BEE Experiments Record.

4. LOAD TEST ON SINGLE-PHASE TRANSFORMER.

☆ PRE-LAB QUESTIONS ⟹

① Explain the working principle of transformer.

→ 1) The electrical transformer has primary and secondary windings. The core laminations are joined in the form of strips in between the strips you can see that there are some narrow gaps right through the cross-section of the core. These staggered joints are said to be 'imbricated'.

2) Both the coils have high mutual inductance. A mutual electro-motive forces is induced in the transformer from the alternating flux that is set-up in the laminated core, due to the coil that is connected to a source of alternating voltage.

3) Most of the alternating flux developed by this coil is linked with the other coil and thus produces the mutual induced electro-motive force. The so produced electro-motive force can be explained with the help of Faraday's law of Electromagnetic Induction as: $e = M \cdot \frac{di}{dt}$

4) If the second coil circuit is closed, a current flows in it and thus electrical energy is transferred magnetically from the first to the second coil.

5) The alternating current supply is given to the first coil and hence it can be

called as the primary winding. The energy is drawn out from the second coil and thus can be called as the secondary winding.

② What are the main parts of a transformer?

→ There are three basic parts of transformer:

1) an iron core which serves as magnetic conductor.
2) a primary winding or coil of wire.
3) a secondary winding or coil of wire.

③ What are the types of transformers?

→ The types of transformers are as follows:

1) Stepup and Stepdown Transformer.
2) Power Transformer.
3) Distribution Transformer.
4) Instrument Transformer.
5) Current Transformer.
6) Potential Transformer.
7) Single - Phase Transformer.
8) Three - Phase Transformer.

④ What is the necessity of the load test for a transformer?

→ The purpose of load test is to determine the parallel operation and calculate the efficiency, thermal stability and dynamic stability of power transformer through measuring the short circuit loss and impedance voltage of power transformer.

⑤ What is the meaning of KVA rating of transformer?

→ 1) KVA stands for Kilovolt - Ampere and is the rating normally used to rate a transformer. The size of a transformer is determined by the KVA of the load.

2) The current that passes through windings of transformer will determine the copper losses, whereas iron losses, core losses or insultion losses depends on voltage.

☆ AIM ⟹

To conduct the load test on the given single-phase transformer for finding the efficiency and its regulation.

☆ APPARATUS REQUIRED ⟹

1) Voltmeter	= (0-150) V	⟶	1
	= (0-300) V	⟶	1
2) Ammeter	= (0-10) A	⟶	1
	= (0-20) A	⟶	1
3) Wattmeter	= 150V, 20A	⟶	1
	= 300V, 10A	⟶	1
4) Auto transformer	= 240 V	⟶	1
	= 2.7 KVA, 10A	⟶	1

☆ FORMULAE USED ⟹

1) Percentage Regulation $= \frac{(V_{02} - V_2)}{V_{02}} \times 100$

where,

V_{02} = secondary voltage on no load

V_0 = secondary voltage at particular load

2) Power Factor = $\frac{P_{out}}{V_2 \cdot I_2}$

where,

P_{out} = secondary wattmeter readings in watts

V_2 = secondary voltage in volts.

I_2 = secondary current in amperes.

