**Important suggestions to examiners**:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

| Q.1 A) | **Attempt any THREE of the following :** **12 Marks** |
|---|---|
| **i)** | **State the factors on which severity of electric shock depends. Also state the effect of current on human system.** |
| Ans: | **(Factors 2 Marks & Effect of current 2 Marks, Total 4 Marks)**<br>**(Any Two factors From following or equivalent are expected 1 Mark each ,Total 2 Marks)**<br>The severity of shock depends on following factors.<br>1. Whether supply is A.C or D.C.<br>2. Magnitude of voltage of the system.<br>3. Magnitude of frequency of supply<br>4. Magnitude of current passing through the body<br>5. The period or duration of electric shock.<br>6. Human body resistance (If wet resistance of body reduces)<br>7. General health of human who gets shock.<br>8. Path of current flowing through the body e.g. brain , heart, muscles.<br>9. The phase of the heart cycle when the shock occurs |

10. The presence of moisture in the environment.

**(Any Two factors From following or equivalent are expected 1 Mark each ,Total 2 Marks)**

**The effect of electrical shock on human bodies depends on following factors:-**

| S.No | The current strength | Effect on human system |
|---|---|---|
| 1 | Between 1m amp to 8 mA | Are just bearable does not cause any pains |
| 2 | Between 8mA-15mA | Give painful shock without loss of muscular control. |
| 3 | Between 20mA-50mA | If passes through chest, it may stop breathing |
| 4 | Between 50mA-100mA | May result in ventricular fibrillation. |
| 5 | Between 100mA-200mA | May cause fibration (Vibration) of heart |
| 6 | Above -200mA | Severe burns, causes death |

**ii) State the importance of electrical maintenance. State different categories of maintenance.**

Ans:

**(Importance 2 Marks, Categories of maintenance 2 Marks, Total 4 Marks)**

**Following are the points of importance of electrical maintenance:-**

**(Any Two points From following or equivalent are expected 1 Mark each ,Total 2 Marks)**

1. To/It keep the machine in good working condition.
2. To /It reduce breakdown to a minimum.
3. To It / prevent premature failure.
4. To /It avoid major breakdown or fault.
5. To/ It reduce breakdown period.
6. To/ It increase life of machine.

7. To/ It provide greater safety & protection to the workers.
8. To / It determine the need for major & minor repairs.
9. To/ It avoid inconvenience.

**Different categories of maintenance:-**

**(Any Two points From following or equivalent are expected 1 Mark each ,Total 2 Marks)**

1. Preventive maintenance
   a) Routine Maintenance/daily Maintenance
   b) Periodic Maintenance/Time based Maintenance
2. Predictive Maintenance
3. Breakdown Maintenance/ Run it till it breaks
4. Productive Maintenance/Total productive Maintenance
5. Overhaul Maintenance/Zero hours Maintenance
6. Contracted Maintenance
7. Corrective Maintenance
8. Maintenance on fault

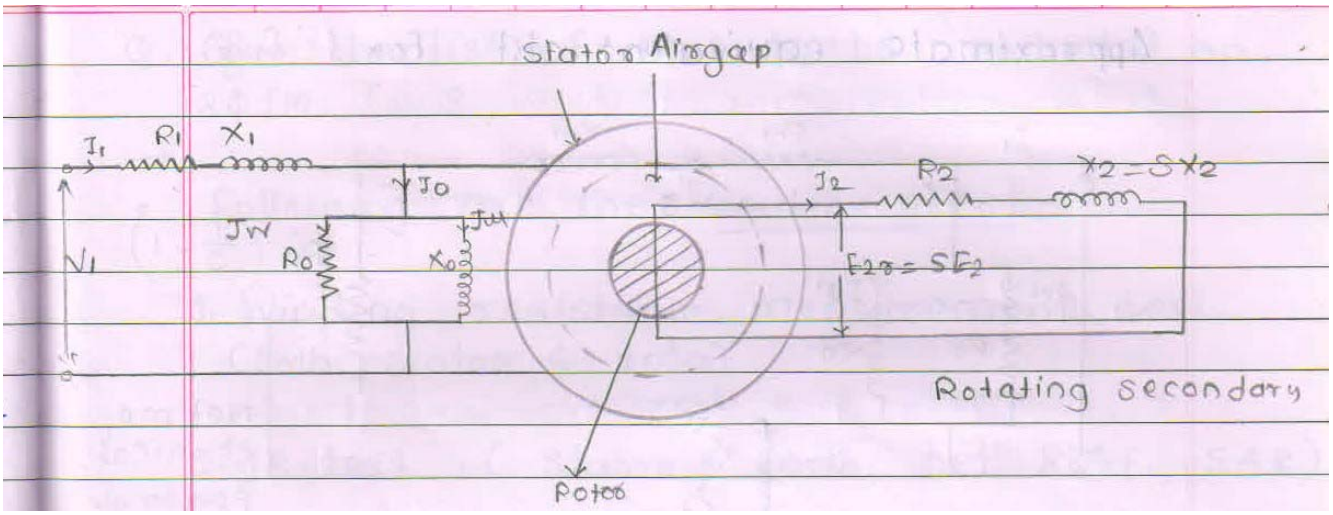
**iii) State and explain the properties of transformer oil (any four).**

Ans: **(Any four properties are expected from following or equivalent 1 Mark each ,Total 4 Marks)**

**Following are the properties of transformer oil:-**

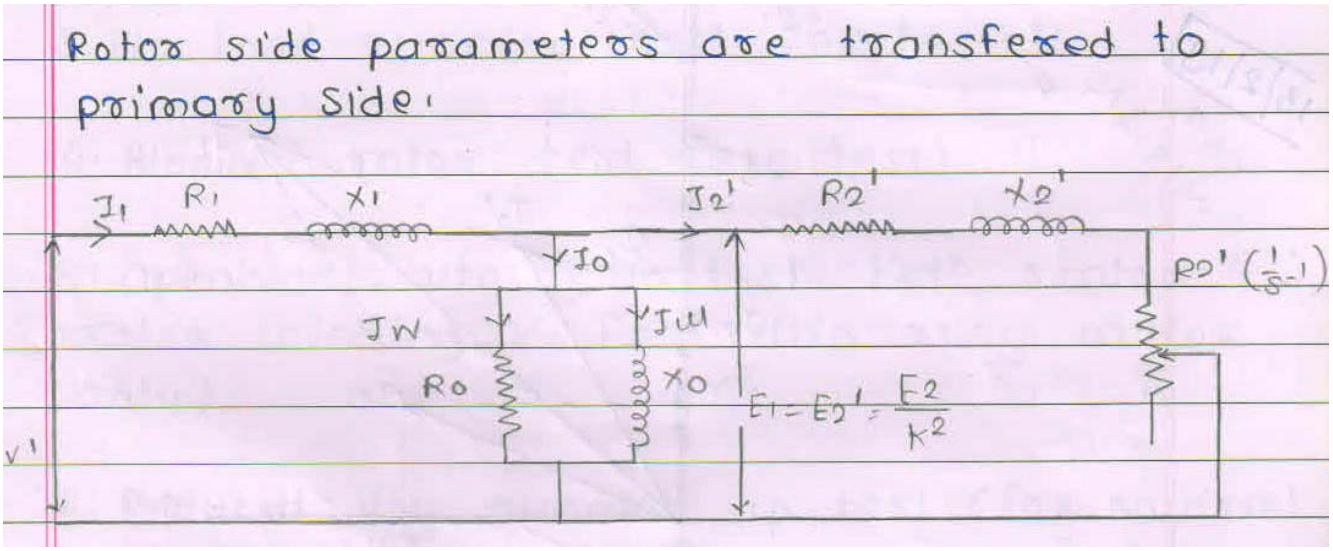
1. Dielectric strength :-
   It should be have a high dielectric strength
2. Specific resistance:-
   It should be have a high Specific resistance.
3. Dielectric dissipation factor (DDF) (tanδ):-
   It should be as low as possible.
4. Relative permittivity (Dielectric constant):-
   It should be 2.2

| | |
|---|---|
| | 5. Flash Point :-<br>Oil should have very high flash point.<br>6. Fire point -<br>It should have high fire temperature. It should be 25% greater than flash point.<br>7. Pour Point: -<br>It should be low<br>8. Viscosity:-<br>Oil should have low viscosity<br>9. Density:-<br>Oil should have low density.<br>10. Moisture content & water content:-<br>Oil should be free from moisture & water content<br>11. Dissolved gas:-<br>Oil should be free from dissolved gas.<br>12. Acidity content:-<br>Acidity content should be very low. Oil should be chemically stable.<br>13. The oil should be clear & plane in colour, transparent & free from suspended matter. |
| **iv)** | **State any four troubles in case of D.C machines.** |
| Ans: | **(Any four points From following or equivalent are expected 1 Mark each ,Total 4 Marks)**<br>**Following are the troubles in case of D.C machines:-**<br>1. Motor fails to start **or** not accelerate<br>2. Motor stalls<br>3. Motor run slow<br>4. Motor Run Hot/ Thermal overload/ Motor overheating<br>5. Vibration/ Noise/ Scraping Noise/ Motor hums |

