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

a) What are the causes of fire due to electrical faults?

Following are the Causes of fire due to electrical faults: - (Any Four points expected: 1Mark each)

i) Overloading on cables/wires/machines causes overloading of installation, which after some time looses its property & Catches fire
ii) Fire may be caused if the installations are not maintained properly.
iii) Poor joints in wiring may cause overheating & lead of fires.
iv) If insulation deterioration, a short circuit may occur causing fire.
v) Due to use of poor quality of material also causes electric fire.
vi) The majority of fires are caused due to incorrect capacity of the fuses or using incorrect rating MCB/RCCB or incorrect setting of safety switch.
vii) It can also result if a ground fault takes place between live wire & frame or body.
viii) Faulty electrical installation may cause fire.
ix) If proper care & precautions are not taken of the electrical installations, equipments, machines etc. it will result into electric fire.
x) Use of too many devices plugged into a circuit, causing heated wire & possible a fire.

b) State the conditions for satisfactory parallel operation of transformer.

(Any four condition expected: 1 Mark each)

The conditions for satisfactory parallel operation of two or more transform are following**.**

1. The polarity should be the same.
2. The voltage ratio should be same.
3. The percentage impedance should be equal.
4. The phase sequence (rotation) should be the same.
5. The vector diagrams & vector group phase displacement should be same.

c) State any four objectives of I.S.S.

Following Objectives of ISS:- (Any four objectives expected: 1 Mark each)

- It specifies the norms standards, specifications & tolerance limit for different product, machine, equipments, apparatus, material, etc
- To maintain informality throughout INDIA for same type of product, machine, equipments, apparatus, material, etc
- Whether the performance is as per design data or not.
- Variation in the actual values & designed values must be within tolerance limits as specified by ISS.
- To check the quality of material used & workmanship.
- To avoid in convinces, avoid accidents & for safety purpose also while working with electrical equipment/machine etc.

d) Explain: i) Routine maintenance ii) Breakdown maintenance

i) Routine maintenance: ---------- (2 Marks)

- It should be carried out daily if possible.
- The maintenance schedule is usually in the form of log sheets on which days, weeks, months of the year are tabulated.
- Routine maintenance is carried out without dismantling the equipment, but it must always be disconnected from supply before any repairs are undertaken.
- The routine maintenance work is carried out by the maintenance staff.
- Routine maintenance means checking/Cleaning/Repairing/Replacement of machine/equipment.

E.g.

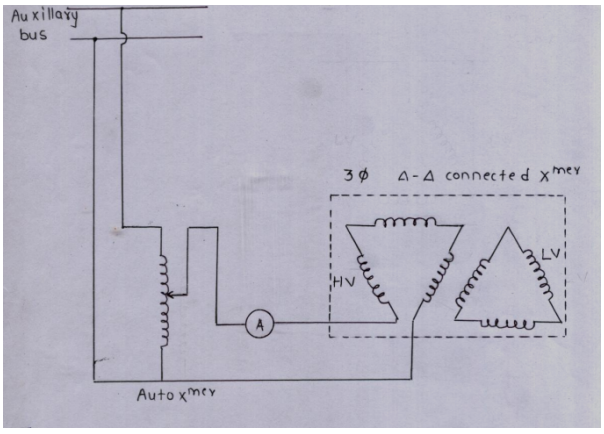
- It includes visual inspection, cleaning, minor repairs such as replacement of small parts and adjustment of equipment.
- Checking of surrounding in which the machinery or equipment has to work i.e atmospheric condition.
- Checking of safety measures.
- Checking of protective device

ii) Breakdown maintenance: ---------- (2 Marks)

- When industrial plants or electrical machines are running and stop incidentally, it is known as breakdown.
- Breakdown maintenance is carried out when machine fail to run.

Q.1 B) Attempt any one of the following. ----------06 Mark

a) With the help of neat figure explain the delta-delta test for temperature rise in 3-phase transformer. ---------- (Fig. 3 – Marks & Explanation- 3- Marks)

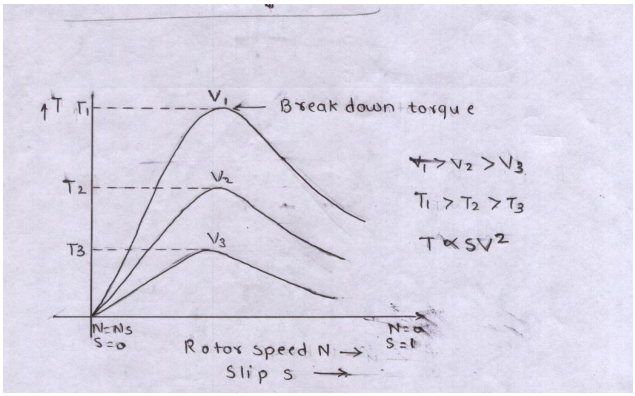


or equivalent figure

- This method is applicable in case of a delta to delta connected transformer.
- To circulate the current in the secondary as well as primary the connection are made as shown in figure.
- Secondary voltage of auxiliary transformer is so adjusted that full load current circulates through 3-ph transformer secondary (as recorded by Ammeter A)
- It will cause Full load current to circulate through transformer primary also.
- Hence a condition similar to full load working conditions is developed.
- To measure the temperature rise, the transformer is kept under rated load condition for several hours till maximum steady temperature is attained.

b) What is the effect of variation of voltage and frequency on the performance of electrical machines?

Effect of variation of voltage on the performance of electrical machines: **(3 Marks)**



The variation in supply voltage has significant effect on the torque, current, slip of the induction motor.

- The torque T is directly proportional to square of Voltage V^2
- The slip S is inversely proportional to square of voltage $1/V^2$
- The starting current is directly proportional to the supply voltage V.
- Full load current is inversely proportional; the effect of change in supply voltage on various functions is indicated in following table. **OR**

Voltage	**Starting Torque & Max. Running torque**	**Synchronous Speed**	**% Slip**	**Full load speed**	**Full load current**	**Temp. rise on full load**	**Starting current**	**P.f**	**Efficiency**
Function of Voltage	αV^2	Constant	$\alpha\ 1/V^2$	Decreases with decreases in voltage	Increases with decreases in voltage	Increases with decreases in voltage	αV		
90 % voltage	Decreases by 20 %	Constant	Increases by 25%	Decreases by 15 %	Increases	Increases by 6^0C	Decreases	Increases by 2 %	dcreases by 2 %
110 % voltage	Increases by 20%	Constant	Reduces by 17 %	Increases by 10%	Decreases	Decreases by 4^0C	Increases	Decreases by 5 to 8 %	Little change

120 % voltage	Increases by 45%	Constant	decreases by 30 %	Increases by 15%	Decreases by 10 %	Decreases by 0^0C	Increases		

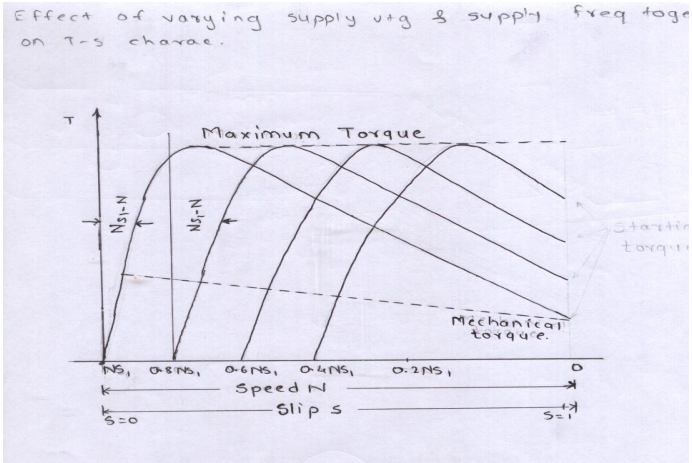
Effect of variation of frequency on the performance of electrical machines: **(3 Marks)**

- The effect of variation of supply frequency on the performance of induction motor is given in the following table

OR

Frequency	**Starting Torque & Max.Running torque**	**Synchronous Speed**	**% Slip**	**Full load speed**	**Full load current**	**Temp. rise on full load**	**Starting current**
Function of frequency	$\alpha\ 1/f^2$	$\alpha\ f$	constant	$\alpha\ f$	Increases Slightly with decreasing frequency	Increases Slightly with decreasing frequency	$\alpha\ 1/f$
95 % frequency	Increases by 11%	decreases by 5 %	No Change	decreases by 5 %	Increases Slightly	Increases Slightly	Increases by 5%
105 % frequency	decreases by 10 %	Increases by 5 %	No Change	Increases by 5 %	Decreases Slightly	Decreases Slightly	Decreases Slightly

OR



Q.2 Attempt any four of the following: ----------16 Marks

a) Enlist any four precautions to be taken while working on an electrical installation.

