## 1. PREAMBLE:

Electrical Machines Lab provides the essential facilities to the students to augment their concepts about the fundamentals of transformers and rotating machines. The lab is equipped with DC series/shunt motor, compound motor, universal motor, single-phase induction motor, single-phase transformer, three-phase induction motor, three-phase synchronous motor and three-phase transformer. The lab is equipped with various tests and monitoring equipment also.

## 2 OBJECTIVE & RELEVANCE:

The objective of the Electric Machine Lab is to expose the students to the operation of D.C. machines and transformers and give them experimental skill. It also aims to understand the generation of D.C. voltages by using different type of generators and study their performance. It also enables the students to understand the working principles of D.C. motors and their load characteristics, starting and methods of speed control.

Further it helps to familiarize with the constructional details of different type of transformers, working principle and their performance.

## OUTCOME:

- After the completion of this course student able to know the basic operation of Dc machines.
- Able to Know the testing method of DC machines
- Applications of DC machines through the characteristics.

## 3. List of Experiments:

1. MAGNETISING CHARACTERISTICS OF DC SHUNT GENERATOR
2. LOAD TEST ON DC SHUNT GENERATOR
3. LOAD TEST ON DC SERIES GENERATOR
4. LOAD TEST ON DC COMPOUND GENERATOR
5. HOPKINSON’S TEST
6. FIELD TEST ON DC SERIES MOTOR
7. SWINBURNE’S TEST ON DC SHUNT MACHINE
8. SPEED CONTROL OF DC SHUNT MOTOR
9. BRAKE TEST ON DC COMPOUND MOTOR
10. BRAKE TEST ON DC SHUNT MOTOR
11. SEPERATION LOSSES IN DC SHUNT MOTOR

## 4 Text and Reference Books

**TEXT BOOKS**

**T1 :** A.E.Fritgerald, C.Kingsley & S.Umans ***"Electric Machinary",*** Mc Graw-Hill Companies, 5thEdition.

**T2 :** P.S.Bhimbra "***Electric Machines*** " Khanna Publications

**REFERENCE BOOKS**

**R1 :** Clayton & Hancock , "***Performance & Design of DC Machines***", B.P.B.Publications

**R2 :** S.K.Bhattacharya "***Electrical Machines***" Tata Mc Graw-Hill Publishers

**R3 :** I.J.Nagrath & D.P.Kothari "***Electric Machines***" Tata Mc Graw-Hill Publishers , 3rd Edition

**R4 :** S. Kamakshiah "***Electromechanics"*** Hi-Tech Publishers

**R5 :** J.B.Gupta, " ***Theory & Performance of Electrical Machines***" S.K.Kataria

## 5. SESSION PLAN

| Sl.No | Name of the Experiment | Week of Experiment |
|---|---|---|
| 1 | MAGNETISING CHARACTERISTICS OF DC SHUNT GENERATOR | Week #1 |
| 2 | LOAD TEST ON DC SHUNT GENERATOR | Week #2 |
| 3 | TEST ON DC SERIES GENERATO | Week #3 |
| 4 | LOAD TEST ON DC COMPOUND GENERATOR | Week #4 |
| 5 | HOPKINSON'S TEST | Week #5 |
| 6 | FIELD TEST ON DC SERIES MOTOR | Week #6 |
| 7 | SWINBURNE'S TEST ON DC SHUNT MACHINE | Week #7 |
| 8 | SPEED CONTROL OF DC SHUNT MOTOR | Week #8 |
| 9 | BRAKE TEST ON DC COMPOUND MOTOR | Week #9 |
| 10 | BRAKE TEST ON DC SHUNT MOTOR | Week #10 |
| 11 | SEPERATION LOSSES IN DC SHUNT MOTOR | Week #11 |

**6.Experiment write up**

## 6.1. MAGNETISING CHARACTERISTICS OF DC SHUNT GENERATOR

**AIM**: To draw the magnetization characteristics of a self excited DC shunt generator and to determine the critical field resistance and critical speed.

**NAME PLATE DETAILS :** **MOTOR** **GENERATOR**

1. Voltage :
2. Current :
3. H.P/ KW Rating :
4. Speed :

**APPARATUS REQUIRED**:

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| **1** | **Voltmeter** | | | |
| **2** | **Ammeter** | | | |
| **3** | **Rheostats**<br>**R1**<br>**R2** | | | |
| **4** | **Tachometer** | | | |

**THEORY:**

The magnetization or Open Circuit Characteristic of a self-excited DC machine shows the relation between the No-load generated e.m.f ($E_0$) and Field current ($I_f$) at a given speed. It is the magnetization curve for the material of the electromagnetic pole core and its shape is practically same for all generators.

From the voltage equation of DC shunt generator,

$$E_g = \phi ZNP/ 60A$$

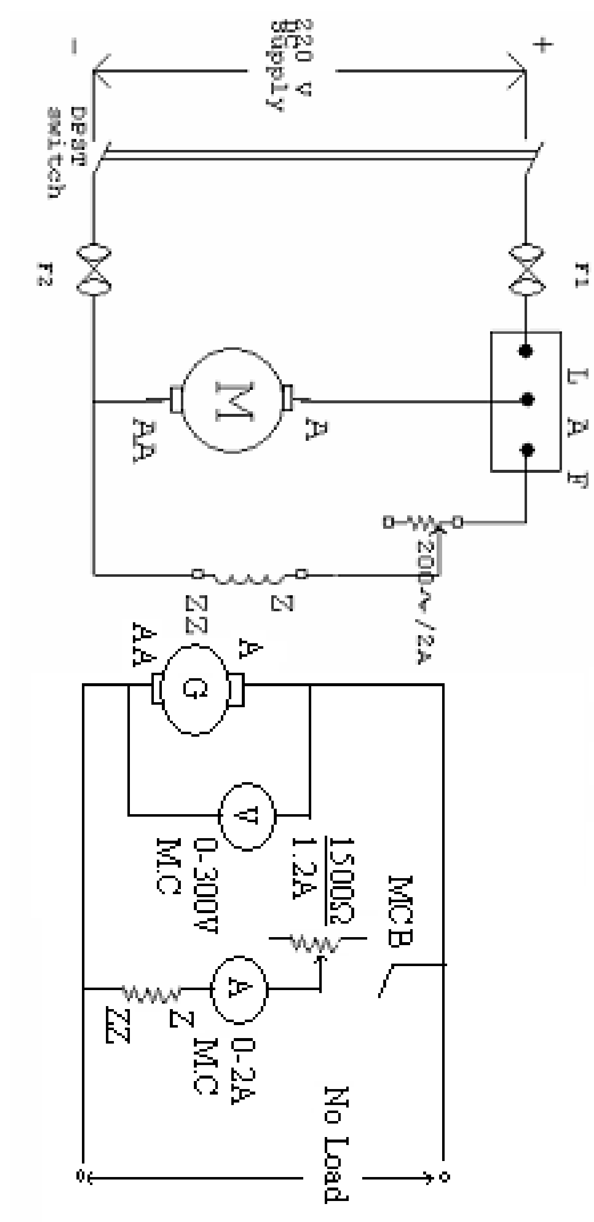
It can be seen that $E \propto \phi$, when N is constant. Due to residual magnetism in the poles some e.m.f is generated even when $I_f = 0$. Hence the curve starts a little way up from the origin. At smaller values of excitation current, $\phi \propto I_f$. During this time the poles are unsaturated and curve is a straight line.

As the flux density increases, the saturation of poles sets in and the excitation current required to produce a particular change in voltage is more when compared to the initial parts of the curve. Hence, the curve bends down.

The maximum voltage to which a shunt generator builds up depends on the total resistance in the field circuit and magnetization curve of the machine.

## CIRCUIT DIAGRAM:

**Self Excited Generator**



**PROCEDURE:**

1. Make the connections as per the circuit diagram.
2. Ensure minimum resistance in the field circuit.
3. Switch on the supply and run the generator without load.
4. Vary the field current in steps using the field rheostat.
5. Note down the values of Field current ($I_f$) and Generated e.m.f. (E) at each step.

**OBSERVATIONS:**

A. Reading to draw OCC curve (If Vs Eo).

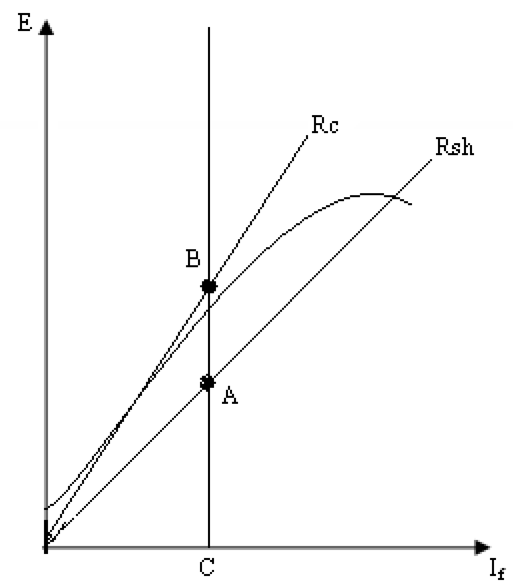
| S.NO | Increasing mode | | Decreasing mode | |
|---|---|---|---|---|
| | If | Eo | If | Eo |
| 1 | 0 | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |

Critical field resistance Rc =___________Ω critical speed Nc =___________rpm

B. Readings to calculate shunt field resistance(Rsh)

| S.NO | Ish in Amps | Vsh in Volts | Rsh=Vsh/Ish in Ω |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

Average Rsh = _______________ Ω




**Model graph:**

Slope of OB-Critical field resistance (Rc)

Slope OD given field resistance (Rf)

FG = Critical speed
EG Rated speed

$$\frac{AC}{BC} = \frac{N_C}{N_1}$$

$$\Rightarrow N_C = \frac{AC}{BC} \times N_1$$

The conditions for satisfactory voltage build up are:

1). Presence of Residual magnetism.

2). Correct direction of rotation.

3). Field Resistance lesser than critical resistance.

Critical Field Resistance:

The maximum allowed value of the field resistance to a DC shunt generator, above which the voltage fails to build up, is called the Critical Field Resistance.

**Critical speed:**

It is the speed below which the machine cannot build up emf.

