ELECTRICAL MACHINES –I LAB

II-B.Tech

DEPARTMENT OF EEE

Aurora's Technological and Research Institute

Parvathapur, Uppal, Hyderabad-500 039

LABORATORY PRACTICE

I HEAR, I FORGET
I SEE, I REMEMBER
I DO, I UNDERSTAND

PRACTCAL APPROACH IS PROBABLY THE BEST APPROACH TO GAIN A CLEAR INSIGHT

CODE OF CONDUCT FOR THE LABORATORIES

- All students must observe the Dress Code while in the laboratory.
- Sandals or open-toed shoes are NOT allowed.
- Foods, drinks and smoking are NOT allowed.
- All bags must be left at the indicated place.
- The lab timetable must be strictly followed.
- Be PUNCTUAL for your laboratory session.
- Experiment must be completed within the given time.
- Noise must be kept to a minimum.
- Workspace must be kept clean and tidy at all time.
- Handle all apparatus with care.
- All students are liable for any damage to equipment due to their own negligence.
- All equipment, apparatus, tools and components must be RETURNED to their original place after use.
- Students are strictly PROHIBITED from taking out any items from the laboratory.
- Students are NOT allowed to work alone in the laboratory without the Lab Supervisor
- Report immediately to the Lab Supervisor if any injury occurred.
- Report immediately to the Lab Supervisor any damages to equipment.

Before leaving the lab

- Place the stools under the lab bench.
- Turn off the power to all instruments.
- Turn off the main power switch to the lab bench.
- **Please check the laboratory notice board regularly for updates**

GENERAL LABORATORY INSTRUCTIONS

- You should be punctual for your laboratory session and should not leave the lab without the permission of the teacher.
- Each student is expected to have his/her own lab book where they will take notes on the experiments as they are completed.
- The lab books will be checked at the end of each lab session. Lab notes are a primary source from which you will write your lab reports.
- You and your batch mates will work closely on the experiments together. One partner doing all the work will not be tolerated. All the Batch mates should be able to explain the purpose of the experiment and the underlying concepts.
- Please report immediately to the member of staff or lab assistant present in the laboratory; if any equipment is faulty.

Organization of the Laboratory

- It is important that the experiments are done according to the timetable and completed within the scheduled time.
- You should complete the prelab work in advance and utilize the laboratory time for verification only.
- The aim of these exercises is to develop your ability to understand, analyze and test them in the laboratory.
- A member of staff and a Lab assistant will be available during scheduled laboratory sessions to provide assistance.
- Always attempt experiments; first without seeking help.
- When you get into difficulty; ask for assistance.

Assessment

- The laboratory work of a student will be evaluated continuously during the semester for 25 marks. Of the 25 marks, 15 marks will be awarded for day-to-day work.
- For each experiment marks are awarded under three heads:
  _ Prelab preparation – 5 marks
  _ Practical work – 5marks, and
  _ Record of the Experiment – 5marks
- Internal lab test(s) conducted during the semester carries 10 marks.
- End semester lab examination, conducted as per the JNTU regulations, carries 50 marks.
- At the end of each laboratory session you must obtain the signature of the teacher along with the marks for the session out of 10 on the lab notebook.

Lab Reports

- Note that, although students are encouraged to collaborate during lab, each must individually prepare a report and submit.
- They must be organized, neat and legible.
- Your report should be complete, thorough, understandable and literate.
- You should include a well-drawn and labeled engineering schematic for each circuit Investigated.
- Your reports should follow the prescribed format, to give your report structure and to make sure that you address all of the important points.
- Graphics requiring- drawn straight lines should be done with a straight edge. Well drawn freehand sketches are permissible for schematics.
- Space must be provided in the flow of your discussion for any tables or figures. Do not collect figures and drawings in a single appendix at the end of the report.
- Reports should be submitted within one week after completing a scheduled lab session.

Presentation

- Experimental facts should always be given in the past tense.
- Discussions or remarks about the presentation of data should mainly be in the present tense.
- Discussion of results can be in both the present and past tenses, shifting back and forth from experimental facts to the presentation.
- Any specific conclusions or deductions should be expressed in the past tense.

Report Format

Lab write ups should consist of the following sections:

- **Aim**: A concise statement describing the experiment and the results. This is usually not more than 3 sentences. Since the abstract is a summary of what you have done, it's a good idea to write this last.
- **Apparatus**: Describe what equipment and components you used to conduct the experiment.
- **Theory**: Several paragraphs that explain the motivation of the experiment. Usually in this statement you state what you intent to accomplish as well as the expected results of the experiment.
- **Procedure**: Describe how you conducted the experiment
- **Results and Analysis**: This is the main body of the report. Graphs, tables, schematics, diagrams should all be included and explained. Results of any calculations should be explained and shown. State the results of the experiment. Include any problems encountered.
- **Conclusion**: Explain how the experiment went, and whether you were able to achieve the expected results stated in the introduction.

EEE Department

SAFETY – 1

1. Power must be switched-OFF while making any connections.
2. Do not come in contact with live supply.
3. Power should always be in switch-OFF condition, EXCEPT while you are taking readings.
4. The Circuit diagram should be approved by the faculty before making connections.
5. Circuit connections should be checked & approved by the faculty before switching on the power.
6. Keep your Experimental Set-up neat and tidy.
7. Check the polarities of meters and supplies while making connections.
8. Always connect the voltmeter after making all other connections.
9. Check the Fuse and it's ratify.
10. Use right color and gauge of the fuse.
11. All terminations should be firm and no exposed wire.
12. Do not use joints for connection wire.
13. 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.
14. Before switch-ON the AC or DC motor, verify that the Belt load is unloaded.
15. 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.
16. Avoid loose connections. Loose connections leads to heavy sparking & damage for the equipments as well as danger for the human life.
17. Before starting the AC motor/Transformer see that their variacs or Dimmerstats always kept in zero position.

18. 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.
19 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.
20 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 permission.

TREATMENT AGAINST SHOCK

(Artificial Respiration)

1. Place him/her on back. Clear his mouth and throat. Turn his/her head to side and remove any foreign bodies with fingers.
2. Tilt his/her head back by holding lower jaw – this gives a clear air passage way to his/her lungs and keep tongue out of throat.
3. You take deep breath of fresh air. Place mouth over his/her nose. Hold mouth closed. Blow into nose. Adults-blow fully, children-puff gently. Watch chest rise. Remove mouth – let chest fall. Continue until patient resumes breathing.

Note: If chest does not rise when you blow check for obstruction in his/her throat.

4. Listen to the air being exhaled. When flow of air stops blow it again.

OBJECTIVE

Electrical engineering is generation,transmission,distribution and utilization of electricity. In all these aspects electrical machines are the mandatory components.The Electrical Machines –I laboratory is the first real time exposure to electrical machines for the students. The laboratory aids the student on real time to confirm the concepts of theory of dc machines learnt in the previous semester.The course has experiments on all the types of dc generators and dc motors.These experiments consolidates the student's knowledge of construction,operation and performance of dc machines.