(Any four precautions expected: 1 Mark each)

Precautions to be taken while working on an electrical installation

1. Always treat circuit as live until you proved it to be dead & earthed.
2. Keep safe distance from HV apparatus it may give leakage shock or flash even without touching.
3. Make a habit of turning your face away whenever an arc or flash may occur
4. The all joints , connections, contacts in the electrical system should mechanically & electrically sound (tight)
5. Use extreme care when breaking an inductive circuit as dangerous high voltage is likely to result.
6. Thoroughly discharge to earth all cables before working on cores.
7. Think carefully before you act
8. Use safety belt while working above ground level.
9. Place rubber mats in front of electrical switch board/Panel
10. .Place Warning board /caution Notice/ Danger board/Safety tagging. These noticed shall be attached to all points of isolation from which apparatus can be made live, before starting the work.
11. Before working on any circuit or apparatus make sure that the all controlling switches are open, earthed & locked. And keys are handed over to the person who is going to work (Portable earthing leads are used for this purpose)(Approved discharge rods should be used in making ground connection.
12. Test rubber gloves, safety equipments, insulated tools periodically. Use appropriate & proper tools are used.
13. Always obey the safety instructions given by the person incharge/ manufactures instructions.
14. Report electrical safety hazards to the person incharge which you may observe.
15. Work deliberately & carefully. Haste causes may accidents. Be sure of what you are doing.
16. Use properly rated extension cords suitable for use outdoors.
17. Earthing rod/Ladder/Crow bars/spiders, hammers etc. tool not to be carried in switched yard by the person above waist level.
18. Wear appropriate clothing always use 100% cotton clothing (avoid loose clothing)
19. When using portable ladders must be placed at safe angle about 75^0 with the horizontal & it should be held by another person firmly.
20. The issue & return of the permit shall be logged in the book in red ink.

21. Rubber gloves should be used on both hands when operating discharge rods.
22. Do barricading of hazard area.
23. All anticipated hazards should be pointed out to workers.
24. Tools/equipments must be stored in safe place after the work is over.
25. While doing maintenance work on transformer, transformer three phases are short circuited & connecting them to ground before starting the work.

b) State the procedure for developing preventive maintenance schedule.

(Any four points of procedure expected: 1 Mark each)

Following is the procedure of preventive maintenance:-

- Periodic visual inspection of various equipments to locate initial condition leading to breakdown.
- Up keep of equipment and plant & repair defects at their initial stage.
- Checking of stationary parts.
- Checking of movable parts.
- Checking of working condition of equipment or machinery.
- Checking of surrounding in which the machinery or equipment has to work i.e atmospheric condition.
- Checking of safety measures.
- Checking of protective device.
- Checking the list of consumable and non consumable items to be used in the equipments and machinery.
- Checking of stores and stored inventory.
- Checking of tools, trackless, jacks and fixtures etc.
- To attend major breakdown and repairs.

c) What is the effect of unequal voltages and change in input to prime mover on parallel operation and load sharing of alternators?

Effect of unequal voltages on parallel operation and load sharing of alternators: (2 Marks)

1. When two alternators are having unequal voltages (induced emfs), then the alternator which is generating more induced emf than the other will share more load current and will be having reduced power factor.

Effect of change in input to prime mover on parallel operation and load sharing of alternators:

(2 Marks)

1) Effect of change input (Steam flow or water flow) to prime movers of alternators:

Suppose input to the prime mover of alternator No.'2' is increased.

- Output power (Active power) of alternator No.'2' will be increased.
- Power factor of alternator '2' will be increased.
- Output of power (Active Power) of alternator No.1 will be reduced.
- Power factor of alternator '1' will be reduced.
- The alternator No.2 will share more load current than alternator No.1

d) Enlist any four tests to be carried out on transformer under routine tests and special tests.

1) Routine Tests after manufacturing: - **(Any four names of tests expected: 1/2 each)**

i) Polarity test
ii) Phasing out test
iii) Winding resistance test
iv) Measurement of Insulation resistance test
v) Voltage ratio test
vi) Magnetizing current & core loss test (O.C test)(No-load losses and current)
vii) Measurement of impedance voltage, S/C impedance & copper loss.(S.C test)
viii) Transformer vector group test
ix) Dielectric tests (H.V. Test**)**
x) Oil pressure test on transformer tank to check against leakages past joints & gasket
xi) Test on ON-load tap-changer,(OLTC) where appropriate

2) Special Tests: **(Any four names of tests expected: 1/2 each)**

i) Noise Level
ii) Harmonics on the no-load current
iii) Vibration test
iv) Short –circuit with stand test
v) Measurement of zero phase sequence impedance of the 3-ph transformer
vi) Dielectric test(H.V. test)(Test with lightning impulse chopped on the tail)
vii) Measurement of the power taken by the fans & oil pump motor.

e) State the factors on which life of insulation depends.

(Any four factors are expected: 1 Mark each)

Life of insulations depends on following factor:-

1. **Water:** If insulation is near water for the long period than its life reduces.
2. **Moisture:** If insulation contains moisture for the long period than its life reduces.
3. **High Temperature:** Due to over loading insulation gets heated than its life reduces
4. Mechanical **Stress:** Any mechanical stress on insulation for the long period than its life reduces
5. **High voltage stress:** If insulation is used other than designed for voltage than there will be high voltage stresses it may reduces life of insulation.
6. **Dirt & Dust Particles:** If dirt & dust particles accumulated on insulation than it will absorb moisture in the air which will reduces the insulation resistance reduces its may cause the failure of insulation.
7. **Improper Handling:** If it is handle roughly than it may damage.
8. **Ageing:** After a long period it's dielectric strength reduces.

OR

Life of insulations depends on following factor:-

1. **Water**
2. **Moisture:**
3. **High Temperature:**
4. Mechanical **Stress:**
5. **High voltage stress:**
6. **Dirt & Dust Particles:**
7. **Improper Handling:**
8. **Ageing:**

f) What are the uses of following equipments in electrical maintenance? i) Bearing puller

ii) Filler gauge iii) Dial indicator iv) Growler **(1 Mark Each)**

i) Bearing Puller:-

- Bearing puller is used for removing from the shaft of the motor and generator.

ii) Filler Gauges:-

- To check the air gap between stator & rotor.

iii) Dial Indicator:-

- Dial type indicator are used to check the run-out of rotating parts.