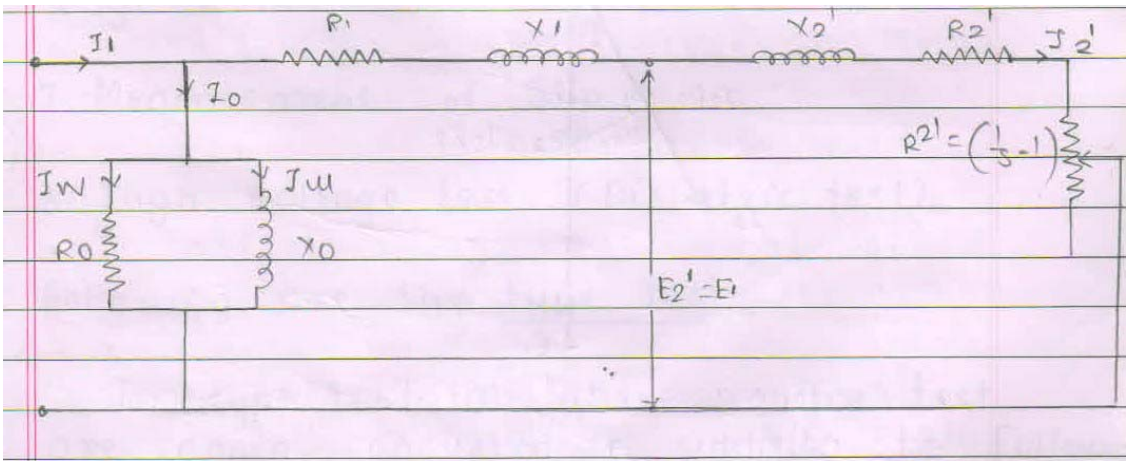
| | |
|---|---|
| | 6. Bearing overheating/bearing continuously fail<br>7. Excessive sparking at brushes<br>8. Motor runs at high speed<br>9. Motor runs in the wrong direction<br>10. Regular clicking |
| **Q.1 B)** | **Attempt any ONE of the following :** **6 Marks** |
| **i)** | **Draw the modified equivalent circuit of induction motor referred to stator diagram. Explain each components.** |
| **Ans** | **(Step by step equivalent circuit: 6 Marks)**<br><br>**<u>Equivalent circuit of I.M.</u> :-**<br>Where,<br>$R_1$ is the stator resistance per phase<br>$X_1$ is the stator reactance per phase<br>$R_2$ is the rotor resistance per phase<br>$X_2$ is the rotor reactance per phase<br>$R_2'$ is the equivalent rotor resistance referred to stator per phase,<br>$X_2'$ is the equivalent rotor reactance referred to stator per phase<br>$R_0$ is the resistance representing core loss ,$X_0$ is the magnetizing reactance per phase<br><br>$V_1$ is the per phase supply voltage to the stator ,s is the slip of the motor<br><br>  <br><br>**or equivalent Figure** |

**or equivalent Figure**

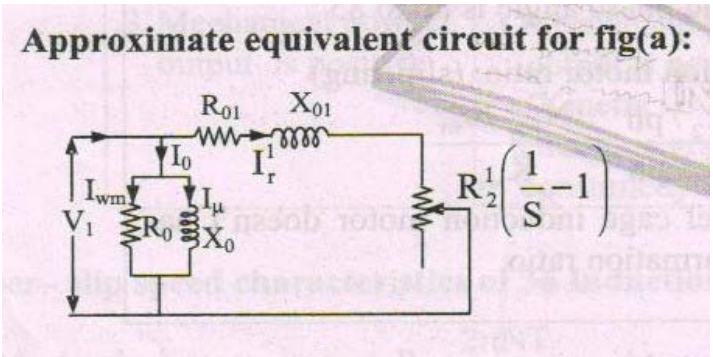
**The exact equivalent circuit model of an Induction motor refer to stator is-**




**OR**

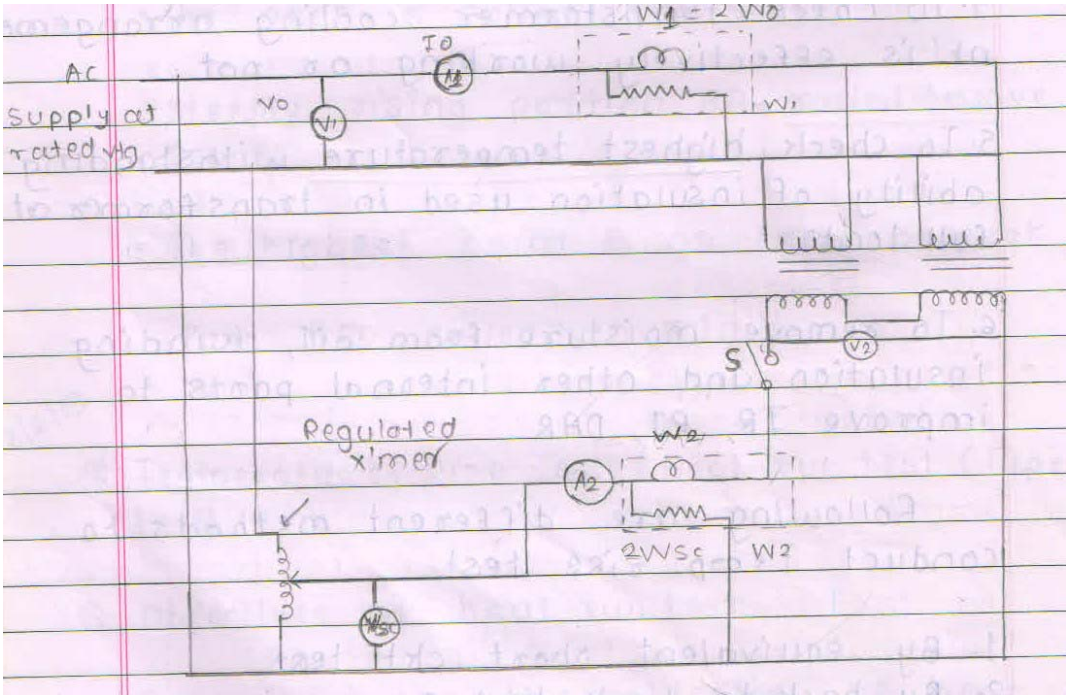



**Approximate equivalent circuit for fig(a):**

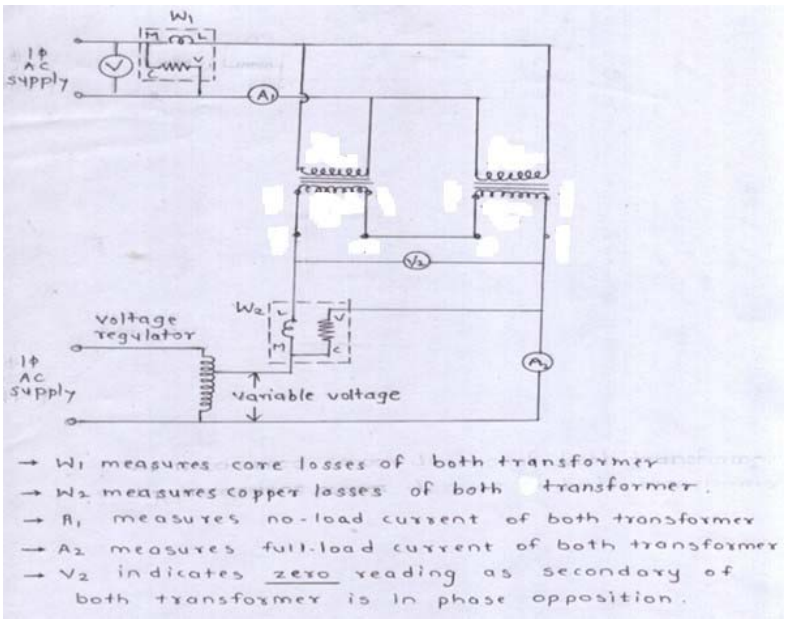


| | |
|---|---|
| ii) | **With the help of neat circuit diagram explain back to back test on single phase transformer to determine efficiency and regulation.** |
| Ans: | **(Circuit diagram 2 Marks, explanation 1 Marks, Observation table 1 Mark, efficiency 1 Marks, regulation 1 Marks , Total 6 Marks)** |

**Diagram :** **( 2 Marks)**




**OR**




**or equivalent Figure**

**Explanation /Precaution /Procedure:-** **(1 Mark)**

- For this test two identical transformer are required.
- Primary of two transformers are connected in parallel and secondaries are connected in series opposition.
- Supply is given at rated voltage and rated frequency generally to LV winding similar to OC test.
- Now supply is given to HV winding with the help of auto-transformer (Regulating-transformer) till full load current is circulated in HV winding similar to short circuit test.