**PRECAUTIONS**:

1). Avoid hanging wires and loose connections.

2). Make sure that the initial value of field Resistance is minimum.

**GRAPH:** Draw the graph between Field current ($I_f$) Vs generated e.m.f (E).

**RESULTS & CONCLUSIONS:**

## 6.2. LOAD TEST ON DC SHUNT GENERATOR

**AIM :** To obtain the internal and external (Performance) characteristics of a DC shunt generator.

**NAME PLATE DETAILS:** **MOTOR** **GENERATOR**

1. Voltage :
2. Current :
3. H.P/ KW Ratings :
4. Speed :

**APPARATUS REQUIRED:**

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | Ammeters<br>A1<br>A2 | | | |
| 2 | Voltmeter | | | |
| 3 | Rheostats<br>R1<br>R2 | | | |
| 4 | Load | | | |

| | | | | |
|---|---|---|---|---|
| **5** | **Tachometer** | | | |

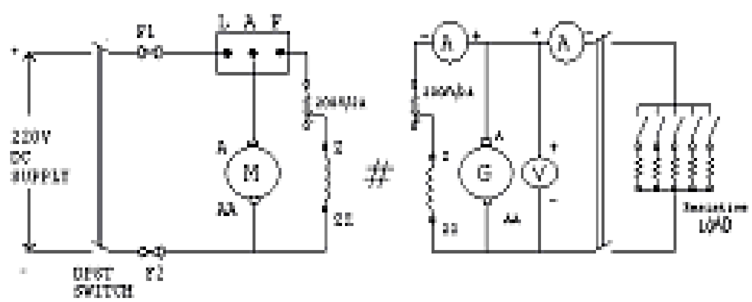
**THEORY:**

One of the most important characteristics of any generator is its behavior with regard to the terminal voltage when load increases. In shunt generator the voltage always falls as more current is delivered to the load. There are three reasons for this.

1. With increase in load current, the voltage drop in the armature ($I_aR_a$) increases, making a lower emf available at the load terminals.
2. Also the armature reaction weakens the field, which reduces the emf generated.
3. The drop of voltage due to (1) and (2) results in a decreased field current which further reduces the flux which in turn decreases the generated emf.

If the field is excited from an external source it will be independent of load current. As the flux is constant the internal characteristics must be a straight line. But due to armature reaction the internal characteristics will be a little dropping.

**CIRCUIT DIAGRAM:**




**PROCEDURE:**

1. The connections are made as shown in the circuit diagram.
2. The Motor generator set is started and brought to rated speed by means of the motor field regulator.

3. When it is running at rated speed the generator field is adjusted to get rated voltage on no load. The generator field regulator is not distributed through out the experiment.
4. Load is varied in steps on the generator. The speed is adjusted to rated value for each load and the load current $I_L$, terminal voltage V and field current $I_f$ are noted down.
5. The step 4 is repeated till the generator is over loaded by about 25 percent.
6. After taking readings up to 25 percent over load, the load is slowly removed and then the set is stopped by switching OFF the supply to the motor.

**OBSERVATIONS:**

A. Readings with loading of DC Shunt Generator.

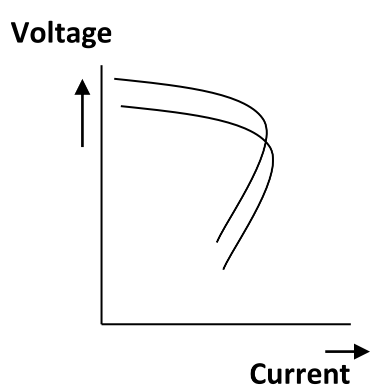
| S.NO | Terminal voltage V in volts | Load current IL In Amps | Field current If in Amps | Armature current Ia= IL+If | Generated Emf Eg= V+IaRa |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |

Readings to calculate Armature resistance (Ra)

| S.NO | Armature current Ia in Amps | Voltage across Armature Va in Volts | Ra=Va/Ia in Ω |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

Average Ra = ________________Ω

**Model graphs**




**GRAPHS:**

1. Draw graphs between E Vs $I_a$ ( internal characteristics)
2. Draw graphs between V Vs $I_L$ (external characteristics)

**RESULTS & CONCLUSIONS:**

## 6.3. LOAD TEST ON DC SERIES GENERATOR

**AIM :** To perform load test on a DC series generator and to draw the internal and external (Performance) characteristics .

**NAME PLATE DETAILS:** **MOTOR** **GENERATOR**

1. Voltage :
2. Current :
3. H.P/ KW Ratings :
4. Speed :

APPARATUS REQUIRED:

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | **Ammeter** | | | |
| 2 | **Voltmeter** | | | |
| 3 | **Rheostat** | | | |
| 4 | **Load** | | | |
| 5 | **Tachometer** | | | |

**THEORY:**

The load characteristics curve of DC series generator shows the relation b/w its terminal voltage and load current. The characteristics are rising in nature and excitation increases with load. At large values of load current, the terminal voltage must be start decreasing owing to the saturation of the machine iron & rapidly increasing voltage drop of armature and armature resistance.

In a series generator, the load current, armature current and field current are same.

The terminal voltage $V = E_g - I_a(R_a+R_{se})$.

Where

$V$ = Terminal voltage

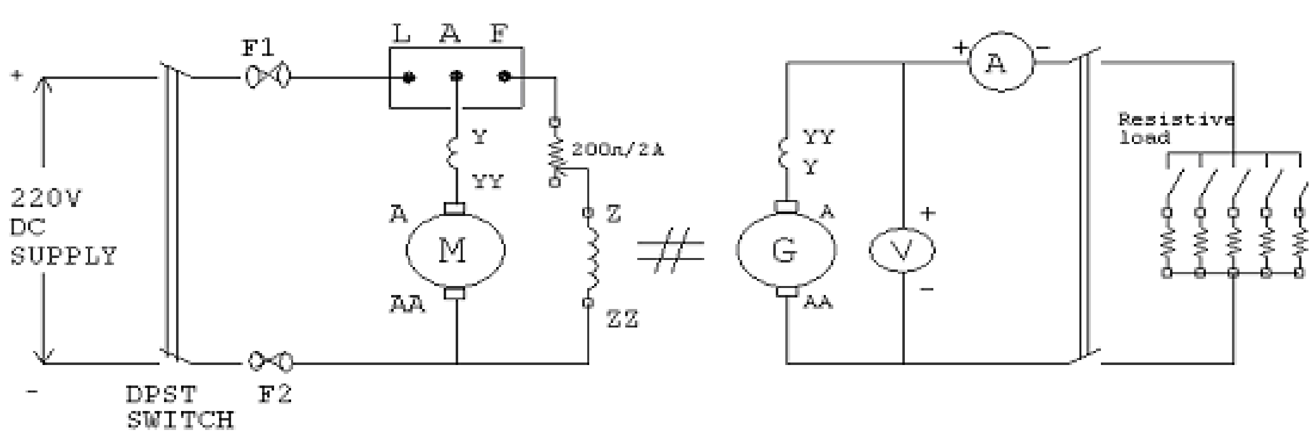
$E_g$= E.M.F. generated in the Armature.

$I_a$ = Armature Current (A) = $I_{se}$ = $I_L$

$R_a$ = Armature Resistance (in Ω).

$R_{se}$= Series field resistance (in Ω).

**CIRCUIT DIAGRAM:**



**PROCEDURE :**

1. The connections are made as shown in the circuit diagram.
2. The Motor generator set is started and brought to rated speed by means of the motor field regulator.
3. When it is running at rated speed the generator field is adjusted to get rated voltage on no load.
4. The generator field regulator is not disturbed through out the experiment.
5. Load is varied in steps on the generator. The speed is adjusted to rated value for each load and the load current $I_L$, terminal voltage V and field current $I_f$ are noted down.
6. The step 4 is repeated till the generator is over loaded by about 25 percent.

**OBSERVATIONS:**

A. Readings with loading of DC Series Generator.

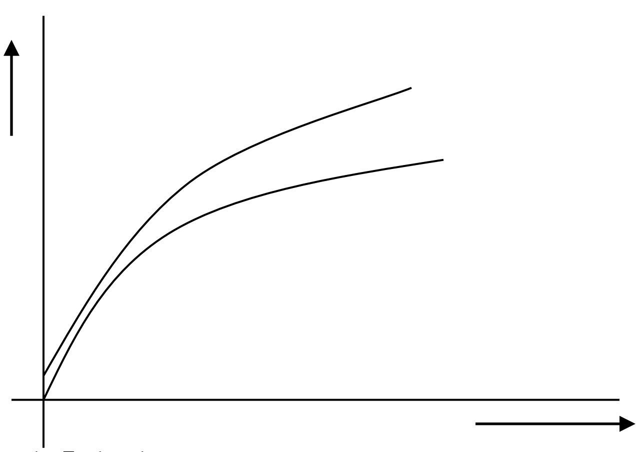
| S.NO | Terminal voltage V in volts | Load current IL=Ia In Amps | IseRse In volts | IaRa In volts | E=V+IaRa+IseRse |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |

B. Readings to calculate resistances

| | Ra | | | Rse | | |
|---|---|---|---|---|---|---|
| S. NO | V | Ia | Ra=V/Ia | V | Ise | Rse=V/Ise |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| Average Ra =___________ Ω | | | | Average Rse =i____________ Ω | | |

**Model Graphs;**



**Internal Characteristics**: It is the characteristic drawn between $E_g$ and $I_a$ ($I_a$=$I_L$=$I_{se}$).

**External Characteristics**: It is the characteristic drawn between Terminal voltage (V) and Load current $I_L$.

## GRAPHS:

1. Draw graphs between E $V_S$ $I_a$ ( internal characteristics)
2. Draw graphs between V $V_S$ $I_L$ (external characteristics)

## RESULTS & CONCLUSIONS:

## 6.4. LOAD TEST ON DC COMPOUND GENERATOR

**AIM:** To obtain the internal and external (Performance) characteristics of a DC compound generator.

**NAME PLATE DETAILS:** MOTOR GENERATOR

1. Voltage :
2. Current :
3. H.P/ KW Ratings:
4. Speed :

**APPARATUS REQUIRED:**

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | **Ammeters**<br>**A1**<br>**A2** | | | |
| 2 | **Voltmeter** | | | |
| 3 | **Rheostats**<br>**R1**<br>**R2** | | | |
| 4 | **Load** | | | |
| 5 | **Tachometer** | | | |

**THEORY:**

D.C. Compound generator consists of both series and shunt field windings. The shunt and series fields can be connected in two ways.

