Objective: - To perform open circuit (OC) & short circuit (SC) test on single phase transformer and calculate the followings.

a. Complete parameters of equivalent circuit.

b. Efficiency at half of the full load and at unity power factor.

Apparatus Used: - One single phase transformer 2 kVA, 230/230 volts and following apparatus

S.No	Name	Type	Range	Quantity	
1	Single phase auto transformer		15A, 230/0-270 Volts	1	
2	Ammeter	MI	0-1 A	1	For OC test
3	Voltmeter	MI	0-250 V	1	
4	Wattmeter (Low PF 0.2)	Dynamometer	1 A, 250 V	1	
5	Ammeter	MI	0-5 A	1	For SC Test
6	Voltmeter	MI	0-30 V	1	
7	Wattmeter (High PF)	Dynamometer	5 A, 75 V	1	

Theory:

1. **Open Circuit (OC) test or No load test:**
   By OC test we can find out
   - Iron losses (P_i)
   - No load current (I_0)
   - $Cos\phi_0$, I_e, I_m, R_0 & X_0

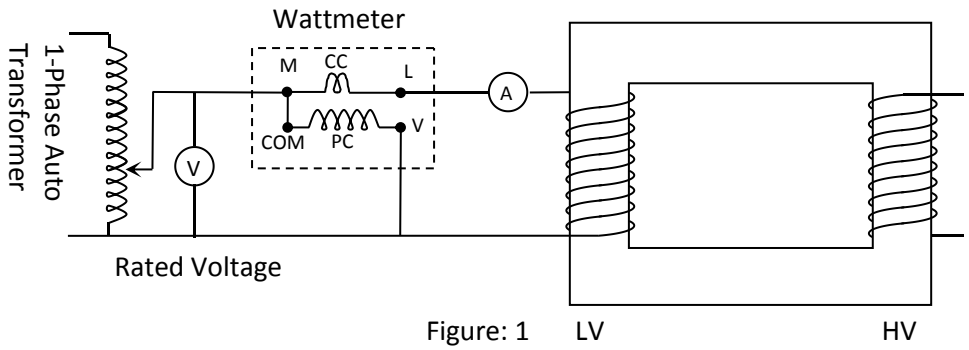

Figure: 1

Iron losses P_i = Reading of wattmeter (P_0)
No load current I_0 = Reading of Ammeter
Let V = Reading of voltmeter

$P_0 = P_i = VI_0\cos\phi_0$

$$\Rightarrow Cos\phi_0 = \frac{P_i}{VI_0}$$

$I_e = I_0\cos\phi_0$
$I_m = I_0\sin\phi_0$

$$R_0 = \frac{V}{I_e} \quad \& \quad X_0 = \frac{V}{I_m}$$

Note:

(i) Rated voltage is applied at LV side.
(ii) This test is generally done on LV side (Why?)

2. Short Circuit (SC) test:

By SC test we can find out

- Copper losses (P_C)
- Equivalent resistance or leakage reactance (R_{01} & X_{01} OR R_{02} & X_{02}) referred to metering side.

Full load Cu losses P_C = Reading of wattmeter (W_{sc})
Let Short circuit current I_{sc} = Reading of Ammeter
Short circuit voltage V_{sc} = Reading of voltmeter

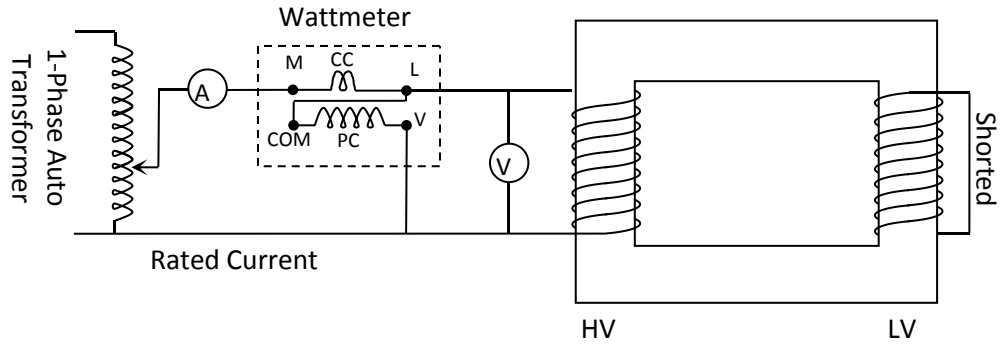

Figure: 2

$$W_{sc} = I_{sc}^2 R_{eq} \qquad \left(R_{eq} = R_{01} \ or \ R_{02}\right)$$
$$V_{sc} = I_{sc} Z_{eq} \qquad \left(Z_{eq} = Z_{01} \ or \ Z_{02}\right)$$

$$X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2} \qquad \left(X_{eq} = X_{01} \ or \ X_{02}\right)$$

Note:

(i) Rated Current is applied at HV side.
(ii) This test is generally done on HV side (Why?)
(iii) Why the position of ammeter and voltmeter is changed as compared to OC test?
(iv) Why com terminal of wattmeter is connected with terminal L not with terminal M?