Name of the student: ________________________________

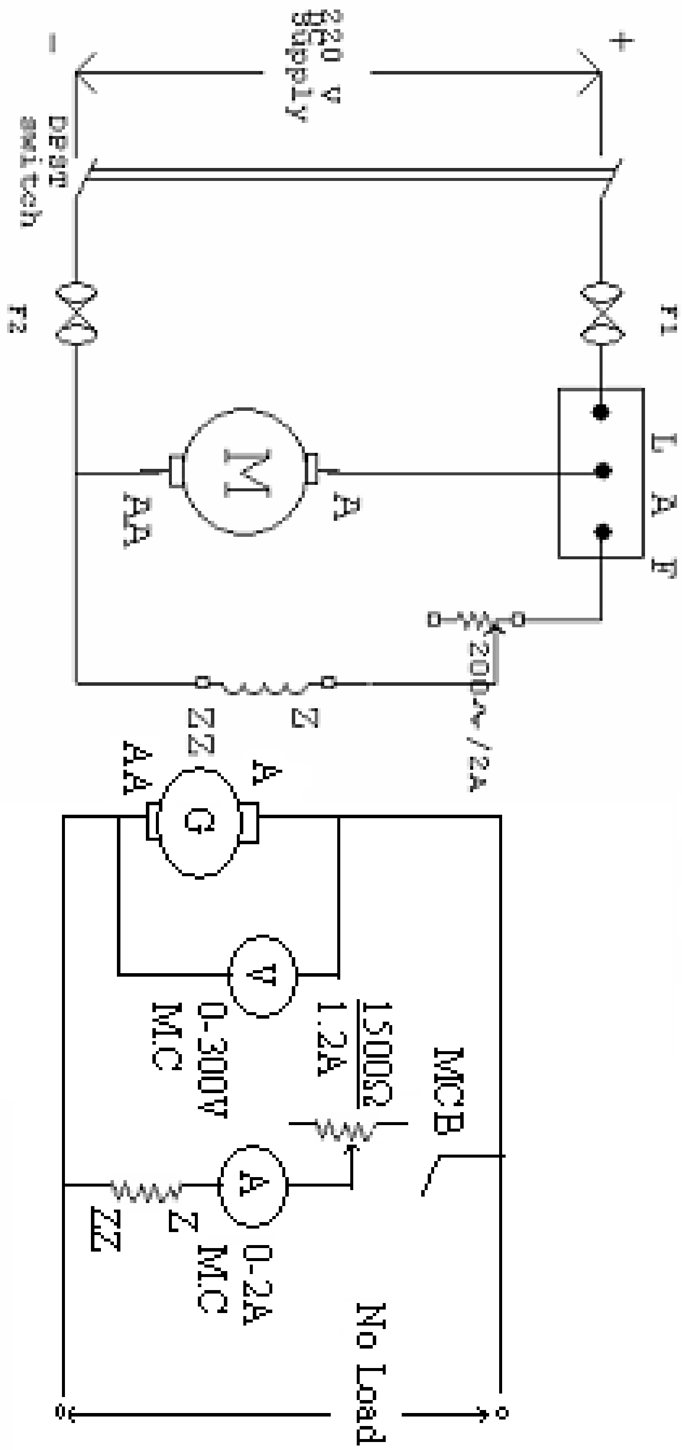
Roll Number: _______________________

INDEX

Sl. No	Name of the Experiment	Page No.	Date of conduction	Grade/ Marks	Incharge sign.
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				

CIRCUIT DIAGRAM:

Self Excited Generator



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** **R1** **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.

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				
11				
12				
13				
14			0	

Critical field resistance Rc =___________Ω

critical speed Nc =___________rpm

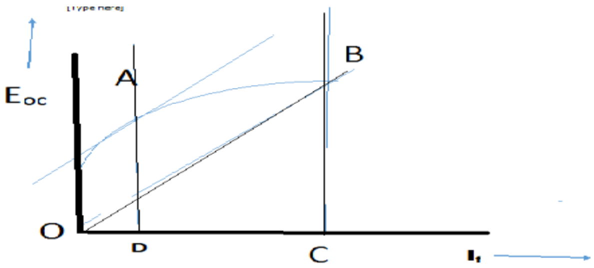
B. Readings to calculate shunt field resistance(Rsh)

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)



$AD/BC = N_c/N$

$N_C = AD/BC \times N$

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

4). Speed more than critical speed

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.

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.

PRECAUTIONS:

1). Avoid hanging wires and loose connections.

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

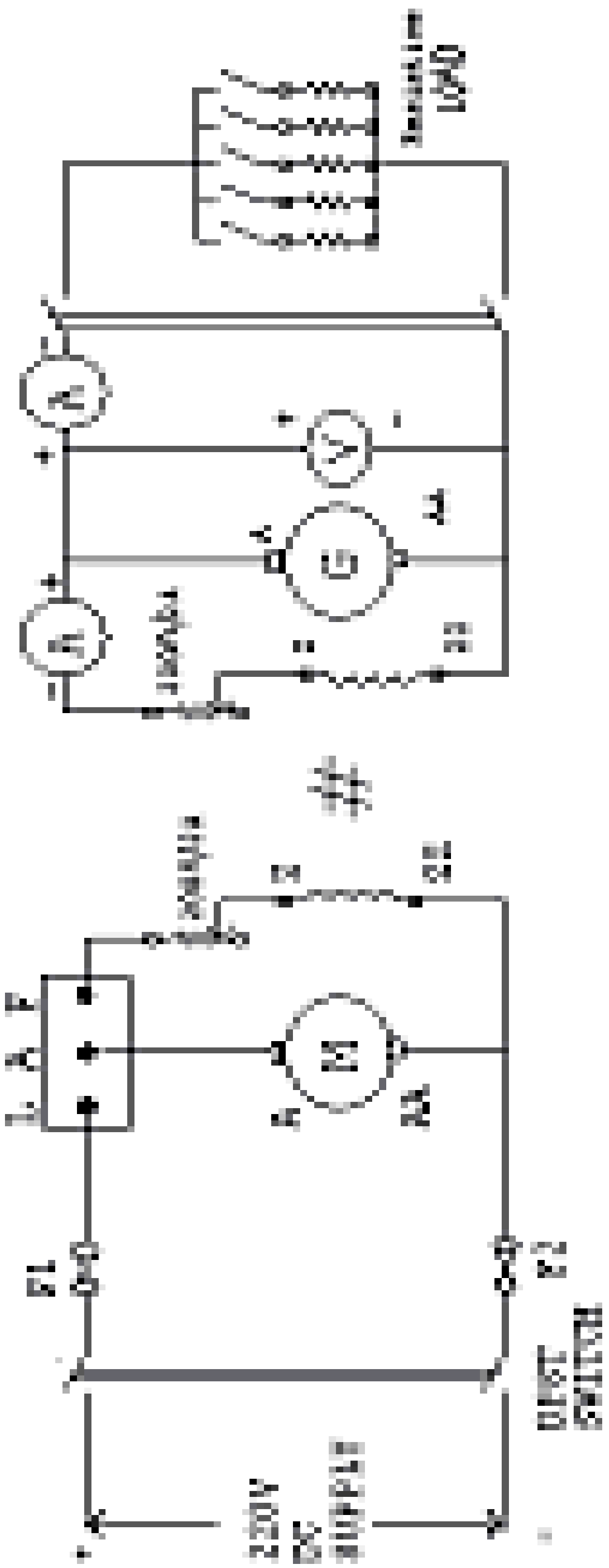
GRAPH: Draw the graph between Field current (I_f) Vs generated e.m.f (E).

RESULTS & CONCLUSIONS:

Reasoning questions:

1. Why is the Magnetization characteristic different for increasing and decreasing of values of I_f
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?

CIRCUIT DIAGRAM:



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 A1 A2			
2	Voltmeter			
3	Rheostats R1 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.

