CHENNAI INSTITUTE OF TECHNOLOGY
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Chennai – 600 069.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

LABORATORY MANUAL

Subject Name : ELECTRICAL MACHINES LAB-I
Subject Code : 
Semester : IV
ELECTRICAL MACHINES LAB-I

LIST OF EXPERIMENTS:

1. Open circuit and load characteristics of separately and self excited DC shunt generators.
2. Load characteristics of DC compound generator with differential and cumulative connection.
3. Load characteristics of DC shunt and compound motor.
4. Load characteristics of DC series motor.
5. Swinburne’s test and speed control of DC shunt motor.
7. Load test on single-phase transformer and three phase transformer connections.
8. Open circuit and short circuit tests on single phase transformer.
9. Sumpner’s test on transformers.
10. Separation of no-load losses in single phase transformer.
OPEN CIRCUIT & LOAD CHARACTERISTICS SEPERATELY EXCITED D.C. SHUNT GENERATOR

AIM

To draw the open circuit characteristics of separately excited D.C. shunt generator.

APPARATUS REQUIRED:-

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ammeter</td>
<td>(0-5) A</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Ammeter</td>
<td>(0-2) A</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter</td>
<td>(0-300) C</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Rheostat</td>
<td>200 Ω, 2A</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Rheostat</td>
<td>400 Ω, 1A</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>Tachometer</td>
<td>(0-10000)rpm</td>
<td>Analog</td>
<td>1</td>
</tr>
</tbody>
</table>

Open Circuit Characteristics:-

PROCEDURE

- The connections are made as per the circuit diagram.
- The DPST switch is closed.
- The motor is started using three point starter.
- By varying the field rheostat of the motor, the speed of the motor, is adjusted to the rated speed of the generator.
- The initial voltage due to residual magnetism is noted & The SPST switch should be closed.
- The field rheostat of the generator is varied in steps.
- In each step the ammeter and voltmeter readings are noted.

PRECAUTION

- All the switches are kept open initially.
- The motor field rheostat is kept at minimum resistance position.
- The generator field rheostat is kept at maximum resistance position.
- The SPST should be kept open at the time of starting to find the residual voltage.
OPEN CIRCUIT DIAGRAM:

CIRCUIT DIAGRAM:

Fuse
27A

220V DC Supply

27A
Fuse

3 Point Starter

1250Ω
0.8A

F1

A1
A2
A3

1250Ω
0.8A

F3

A1
A2
A3

1250Ω
0.8A

F1

A1
A2
A3

(0-300)V MC

FUSE RATING:

125% of rated current

125 x 21

---

100

= 26.25A

NAME PLATE DETAILS:

Motor

Generator

Rated Voltage : 220V
Rated Current : 21A
Rated Power : 3.5kW
Rated Speed : 1500 RPM

(0-1)A MC

LOAD TEST DIAGRAM:

CIRCUIT DIAGRAM:

Fuse
27A

220V DC Supply

27A
Fuse

3 Point Starter

1250Ω
0.8A

F1

A1
A2
A3

1250Ω
0.8A

F3

A1
A2
A3

1250Ω
0.8A

F1

A1
A2
A3

(0-300)V MC

FUSE RATING:

125% of rated current

125 x 21

---

100

= 26.25A

NAME PLATE DETAILS:

Motor

Generator

Rated Voltage : 220V
Rated Current : 21A
Rated Power : 3.5kW
Rated Speed : 1500 RPM

(0-2)A MC

Load
TABULAR COLUMN FOR OPEN CIRCUIT TEST:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Field current, $I_f$ Amperes</th>
<th>Generated EMF, $E_g$ volts</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

Load test:

PROCEDURE

- The connections are given as per the circuit diagram.
- The DPST of the motor side is closed.
- The motor is started using the 3-point starter.
- By varying the field rheostat of the motor, the speed of the motor is adjusted to the rated speed of the generator.
- The DPST switch of the generator side is closed.
- The load on the generator is applied in steps.
- At each step of loading the meter readings are noted.
- The procedure is repeated till the ammeter reads the rated current of the generator.

PRECAUTION

- All the switches are kept open initially.
- The motor field rheostat is kept at minimum resistance position.
- The generator field rheostat is kept at maximum resistance position.
- There should not be any load on the generator when start and stop the motor.
### TABULAR COLUMN FOR LOAD TEST

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage, ( V ) (Volts)</th>
<th>Current, ( I_L ) (Amperes)</th>
<th>Armature Current, ( I_a ) (Amperes)</th>
<th>Field current, ( I_f ) (Amperes)</th>
<th>Generated EMF, ( E_g ) (Volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

### DETERMINATION OF ARMATURE RESISTANCE:

![Diagram of DC Motor Test Circuit]

- Supply: 220V DC
- Load: 5 KW, 230V
- Current Measurement: Ammeter (A) and Voltmeter (V)
**TABULAR COLUMN:**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Voltage V (Volts)</th>
<th>Current I (Amps)</th>
<th>Armature Resistance Rₐ (Ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MODEL CALCULATION:-**

Armature current, \( I_a = I_L + I_f \)

Generated EMF, \( E_g = (V + I_a R_a) \)

**MODEL GRAPH:**

![Model Graph]

