Lecture Note Electrical Drives

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Q: Discuss effect of variation in rotor resistance on induction motor performance

In a slip ring induction motor (SRIM) , a three phase variable resistor R_2 can be inserted in the rotor circuit as shown in Fig 1 . By varying the rotor circuit resistance R2 the motor torque can be controlled as shown in fig 2

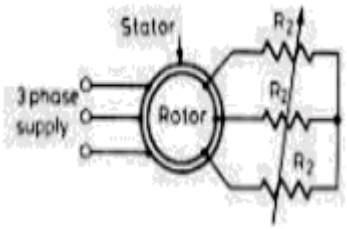


Fig.1 Wound rotor with external resistance

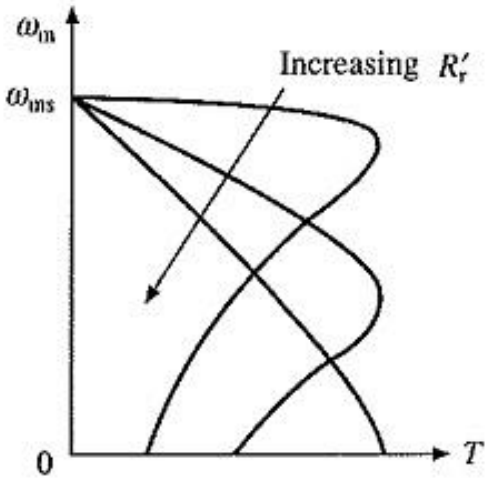


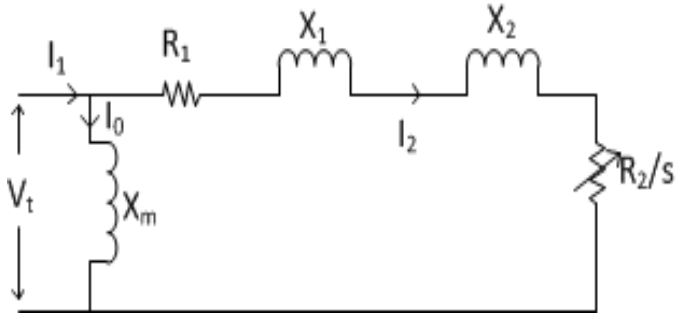
Fig. 2 Torque speed characteristics by varying rotor resistance

$$S_{\max T} = \frac{\pm R_2}{\sqrt{R_1^2 + (X_1 + X_2)^2}}$$

Maximum torque

$$T_{\max} = \frac{3}{2\omega_s} \frac{V_1^2}{R_1 \pm \sqrt{R_1^2 + (X)^2}}$$

As seen in above, by varying the rotor resistance T_{max} does not varies but slip at which maximum torques can occurs are chaged. The starting torque and starting current can also be varied by controlling the rotor circuit resistance.



Dynamics involved when we increase the rotor resistance:

As we increase the rotor resistance current in the rotor circuit decreses; and thus machine torque will reduce $T = \frac{3}{\omega_s} I_2^2 \frac{R_2}{S}$; so speed of the machine will falls ($T_m - T_L = J\frac{d\omega}{dt}$; and thus Slip 's' will increase and again Current 'I' start to increase and as a result machine torque increases to meat the load torque.

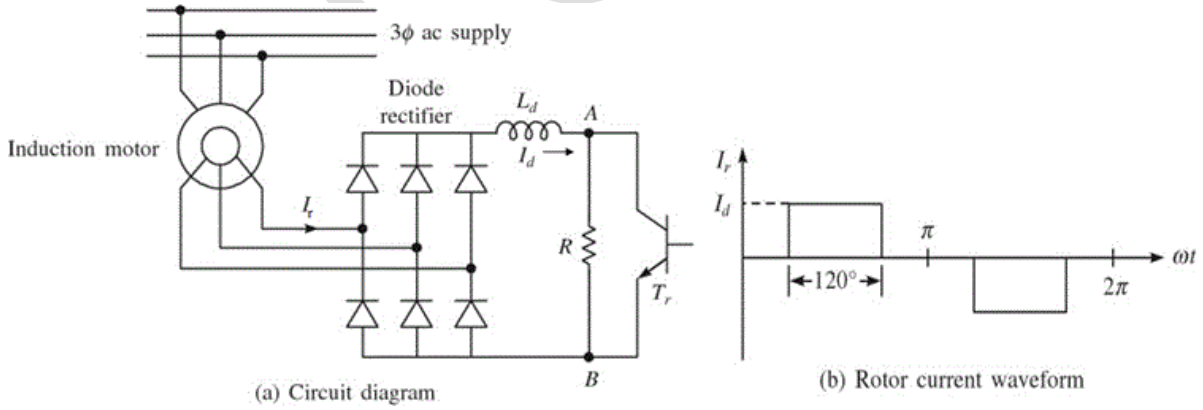
The disadvantages of this method of speed control are

- Reduced efficiency at low speeds
- Speed changes very widely with load variation
- Unbalances in voltages and currents if rotor circuit resistances are not equal.
- Speed cannot increase beyond synchronous speed

In spite of these , this method of speed control is used when speed drop is required for short time, as for example in overhead cranes, in load equalization.

Q Power Electronics way to control Rotor Resistance

The rheostat which is used to vary the resistance per phase causes unbalancing in rotor. Also, The resistances generate huge losses and generate heat in the system. In case of a large machine the size of the rheostat will be large and in such case it is not easily portable. It requires more maintenance, hence the cost associated with it is more. This method cannot be used for industrial automation purpose since we have to change manually the value of the resistance.



(a) Circuit diagram (b) Rotor current waveform

The above mentioned problems can easily be eliminated by using Pulse Width Modulation (PWM), or Pulse Duration Modulation (PDM) with the bridge rectifier and a switching transistor. Rotor resistance can also be varied steplessly using the circuit shown in figure (a). The AC output voltage of the rotor is rectified by diode bridge rectifier and fed to parallel combination of fixed resistor R and a semiconductor switching transistor Tr. Effective value of resistance across terminal A and B i.e., RAB is varied by varying duty cycle of the transistor Tr, which in turn varies the resistance of the rotor circuit.

Resistance between A and B terminal will be zero when the transistor is on and it will be R when it is off. Therefore average value of resistance between the terminals is given by

$$R_{AB} = (1 - \delta)\mathrm{R}$$

Where, δ is the duty ratio of the transistor.

Advantages of Speed Control of Induction Motor Using Static Devices

- Smooth variations of rotor resistance.
- Simplicity of operation using close loop control.
- Quick response of system.
- Rotor resistance unbalanced can be eliminated using power electronics devices.