**Observation:-** **( 1 Mark)**

**1.**

| $V_1$ in volt | $I_1$ in Amp | $W_1$ in watt | $V_2$ in volt | $I_2$ in Amp | $W_2$ in watt |
|---|---|---|---|---|---|
| Rated primary voltage | $= 2I_0$ | $\approx 2\ w_i$ | It is a voltage at which F.L. Current circulate through Sec $=2.V_2$ | $= I_2$ F.L. Current | $\approx 2\ w_{Cu}$ Full load copper losses |

2. Note down the room temperature.

3. When steady state temperature is reached, take the temperature of oil with the help of thermometer.

4. Measure the resistance of winding when immediately after steady state temperature is reached to calculate temperature of winding.

**Calculations:-**

1. **For efficiency measurement: :** **( 1 Mark)**

Iron losses = Wi / 2 watt

Full load copper losses = Wcu / 2 watt.

$$Efficiency = \frac{output\ (KVA) \times P.f}{output\ KVA \times P.f + W_1/2 + W_2/2} \times 100$$

**2. For regulation measurement:** **( 1 Mark)**

$$W_{cu}/2 = I_2^2 R_{02}$$
$$Z_{02} = V_2/2 / I_2$$
$$X_{02} = \sqrt{Z_{02}^2 - R_{02}^2}$$
$$\% \text{ Regulation} = I_2 (R_{02}\cos\emptyset \pm X_{02}\sin\emptyset)/ V2$$

| | |
|---|---|
| **Q.2** | **Attempt any TWO of the following :** **16 Marks** |
| **a)** | **State the causes of fire due to electrical faults. Describe the operation of fire extinguishers.** |
| **Ans:** | **(Any six causes are expected from following or equivalent 1 Mark each , 6 Marks and operation of fire extinguishers 2 Marks , Total 8 Marks)** |

**Following are the Causes of electrical Fires:-** **(6 Marks)**

1. Overloading on cables/wires/machine for long period, increases temperature, causes possibility of fire.
2. The majority of fires are caused due to selection of incorrect rating of the fuses or use of incorrect rating MCB/RCCB/MCCB or incorrect setting of safety switch.
3. Poor joints in wiring/cables may cause overheating & lead to fire.
4. Due to loose connection in the electrical installation may produces spark causes fire.
5. Stored highly flammable liquids near electric oven/furnace.
6. Kept electric heaters near curtains/furniture.
7. If HV/equipment clearances are not maintain as per voltage level, there is possibility of sparking leads to fire.
8. If insulation damage/deterioration, a short circuit may occur causing fire.
9. Electrical faults inside appliances are a common cause of electric fire.
10. Faulty electrical installation may cause fire.
11. Due to old wiring and unsafe appliances may cause fire.
12. Electrical installation & equipment's used in hazards area are not used as per the

specification/type of protection.

**Operation of fire extinguishers:** **(2 Marks)**

To extinguish the fire with the help of fire extinguisher, stand 6 to 8 feet away from the fire and follow the four-step PASS procedure as below:-

- **P**ull the safety pin from the handle.
- **A**im the extinguisher nozzle at the base of the fire.
- **S**queeze the handle or lever slowly to discharge the agent.
- **S**weep side to side over the fire until expanded.

**b) Prepare the maintenance schedule for three phase induction motor as per IS 900-1992**

**Ans:** **(Any eight points from following or equivalent are expected 1 Mark each point total 8 Marks)**

Following are the maintenance schedule given by the manufacturer as Daily, weekly, monthly, half yearly and yearly or as per requirements

1. Clean the machine externally and its surrounding area.
2. Clean the machine internally as per requirement/depending upon atmospheric condition
3. Clean and tight the connections of terminal boxes, starting unit, control unit, protective unit etc.
4. Renew worn out contacts and connections
5. Check and rectify the faulty accessories like starter, relays, control equipment etc.
6. Air passages for ventilation of machine are cleaned if there are any blockage
7. Replace, if slip-rings are worn out
8. Tight the connection of winding to slip-ring
9. Replace worn out bearings
10. Clean and recharge bearing by suitable grade of grease, if they are noisy and running hot
11. Replace lubricating oil in case of sleeve type bearing
12. Replace cooling fan bearing if worn out
13. In case of indirect drive adjust the belt tension
14. Measure IR, If it is less than permissible limit then varnishing and baking is carried out
15. Re-varnishing is done if winding insulation is detoriated
16. Overhaul the motor as prescribed by manufacturer
17. Measure earth resistance and if found more then take action to reduce it.
18. Tight all nut bolts of base plate fixed on foundation
19. Check the gasket for any damage and replace it if required.

**OR STUDENT MAY WRITE THIS WAY**

**(Any Four points from following or equivalent are expected 2 Mark each point total 8 Marks)**

**1. Hourly Maintenance**

1. For important machine check & measure voltage current and compare with rated figure given on name plate.
2. Check and measure the ambient temperature.
3. For important machine check & measure the surface temperature of stator winding & bearing temperature. Ensure that temperature rise within permissible limit.

**2. Daily maintenance**

After completing activities during Hourly schedule following activity are necessary during daily schedule.

1. Check the physical condition of machine.
2. machine should be kept clean and dry
3. Check the accessories like starter, relays & control equipments.
4. Checking of cooling arrangements.
5. Checking lubricating system.
6. Air passage for ventilation should be clean for cooling system.
7. To check the motor earthing connection.
8. To check the vibrators, noise & coupling.
9. In case of indirect drive, check the belt tension & condition.

**3. Weekly Maintenance:-**

After completing activities during Daily schedule following activity are necessary during weekly schedule.

1. Examine contacts of starting equipment and protective equipment.
2. In case of slew bearings motor check air gap.

3. Alignment should be thoroughly checked.

4. All bolts , nuts , fasteners , etc. shall be thoroughly checked.

4. **Monthly Maintenance**:-

After completing activities during Weekly schedule following activities are necessary during monthly schedule.

1. Check condition of lubricating oil .
2. Clean machine internally by industrial vaccum pump.
3. Check insulation resistance.
4. Check the bearing condition.
5. Slip ring set must be cleaned.

5. **Half Yearly Maintenance**:-

After completing activities during weekly maintenance following activities are necessary during Half Yearly schedule.

1. Cleaning of motors internally and externally against affected due to surrounding atmosphere condition.
2. Check grease in ball and roller bearings.
3. Check Slip-rings against unequal wearing.
4. Check for signs of corrosion of metallic parts.
5. Varnishing and Baking is carried out if found necessary.

6. **Yearly Maintenance**:-

After completing activities during Half Yearly maintenance following activities are necessary during Yearly schedule.

1. Check bearing against worn-out.
2. Check the brushes against worn-out.

3. Check the slip ring against worn-out.
4. Check the condition of starting & protective equipment.
5. Check the condition of foundation.
6. Check the insulation resistance.
7. Check the earth resistance.