**Critical Resistance = \( E_o / I_f \) Ohms**

**RESULT:**

Thus the O.C.C. and load characteristics of separately excited D.C. shunt generator have been drawn.
OPEN CIRCUIT & LOAD CHARACTERISTICS SELF EXCITED D.C. SHUNT GENERATOR

AIM

To draw the open circuit characteristics of self excited D.C. shunt generator

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ammeter</td>
<td>(0 - 20A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Ammeter</td>
<td>(0 - 2A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Voltmeter</td>
<td>(0 - 300V)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Rheostat</td>
<td>200 Ω, 2A</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Tachometer</td>
<td>(0 -10000rpm)</td>
<td>Analog</td>
<td>1</td>
</tr>
</tbody>
</table>

Open Circuit Characteristics:-

PRECAUTION

❖ All the switches are kept open initially.
❖ The motor field rheostat is kept at minimum resistance position.
❖ The generator field rheostat is kept at maximum resistance position.
❖ The SPST should be kept open at the time of starting to find the residual voltage.

PROCEDURE

❖ The connections are made as per the circuit diagram.
❖ The DPST switch is closed.
❖ The motor is started using three point starter.
❖ By varying the field rheostat of the motor, the speed of the motor, is adjusted to the rated speed of the generator.
❖ The initial voltage due to residual magnetism in noted & The SPST switch should be closed.
❖ The field rheostat of the generator is varied in steps.
❖ In each step the ammeter and voltmeter readings are noted.
### TABULAR COLUMN OPEN CIRCUIT TEST

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Field current, $I_f$ Amperes</th>
<th>Generated EMF, $E_g$ volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
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<tr>
<td>2.</td>
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<td>4.</td>
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<td>8.</td>
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<tr>
<td>9.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
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</tr>
</tbody>
</table>

**FUSE RATING:**

125% of rated current

$$125 \times \frac{21}{100} = 26.25 \text{A}$$

**NAME PLATE DETAILS:**

<table>
<thead>
<tr>
<th></th>
<th>Motor</th>
<th>Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>220V</td>
<td>220V</td>
</tr>
<tr>
<td>Rated Current</td>
<td>21A</td>
<td>21A</td>
</tr>
<tr>
<td>Rated Power</td>
<td>3.5kW</td>
<td>7.5kW</td>
</tr>
<tr>
<td>Rated Speed</td>
<td>1500 RPM</td>
<td>1500 RPM</td>
</tr>
</tbody>
</table>

**CIRCUIT DIAGRAM:**

- DC Supply
- Fuse 27A
- 3 Point Starter
- SPST Switch
- 1250Ω 0.8A
- Motor
- Generator
- (0-300) V MC
Load test

PROCEDURE

- The connections are given as per the circuit diagram.
- The DPST of the motor side is closed.
- The motor is started using the 3-point starter.
- By varying the field rheostat of the motor, the speed of the motor is adjusted to the rated speed of the generator.
- The DPST switch of the generator side is closed.
- The load on the generator is applied in steps.
- At each step of loading the meter readings are noted.
- The procedure is repeated till the ammeter reads the rated current of the generator.

PRECAUTION

- All the switches are kept open initially.
- The motor field rheostat is kept at minimum resistance position.
- The generator field rheostat is kept at maximum resistance position.
- There should not be any load on the generator when start and stop the motor.

CIRCUIT DIAGRAM:

**Fuse Rating:**

\[
125\% \text{ of rated current} = \frac{1.25 \times 21}{100} \approx 26.25\text{A}
\]

**Name Plate Details:**

<table>
<thead>
<tr>
<th>Motor</th>
<th>Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage : 220V</td>
<td>220V</td>
</tr>
<tr>
<td>Rated Current : 21A</td>
<td>21A</td>
</tr>
<tr>
<td>Rated Power : 3.5kW</td>
<td>7.5kW</td>
</tr>
<tr>
<td>Rated Speed : 1500 RPM</td>
<td>1500 RPM</td>
</tr>
</tbody>
</table>
### TABULAR COLUMN FOR LOAD TEST

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage, V (Volts)</th>
<th>Current, $I_L$ (Amperes)</th>
<th>Field current, $I_f$ (Amperes)</th>
<th>Armature Current, $I_a$ (Amperes)</th>
<th>Generated EMF, $E_g$ (Volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

### MODEL CALCULATION:

Armature current, $I_a = I_L = I_f$

Generated EMF, $E_g = (V + I_a R_a)$

### RESULT

Thus the O.C.C. and load characteristic of self excited D.C. shunt generator were drawn.
LOAD TEST ON D.C. COMPOUND GENERATOR

AIM

To conduct the load test on the given D. C. compound generator in the following modes.

1. Cumulative
2. Differential

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ammeter</td>
<td>(0 - 20A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Ammeter</td>
<td>(0 - 20A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter</td>
<td>(0 - 300V)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Rheostat</td>
<td>200, 2AΩ</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Tachometer</td>
<td>(0 -10000rpm)</td>
<td>Analog</td>
<td>1</td>
</tr>
</tbody>
</table>

PRECAUTION

- All the switches should be kept open.
- The field rheostat of the motor should be kept at minimum resistance position.
- The field rheostat of the generator should be kept at maximum resistance position.

