Ch 31 — Testing of DC Machines || DC Machines

1- Swinburn's Test " No-load Test or Losses Methods

A- Losses Measured Separately.

i) efficiency at any desired load can be ~~predetermi~~ predetermined in advance.

ii) only running test needed is No-load Test.

iii) this test applicable to those Machines in which flux is ~~ap~~ apractically constant [Shunt & Compound -wound machines]

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* Machine is running at the rated Voltage with No-load, Speed (N) adjusted to the rated speed

- I_0 = No-load current.

$I_{sh} = V/R_{sh}$

$I_{a_0} = (I_0 - I_{sh})$ — No-load armature current.

V = Supply

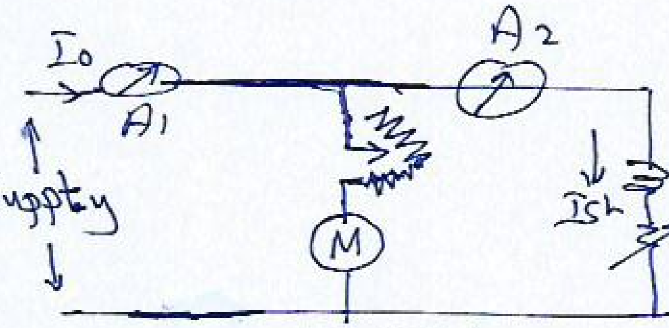


Fig. 31.1

* No-Load input power $= V I_0$ →

→ Field Power $I_{sh} V$

→ armature input power $= V(I_0 - I_{sh})$

No-Load power i/p to Armature supplies the following.

- مفاقيد الحديد — Iron Losses in core
- مفاقيد الاحتكاك — Friction Loss
- مفاقيد احتكاك الهواء (air gap) — Windage Loss
- Armature Cu loss ($I_{a_0}^2 R_a$)

To calculating Cu Loss in armature (hot resistance) of armature should be used.

– hot resistance allowing a temperature rise of 50°C

$$R_{15} = R_0 (1 + 15\alpha_0), \quad R_{65} = R_0 (1 + 65\alpha_0)$$

$$\Rightarrow R_{65} = R_{15} * \frac{1 + 65\alpha_0}{1 + 15\alpha_0}, \quad \text{Taking } \alpha_0 = 1/234.5$$

$$\boxed{\Rightarrow R_{65} \simeq 1.2 R_{15}}$$

$$\text{* Constant Losses} = W_c = V I_0 - I_{a_0}^2 R_a$$

$I_a = I - I_{sh}$ — Motor
$I_a = I + I_{sh}$ — gen.

I: Loading current.

$\eta\%$ When running as Motor

$P_{in} = VI$, $Cu\ Loss = I_a^2 R_a = (I - I_{sh})^2 R_a$

W_c = constant Loss

∴ Total Losses = Cu Losses + W_c

$$\eta_{motor} = \eta_m = \frac{P_{in} - P_{losses}}{P_{in}} = \frac{VI - (I - I_{sh})^2 R_a + W_c}{VI}$$

$\eta\%$ when running as gen.

$P_o = VI$, $Cu\ Losses = I_a^2 R_a = (I + I_{sh})^2 R_a$

W_c = Constant losses.

$$\eta_g = \frac{P_o}{P_o + P_{losses}} = \frac{VI}{VI + (I + I_s)^2 R_a + W_c}$$

* Advantages of Swinburn's :- it is convenient and economical because power required to test large Machine is small only no-load input power.

2- The efficiency can be Predetermined at any load because the (W_c is known)

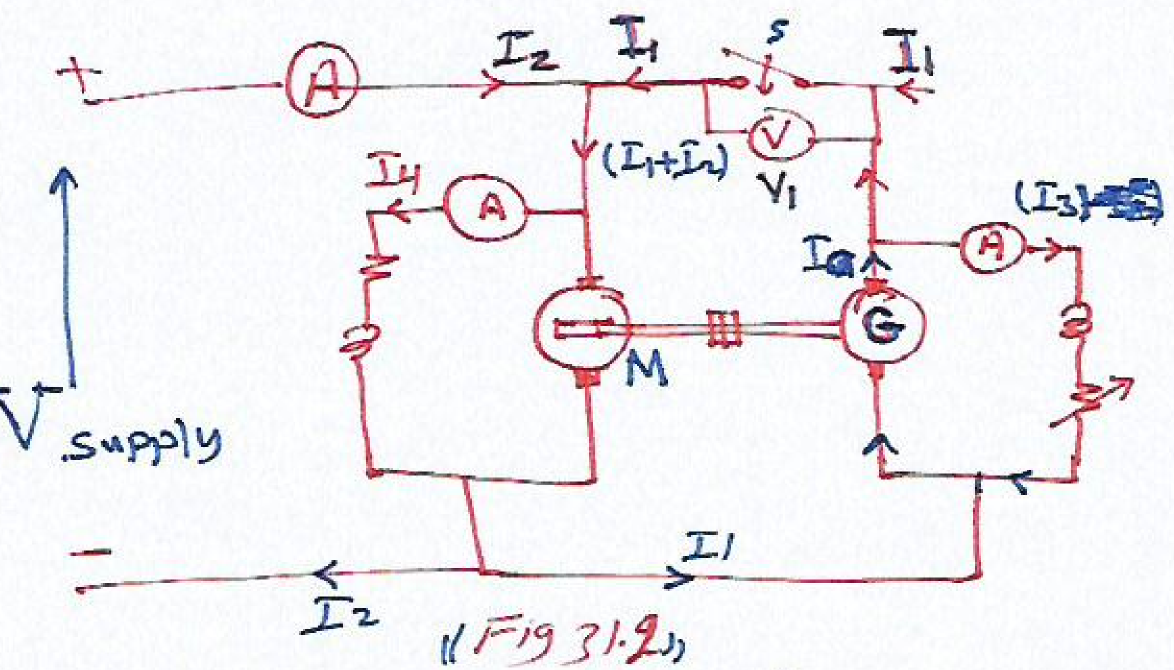
disadvantages:- No account is taken of the Change in iron losses from No-load to full load due to (armature Reaction ⇒ flux is distroted ⇒ iron loss increase. in some cases ↑ 50%

