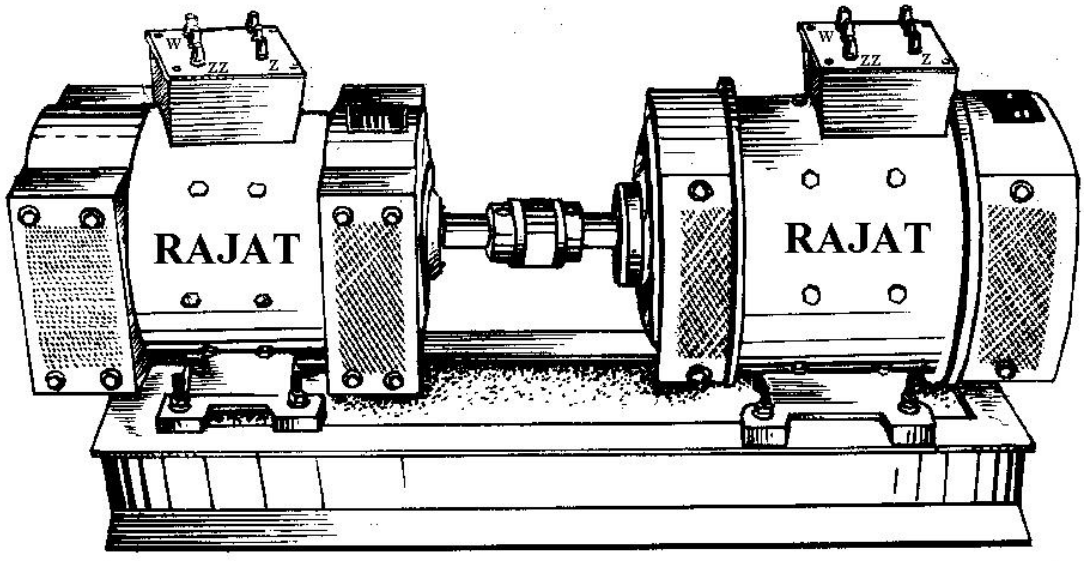
INDEX NO. : M-18

RAJAT

TECHNICAL MANUAL FOR

HOPKINSON'S TEST



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HOPKINSON' TEST

AIM : (a) To perform Hopkinson's test on two identical DC machines.

(b) To determine the efficiency of the DC Machine as motor at 50%, 75%, and 100% of full load.

MACHINES USED

Two identical D.C. machines, 230 V, 1500 RPM, coupled mechanically through flexible coupling and mounted on m.s. channel base.

M.G. SET: D.C. SHUNT MOTOR/D.C. SHUNT GENERATOR (IDENTICAL MACHINES)

SPECIFICATIONS:

DC SHUNT MOTOR : 1.5 HP/KW, 230V ,1500 R.P.M. Screen Protected, Horizontal Foot Mounted, Class 'B' Insulation, Internally Fan Cooled, With Interpoles . **'RAJAT'** Make with DC starter faceplate type.

D.C. SHUNT GENERATOR : 1.5 HP/KW, 230V,1500 R.P.M. Screen Protected, Horizontal Foot mounted, Self Excited Type, Class 'B' Insulation ,Internally Fan Cooled With Interpoles. **'RAJAT'** Make

Both the machines are flexibly coupled and mounted on sturdy m.s. channel base. The terminals of armature and shunt field windings of both the machines shall be brought over to bakelite plate fixed on c.i. terminal box fitted on top of machine .

INSTRUMENTS REQUIRED ON CONTROL PANEL FOR MG SET : DC SHUNT MOTOR/DC SHUNT GENERATOR

Fitted on bakelite sheet enclosed in almirah type ms box with lock & handle arrangement suitable for table mounting.

FOR DC MOTOR :-

(i) MC Voltmeter 96 x 96 mm flush mounted 0-300V – 1 No. (Source Voltage–Vs)
(ii) MC Ammeter 96 x 96 mm flush mounted 0-10 A. – 1 No. (Load Amp. -I_1)
(iii) MC Ammeter 96 x 96 mm flush mounted 0-2.5 A. – 1 No. (Field Amp. – I_3)
(iv) Indicating light
(v) Educational type insulated terminals
(vi) DPIC Switch 16A, 240V.
(vii) DC starter face plate type
(viii) Tubular Rheostat 1.2 A, 260 Ohms

FOR DC GENERATOR :

(i) MC Voltmeter 96 x 96 mm flush mounted 0-600V – 1 No. (V_1 – to check the condition for closing of switch)
(ii) MC Voltmeter 96 x 96 mm flush mounted 0-300V – 1 No. (V_G)
(iii) MC Ammeter 96 x 96 mm flush mounted 0-10 A. – 1 No. (Load Amp.- I_2)

(iv) MC Ammeter 96 x 96 mm flush mounted 0-2.5 A. – 1 No. (Field Amp. – I_4)
(v) Knife Blade Switch SPST -1 No.
(vi) Tubular Rheostat 1 A. 800 Ohms – 1 No.
(vii) Indicating light
(viii) Educational type insulated terminals

THEORY

The efficiency of the DC machine can be accurately determined by the regenerative method, normally known as Hopkinson's test. This test overcomes the drawback of Swinburne's test, which does not take any account of the stray load losses occurring in DC machines under loaded condition. As such the efficiency, calculated by Swinburne's test is comparatively higher than the actual one. Hopkinson's test needs two identical DC machines coupled mechanically and connected electrically as shown in Fig. 'A'. One of the machines is operated as motor, driving the other machine as a generator. The output power of the generator is fed to the motor. Thus the power drawn from the supply is only to overcome the losses of both the machines. By varying the field current of generator and motor i.e. I_4 and I_3 any desired load can be adjusted on these two machines. Rating the circuit diagram of Fig 'A' following expression can be established for the case.