PROCEDURE

- The connections are made as per the circuit diagram.
- The DPST switch is closed.
- The motor is started using four point starter.
- The field rheostat of the motor is adjusted to bring the motor speed to the rated speed of the generator.
- The generator field rheostat is adjusted till the voltmeter reads the rated voltage of the generator.
- DPST switch on the generator side is closed.
- The load is increased in steps.
- At each step of loading all the meter readings are noted.
- The above procedure is repeated till the ammeter reads the rated current.
- Switch off the load gradually and make the motor and generator rheostat resistance position instructed in the precaution.
- Turn off the supply
- Interchange the terminal connection of the generator series field coil and repeat the procedure right from the first step.
RESULT

Thus the performance characteristics of the DC compound generator were drawn.
LOAD TEST ON D.C. COMPOUND MOTOR

AIM

To draw the performance characteristics of DC compound motor by conducting load test.

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the Apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ammeter</td>
<td>(0 - 20A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Voltmeter</td>
<td>(0 - 300V)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Rheostat</td>
<td>200Ω, 2 A</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Tachometer</td>
<td>(0 - 10000rpm)</td>
<td>Analog</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Ammeter</td>
<td>(0 - 2A)</td>
<td>MC</td>
<td>1</td>
</tr>
</tbody>
</table>

PRECAUTION

❖ All the switches are kept open initially.
❖ The field rheostat should be kept a minimum resistance position.
❖ There should not be any load when start and stop the motor.

PROCEDURE

❖ The connections are given as per the circuit diagram.
❖ The DPST switch is closed.
❖ The motor is started using the four point starter.
❖ The speed of the motor is adjusted to the rated value by varying the field rheostat.
❖ The no load readings are noted.
❖ The load on the brake drum increased in steps.
❖ At each step of loading the meter readings are noted.
❖ The procedure is repeated till the ammeter reads the rated current.
CIRCUIT DIAGRAM:

FUSE RATING:
125% of rated current
125 x 18.6
------------------ = 23.22 A
100

NAME PLATE DETAILS:
Rated Voltage : 220V
Rated Current : 18.6 A
Rated Power : 3.5 KW
Rated Speed : 1500 rpm

TABULAR COLUMN

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage, $V_L$ (V)</th>
<th>Current $I_L$ (A)</th>
<th>Spring balance $S_1$ Kg</th>
<th>$S_2$ Kg</th>
<th>Speed Rpm</th>
<th>Torque N-m</th>
<th>Input $P_i$ watts</th>
<th>Output $P_m$ watts</th>
<th>Efficiency In %</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
MODEL CALCULATION:-

Circumference of brake drum = $2 \times \pi \times R$ in meter

$R$ – Radius of the brake drum

Torque, $T = (S_1 - S_2) \times 9.81 \times R$ in Nm

Input power, $P_i = V_i \times I_i$ in Watts

Output power, $P_m = \frac{(2 \times \pi \times N \times T)}{60}$ in Watts

% Efficiency, $\eta = \frac{P_m}{P_i} \times 100$

RESULT

Thus the performance characteristics of the DC compound motor were drawn.
LOAD TEST ON DC SHUNT MOTOR

DATE: 

AIM: To conduct a load test on DC shunt motor and to find its efficiency

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ammeter</td>
<td>(0-20)A</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Voltmeter</td>
<td>(0-300)V</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Rheostat</td>
<td>1250Ω, 0.8A</td>
<td>Wire Wound</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Tachometer</td>
<td>(0-1500) rpm</td>
<td>Digital</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Connecting Wires</td>
<td>2.5sq.mm.</td>
<td>Copper</td>
<td>Few</td>
</tr>
</tbody>
</table>

PRECAUTIONS:

1. DC shunt motor should be started and stopped under no load condition.
2. Field rheostat should be kept in the minimum position.
3. Brake drum should be cooled with water when it is under load.

PROCEDURE:

1. Connections are made as per the circuit diagram.
   Circumference of the Brake drum = cm.

2. After checking the no load condition, and minimum field rheostat position, DPST switch is closed and starter resistance is gradually removed.

3. The motor is brought to its rated speed by adjusting the field rheostat.

4. Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.

5. The load is then added to the motor gradually and for each load, voltmeter, ammeter, spring balance readings and speed of the motor are noted.
6. The motor is then brought to no load condition and field rheostat to minimum position, then DPST switch is opened.

**Circuit Diagram:**

![Circuit Diagram](image)

**Fuse Rating:**

\[
125\% \text{ of rated current} \\
125 \times 21 = 26.25 \text{A}
\]

**Name Plate Details:**

- Rated Voltage: 220V
- Rated Current: 21A
- Rated Power: 3.5KW
- Rated Speed: 1500 RPM

**Model Graphs:**

- Speed N (rpm)
- Torque T (Nm)
- Efficiency %
- Output Power (Watts)
MODEL CALCULATION:-

Circumference of brake drum = 2 x \( \pi \) x R

R – Radius of the brake drum

Torque, \( T = (S_1 - S_2) \times 9.81 \times R \) Nm

Input power, \( P_i = V_L \times I_L \) Watts

Output power, \( P_m = (2 \times \pi \times N \times T) / 60 \) Watts

% Efficiency, \( \eta = (P_m / P_i) \times 100 \)

RESULT: Thus the load test on DC shunt motor is conducted and its efficiency is determined.
LOAD TEST ON D.C. SERIES MOTOR

AIM

To draw the performance characteristics of the D.C. series motor.

