EXPERIMENT - 1
Brake Test on DC Shunt motor

Aim: To conduct the brake test on the given DC Shunt motor and draw its performance curves.

Nameplate details of the machine: -

Motor

H.P: 3.0
Volts: 220
Amps: 12
RPM: 1500
Extn volts 220V; 0.6A

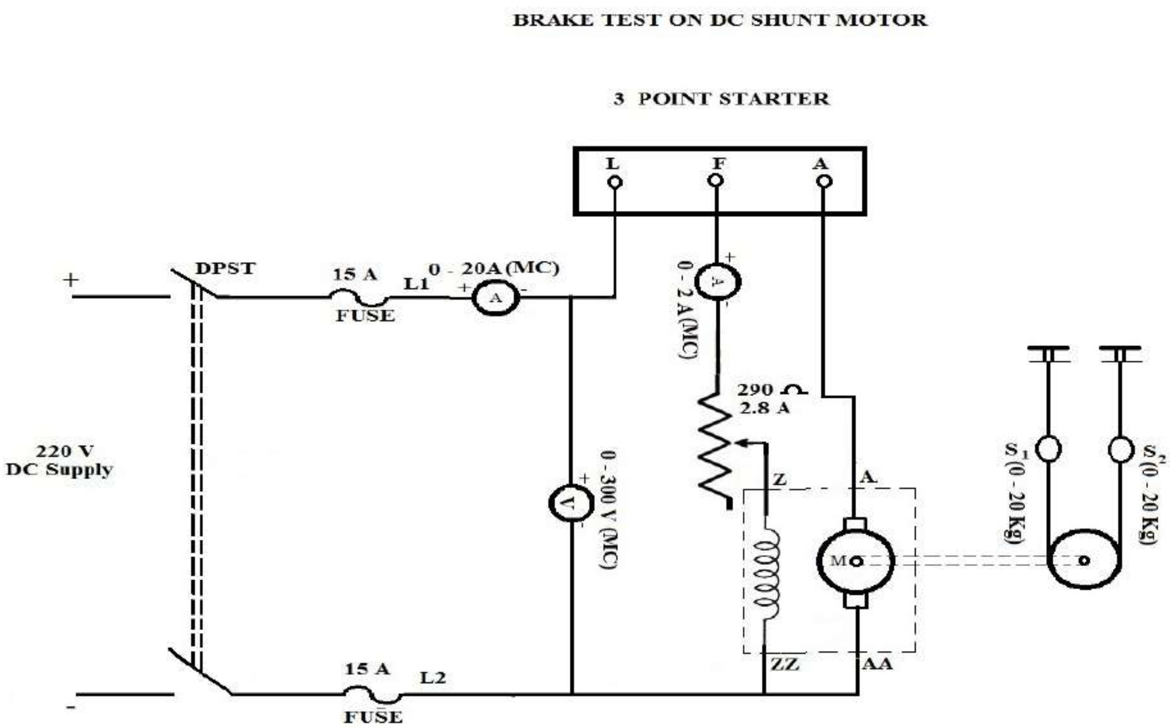
Excitation type: Compound
M/c no. 9904.4180
Type: DO112.178.302
Rating: CMR
Insulation class B

Apparatus Needed:

S.No.	***Apparatus***	***Type & Range***	***Quantity***
1	Ammeter	MC, (0-20A)	1
2	Ammeter	MC, (0-2A)	1
3	Voltmeter	MC, (0-300V)	1
4	Rheostat	290Ω, 2.8A	1
5	Tachometer	-	1
6	Connecting wires	-	As required

Caution: Although this machine has both series winding and shunt winding on its poles, use only shunt winding for Experimentation. Do not connect series winding.

Circuit diagram: -



THEORY:

The Brake test is a direct test on the DC motor. Therefore, the performance characteristics correspond to the actual performance of the motor under running conditions. This test can be used only for small motors. Because, for large machines, dissipation of heat produced on the pulley is a problem.

For loading the motor, a brake drum fixed on the shaft of the motor is used as shown in the figure. A belt is placed around the drum and its two ends are attached to two spring- balances S_1 and S_2. The tension of the belt can be adjusted with the help of handles on the frame. The force acting tangentially on the drum is equal to the difference between the two readings of the spring balances S_1 and S_2.

Let

The radius of the drum = R meters

Shaft torque

, $T_{sh} = (s_1 \sim s_2) \times R \times 9.81$ Newton-meters

Motor output = $T_{sh}\omega = T_{sh} \times \frac{2\pi N}{60}$ Watts

, where ω is the angular velocity of the rotor in rad/sec. N is the speed of the motor in RPM. Evidently, the output of the motor is utilized in overcoming the mechanical friction between the drum and the belt, and heat is produced. Cooling of the drum is therefore required to dissipate this heat. The following performance curves can be drawn in this test.

1) Efficiency(η) vs BHP
2) Speed (N) vs BHP
3) Speed(N) vs Torque (T)
4) Armature current (I_a) vs Torque (T)

Model Graphs:

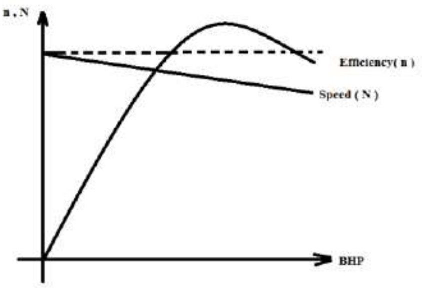


Fig 1 Model Graph Efficiency Vs BHP

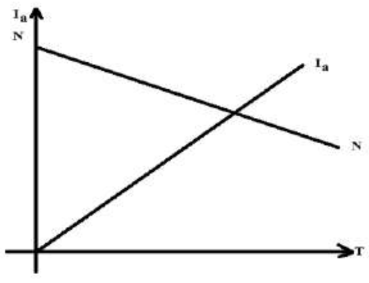


Fig 2 Model Graph Speed vs Torque, I_a Vs Torque

PROCEDURE:

1. Make the circuit as per the circuit diagram.

2. Study the operation of a three-point starter.
3. Keep the rheostat connected in series with the field winding to the minimum value.
4. Check up and ensure that there is no load on the brake drum.
5. Start the machine by means of the 3-point starter and adjust the speed of the motor to its rated value on no load. by varying field rheostat.
6. Take the readings of all meters at no-load. Also, note down the readings of spring balances when the belt is free this gives the initial reading of sprig balances. Now load the motor by gradually tightening the belt with the help of wheels mounted on the frame.
7. At each load, note the readings of meters, and the spring balances. Cool the brake drum by pouring cold water in the drum when the motor is on load. Continue this process till a full load is reached. (I_L= 12 A) Release the load on the motor and stop the machine.

Observation Table:

Tabulate the results as below. Measure the radius of the drum.

S. No	***V_L* V**	***I_L* A**	***I_f* A**	***S_1* Kg**	***S_2* Kg**	***N***	***Torque in N-m 9.81*(S_1-S_2)R***	***Output***		***Input in Watts V_L I_L***	***Efficiency % η***
								In Watts 0.1047 TN	***In HP 1.403* 10^{-4} T*N***		
1	2	3	4	5	6	7	8	9	10	11	12

CALCULATIONS AND GRAPH

Calculate the efficiency of the machine and torque at each load current and plot the graphs.

1. Efficiency vs BHP (BHP on X-Axis)
2. Speed vs BHP (BHP on X-Axis)
3. Speed vs Torque (Torque on X-Axis)
4. Armature current (I_a) vs Torque (Torque on X- Axis)

Precautions:
1. Field Rheostat of the motor should be at minimum position.
2. Avoid Parallax errors and loose contacts

RESULT:

QUIZ:

1. What are the various losses in the D.C motor?
2. At what load the efficiency is maximum**?**
3. Why the iron – losses are constant in a d.c. Shunt motor?
4. What is the application of d.c. Shunt motors?
5. Why d.c. Shunt motor is called a constant speed motor?
6. How do the hysteresis and eddy current losses depend on the speed?
7. Why are the armature and pole cores laminated?
8. What is the advantage of this test over Swinburne's test?

Experiment - 2

LOAD TEST ON DC SHUNT GENERATOR

AIM:

To conduct load test on DC shunt generator and to draw its external and internal characteristics

NAME PLATE DETAILS:

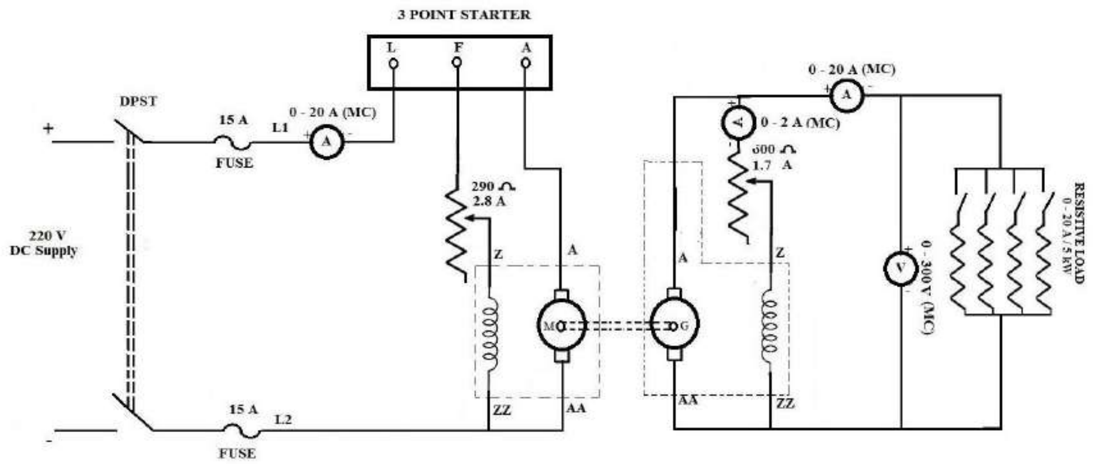
Motor Generator

Voltage		Voltage	
Current		Current	
Output		Output	
Speed		Speed	

APPARATUS:

S. No.	Item	Type	Range	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	Tachometer			

CIRCUIT DIAGRAM:



THEORY:

The behavior of the D.C shunt generator under the No-Load and Load condition is best expressed in terms of three characteristic curves. They are

1. No-load saturation curve (E_0 / I_f):

This gives the variation of E_0 (the open circuit Voltage) with I_f, the field current, at a constant speed. it is nothing but the magnetization curve.

2. Internal or total characteristic (E / I_a):

This gives the relationship between E, emf actually induced (After allowing the demagnetizing effect of armature reaction) and the armature current I_a. This characteristic is important for a designer.

3. External Characteristic (V /I_L):

This gives the variation of the terminal voltage "V" with the variation of load current I_L.