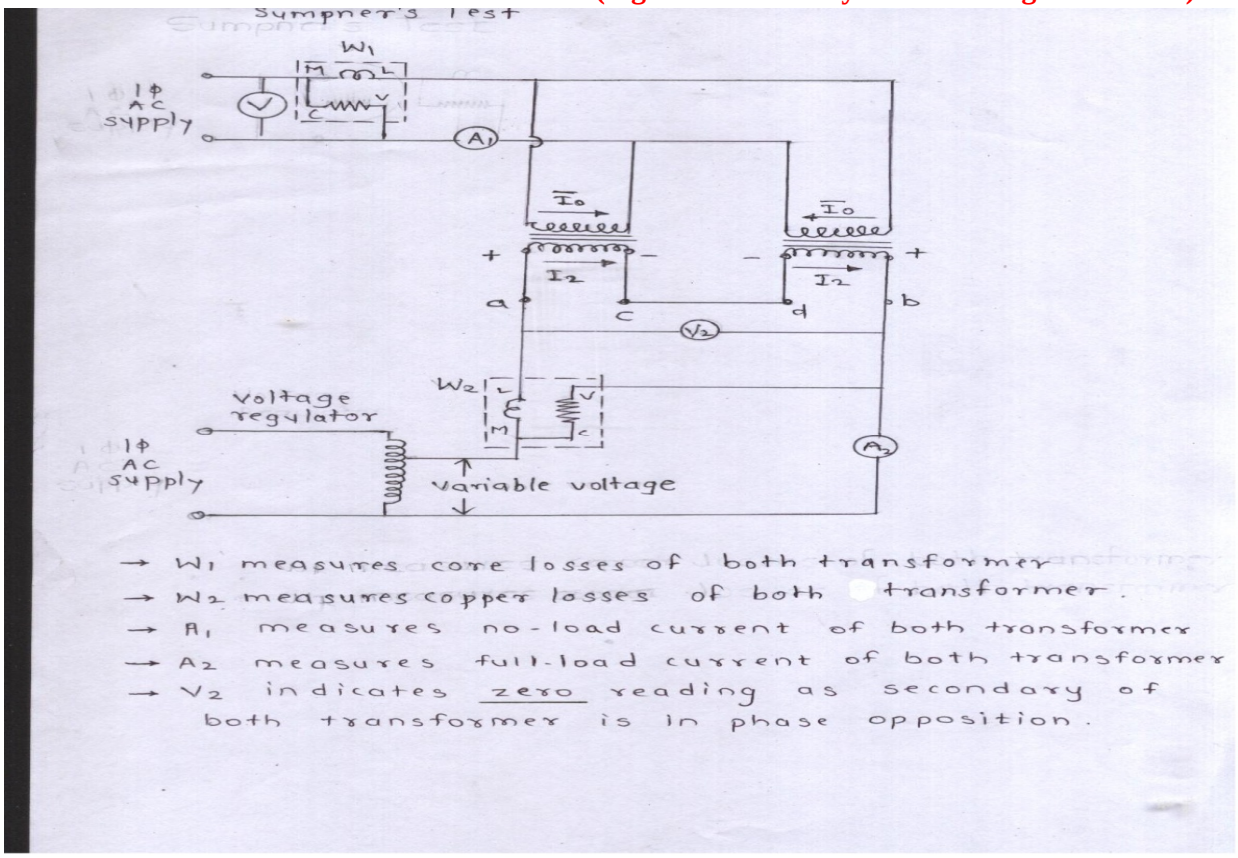
iv) Growler:

- It is a equipment used for finding shorted turns of armature coil or stator/rotor winding. It is essentially a single winding transformer.

Q.3 Attempt any four of the following: ----------16 Marks

a) Draw the experimental setup of Sumpner's test and state its advantages.

(Fig. 3 Marks & any two advantages: 1- Mark)



Advantages:-

1. Power consumption is low (only to met the losses)
2. No external load is required.
3. In addition to temperature rise we can determine efficiency & regulation of a transformer by this test.
4. Transformer with full flux drawing full load currents & hence is closest to the actual loading conditions with a physical load.

b) Compare direct, indirect and regenerative type of testing. **(Any 4 points: 1 Mark Each)**

No	Parameter	Direct type testing	Indirect type testing	Regenerative type testing
1	**Definition**	In which the machine under test can be loaded directly.	In which the machine under test can be loaded indirectly.	In which the machine under test can be loaded back to back
2	**Testing**	This test is conducted for small capacity equipment/ machine/ transformer	This test is conducted for large capacity equipment/ machine/transformer	This test is conducted for large capacity equipment/machine/transformer
3	**Power consumption**	Power consumption is more	Power consumption is less	Power consumption is less.
4	**Results obtained**	Results obtain are more accurate.	Results obtain are approximately accurate	Results obtain are approximately accurate
5	**Methods**	e.g. Brake load Test, Calibrated machine test	e.g. Swinburne's test, OC/SC Test	e.g. Hopkinson's test for shunt & Series machines
6	**Condition for testing**	Machine/equipment should be loaded at full load	Machine/equipment should be run on no load	Two identical machines are required while testing

c) How to rescue a person who has received electric shock?

(Any four activities are expected: 1 Mark each)

Activities to be carried out for the person who received electrical shocks:-

i) Switching OFF the supply: when a person comes in contact with live conductor, switch off the main supply immediately if it is nearby or cut the wires with insulated pliers from the wiring circuit.

ii) Removing the person from the contact of current:- Push a person with a dry sticks of wood or pull him by using hands wear by insulated hand gloves, or use cotton thick cloths or use dry news paper folded of sufficient thickness.

iii) Removing the person from fire: If a person's cloth catches fire, then wrap him in the blanket or coat & roll him on the ground to extinguish.

iv) Call to doctor immediately.

v) Before coming doctor, if any burns or wound occurs on the body of the person use proper oil/ medicine (first aid)

vi) If the person is not breathing, immediately start artificial respiration until the medical aid arrives.

vii) Do not touch the person with bare hands.

viii) Do not give liquid until the patient is conscious.

ix) Give artificial respiration to the person who received electrical shocks by any one method.

d) Which are the factors involved in designing the foundation of electrical machine?

(Any four factors are expected: 1 Mark each)

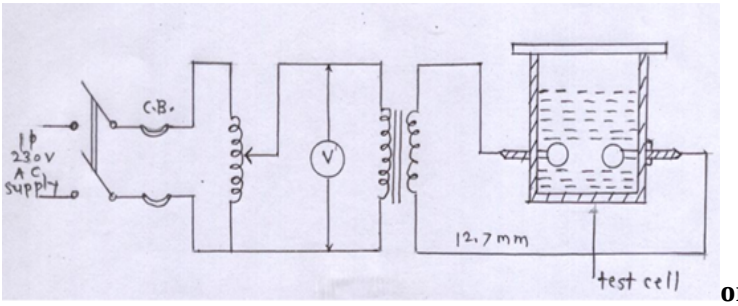
Following factors to be considered in designing the machine foundation:-

- The foundation should absorb the vibrations created by the machine while operating at its full capacity.
- Load on the foundation should not exceed the bearing capacity of the soil.
- Foundation should be so designed that it should bear all the resultant forces caused by machine.
- Horizontal Level.
- Rigidity or Safe bearing capacity.
- Freedom from vibrations or the capacity of absorption of vibration.
- Type of machine-static or dynamic.
- Sufficient frictional resistance to withstand the possible horizontal thrust.

e) With the help of neat figure explain the dielectric strength test on transformer oil.

(Fig. 2 – Marks & explain - 2- Mark)

Dielectric strength test on transformer:-



or equivalent figure

- The sample of oil is drawn from near the top & bottom of the transformer.
- The gap of electrode is first checked with a gauge.
- The cup is filled with sample of oil to be tested up to about 1 cm above the electrodes.
- The cup to is covered with clean glass plate.
- The supply is switched ON & voltage is raised gradually by the variac.
- Till final break down of oil takes place & circuit breaker gets tripped & disconnect the transformer from the main supply.
- The test is performed with 2 or 3 consecutive samples of the oil one by one.
- Average of all subsequent tests is considered as the breakdown voltage of oil sample.
- This value is noted down which must be 30 KV (rms) for 4 mm $\pm$ 0.02 mm gap.
- Oil in good condition when its breakdown voltage is 45 KV (rms) for 4mm gap for one minute.

f) Enlist any four internal and external causes of faults.