1. Short shunt.
2. Long shunt.

When the MMF of series field opposes the MMF of shunt field, the generator is differentially compound. The terminal voltage decreases sharply with increasing load current. Evidently this connection is not used.

In cumulative compound the connections of the two fields are such that their MMF's add and help each other. If the series field is very strong, the terminal voltage may increase as the load current increases and it is called over compounding. When terminal voltage on full load and no load are equal, it is known as flat compounded generator. If the series field is not strong, the terminal voltage will decreases with increase in load current (under compound)

II. Differential mode.

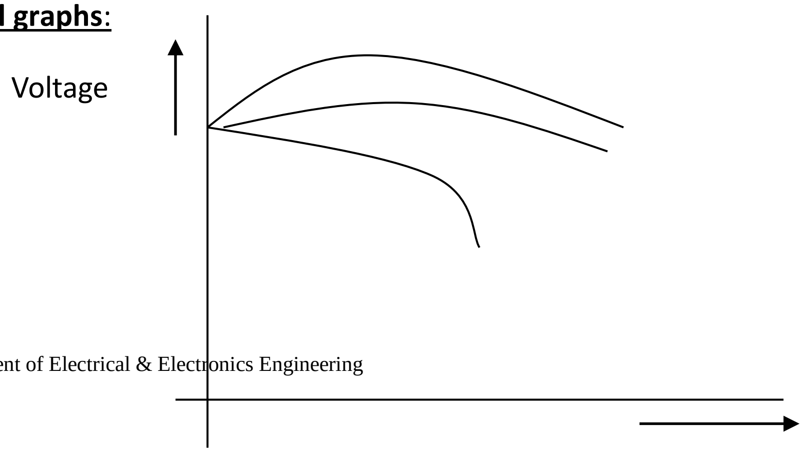
| S.NO | Terminal voltage V in volts | Load current IL In Amps | Shunt field Current If in Amps | Armature Current Ia in Amps =IL+If | IaRa+IaRse In volts | E=V+IaRa+IaRse |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |

B. Readings to calculate resistances

| | Ra | | | Rse | | |
|---|---|---|---|---|---|---|
| S. NO | V | Ia | Ra=V/Ia | V | Ise | Rse=V/Ise |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| Average Ra =___________ Ω | | | | Average Rse =i____________ Ω | | |

**Model graphs**:



Current

**PROCEDURE:**

1. The connections are made as shown in the circuit diagram.
2. The Motor generator set is started and brought to rated speed by means of the motor field regulator.
3. When it is running at rated speed the generator field is adjusted to get rated voltage on no load. The generator field regulator is not distributed through out the experiment.
4. Load is put in steps on the generator. The speed is adjusted to rated value for each load and the load current $I_L$, terminal voltage V and field current $I_f$ are noted down.
5. The step 4 is repeated till the generator is over loaded by about 25 percent.
6. After taking readings up to 25 percent over load, the load is slowly removed and then the set is stopped by switching OFF the supply to the motor.

**GRAPHS :**

1. Draw graphs between E $V_S$ $I_a$ ( internal characteristics)
2. Draw graphs between V $V_S$ $I_L$ (external characteristics)

**RESULTS & CONCLUSIONS :**

# 6.5. HOPKINSON'S (REGENERATIVE) TEST

**AIM:** To find the efficiency of the D.C. shunt machine using Hopkinson's test.

**NAME PLATE DETAILS:** MOTOR GENERATOR

1. Voltage :
2. Current :
3. H.P/ KW Ratings:
4. Speed :

**APPARATUS REQUIRED:**

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | **Ammeters**<br>**A1**<br>**A2**<br>**A3**<br>**A4** | | | |
| 2 | **Voltmeter** | | | |
| 3 | **Rheostats**<br>**R1**<br>**R2** | | | |
| 4 | **Knife switch** | | | |
| 5 | **Tachometer** | | | |

**THEORY:**

By this method, full load test can be carried out on two shunt machines, preferably identical ones, without wasting their outputs. The two machines are mechanically coupled and are so adjusted electrically that one of them runs as a motor and the other as a generator. The mechanical output of the motor drives the generator and the electrical output of the generator is used in supplying the greater part of input to the motor. If there were no losses, generator output is sufficient to drive the motor and vice-versa. The losses are supplied either by an extra motor which is belt-connected to the motor-generator set or electrically from the supply mains.

Let V = Supply Voltage

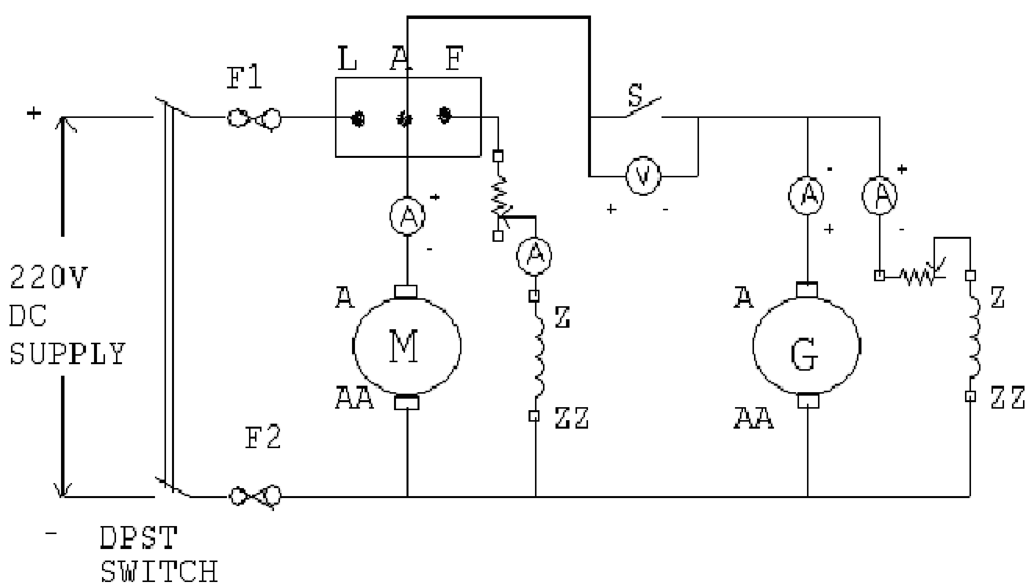
$I_1$ = Current taken from the Supply.

$I_2$ = Armature current of the motor.

$I_4$ = Armature current of the generator.

$I_3$ = Exciting current of the motor .

**CIRCUIT DIAGRAM :**



**PROCEDURE :**

1. Make the connections as per the circuit diagram.
2. Start the machine M from the supply mains with the help of a starter whereas the switch S of the other machine is open.
3. Adjust the speed of the motor to its rated value by the rheostat.
4. Adjust the Voltage of the machine G by the field rheostat until the voltmeter $V_1$ reads zero, there by showing that its voltage is same, both in polarity and magnitude as that of the main supply.
5. Close the switch S to parallel the machines.
6. Note down the readings of $I_1$, $I_2$, $I_3$, $I_4$, $I_5$ and V.
7. Calculate efficiency from readings.

**Observations:**

$I_5$ =Exciting current of the Generator .

$R_a$ = Armature resistance of each motor.

Armature Copper losses in Generator $= I_4^2 R_a$

Armature Copper losses in Motor $= I_2^2 R_a$

Shunt Copper losses in Generator $= VI_5$.

Shunt Copper losses in Motor $= VI_3$.

But total motor and generator losses are equal to the power supplied by the mains.

Power drawn from the supply $= VI_1$.

∴ Total stray losses i.e. iron, friction and wind age losses for the two machines are

$$= VI_1 – [(I_4^2 R_a) + (I_2^2 R_a)] = W \text{ (say)}$$

**CALCULATIONS:**

**V =**

**$I_1$ =**

**$I_2$ =**

**$I_3$ =**

**$I_4$ =**

**$I_5$ =**

**Motor input =**

**Motor output =**

**Motor efficiency =**

**Generator input =**

**Generator output =**

**Generator efficiency =**

$\therefore$ stray losses for each machine = W/ 2.

Motor efficiency:

Motor input = Armature input + shunt field input = $VI_2 + VI_3 = W_{input.}$

Motor losses = Armature Cu. Losses + shunt Cu loss + stray losses

$$= I_4^2 R_a + VI_3 + W/2 = W_m \text{ (say)}$$

Motor efficiency = $[(W_{input} – W_m)/ W_{input}] \times 100$

Generator efficiency:

Generator output = $V(I_4 - I_5)$

Generator losses = Armature Cu. Losses + shunt Cu loss + stray losses

$$= I_4^2 R_a + VI_5 + W/2 = W_g \text{ (say)}$$

Generator efficiency = $\{V(I_4-I_5)/ [V(I_4-I_5) + W_g] \}x\ 100$

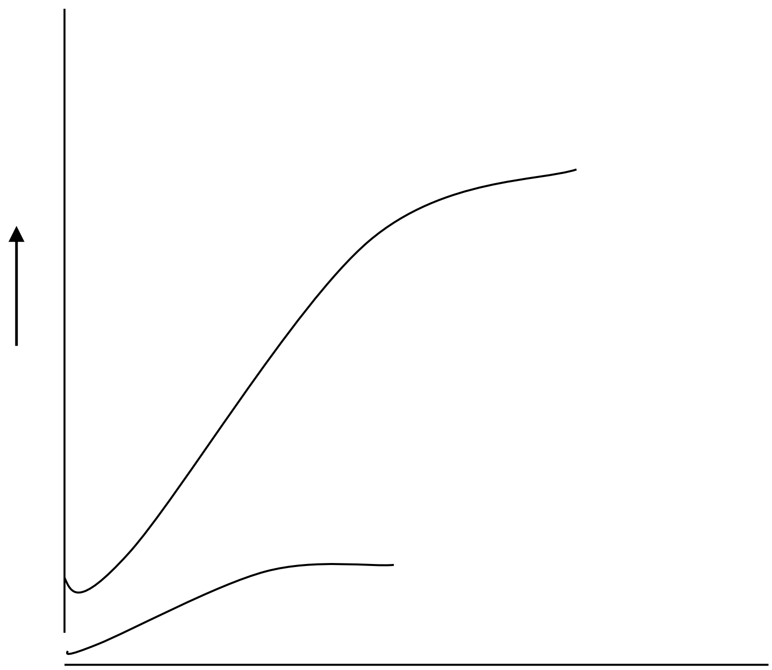
B. Readings to calculate resistances

| | Ra | | | Rse | | |
|---|---|---|---|---|---|---|
| S. NO | V | Ia | Ra=V/Ia | V | Ise | Rse=V/Ise |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| Average Ra =___________ Ω | | | | Average Rse =i____________ Ω | | |