For getting the external characteristic, the machine is run at a constant speed, and the field current is adjusted for normal open-circuit voltage at No- Load. The load current is gradually increased and the corresponding reading of the terminal voltage is obtained. The external characteristic (V vs I_L) is obtained as shown fig 2.2

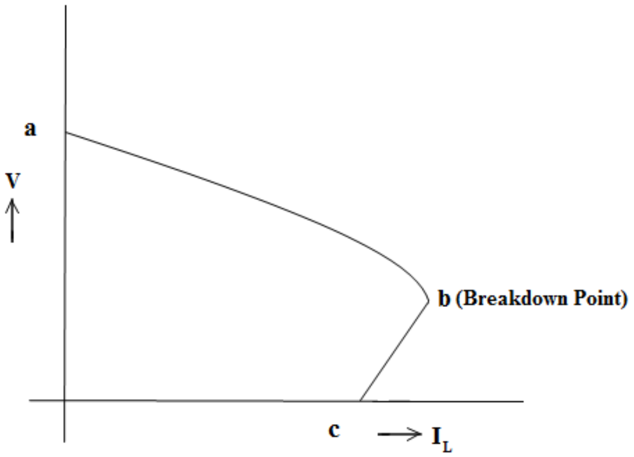


Fig 2.2 External characteristics

The behaviour of the characteristic can be understood by referring to any standard textbook. The normal working range is "ab" shown in fig 2.2.

The internal characteristic E vs Ia is found from the external characteristic as explained below. Let the external characteristic be reproduced below as in fig 2.3.

In the above figure, "ab" represents the external characteristic. The armature resistance drop line OR is drawn, knowing the armature resistance and it is a straight line passing through the origin. The generated emf can be obtained for any given value of the current say OM, by adding the IaRa drop to the terminal voltage. When the current is OM, the drop in the armature resistance is MN and the terminal voltage is MP. The generated emf on Load at current OM can be obtained as E = MQ such that MN = PQ = I_aR_a. Q is a point on the internal characteristic. The other points on the internal characteristics are also obtained in a similar way. "ac" represents the internal characteristics in fig 2.3.

PROCEDURE:

1. Make the connections as shown in the circuit diagram. Keep the motor field rheostat in the minimum position and the generator field rheostat in the maximum position at starting.
2. Start the MG set and bring it to the rated speed (1500 rpm) of the generator by adjusting the motor field rheostat.
3. Adjust the terminal voltage to the rated value by means of the generator field rheostat. Keep the rheostat in this position throughout the experiment as its variation changes the field circuit resistance and hence the generated emf.
4. Put on the load and note the values of the load current, I_L; terminal voltage, V, and field current, I_f at different values of the load until full load current is obtained.
5. Calculate the armature current in each case: $I_a = I_L + I_f$.
6. Measure the armature resistance by the volt-ampere method. Note down the voltage drop Va across the armature for different values of current I passing through it. Armature resistance in each case is calculated. $R_a = V_a / I$., R_a (Hot) = 1.25 R_a. Take the mean of the values which are close together as the resistance of the armature, R_a.
7. Calculate the generated e.m.f. E at each value of the load current. $E = V + I_a R_a$.
8. Draw external characteristics, V_T versus I_L, and internal characteristics, E versus Ia.

TABULAR COLUMN:

S.No	I_L(Amp)	I_F(Amp)	I_a(Amp)	V_T(Volt)	E(Volt)
1					
2					
3					
4					
5					
6					
7					
8					

MODEL GRAPH:

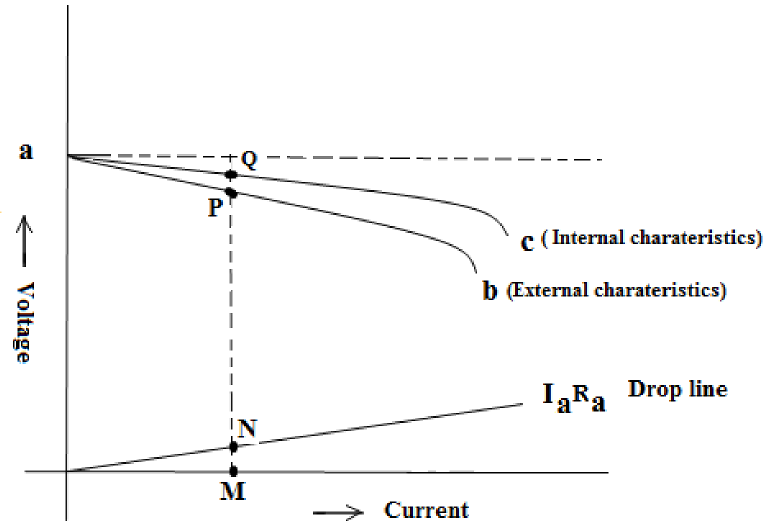


Fig 2.3 Getting Internal Charateristics from the External Charateristics

Fig - 2.3 Internal and External Characteristics of DC Shunt Generator

RESULT:

PRE-LAB VIVA QUESTIONS:

1. Why is the generated emf not constant even though the field circuit resistance is kept unaltered?
2. Find out the voltage drop due to the full load armature reaction?
3. State the conditions required to put the DC shunt generator on load.
4. What happens if shunt field connections are reversed in the generator?
5. The EMF induced in armature conductors of the DC shunt generator is AC or DC?
6. Specify the applications of DC shunt generators.
7. Why the terminal voltage decreases when the load is increased on the generator?

Experiment – 3
LOAD TEST ON DC COMPOUND GENERATOR

AIM : To conduct the load test on the given D.C compound generator and plot its external & internal characteristics for (a) cumulative and (b) Differential connections.

Name plate details of the machine: -

Motor

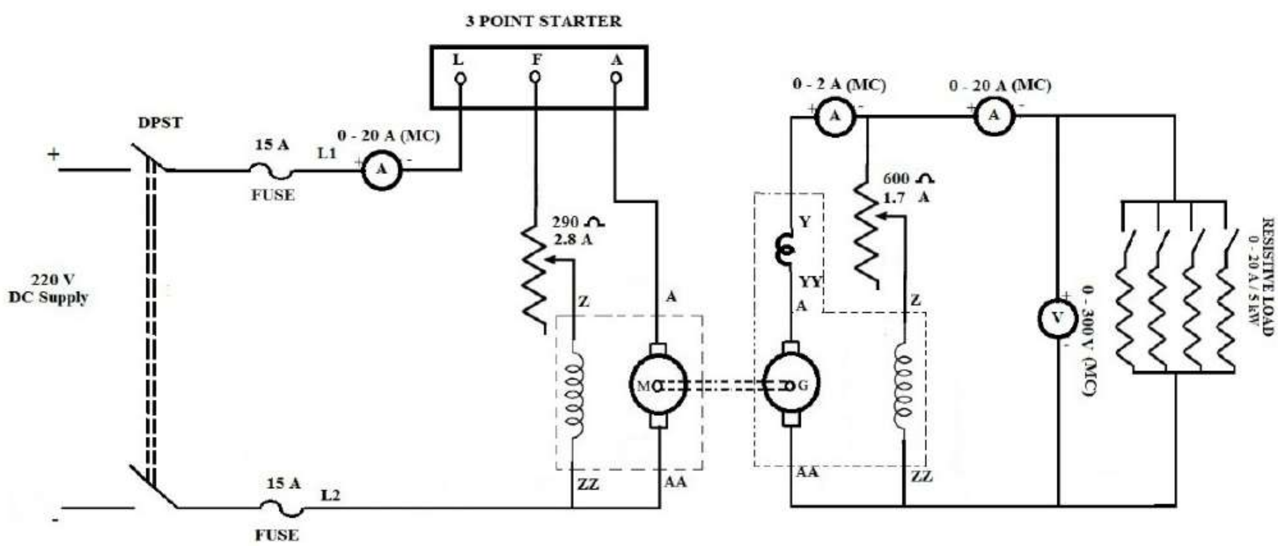
HP:5
Volts: 220 — Excitation type: Shunt 220V; 1 A
Amps: 19A — M/c no. 7736.0101
RPM: 1500 — Rating: CMR
Insulation class B

Generator

KW: 3 — Excitation type: Compound 220V; 1 A
Volts: 220 — M/c no. G1443.9904
Amps: 13.6A — Rating:CMR
RPM: 1500 — Insulation class B

CIRCUIT DIAGRAM:

LOAD TEST ON DC COMPOUND GENERATOR



THEORY: A compound generator has two fields, namely shunt and series fields. Depending on whether the flux produced by the series field adds or subtracts flux of the shunt field, we have two types of compounding.

a. Cumulative compounding – Series field aids the shunt filed.
b. Differential compounding –Series field opposes the shunt field.

Depending on whether the shunt field connected across the armature alone are whether the shunt field is connected across the armature and the series field, (as in the circuit shown in fig 3.1 1) we have two types of compounding namely

a. Short shunt
b. Long shunt.

A D.C series generator gives a rising characteristic (V increasing with I_L), while a shunt generator gives a dropping characteristic. By a suitable combination of series and shunt fields, it is possible to get the desirable characteristics. It is even possible to get nearly constant voltage at all load currents when suitably designed. The shape of the external characteristics and internal characteristics will be as shown in fig 3.2 & fig 3.3

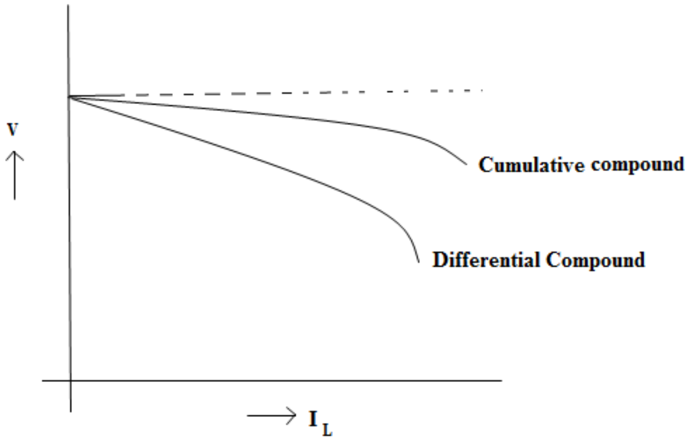


Fig 3.2 External Characteristics

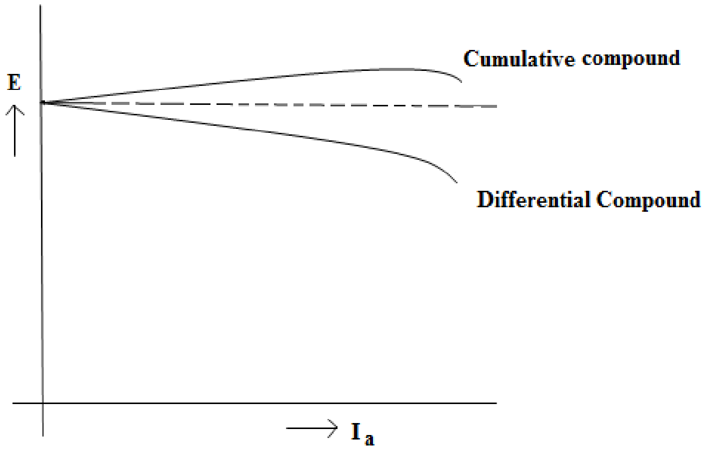


Fig 3. 3 Internal Characteristics

PROCEDURE:

1. Make connections as shown in the circuit diagram 3.1.
2. Adjust the speed of the motor-generator set by varying field resistance of the motor. Keep this speed constant at all loads throughout the experiment.
3. Connect the series field such that it aids the shunt filed. The generator is now called the cumulative compound generator.
4. Conduct the load test on the generator by
    - First adjusting the field rheostat in the generator circuit such that the field current gives rated terminal voltage at no load.
    - Corresponding to the above field current note the No-Load open-circuit voltage. Switch on the load and by gradually increasing the load up to the full load, note down the readings of all the meters.
5. Connect the series field such that it opposes the shunt field (Differential compound) and repeat the load test. Tabulate the results as below.

