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EXPERIMENT NO. 19

SERIES MOTOR CHARACTERISTICS

PURPOSE:

To discover the characteristic change in speed of a DC series motor as it is loaded.

To discover the characteristic change in torque output of a DC series motor as it is loaded.

PERFORMANCE OBJECTIVES:

Upon successful completion of this experiment the student will be able to:

1. Analyze series motor characteristics.

2. Explain why series motors must be rigidly connected to the load.

BRIEFING:

DC series motors are widely used in traction vehicles, such as locomotives and electric cars, because of their ability to produce a high torque without a corresponding high armature current. However, there is a drastic change in speed when a series motor is loaded. In traction equipment, the heaviest load is at start, when torque is more important than speed.

In a DC series motor, the armature current and the field current are the same current, since the two are in series. Torque output is proportional to the armature current and field flux. The field flux, then is proportional to armature current. This makes torque proportional to the square of armature current. For light loads a series motor produces less torque for the same armature current; for heavy loads it produces more torque than a shunt motor.

Series motors are always rigidly connected to their loads, and never operated without some load. A shunt motor can operate unloaded because a strong field flux is always present. Enough CEMF is generated to lower armature current to just the amount needed to overcome windage and friction losses. A series motor, on the other hand, will get into a "run away" condition, if unloaded. That is when the motor continues to increase in speed until it tears itself to pieces.

Assume a series motor is running under load and the load is suddenly removed. The torque that was driving the load is now applied to the motor shaft as accelerating torque. As the motor begins to speed up, additional CEMF is generated, reducing armature current. But this also reduces the strength of the field flux. Not enough CEMF is generated to reduce the armature current enough to stop the motor from accelerating. The motor speeds up more.

Armature current continues dropping but the field keeps getting weaker. CEMF can never catch up with the armature current. Even at light loads, the speed can become excessive before armature current decreases enough to eliminate the accelerating torque.

MACHINES REQUIRED:

DM-100A DC Machine operating as a motor
DYN-100DM Dynamometer

POWER REQUIRED:

0-125 volt Variable DC, 5 amps
0-150 volt Variable DC, 1 amp

METERS REQUIRED:

0-150 volt DC voltmeter
0-150 volt DC voltmeter
0-5 amp DC ammeter

ADDITIONAL MATERIAL REQUIRED:

MGB-100-DG Bedplate
RL-100A Resistance Load Bank
HT-100J Tachometer
SFR-100 Series Field (Diverter) Rheostat

PROGRAM PLAN:

Step 1. Place the two machines on the bedplate with the motor on the left and the dynamometer on the right.

Step 2. Couple the two machines tightly, using the rubber coupling. Be sure the coupling fits snugly inside both flanges. Be sure the rotor locking device has been removed from the dynamometer.

Step 3. Clamp the machines tightly to the bedplate. Place the coupling guard over the coupling and the shaft guard over the motor and dynamometer shafts.

Step 4. Connect the motor as shown in Figure 19-1. Note that this is a series motor connection. Set the diverter rheostat to 5 ohms (mid point) in parallel with the series field.

Step 5. Turn the knob of the 0-125 volt supply fully counterclockwise to its zero output position. Power should remain off.

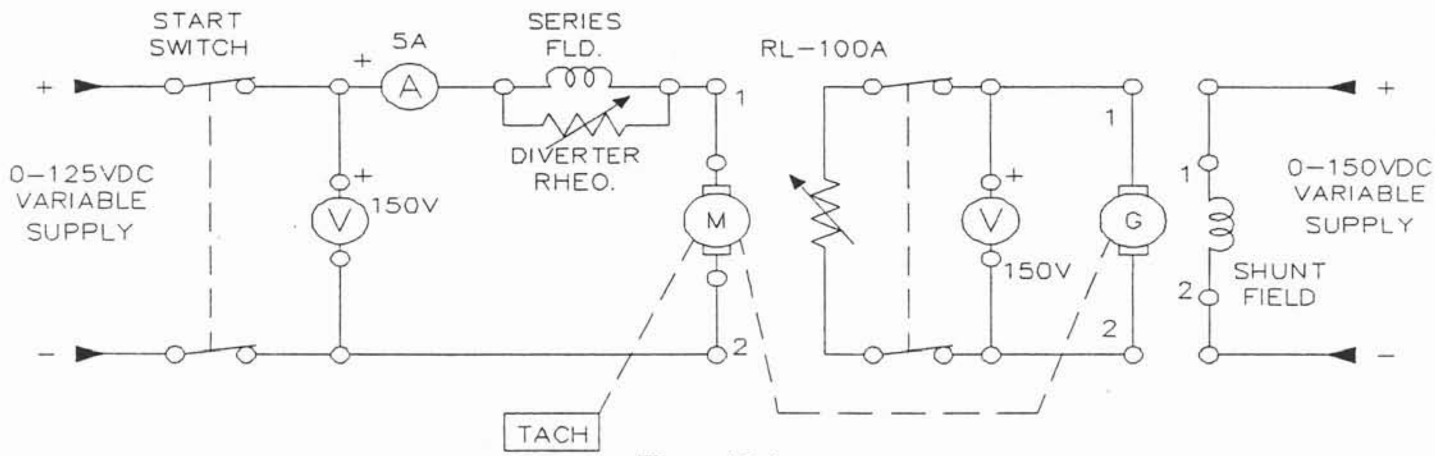


Figure 19-1

Step 6. Connect the dynamometer as shown in Figure 19-1. Note that this is a separately excited generator connection. Note also that the shunt field rheostat is not being used.

