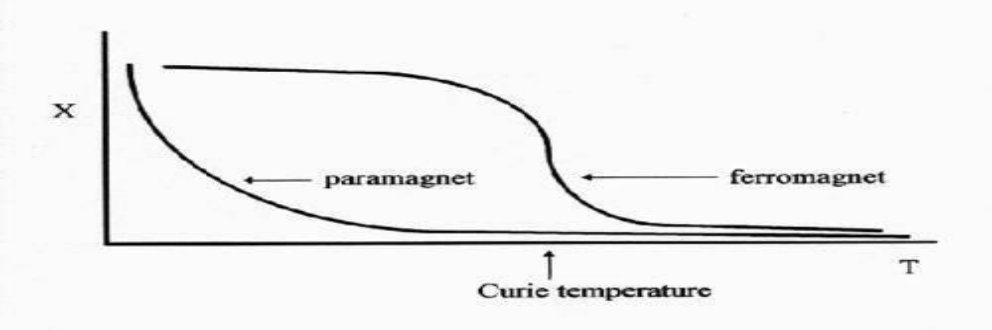
- Eddycurrentsareloopsofelectricalcurrentinducedwithinconductorsbyachangingmagnetic field in the conductor according to Faraday's law of induction.
- Eddycurrentsflowinclosedloopswithinconductors,inplanesperpendicular tothemagnetic field.



- InLenz'slaw,experimentsdonetoexplaintheeddycurrents.
- Thefirsttestshowedthatinsideasolenoidasoftironcoreisintroducedanditisconnectedtothe alternating electromotive force.
- Whenthemetallicdiscisplacedoverthesoftironcore,thecircuitisswitchedonandwhenthe circuit is turned on the metallic disc is thrown up away from the iron core.

Curie point

- InCuriepoint,temperatureatwhichcertainmagneticmaterialsundergoasharpchangeintheir magnetic properties.
- Inthecaseofrocksandminerals,remanentmagnetismappearsbelowtheCuriepoint.



Properties of Hard Magnetic Materials

- Utmostretentivelyandcoercively.
- Valueofenergyproduct(BH)willbelarge.
- TheshapeofBHloopisnearlyrectangle.
- Highhysteresisloop.
- Smallinitialpermeability.

Application of Hard magnetic materials

- Automotive:motordrivesforfans,wipers,injectionpumps;starter motors;Controlforseats, windows etc.
- Telecommunication:Microphones,LoudSpeakers,TelephoneRingersetc.
- Dataprocessing:Printers,SteppingMotors,DiscDrivesandActuators.
- Consumerelectronics:Homecomputers,Clocks,DCMotorsforshowersetc.
- Electronicandinstrumentation:EnergyMeterDisc,Sensors,Dampersetc.
- Industrial:Liftingapparatus,Robotics,Metersetc.
- Astroandaerospace:Auto-compass,Couplings,Instrumentationetc.
- Biosurgical:NMR/MRIbodyscanner

Properties of Soft Magnetic Materials

- Utmostpermeability.
- Slightcoerciveforce.
- Smallhysteresisloss**.**

****

CHAPTER-6(MATERIAL FOR SPECIAL PURPOSE)

Structural materials

1. Structuralmaterialsarematerialsusedorstudiedprimarilyfortheirmechanicalproperties,as opposed to their electronic, magnetic, chemical or optical characteristics.
2. Thiscanincludeamaterialsresponsetoanappliedforce,whetherthisresponseiselasticorplastic, its hardness, and its strength.
3. Bimetals
4. Theworkingofbimetals isbasedonthetheorythata metalexpendsonheating andcontractson cooling. If we consider a strip of metal of length of l.
5. Whenthetemperatureincreases,itlengthincreased.Theincreaseinlengthofstripduetorisein temperature is related by Coefficient of linear thermal expansion.
6. Itdenotedby"α_L"
7. BimetalisconsistsoftwostripsoftwodifferentmetalshavingdifferentCoefficientoflinearthermal expansion, welded together lengthwise.

Protective Material

- ProtectingMaterialusedfor manufacturingcombatclothingshouldbecapableofprotectingthe wearer.

Fuse and Fuse Material

1. Fuseisanessentialdeviceusedinelectricalcircuitswhichgivestheprotectionfromtheover current.
2. Itcomprisesastriporametalwirethatdissolveswhentheheavyflowofcurrent supplies through it
3. Thefuseelementismadeofzinc,copper,silver,aluminum,oralloystoprovidestableand predictable characteristics.
4. Thefuseideallywouldcarryitsratedcurrentindefinitely,andmeltquicklyonasmallexcess.
5. Thematerialusedforfuseelementsmustbeoflowmeltingpoint,lowohmicloss,high conductivity, low cost and free from detraction.
6. Thematerialusedformakingfuseelementhasalowmeltingpointsuchastin,lead,orzinc.
7. Alowmeltingpointis,however,availablewithahighspecificresistancemetal.

Soldering Material

1. Solderalloysareusuallyformedoftin(Sn)andlead(Pb)withelements,suchasbismuth(Bi), indium (In), silver (Ag), copper (Cu), cadmium (Cd), and antimony (Sb) added.

2. Depending on which element is added,we can adjust the properties of the alloy,like lowering the melting point.
3. Alloys commonly used for electrical soldering are60/40Sn-Pb,which meltsat188°C(370°F), and used principally in electrical/electronic work.
4. While mechanical soldering is used by plumbers for making mechanical connections, electrical soldering is the process by which electronic components are connected to the circuit board using a filler material to form the joint between them.