Internal Causes: **(Any four causes expected: 1/2 Mark each)**

1. High temperature due to prolonged overloads
2. Short-circuited fault in winding.
3. Phase to ground fault
4. Open-circuit fault in one phase
5. Rotor faults
6. Failure of bearings.
7. Magnetic locking between stator and rotor.
8. Uneven air gap.
9. Unbalanced rotating weights.
10. Shorted turns of phase windings.

2) External Causes: **(Any four causes expected: 1/2 Mark each)**

1. Sustained overloads.
2. Single phasing from supply side.
3. Unbalanced voltage, causing heating due to negative phase sequence currents.
4. Over voltage or under voltage
5. Change in supply frequency.
6. Short circuit fault in supply system.
7. Loss of supply voltage.
8. Defective starting mechanism
9. Loose contacts.

Q.4 Attempt any four of the following: ----------16 Marks

a) State and explain any four properties of good transformer oil.

Following are the properties of good transformer oil:

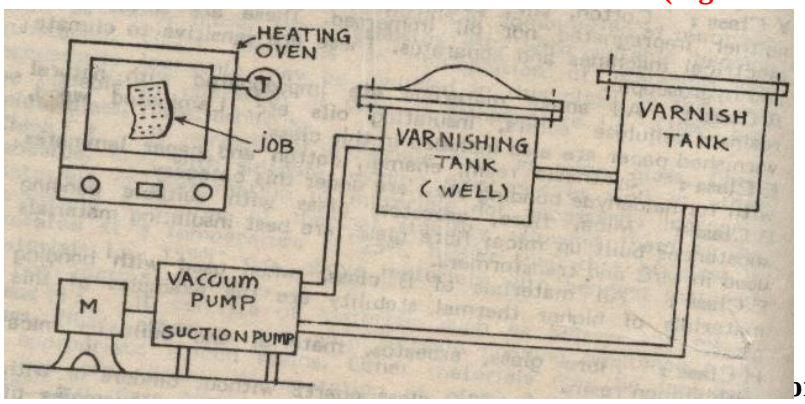
(Any four properties expected: 1Mark each)

1. It should be have a high dielectric strength i.e not less than 30KV (rms) for the gap 4mm of the electrodes.
2. It should be free from moisture contents & water vapour limiting value should not be more.
3. Acidity contents should be very in the oil limiting value 0.4mg of KOH/g.
4. It should have high flash point i.e. 160^0C & lower point as per specification led down (145^0C).

5. The temperature at which the oil will ignite & continue burning should be about 200^0C.
6. The oil should be chemically stable.
7. It should be not contain impurities such as sulpher & its compounds to avoid rusting & sludge formation.
8. It should posses low viscosity.
9. Sludge value of the oil after treating should be 1.2% (limiting value is less than 0.1%)
10. Density of oil at 20^0C should be 0.89 gm/cm^3.
11. Relative permittivity should be 2.2
12. The oil should be frequently clear & plane in colour, transparent & free from suspended matter sediments.
13. Mineral oil grade B should be used.
14. The properties of good transformer & switchgear oil are recommended by IS 335-1963.
15. And to maintain the properties IS code of practice No. 1866-1961 to be refer.

b) Explain the hot dip method of varnishing for a transformer.

(Fig. 2 Marks & Explain - 2- Mark)



or equivalent figure

- This method is used for small coils and windings of armatures and stators or rotors etc.
- They are very simple, cheap and are carried out when baking oven is available.

Procedure:

- The winding is heated in a baking oven at about 100^0C for at least one hour, so that any moisture present in it will get evaporated.
- It is then completely immersed in a varnish tank and kept in immersed condition for at least 1/2 an hour, so that varnish will get filled in all air pockets in winding and slots etc.
- It is then taken out and kept on an iron grill for some time so that excess varnish gets drained out.
- It is then kept in a baking oven at a temperature of 100 to 110^0C for about four to eight hours, so that the varnish will become bone dry.

c) What is the effect of misalignment on the performance of machine?

(Any four effects expected: 1 – Mark each)

Effect of misalignment on the performance of machine: (direct coupled)

1. Increase load on bearing.
2. Increase in vibration.
3. Increases stresses on coupling & shaft.
4. Final effect of this the bending of shaft, worn out bearing & overloading of driving machine causing it failure
5. Overall performance of machine reduces

OR

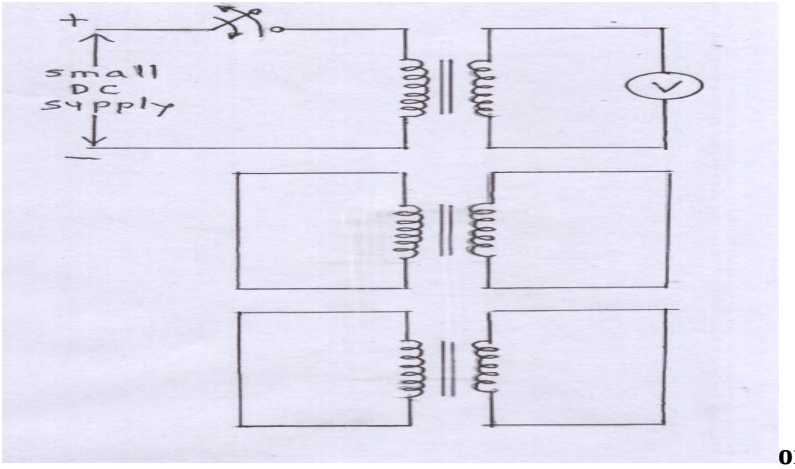
Effect of misalignment on the performance of machine: (indirect coupled)

1. The life of belt, rope & chain is shorted..
2. Produces distribute vibration.
3. Increase noise level..
4. Bent shaft.
5. Worn out bearing.
6. Final effect of this is early wear & tear of both driven & drying machine
7. Overall performance of machine reduces

d) With the help of neat figure explain phasing out test carried out on transformer.

(Fig. 2 – Marks & Explain - 2- Mark)

Objective: - This test is carried out to identify primary & secondary windings belonging to same phase.



or equivalent figure

Procedure:-

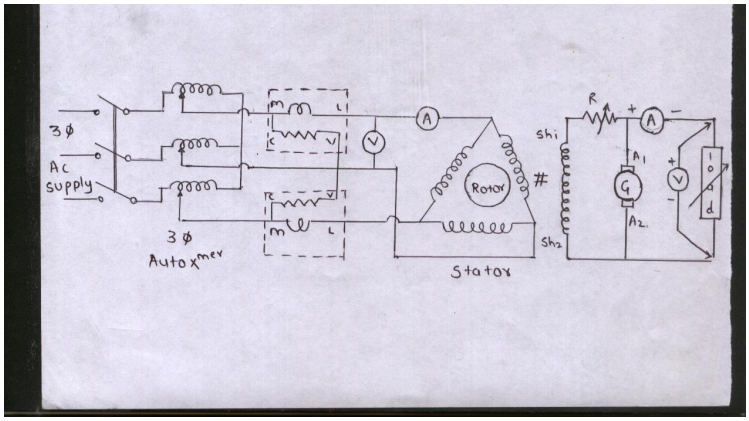
- Short primary & secondary winding of other phases expect the one under test.