OBSERVATIONS:

A. Readings with loading of DC Shunt Generator.

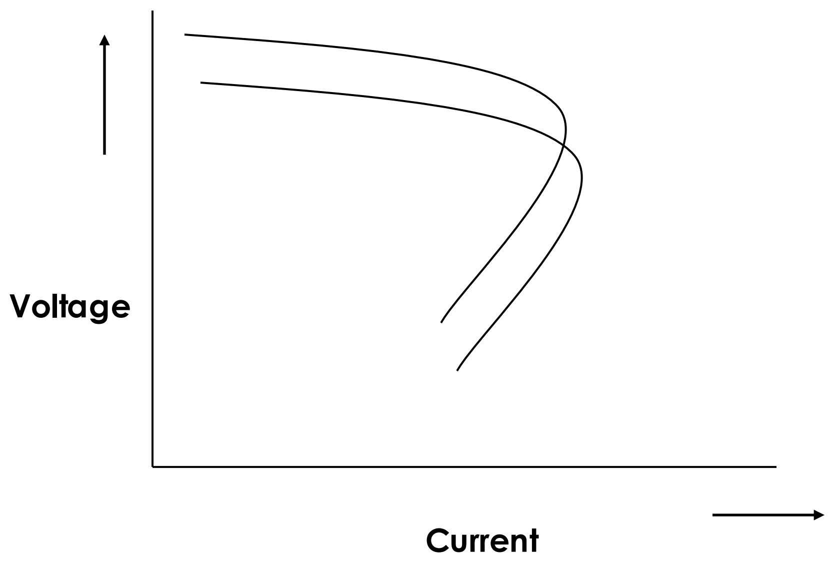
S.NO	Terminal voltage V in volts	Load current IL In Amps	Field current If in Amps	Armature current Ia= IL+If	Generated Emf Eg= V+IaRa
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

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			

Average Ra = _______________Ω

Model graphs:



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.

GRAPHS:

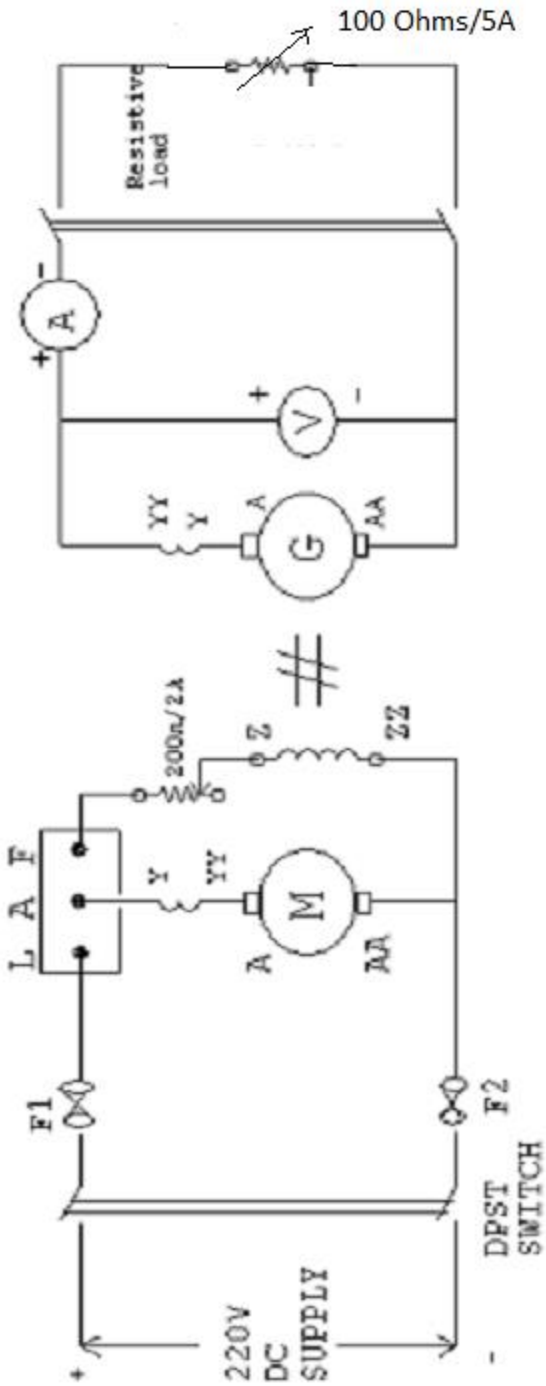
1. Draw graphs between E Vs I_a (internal characteristics)
2. Draw graphs between V Vs I_L (external characteristics)

RESULTS & CONCLUSIONS:

Reasoning questions:

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.

CIRCUIT DIAGRAM:



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).

OBSERVATIONS:

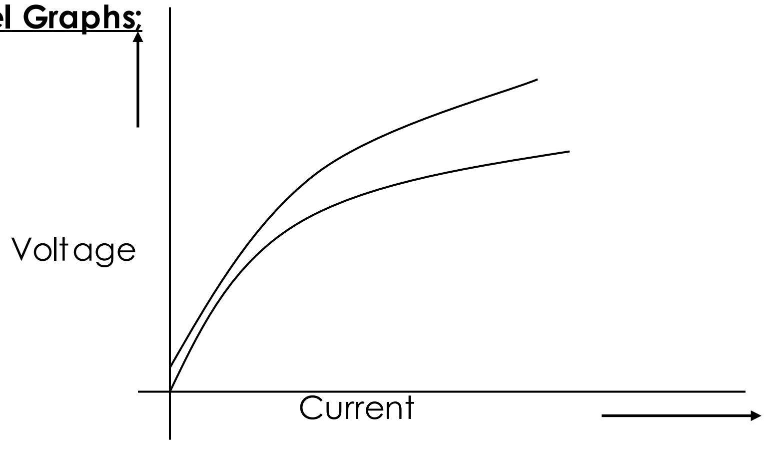
A. Readings with loading of DC Series Generator.

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.

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.

PRECAUTIONS:

1. Avoid the loose connections.
2. Do not start the series motor without load.
3. Keep the armature rheostat in maximum position.

GRAPHS:

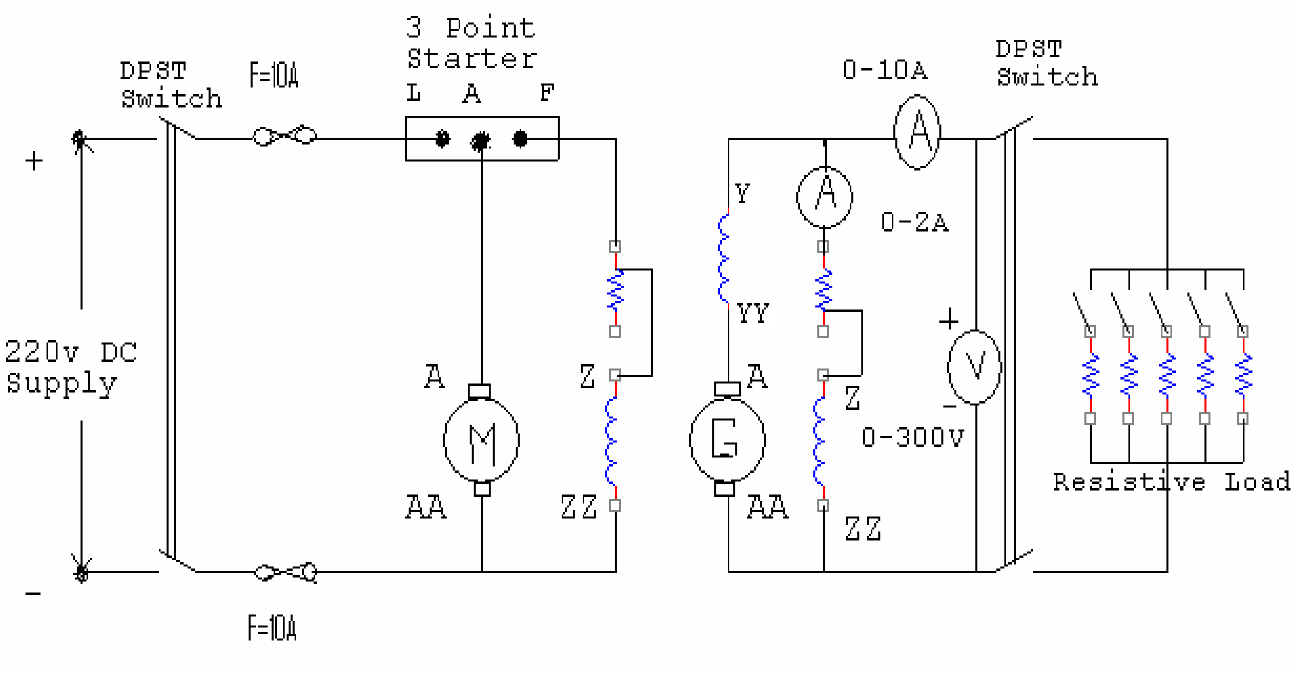
1. Draw graphs between E Vs I_a (internal characteristics)
2. Draw graphs between V Vs I_L (external characteristics)

RESULTS & CONCLUSIONS:

Reasoning Questions;

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?

CIRCUIT DIAGRAM:



OBSERVATIONS:

A. Readings with loading of DC Compound Generator.

I. Cumulative 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						

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 A1 A2			
2	Voltmeter			
3	Rheostats R1 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)

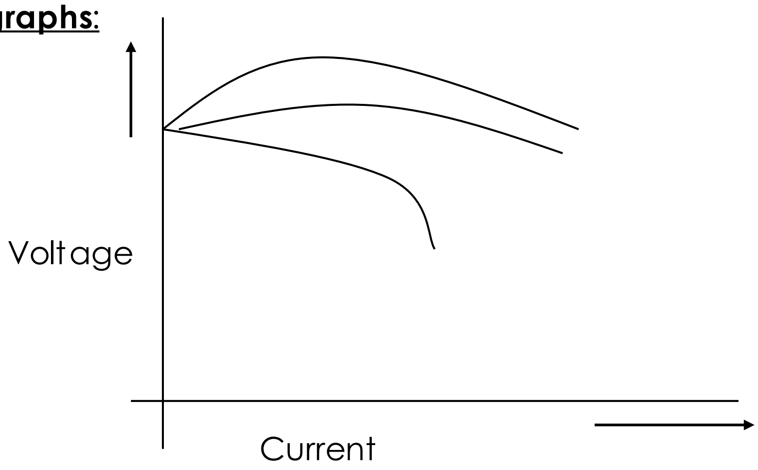
II. Differential mode.

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:



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 :

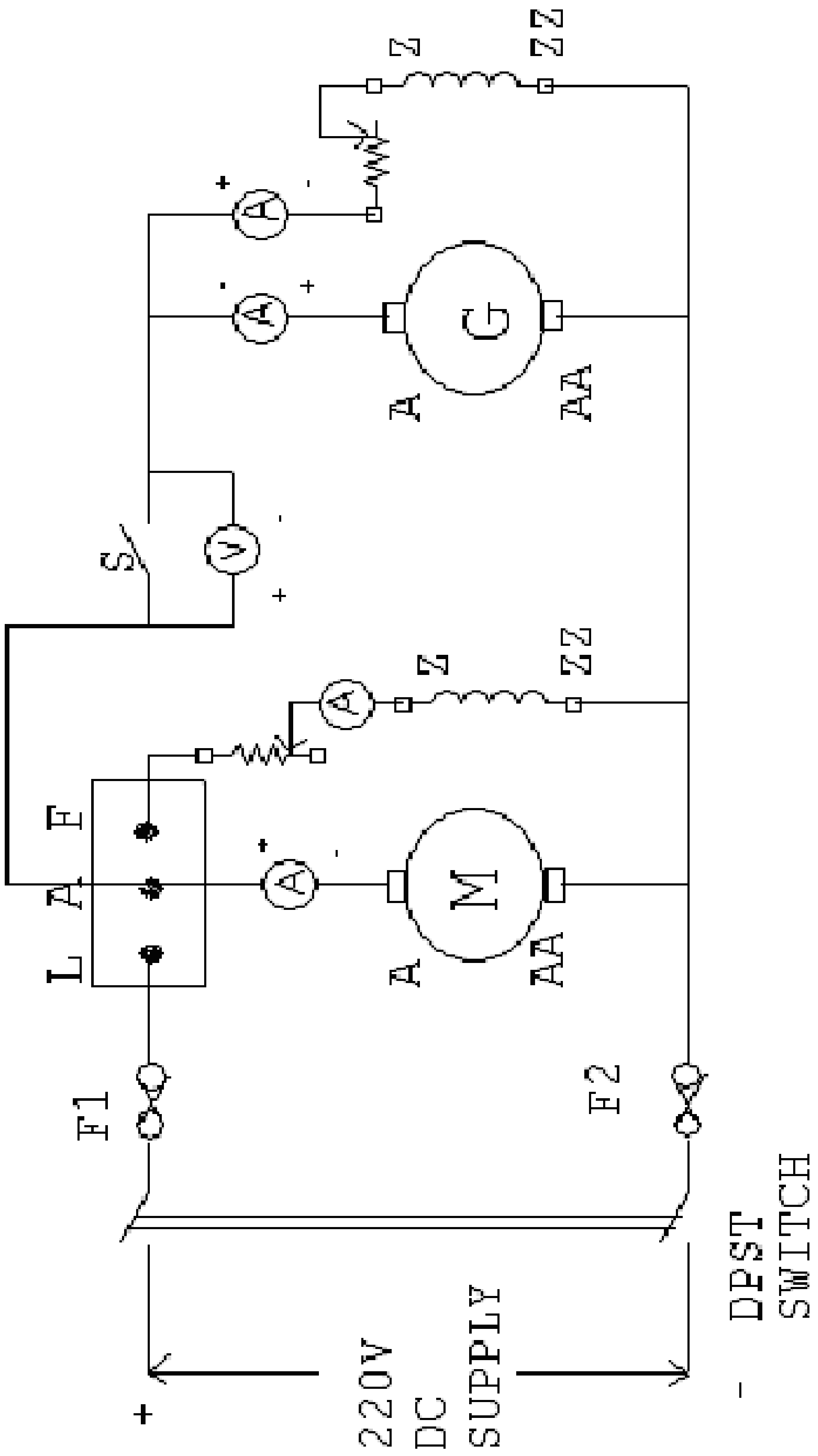
1. Draw graphs between E Vs I_a (internal characteristics)
2. Draw graphs between V Vs I_L (external characteristics)

RESULTS & CONCLUSIONS :

Reasoning Questions:

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?