**c) Prepare a troubleshooting chart for transformer as per IS 10028-1981.**

**Ans:**

➢ **Troubleshooting chart for transformer as per IS- 10028-1981:-**

**(Any four troubleshooting points are expected from following or equivalent 2 Mark each ,Total 8 Marks)**

| Sr.no | Troubles | Any two Causes are expected | Remedial Measures |
|---|---|---|---|
| 1. | Transformer does not show output voltage | 1. Circuit breaker may trip.<br>2. Loose connection at bushing<br>3. Connection may be open in bushing.<br>4. Loose contact of tap changer,<br>5. Failure of primary winding. | Rectify the Cause |
| 2. | Incorrect secondary voltage | 1. Primary voltage is not rated voltage<br>2. Shorted secondary turns so Improper turns ratio<br>3. Faulty OLTC | Rectify the Cause |
| 3. | Unequal voltage on secondary side | 1. Primary input voltage is unequal<br>2. Unbalance Loading.<br>**3.** Unsymmetrical fault | Rectify the Cause |
| 4. | Overheating of transformer | 1. Prolonged overloading.<br>2. Failure of cooling System.<br>3. Low oil level in transformer tank.<br>4. High ambient temperature. | Rectify the Cause |
| 5. | Rapid deformation of oil/Low dielectric strength of oil/Low BDV | 1. Presence of dissolved moisture content.<br>2. Presence of water content.<br>3. Presence of dissolved gases content. | Rectify the causes. |

| | | | |
|---|---|---|---|
| | | 4. Presence of acidic content.<br>5. Presence of sludge content<br>6. Presence of carbon deposits content.<br>7. Presence of dirt & dust content.<br>8. Presence of sulpher content<br>9. Presence of acetones content.<br>10. Presence of dissolved oil decay products content | |
| 6. | Incorrect oil level (oil level to low)/Leakage of transformer liquid | 1. Due to leakages through transformer tank or radiators or drain valve or gasket or accessories.<br>2. Insufficient tightness of mechanical parts. | Rectify the Cause |
| 7. | Noise/vibration/ humming sound | 1. Bad/loose foundation nut bolts<br>2. Loose clamping of magnetic core.<br>3. Low/high input frequency<br>4. Magnetostriction. | Rectify the Cause |
| 8. | Bushing failure | 1. Mechanical injury to bushing<br>2. Improper bolting of bushing<br>3. Lightning stroke.<br>4. Flash over due to dirt accumulation on bushing.<br>5. Harsh environmental condition | Rectify the Cause |
| 9. | Winding insulation failure | 1. Overload for prolonged period<br>2. Over current condition<br>3. Transformer oil containing excess moisture and contaminants.<br>4. Low IR value | Rectify the Cause |
| 10. | Pressure-relief diaphragm broken | 1. Due to mechanical injury<br>2. Excessive internal pressures due to over loading of transformer. | Rectify the cause and replace |

| | | | |
|---|---|---|---|
| | | 3. The transformer oil level being too high | Pressure-relief diaphragm |
| 11. | Short circuit between adjacent turns (Turn to turn fault) | 1. Insulation failure between turn to turn<br>2. Overheating due to Overload for prolonged period<br>3. Moisture in oil | Rectify the cause. |
| 12. | High exciting current | 1. Short circuited core<br>2. Open core joints<br>3. Poor magnetic coupling<br>4. Low/high frequency<br>5. Shorted turns | Rectify the Cause |
| 13. | Excessive core heating | 1. Due to high magnetizing current<br>2. High inrush current | Rectify the Cause |
| 14. | Transformer body gives shock | 1. Insulation resistance reduced.<br>2. Any live wire touches the transformer tank (Earth fault). | Rectify the Cause |
| 15. | Unexpected voltage to earth measurement | ➢ Earth failure on one phase. | Rectify the Cause |
| 16. | External Short circuit | 1. It may be due to insufficient clearance on overhead line.<br>2. Accumulation of dust on insulator (Transformer bushing). | Rectify the Cause |
| 17. | Internal Short circuit | 1. Continuous overloaded transformer, due to this temperature increases so, possibility of insulation failure.<br>2. Fault in tap changer.<br>3. Loose connections, causing local overheating.<br>4. Vibration on Insulation resulting internal short circuit | Rectify the cause. |
| 18. | Carbon & other conducting particles in oil | 1. Sparking.<br>2. Excessive temperature of oil | Rectify the Cause |

| | | | |
|---|---|---|---|
| 19. | Oxidation of oil | 1. Mainly due to exposure to air<br>2. High operating temperatures. | Rectify the Cause |
| 20. | Internal arcing | 1. Low liquid level<br>2. Loose connections,<br>3. Failure of the transformer dielectric. | Rectify the Cause |
| 21. | Transformer switching equipment troubles | 1. May be excessive wearing of contacts,<br>2. Mechanism Over travel,<br>3. Moisture condensation in mechanism liquid. | Rectify the Cause |

**Q. 3** **Attempt any FOUR of the following :** **16 Marks**

**a)** **State any four internal causes for the abnormal operation of electrical equipment's.**

Ans: **(Any four internal causes are expected from following or equivalent 1 Mark each ,Total 4 Marks)**

**Internal causes:-**

1. Open circuit
2. Short circuit
3. Earth fault
4. Inter turn fault
5. Loose connection
6. Low insulation resistance
7. Improper maintenance
8. Poor ventilation

**b)** **State the objectives of the testing's.**

Ans: **(Any four objectives are expected from following or equivalent: each objective : 1 Mark: Total 4 Marks)**

**Following are the objectives of testing:-**

1. To confirm whether machine/equipment/ product is manufactured as per design data or not.
2. To confirm whether the performance of machine/equipment/ product is as per

design data or not.

3. To find errors/defects in machine/equipment/ product.
4. To determine that the machine/equipment/ product appears to be working as stated in the specifications
5. To confirm whether the results obtain during testing are within tolerance limits specified by BIS / ISS
6. To determine the quality of material used & workmanship.
7. Testing in all respect is also required when a new design or modified design is used,
8. Testing of equipment/machinery is also done after major maintenance of machine/equipment
9. To avoid in convinces, accidents, minimize risk & for safety purpose.

**c) State the classification of insulating materials as per IS 1271- 1985. With maximum operating temperature and with two examples of each.**

Ans: **Classification of insulating materials as per IS 1271- 1985. With maximum operating temperature and with two examples**

**(Any Four classification expected: 1 Mark each, Total 4 Marks)**

| Sr.No. | Insulation Classes | Maximum permissible temperature ($^0$C) | Insulating Material (Any TWO Example Is Expected) |
|---|---|---|---|
| 1 | Class-Y or O | $90^0$ | Cotton, silk, paper, press board, wood , cellulose-,PVC,VIR .(Neither impregnated nor varnished comes under this class) |
| 2 | Class- A | $105^0$ | Cotton, silk & paper impregnated with natural resins or immersed in oil comes under this class. |
| 3 | Class- E | $120^0$ | Laminated Cotton, laminated |

| | | | |
|---|---|---|---|
| | | | paper Synthetic resin enamels |
| 4 | Class- B | $130^0$ | Mica , Glass, fiber, asbestos with suitable bonding substances comes under this class. |
| 5 | Class- F | $155^0$ | Laminated asbestos, Glass, fiber, and asbestos with suitable bonding substances of high thermal stability comes under this class. . |
| 6 | Class- H | $180^0$ | Mica, Glass, fiber, asbestos with suitable bonding substances such as silicones or adhesive coated on mica, glass fiber comes under this class. |
| 7 | Class- C | Over $180^0$ | Porcelain, ceramics, glass, quartz's. |

**OR**

**This led IEC (International Electro technical Commission) to come up with the new categories:**

- Class Y : $90^0$ C: Paper, cotton, silk, natural rubber, polyvinyl chloride, etc. without impregnation. (formerly O)
- Class A : $105^0$ C: Same as class Y but impregnated, plus nylon.
- Class E : $120^0$ C: Polyethylene terephthalate (terylene fibre, melinex film), cellulose triacetate, polyvinyl acetate enamel.
- Class B : $130^0$ C: Mica, fiberglass (alkali free alumino borosilicate), bituminized asbestos, bakelite, polyester enamel.
- Class F : $155^0$ C: As class B but with alkyd and epoxy based resins, polyurethane.
- Class H : $180^0$ C: As class B with silicone resin binder, silicone rubber, aromatic polyamide (nomex paper and fiber), polyamide film (enamel, varnish and film) and

estermide enamel.