Tabular column:

Compound Generator **Speed: 1500 rpm**

S.No	**Cumulative**				
	I_L	**I_f**	**I_a**	**V**	**E**
1					
2					
3					
4					
5					
6					
7					
8					

S.No	Differential				
	I_L	I_f	I_a	V	E
1					
2					
3					
4					
5					
6					
7					
8					

GRAPHS

From the readings obtained above plot V vs I_L (external characteristic) & E vs I_a (Internal Characteristics) for both Cumulative and Differential connections.

Result:

Experiment – 4

MAGNETIZATION CHARACTERISTIC OF DC SHUNT GENERATOR

AIM:

To determine the magnetization (open circuit) characteristics of DC shunt generator, the critical field resistance and critical speed.

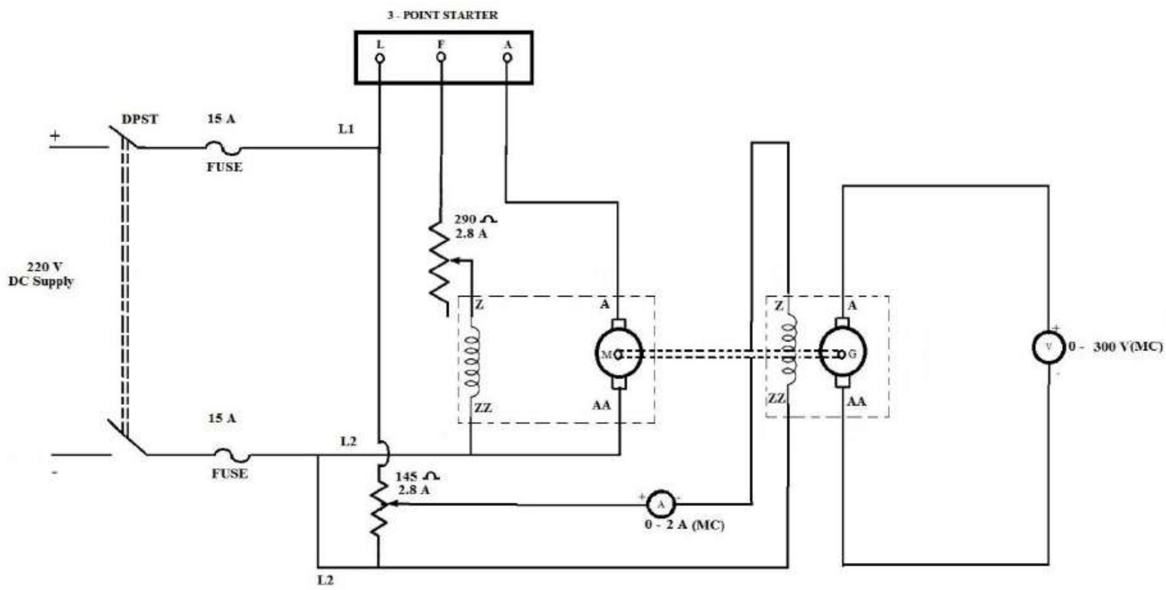
NAMEPLATE DETAILS:

Motor			Generator	
Voltage			Voltage	
Current			Current	
Rating			Rating	
Speed			Speed	

APPARATUS:

S.No.	Item	Type	Range	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostat			
4	Tachometer			

CIRCUIT DIAGRAM: Fig - 1 DC Shunt Motor - Generator Set



THEORY:

Magnetization characteristic of DC shunt generator is defined as "The flux vs field current" graph at constant speed. Since, the induced emf in DC generator is directly proportional to the flux, at constant speed, induced emf vs field current can be treated as magnetization characteristic. In this experiment the characteristic is drawn by separately exciting the field circuit. The magnetization characteristic can be divided in to the following sections as shown in
figure 2: -

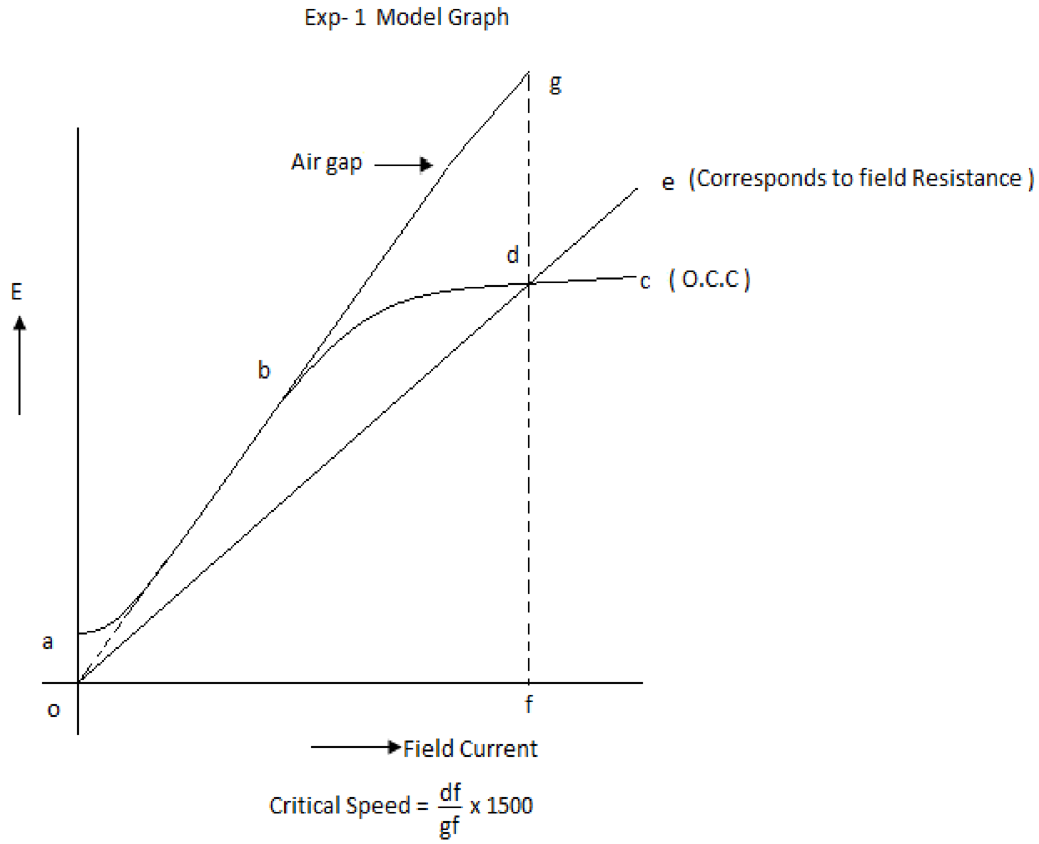


Fig No . 2

ab: When the field current is zero there will be a small amount of flux due to residual magnetism. Due to this residual flux a small voltage is induced and that is given as 'oa' on the graph. As the field current is increased the flux increases in direct proportion to it.. In the section ab, the flux produced and hence the induced voltage increases in proportion to the field current and therefore the characteristic is a straight line.

bc: At b called the knee point, the core of the field starts getting saturated and the increase in flux or induced voltage is not in proportion to the current thereafter.

At the point c, the core is almost saturated and any further increase in field current does not produce a change in the flux or EMF. Hence the characteristic is almost horizontal line beyond 'c'.

Critical field resistance: - This is specified for self-excited D.C. Generator ie. D.C shunt generator. The critical resistance of the field winding is defined as the maximum resistance of the field circuit above which the generator fails to self-excite at a given speed. This is obtained by drawing a tangent to the magnetization or open circuit characteristic of the machine (o.c.c) as shown in figure2.

Find out the resistance of field winding and draw a straight line "oe" that represents the value of the field resistance. Let it cut the open circuit characteristic at 'd'. With this resistance the generator builds up a max. voltage given by "df". Increase of this resistance increases the slope and the point "d" goes lower and finally "od" becomes a tangent. This corresponds to the tangent to the magnetization characteristic. Thus, the resistance of the field corresponding to the tangent gives the critical resistance.

For a given resistance of the shunt field corresponding to "od", suppose the speed of the machine is decreased. Evidently all the points in the magnetization characteristic move lower and for a particular speed, "od" becomes a tangent to it. This speed is called the critical speed of the generator.

PROCEDURE:

1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.
2. Keep the motor field rheostat in the minimum resistance position.
3. Keep the generator field rheostat in the maximum resistance position
4. Observe the speed of the generator using a tachometer and adjust to the rated value (1500 rpm) by varying the motor field rheostat. Keep the same speed throughout the experiment.
5. Note down the terminal voltage of the generator. This is the e.m.f. due to residual magnetism.
6. Increase the generator field current I_f (ammeter) by gradually moving the rheostat for every value and note down the corresponding voltmeter reading. Increase the field current till induced e.m.f is about 120% of rated value or up to saturation.
7. Draw the characteristics of generated emf (E_g) versus field current (I_f) and Field resistance line.
8. Draw a tangent to the initial portion of O.C.C from the origin. The slope of this straight line gives the critical field resistance and also calculates critical speed.

TABULAR COLUMN:

S No	Field Current I_f (Amp)	Generated Voltage E_o (Volts)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

MODEL GRAGH: Magnetization Characteristics

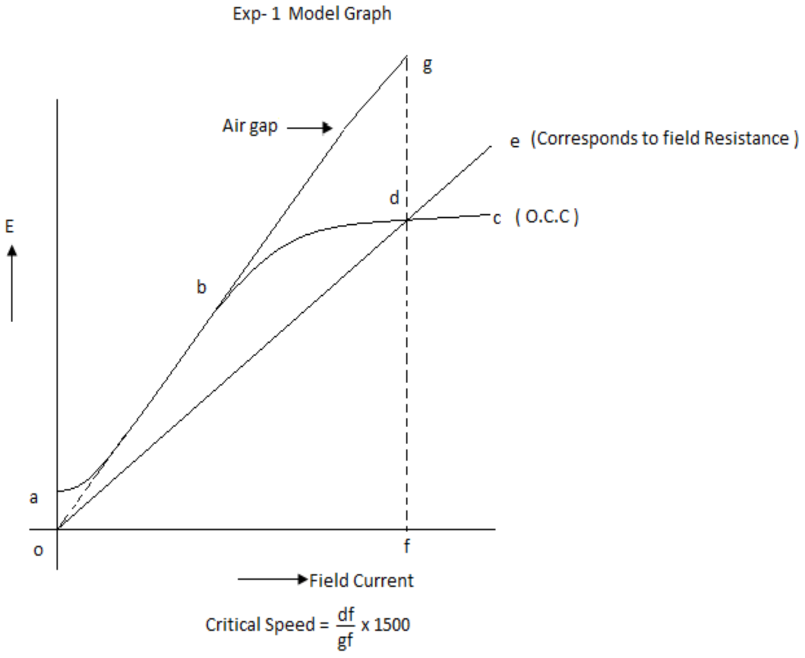


Fig No . 2

PRECAUTIONS:

1. Field rheostat of motor should be at minimum position
2. Avoid parallax errors and loose connections

RESULT:

PRE-LAB VIVA QUESTIONS:

1. Under what conditions does the DC shunt generator fail to self - excite?
2. OCC is also known as magnetization characteristic, why?
3. How do you check the continuity of field winding and armature winding?
4. How do you make out that the generator is DC generator without observing the name plate?
5. Does the OCC change with speed?