3. Efficiency of transformer:

Efficiency at x time of full load

$$\eta = \frac{xP_2}{xP_2 + P_i + x^2 P_C} \times 100 \qquad Where \quad P_2 = V_2 I_2 Cos\phi_2 = Rated\ VA \times Cos\phi_2$$

$$Cos\phi_2 = Load\ PF$$

Circuit Diagram:- See figure 1 & 2

Observation table:-

OC Test			SC Test		
P_i or P_0 (W)	**V (V)**	**I_0 (A)**	**P_c or W_{sc} (W)**	**V_{sc} (V)**	**I_{sc} (A)**

Calculation:-

Equivalent circuit of transformer:

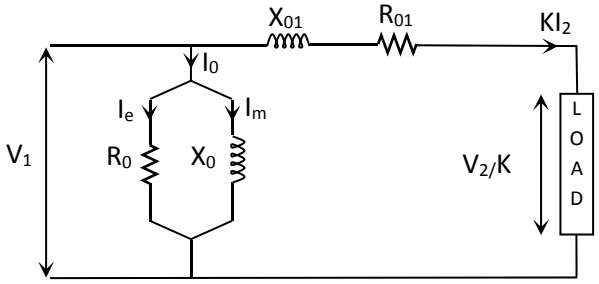

Figure 3: Approximately & simplified Equivalent Circuit Referred to primary side

For OC test: find MF

$$\text{Multiplying Factor (M.F.)} = \frac{\text{VI Cos}\Phi}{\text{Full scale deflection(FSD)}} \qquad \cos\Phi = 0.2$$

$$Cos\phi_0 = \frac{P_i}{VI_0}$$

$I_e = I_0 Cos\phi_0$

$I_m = I_0 Sin\phi_0$

$$R_0 = \frac{V}{I_e} \;\&\; X_0 = \frac{V}{I_m}$$

For SC test: find MF

$$\text{Multiplying Factor (M.F.)} = \frac{\text{VI Cos}\Phi}{\text{Full scale deflection(FSD)}} \qquad \cos\Phi = 1$$

$$W_{sc} = I_{sc}^2 R_{eq} \qquad \left(R_{eq} = R_{01} \;\; or \;\; R_{02}\right)$$

$$V_{sc} = I_{sc} Z_{eq} \qquad \left(Z_{eq} = Z_{01} \;\; or \;\; Z_{02}\right)$$

$$X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2} \qquad \left(X_{eq} = X_{01} \;\; or \;\; X_{02}\right)$$

Efficiency at full load: x =1 & PF = 1

$$\eta = \frac{P_2}{P_2 + P_i + P_C} \times 100 \qquad Where \quad P_2 = V_2 I_2 Cos\phi_2 = Rated\ VA \times Cos\phi_2$$

Result: - The OC & SC test has been performed on given transformer and the calculated value of equivalent parameters & efficiency is given in following table

From OC Test					From SC Test			
Iron Loss (P_i) (W)	**No load Current I_0 (A)**	**No Load PF $Cos\phi_0$**	**X_0 (Ω)**	**R_0 (Ω)**	**Full load cu loss P_c (W)**	**R_{eq} (Ω)**	**X_{eq} (Ω)**	**Efficiency (%)**

Precautions:-

1. In SC test applied voltage is very less to get the rated short circuit current. Don't give rated voltage otherwise very high current will follow and system will get damage.
2. Make sure that auto transformer is at zero position.
3. The main switch should be at off position before doing the connections.
4. All connection should be tight and clean.
5. The reading in instruments should not exceed from their permissible limit.
6. Don't touch the necked terminals as voltage is high.
7. Always wear shoes when working in the lab. Avoid wearing loose clothes, hanging chains etc.

Answer the following questions

Q1. Which types of losses are found by OC & SC tests?

Q2. Why transformers are rated in KVA not in KW?