- Connect voltmeter to secondary winding.
- A small DC current is circulated through the primary winding through switch.
- Now with the help of switch interrupt the DC supply instantly & repeatedly.
- If voltmeter indicator deflects than it indicates the two windings concerned belong to the same phase.
- If not deflect then two windings are not belong to same phase.
- Repeat the procedure by connecting voltmeter to secondary side to next secondary winding till voltmeter gives deflection.

In this way we can search the phasing out test.

e) Explain the load test on 3-ph induction motor. (Fig. 2 – Marks & explain - 2- Mark)

- **Load Test Circuit Diagram:**



or equivalent figure

Precaution:-

- This test is conducted for small capacity equipment/machine/transformer.
- When a belt drive is used, the power loss in belt should be considered.
- If the load is more the band brake gets extremely hot, so that observations have to be taken quickly.
- Pulley must be water cooled at regular intervals.
- Use two wattmeter method for measurement of input power.

Procedure:-

- Connection are made in as shown in figure,
- Keep the auto transformer at zero volt position initially.

- Increase the applied voltage to the stator gradually upto its rated value.
- Now increase load gradually and measured the readings of applied voltage, current, Power, and Speed for various loads on the motor upto full load.
- The motors may be loaded by any one of the following method

a) Brake load Test b) Calibrated machine test c) Uncalibrated machine d) Dynamometer method

Disadvantage:-

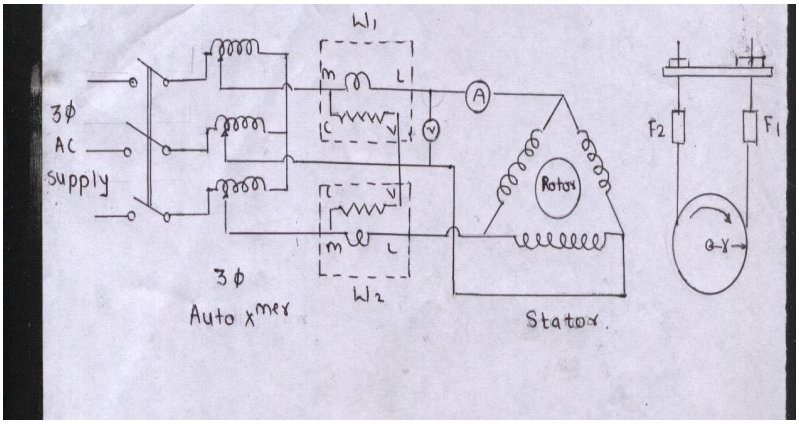
- Power consumption is more
- During this test more heat is generated.

Advantages:-

- Results obtain are more accurate.

OR Student may write this way

If Brake arrangement is used load test on 3-ph Induction motor:-



or equivalent figure

Procedure:-

- Connect the circuit as shown in circuit diagram.
- Measure the radius of pulley.
- Switch ON supply and start the motor .
- Keep the spring tension to minimum.
- Note down the reading at no load.
- Adjust the tension of the spring such that (F_1-F_2) is higher. Note down the corresponding reading of all the meters.
- Pulley must be water cooled at regular intervals.
- Increase the load gradually on the motor up to full load.
- Release the spring tension slowly and at no load switch OFF the supply.
- Calculate the torque, output power and efficiency.
- Plot a graph of torque vs. speed and armature current, motor output vs. speed and efficiency

Observation Table:-

V in volts	I in amp	W (P) in watt	Speed in rpm	F_1in Kg	F_2 in Kg	F_1-F_2 in Kg

Calculations:-

- T *is the torque in kg meter and* $T = (F_1 - F_2) \times r$ *mkg* (Where **r** is radius of pulley in meter)
- $output\ of\ motor = \frac{2\pi NT}{60}$ *mkg / Sec* , $output\ of\ motor = \frac{2\pi NT}{60} \times 9.81$ *watts*
- Efficiency of I.M $= \frac{Output\ of\ motor}{Input\ \ watt\ meter\ reading}$
- Note:- Calculation of each load reading is calculated as above and average is taken to calculate efficiency of motor

f) How to prevent an electrical machine during its inactivity?

(Any four points expected: 1Mark each)

Following care (protection) to be taken electrical equipments during the period of inactivity

1) All electrical connection should be disconnected.
2) Surrounding area of equipment should be made clean.
3) Equipment should be covered by suitable means so that no dirt, dust and moisture enter directly in equipment.
4) Caution board should be placed near machine **"THAT MACHINE IS UNDER IN ACTIVE"**

OR Student may write this way

1. Space heaters are used.
2. Radiating lamps are used for drying or removing moisture from machine.
3. Use moisture proof cover over machine.
4. Store the machine in a such a location that it is not expose to water.
5. Run the machine in inactivity period to check its performance.
6. Pour varnish into insulation of winding if necessary.
7. Clean the machine parts as well as winding to remove dirt & dust.
8. Drying out is carried out if we want to be required.

Q.5 Attempt any Two of the following: ----------16 Marks

a) Two single phase transformers are supplying a total load of 200 kW at 0.8 lagging p.f. operated in parallel. The two transformers have equal turns but their impedances are different. Z_1= 0.6 + j10 and Z_2 = 0.5+ j3. Find the load sharing and P.f of each transformer

Solutions:-

T_1 = 100 KVA,

Step: 1: $Z_1 = 0.6 + j\,10$ …….. Rec. form

$Z_1 = 10.0179 \angle 86.5663^0\ \Omega$..... *Polar form* ---------- **(1/2 Marks)**

$Z_2 = 0.5 + j\,3$ …….. Rec. form

$Z_2 = 3.0413 \angle 80.5376\,\Omega$..... *Polar form* ---------- **(1/2 Marks)**

$Z_1 + Z_2 = (0.6 + j10) + (0.5 + j3)$

$Z_1 + Z_2 = 1.1 + j13$ ..... *Rec form*

$Z_1 + Z_2 = 13.0464 \angle 85.1634^0\ \Omega$ ..... *Polar form* --- **(1/2 Marks)**

Step 2: Load-200kW at 0.8 P.f. lag:

$$KVA = \frac{KW}{P.f.} = \frac{200}{0.8}$$

$\therefore KVA_L = 250\ KVA$---------- **(1/2 Marks)**

Step 3: Load Shared by Transformer '1' in KVA:

$$(KVA)_1 = (KVA)_L \times \frac{Z_2}{Z_1 + Z_2}$$ ---------- **(1/2 Marks)**

$$(KVA)_1 = 250 \angle -36.8698 \times \frac{3.0413 \angle 80.5376}{13.0464 \angle 85.1634}$$

$(KVA)_1 = (250 \angle -36.8698) \times (0.2331 \angle -4.6258)$

$(KVA)_1 = 58.275 \angle -41.4958\ KVA$..... *polar form* - **(1/2 Marks)**

Power factor transformer 1:

$$\therefore (p.f)_1 = Cos\ (-41.4958)$$

$$\therefore (p.f)_1 = 0.7490\ lag$$ ---------- **(1 Marks)**

$$(KW)_1 = (KVA)_1 \times (p.f)_1$$

$$(KW)_1 = 58.275 \times 0.7490$$

$$(KW)_1 = 43.6447\ KW$$ ---------- **(1 Marks)**

Step 3: Load Shared by Transformer '2' in KVA:

Transformer 2= $(KVA)_2 = (KVA)_L \times \frac{Z_B}{Z_A + Z_B}$

$$(KVA)_2 = 250 \angle -36.8698 \times \frac{10.0179 \angle 86.5663}{13.0464 \angle 85.1634}$$

$$(KVA)_2 = (250 \angle -36.8698) \times (0.7678 \angle -1.4029)$$

$$(KVA)_2 = 191.95 \angle -35.4669^0\ KVA.....polar\ form$$ -------- **(1 Marks)**

Power factor transformer 2:

$$\therefore (p.f)_2 = Cos\ (-35.4669)$$

$$\therefore (p.f)_2 = 0.8144\ lag$$ ---------- **(1 Marks)**

$$(KW)_2 = (KVA)_1 \times (p.f)_1$$

$$(KW)_2 = 191.95 \times 0.8144$$

$$(KW)_2 = 156.324\ KW$$ ---------- **(1 Marks)**

b) A total load of 1200 kW is shared equally by two identical alternators at 60000V and 0.866 lagging p.f. The current of one alternator is 70A at lagging p.f. Find the p.f. of both the alternators. Both alternators are star connected.