- Class C : Above $180^0$ C: As class B but with suitable non-organic binders; (Teflon, Mica, Micanite, Glass, Ceramics, Poly tetra fluoroe thylene)

**d) Define the term 'Polarization Index'. How is it used for interpreting the condition of insulation?**

Ans: **(For Defination 2 Marks, for interpreting the condition of insulation 2 Marks,Total 4 Marks )**

**Polarization index (PI):** **(2 Marks)**

- Polarization index is the ratio of megger value taken for 600 sec (10 min.) to the megger value taken for 60 sec (1 min.).

$$PI = \frac{IR_{600}}{IR_{60}}$$

($R_{600}$ = 600 sec. reading of insulation resistance & $R_{60}$ = 60 sec. reading of insulation resistance)

**How is it used for interpreting the condition of insulation?** **(2 Marks)**

| Insulation Condition | Value of PI |
|---|---|
| Insulation Resistance is **insufficient** | less than 2 |
| Insulation Resistance is **OK** | Between 2 To 4 |
| Insulation Resistance is **excellent** | Greater than 4 |

**OR**

It is always desired to have polarization index of an electrical insulator more than 2. It is hazardous to have polarization index less than 1.5.

**e) Compare direct and indirect method of testing (any four points).**

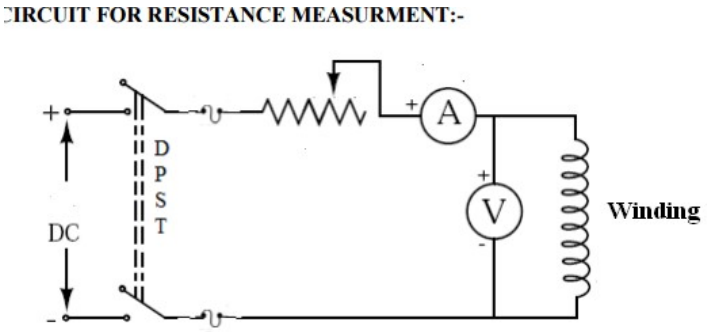
Ans: **Any Four points are expected from following or equivalent 1 Mark each ,Total 4 Marks)**

| Sr No. | Parameter | Direct Testing | Indirect Testing |
|---|---|---|---|
| 1 | Nature of loading | The m/c is actually loaded at full load. | The m/c is not actually loaded but machine run on N.L. |
| 2 | Suitability | Suitable for m/c of low rating | Suitable for m/c of high rating |
| 3 | Power consumption | More | Less |
| 4 | Time period | More | Less |
| 5 | Assumption | Generally no assumptions are made | Generally some assumptions are to be considered while calculating performance |
| 5 | Calculation | Calculations are less & Simple | Calculations are more & complicated |
| 6 | Accuracy | This method gives the most accurate results | This method gives less accurate result. The result obtained are either less or more than the actual |
| 7 | Testing place /Location | It is suitable for indoor testing i.e. in industry or lab | It is suitable for outdoor testing i.e. on the site |
| 8 | Equipment's/Apparatus | It requires more number of equipment's | It requires less number of equipment's |
| 9 | Type of connections | The connection are more and difficult | The connections are less and Simple |
| 10 | Safety | It is less safe due to full load. | It is more safe due to no load. |
| 11 | Method of testing and calculation | Simple | Complicated |
| 9 | Example | 1.With the help of brake load test/arrangement,<br>2. Coupling a machine to its shaft for loading purpose. | 1.O.C. and S.C test<br>2. Sumpners test<br>3. Swinburne test. |
| 13 | Space required | More | Less |

| Q.4 A) | Attempt any THREE of the following : 12 Marks |
|---|---|
| i) | Describe the procedure of measuring dc resistance of transformer winding with the help of circuit diagram and related formulae. |

Ans: **(Diagram : 3 Mark & formula : 1 Mark, Total 4 Marks)**

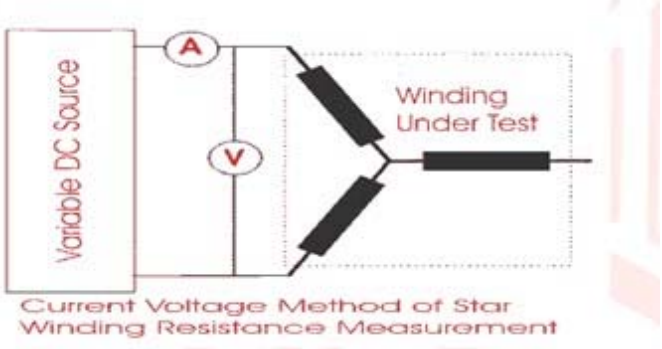
**Diagram: Measuring DC resistance of transformer winding:**




**or equivalent diagram**

**OR**

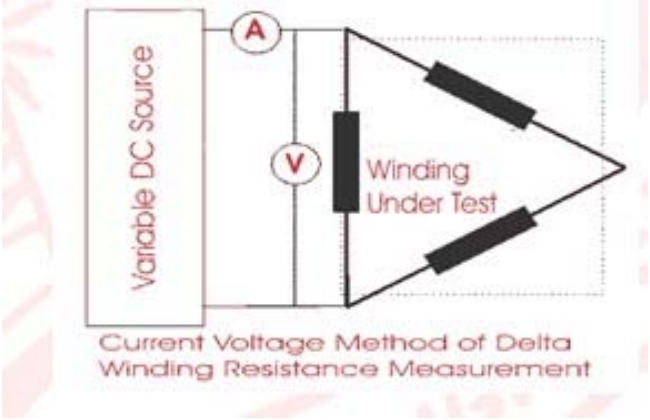
**In Star Connection:**




- **Winding resistance per phase is equal to 1/2 of measured resistance between two line terminals of transformer.**

**OR**

**In Delta Connection:**



- **The resistance per phase would be 0.67 times of measured resistance between two line terminals**

**Observation table:**

| I | V | R = V/I | RaV |
|---|---|---|---|
| | | | |

- **To calculate AC resistance of winding**
- **AC resistance = 1.6 x measured value of DC resistance ( Due to skin effect)**

**ii) Describe any four methods used for reducing earth resistance.**

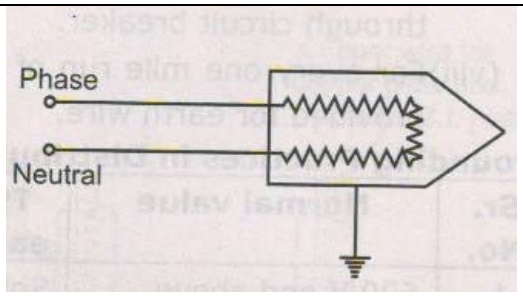
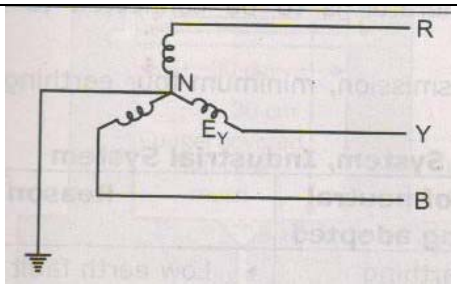
Ans: **(Any Four points/methods are expected from following or equivalent 1 Mark each ,Total 4 Marks)**

**To reduce earth resistance following steps/methods are necessary:**

1. Earth pit of more depth & width- breadth should be made.
2. Use of large cross section of earthing wire and earth electrode.
3. Use of copper material for earthing instead of aluminum material
4. Use chemical /charcoal in earth pit to reduce the resistance
5. Poured sufficient salt water in earth electrode pit.
6. Use earth wire without joint in between.
7. Earth resistance can be reduced by increasing number of earth electrodes inter connected in parallel.
8. Remove Oxidation on joints.
9. Tighten the earth connections.

**iii) Distinguish between installation earthing and system earthing.**

**Ans:** **(Any Four points are expected from following or equivalent 1 Mark each ,Total 4 Marks)**

| SR. NO. | Installation earthing | System earthing |
|---|---|---|
| 1. |  |  |
| 2. | Installation Earthing means connecting the dead part (it means the part which does not carries current under normal condition) to the earth with the help of earth wire. | System Grounding means connecting the live part (it means the part which carries current under normal condition) to the earth with the help of earth wire. |
| 3. | It is equipment earthing. | It is source or system earthing. |
| 4. | Earthing is path for leakage current. | It is a path for unwanted |
| 5. | It is done to minimize risk of receiving an electric shock. | It is done for the protections of power system equipment and to provide an effective return path. |
| 6. | It does not control/eliminate arcing ground and over voltage surge. | It eliminates arcing ground and over voltage surge. |
| 7. | It is nothing to do with the system stability. | It increases stability of the system. |
| 8. | Generally Green wire is used for earthing. | Generally Black wire is used for system grounding. |

| | | | |
|---|---|---|---|
| | 9. | Earthing connections are of four types:<br>• Plate earthing<br>• Pipe earthing<br>• Rod earthing<br>• Strip earthing | Grounding connections are of three types:<br>• Solid earthing<br>• Resistance earthing<br>• Reactance earthing |

**iv) State any four Do's and Don'ts regarding safety while working on electrical installations.**

**Ans:** **(Any Four points are expected from following or equivalent for Do's and Don'ts 1/2 Mark each ,Total 4 Marks)**

**Do's:-** **(Any Four points)** **(2 Marks)**

1. Safety training / book should be given to all persons working in plant.
2. Work allotted to only qualified & trained person (worker) to do the work
3. Know the work content, work sequence and especially all safety measures before starting the work.
4. Always use proper insulated tools & safety devices. / Always use proper insulated tools, rubber gloves, safety devices while working.
5. Do not make safety devices inoperative
6. Provide (Do) barricading to hazards area.
7. Always take the permit to shut down the supply, from authority during major maintenance work.
8. Lock Open switches / Isolator while doing maintenance work
9. Keep safe distance from HV / equipment / conductor.
10. Do not allow working on defective equipment.
11. Do not Use defective material.