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ammeter</td>
<td>(0 - 20A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Voltmeter</td>
<td>(0 - 300V)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Rheostat</td>
<td>200, 2AΩ</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Tachometer</td>
<td>(0 -10000rpm)</td>
<td>Analog</td>
<td>1</td>
</tr>
</tbody>
</table>

PRECAUTION

❖ There should be some load on the brake drum while start and stop the experiment.
❖ The brake drum should be cool down instantaneously by pouring the water on the brake drum.

PROCEDURE

❖ The connections are made as per the circuit diagram.
❖ The DPST switch is closed.
❖ The motor is started using two point starter.
❖ The no load readings are noted.
❖ Load on the brake drum is increased in steps.
❖ At each step of loading all the meter readings are noted.
❖ The procedure is repeated till the ammeter reads the rated current of the motor.

MODEL CALCULATION:

Circumference of brake drum = 2 x π x R  in Meter

R – Radius of the brake drum

Torque, T = (S₁ – S₂) x 9.81 x R  in Nm

Input power, Pᵢ = Vᵢ x Iᵢ  in Watts

Output power, Pₘ = (2 x π x N x T) / 60 in Watts

% Efficiency, η = (Pₘ / Pᵢ) x 100
### Circuit Diagram:

```
+-----------------+       +-----------------+       +-----------------+
|                A |       |                L |       |                A |
| V               |       | (0-300)V MC     |       | (0-20)A MC     |
| D P S T         |       |                  |       |                  |
| S W T C H       |       |                  |       |                  |
| 220V DC Supply |       |                  |       |                  |
| Fuse           |       |                  |       |                  |
|                25A|       |                  |       | 2 Point Starter |
|                |       |                  |       |                  |
| S_1 Kg         |       |                  |       | S_2 Kg          |
| S_2 Kg         |       |                  |       |                  |
| Brake Drum     |       |                  |       |                  |
```

### Fuse Rating:

125% of rated current

\[
\frac{125 \times 20}{100} = 25 A
\]

### Name Plate Details:

- Rated Voltage: 220V
- Rated Current: 20A
- Rated Power: 5Kw
- Rated Speed: 1500 RPM

### Tabular Column

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage, ( V_L ) (V)</th>
<th>Current, ( I_L ) (A)</th>
<th>Spring balance ( S_1 ) Kg, ( S_2 ) Kg</th>
<th>Speed Rpm</th>
<th>Torque N-m</th>
<th>Input ( P_i ) watts</th>
<th>Output ( P_m ) watts</th>
<th>Efficiency In %</th>
</tr>
</thead>
</table>
Thus the performance characteristics of the DC series motor were drawn.
SWINBURNE’S TEST

AIM

To predetermine the efficiency of the D.C. machine as

(i) Motor
(ii) Generator

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Name of the apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ammeter</td>
<td>(0 - 10A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Ammeter</td>
<td>(0 - 2 A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter</td>
<td>(0 - 300 V)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Rheostat</td>
<td>200, 2АΩ</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Tachometer</td>
<td>(0 -10000rpm)</td>
<td>Analog</td>
<td>1</td>
</tr>
</tbody>
</table>

PRECAUTION

- The field rheostat should be kept at minimum resistance position.
- There should be no load at the time of starting the experiment.

PROCEDURE

- The connections are made as per the circuit diagram.
- The DPST switch is closed.
- The motor is started using three point starter.
- The field rheostat of the motor is adjusted to bring the motor speed to the rated value.
- The no load current, voltage and shunt field current are noted.
### Tabular Column

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage, V (volts)</th>
<th>Field current, $I_r$ (A)</th>
<th>No load current, $I_0$ (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

**For generator**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage (volts)</th>
<th>Load Current, $I_L$ (A)</th>
<th>$I_a = I_L + I_r$ (A)</th>
<th>$I_a^2 R_a$ (watts)</th>
<th>Total Loss (watts)</th>
<th>Input Power (watts)</th>
<th>Output Power (watts)</th>
<th>Efficiency %$\eta$</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>
### For motor

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage (volts)</th>
<th>Load Current, $I_L$ (A)</th>
<th>$I_a = I_L + I_f$ (A)</th>
<th>$I_a^2 R_a$</th>
<th>Total Loss (watts)</th>
<th>Input Power (watts)</th>
<th>Output Power (watts)</th>
<th>Efficiency % $\eta$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

### FORMULAE

- **Hot Resistance** $R_a = 1.2 \times R \ \Omega$
- **Constant losses** $= VI_o - I_{ao}^2 R_a \ \text{watts}$
  - Where $I_{ao} = (I_o - I) \ \text{Amps}$

### AS MOTOR:

- **Load Current** $I_L = \_\_\_\_ \ \text{Amps}$ (Assume 15%, 25%, 50%, 75% of rated current)
- **Armature current** $I_a = I_L - I_f \ \text{Amps}$
- **Copper loss** $= I_a^2 R_a \ \text{watts}$
- **Total losses** $= \text{Copper loss} + \text{Constant losses}$
- **Input Power** $= VI_L \ \text{watts}$
- **Output Power** $= \text{Input Power} - \text{Total losses}$
  - Output power
- **Efficiency $\%$** $= \frac{\text{Output Power}}{} \times 100\%$