CIRCUIT DIAGRAM :



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 A1 A2 A3 A4			
2	Voltmeter			
3	Rheostats R1 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 .

Observations:

S. NO	V	I-1	I-2	I-3	I-4	Ws	Ws/2	Pog	Pig	Pom	Pim	ηg	ηm

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 =

∴ 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

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

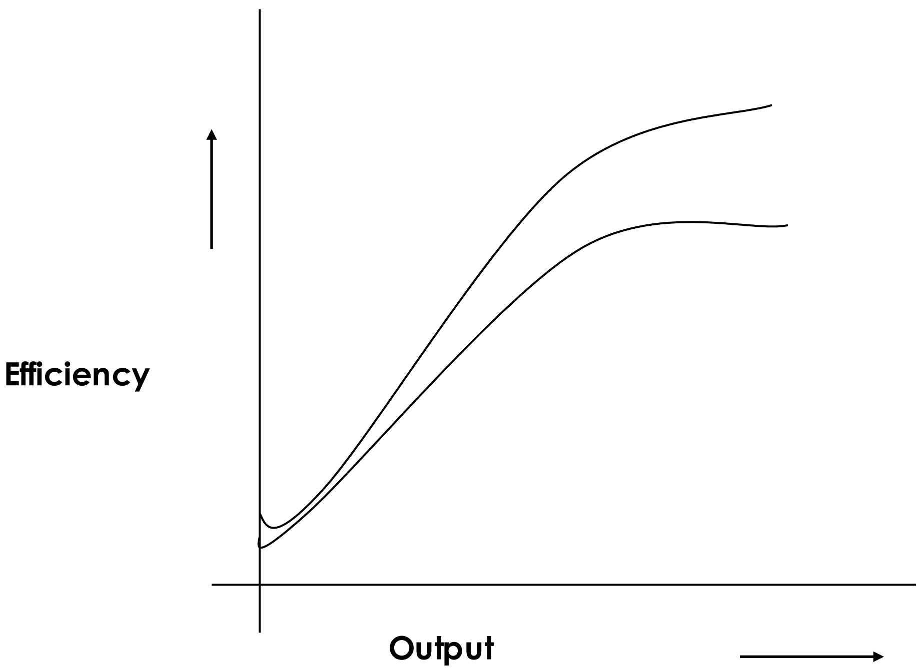
Generator efficiency = $\{V(I_4-I_5)/ [V(I_4-I_5) + W_g] \} \times 100$

B. Readings to calculate resistances

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

Sample calculations:

Model Graph:



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.

Graph:

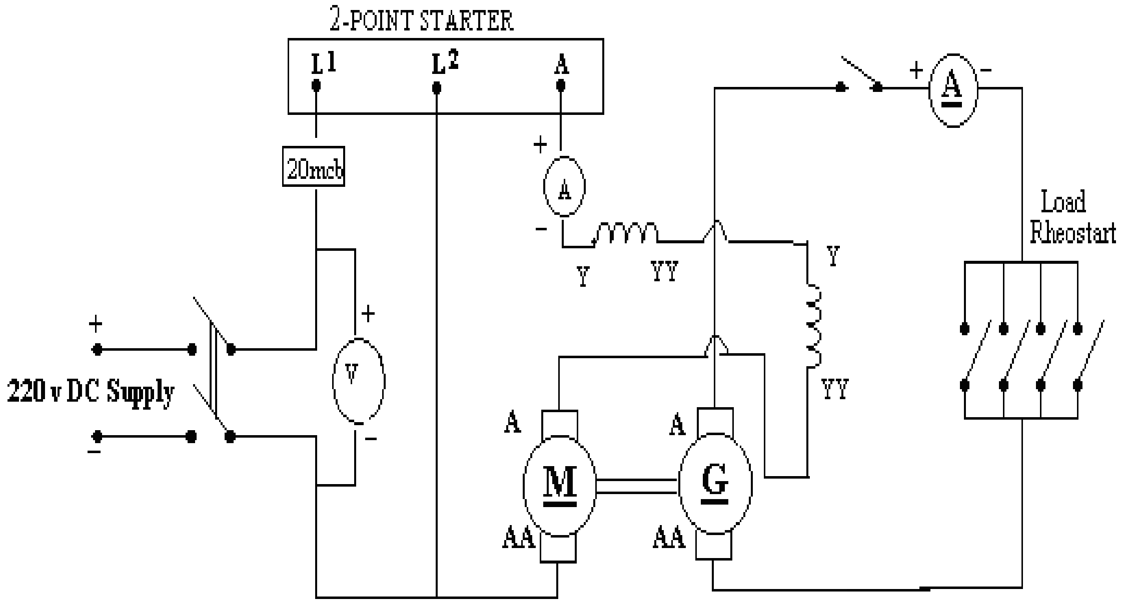
1. Draw the graph between output Vs efficiency for motor
2. Draw the graph between output Vs efficiency for generator.

RESULT:

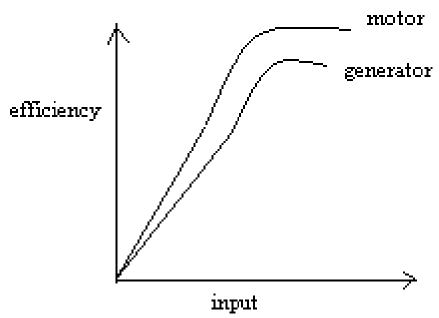
Reasoning Questions:

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?

CIRCUIT DIAGRAM:



Model Graph:



B. Readings to calculate resistances

S. NO	Ra			Rse		
	V	Ia	Ra=V/Ia	V	Ise	Rse=V/Ise
1						
2						
3						
Average Ra =__________ Ω				Average Rse =i___________ Ω		

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** **A1** **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.

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.

Observations:

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

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.

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:

3. Draw the graph between output Vs efficiency for motor
4. Draw the graph between output Vs efficiency for generator.

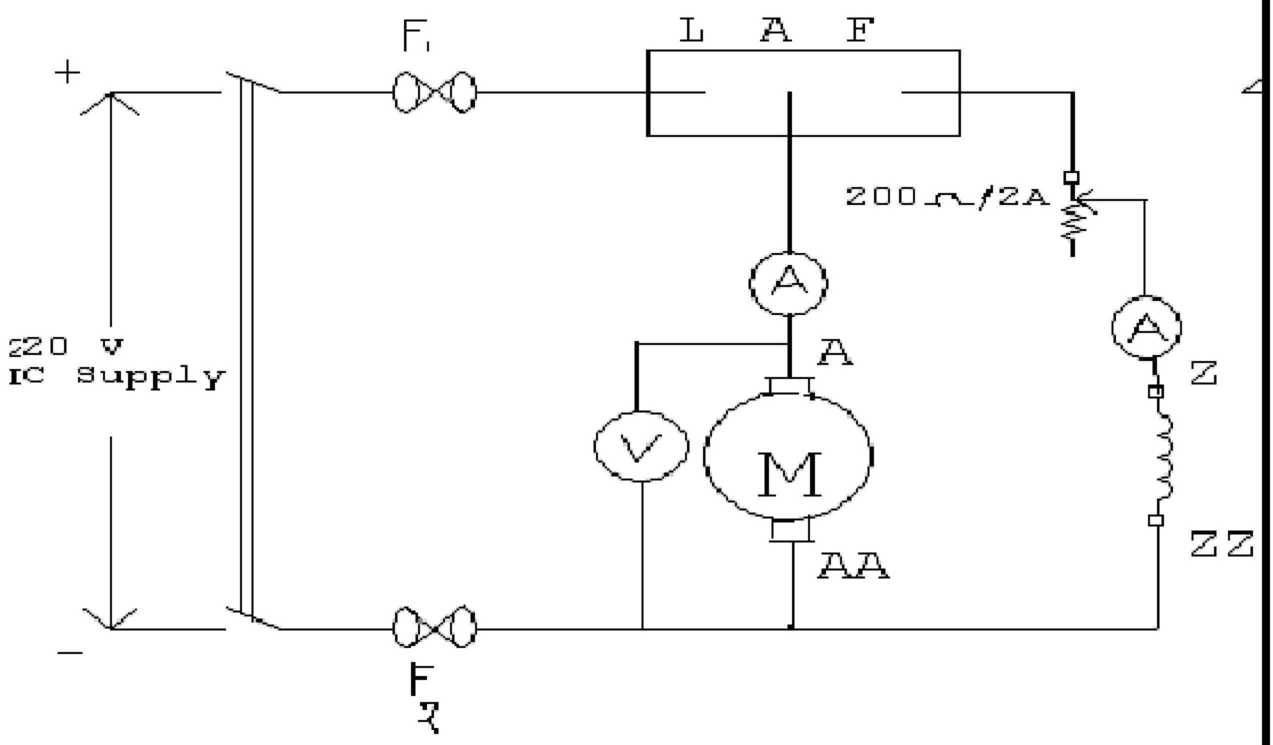
Result:

Conclusion:

1. Both identical series machines are coupled mechanically and electrically.
2. It is not a regenerative test. The main disadvantage is that a relatively small error in the measurement of motor input or generator output may result in a relatively large error in the calculated efficiency.
3. The efficiency can be calculated on the series motor at light loads.

Reasoning Questions:

CIRCUIT DIAGRAM:



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** **A1** **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 = $(I_o - I_{sh})^2 R_a$

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

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

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)

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 = $\frac{Input-Output}{Input} = \frac{VI-(I-I_{sh})^2R_a-W_C}{VI}$

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 = $\frac{Input-Output}{} = \frac{VI}{}$.

Input $VI-(I-I_{sh})^2R_a-W_C$

PROCEDURE:

1. Connect as per the circuit diagram.
2. Run the motor at rated speed by adjusting the field rheostat.
3. Take the readings of line current, shunt field current and supply voltage at no-load.
4. Measure the resistance of the armature.

Graph:

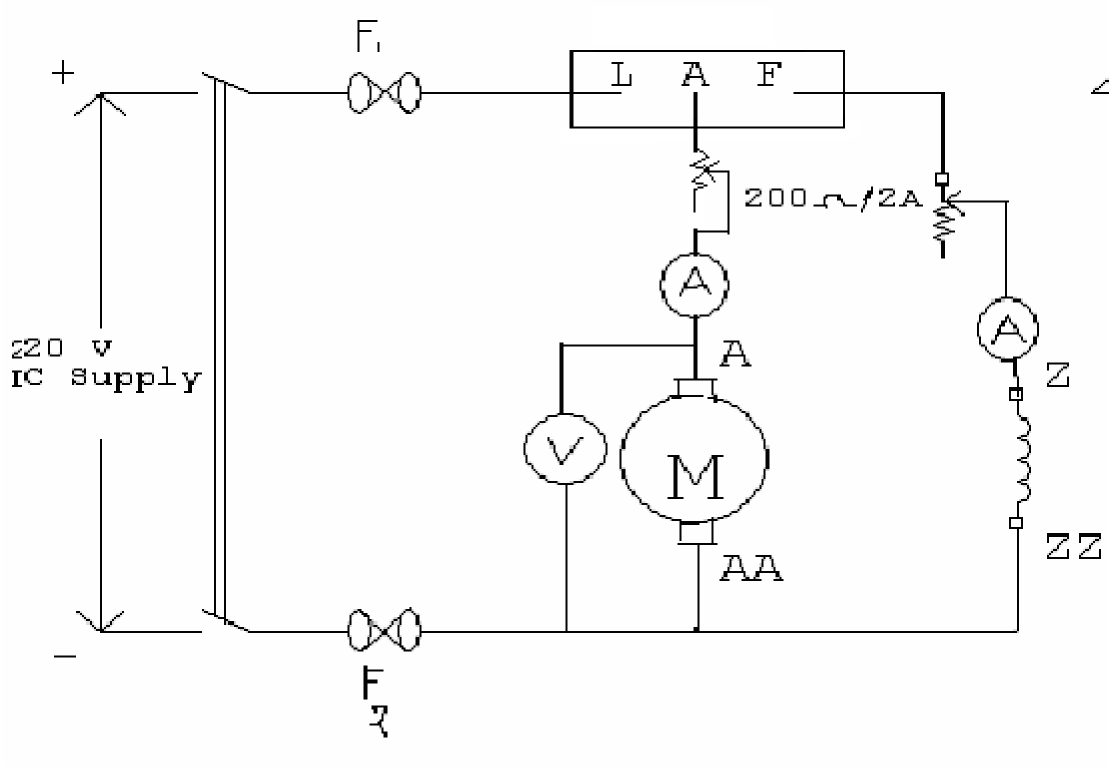
1. Draw the graph between output Vs efficiency for motor
2. Draw the graph between output Vs efficiency for generator.

RESULTS & CONCLUSIONS:

Reasoning Questions:

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

CIRCUIT DIAGRAM:



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 ϕ, (field flux control) or the armature resistance, R_a (Armature control).

Field flux control method:

It can be seen that $N \propto 1/\phi$. 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 the rated 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

OBSERVATIONS:

1. Armature control method:-

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				
4				
5				
6				
7				
8				
9				
10				

2. .Field control method:-

S.NO	Shunt field Current- If in Amps	RPM - N
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

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.

$$N = N_0 (1 - I_a R_t / V)$$

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.

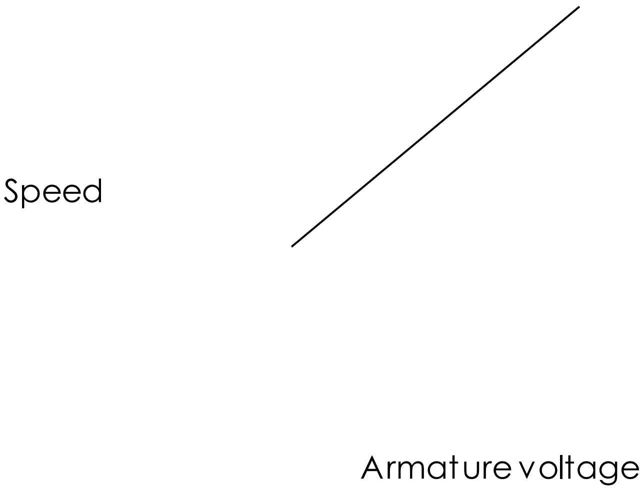
b).Take the speed and field resistance values varying the field resistance (decreasing I_f).

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

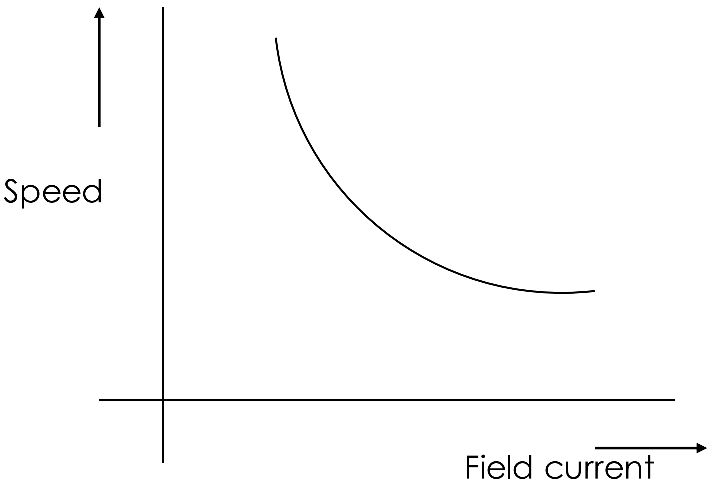
d). Repeat till near the rated speed.

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:

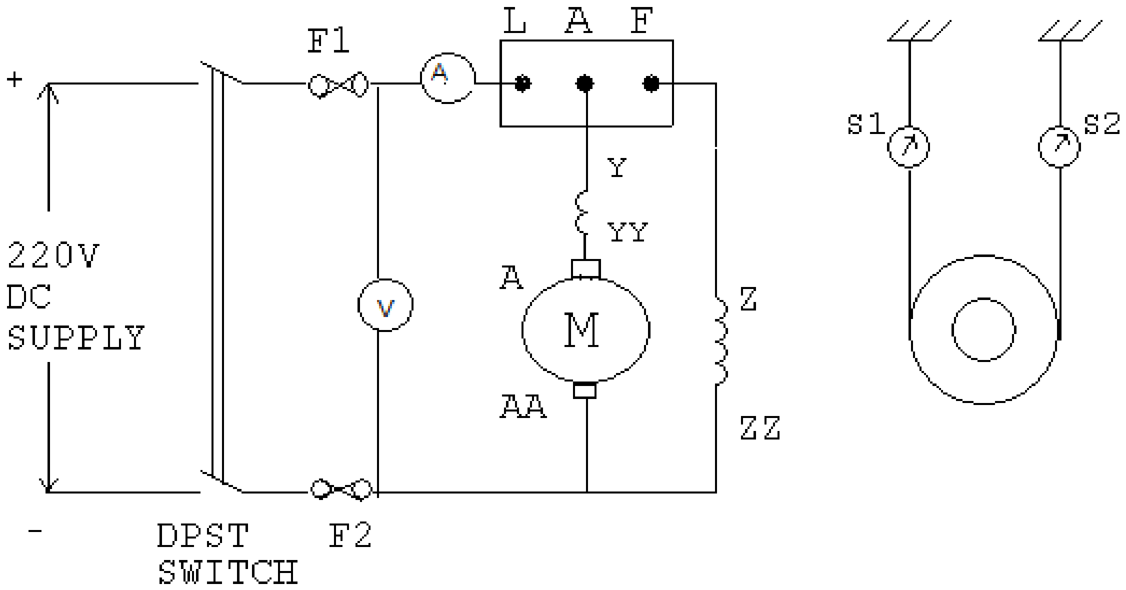
1. Plot the graph between Speed Vs Armature Voltage
2. Plot the graph between Speed Vs Field current

RESULTS & CONCLUSIONS:

Reasoning Questions:

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?

CIRCUIT DIAGRAM:



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

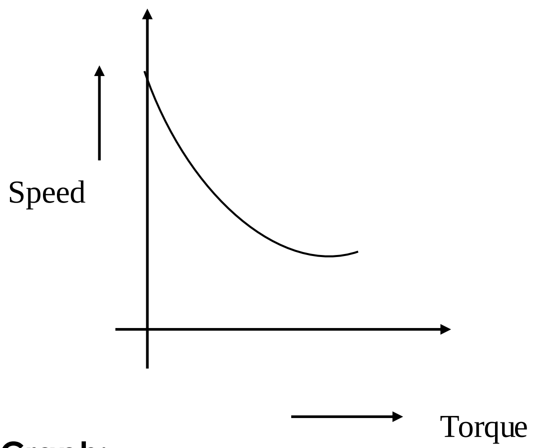
Torque (T) = $(S_1 - S_2)$ R x 9.81 N-m.
Motor output = 2ΠNT / 60 watts
Motor input = VI watts
Efficiency = output/ input = 2ΠNT / 60 (VI)

OBSERVATIONS:

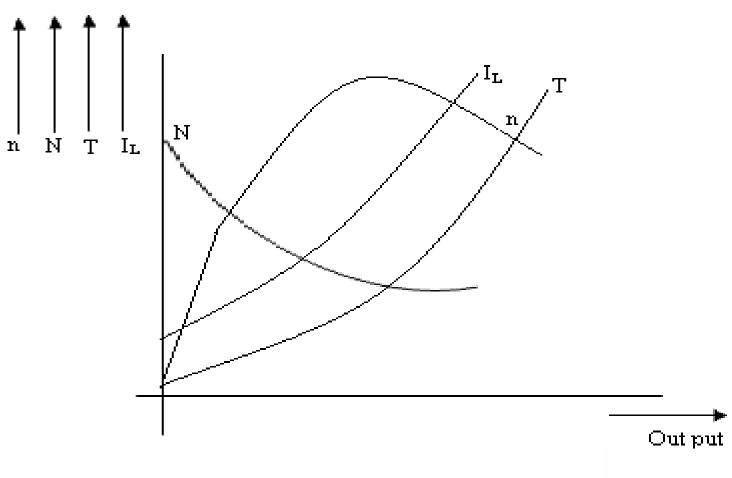
Radius of the pulley (in meters) =

S.NO	VL	IL	If	Ia	N	S1	S2	T	O/P	I/P	%η
1											
2											
3											
4											
5											
6											
7											
8											
9											

Model Graph:



Model Graph:



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.

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: -

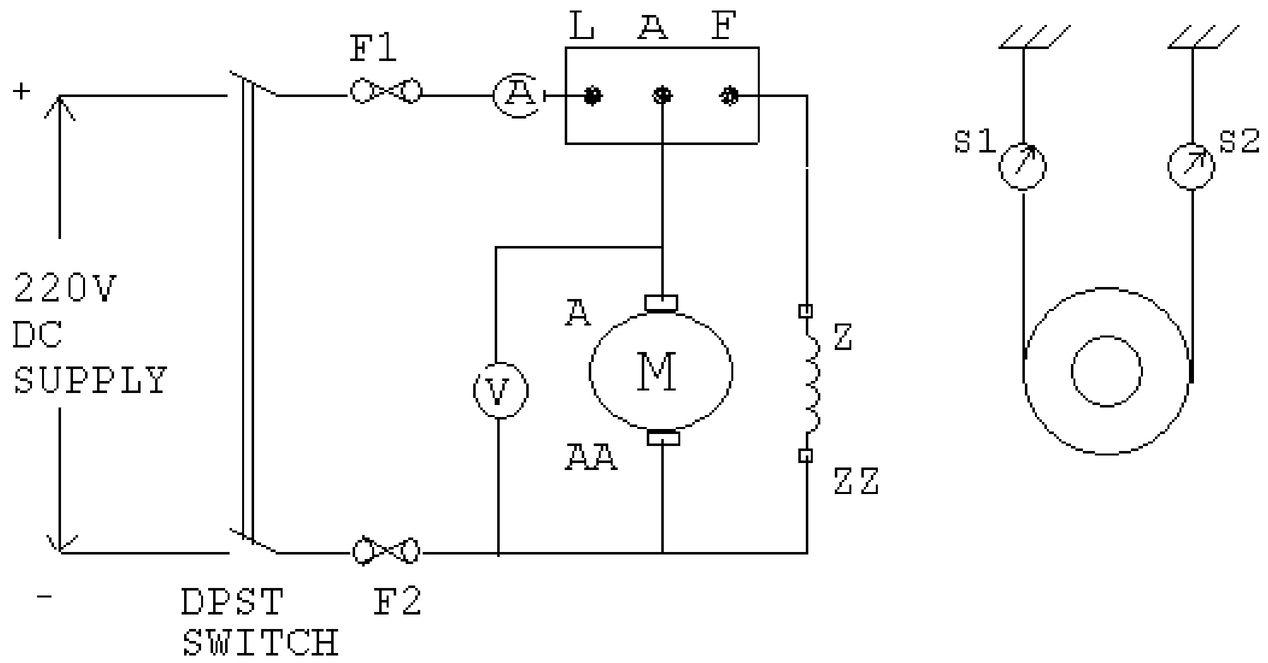
1. Efficiency Vs Output
2. Speed Vs Output
3. Torque Vs Output
4. Load current Vs Output
5. Speed Vs Torque.