2- As the test on no-load, it is impossible to know whether commutation would be satisfactory at full load. and wheter the temperature rise would be within the specified limits.

2- Regenerativ OR Hopkinson's Test (Back to Back) Test.

* In this Test we need to Two identical Machines which are coupled to each other Mechanical
* is full load Test.
* one of them runs as motor and the other as generator. # The Mechanical output of the Motor drives the generator and the electrical output of generator is used in supply the greater part of input to the motor.
* If there were no losses in the machines, They would have run with out any « external power supply »

* generator out put is not sufficient to drive the Motor and vice - versa. (Called Back to Back)



((Fig 31.2))

∴ due to the drop in the generator out put voltage we need an extra voltage source to supply the proper input voltage to motor.

* the power drawn from the external supply is therefore used to overcome the internal losses of the motor-generator set.

- Essential connections for this test shown in fig 31.2

- Machine M is started up from the supply mains
- S = switch is open, speed adjusted to normal value.
- Machine M drives Machine G as a generator

and its voltage is read on volt meter (V_1)

- the voltage of generator is adjusted by its field regulator until voltmeter V_1 reads zero volt. This means the voltage is same both in polarity and magnitude as that of the main supply.
- S_1 is closed to parallel machines.
- I_1 generated current can be adjusted to any desired value by increasing the excitation of G or by reducing the excitation of M.

* Calculation of Efficiency by Hopkinson's Test

V : is the supply voltage.

Motor i/p = $V(I_1 + I_2)$: where I_2 current taken from the supply.

Generator output = VI_1

* Assuming that both machines have the same efficiency

- o/p of motor = η * i/p = $\eta V(I_1 + I_2)$ = generator i/p
- output of gen. = η * i/p = $\eta * \eta V(I_1 + I_2) = \eta^2 V(I_1 + I_2)$

$$\eta^2 V(I_1 + I_2) = VI_1 \quad \text{or} \quad \eta = \sqrt{\frac{I_1}{(I_1+I_2)}}$$

* Armature Cu Loss of gen. $= (I_1 + I_3)^2 R_a$
* Armatur Cu loss in motor $= (I_1 + I_2 - I_4)^2 R_a$
* Shunt Cu loss in gen. $= V I_3$
* shunt Cu loss in M $= V I_4$

** Totale (M & G) Losses are equals to the power supplied by the mains.

* Power drawn from supply $= V I_2$

* Total stray Losses for the set. ((both Machines))

$$= V I_2 - \left[(I_1+I_3)^2 R_a + (I_1+I_2-I_4)^2 R_a + V I_3 + V I_4 \right] = W_c$$

∴ the stray losses for each Machine $= W_c/2$ when we assuming the stray losses is divided equally.

∴ Total Losses for generator $= (I_1 + I_3)^2 R_a + V I_3 + W_c/2 = W_g$

o/p of gen. $= VI_1 \Rightarrow \eta_g = \dfrac{VI_1}{VI_1 + W_g}$

for Motor $W_m = (I_1+I_2-I_4)^2 R_a + VI_4 + \frac{W_c}{2}$

Motor i/p $= V(I_1+I_2) \Rightarrow \eta_m = \dfrac{V(I_1+I_2) - W_m}{V(I_1+I_2)}$

Advantages of Hopkinson's Test

The merits of this test are…

1. This test requires very small power compared to full-load power of the motor-generator coupled system. That is why it is economical. Large machines can be tested at rated load without much power consumption.
2. Temperature rise and commutation can be observed and maintained in the limit because this test is done under full load condition.
3. Change in iron loss due to flux distortion can be taken into account due to the advantage of its full load condition.
4. Efficiency at different loads can be determined.

Disadvantages of Hopkinson's Test

The demerits of this test are

1. It is difficult to find two identical machines needed for Hopkinson's test.
2. Both machines cannot be loaded equally all the time.
3. It is not possible to get separate iron losses for the two machines though they are different because of their excitations.
4. It is difficult to operate the machines at rated speed because field currents vary widely.