Solution: Total load: 1200 kW, Voltage: 6000V, P.f: 0.866 lag current of all = 70 A

Step 1: Total active load (KW_L) = 1200 kW

Step 2 : Total reactive load :

$\therefore \phi = \cos^{-1}(0.866) = 30^0$ *Elec.* ---------- **(1 Marks)**

$\therefore$ *Total racyive load* $= 1200\ kW \times \tan 30$

$\therefore$ *Total racyive load* $= 692.8203$ *KVAR* ---------- **(1 Marks)**

Step 3: Reactive Power shared by alternator 1:

$\therefore = P_1 \tan \phi_1$ ---------- **(1 Marks)**

$\therefore P_1 = \sqrt{3}\, V_L \times I_L \times Cos\phi$

$\therefore \phi_1 = Cos^{-1}[\frac{P}{\sqrt{3} \times V_L \times I_L}]$ ---------- **(1/2 Marks)**

$\therefore \phi_1 = Cos^{-1}[\frac{600 \times 10^3}{\sqrt{3} \times 6000 \times 70}]$

$\therefore \phi_1 = Cos - 1(34.431)$

$\therefore Cos\ \phi_1 = 0.8247$ *lag* ---------- **(1 Marks)**

Reactive power shared by alternator 1 = $600 \times \tan(34.4331)$

$= 411.3379$ *KVAR* ---------- **(1 Marks)**

Step 4: Reactive Power shared by alternator 2 = Total reactive – Reactive power of alt 1

= 692.8203 –411.3379

Reactive Power shared by alternator 2 = 281.4824 KVAR---------- **(1 Marks)**

But,

Reactive power shared by alternator 2 = $P_1 \tan \phi_2$

$281.4824 = 600 \times \tan \phi_2$ ---------- **(1/2 Marks)**

$$\tan \phi_2 = \frac{281.4824}{600}$$

$$\tan \phi_2 = 0.4691$$

$$\phi_2 = \tan^{-1}(0.4691)$$

$$\phi_2 = 25.1331^0$$

$$Cos\ \phi_2 = 0.9053^0$$ ---------- **(1 Marks)**

OR student may write this way

Step 1: Total active load (KW_L) = 1200 kW is shared equally by two indicate alternators 1 & 2

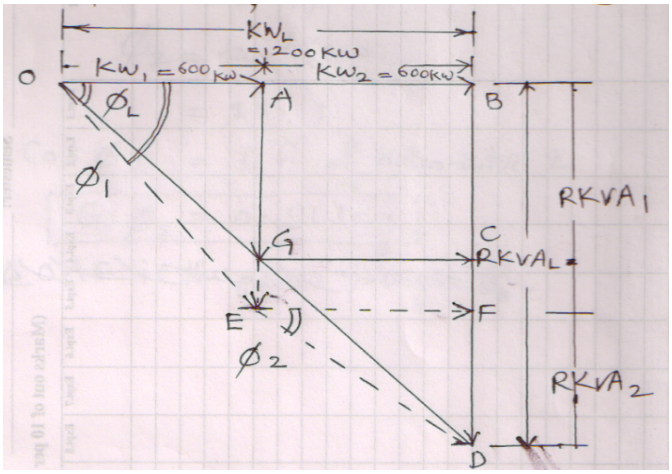


figure is not compulsory

- **The load current shared alternator 1 = I_1= 70 Amp**

$$\therefore \cos\phi_1 = \frac{KW_1}{\sqrt{3}\, V_T\ I_1}$$ ---------- **(1 Marks)**

$$\therefore \cos\phi_1 = \frac{600 \times 10^3}{\sqrt{3} \times 6000 \times 70}$$

$$\therefore\ Power\ \ factor\ alternator \cos\phi_1 = 0.825\ lag$$ ---------- **(1/2 Marks)**

$$\therefore \phi_1 = \cos^{-1}(0.825) = 34.43^0\ \ Elec.$$ ---------- **(1 Marks)**

$\therefore length\,(l)'AE' = l\,(BF) = l\,(OA)\ \tan\phi_1$.

$\therefore RKVA_1\ of\ \ alternator\,1 = 600\,kW \times \tan 34.43$

$\therefore RKVA_1 = 411.3\ RKVA$ ---------- **(1 Marks)**

$\therefore length\,(l)'BD' = KVA\ \ of\ \ \ load = l\,(OB)\ \tan\phi_L$.

$\therefore \phi_L = \cos^{-1}(0.866) = 30^0\ \ Elec.$ ---------- **(1 Marks)**

$\therefore RKVA_L = 1200\,kW \times \tan 30$

$\therefore RKVA_L = 692.82\ RKVA$ ---------- **(1 Marks)**

$\therefore RKVA\ of\ \ alternator = l\,(FD) = l\,(BD) - l\,(BF) = 692.82 - 411.3$

$\therefore RKVA_2 = 281.52$ ---------- **(1 Marks)**

RA Δ EFD is the power triangle of alternator No.2:

$\therefore \tan\phi_2 = \dfrac{l\,(FD)}{l\,(EF)} = 0.47$ ---------- **(1/2 Marks)**

$\therefore \phi_2 = \tan^{-1}(0.47)$

$\therefore \phi_2 = 25.17$

$\therefore\ Cos\phi_2 = P.f.\ of\ \ alternator\ \ 2$

$\therefore\ \ Power\ \ factor\ alternator \cos\phi_2 = 0.91\ \ lag$ ---------- **(1 Marks)**

c) Explain the trouble shooting chart of 3-phase transformer.

(Any four points expected: 2Mark each)

No	Troubles	Causes	Remedies
1	Overheating	It may be due to overloading	Check cooling system, whether fans are operating
		Failure of cooling system	Whether cooling oil/water is circulating
		High ambient temperature	Reduce the load on transformer, If temperature of oil is too high switch off the transformer till safe temperature reached for long durations, install another transformer in parallel
2	External Short circuits	It may be due to Insufficient clearance on overhead line	Provide sufficient clearance on overhead line
3		Accumulation of dust on insulators	Clean the insulator. And Transformer should be provided with over current protection. Transformer windings should be capable of withstand repeated external s/c without failure
4	Short circuit between adjacent turns, usually high voltage winding.	-Fluctuating loads -Transient over voltage -Moisture in oil. -Reason of external short circuit	-Buchholz relay should operate & sound alarm. -Over current & differential protection.
5	Internal short circuit	-Sustained over load & insulation failure -Fault in tap changer. -Failure of end turns of coil due to over voltage surge. -Bad solder joints causing local overheating & open circuit. -Ageing of insulation. -Vibration of insulation resulting in to short circuit.	- Overheating protection. - Earth fault protection. - Differential protection.
6	Moisture in oil	-It may be due to Defective seals. - Breather gets saturated. -Moisture in the oil while filling.	- Gaskets should be replaced. - Silica jel should be replaced. - Oil should be filtered. - Transformer should be dried out.
7	Rapid deterioration of oil	- It may be due to Excessive overheating. - Presence moisture. - Poor quality of oil.	- Cause should be determined & corrective action to be taken.
8	Carbon & other conducting	- Sparking of oil. - Excessive temperature of oil.	Transformer needs over hauling since conducting particles line up on insulation

	particles in oil.		surface causing reduction in insulation resistance
9	Transformer does not show o/p voltage	-Primary side fuses blown or trip the circuit breaker. - Failure of primary winding. - Open Wire connection in bushing.	- Replace fuse. - Rewinding the primary. - Tight connection at bushing.
10	Phase voltages unequal	- Unequal loading. - Single phasing.	- Make load equal. - Repair fault
11	Transformer body gives shock	- Insulation resistance reduces. - Earth fault	

Q.6 A) Attempt any three of the following: ----------12 Marks

a) State the various devices and tools used for loading and unloading heavy equipments.