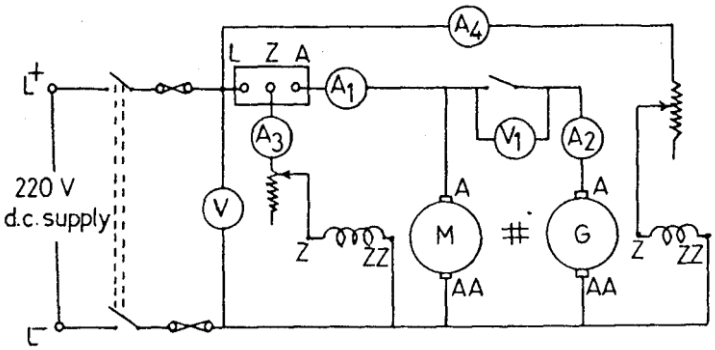

Fig 'A' : Schematic diagram for Hopkinson's test on DC machine.

Armature copper losses in the generator = $I_2^2\ r_g$

Armature circuit copper losses in the motor = $(I_1 + I_2)^2\ r_m$

Total power drawn by the armature circuit of the motor = $V \times I_1$ watts

Let the sum of iron losses and mechanical losses of each machine be W_c, then

$$V \times I_1 = 2W_c + I_2^2\ r_g + (I_1 + I_2)^2\ r_m$$

Thus, $W_c = \frac{1}{2}[\ V \times I_1 - I_2^2\ r_g - (I_1 + I_2)^2\ r_m\ ]$

Efficiency of Motor

Shunt field copper losses of the motor = $V \times I_3$

Hence, total losses of the motor = $W_c + (I_1 + I_2)^2\ r_m + V \times I_3$

Total power input to the motor, $P_1 = V \times (I_1 + I_2 + I_3)$

Thus, efficiency of the motor, $\eta_m = \dfrac{V(I_1 + I_2 + I_3) - [W_c + (I_1 + I_2)^2 r_m + V I_3]}{V(I_1 + I_2 + I_3)} \times 100$ percent

Hence, the efficiency of the both machines at various loads can be worked out, recording the various currents and voltage during the experiment and measuring the resistance of armature of both the machines.

The major advantages of this test are as follows :

1. Power drawn from the supply is low.

2. Both the DC machines are operating under loaded conditions, can such stray load losses are taken into account.

CIRCUIT DIAGRAM

Fig 'A' shows the circuit diagram; in which two identical DC machines are connected in such a way that one of them is acting as a motor and another as a generator. The following instruments connected in the circuit serve the function indicated against each.

1. Ammeters $A_1(I_1)$, $A_2(I_2)$ – to measure the current drawn from the supply and the generator current respectively.

2. Ammeters, $A_3(I_3)$, $A_4(I_4)$ – to measure the field current of motor and generator respectively.

3. (a) Voltmeter, Vs – to measure applied voltage.

   (b) Voltmeter, V_G – to measure generated voltage – to be connected externally of terminals A & AA of DC machine which is used as generator.

4. Voltmeter, V_1 – to check the condition for closing the switch, S.

5. Rheostats – to vary field current of motor and generator respectively.

PROCEDURE :

1. Connect the two DC machines, coupled mechanically as per the circuit diagram shown in attached sheet.

2. Ensure that the switch, SPST is in the open position.

3. Adjust the rheostat, so that the field current of the motor is MAXIMUM.

4. Adjust the rheostat, so that the field current of the motor is MINIMUM.

5. Switch on the DC supply and start the DC motor using the starter properly.

6. Adjust the speed of the motor to rated value by varying the rheostat provided in its field circuit.

7. Adjust rheostat in the field circuit of generator, so that the generated voltage of the generator is equal to the supply voltage.

8. The control panel connection diagram is done as per the schematic diagram given in figure 'A'. We have internally connected as per the polarity the respective armature terminals of motor and generator i.e. armature terminals A and AA of motor is connected to respective armature terminals A and AA of generator and now check the voltage across the switch, S. In case of right polarity the voltmeter V1 will read practically zero voltage but if you have to show to the students regarding the wrong polarity connections then you have to interchange the sequence of armature connections of generator, then in that case the voltmeter will record twice the supply voltage. Repeat steps 5, 6 and 7. Now the voltmeter V_1 reads zero. Under this condition, the machine working as a generator is just floating i.e. neither drawing any current from nor giving into the lines. Now check the applied voltage Vs and generated voltage Vg, and observed that both the applied voltage and generated voltage are nearly same.

9. Now to study the behaviour under various load conditions, the SPST switch is put to ON position and various values of load current is put on the generator, keeping the motor to its rated speed under various load conditions (which is done by decreasing the field current of the motor). At various load setting note down the corresponding applied voltage Vs, I_1, I_2, I_3 & I_4.

10. Repeat step 9 for various values of load current.

11. Reduce the load on the generator and motor by varying their field current.

12. Switch off the DC supply.

13. Measure the resistance of the armature circuit of motor and generator by usual voltammeter method.

OBSERVATIONS : May be tabulated as follows.

S No.	Vs	Vg	I_1	I_2	I_3	I_4	W_c	η_{m1}	η_{m2}

PANEL LAYOUT FOR HOPKINSON'S TEST ON DC MACHINES