POST LAB VIVA QUESTIONS:

1. Define critical field resistance.
2. How do you get the maximum voltage to which the generator builds up from OCC?
3. What does the flat portion of OCC indicate?
4. Why OCC does not start from origin?
5. Why is Rf > Ra in dc shunt machine?
6. How do you create residual magnetism if it is wiped out?
7. Why does the OCC differ for decreasing and increasing values of field current?

Experiment – 5

LOAD TEST ON DC SERIES GENERATOR

AIM:

To obtain the external and internal characteristics of DC series generator by conducting load test.

NAME PLATE DETAILS:

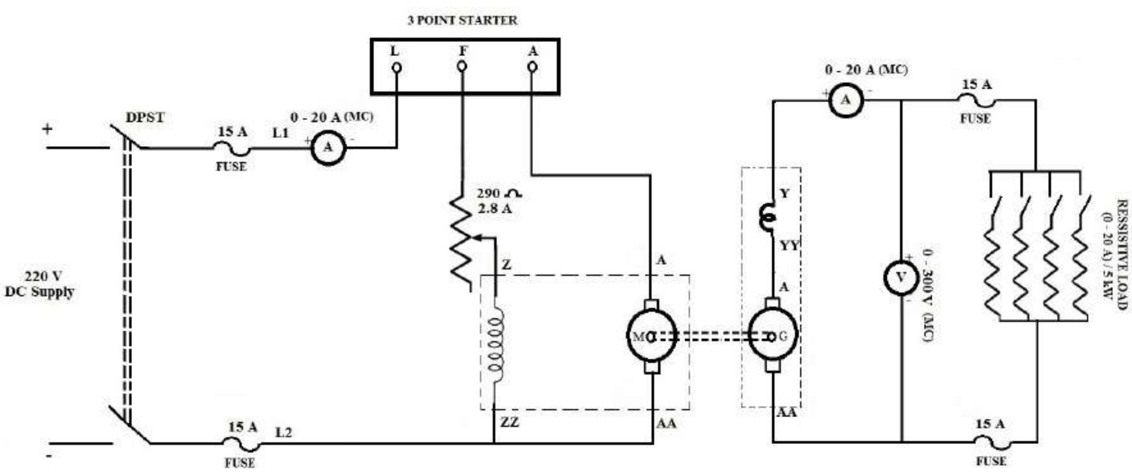
Motor			Generator	
Voltage			Voltage	
Current			Current	
Output			Output	
Speed			Speed	

APPARATUS:

S.No.	Item	Type	Range	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostat			
4	Tachometer			

CIRCUIT DIAGRAM:

LOAD TEST ON SERIES GENERATOR



THEORY:

The external characteristics is the graph of terminal voltage of a generator plotted against load current. The internal characteristics is the graph of induced e.m.f. of a generator plotted against load current.In a series generator armature and field winding are connected in series. The load is also connected in series with the field winding. Since the load current passes through the field winding, flux produces increases as the load current increases. As the flux increases, the e.m.f. induced in the armature also increases. In short as the load current increases, the induce e.m.f. also increases.In a series generator,

E=V+IaRa+IaRse =V+Ia(Ra+Rse)

Where, E=induced e.m.f. ; V = terminal voltage ; Ia = current through armature;

Ra = armature resistance; Rse = resistance of series field winding

Ia Ra = armature voltage drop; Ia Rse = voltage drope in series field winding

Initially, when load current is zero, very small voltage is induced in the armature. This is because of residual magnetic flux. Further increasing the load, voltage magnitude also will increase.

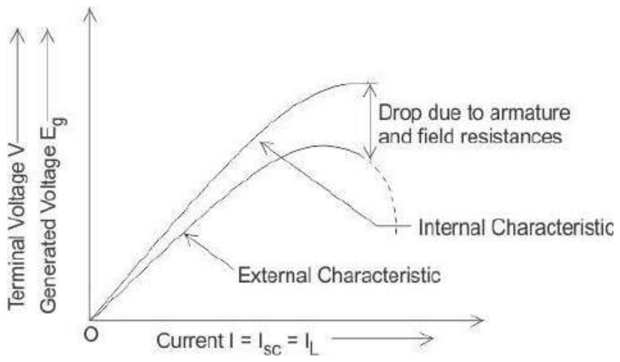
PROCEDURE:

1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.
2. Keeping the motor field resistance minimum and the generator output terminals are open circuited, give supply and start the motor - generator set.
3. Adjust the speed of the MG Set to the rated speed of the generator using the motor field rheostat (R_f)
4. Note down the voltage due to residual magnetism on no load.
5. Now gradually add load on the generator till the rated value of current and note down all the readings for each load.
6. Calculate the generated emf E at each load from the relation, $E_g = V + I(R_a + R_{Se})$.
7. Draw the external characteristic, V_T vs. I_L and the internal characteristic, E_g Vs I_a on the same graph sheet.

TABULAR COLUMN:

S. NO.	**I_L(Amp)**	**V_T(Volt)**	**$E_g = (V_T + I_L(R_a + R_S))$**
1			
2			
3			
4			
5			
6			
7			
8			

MODEL GRAPH: Fig - Internal and External Characteristics of DC series generator



RESULT:

VIVA QUESTIONS:

1. What are the applications of DC series generator?
2. To conduct the test on a DC series generator, can we use any other prime mover other than DC shunt motor?
3. Why should a DC series motor should not start without any load?
4. State the applications of the series generator.
5. State voltage builds up conditions of a series generator.
6. In what way does the series generator differ fundamentally from a shunt generator?
7. Why does a series generator have rising characteristics?
8. Why will the series generators be only built up when the load switch is on?
9. Why is the series generator used as a voltage booster in transmission systems?

Experiment – 6
Brake Test on DC Compound Motor

Aim:

To conduct the brake test on the DC compound motor and draw performance characteristics namely
(1) Speed vs Armature current I_a and
(2) Torque vs. Armature current I_a
(3) Speed vs Torque
(4) Load vs BHP for (i) cumulative and (ii) differential connections.

Name plate details of the machine: -

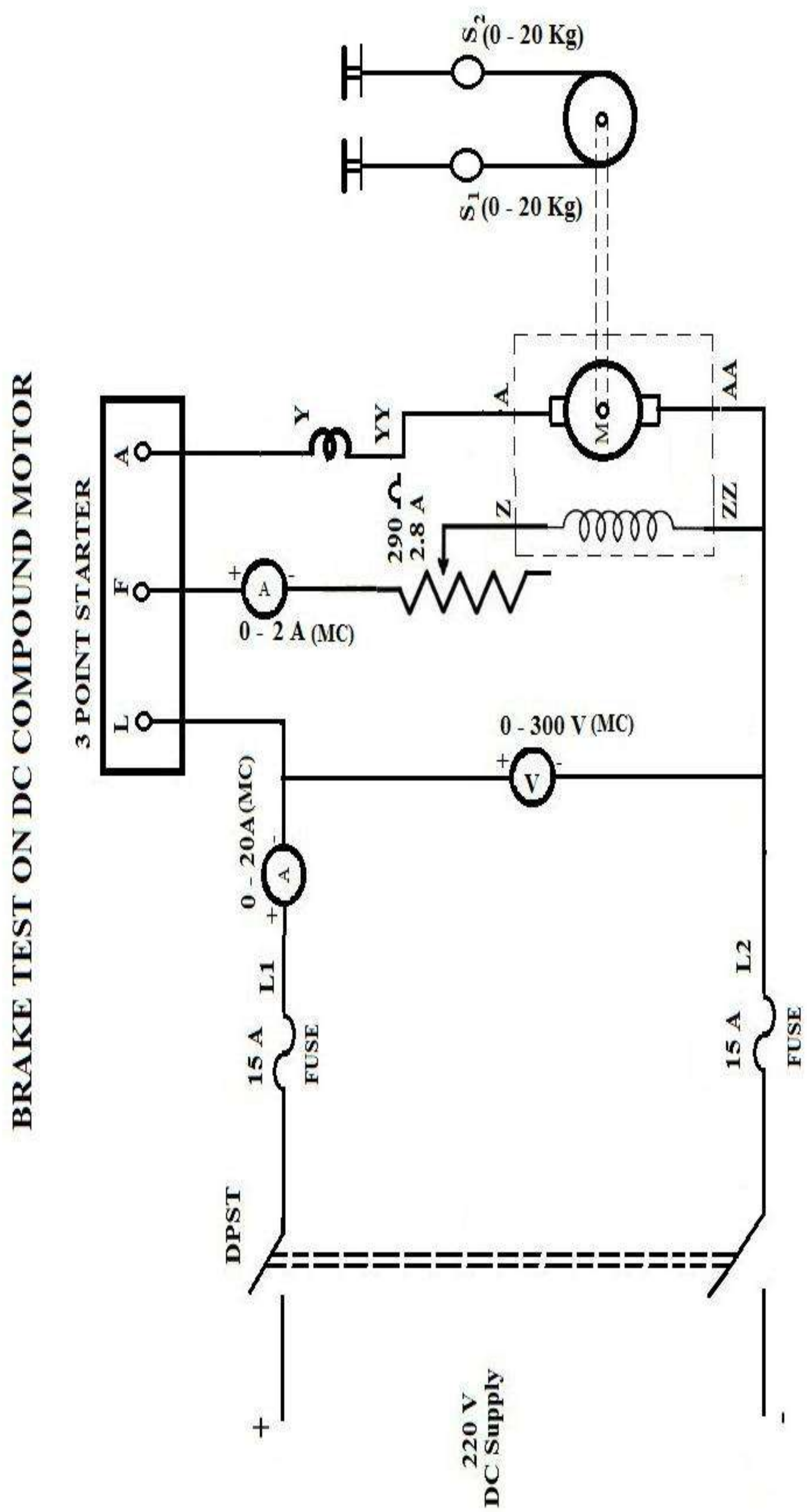
Motor

H.P: 3.0	Excitation type: Compound
Volts: 220	M/c no. 9904.4180
Amps: 12	Type: DO112.178.302
RPM: 1500	Rating: CMR
Extn volts 220V; 0.6A	Insulation class B

Apparatus Needed:

S.No.	***Apparatus***	***Type & Range***	***Quantity***
1	Ammeter	MC, (0-20A)	1
2	Ammeter	MC, (0-2A)	1
3	Voltmeter	MC, (0-300V)	1
4	Rheostat	290Ω , 2.8A	1
5	Tachometer	-	1
6	Connecting wires	-	As required

Circuit diagram:



THEORY:

In the case of compound motor, there are two windings on the poles. One winding is connected across the armature or supply and is called the shunt winding. The second winding is connected in series with the armature or supply as shown in figure. If the shunt winding is connected across the armature, it is called short shunt compound motor. If it is connected across the supply, it is called long shunt compound motor.