Equipment used for lifting heavy electrical machine:-

(Any four names of devices expected: 1Mark each)

i) Stationary Cranes
ii) Overhead or Gantry Cranes
iii) Mobile Cranes
iv) Truck Mounted Crane
v) Steam Crane
vi) Chain pulley Block
vii) Chain Hoist
viii) Electric Hoist
ix) Screw Jacks
x) Winches
xi) Hoses &tripods(are the simplest temporary supports)
xii) Ceiling ropes.

b) Enlist the specific tests before/after commissioning of transformer. :-

(Any four names of tests expected: 1Mark each)

Following Specific tests are required before/after commissioning of a transformer.

a) Overall inspection of control & relay panels
b) Tests on relays & alarm contacts
c) Voltage ratio test on all phases.
d) Measurement of earth resistance
e) Test on Buchholz relay
f) Testing of cooling system fans, cooling water pump etc
g) Operation of tap-changing arrangement
h) If required Phasing out test
i) Insulation resistance measurement
j) Oil level in conservator
k) Closing of neutral earthing switch
l) Working of meters on both sides, when transformer is loaded.
m) Operation of No-load tap changing arrangement is checked.

c) Give the trouble shooting chart of 3-phase induction motor (any 4 points)

Trouble shooting chart of 3-phase induction motor: (Any four points expected: 1 Mark each)

S.No	Type of fault/abnormal conditions/Troubles	Causes	Remedies
1	Abnormal Supply conditions	- Loss of supply voltage. - Unbalanced supply voltage. - Phase sequence reversal of supply voltage. - Over /Under frequency - Over /Under Voltage - Single Phasing	Rectify The Cause
2	High input current in all 3 phases	- Line voltage 10% or above /below the motor nameplate voltage. - Motor overloaded.	Rectify The Cause
3	Faults in starting supply circuit	- Defective starting mechanism	Rectify The Cause

	(Motor fails to start up)	- Interruption in phases. - blowing of fuse/single phasing - Short circuit in supply cable. - Open circuit in DOL or star delta starter. - Worn Contacts of Star-delta starter - Terminal voltage too low - Loose contact. - The motor controller will not operate. - Motor rotor, bearings or driven load is locked. - Overloaded	Rectify the Cause
4	Mechanical Overload	- Sustained overloads. - Prolonged starting or locked rotor. - Stalling (due to excessive load)	Rectify the Cause
5	Run Slow (Motor starts Sluggishly)	- Power failure - Overload - Low voltage. - Low frequency - Broken rotor bars - Shorted stator coils - Open Stator coil - Single phasing. - Stator connected in star instead of delta. - One motor terminal was by mistake connected to neutral instead of phase or - Improper connection of motor leads to supply line - Open primary circuit	Rectify the Cause
6	Internal Faults in motor itself	- Open circuit fault. - Short circuit fault. - Phase to phase fault. - Earth fault (phase to earth) - Mechanical failure	Rectify the Cause
7	Run Hot/ Thermal overload/ Motor overheating/ Motor frame Hot to touch	- Overload - Over/Under voltage. - Unbalance voltage - Over/Under frequency - Broken rotor bars - Shorted stator coils - Dirt in motor - Grounded coil - rotor rubbing on stator - Worn bearings - Starting mechanism does not open. - Single phasing. - Poor motor ventilation/ Air flow	Rectify the Cause

		obstructed or Inadequate ventilation. - Ventilating Fan is not working - Stator winding is in correct connected (Wrong connection) - It may be due to internal faults inside the winding or for winding to earth - High ambient temperature at the motor controller. (above 40^0C (104^0 F)	
8	Bearing overheating	- Oil level too high/ low. - Misalignment - Bearing may worn out. - Excessive end thrust. - Too much grease/ No grease/ Foreign matter in grease. - Bent or spring shaft. - Excessive belt pull. - Pulleys too far away. - Pulley diameter too small. - Overloaded bearing. - Broken ball or rough races	Rectify the Cause
9	Vibration	- Misalignment in coupling - Motor load out of balance - Rotor is unbalanced - Accumulation of dirt on fan. - Twisted base/ flange - Armature shaft bend slightly. - Bearing may be worn out. - Loose foundation in nut bolts/ Weak support. - Lubricating system may fail. - Damaged bearings, too much grease, no grease, or foreign matter in grease. - Excessive belt pull - Driven equipment unbalanced - Balancing weights shifted. - Excessive end play	Rectify the Cause
10	Noise	- Single phasing. - Cooling fan is touching on stationary part. - Unbalanced voltage. - Bearing poorly fit. - Normal motor noise amplified by resonant mounting. - Rotor unbalanced - Loose on bed plate - Voltage boost may too high. - Noise in operating frequency range.	Rectify the Cause

		- Current loop is unstable. - Motor mounting is loose. - No uniform air gap or rotor rubbing on stator. - Sheave or coupling out of balance.	
11	Regular clicking (Short sound)	- Foreign matter in air gap. - Dirt in motor.	Rectify the Cause
12	Motor hums a) During Start up b) When running	- Unequal phase resistance - Open circuit - Interturn short circuit on motor. - Short circuit between turn to turn or parts of stator winding. - Earth fault (Winding to frame short circuit)	Rectify the Cause Rectify the Cause

OR

S.No	Type of fault	Causes	Remedies
1	Motor fails to start up	-Open circuit in DOL/Star-delta starter. -Brushes make no contact with slip rings. -Rotor of fan rubbing on stator -Worn contacts of star-delta starter. -Excessive load on starting. -Terminals voltage too low	Rectify The Cause.
2	Motor starts up sluggishly/Excessive speed reduction when motor is loaded	- Supply voltage is too low (Voltage drop when motor is loaded) - Stator connected in Star instead of delta. - One motor terminal was by mistake connected to neutral instead of phase	Rectify The Cause.
3	Motor hums a) During Stat up b) When running	a)Unequal phase resistance - Open circuit - Or inter turn short circuit on rotor b) Short circuit between turn to turns or parts of stator winding - Multiple winding to frame short circuit (earth fault)	Rectify The Cause.
4	Thermal overload protection operate while motor is running	-System frequency too high -Excessive core loss -Single phasing i.e O.C. in stator winding or supply cable -Stator winding is incorrectly connected i.e. in star instead of delta -Motor was incorrectly selected for type of duty involved. e.g selecting short time or	Rectify The Cause.

		intermittent duty instead of continuous duty at full load -Inadequate ventilation (i.e cooling system) -Air flow obstructed -Thermal overload protection incorrectly rated or adjusted.	
5	Regular Clicking(short sound)	Foreign matter in air gap	Remove foreign matter
6	Vibration	-Misalignment in coupling or flange -Accumulation of dirt on fan. -Vibration in driven machine -Twisted base or flange -Excessive end play. -Shaft bent or flange face run out	-Realign motor& driven equipment. -Clean motor -Run motor disconnected from driven load & check for vibration. Eliminate source in driven equipment. -Alter rigidity of base structure -Check flange alignment and shims. -Adjust end play. -Straighten or replace shaft, Reface or replace housing
7	Motor over heating (Check with thermocouple or by resistance method, do not depend on touch)	-Overload -Single phasing - Dirt in motor - Unbalanced voltage - Rotor rubbing on stator - High ambient -Open Stator winding - Air Recirculation -Over voltage/under voltage - Ground - Improper electrical connections	- Measure load & compare with nameplate rating and reduce the load. - Check current all phases - Check flow of air, filters, if so equipped and clean motor. - Check voltage, all phases - Check air gap, repair motor as necessary. -Check air inlet temperature. - Disconnect motor from load. Check