**Sample calculations:**

## Model Graph

Efficiency



Output

## Graph:

1. Draw the graph between output Vs efficiency for motor
2. Draw the graph between output Vs efficiency for generator.

## RESULT:

## 6.6. FIELD TEST ON DC SERIES MOTOR

**AIM :** To Determine the efficiency of the two given D.C. series machines which are mechanically coupled.

**NAME PLATE DETAILS** : Motor Generator

1. Voltage :
2. Current :
3. H.P/ KW Ratings :
4. Speed :

**APPARATUS REQUIRED:**

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | **Ammeters**<br>**A1**<br>**A2** | | | |
| 2 | **Voltmeter** | | | |
| 3 | **Load** | | | |
| 4 | **Tachometer** | | | |

**THEORY:**

Testing of series motors in the laboratories rather more difficult compared to testing of shunt motors.

This is because:

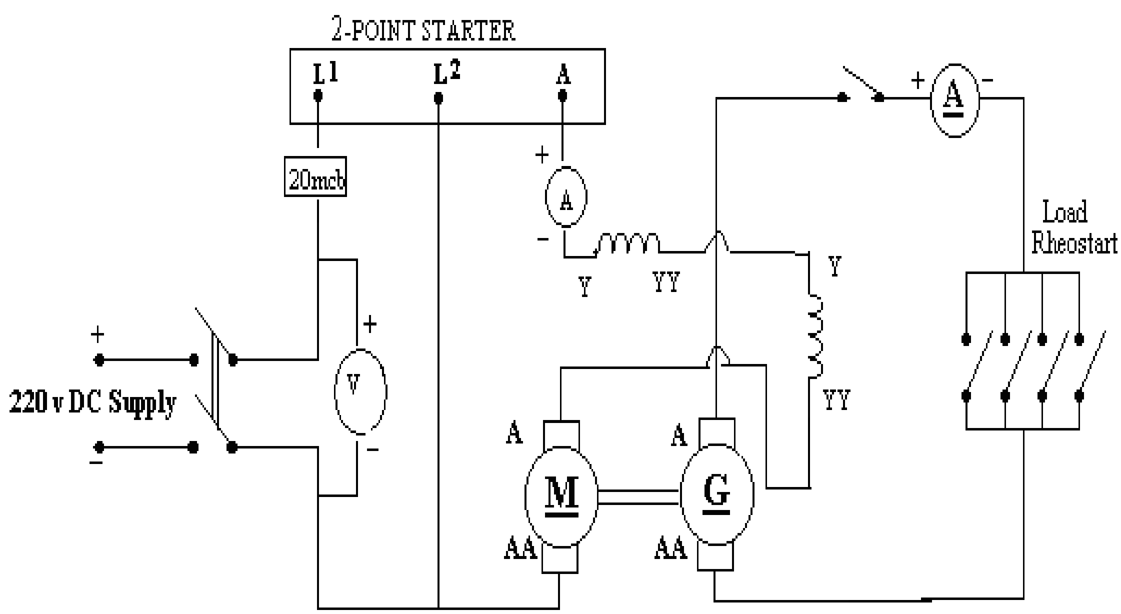
(A) the field current varies over a wide range during normal working condition of a series motor

(B) on no-load, the series motor attains dangerously high speed. So no-load test is not possible.

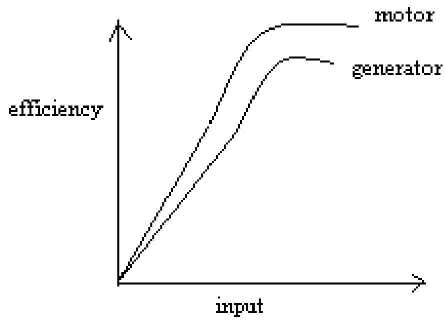
Field's test is conducted on series machines to obtain its efficiency. In this test,

- Two similar rating series machines are mechanically coupled.
- One machine runs as a motor and drives the second series machines which runs as a generator is connected in series with the motor series field winding is shown in the figure.
- This test is not a regenerative test.

**CIRCUIT DIAGRAM:**



Model Graph:




**PROCEDURE :**

1.) Connect the circuit as per the circuit diagram.
2.) Ensure that rated load (rated voltage of generator/rated current) is connected to generator.
3.) Switch on the supply to the motor-generator set and start the motor.
4.) At this point, note down the readings of ammeter and voltmeter of motor and generator.
5.) Gradually reduce the load and note down the readings at every step. The motor speed should not exceed 1800 rpm.
6.) After completion of experiment, switch off the supply.

**Observations:**

B. Readings to calculate resistances

| | Ra | | | Rse | | |
|---|---|---|---|---|---|---|
| S. NO | V | Ia | Ra=V/Ia | V | Ise | Rse=V/Ise |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| Average Ra =___________ Ω | | | | Average Rse =i____________ Ω | | |

| S. NO | V | V1 | V2 | I1 | I2 | Pig | Pog | Pig | Pim | Pom | PLm | ηg | ηm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

**Calculations:**

Pin = V1 * I1

Pout = $V_L$ * $I_L$

Wc = Pin – Pout

Pcu = ($I1^2$ * Rse1) + ($I1^2$ * Rse2) + ($I1^2$ * Ra1) + ($I1^2$ * Ra2)

[ Rse1 : resistance of series field winding 1

Rse2 :resistance of series field winding 2

Ra1 : motor armature resistance

Ra2 : generator armature resistance ]

Ws = (Wc – Pcu)/2

Total Losses = Pcu/2 + Ws

Efficiency of motor = (Pin – total losses)/Pin * 100

Efficiency of generator = Pout/(Pout + total losses) * 100

**Graph:**

1. Draw the graph between output Vs efficiency for motor
2. Draw the graph between output Vs efficiency for generator.

**Result:Conclusion:**

# 6.7. SWINBURNE'S TEST ON DC SHUNT MACHINE

AIM : **To** perform the Swinburne's test on the given DC machine and predetermine its efficiency at any desired load both as motor and as generator.

**NAME PLATE DETAILS** : Motor

1. Voltage :
2. Current :
3. H.P/ KW Ratings :
4. Speed :

**APPARATUS REQUIRED:**

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | **Ammeters**<br>**A1**<br>**A2** | | | |
| 2 | **Voltmeter** | | | |
| 3 | **Tachometer** | | | |

**THEORY**:

It is a simple indirect method in which losses are measured separately. The machine is run as motor on no-load at its rated speed and voltage. The machine supplies the following losses.

1. Constant losses

   a). Iron losses in core

   b). Friction losses

   c). Windage losses

2. Armature copper losses

Let supply voltage = V volts

No-load current = $I_o$ amps

Shunt field current = $I_{sh}$

No-load power input = $VI_0$ watt

Power input to the armature = $V(I_o-I_{sh})$

Armature copper losses = $(I_o-I_{sh})^2R_a$

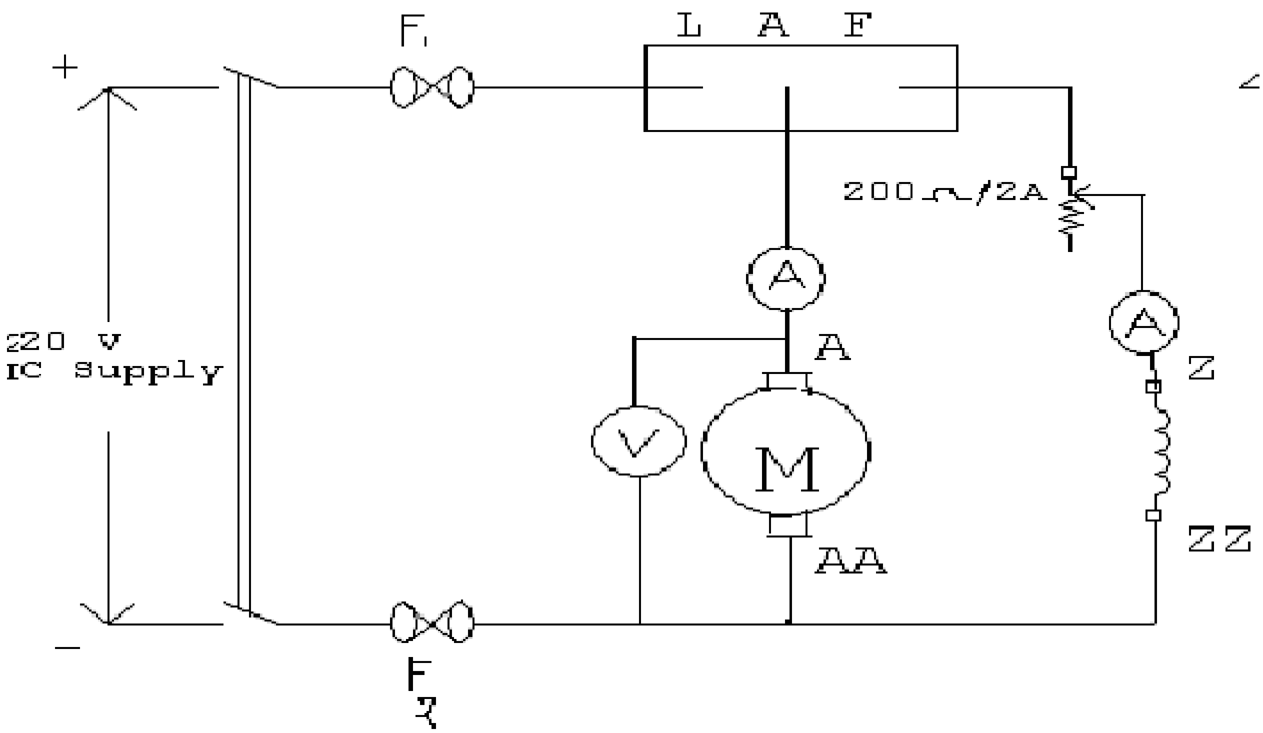
Constant losses = I/P – Armature copper losses = $VI_O - (I_o-I_{sh})^2R_A$

Let $I_L$ is the load current at which efficiency is required.