Step 7. Have someone check your connections to be sure they are correct. Then turn ON resistance legs 1, 2, and 3 on the load bank.

Step 8. Turn ON the main AC and the 0-150 volt supply circuit breakers.

Step 9. Temporarily connect a voltmeter across the 0-150 volt excitation supply and adjust the knob for 125 volts. Then connect the voltmeter across the RL-100A Resistance Load Bank.

Step 10. Turn ON the 0-125 volt supply and the motor circuit breaker switches. Start the motor by slowly increasing the output of the 0-125 volt supply to 115 volts.

Step 11. Use the 0-150 volt excitation supply knob to adjust the dynamometer's output voltage to 125 volts. If necessary, re-adjust the 0-125 volt supply to 115 volts.

Step 12. Read, and record in Table 19-1 of TEST RESULTS, the values of motor speed, armature voltage, armature current, torque, and load voltage.

Step 13. Switch ON resistance legs 4, 5, and 6 on the load bank.

Step 14. Repeat Steps 11 and 12.

Step 15. Switch ON resistance legs 7, 8, and 9 on the load bank.

Step 16. Repeat Steps 11 and 12.

Step 17. Turn OFF all circuit breaker switches. Disconnect all loads.

TEST RESULTS:

	STEP 12	STEP 13	STEP 15
SPEED			
ARMATURE VOLTAGE			
ARMATURE CURRENT			
TORQUE (N-m)			
GENERATED VOLTAGE			

TABLE 19-1

DE-BRIEFING:

1. On the graph provided, use the data you have recorded in Table 19-1 to plot a curve showing how the speed of a DC series motor changes as the armature current increases with increasing load. Label this curve SPEED.

2. On the same graph, use the data from Table 19-1 to plot a curve showing how the output torque of a DC shunt motor changes as the armature current increases with increasing load. Label this curve TORQUE.

3. When lightly loaded, the field strength of a DC series motor is:

a. About the same as a shunt motor driving the same load.

b. Less than that of a shunt motor driving the same load.

c. Greater than that of a shunt motor driving the same load.

4. DC series motors are better able to handle overloads because:

a. The field strength increases as armature current decreases.

b. The field strength and armature current increase together.

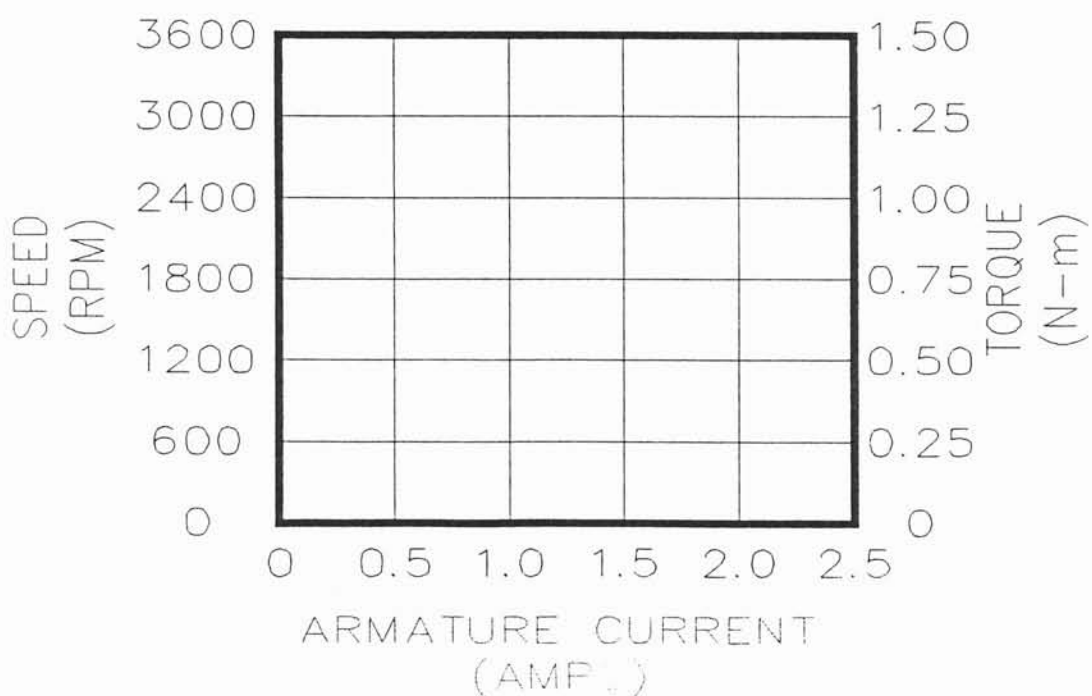
c. The field strength decreases as armature current increases.

5. The top speed of a DC series motor with no load is:

a. About the same as a shunt motor.

b. Less than a shunt motor.

c. Infinite - there is no limit.



3. Does the field flux become stronger or weaker as a series motor is loaded? Explain why.

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4. A hoist should travel fast when it does not have a load, and slowly when lifting a load. Would you choose a series motor or shunt motor? Explain why.

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5. At light loads, a series motor has a larger armature current than a shunt motor for the same torque output. At rated load, a series motor has about the same armature current as a shunt motor for the same torque output. At heavy loads, a series motor has less armature current than a shunt motor for the same torque output. Explain why this is so. (Hint: Torque is proportional to the product of armature current and field flux).

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QUICK QUIZ:

1. As additional load was placed on the series motor, its field current:

   a. Increased.

   b. Decreased.

   c. Stayed the same.

2. In a DC series motor the field current is the same as:

   a. Armature current.

   b. Current through the load.

   c. Shunt field current.