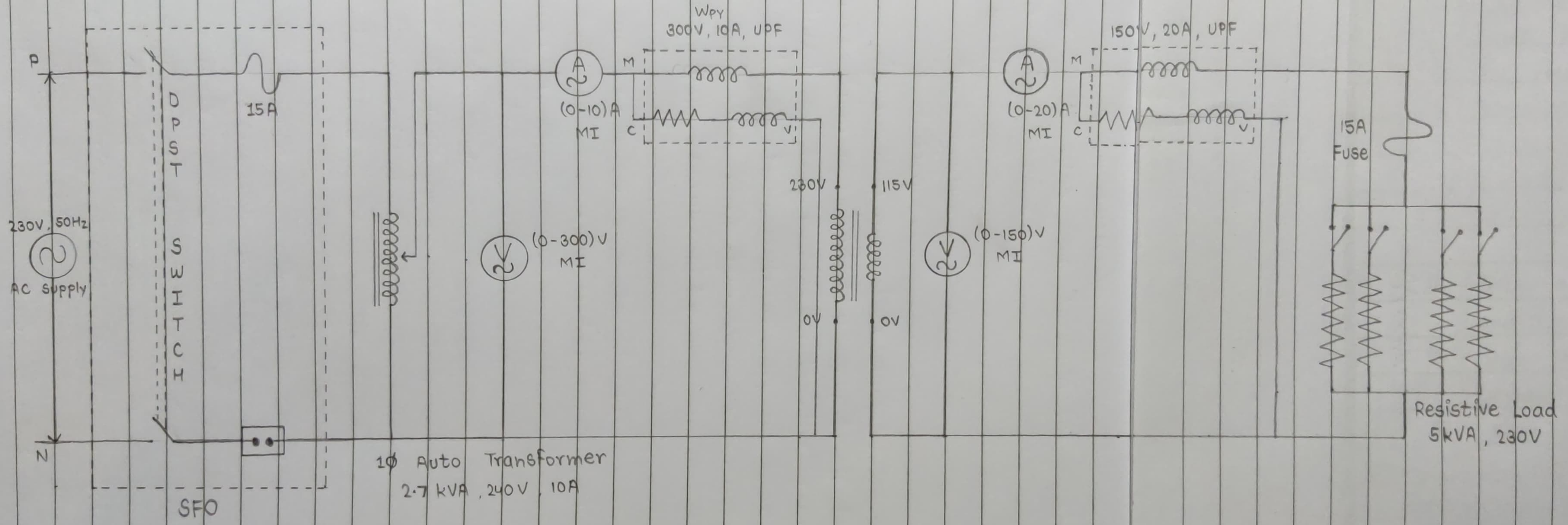
3) Percentage efficiency = $\frac{P_{out}}{P_{in}} \times 100$

where,

P_{out} = secondary wattmeter readings in watt

P_{in} = primary wattmeter readings in watt

☆ CIRCUIT DIAGRAM ⟹


Wpy
300V, 10A, UPF
150V, 20A, UPF
P
N
230V, 50Hz
AC supply
DPST
SWITCH
15A
SFO
M
C
V
(0-10)A
MI
(0-20)A
MI
(0-300)V
MI
(0-150)V
MI
230V
115V
0V
0V
15A
Fuse
1ϕ Auto Transformer
2.7 kVA, 240V, 10A
Resistive Load
5kVA, 230V

☆ TABULAR COLUMN ⟹

	Primary Voltage (V_1)	Primary Current (I_1)	Primary Watt (W_1)	Secondary Voltage (V_2)	Secondary Current (I_2)	Secondary Watt (W_2)	Power Factor ($\cos\theta$)	% Regulation (%)	% η
	(V)	(A)	(W)	(V)	(A)	(W)		(%)	(%)
1)	230	0.2051	11.29	115.41	0.1101	0	0	0	0
2)	230	0.2765	28.22	86.78	0.2256	16.10	0.8222	24.807	57.15
3)	230	0.2493	30.04	86.80	0.2227	17.17	0.8881	24.789	63.27
4)	230	0.2475	29.84	86.83	0.2194	18.88	0.9915	24.763	57.05
5)	230	0.2466	29.76	86.85	0.2178	18.75	0.9912	24.746	63.00
6)	230	0.2451	29.70	86.86	0.2159	18.67	0.9957	24.737	62.86

☆ CALCULATIONS ⟹

1) Power Factor.

$$\rightarrow \quad P.F = \frac{P_{out}}{V_2 \cdot I_2}$$

$$= \frac{16.10}{86.78 \times 0.2256} = \frac{16.10}{19.577} = 0.8222$$

$$\rightarrow \quad P.F = \frac{P_{out}}{V_2 \cdot I_2}$$

$$= \frac{18.88}{86.83 \times 0.2194} = \frac{18.88}{19.050} = 0.9915$$

$$\rightarrow \quad P.F = \frac{P_{out}}{V_2 \cdot I_2}$$

$$= \frac{18.67}{86.86 \times 0.2159} = \frac{18.67}{18.753} = 0.9957$$

2) Percentage Regulation.