Then $I_a = I_L-I_{sh}$ ---- if machine is motoring

$I_a = I_L+I_{sh}$ ----- if machine is generating

CIRCUIT DIAGRAM:




**PRC**

3. Take the readings of line current, shunt field current and supply voltage at no-load.
4. Measure the resistance of the armature.

**OBSERVATIONS:**

A. Readings of Swinburne’s test.

| S.NO | Line voltage VL in Volts | Line current IL in Amps | Shunt field Current- If in Amps | Armature current in Amps Ia= (IL-If) |
|---|---|---|---|---|
| | | | | |

| | | | | |
|---|---|---|---|---|
| 1 | | | | |

B. Readings to calculate Armature resistance (Ra)

| S.NO | Armature current Ia in Amps | Voltage across Armature Va in Volts | Ra=Va/Ia in Ω |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

**Sample Calculations:**

**Efficiency when running as a motor :**

Input = VI

Constant losses = $W_c$

Armature copper losses = $I_a^2R_a = (I-I_{sh})^2R_a$

Total losses = $(I-I_{sh})^2R_a + W_c$

Efficiency of the motor = $\frac{\text{Input- Output}}{} = \frac{VI-(I-I_{sh})^2R_a-W_C}{}$

Input VI

**Efficiency when running as Generator:**

Output = VI

Constant losses = $W_c$

Armature copper losses = $I_a^2R_a = (I+I_{sh})^2R_a$

Total losses = $(I+I_{sh})^2R_a + W_c$

Efficiency of the motor = $\frac{\text{Input- Output}}{\text{Input}} = \frac{VI}{VI-(I-I_{sh})^2R_a-W_C}$

## Graph:

1. Draw the graph between output Vs efficiency for motor
2. Draw the graph between output Vs efficiency for generator.

## RESULTS & CONCLUSIONS:

## 6.8. SPEED CONTROL OF DC SHUNT MOTOR

AIM: To study the speed control of a DC shunt motor by Armature voltage control method and Field flux control method.

**NAME PLATE DETAILS** : Motor

1. Voltage :
2. Current :
3. H.P/ KW Ratings :
4. Speed :

APPARATUS REQUIRED:

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | Ammeter | | | |
| 2 | Voltmeter | | | |
| 3 | Tachometer | | | |

**THEORY:**

The speed of a DC motor is given by the relation,

$$N = \frac{VI - I_a R_a}{Z\,\phi}\,\frac{A}{P} = K\,\frac{VI - I_a R_a}{\phi}$$

Therefore, the speed of a such motor can be controlled by varying either the flux per pole $\phi$, (field flux control) or the armature resistance, $R_a$ (Armature control).

**Field flux control method**:

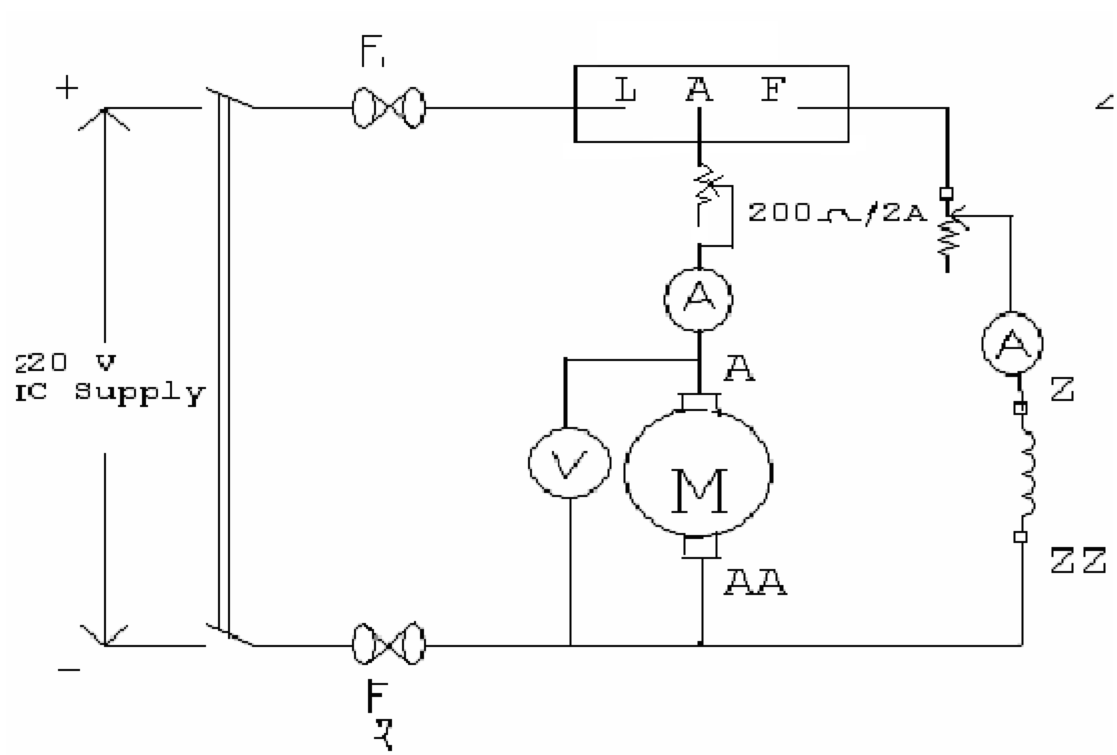
It can be seen that N∝ 1/ ϕ. Hence, the speed can be increased by decreasing the flux and vice versa. The flux of a DC shunt motor can be changed by changing the shunt field current ($I_{sh}$) with the help of a rheostat in the shunt field circuit. This method is commonly used to get speeds above trated speed.

A speed ratio of 2:1 can be obtained in non inter polar machines. Any further weakening flux adversely affects commutation.

**Armature control method:**

This method is used when speeds below the no-load speed are required. As supply voltage is normally constant, the voltage across the armature is varied by

**CIRCUIT DIAGRAM:**



**OBSERVATIONS:**

| S.NO | Armature current in Amps - Ia | Voltage across Armature Va in Volts | RPM - N | Back emf Eb=V-IaRa in volts |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

1. Armature control method:-

2. .Field control method:-

| S.NO | Shunt field Current- If in Amps | RPM - N |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

inserting a variable rheostat (called controller resistance) in series with the armature circuit. As the controller resistance increased, potential difference across the armature is decreased, thereby decreasing the armature speed. For a load of constant torque, speed is approximately proportional to the potential difference across the armature. From the speed/ armature current characteristic it is seen that greater the resistance in the armature circuit, greater is the fall in speed.

The speed (N) with a total armature resistance $R_t$ is related to the No-load speed $N_0$ by the following equation.

$$N = N_o (1 - I_a R_t / V)$$

The load current following the speed will be zero is obtained by putting N = 0 in the above formula. $I_a = V/ R_t$

This is the maximum armature current and is known as stalling current.

**PROCEDURE:**

1. Make the connections as shown in the figure.
2. Ensure maximum resistance in the armature circuit and minimum resistance in the field circuit.
3. Ensure free rotation of brake drum and switch ON the power supply.

**Armature control method:**

a). Keep the field current constant and vary the armature resistance in steps.

b). At each step, ensure field current is constant and note down the Armature voltage and speed till near rated speed.

c). Finally adjust the armature resistance such that the voltage across the armature is 70–90v.

**Field control method:**

a). Keep the armature voltage constant.

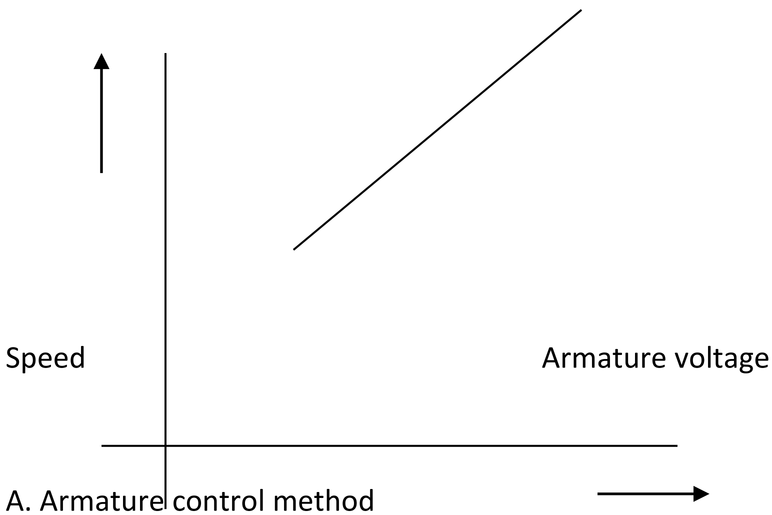
b).Take the speed and field resistance values varying the field resistance (decreasing $I_f$).

c). At each step, ensure the armature voltage is constant.

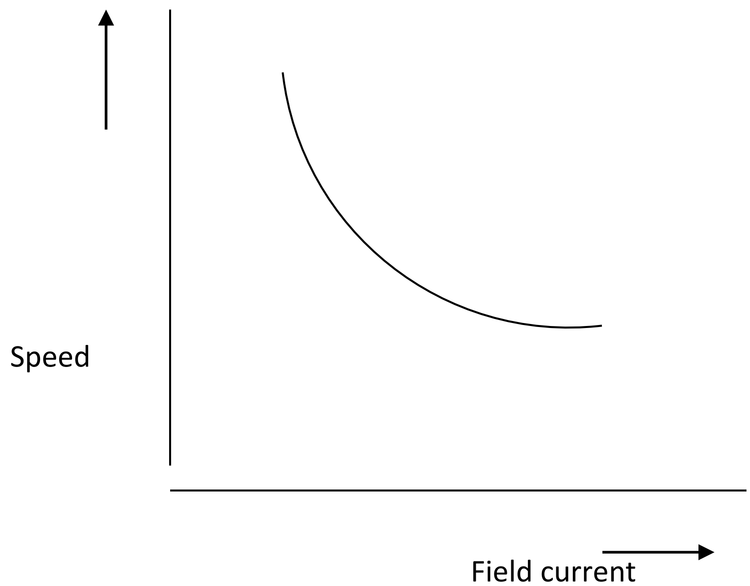
d). Repeat till near the rated speed.