		-Heat exchanger tubes blocked	idle amps for balance in all phases, check stator resistance in all phases for balance -Check intake & exhaust for obstructions. -Check voltage and compare to rating plate. - Locate with test lamp or insulation tester and repair -Recheck electrical connections. Clean tubes, if so equipped
8	Bearing Overheating	- Oil level too high or low -Misalignment - Excessive end thrust - Too much grease (ball or roller Bearing)	- Correct oil level - Realign motor and driven equipment. - Reduce thrust. Recheck mounting & alignment.

d) Enlist the methods used for detection and recording temperature of electric machines and explain any one. **(List of methods 2 – Marks & explain - 2- Mark)**

The following methods used for detection and recording temperature of electric machine:

1. Thermometer Method
2. Resistance Method
3. Embedded Temperature Detector Method

Explanation of Methods of measurement of temperature:- (Any one explanation expected)

- **Thermometer method:**

This method is used to measure temperature of accessible part of machine i.e. surface only. Bulb thermometers are used where there is a strong moving magnetic field, Alcohol thermometers are used instead of mercury thermometers.

- **Resistance Method: -**

When the temperature of winding is determine by resistance method, the temperature of winding (ambient temperature) should be recorded before loading machine.

This method is used for determination of temperature-rise of the windings. This method involves the measurement of resistance, cold and hot, and estimation of average temperature rise from the relation

$$R_2 = R_1 (1+\alpha_1 \times t_1)$$

Where, R_1 is resistance at $t_1{}^0C$ and R_2 is resistance at $t_2{}^0C$, α_1 is temperature coefficient of resistance at $t_1{}^0C$

$$\frac{R_2}{R_1} = \frac{t_2 + 234.5}{t_1 + 234.5}$$

- **Embedded Temperature Detector Method: -**

Embedded temperature detectors are resistance thermometers or thermocouples (RTD and BTD) built into the machine during construction at points, which are inaccessible after the machine is completed. The terminals of thermocouples are connected to micro voltmeter. &the reading of voltage is proportional to temperature rise.

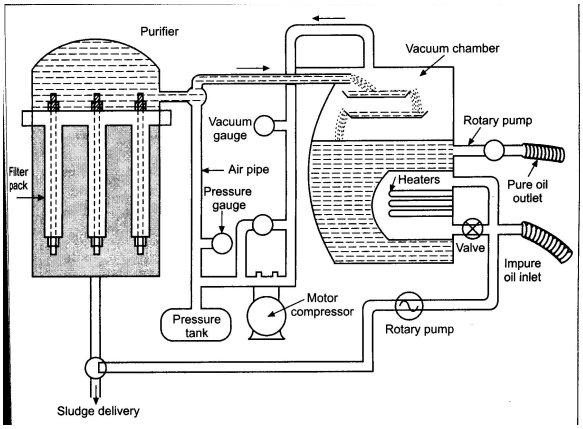
The two numbers of RTD (Resistance Temperature Detector) per phase (total 6 numbers) they are embedded in the stator winding one in the top layer and other in the bottom layer for measurement of temperature of winding, these are temperature sensitive resistance devices.

Two BTD are used, one BTD (Bearing Temperature Detector) each for drive end and non-drive end bearings are used for bearing temperature measurement.

Q-6 B) Attempt any one of the following. ----------06 Mark

a) With the help of neat figure explain the method of filtration of improve oil using streamline filter (Vacuum type) **(Fig. 3 – Marks & explain - 3- Mark)**

1. **Stream Line Purifiers:-**



- In this process oil under high pressure is passed through very thin paper-discs (Filter packs).
- The purified oil will go down and impurities remain in paper-discs.
- Compressed air is passed to release the collected impurities. (deposited dirt & carbon)
- This type of purifier is most efficient to remove the moisture from oil.

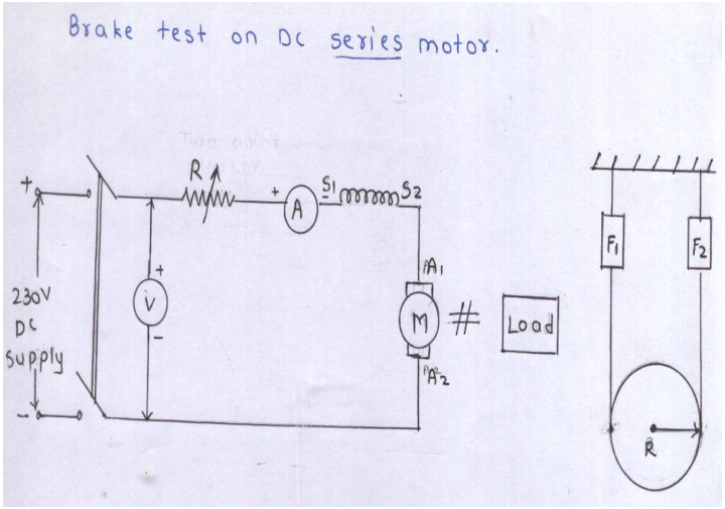
b) Explain with neat figure how a brake test is carried out an DC machine.
(Fig. 3 – Marks & explain - 3- Mark)

Brake test is direct testing method of a DC Machine. It consists of mechanically coupled '' Brake drum'' (i.e. pulley and belt arrangement) with spring balance on both sides. By adjusting spring tension motor can be loaded from no load to full load

Objectives:-

- This test is carried out on small ratings motors to determine performance such as efficiency, speed and temperature rises.

Diagram -



or equivalent figure

Precaution:-

- This test is conducted for small capacity machine.
- When a belt drive is used, the power loss in belt should be considered.
- If the load is more the band brake gets extremely hot, so that observations have to be taken quickly.
- Pulley must be water cooled at regular intervals

Procedure to perform brake test on DC Series motor:-

- Connect the circuit as shown in circuit diagram.
- Measure the radius of pulley.
- Switch ON DC supply and start the motor with the help of starter.
- Adjust field rheostat of motor to obtain rated speed of motor.
- Keep the spring tension to minimum.
- Note down the reading at no load.
- Adjust the tension of the spring such that (F_1-F_2) is higher. Note down the corresponding reading of all the meters.
- Pulley must be water cooled at regular intervals.
- Increase the load gradually on the motor up to full load.
- Release the spring tension slowly and at no load switch OFF the supply.
- Calculate the torque, output power and efficiency.
- Plot a graph of torque vs. speed and armature current, motor output vs. speed and efficiency.

Observation:-

No	V_1 in Volts	I_1 in Amp	Motor I/p = V_1 X I_1	F_1 in Kg	F_2 in Kg	Speed in rpm. N	Torque (T) = [9.81 re (F_1-F_2)] N-m	Power O/p P = $2\pi \frac{N}{60} T$ watts	$\% \eta = \frac{O/p\ power}{I/p\ Power}$

Calculations:-

- T *is the torque in kg meter and* $T = (F_1 - F_2) \times r$ *mkg* (Where **r** is radius of pulley in meter)
- $output\ of\ motor = \frac{2\pi\ NT}{60}\ mkg/Sec$

  $output\ of\ motor = \frac{2\pi\ NT}{60} \times 9.81\ watts$

- Efficiency of motor $= \frac{Output\ of\ motor}{Input\ \ watt\ meter\ reading}$
- Note:- Calculation of each load reading is calculated as above and average is taken to calculate efficiency of motor