$\longrightarrow \% R = \dfrac{(V_{o2} - V_o)}{V_{o2}} \times 100$

$= \dfrac{(115.41 - 86.80)}{115.41} \times 100$

$= \dfrac{28.61}{115.41} \times 100 = 0.24789 \times 100 = 24.789\%$

$\longrightarrow \% R = \dfrac{(V_{o2} - V_o)}{V_{o2}} \times 100$

$= \dfrac{(115.41 - 86.85)}{115.41} \times 100$

$= \dfrac{28.56}{115.41} \times 100 = 0.24746 \times 100 = 24.746\%$

$\longrightarrow \% R = \dfrac{(V_{o2} - V_o)}{V_{o2}} \times 100$

$= \dfrac{(115.41 - 86.78)}{115.41} \times 100$

$= \dfrac{28.63}{115.41} \times 100 = 0.24807 \times 100 = 24.807\%$

3) Percentage Efficiency.

$\longrightarrow \% \eta = \dfrac{P_{out}}{P_{in}} \times 100$

$= \dfrac{0}{11.29} \times 100 = 0 \times 100 = 0\%$

$\longrightarrow \% \eta = \dfrac{P_{out}}{P_{in}} \times 100$

$= \dfrac{18.75}{29.76} \times 100 = 0.6300 \times 100 = 63.00\%$

$\longrightarrow \% \eta = \dfrac{P_{out}}{P_{in}} \times 100$

$$= \frac{18.67}{29.70} \times 100 = 0.6286 \times 100 = 62.86\%$$

☆ RESULT ⟹

The load test on the given single-phase transformer for finding the efficiency and its regulation is conducted.

☆ POST - LAB QUESTIONS ⟹

① What is meant by eddy current losses?

→ 1) When an alternating current field is applied to a magnetic material, an emf is induced in the material itself according to Faraday's Law of Electromagnetic Induction.

2) Since, the magnetic material is conducting material, these EMFs circulate current within the body of the material. These circulating currents are called Eddy Currents.

3) They will occur when the conductor experiences a changing magnetic field. As these currents are not responsible for doing any useful work, and it produces a (I^2R loss) in magnetic material known as an Eddy Current Loss.

② How can we minimize the core losses in a transformer?

→ There are two types of core losses:

1) EDDY CURRENT LOSS: Eddy current loss can be reduced by increasing the number of laminations. The laminations provide small gaps between the plates. As it is easier for magnetic flux to flow through iron than air or oil, stray

Flux that can cause core losses in minimized, reducing eddy currents.

2) HYSTERESIS LOSS: The formula for hysteresis loss is: $P_h = \eta f B_{max}$

where,

P_h = hysteresis loss.

f = frequency.

B_{max} = maximum flux density.

Hence, from above formula only thing that can be reduced is the hysteresis loss (coefficient). It depends on the material, so we have to choose a material which has low hysteresis coefficient and high permeability.

③ What are the losses in a transformer?

→ The types of losses in a transformer are as follows:

1) Copper or Ohmic losses.
2) Stray losses.
3) Dielectric losses.
4) Iron or core losses.
   → Eddy-current.
   → Hysteresis.

④ What will happen if a DC voltage is given to the transformer primary winding?