4. Reset armature and field resistance to original values and switch OFF the machine.

**Model Graphs:**




A. Armature control method




B. Field control method.

**GRAPHS:**

1. Plot the graph between Speed $V_s$ Armature Voltage
2. Plot the graph between Speed $V_s$ Field current

**RESULTS & CONCLUSIONS:**

## 6.9. BRAKE TEST ON DC COMPOUND MOTOR

**AIM:** To study the performance of a DC compound motor by conducting Brake test.

**NAME PLATE DETAILS** : Motor

1. Voltage :
2. Current :
3. H.P/ KW Ratings :
4. Speed :

APPARATUS REQUIRED:

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | **Ammeter** | | | |
| 2 | **Voltmeter** | | | |
| 3 | **Tachometer** | | | |

THEORY:

It is a direct method in which a braking force is applied to a pulley mounted on the motor shaft. A belt is wound round the pulley and its two ends are attached to the frame through two spring balances $S_1$ and $S_2$. The tension of the belt can be adjusted with the help of tightening wheels. The tangential force acting on the pulley is equal to the difference between the readings of the two spring balances.

Spring balance readings are $S_1$ and $S_2$ in Kg.

Radius of the shaft is R meters.

Speed of the motor is N rpm.

Input voltage across the motor is V volts

Input current is I amps

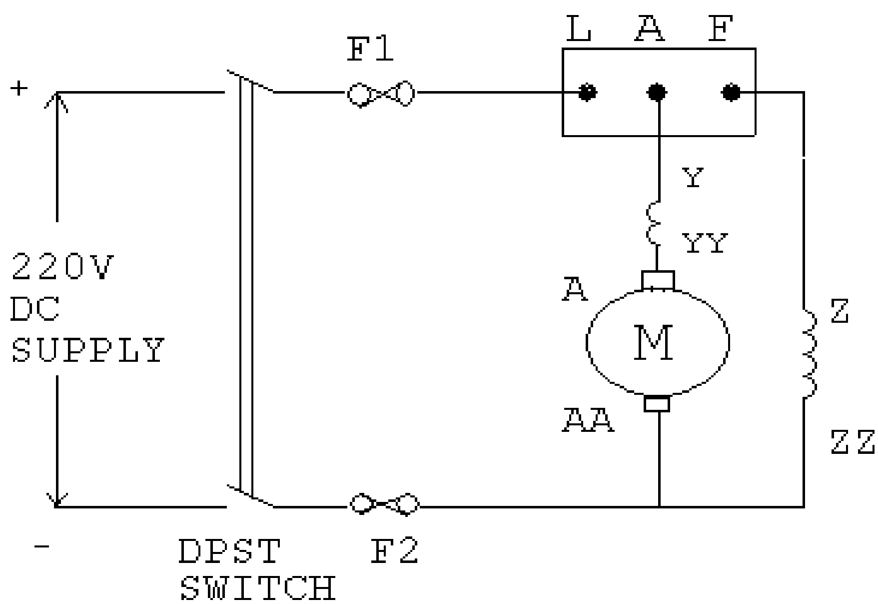
Torque (T) = $(S_1 - S_2)\ R \times 9.81$ N-m.

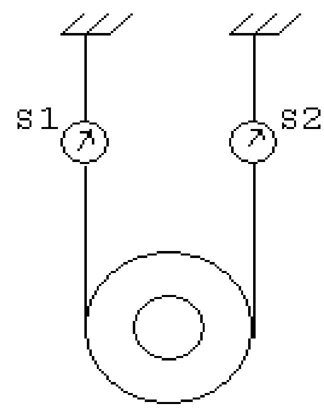
Motor output = $2\Pi NT / 60$ watts

Motor input = $VI$ watts

Efficiency = output/ input = $2\Pi NT / 60\ (VI)$

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Make the connections as per the circuit diagram.
2. Ensure minimum resistance in the field circuit and check the brake drum for free rotation.
3. Switch on the supply and slowly push the starter till the end.
4. Adjust the speed of the motor to the rated value by adjusting field resistance.
5. Take the No-load readings of voltmeter, Ammeter and speed.
6. Slowly increase the load on the brake pulley by tightening the wheels in steps. At each step note down the readings of voltmeter, Ammeter, spring balance readings and speed.
7. Release the load on the pulley and switch OFF the supply.

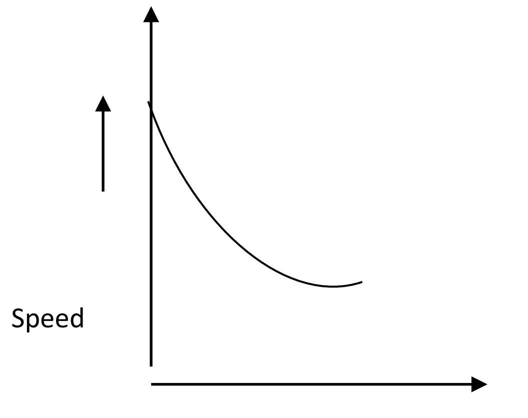
.

**OBSERVATIONS:**

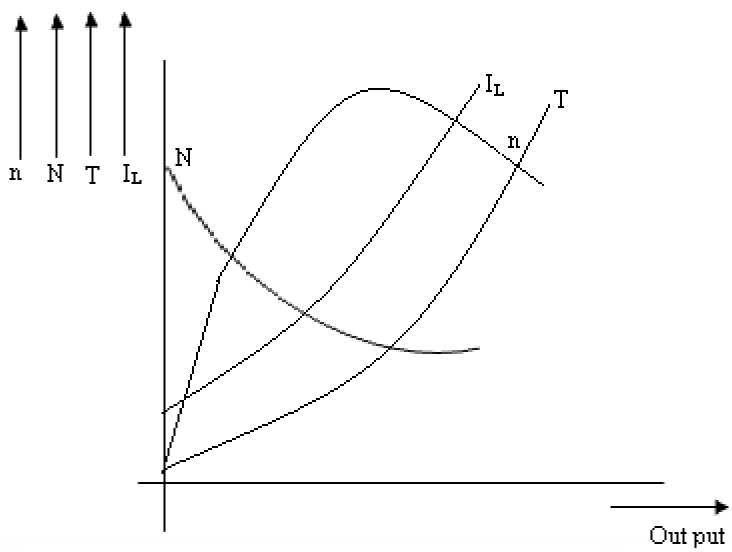
**Radius of the pulley (in meters) =**

| S.NO | VL | IL | If | Ia | N | S1 | S2 | T | O/P | I/P | %η |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |

## Model Graph:




## Model Graph:




GRAPHS:

**Plot the graphs: -**

1. Efficiency Vs Output
2. Speed Vs Output
3. Torque Vs Output
4. Load current Vs Output
5. Speed $V_s$ Torque.

## RESULTS & CONCLUSIONS:

# 6.10. BRAKE TEST ON DC SHUNT MOTOR

AIM: To study the performance of a DC shunt motor by conducting Brake test.

**NAME PLATE DETAILS** : Motor

1. Voltage :
2. Current :
3. H.P/ KW Ratings :
4. Speed :

APPARATUS REQUIRED:

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | **Ammeter** | | | |
| 2 | **Voltmeter** | | | |
| 3 | **Tachometer** | | | |

**THEORY:**

It is a direct method in which a braking force is applied to a pulley mounted on the motor shaft. A belt is wound round the pulley and its two ends are attached to the frame through two spring balances $S_1$ and $S_2$. The tension of the belt can be adjusted with the help of tightening wheels. The tangential force acting on the pulley is equal to the difference between the readings of the two spring balances.

Spring balance readings are $S_1$ and $S_2$ in Kg.

Radius of the shaft is R meters.

Speed of the motor is N rpm.

Input voltage across the motor is V volts

Input current is I amps

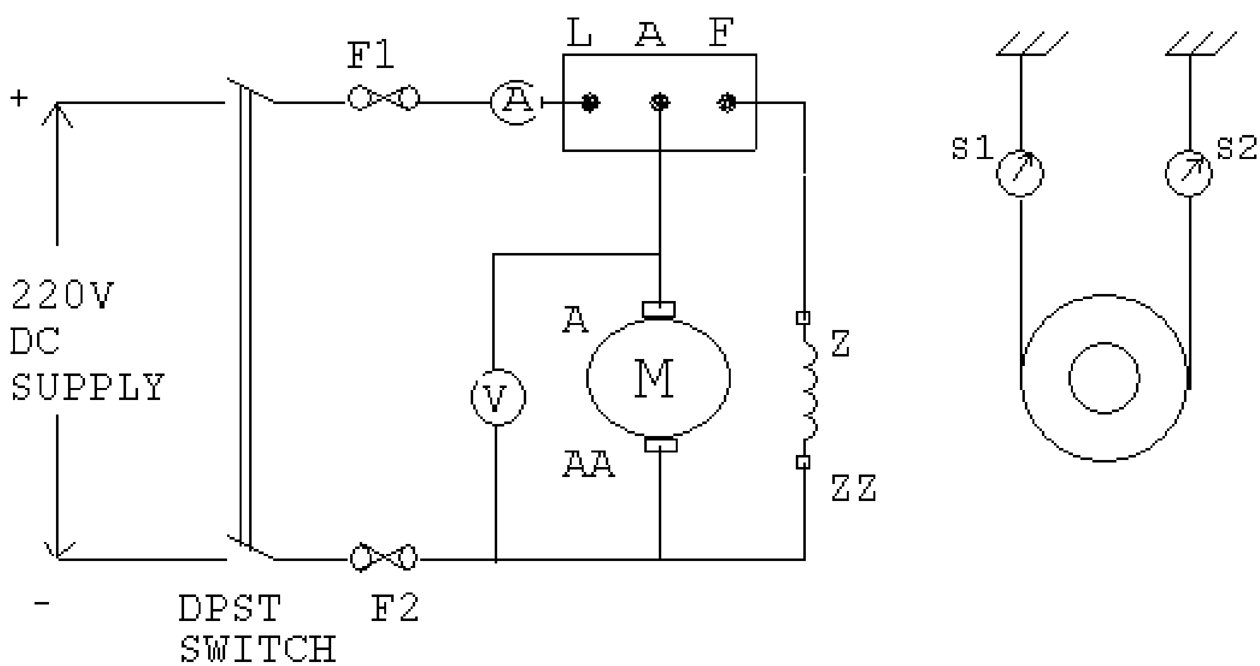
Torque (T) = $(S_1 – S_2)$ R x 9.81 N-m.