### AS GENERATOR:

- **Load Current** $I_L = \_\_\_\_ \ \text{Amps}$ (Assume 15%, 25%, 50%, 75% of rated current)
- **Armature current** $I_a = I_L + I_f \ \text{Amps}$
Copper loss = I_a^2 R_a watts
Total losses = Copper loss + Constant losses
Output Power = V I_L watts

Input Power = Input Power + Total losses
Output power

Efficiency \( \% \) = \(
\frac{\text{Output Power}}{\text{Input Power}}\)
\times 100%

RESULT
Thus the efficiency of the DC machine has been predetermined and characteristic were drawn.
SPEED CONTROL OF D.C. SHUNT MOTOR

AIM

To draw the speed characteristics of DC shunt motor by

(1) Armature control method
(2) Field control method

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the Apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ammeter</td>
<td>(0 - 20 A)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Voltmeter</td>
<td>(0 - 300 V)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Rheostat</td>
<td>200Ω, 2 A</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Tachometer</td>
<td>(0-10000 rpm)</td>
<td>Analog</td>
<td>1</td>
</tr>
</tbody>
</table>

PRECAUTION

❖ All the switches are kept open initially.
❖ The field rheostat should be kept at minimum resistance position.
❖ The armature rheostat should be kept at maximum resistance position.

PROCEDURE

(1) Armature control method:-

❖ The connections are given as per the circuit diagram. The DPST switch is closed.
❖ The field current is varied in steps by varying the field rheostat.
❖ In each step of field current the armature voltage is varied in steps by varying the armature rheostat.
❖ In each step of armature rheostat variation the meter readings (Voltmeter & Tachometer) are noted.

(2) Field control method:-

❖ The connections are given as per the circuit diagram.
❖ The DPST switch is closed.
❖ The armature voltage is varied in steps by varying the armature rheostat.
❖ In each step of armature voltage the field current in steps by varying the field rheostat.
❖ In each step of field rheostat the meter readings (Ammeter & tachometer) are noted.
CIRCUIT DIAGRAM:

FUSE RATING:

125% of rated current

\[
\frac{125 \times 21}{100} = 26.25 \text{A}
\]

NAME PLATE DETAILS:

Rated Voltage: 220V
Rated Current: 21A
Rated Power: 3.5KW
Rated Speed: 1500 RPM

MODEL GRAPHS:

- Speed N (rpm) vs. \( V_a \) (Volts)
- Speed N (rpm) vs. \( I_r \) (Amps)
## Armature control method

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>( I_f = )</th>
<th>( I_f = )</th>
<th>( I_f = )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( V_a ) volts</td>
<td>( N ) rpm</td>
<td>( V_a ) volts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Field method:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>( V_a = )</th>
<th>( V_a = )</th>
<th>( V_a = )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( I_f ) volts</td>
<td>( N ) rpm</td>
<td>( I_f ) volts</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

RESULT:

Thus the speed control of DC Shunt Motor is obtained using Armature and Field control methods.
HOPKINSON’S TEST

AIM

To draw the efficiency characteristics of a DC machine as

(i) DC motor
(ii) DC generator

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ammeter</td>
<td>(0 - 2 A)</td>
<td>MC</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Ammeter</td>
<td>(0 - 20 A)</td>
<td>MC</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter</td>
<td>(0 - 300 V)</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Rheostat</td>
<td>200 Ω, 2A</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Tachometer</td>
<td>(0-10000 rpm)</td>
<td>Analog</td>
<td>1</td>
</tr>
</tbody>
</table>

PROCEDURE

- The connections are given as per the circuit diagram. The DPST switch is closed.
- The motor is started using 3 point starter.
- The speed of the motor is adjusted to the rated speed of the generator by varying the field rheostat of the motor.
- The voltage generated by the generator is made equal to the supply voltage by varying the generator field rheostat (monitored by the voltmeter connected across the SPST switch).
- The SPST switch is closed.
- The machine is loaded by varying any one of the field rheostat & all the meter readings are noted.

PRECAUTION

- All the switches are kept open initially.
- The motor field rheostat should be kept at minimum resistance position at the time of start.
and stop the experiment.

- The generator field rheostat should be kept at maximum resistance position at the time of start and stop the experiment.

**CIRCUIT DIAGRAM:**

**NAME PLATE DETAILS:**

<table>
<thead>
<tr>
<th>SHUNT MOTOR</th>
<th>SHUNT GENERATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage : 220V</td>
<td>220V</td>
</tr>
<tr>
<td>Rated Current : 21A</td>
<td>21A</td>
</tr>
<tr>
<td>Rated Power : 3.5KW</td>
<td>7.5KW</td>
</tr>
<tr>
<td>Rated Speed : 1500 rpm.</td>
<td>1500 rpm.</td>
</tr>
</tbody>
</table>

**TABULAR COLUMN:**

<table>
<thead>
<tr>
<th>V_L</th>
<th>I_L</th>
<th>Generator</th>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volts</td>
<td>Amperes(i_2)</td>
<td>I_g in A (I_1)</td>
<td>I_am in A (I_1+I_2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### DC motor:

<table>
<thead>
<tr>
<th>$V_L$ (Volts)</th>
<th>$I_L$ (Amperes)</th>
<th>$I_a = I_L - I_F$</th>
<th>$I_a^2 R_a$</th>
<th>Constant Loss in watts</th>
<th>Total Loss in watts</th>
<th>Input watts</th>
<th>Output watts</th>
<th>Efficiency in %</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

### DC generator:

<table>
<thead>
<tr>
<th>$V_L$ (Volts)</th>
<th>$I_L$ (Amperes)</th>
<th>$I_a = I_L + I_F$</th>
<th>$I_a^2 R_a$</th>
<th>Constant Loss in watts</th>
<th>Total Loss in watts</th>
<th>Input watts</th>
<th>Output watts</th>
<th>Efficiency in %</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

### Formulae:

1. **Input Power** = $VI_1$ watts
2. **Motor armature cu loss** = $(I_1 + I_2)^2$ Ra watts
3. **Generator armature cu loss** = $I_2^2$ Ra watts
4. **Total Stray losses** $W$ = $V I_1 - (I_1 + I_2)^2 Ra + I_2^2 Ra$ watts.
W/2 watts.

**AS MOTOR:**

Input Power = Armature input + Shunt field input
= \((I_1 + I_2) \cdot V + I_3 \cdot V = (I_1 + I_2 + I_3) \cdot V\)

Total Losses = Armature Cu loss + Field loss + stray loss
= \((I_1 + I_2)^2 \cdot Ra + V \cdot I_3 + W/2\) watts

Efficiency \(\eta\) % = \frac{\text{Input power} - \text{Total Losses}}{\text{Input Power}} \times 100\%

**AS GENERATOR:**

Output Power = \(VI_2\) watts

Total Losses = Armature Cu loss + Field Loss + Stray loss
= \(I_2^2 \cdot Ra + V \cdot I_4 + W/2\) watts

Efficiency \(\eta\) % = \frac{\text{Output power}}{\text{Output Power} + \text{Total Losses}} \times 100\%

**MODEL GRAPH:**

As a Generator

As a Motor

OUTPUT POWER \(P_0\) (W)

**RESULT:**

Thus the efficiency characteristics of the DC machine have been drawn.
LOAD TEST ON SINGLE PHASE TRANSFORMER

AIM

To draw the efficiency and regulation characteristics of single phase transformer

APPARATUS REQUIRED:-

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ammeter</td>
<td>(0 -10A)</td>
<td>MI</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Ammeter</td>
<td>(0 - 20A)</td>
<td>MI</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter</td>
<td>(0 - 300V)</td>
<td>MI</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Voltmeter</td>
<td>(0 -150V)</td>
<td>MI</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Voltmeter</td>
<td>150 V/20 A, UPF</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>Voltmeter</td>
<td>300 V / 10 A, UPF</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

PRECAUTION

- All the switches are kept open initially.
- The auto transformer is kept at minimum potential position at time of starting and stopping the experiment.

PROCEDURE

- The connections are given as per the circuit diagram.
- The DPST switch is closed.
- The terminal (secondary) voltage of the transformer is adjusted to the rated value by varying the auto transformer.
- The initial readings of all the meters are noted.
- The load is applied in steps.
- At each step of loading all the meters readings are noted.
- The procedure is repeated till ammeter reads rated current of the secondary side.
Circuit Diagram:

Fuse Rating:
125% of rated current
\[
\frac{1.25 \times 5}{100} = 0.25 \text{A}
\]

Name Plate Details:

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>200V</td>
</tr>
<tr>
<td>Rated Current</td>
<td>5A</td>
</tr>
<tr>
<td>Rated Power</td>
<td>1KVA</td>
</tr>
</tbody>
</table>

Model Graphs:

Efficiency \(\eta\) % vs. Output Power (Watts)

Regulation \(R\) % vs. Output Power (Watts)
MODEL CALCULATION

Efficiency = \( \frac{W_2}{W_1} \)

% Regulations = \( \frac{V_{NL} - V_1}{V_{NL}} \times 100 \)

TABULAR COLUMN

\( V_{NL} = \text{-------- Volts} \)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Primary readings</th>
<th>Secondary readings</th>
<th>Efficiency in %</th>
<th>Regulation in %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( W_1 )</td>
<td>( V_1 )</td>
<td>( I_1 )</td>
<td>( W_2 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

RESULT

Thus the efficiency and regulation characteristic of single phase transformer has been drawn.
OPEN CIRCUIT & SHORT CIRCUIT TEST ON A SINGLE PHASE TRANSFORMER

AIM:

To predetermine the efficiency and regulation of a transformer by conducting open circuit test and short circuit test and to draw equivalent circuit

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ammeter</td>
<td>(0-2)A</td>
<td>MI</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0-5) A</td>
<td>MI</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Voltmeter</td>
<td>(0-150)V</td>
<td>MI</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Wattmeter</td>
<td>(150V, 5A)</td>
<td>LPF</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(150V, 5A)</td>
<td>UPF</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Connecting Wires</td>
<td>2.5sq.mm</td>
<td>Copper</td>
<td>Few</td>
</tr>
</tbody>
</table>

PRECAUTIONS:

1. Auto Transformer should be in minimum voltage position at the time of closing & opening DPST Switch.

PROCEDURE:

OPEN CIRCUIT TEST:

1. Connections are made as per the circuit diagram.
2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer variac is adjusted get the rated primary voltage.
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again brought to minimum position and DPST switch is opened.