12. Do not scarify safety for speed.

13. Avoid / do not allow working in unfavorable conditions such as high rain fall, fog or high wind.

14. Avoid /do not allow working in improper illumination such as in sufficient light or unsuitable location producing glare or shadows.

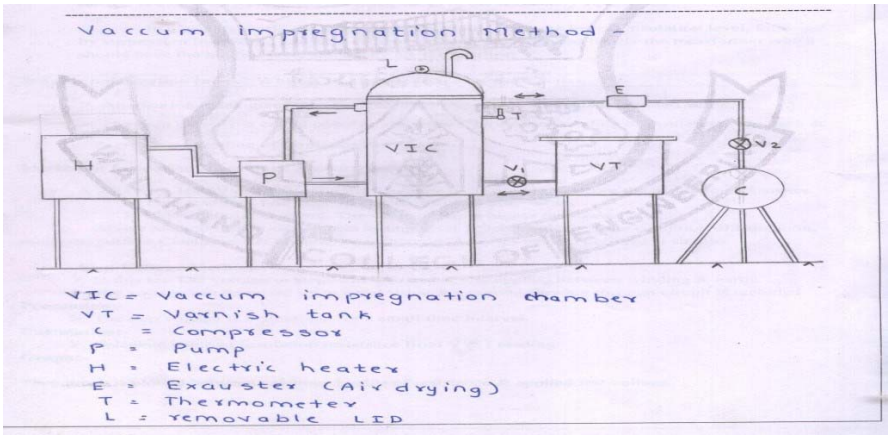
**Don'ts:-** **(Any Four points)** **(2 Marks)**

1. Untrained person (worker) allotted to handle electrical equipment/installation.
2. Not knowing the work content, work sequence and especially all safety measures while working may lead to accident.
3. Not using proper insulated tools & safety devices during working.
4. Making safety devices inoperative
5. No barricading to hazards area.
6. Not taken the permit to shut down the supply, from authority, during major maintenance work.
7. Open switches / Isolator are not locked
8. Not kept safe distance from HV / equipment / conductor as per voltage level.
9. Working on defective equipment.
10. Use poor quality of electrical material May lead to accident.
11. Sacrificing safety for speed may be lead to accident.
12. Most electrical accidents result from one of the following three factors:
    - Unsafe equipment or installation
    - Unsafe environment or
    - Unsafe work practices
13. While working there is improper illumination such as in sufficient light or unsuitable location producing glare or shadows may cause accident.

| Q. 4B) | Attempt any ONE of the following : 6 Marks |
|---|---|
| i) | Draw a neat diagram of vacuum impregnation plant and write stepwise procedure of revarnishing the insulation. |

**Ans:** (Diagram 1 Mark, Procedure 5 Marks, Total 6 Marks)

**Diagram of vacuum impregnation plant:-** (Diagram 1 Mark)




or equivalent figure

**Steps /procedure for revarnishing the insulation.:-** (Procedure 5 Marks)

**Step 1 :-**

The surfaces of all coils windings are perfectly clean and it should be free from dirt & dust, oily matters etc.

**Step 2 :-**

For the moisture removal heat the winding with the help of lamp (carbon filament) or in an oven till all moisture get evaporated.

**Step 3 :-**

Than winding is placed into a processing chamber (tank).

**Step 4 :-**

A vacuum is created in the process tank to remove all air, including air within the pores (Air gaps) of the job. (This is called dry vacuum)

**Step 5 :-**

Then Varnish is transferred from storage tank to the processing tank till the entire job is submerged.

**Step 6 :-**

Again another time vacuum is created in the processing chamber with the help of pump (This is called wet vacuum)

**Step 7 :-**

After that vacuum is released and desired pressure is applied into the processing tank above the varnish level using compressed air/nitrogen for better penetration.

**Step 8 :-**

After desired amount of time, the pressure is released and the varnish is drained back into the varnish storage tank with the help of pump.

**Step 9 :-**

The winding is taken out from the processing chamber and kept on iron grill tray to drain out the excess varnish

Then coil/winding is removed and applies finishing gel (varnishes) by brushing or spraying to job for additional protection.

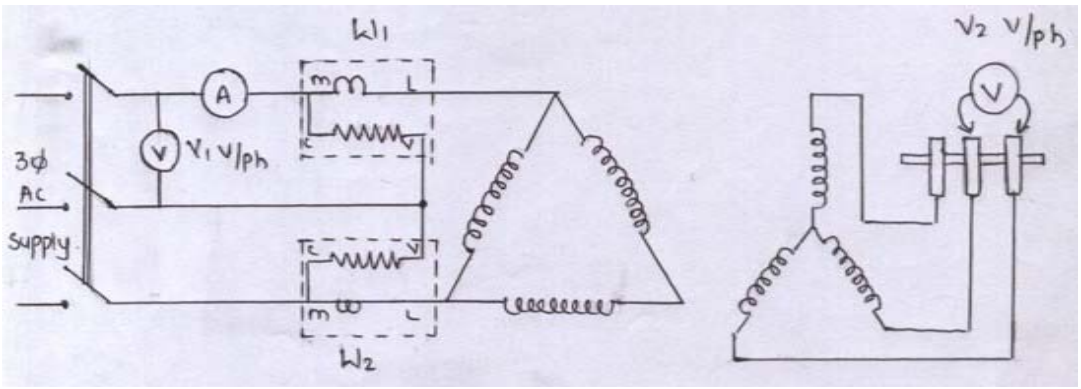
**Step 10 :-**

It is then kept in a baking oven till it gets set properly and become dry up to 10 to 20 minutes or in some case 1 to 2 hours.

**ii) Explain with circuit diagram the open circuit voltage ratio test on 3 phase slip ring induction motor.**

**Ans:** **(Circuit diagram 2 Marks ,Explanation 4 Marks, Total 6 Marks)**

**Circuit Diagram:-** **( 2 Marks)**




**Explanation:-** **(4 Marks)**

**Objectives:-** **(1 Mark)**

- To confirm the voltage ratio, or turns ratio between stator & rotor of slip ring induction motor is

as per design values are not

**Procedure:-** **(1 Mark)**

- In this test the rotor is kept open circuited,
- The stator winding is connected to rated voltage at rated frequency,
- Measure the input voltage ($V_1$)
- Measure voltage between slip rings to check the balance. ($V_2$)

**Calculations:-** **(1 Mark)**

- The turn's ratio between stator turns and rotor turns is approximately equal to

$$= \frac{1}{2} \frac{V_1 + V_2}{V_2}$$

*Where,* $V_1$ *is voltage measured across stator terminals*

$V_2$ *is voltage across to rotor winding*

**Conclusion:-** **(1 Mark)**

1. If actual values & designed values of voltage ratio/turns ratio are not matching then it can be balanced by adding or subtracting some turns of rotor side.

| Q.5 | **Attempt any TWO of the following :** **16 Marks** |
|---|---|
| a) | **State the necessity of drying out of transformers. Give the procedure of drying out of transformers both by external and internal heat methods.** |

Ans: **(Necessity: 4 Marks, Procedure: 4 Mark: Total 8 Marks)**

**Necessity of drying out of transformers:-**

**(Any four point expected: 1 Mark each, Total 4 Marks)**

1. If transformer is kept idle or out of use for long period than Insulation will absorb moisture so it will reduce the insulation resistance.
2. If P.I. is found less than 2 & DAR is found less than 1.25 indicates a need of drying out.
3. If the transformer is kept in damp/high moisture environment /high humidity condition, Insulation will absorb moisture so it will reduce the insulation resistance
4. If transformer is accidently immersed in water, Insulation will absorb moisture so it will reduce the insulation resistance
5. Drying out is necessary particularly for high voltage transformer (above 1000V rating)

The drying out of transformer can be carried out by applying heat by any of the following

methods.