Motor output = 2ΠNT / 60 watts

Motor input = VI watts

Efficiency = output/ input = 2∏NT / 60 (VI)

CIRCUIT DIAGRAM:



**PROCEDURE:**

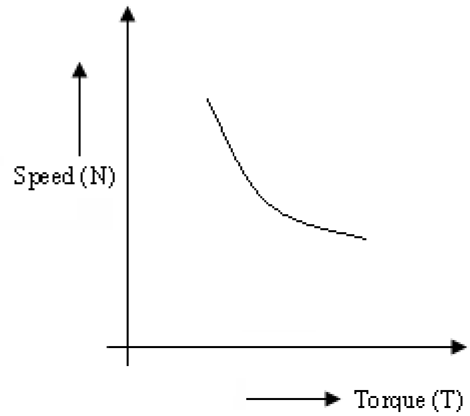
1. Make the connections as per the circuit diagram.
2. Ensure minimum resistance in the field circuit and check the brake drum for free rotation.
3. Switch on the supply and slowly push the starter till the end.
4. Adjust the speed of the motor to the rated value by adjusting field resistance.
5. Take the No-load readings of voltmeter, Ammeter and speed.
6. Slowly increase the load on the brake pulley by tightening the wheels in steps. At each step note down the readings of voltmeter, Ammeter, spring balance readings and speed.
7. Release the load on the pulley and switch OFF the supply.

**OBSERVATIONS:**

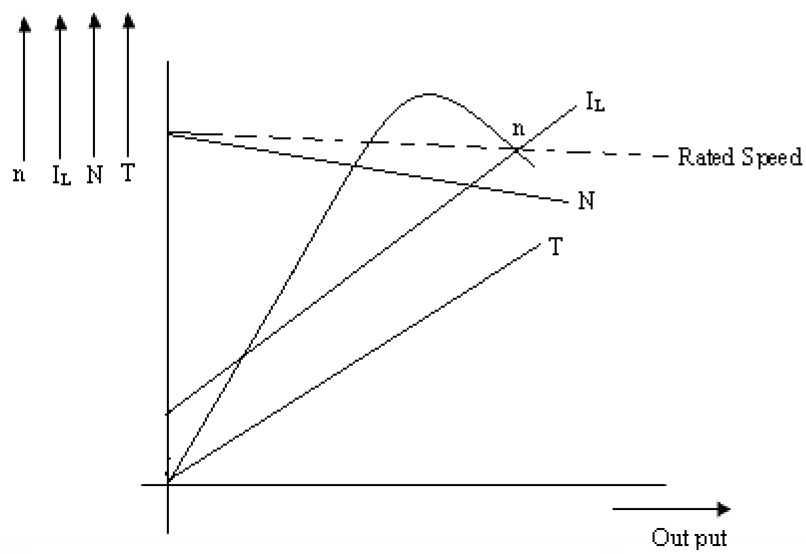
**Radius of the pulley (in meters) =**

| S.NO | VL | IL | If | Ia | N | S1 | S2 | T | O/P | I/P | %η |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |

**Model Graph:**




**Model Graph:**




**PRECAUTIONS:**

1). Avoid hanging wires and loose connections.

2). Make sure that the initial value of Field Resistance is minimum.

3). Ensure that the loading belt is slack when the machine is started.

**GRAPHS:** Plot the graphs: -

1. Efficiency Vs Output
2. Speed Vs Output
3. Torque Vs Output
4. Load current Vs Output
5. Speed $V_s$ Torque.

**RESULTS & CONCLUSIONS:**

## 6.11. SEPERATION OF LOSSES IN A DC SHUNT MACHINE

**AIM:** To perform a suitable test on the given DC shunt machine and determine from the experiment the stray losses and separate these into friction, hysteresis and eddy current losses.

**NAME PLATE DETAILS** : Motor

1. Voltage :
2. Current :
3. H.P/ KW Ratings :
4. Speed :

**APPARATUS REQUIRED:**

| S.No | Name of the equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | Ammeter | | | |
| 2 | Voltmeter | | | |
| 3 | Tachometer | | | |

**THEORY:**

The various losses that occur in a DC machine are:

1) Copper losses :

a) $Ia^2Ra$ the armature copper loss (30 to 40% of total full load losses)

b) Field copper losses $Ish^2Rsh$ in a short winding, $Ise^2Rse$ in a series winding (20 to 30% of total load losses)c) Loss due to brush contact resistance.

2) Stray Losses :

a) Iron Losses

b) Hysteresis loss and

c) Eddy current loss (20 to 30% of total full load loss)

d) Mechanical losses

i) Friction at bearing and commutator

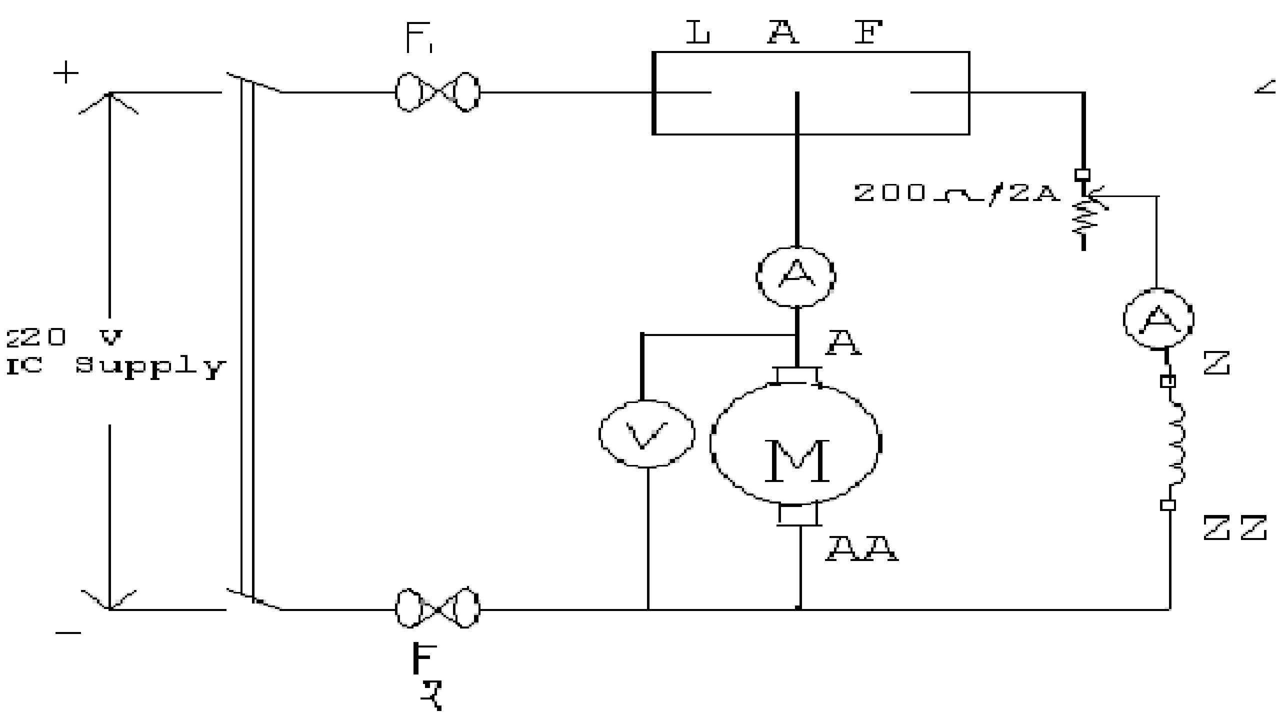
ii) windage of rotating armature (10% to 20% of total full load losses)

Iron losses and mechanical losses are together called stray losses.

Hysteresis loss Wh α (Flux) X (speed)

Eddy current loss We α $(Flux)^2$ X $(Speed)^2$

**CIRCUIT DIAGRAM:**




**P**

D

2. Start the motor slowly using starter keeping the field and armature rheostats in minimum and maximum position respectively.

**PROCEDURE**

1. Adjust the field current to the rated value at no load.
2. Reduce the armature circuit resistance in steps, increasing the speed.
3. Take the readings of voltmeter, ammeter and speed at constant field current.
4. Continue the experiment till maximum speed is obtained by cutting out the complete resistance in armature circuit. (Do not exceed the rated speed.)
5. Bring the armature rheostat back to full resistance (initial) position.
6. Repeat the experiment with a reduced field current. (75% rated excitation) stop the motor.
7. Stop the motor.
8. Measure the armature resistance by voltmeter-ammeter method using the circuit diagram as shown in fig.
9. Tabulate the readings.

**OBSERVATIONS:**

A. Readings to calculate losses. I.If=1_________ A.(Full excitation).

| S.NO | Voltage across armature V in volts | Armature current Ia in Amps | Back emf Eb in volts (Eb-V-IaRa) | Stray Losses Ws in watts (Ws=IaEb) | Speed N in RPM | Ws/N |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |

II.If=_______________A(3/4 excitation).

| **S.NO** | **Voltage across armature V in volts** | **Armature current Ia in Amps** | **Back emf Eb in volts (Eb-V-IaRa)** | **Stray Losses Ws in watts (Ws=IaEb)** | **Speed N in RPM** | **Ws/N** |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |

B. Readings to calculate Armature resistance (Ra)

| S.NO | Armature current Ia in Amps | Voltage across Armature Va in Volts | Ra=Va/Ia in Ω |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

Thus in a shunt machine as flux (Ish) is fairly constant Wh α N or Wh = AN

Eddy current loss We α $N^2$ or We = $BN^2$

The iron or magnetic losses are then $We + Wh = AN+BN^2$

$W/N = A+BN+C+DN = (A+C) + (B+D) N$

The graph Ws/N would be a straight line. Then, if the experiment is performed at two different excitations full load excitation and reduced excitation (at about 3/4th of full load) then two sets of graphs can be obtained.