SHORT CIRCUIT TEST:

1. Connections are made as per the circuit diagram.
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2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer variac is adjusted get the rated primary current.
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again brought to minimum position and DPST switch is opened.

CIRCUIT DIAGRAM:

OPEN CIRCUIT TEST:

FUSE RATING:

10% of rated current

\[ \frac{10 \times 5}{100} = 0.5A \]

NAME PLATE DETAILS:

Primary  Secondary
Rated Voltage : 115V  230V
Rated Current : 10A  5A
Rated Power : 1KVA  1KVA

SHORT CIRCUIT TEST:

FUSE RATING:

125% of rated current

\[ \frac{125 \times 5}{100} = 6.25A \]

NAME PLATE DETAILS:

Primary  Secondary
Rated Voltage : 230V  115V
Rated Current : 5A  10A
Rated Power : 1KVA  1KVA
EQUIVALENT CIRCUIT:

\[ Z_L' = \frac{Z_i}{K^2} \]

TABULAR COLUMN:

SHORT CIRCUIT TEST:

<table>
<thead>
<tr>
<th>( V_{s/c} ) (Volts)</th>
<th>( I_{s/c} ) (Amps)</th>
<th>( W_{s/c} ) (Watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OPEN CIRCUIT TEST:

<table>
<thead>
<tr>
<th>V_{o/c} (Volts)</th>
<th>I_{o/c} (Amps)</th>
<th>W_{o/c} (Watts)</th>
</tr>
</thead>
</table>

MODEL GRAPH:

- Efficiency $\eta\%$ vs. Output power (Watts)
- PF vs. $\% \eta$
FORMULAE:

Core loss: \( W_o = V_o I_o \cos \phi_o \)

\[
\cos \phi_o = \frac{W_o}{V_o I_o} \quad \phi_o = \cos^{-1} \frac{W_o}{V_o I_o}
\]

\( l_o = I_o \cos \phi_o \) (Amps) \quad \( l_o = I_o \sin \phi_o \) (Amps)

\[
\frac{V_o}{V_o} = \frac{W_{sc}}{R_o}
\]

\[
R_o = \frac{X_o}{X_o} = \frac{R_{o2}}{R_{o2}} = \frac{l_o}{l_o} \quad \frac{I_o}{I_o} = \frac{I_{sc}^2}{I_{sc}^2}
\]

\[
Z_{o2} = \frac{X_{o2}}{X_{o2}} = \frac{(Zo2 - R_{o2})^{1/2}}{l_{sc}}
\]

\[
R_{o2} = \frac{X_{o2}}{X_{o2}} = \frac{V_2}{V_1} = K^2 = K^2 = 2
\]

Percentage Efficiency: for all loads and p.f.

\[
\text{Output Power} = (X) \times \text{KVA rating} \times 1000 \times \cos \phi
\]

\[
\text{Efficiency} \% = \frac{\text{Input Power}}{\text{Output power + losses}} = \frac{\text{Input Power}}{\text{Output power + losses}}
\]
Percentage Regulation:

\[
R\% = \frac{(X) \times I_{nc} (R_{o2} \cos \phi \pm X_{o2}\sin \phi) \times 100}{(X) \times KVA \text{ rating} \times 1000 \times \cos \phi
\]

Where \( X \) is the load and it is 1 for full load, \( \frac{1}{2} \) for half load, \( \frac{3}{4} \) load, \( \frac{1}{4} \) load etc.. and the power factor is, upf, 0.8 p.f lag and 0.8 p.f lead

RESULT:

Thus the efficiency and regulation of a transformer is predetermined by conducting open circuit test and short circuit test and the equivalent circuit is drawn.
SUMPNER’S TEST

AIM

To predetermine the efficiency of given single phase transformers by conducting back to back test.

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the Apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Auto Transformer</td>
<td>(0-270) V</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Wattmeter</td>
<td>300 V, 10A, 75 V, 5 A</td>
<td>LPF, UPF</td>
<td>1, 1</td>
</tr>
<tr>
<td>3</td>
<td>Ammeter</td>
<td>(0-2) A, (0-20) A</td>
<td>MI, MI</td>
<td>1, 1</td>
</tr>
<tr>
<td>4</td>
<td>Voltmeter</td>
<td>(0-75) V, (0-150) V</td>
<td>MI, MI</td>
<td>1, 1</td>
</tr>
<tr>
<td>5</td>
<td>Connecting Wires</td>
<td>2.5 sq.mm</td>
<td>Copper</td>
<td>Few</td>
</tr>
</tbody>
</table>

PROCEDURE

- The connections are made as per the circuit diagram. The DPST switch is closed.
- The auto transformer is gradually varied till the voltmeter reads the rated voltage.
- The A. C. supply in the secondary side is switched ON and the secondary auto transformer is increased till the secondary voltage is reached.
- Corresponding meter readings on both sides are noted.