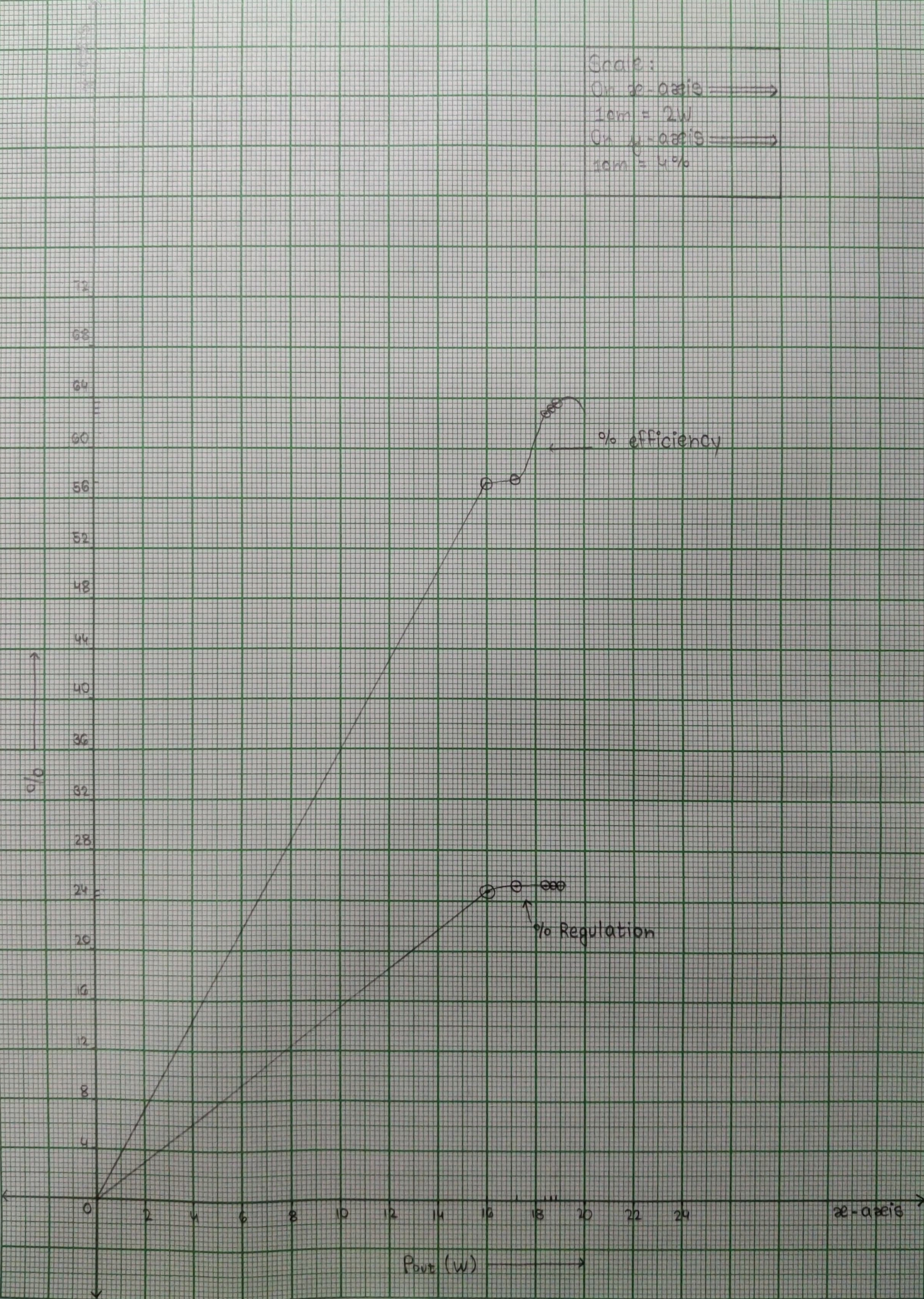
→ 1) When a DC voltage is applied to the primary winding of a transformer, due to low resistance, the winding acts as a short-circuit across the terminals of the DC source that lead to the flow of heavy current through the winding resulting in overheating of the winding.

⑤ How hysteresis loss can be reduced?

→ 1) Hysteresis loss can be reduced by using material having least hysteresis loop area.

2) Hence, silicon steel or high-grade steel is used for manufacturing of transformer core as it is having very less hysteresis loop area.

3) One can also laminate the core.


Scale :
On x-axis
1cm = 2W
On y-axis
1cm = 4%
% efficiency
% Regulation
%
Pout (W)
x-axis
0
2
4
6
8
10
12
14
16
18
20
22
24
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4