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20Ω section $\Rightarrow 5\left(\frac{5}{5+20}\right) \Rightarrow 1A$

5Ω resistor section $\Rightarrow 5\left(\frac{20}{5+20}\right) = 4A$

3Ω $\Rightarrow 1\left(\frac{6}{6+3}\right) = \frac{2}{3}A$

6Ω $\Rightarrow 1\left(\frac{3}{6+3}\right) = \frac{1}{3}A$

18Ω $\Rightarrow$ 1A

8Ω $\Rightarrow$ 5A

Voltage

8Ω resistor $\Rightarrow 8 \times 5 \Rightarrow 40V$

18Ω resistor $\Rightarrow 18 \times 1 \Rightarrow 18V$

6Ω resistor $\Rightarrow \frac{1}{3} \times 6 \Rightarrow 2V$

3Ω resistor $\Rightarrow \frac{2}{3} \times 3 \Rightarrow 2V$

5Ω resistor $\Rightarrow 4 \times 5 \Rightarrow 20V$

MCB

1 2 3

Voltmeter

V

4 5

Ammeter

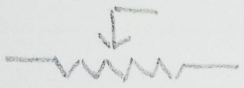
A

6 7

Wattmeter

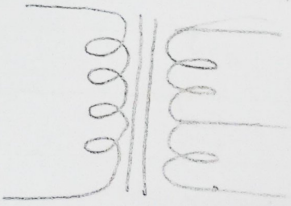
W

8 9 10 11



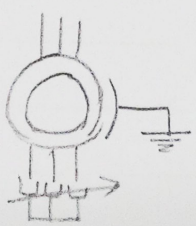
18 19 20

12 13 14



21 22 23

15 16 17



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Aim : Speed control of slip ring induction motor

Apparatus : MCB, Voltmeter, Ammeter, Wattmeter, rheostat, Autotransformer, 3 ϕ induction motor, connecting wires.

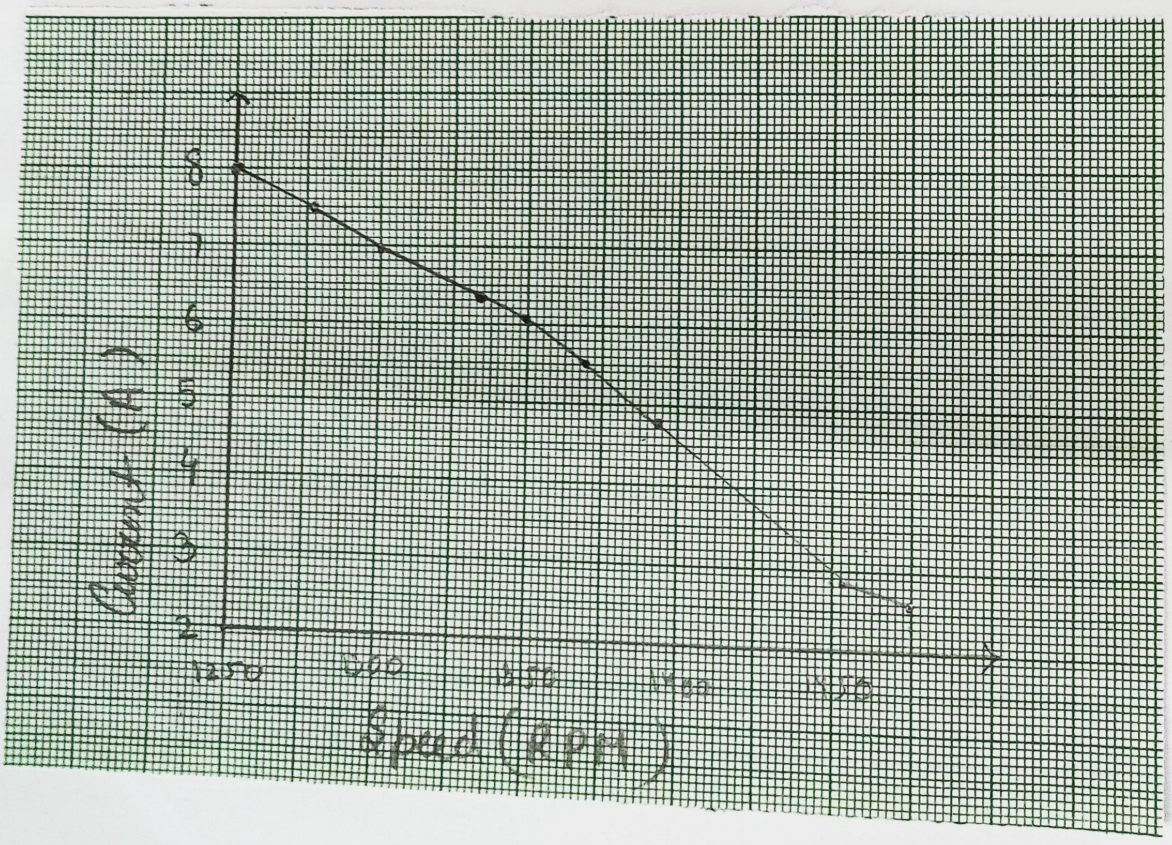
Theory : A wound induction motor, or slip ring induction motor, features stator similar to squirrel cage motor but has insulated rotor windings connected via slip rings and brushes. These slip rings do not carry powers; instead, they allow for resistance to be added in series with the rotor windings during startup