PRECAUTION

- The polarity of transformers should be the same.
- The auto transformer should be kept at minimum potential position.
MODEL CALCULATION:

Copper loss per transformer = $W_{SC}/2$

Core loss per transformer = $W_{OC}/2$

Equivalent resistance, $R_{02} = \left(\frac{W_{SC}}{2}\right) I_{SC}^2$

Equivalent impedance, $Z_{02} = V_{SC} / I_{SC}$

% Efficiency, $\eta = \frac{\text{output}}{\text{input}} \times 100$

Output power = $x \cdot \text{kVA} \cdot \text{power factor}$

Copper loss = $W_{SC} \cdot x^2$
Input power = output power + losses

**TABULAR COLUMN**

<table>
<thead>
<tr>
<th>$V_{oc}$</th>
<th>$I_{oc}$</th>
<th>$W_{oc}$</th>
<th>$V_{sc}$</th>
<th>$I_{sc}$</th>
<th>$W_{sc}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volts</td>
<td>Amperes</td>
<td>Watts</td>
<td>Volts</td>
<td>Amperes</td>
<td>Watts</td>
</tr>
</tbody>
</table>

% of load | Output power | Total loss | Input power | Efficiency
---|----------------|-----------|--------------|---------|
$X$ | $X \cdot kVA \cdot \cos \phi \cdot 1000$ | $W_{oc} + (X^2 \cdot W_{sc})$ | Output + losses | $(output/ input) \cdot 100$

**RESULT**

Thus the efficiency of a given single phase transformer is predetermined by conducting back to back test.
SEPARATION OF NO LOAD LOSSES IN A SINGLE PHASE TRANSFORMER

AIM:
To separate the eddy current loss and hysteresis loss from the iron loss of single phase transformer.

APPARATUS REQUIRED:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the Apparatus</th>
<th>Range</th>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rheostat</td>
<td>1250Ω, 0.8A</td>
<td>Wire Wound</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Wattmeter</td>
<td>300 V, 5A</td>
<td>LPF</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Ammeter</td>
<td>(0-2) A</td>
<td>MC</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Voltmeter</td>
<td>(0-300) V</td>
<td>MI</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Connecting Wires</td>
<td>2.5sq.mm</td>
<td>Copper</td>
<td>Few</td>
</tr>
</tbody>
</table>

PRECAUTIONS:
1. The motor field rheostat should be kept at minimum resistance position.
2. The alternator field rheostat should be kept at maximum resistance position.

PROCEDURE:
1. Connections are given as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. The DC motor is started by using the 3 point starter and brought to rated speed by adjusting its field rheostat.
4. By varying the alternator filed rheostat gradually the rated primary voltage is applied to the transformer.
5. The frequency is varied by varying the motor field rheostat and the readings of frequency are noted and the speed is also measured by using the tachometer.
6. The above procedure is repeated for different frequencies and the readings are tabulated.
7. The motor is switched off by opening the DPST switch after bringing all the rheostats to the initial position.
CIRCUIT DIAGRAM:

NAME PLATE DETAILS:

<table>
<thead>
<tr>
<th></th>
<th>Motor</th>
<th>Alternator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>220V</td>
<td>41.5V</td>
</tr>
<tr>
<td>Rated Current</td>
<td>27.5A</td>
<td>7A</td>
</tr>
<tr>
<td>Rated Power</td>
<td>5.5kW</td>
<td>5kVA</td>
</tr>
<tr>
<td>Rated Speed</td>
<td>1500 RPM</td>
<td>1500 RPM</td>
</tr>
</tbody>
</table>

FUSE RATING:

125% of rated current

\[
\frac{125 \times 27.5}{100} = 34.375 A
\]

NAME PLATE DETAILS:

<table>
<thead>
<tr>
<th></th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>230V</td>
<td>115V</td>
</tr>
<tr>
<td>Rated Current</td>
<td>5A</td>
<td>10A</td>
</tr>
<tr>
<td>Rated Power</td>
<td>1kVA</td>
<td>1kVA</td>
</tr>
</tbody>
</table>

MODEL GRAPH:
**TABULAR COLUMN**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Speed N (rpm)</th>
<th>Frequency f (Hz)</th>
<th>Voltage V (Volts)</th>
<th>Wattmeter reading Watts</th>
<th>Iron loss Wi (Watts)</th>
<th>Wi / f Joules</th>
</tr>
</thead>
</table>

**FORMULAE USED:**

1. Frequency, $f = (P \times N_s) / 120$ in Hz $P = \text{No. of Poles}$ & $N_s = \text{Synchronous speed in rpm.}$
2. Hysteresis Loss $W_h = A \times f$ in Watts $A = \text{Constant (obtained from graph)}$
3. Eddy Current Loss $W_e = B \times f^2$ in Watts $B = \text{Constant (slope of the tangent drawn to the curve)}$
4. Iron Loss $W_i = W_h + W_e$ in Watts $W_i / f = A + (B \times f)$
   
   Here the Constant $A$ is distance from the origin to the point where the line cuts the Y-axis in the graph between $W_i / f$ and frequency $f$. The Constant $B$ is $\Delta (W_i / f) / \Delta f$.

**RESULT:**

Thus separation of eddy current and hysteresis loss from the iron loss on a single-phase
transformer is conducted.