RESULTS & CONCLUSIONS:

Reasoning Questions:

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?

CIRCUIT DIAGRAM:



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

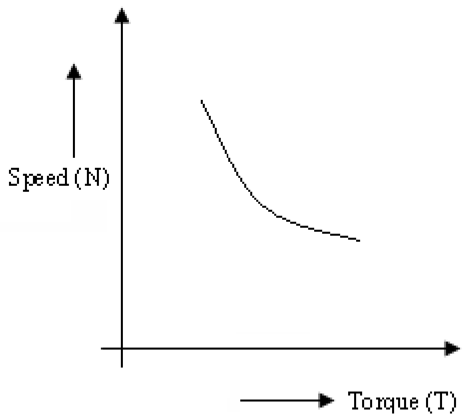
Efficiency = output/ input = 2∏NT / 60 (VI)

OBSERVATIONS:

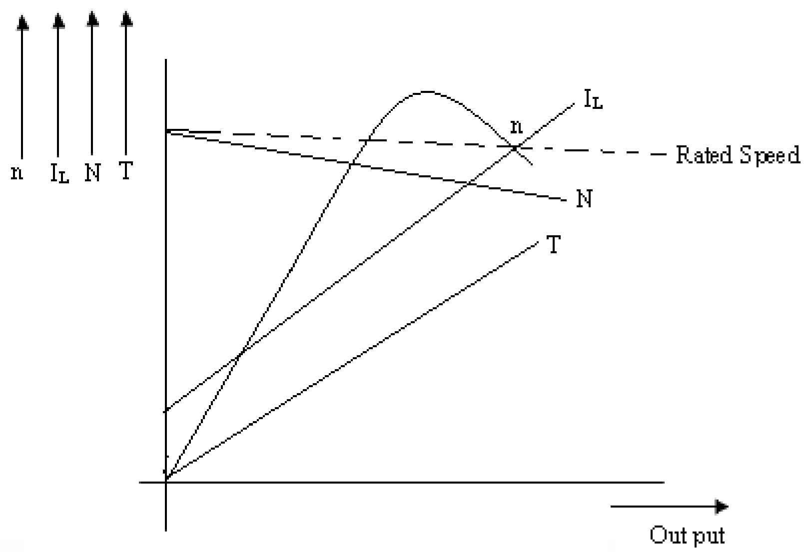
Radius of the pulley (in meters) =

S.NO	VL	IL	If	Ia	N	S1	S2	T	O/P	I/P	%η
1											
2											
3											
4											
5											
6											
7											
8											
9											

Model Graph:



Model Graph:



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.

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: -

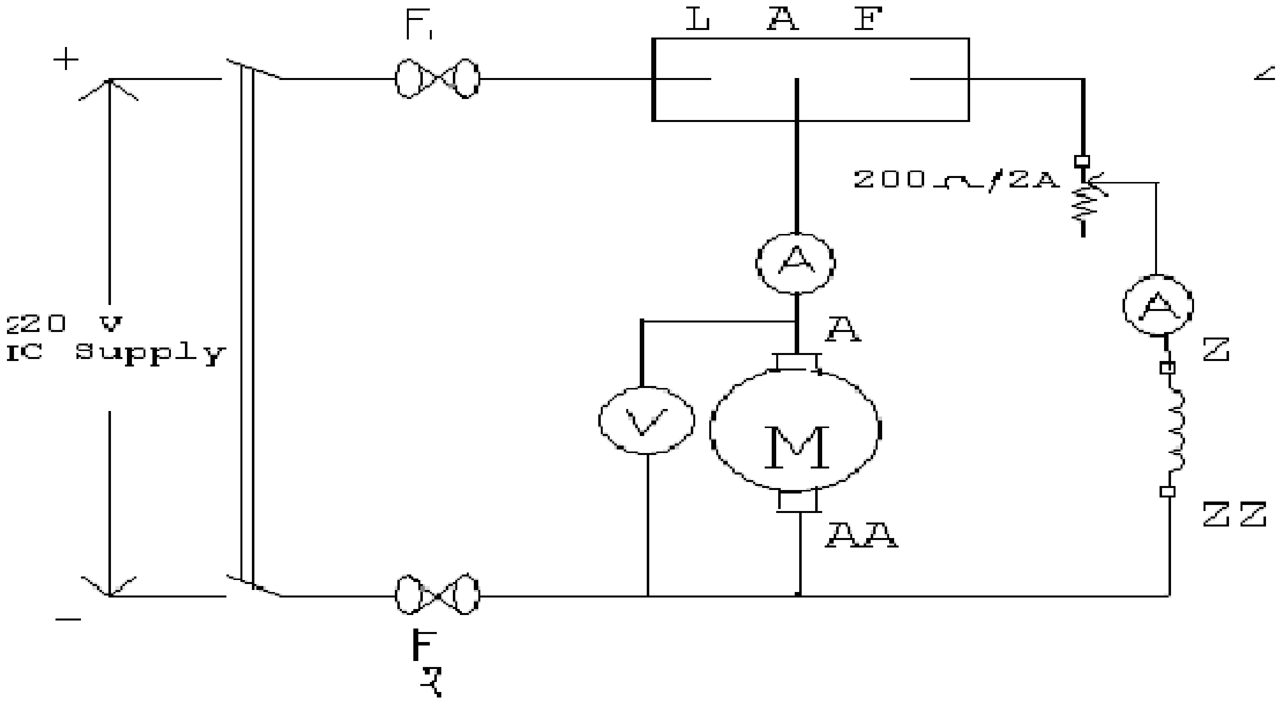
1. Efficiency Vs Output
2. Speed Vs Output
3. Torque Vs Output
4. Load current Vs Output
5. Speed Vs Torque.

RESULTS & CONCLUSIONS:

Reasoning questions:

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?

CIRCUIT DIAGRAM:



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 a (Flux) X (speed)

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

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						
4						
5						
6						
7						
8						
9						
10						
11						
12						

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						
4						
5						
6						
7						
8						
9						
10						
11						
12						

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 a N or Wh = AN

Eddy current loss We a 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.

PROCEDURE:

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

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 =

REASONING QUESTIONS:

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.