If the flux produced by the series field aids the flux of the shunt field, it is called cumulative compounding.

If the flux of the series field opposes the flux of the shunt field, it is called differential compounding.

A DC series motor is inherently a variable speed motor. It should never be run at light loads or no-load. It gives a high starting torque. A shunt motor gives nearly a constant speed (slightly dropping). But its starting torque is small. In a compound motor, the two fields i.e., series and shunt field are designed in such a way that we get the advantages of both the series and shunt motors. Cumulative or differential connections are chosen based on the load requirements.

For loading the motor, a brake drum fixed on the shaft of the motor is used as shown in figure. A rope is wound round the drum and its two ends are attached to two spring- balances S_1 and S_2. The tension of the rope can be adjusted with the help of handles on the frame. The force acting tangentially on the drum is equal to the difference between the two readings of the spring balances S_1 and S_2.

Let

The radius of the drum = R meters

Shaft torque, $T_{sh} = (s_1 \sim s_2) \times R \times 9.81$ Newton-meters

Motor output = $T_{sh}\omega = T_{sh} \times \frac{2\pi N}{60}$ Watts

where ω is the angular velocity of rotor in rad/sec. N is the speed of the motor in RPM.

Evidently, the output of the motor is utilized in overcoming the mechanical friction between the drum and the belt, and heat is produced. Cooling of the drum is therefore required to dissipate this heat. The following performance curves can be drawn in this test.

1. BHP vs Efficiency(η)
2. BHP vs Speed (N)
3. I_a vs Torque (T)

Model Graphs:

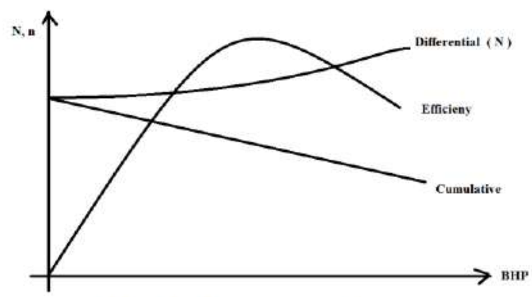


FIG MODEL GRAPH EFFICIENY Vs BHP

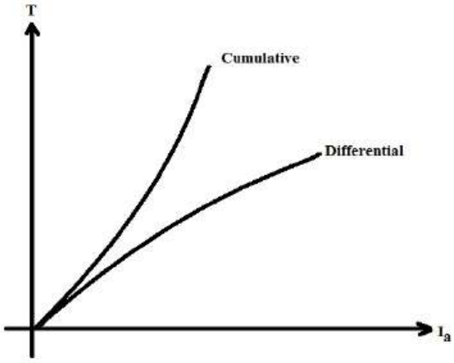


Fig 2 : Model graph Torque Vs I_a

PROCEDURE:

1. Make connections as per the circuit diagram
2. Study the operation of three-point starter.
3. Mark the polarities of the field and shunt field so that they can be connected either in
4. cumulative or differential modes. Connect the two fields for cumulative connection.
5. Keep the resistance connected in series with field winding to minimum value.
6. Check up and ensure that there is no load on the brake drum.
7. Start the machine by means of the 3-point starter and adjust the speed of the motor to its rated value on no load. by varying field resistance.
8. Take the readings of all meters at no-load. Also note down the readings of spring balances when the belt is free-: this gives initial reading of spring balances. Now load the motor by gradually tightening the belt with the help of wheels mounted on frame.
9. At each load, note the readings of meters, and the spring balances. Cool the brake drum by pouring cold water in the drum when the motor in on load. Continue this process till full load is reached. (I_L= 12 A) Release the load on the motor and stop the machine.

Cumulative Compound Motor :

S.No.	***V_L*** (V)	***I_L*** (A)	***I_f*** (A)	***S_1*** (Kg)	***S_2*** (Kg)	***N*** RPM	***Torque = 9.81* (S_1-S_2) R*** (N-m)	***$\omega=$ $2\pi\frac{N}{60}$ $2\pi\frac{N}{60}$*** (rad/s)	***Output = ω T*** (Watts)	***BHP= Watts / 746***	***Input =V_L I_L*** (Watts)	***Efficiency =Output /Input *100***	***I_a = I_L -I_f*** (A)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

Differential Compound Motor:

S.No.	***V_L*** ***(V)***	***I_L*** ***(A)***	***I_f*** ***(A)***	***S_1*** ***(Kg)***	***S_2*** ***(Kg)***	***N*** ***RPM***	***Torque = 9.81*(S_1-S_2) R*** ***(N-m)***	***ω= $2\pi\frac{N}{60}$ $2\pi\frac{N}{60}$*** ***(rad/s)***	***Output = ω T*** ***(Watts)***	***BHP= Watts / 746***	***Input =V_L I_L*** ***(Watts)***	***Efficiency =Output /Input *100***	***I_a = I_L -I_f*** ***(A)***
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

CALCULATIONS AND GRAPHS:

Calculate the efficiency of the machine and torque at each load current and plot the graphs.
a) BHP vs Efficiency (η)
b) BHP vs Speed (T)
c) Torque (T) vs Armature current (I_a **)**

Precautions:
1. Field Rheostat of the motor should be at minimum position.
2. Avoid Parallax errors and loose contacts

Result:

QUIZ:
1. What type of DC motor is best suited for electrical traction? Why?
2. Why differential compound motor sometimes becomes unstable?
3. Why a DC series motor should never be run at light loads?
4. Why a 4-point starter is superior to the 3-point starter?
5. How is torque related to the armature current in series and shunt motors?

Experiment No.7
Hopkinson's test

Aim: To conduct the Hopkinson's test on the given pair of d.c shunt machines and determine their efficiency characteristics.

Name plate details of Machine

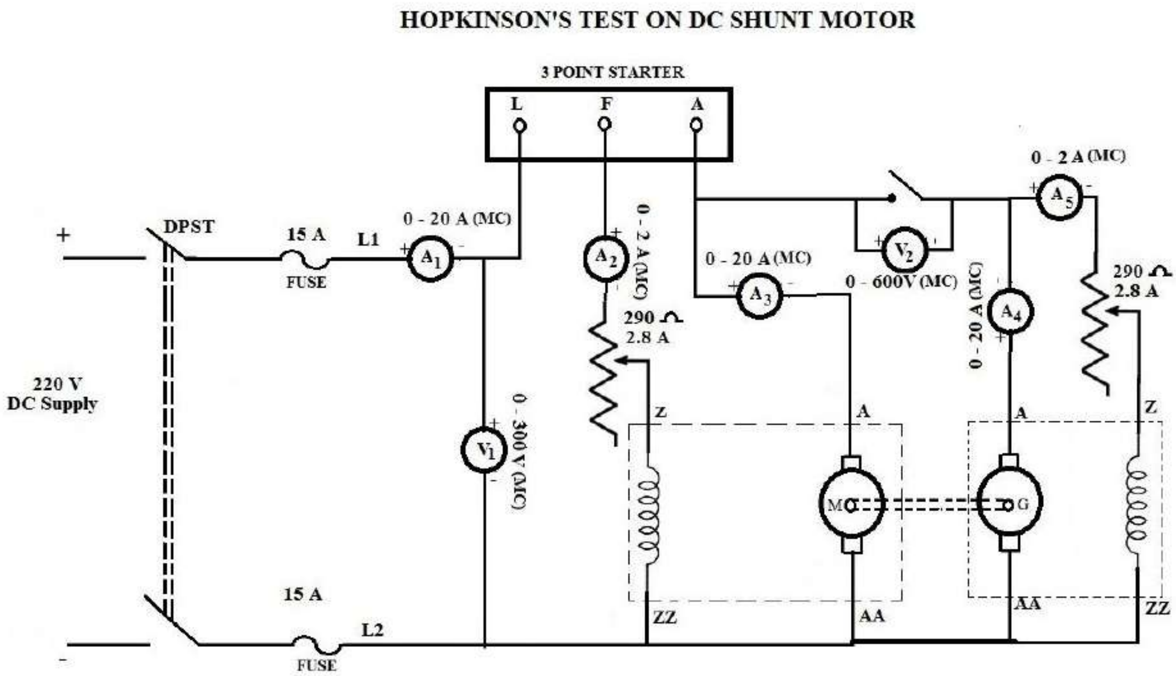
DC MOTOR:

KW :3	Excitation Type : Shunt
HP:3	Extn : 220V, 1A
Volts :220	Rating CMR
Amps:13.6	M/C No: G1446.9904
RPM: 1500	Type C 132.140.285

GENERATOR:

KW :3	Excitation Type : Shunt
HP:3	Extn : 220V, 1A
Volts :220	Rating CMR
Amps:13.6	M/C No: G1446.9904
RPM: 1500	Type C 132.140.285
	Insulation Class 'B'

CIRCUIT DIAGRAM:



THEORY:

This test requires two identical dc shunt machines. In this test it is possible to get full load conditions by regeneration. Hence there is no need to dissipate full load power. It is therefore possible to find the temperature rise in the machines and also the performance of commutation. This is the advantage of the test over the Swineburne's test. The two machines under test are mechanically coupled and are so adjusted electrically that one of them nets as a motor and the other nets like a generator. In fig., machine M is started from the supply mains with the help of a starter while the switch S is kept open. Its speed is adjusted to the rated value. Machine M drives the generator G and its generated voltage is adjusted till V_1 reads zero. This shows that the supply voltage and the generator voltage are equal and opposite. When the switch S is closed the two machines are paralleled. By adjusting the field regulators, it is possible to make any machine run as a motor and the other as a generator. The electrical output of the generator plus the small power taken from the supply is given to the motor. This motor drives the generator and generator electrical power. Let

Procedure:

1. Make connections as shown in the circuit diagram. Keep the SPST switch open. Keep the external resistances connected in series with the field windings in minimum position.
2. Start the motor using the three point starter and adjust the speed to rated speed of 1500 rpm.
3. Look at the 600V voltmeter and adjust the field rheostat of the generator till this voltmeter reads zero.
   (**Note:** It is possible that you will not get zero reading ever through you adjusting the rheostat. This is due to the generator not building the voltage because of improper connections of field winding across armature.Now stop the motor and inter change connection to Z and ZZ.(i.e. you are changing the direction of field current of the generator so that the polarity of voltage at the terminals of the generator is now reversed).Restart the motor, run at rated speed. Now adjust the field rheostat of the generator till the voltmeter across SPST reads zero.)
4. Now close the SPST switch. (**Note:**At this instant the output current of the generator is zero. The generator armature current will be equal to its field current.)
5. Now slowly reduce resistance of the generator field thus increasing the armature currents of both generator and motor. Increase the armature current of the generator in steps of 2 amps, continue till the armature current is 10 amps.
6. Note down the armature current of the motor. It should not exceed the rated current. Note the readings of all the five ammeters and the supply voltage.The speed should be maintained constant of 1500 rpm.
7. Mark the readings in the prescribed tabular statement. Measure the resistance of the armature of both motor and generator.
8. Compute the copper losses in armatures and filed circuits. Then compute stray loss of each machine.