Slip ring Characteristics :

Can be started with full line voltage applied to its stator. The rotor winding terminals connect to three slip rings insulated from the shaft, with brushes leading to external resistance. At startup, the external resistance is added to limit starting current as rotor accelerates, the resistance is gradually reduced to maintain maximum torque. Eventually external resistance is fully removed, allowing the motor to develop full torque at a low slip. Notably, the slip required for max torque is directly proportional to rotor resistance, meaning inc resistance inc slip

DELTA

SNo	Current (A)	Power (W)	Speed (RPM)
1	2.6	40	1474
2	2.9	140	1454
3	4.8	680	1388
4	5.5	820	1363
5	6.1	940	1352
6	6.4	1040	1334
7	6.9	1100	1300
8	7.5	1160	1278
9	8	1200	1250



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⇒ Methods of speed control (Rotor - Rheostat)

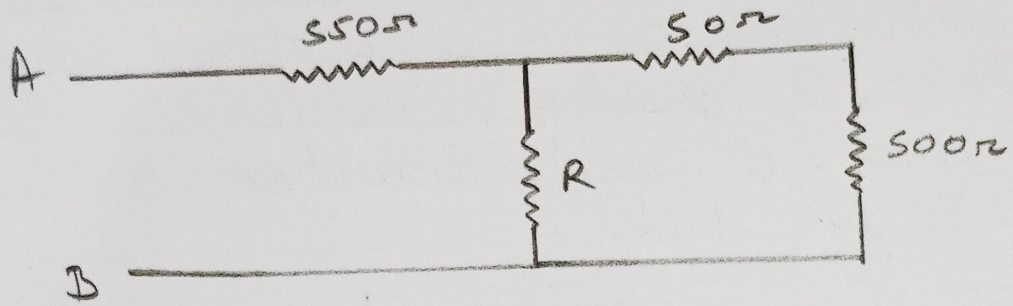
External rheostat used for starting can also control speed, provided it is rated for continous operation. Initially, maximum resistance is applied during startup which is gradually reduced to increase speed. If speed reduction is needed at full speed.

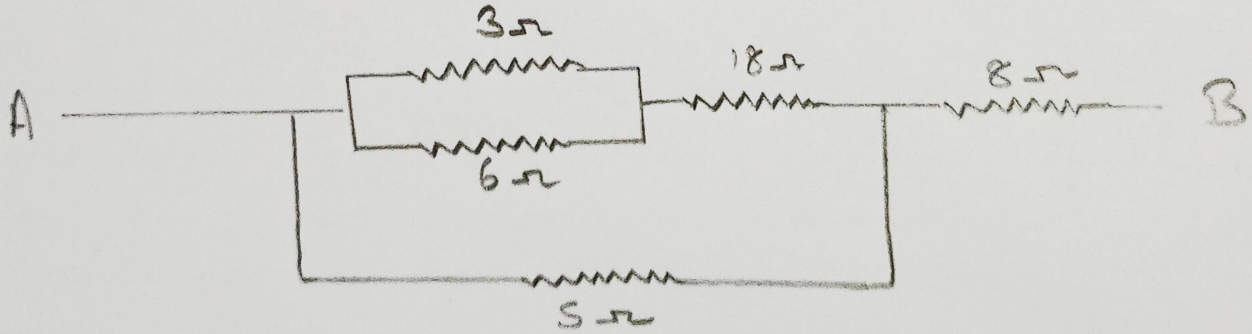
$$\text{Torque}(T) = \frac{\text{Slip}(S)}{\text{rotor resistance}(R)}$$

⇒ Disadvantages :

- Increased I^2R losses as rotor resistance rises.
- Decreased motor efficiency
- Loss directly proportional to the reduction in speed

DELTA


A
550Ω
50Ω
R
500Ω
B


3Ω
18Ω
8Ω
A
B
6Ω
5Ω

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Questions

Q1 Value of unknown resistor R if the voltage drop across the 500 Ω resistor is 2.5 V

R = 550 Ω

Current in 500 Ω resistor = $\frac{2.5}{500} = 0.003$

50 Ω resistor has the same current

50 × 0.005 = 0.25 V across 50 Ω resistors

Across R = 0.25 + 2.5 = 2.75 V

Q-2 Calculate the effective resistance of the following combination of resistors and voltage drop across each resistor if voltage of 60 V is applied between A & B

Resistance

$\frac{1}{R} = \frac{1}{3} + \frac{1}{6} = \frac{3}{6} \Rightarrow R = 2\,\Omega$

$2\,\Omega + 18\,\Omega = 20\,\Omega$

$\frac{1}{R} = \frac{1}{20} + \frac{1}{5} = \frac{5}{20} \Rightarrow R = 4\,\Omega$

Total $\Rightarrow 4\,\Omega + 8\,\Omega = 12\,\Omega$

Total Current = $\frac{60}{12} = 5$ A at start

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