**Procedure of drying out:-** **( 4 Marks)**

1. Arrange the set-up, measurement equipment's etc. with including the fire extinguisher for use in the event of an emergency
2. Heat is applied gradually by any suitable method as stated below for prolong period.

**External heat methods:-** **(Any one method expected)**

a. By Circulating hot oil through suitable purifying plant (Stream line filter machine).

b. By blowing in hot air through transformer tank, with tank dry

c. By hot oil spray under vacuum

d. Keeping transformer in suitable size electric ventilated oven.

e. By use of space heaters/ heat radiating high wattage lamp

f. By connecting several immersion type heaters in to the transformer tank.

**Internal heat methods:-** **(Any one methods expected)**

a. By short circuiting LV winding and applying reduced voltage to HV winding.

3. Take care that temperature of oil should not be increased greater than $80^0$ and temperature of winding is not greater than to $90^0$ C irrespective of surrounding air temperature variations.
4. During drying out procedure following readings are taken frequently
   a. The temperature of oil and winding
   b. Value of IR between LV and HV windings.
   c. Value of IR between LV windings and earth, HV windings and earth.
   d. BDV of oil after every four hours.
   e. From value of IR calculate PI and DAR
5. The drying is stopped when desired hot values of IR, PI and DAR are obtain.

6. After drying out varnish is applied on the winding surface immediately to prevent absorption of moisture.
7. Then cool down the transformer gradually.
8. Even if drying out for prolong period, if there is no improvement in the value of IR, than it means insulation is wear or detoriated. At that time replace it by new one.

**OR**

There are basically two methods of drying out, of transformer

- With the tank dry (i.e. with the core and windings in position but without oil) or
- With the tank filled with oil.

1. **With the tank dry:-**

The heat required for drying may be produced in two ways:

(i) By blowing in hot air through the transformer tank. The inlet air should be at a temperature not less than $85^0$nor more than $100^0$C. The air is blown into the tank through a suitable opening at the bottom of the tank (such as the drain pipe or radiator pipe outlet.) An air outlet should be left at the top by removing the explosion vent or manhole cover.

(ii) By short circuiting the LV winding and applying a reduced voltage on the HV winding, as in the heat run test. The top cover should be kept open for free flow of air.

2. **With the tank filled with oil:-**

Heat could be produced in three different ways:

i) By short-circuit method

ii) By circulating hot oil through a suitable purifying plant (Streamline filter machine).

iii) By connecting several immersion type heaters and letting them into the transformer tank.

| | |
|---|---|
| b) | **What are the basic requirements of foundation for (i) Static equipment's (ii) Rotating machines?** |
| Ans: | **(Any eight requirements are expected from following or equivalent 1 Mark each ,Total 8 Marks)**<br><br>**NOTE:- Answer written common to both or separately may be accepted**<br><br>Following are the **basic requirements of foundation to be** considered in designing the machine foundation **for :(i) Static equipment's (ii) Rotating equipment's**<br><br>1. Depth of foundation should be proportional to the bearing capacity of soil.<br>2. The foundation should be able to carry weight:-<br>➢ Weight of machine<br>➢ Erection weight<br>➢ Operating weight<br>➢ Accessories weight<br>3. The foundation should be sufficiently rigid<br>4. The foundation should be able to absorb the vibration while operating at its full capacity.<br>5. There should be sufficient space all around the machine.<br>6. Use a quality concrete / for concrete foundations use concrete ratio of 1:2:4.<br>7. The surface of foundation should be perfectly plane to avoid misallignment.<br>8. The foundation should be well cure before machine put on it.<br>9. The surface of foundation must be protected by means of suitable chemical coating or suitable chemical treatment.<br>10. Vibration energy absorbers such as Sprigs, rubber mats are to be used in foundation structure to reduce vibration.<br>11. Level of plinth of foundation should be above the maximum flood level of the site.<br>12. The combined center of gravity of machine and foundation should be as far as possible, be in the same vertical line. |

| | |
|---|---|
| c) | **A 400 V, 40 HP, 50 Hz, 4 pole delta connected induction motor gave the following test data: No load test: Vo = 400 V, $I_0$ = 20 A, Wo = 1200 W, Blocked rotor test: Vsc = 100 V, Isc = 45 A, Wse = 2800 W, Draw circle diagram and determine: (i) The line current and power factor at rated output (ii) The maximum output (iii) The maximum torque (iv) The full load efficiency (v) The full load rotor speed. Assume stator and rotor copper losses to be equal at standstill** |

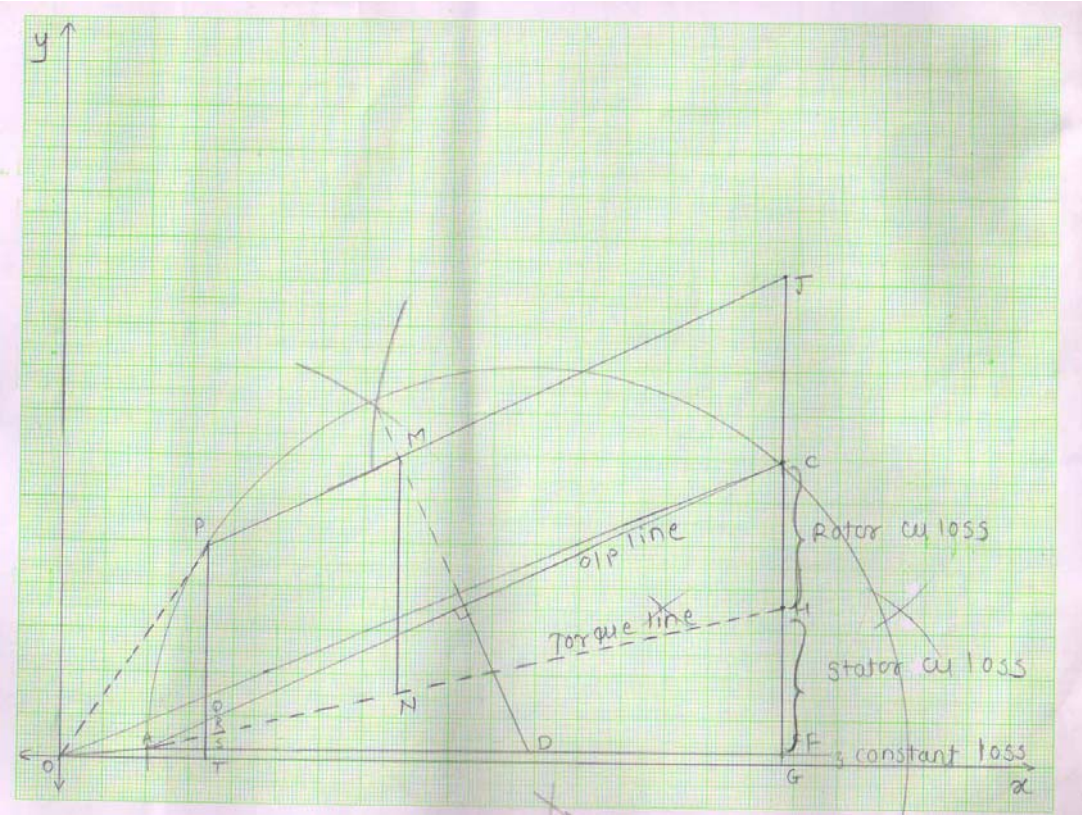
Ans: **Procedure is given only for examiner for reference of the terminology used in circle diagram)**

**Given Data:**

No load test:- $V_{0=}$ 400 V; Io = 20 Amp; $W_0$ = 1200 W;

Blocked circuit test:- $V_{SC}$ = 100 V; $I_{SC}$ = 45 Amps; $W_{SC}$ = 2800 W

**Solution:- OR Equivalent figure** **( 1 Mark)**




3-Ph, 400V, 40 HP I.M

1) **No Load Test :** $V_{0=}$ 400 V; Io = 20 Amp; $W_0$ = 1200 W; **( 1/2 Mark)**

$$\phi_O = Cos^{-1}\left(\frac{W_O}{\sqrt{3}\,V_0\,I_O}\right)$$

$$\phi_O = Cos^{-1}\left(\frac{1200}{\sqrt{3}\times 400\times 20}\right)$$

$$\phi_O = 85.03^0 \ Elec. \ \text{-}$$

**The vector OO′ represents -** $I_O \angle \phi_O$

2) **Short Circuit (Blocked Rotor) Test: -** $V_{SC}$ = 100V, $I_{SC}$ = 45A & $W_{SC}$ = 2800 watt **( 1/2 Mark)**

$$\phi_{SC} = Cos^{-1}\left(\frac{W_{SC}}{\sqrt{3}\,V_{SC}\,I_{SC}}\right)$$

$$\phi_{SC} = Cos^{-1}\left(\frac{2800}{\sqrt{3}\times 100\times 45}\right)$$

$$\phi_{SC} = 68.95^0 \ Elec. \ \text{-}$$

3) **The vector 0A represents -** $I_{SN} \angle \phi_{SC}$ **( 1 Mark)**

$$I_{SN} = I_{SC}\ \left(\frac{V_0}{V_{SC}}\right)$$

$$I_{SN} = 45\left(\frac{400}{100}\right)$$

$$I_{SN} = 180\ A$$

**Current scale: -** 1 cm = 10A

$$I_{SN} = \left(\frac{180}{10}\right) = 18\ cm$$

**Power scale:-** **( 1 Mark)**

$$= \sqrt{3}\ \times X \times V_{rated}$$

$$= \sqrt{3}\ \times 10 \times 400$$

$$1\ cm = 6928.20\ w$$

**Wattage of Motor:-**

$$= HP \times 735.5$$

$$= 40 \times 735.5$$

$$= 29420 \ \ w$$

$$J_C = \frac{Wattage\ of\ motor}{power\ sacle}$$

$$J_C = \frac{29420}{6928.20}$$

$$J_C = 4.24\ cm$$

**i) Line current =** Length of vector OP x Current scale

= 6 cm x 10 amp/cm

$I_L$ = 60 amp ---------- **(1 Mark)**

**ii) Full load P.F =**

$$= \frac{length\ (PT)}{Length\ (OA)}$$

$$= \frac{5}{6}$$

$$= 0.833\ \ lag$$ ---------- **(1 Mark)**

**iii) Maximum output =**

$$= Length\ (PQ) \times Power\ scale$$

$$= 4.1 \times 6928.20$$

$$= 28405.62\ watt$$ ---------- **(1/2 Mark)**

**iv) o/p at Maximum Torque :**

**o/p at Maximum Torque :** Length (MN) x Power Scale

= 5.4 x 6928.20

$T_{max}$ = 37412 watt ---------- **(1/2 Mark)**

**v) % Efficiency** $= \frac{length\ (PQ)}{Length\ (PT)} \times 100$

$= \frac{4.1}{5} \times 100$

$= 82\ \%$ - ---------- **(1/2 Mark)**

**vi) Full load rotor speed =**

$$N_S = \frac{120f}{P}$$

$$= \frac{120 \times 50}{4}$$

$$N_S = 1500\ rpm$$

$$S_F = \frac{length\ (QR)}{Length\ (PR)}$$

$$S_F = \frac{0.4}{4.5}$$

$$S_F = 0.088$$

$$N_{FL} = (1 - 0.088) \times 1500$$

$N_{FL} = 1368\ rpm$ ---------- **(1/2 Mark)**

| Q.6 | **Attempt any FOUR of the following :** | **16 Marks** |
|---|---|---|
| **a)** | **List the devices and tools required for loading and unloading; lifting and carrying heavy electrical equipments.** | |
| **Ans:** | **(Any Four devices and tools from following or equivalent are expected 1 Mark each Total 4 Marks)**<br><br>**List the devices and tools required for loading, unloading, lifting and carrying heavy equipment** :-<br><br>1) Stationary Cranes | |

| | |
|---|---|
| | 2) Mobile Cranes<br>3) Overhead or Gantry Cranes<br>4) Steam Crane<br>5) Mini lift machine<br>6) Chain pulley Block<br>7) Chain Hoist<br>8) Electric Hoist<br>9) Screw Jacks<br>10) Winches<br>11) Hoses & tripods (For temporary supports)<br>12) Ceiling ropes. |
| **b)** | **State the effects of mis-alignment in rotating machines.** |
| Ans: | **(Any Four Points From the following or equivalent points are Expected 1 Mark to Each Point: Total 4 Marks)**<br><br>**Effect of mis-alignment in rotating machines.-**<br>1. There will be excessive vibrations.<br>2. Increase noise level.<br>3. Increases in friction loss.<br>4. The shaft will bent.<br>5. Premature bearing and coupling failure<br>6. Premature failure of belt/Rope/chain in case of indirect drive.<br>7. It will increase maintenance cost.<br>8. It will increase bearings temperature.<br>9. It reduces motor efficiency.<br>10. Increases stresses on coupling and driven machine |

11. Early wear & tear of both driving & driven machine.
12. Loose or broken foundation bolts and coupling bolts
13. It increases energy consumption.
14. Overall performance of machine reduces.
15. High lubricating oil temperature.

**c) Define the tolerances. Give the values of tolerances for power transformer as per IS 2026-2011.**

Ans: **(Definition 1 Mark , Any three tolerance limits are expected 1 Mark each , Total 4 Marks )**

**Tolerance:** **(Definition 1 Mark)**

Tolerance is the allowable variation for any given parameters such as losses, efficiency, temperature rise, slip, speed, frequency, and voltage unbalance IR etc. in order to achieve a proper function.

**OR**

Tolerance is the maximum permissible variation in the actual and design values as specified by BIS/ISS

Tolerance is expressed by using both minus and plus variations.

**Values of tolerances for power transformer as per IS 2026-2011: (Any three tolerance limits form following or equivalent are expected 1 Mark each Total 3 Marks)**

| Sr.No. | Test Item | Tolerance |
|---|---|---|
| 1. | No-load losses (Iron Losses) | Not exceed +15 % |
| 2. | Load losses (Copper Losses) | Not exceed +15% |
| 3. | Voltage ratio /turns ratio. | ± 0.5 % for each tap |

| | | |
|---|---|---|
| 4. | No load current | Not exceed +15% |
| 5. | Insulation resistance | Greater than 2000 M.ohm between HV-LV<br>Greater than 2000 M.ohm between HV-GND<br>Greater than 500 M.ohm between LV-GND |
| 6. | Short circuit impedance | Not exceed ± 10% |
| 7. | Maximum permissible temperature rise over ambient while delivering full load continuously | Oil - 45$^{o}$C<br>Winding- 55$^{0}$C |
| 8. | Measurement of winding Resistance | HV winding within ± 8 % and LV winding within ± 12 % |
| 9. | Minimum percentage impedance for transformer of 33/11 KV rating are | Up to 1 MVA -5%<br>3 MVA - 6%<br>5 MVA - 7%<br>7.5 MVA - 8%<br>8 MVA to 12 MA - 9% |
| 10. | Standards for transformer noise | from 40 dB to 60 dB for units below 500kVA,<br>And 76 dB for units between 8MVA and 10M VA. |

**d) Describe the factors affecting the preventive maintenance schedule.**

**Ans:** **(Any four factors are expected from following or equivalent 1 Mark each ,Total 4 Marks)**

**Following factors affect the preventive maintenance schedule:-**

1. Non availability of spares & raw material required for preventive maintenance (PM)

| | |
|---|---|
| | 2. Non availability of tools, trackless, jacks, fixture required for PM.<br>3. Non availability of trained & skilled technician.<br>4. If the machine is continuously in working condition due to production requirement it affects PM schedule.<br>5. Ageing of machine/equipment (If the breakdown takes place, the cost of the repair will be more than the cost of the machine.)<br>6. Cost of the maintenance affects PM schedule.<br>7. Machine and its Importance.<br>8. Due to accident, fires, worker strike the work is held up for certain period. This is also a cause of disturbing a PM schedule.<br>9. Production requirement. |
| **e)** | **List the routine tests conducted on synchronous generator as per IS 7132-1973** |
| **Ans:** | **(Any four routine tests conducted are expected from following or equivalent 1 Mark each ,Total 4 Marks)**<br>**Following are the routine tests conducted on synchronous generator as per IS 7132-1973:-**<br>1. Winding resistance test<br>2. Insulation resistance test<br>3. High voltage test<br>4. Open circuit test<br>5. Short circuit test<br>6. Phase sequence test w.r.t. direction of rotation<br>7. Voltage balance test<br>8. Vibration measurement test<br>9. Momentary overload test |

---------- END----------