9. Using this data, compute efficiency and draw graphs between output and efficiency for both motor and generator.

S.No	A_1	A_2	A_3	V	Remarks

S No	Supply Voltage (V1)	Input current (A1)	Motor			Generator			Stray losses
			Field current (A2)	Armature current (A3)	Input W* V_1 *(A_2+A_3)	Armature current (A4)	Field current A5	Output W*V1*(A_4 - A_5)	
1	220								
2	220								
3	220								
4	220								
5	220								
6	220								

Calculations & Graphs:

At each load current, find the efficiency of the motor and generator as explained in theory. Plot

1. Efficiency vs load curves for motor
2. Efficiency vs load curves for generator

QUIZ:

1. What is the superiority of this test over the SwineBurne's Test?
2. What is the function of the switch S in the circuit shown in fig 5.1
3. During the conduct of this test, is it possible to convert the machine running as a motor to a generator and vice versa? How do you know whether a machine in the set is running as a motor or generator

4. How do you reverse the direction of rotation of dc motors
5. What are the possible causes of excessive sparking at the brushes of a dc motor?

Result:

Hopkinson's Test Model Calculations:

S No	Supply Voltage V1	Input current	Motor			Generator			Stray losses
			Field current A2	Armature current A3	Input W V_1 (A_2+A_3)	Armature current A4	Field current A5	Output WV_1 $(A_4 - A_5)$	
1	220	2.1	0.56	16	475.2	0.56	0.56	0	104.1
2	220	2.3	0.56	3.3	849.2	0.64	0.64	299.2	101.65
3	220	2.7	0.56	6.0	1443.2	0.68	0.68	730.4	93
4	220	3.0	0.56	7.9	1861.2	0.7	0.7	1166.0	63
5	220	3.8	0.56	10.7	2477.2	0.7	0.7	1606	47.35
6	220	5.0	0.56	14	3203.2	0.74	0.74	2037.2	22.2

1. Motor VI_f = 220 x 0.56 =123.2
$I_a^2 R_a$ = 1.6^2 x 2.6 = 6.65
Gen VI_f = 220 x 0.56 = 123.2
$I_a^2 R_a$ = 0.56^2 x 2.6 = 0.815

253.8

Input = 220 x 2.1 = 462

Stray losses = $\frac{462-253.8}{2}$ = 104.1 W

2 . Motor VI_f = 220 x 0.56 =123.2
$I_a^2 R_a$ = 3.3^2 x 2.6 = 28.3
Gen VI_f = 220 x 0.64 = 140.8
$I_a^2 R_a$ = 2^2 x 2.6 = 10.4

302.7

Input = 220 x 2.3 = 506

Stray losses = $\frac{506-302.7}{2}$ = 101.65 W

3. Motor VI_f = 220 x 0.56 =123.2
$I_a^2 R_a$ = 6^2 x 2.6 = 93.6
Gen VI_f = 220 x 0.68 = 149.6
$I_a^2 ZR_a$ = 4^2 x 2.6 = 41.6
----
408 w

Input = 220 x 2.7 = 594

Stray losses = $\frac{594-408}{2}$ = 93 W

4. Motor VI_f = 220 x 0.56 =123.2
$I_a^2 R_a$ = 7.9^2 x 2.6 = 162.3
Gen VI_f = 220 x 0.7 = 154
$I_a^2 R_a$ = 6^2 x 2.6 = 93.6

533.1

Input = 220 x 2.1 = 462

Stray losses = $\frac{660-533.1}{2}$ = 63.45 W

5. Motor VI_f = 220 x 0.56 =123.2
$I_a^2 R_a$ = 10.7^2 x 2.6 = 297.7
Gen VI_f = 220 x 0.7 = 154
$I_a^2 R_a$ = 9^2 x 2.6 = 166.4

741.3

Input = 220 x 3.8 = 836

Stray losses = $\frac{836-741.3}{2}$ = 47.35 W

6. Motor VI_f = 220 x 0.56 =123.2
$I_a^2 R_a$ = 14^2 x 2.6 = 509.6
Gen VI_f = 220 x 0.74 = 162.8
$I_a^2 R_a$ = 10^2 x 2.6 = 260

1055.6

Input = 220 x 5 = 1100

Stray losses = $\frac{1100-1055.6}{2}$ = 22.2 W

Calculation of Efficiency

Generator:

S.no	Output Vx(A_4 – A_5)	Armature copper Losses	Field Coupled	Stray Losses	Total Losses	Input	Efficiency
1	0	0.815	123.2	104.1	228.1	228.1	0
2	299.2	10.4	140.8	101.65	252.8	552.05	54.2
3	730.4	41.6	149.6	93	284.2	1014.6	72.0
4	1166.0	93.6	154	63.45	311.05	1477	78.9
5	1606	166.4	154	47.35	367.75	1974	81.35
6	2037.2	260	162.8	22.2	445	2482	82.07

Motor:

S.no	Output $V x (A_2 - A_3)$	Armature copper Losses	Field Coupled	Stray Losses	Total Losses	Input	Efficiency
1	475.2	6.65	123.2	104.1	234	241	50.7
2	349.2	28.3	123.2	101.6	253.1	596.1	70.2
3	1443.2	93.6	123.2	93	309.8	1133.4	78.5
4	1861.2	162.3	123.2	63.45	348.95	1512.3	81.25
5	2477.2	297.7	123.2	47.35	468.25	2009	81.1
6	3203.2	509.6	123.2	22.2	655	2548.2	79.55

Experiment No.8
Fields Test on D.C Series Machines

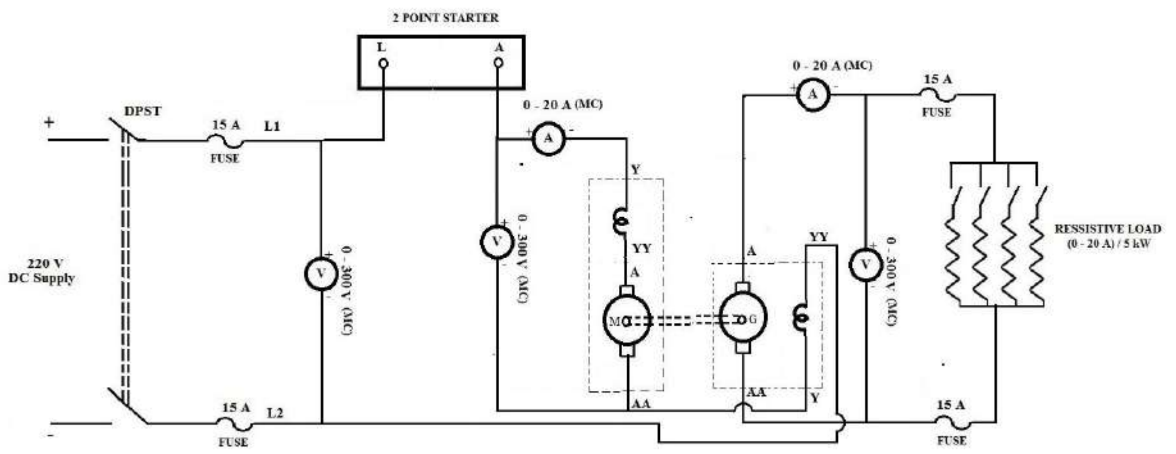
Aim:. To conduct the fields test on D.C series and determine the efficiency at 1/4, 1/2, 3/4,of full-load and full-loads.

Name plate details of the machine:-

D.C.Series generator	**D.C Series Motor**
KW:3.0	KW:3.0
Volts: 220V	Volts: 220V
Amps: 13.6	Amps: 13.6
RPM: 1500	RPM: 150
Excitation type: Series	Excitation type: Series
M/c no. 61450-9904	M/c no. 61449-9904
Type: C132.140.289	Type: C132.140.289
Rating:CMR	Rating:CMR
Insulation class II	Insulation class II
H.P: Identical	H.P: Identical

CIRCUIT DIAGRAM:

FIELD TEST ON DC SERIES MOTOR



THEORY: None of the methods commonly used for the determination of efficiency of a D.C shunt / compound motor, namely, Swinburne’s test, Hopkinson’s test and the Brake test are suitable for D.C series motor because this motor is a variable-speed motor and operates with varying flux densities at different loads. This test is suited for series machines only. It requires a pair of identical d.c series machines.

As shown in the circuit diagram in the armature, field of the first machine and the field of the second machine are connected in series. The second machine which functions like a generator supplies power, which is wasted in the resistance R_L. The equality of iron and friction losses is ensured because of the series connection shown. Efficiency of each machine is calculated as below.

Let The Supply Voltage = V
Motor Current = I_1
Terminal voltage of generator = V_2
Load current of generator = I_2
Intake of the whole set = VI_1
Output = V_2I_2

Total losses in the set = $W_1 = VI_1 - V_2I_2$
Armature and Field Cupper losses = $W_{cu} = (R_a + 2R_{se}) I_1^2 + I_2^2 Ra$
Where Ra = Hot armature resistance of each machine.
R_{se} = Hot series field resistance of each machine.
Stray losses of the set = $W_1 - W_{cu}$
Stray losses per machine = $W_s = (W_1 - W_{cu}) / 2$

It is assumed that stray loses are equally divided between the two machines.

Motor Efficiency:

Motor input = V_1I_1
Motor losses = Armature and field cupper losses + stray losses
= $(R_a+R_{se}) I_1^2 + W_s = W_m$, say

$\eta_m = (V_1I_1 - W_m) * 100 / V_1I_1$

<u>Generator Efficiency:</u> The generator efficiency will be of little use because it is running under abnormal condition of separate excitation. However, under these unusual conditions, it can be found as below.

Generator output = V_2I_2
Armature and field cupper loses = $I_1^2R_{se} + I_2^2R_a$
Stray Losses = W_s
Total Losses = $I_1^2 R_{se} + I_2^2R_a + W_s = W_g$ (say)
$\eta_g = (V_2I_2) * 100 / (V_2I_2 + W_g)$

PROCEDURE:

1. Make the connections as per the circuit diagram shown in fig.6.1
2. Study the operation of Two-point starter.
3. Make sure that the d.c series motor should be started on load hence slightly tighten the belt on the drum.
4. Start the machine by means of the 2-point starter and adjust I_1 (reading of A_1) to 1/4 of full load current. Take readings of all meters, maintaining rated speed.
5. Adjust R_L for I_1 to be 1/2 of full load current and note the readings of all meters, maintaining rated speed.
6. Repeat the procedure in (2) and (3) for 3/4 and full load currents of I_1.
7. Stop the machine and measure the cold resistance of both the armatures and fields of the set by drop or any other method.
8. Assume a temperature rise of 45^0c and determine the hot-resistance of the armature.
9. Tabulate the results as below.

Observation Table:

S.No	V	I_1	V_1	V_2	I_2	η_m	η_g

CALCULATIONS AND GRAPHS:

Determine η_m and η_g as explained in theory and plot the Load current vs efficiency

Result:

QUIZ:

1. A d.c series generator fails to excite at no-load. Why?
2. Why do you prefer d.c series motor for electrical traction?
3. D.C series motor should never be run at light loads. Why?
4. Is the fields test a regenerative test? Comment
5. Why can't you use the Swinburne's test for d.c series motor.