$W/N = (A+C) + (B+D) N$ at full excitation (If)

$W/N = (A1 + C) + (B1 + D) N$ at full reduced excitation ($If^1$)

$(A/A^1)(\Phi^{1.6}/\Phi) = (I_1/ I_1^1)^{1.6}$

$(B/B^1)(\Phi/\Phi^1)^2 = (I_f/I_f^1)^2$

$(A+C).(A^1C).(B^1+B)$ are determined from the slopes and intercepts

A.B.C.D and $A^1$ and $B^1$ can be determined from the above relationships.

**Sample calculations:**

**Model Graphs:**

**PRECAUTIONS:**

1. Keep the field current constant during each part of the experiment.
2. Check the position of the rheostat position before starting the motor.

**GRAPH:**

Plot W/N Vs N for both the field excitations:

From the graph find out

B1 + D = bc/ab

B + D = ef/de

Determine

A-C and A1 + C

Solve for A. A1.B.B1.C.D

**RESULT:**

At rated speed the various losses are

Hysteresis loss =

Eddy current loss =

Friction loss =

Windage loss =

## 7. Content beyond syllabus:

1 Separation of no-load losses in single phase transformer
2 Open circuit and load characteristics of separately and self excited dc shunt generators.
3 Load test on dc series motor
4 Speed control of dc shunt motor

## 8. Sample Viva Voce Questions

### Exp 1

1. Why is the Magnetization characteristic different for increasing and decreasing of values of $I_t$
2. What is the purpose of starter for the motor ?
3. Why is the speed maintained constant during the experiment ?
4. Why is the motor field resistance kept to a minimum while starting the motor ?
5. What is residual magnetism ?
6. Define critical resistance ?
7. Define critical speed ?
8. How do you determine critical resistance with help of O.C.C.
9. Explain magnetization curve.
10. How do you determine critical speed graphically ?
11. Define coercive force ?
12. Explain hysteresis phenomena?

### Exp 2

1. If the shunt generator fails to build-up the voltage what could be the reason for it?. Explain how this can be over come.
2. what is meant by armature reaction/
3. Why are the characteristics of the shunt generator drooping?
4. Why DC generators are normally designed for maximum efficiency around the load?
5. What will happen when R-C load is connected across armature?
6. For properly designed DC generators the over all efficiency could be of the order of-----------%.
7. Define commercial and electrical efficiencies for DC generators?
8. Which losses in a DC generator vary significantly with the load current?
9. Draw the internal and external characteristics for a DC shunt generator

### Exp 3

1. How the internal characteristics are derived from the external characteristics?
2. What are the reasons for the failure of a DC series generator to build-up voltage?
3. What is meant by critical resistance of a DC series generator?
4. What is the necessity of starter in DC motors?
5. What material used for brushes. Why?
6. Why external characteristics are lies below the internal chrematistics in DC shunt generator?
7. What is the critical load resistance?
8. How do you control the speed of DC motor?

**Exp 4**

1. How many field windings are there in a compound generator? What are they?
2. What does compounding mean?
3. Draw the external characteristics for a level compound generator.
4. In a compound wound generator which of the two fields dominates?
5. Discuss the performance of a DC compound generator using only one field winding at a time?
6. What is meant by commutation?
7. What are the different methods of obtaining spark less or good commutation?
8. Why do you perform load test?
9. Differentiate cumulative and differential compound generators?
10. Give at least three applications of Dc compound generators?

**Exp 5**

1. What are the advantages of this test?
2. an this test be applied to compound machines? Explain.
3. when two DC machines are paralled as is done in this test, which machine acts as a generator and which machine acts as a motor?
4. what are the disadvantages of this test/
5. what are heat run tests?
6. what is the other name for this test/
7. Hopkinsons test on DC machines is conducted at what load?
8. the armature voltage control of DC motor provides -----------drive?

**Exp 6**

1. In a Dc machine, winding losses varies with speed in the proportion of ----------
2. Break test on DC motors are usually restricted to ------------HP motors?
3. Why do we pour water in the break drum during break test?
4. What is the effect on speed of DC compound for if the

**Exp 7**

1. What are the advantages of Swinburne test?
2. Why Swinburns test cannot be performed on series machines? Explain.
3. How do you obtain accurate measurements in this experiments/
4. How do you reverse the direction of motor?

**Exp 8**

1. What will happen if the shunt field is open during running?
2. What is the purpose of NO VOLT coil in a D.C Motor?
3. How do you change the direction of rotation of DC shunt motor?
4. What are the methods of speed control in a DC shunt motor?
5. In which method of speed control, above the base speed can be achived. Why?
6. List the merits and demerits of armature voltage control method?
7. What is the necessity of starter?
8. What is the function of OLR coil in Dc starters?
9. What is the advantage of 4-point starter over 3-point starter?
10. Which is the precise method of speed control of DC motors?

**Exp 9**

1. Explain the difference between long shunt and short shunt compounding?
2. What are the uses of different types of compound motors?
3. What is differential compounding? How it is different from cumulative compounding?
4. How do you reverse the direction of motor?
5. Draw the speed- torque curve for differential compound motor?
6. What is flat compounding?
7. In a DC machine windage loss varies with speed in the proportion of……
8. Break test on Dc motors is usually restricted to -------HP motors?
9. What is the effect on speed of DC compound motor if the series field winding is shorted?
10. How do you minimize iron losses in a DC machine?

**Exp 10**

1. What is the back emf of the motor?
2. Why the speed falls as load increases for a DC shunt motor?
3. What are the applications of Dc shunt motor?
4. When is the efficiency of the motor maximum?
5. Define commutation?
6. How do you minimize reactance voltage for sparkles commutation?
7. What should be the position of rheostat in the field circuit while starting?
8. What is the nature of load connected across DC motor?
9. What will happen when Dc shunt motor is started with load?
10. Give the expressions for various torques in DC motors?
11. What is the effect on speed if part of the field winding is shorted?

**Exp 11**

1. How does hysteresis loss occur in a DC machine?
2. Where are the eddy current losses occurring in a DC machine?
3. How are magnetic losses minimized?
4. How is brush contact resistance loss taken into consideration in practice?
5. Give the expression for hysteresis loss.
6. What is the effect of armature reaction?
7. How do you minimize cross magnetizing effect of armature reaction.

## 9. Sample Question paper of the lab external

1) Draw the magnetising characteristics of dc shunt generator

2 perform the load test on dc shunt generator

3 perform the load test on dc series generator

4 perform the load test on dc compound generator

5 perform the hopkinson's test

6 perform the field test on dc series motor

7 perform the swinburne's test on dc shunt machine

8 perform the speed controltest on dc shunt motor

9 perform the brake test on dc compound motor

10 perform the brake test on dc shunt motor

11 perform the seperation losses test on dc shunt motor

## 10 Applications of the laboratory

i. To get the knowledge of electrical DC machines.
ii. To know the different performance of the different electrical DC machines
iii. To know the effiency of the different electrical DC machines

## 11 Precautions to be taken while conducting the lab

**SAFETY – 1**

- Power must be switched-OFF while making any connections.
- Do not come in contact with live supply.
- Power should always be in switch-OFF condition, EXCEPT while you are taking readings.
- The Circuit diagram should be approved by the faculty before making connections.
- Circuit connections should be checked & approved by the faculty before switching on the power.
- Keep your Experimental Set-up neat and tidy.
- Check the polarities of meters and supplies while making connections.
- Always connect the voltmeter after making all other connections.
- Check the Fuse and it's ratify.
- Use right color and gauge of the fuse.
- All terminations should be firm and no exposed wire.
- Do not use joints for connection wire.

- While making 3-phase motor ON, check its current rating from motor name plate details and adjust its rated current setting on MPCB(Motor Protection Circuit Breaker) by taking approval of the faculty.
- Before switch-ON the AC or DC motor, verify that the Belt load is unloaded.
- Before switch-ON the DC Motor-Generator set ON, verify that the DC motor field resistance should be kept in minimum position. Where as the DC generator / AC generator field resistance should be kept in Maximum position.
- Avoid loose connections. Loose connections leads to heavy sparking & damage for the equipments as well as danger for the human life.
- Before starting the AC motor/Transformer see that their variacs or Dimmerstats always kept in zero position.

- For making perfect DC experiment connections & avoiding confusions follow color coding connections strictly. Red colour wires should be used for positive connections while black color wires to be used for Negative connections.
- After making DPST switch/ICTPN switch-OFF see that the switch in switched-OFF Perfectly or not. Open the switch door & see the inside switch contacts are in open. If in-contact inform to faculty for corrective action.
- For safety protection always give connections through MCB (Miniature circuit breaker) while performing the experiments.

**SAFETY – II**

1. The voltage employed in electrical lab are sufficiently high to endanger human life.
2. Compulsorily wear shoes.
3. Don’t use metal jewelers on hands.
4. Do not wear loose dress
5. Don’t switch on main power unless the faculty gives the permission4 Do not start the series motor without load.
6. Keep the armature rheostat in maximum position

## 12. Code of Conduct:

1. Students should report to the labs concerned as per the timetable.
2. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.
3. After completion of the experiment, certification of the staff in-charge concerned in the observation book is necessary.
4. Students should bring a notebook of about 100 pages and should enter the readings/observations/results into the notebook while performing the experiment.
5. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate previous session should be submitted and certified by the staff member in-charge.
6. Not more than three students in a group are permitted to perform the experiment on a set up.
7. The group-wise division made in the beginning should be adhered to, and no mix up of student among different groups will be permitted later.
8. The components required pertaining to the experiment should be collected from Lab-in-charge after duly filling in the requisition form.
9. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
10. Any damage of the equipment or burnout of components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year.
11. Students should be present in the labs for the total scheduled duration.
12. Students are expected to prepare thoroughly to perform the experiment before coming to Laboratory.
13. Procedure sheets/data sheets provided to the students' groups should be maintained neatly and are to be returned after the experiment.

## 13.Graph if any