Experiment – 9

Swinburne's Test

Aim: To conduct Swinburne's test on the given dc shunt machine and to predetermine its efficiency at various loads when it is working a) As generator and b) As motor

Name plate details of the machine:-

D.C. motor:

KW:3 Volts :220	Mc No: G11578.0101
Amps :13.6 RPM:1500	Type C132.140.285
Extn Type: Shunt	Rating: CMR
V: 220, I: 1 Amps	INS Class: B

Caution: Although this machine has both series winding and shunt winding on its poles, you have to use only shunt winding. Do not connect series winding.

Theory:

In this test, the dc shunt machine is run as a motor on no load at the rated speed applying rated voltage. The power input to the motor can be easily calculated from the readings of meters and the constant losses are determined as given below.

Power input to the motor = VI_o, where

V= Rated applied voltage

I_o = Line current taken by the motor at no load

Armature current $I_a = I_o - I_f$ where I_f is the field current

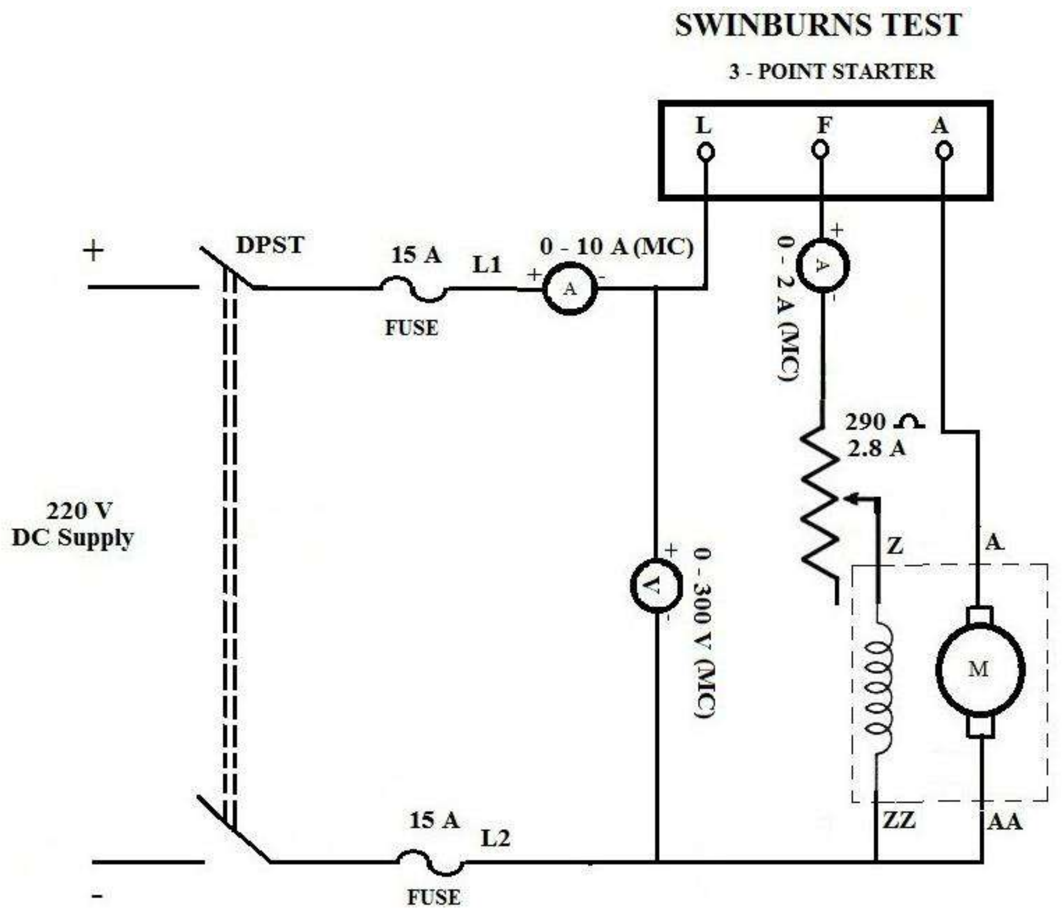
Armature copper loss = $I_a^2 R_a$ where R_a is the armature resistance in ohms

Field copper loss = $V I_f$

W_c = Constant losses = $VI_o - (I_a^2 R_a)$ watts

Note that the constant losses W_c includes field copper losses, iron (hystresis and eddy current losses) and mechanical (friction and windage) losses

Circuit diagram: -

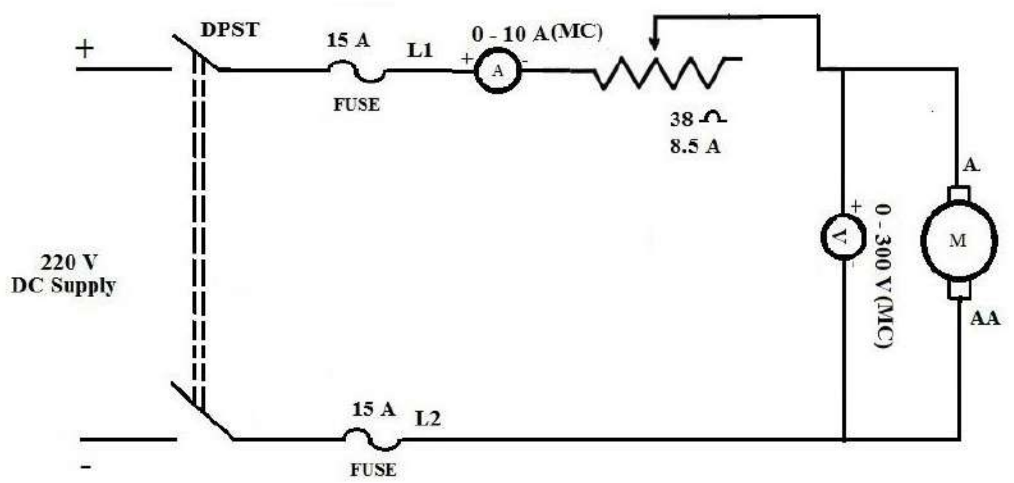


a) **No - load test:** Make connections as shown in the circuit diagram given in fig 1. Start the motor and run it rated speed of 1500 rpm by adjusting the field rheostat take the reading of the meters and tabulate as shown below.

Sl No	V	I_o	I_f	$V*I_0$	$I_{a0} = I_0 - I_f$	$I_{a0}^2*R_a$	$W_c = V*I_0 - I_{a0}^2*R_a$

The last column indicates constant losses

b) **Measurement of armature resistance**:



Make connections as shown above. Adjust the rheostat till the armature current (I_a is equal to 12A. Measure the voltage (V_a) across the armature, Now the armature resistance $R_a = V_a/I_a$ ohms. This resistance is measured at room temperature (20^0 C). Let it be designed as R_{20}. It is to be corrected to 70^0 C by the equation: $R_{70} = R_{20} * (234.5 + 70)/(234.5+20)$. This resistance R_{70} is known as hot resistance and it is assumed that it will be the resistance of the armature if the motor is run continuously for long time as full load. Alternately the resistance of the armature may be measured with multi meter.

Sl.No	V_a	I_a	$R_a=V_a/I_a$

c) **Predetermination of Efficiency**:

As a Generator: Output of the generator is electrical power and for different output powers the efficiency can be calculated as given below. For the given output lad current I_L is calculated using the equation I_L = the power output / voltage applied.

R_a is to be taken as the hot resistance R_{70}

Output		V	I_L = Watts /V	$I_a = I_L + I_r$	$I_a^2 * R_a$	Input = Output +Wc+$I_a^2 * R_a$	Efficiency (Output/Input) * 100
%	Watts						
100%	3000						
75%	2250						
50%	1500						
25%	750						
15%	450						

As motor: the output for motor is mechanical power normally given in horse –power (HP). It is also given in watts. At different outputs we have to calculate the efficiency. The power input is electrical and is equal to V (I_a +I_f) for shunt motor I_f is taken as constant and it is measured during the no load test. For given mechanical power output I_a is not directly known. It is to be computed. The electrical power input to the armature is utilized to overcome the armature copper losses, stray losses (i.e. friction & windage losses plus magnetization losses) and the balance is converted to mechanical power…

Stray losses = constant losses – field copper losses
Power input to the armature = $V*I_a$
Armature copper losses = $I_a^2R_a$
Power output in watts = P_0
Stray losses = P_s watts
Then $V*I_a = I_a^2 R_a + P_s + P_0 = I_a^2 R_a + (W_c – V I_{sh}) + P_o$
Using this equations I_a has to be calculated for different power outputs p_0 power input to the motor $P_1 = V(I_a + I_f)$ watts
% efficiency = $(P_0 /P_i)100$

Output		I_a	Input = V *(I_a +I_f)	% Efficiency = (Output/Input) * 100
%	Watts			
100%	3000			
75%	2250			
50%	1500			
25%	750			
15%	450			

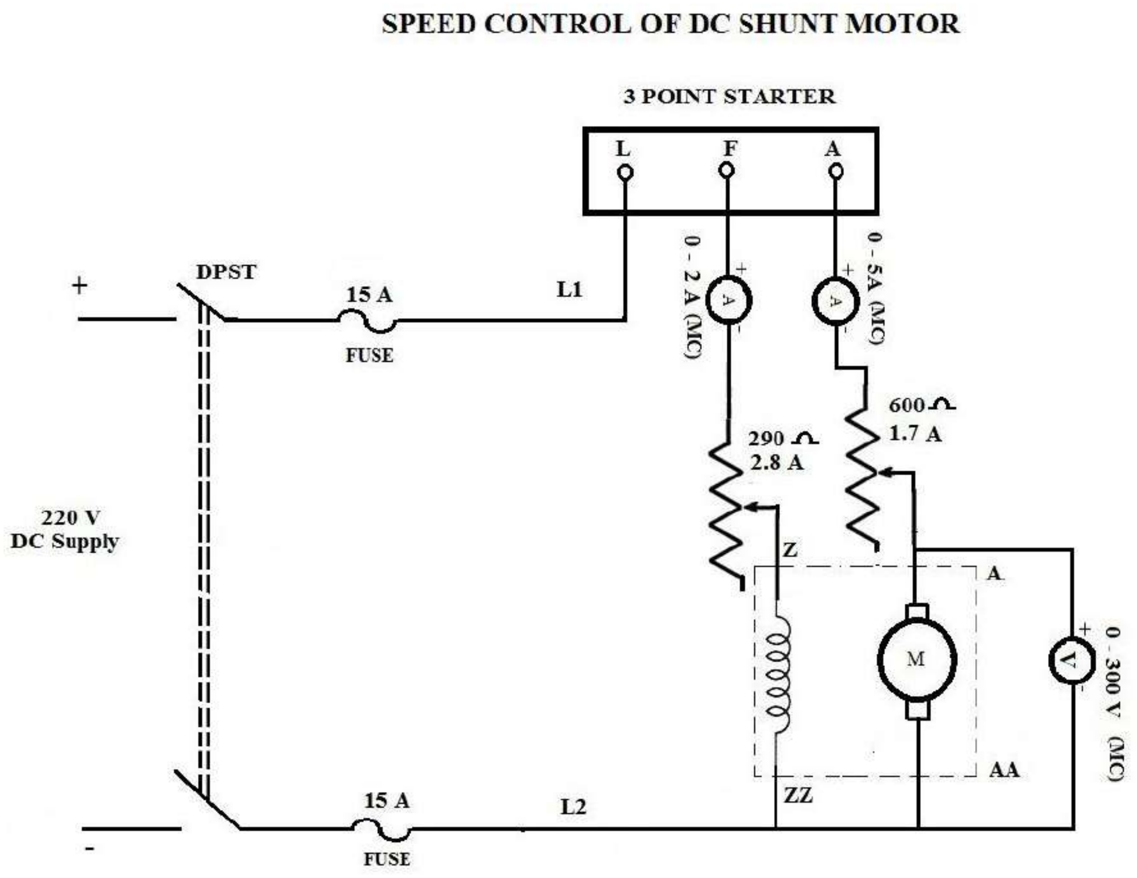
After calculating the efficiencies draw the curves between output and efficiency separately for motor and generator.

Result:

SPEED CONTROL OF A DC SHUNT MOTOR

AIM: to study the speed control of DC shunt motor by (i) field control and (ii) armature control methods at no load

CIRCUIT DIAGRAM:



THEORY:

The formula for the speed of a dc motor is given by

$$N= \frac{V-I_aR_a}{Z\emptyset}\frac{A}{P} X\ 60$$

Where V = Applied Voltage

I_a= Armature current

R_a = Armature resistance

Φ = Flux per pole

A= No. of parallel paths in armature winding

P=No. of poles

Z= No. of armature conductors

From the above formula. It can be seen that given speed is controlled by

(1) Varying the applied voltage V
(2) Variation flux produced Φ or "field current"
(3) Variation of armature resistance "R_a"

In the above three methods, the first method is expensive since it requires the variation of the applied voltage. The other two methods are simple. These are studied in this experiment.

1. Variation of flux or field current: Is is seen from equation (1), other factors remaining same.
   $N \propto 1/\Phi$,
   That is, speed is inversely proportional to the flux. The speed variation is very simple since, we need only a rheostat in the field circuit. Since field current is usually small, the loss of power due to this resistance is negligible. But in this method, speed can only be increased above the normal value (R_{ah} =0).
2. Variation of armature resistance: Formula for the speed of the motor given in eqn (1) can be written as
   $$N=\frac{V-I_{a(R_a}+R_{1)}}{Z\emptyset}\left(\frac{A}{P}\right)$$

   Where R_1 is the resistance connected in series with the armature.
   Evidently, when R_t is increased the speed decreases. Thus in this method of speed control, speed can only be decreased than the speed when R_t = 0. The armature current is nearly equal to the load current. Hence for speed control, the current losses I is quite high. Therefore this method of speed control is not efficient.

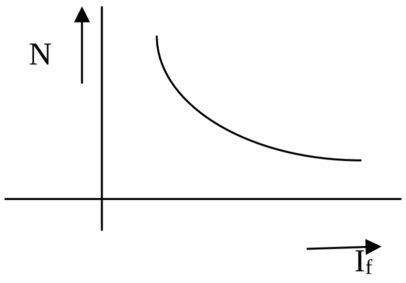
PROCEDURE:

1. Make connections as per circuit diagram
2. Start the motor with the help of the starter and adjust the speed to its rated value at no-load
3. Gradually vary field current in steps and at each field current measure the speed.
4. Plot the variation of speed Vs field current curve

5. By varying armature resistance gradually note the value of armature current and the corresponding speeds. Plot the variation of speed V_s V_a

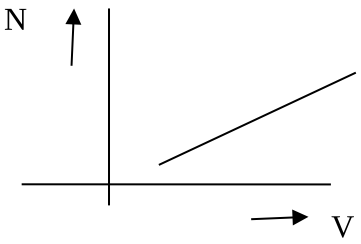
Field control method

S.No	I_f (Amp)	N (rpm)



Armature control method

S.No	I_a (Amp)	V (volt)	N (rpm)



Result

Experiment N0-10

Separation of Losses Test

Aim; to determine Hysteresis, eddy current, friction and windage losses separately by conducting separation of losses test on given DC shunt motor.

Name plate details of machine:

Motor:

HP: 5

Volts :220

Amps :19

RPM:1500

Mc No: 6544.9904

Type: C132.148.293

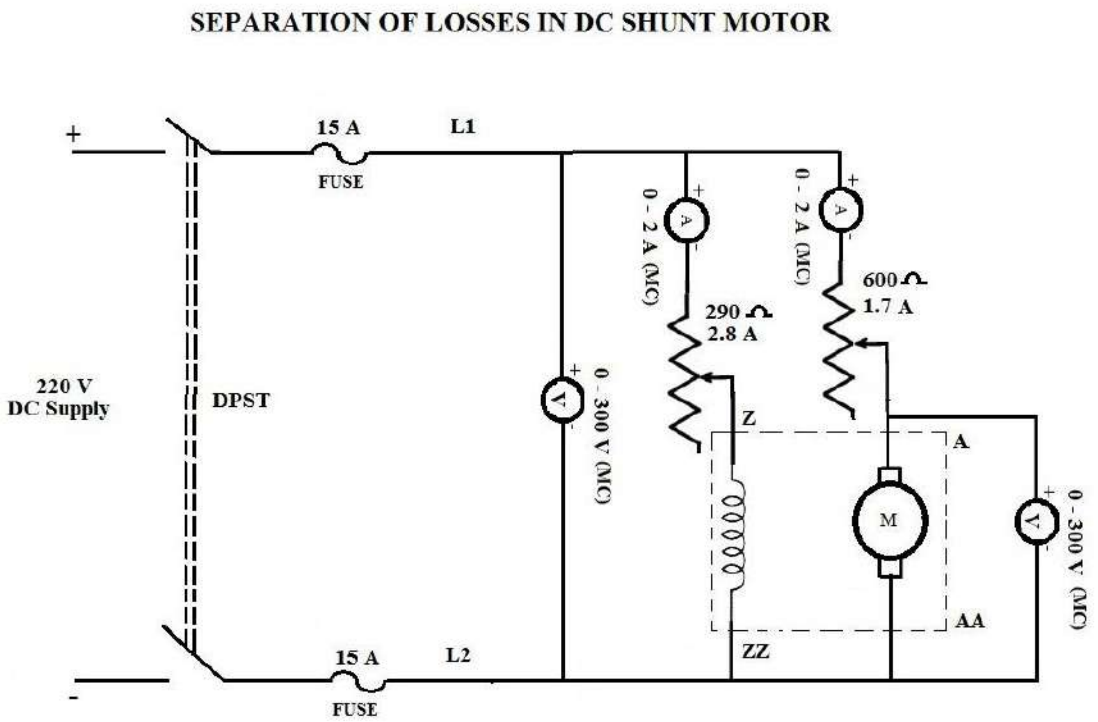
Rating: CMR

INS Class: B

Extn Type: Shunt

V: 220, I: 1 Amps

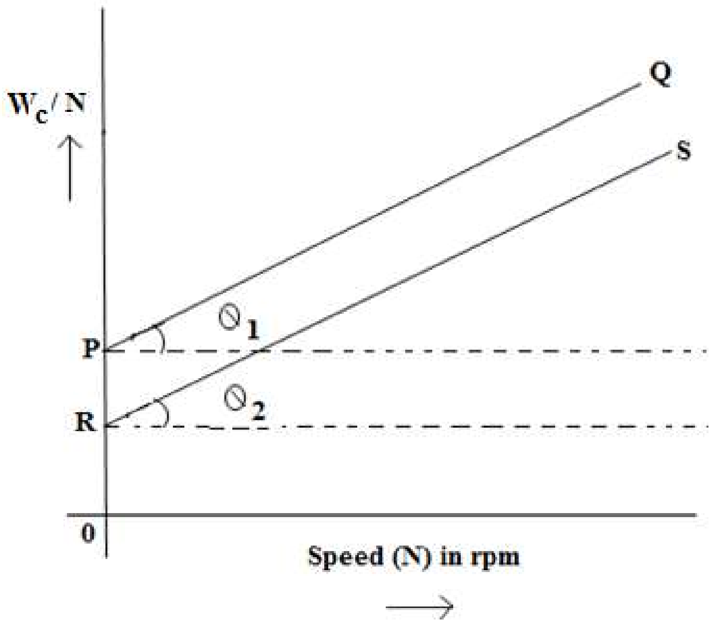
CIRCUIT DIAGRAM:



PROCEDURE:

1. Conduct the circuit as shown in this figure
2. Keep the rheostat R_s , connected in armature circuit, at maximum resistance position and field rheostat at minimum resistance position.
3. After closing switch, R_s is fully cut out so that the rated voltage is applied across the armature.
4. The speed of the motor is then adjusted to the rated value by changing the excitation.
5. Then note down the speed, the voltage across armature and armature current.
6. Keeping the excitation constant, vary the speed of the motor by simply controlling the armature voltage vy varying the series resistance R_s.
7. Note down the readings of armature, conmnected in armature circuit, and voltmeter, connected across armature corresponding to each speed.
8. Calculate no-load losses corresponding to each speed
9. Calculate W/N for each value of speed. Then draw W/N Vs N graph.
10. Then repeat the experiment at half of the normal excitation.
11. Calculate W/N for each value of speed at half of normal excitation. Then draw W/N Vs N graph.
12. Determine A,B,C and D by using appropriate formulas.

Expected Graph:



PQ- Curve corresponds to normal excitation

RS – Curve corresponds to half of normal excitation

Sample Calculations:

OP =A+C B+D =Tanθ_1

OR=A+C^1 B+D^1 = Tanθ_2

C-C^2 =OP –OR - (1)

$\frac{C}{C^1} = \left(\frac{E_{b1}}{E_{b2}}\right)^{1.6}$ - (2)

D-D^1 = Tan θ_1 - Tan θ_2 - (3)

$\frac{D}{D^1} = \left(\frac{E_{b1}}{E_{b2}}\right)^{2\ 1.6}$ - (4)

A = Frictional loss constant
B= Windage loss constant
C= Hysterisis loss constant
D= Eddy current loss constant
Determine C and C^1 from eqn (1) and (2) & D, D$^{|}$ from (3) & (4)

E_{b1} = Back emf at normal excitation
E_{b2} = Back emf at 3 /4 th Normal excitation
} At Same speed

Determine D and D^1 from eqn (3) and (4)

E_{b1} is the back emf corresponding to normal excitation and E_{b2} is the back emf corresponding to half of normal excitation at same speed.

Tabular columns:

1. Tabular column under normal excitation

S.No	Speed (rpm)	Armature Voltage (volts)	Armature current (Amps)	Armature (culoss) Weu	I/P (watts)	Constant Losses W_c
1	1500					
2	1400					
3	1300					
4	1200					
5	1100					
6	1000					

2. Tabular column under ¾ of excitation

S.No	Speed (rpm)	Armature Voltage (volts)	Armature current (Amps)	Armature (culoss) Weu	I/P (watts)	Constant Losses W_c	W/N	E_b
1	1500							
2	1400							
3	1300							
4	1200							
5	1100							
6	1000							

Result: