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Hysteresis Motor

Hysteresis motor is a constant torque motor. It has two stator windings: starting and running windings. Both windings are excited by AC supply. To eliminate minor parasitic hysteresis loops, closed or semi-closed slots are used. The rotor has no windings. Rotor is made up of chrome or cobalt alloy steel. This material has high resistivity and large hysteresis loop as shown in Fig. 1 1. The resistivity is approximately equal to that of an insulator. Due to its high resistivity, the formation of eddy current is avoided. Thus, practically there is no eddy current loss in hysteresis motor. The rotor is of laminated structure. In some construction, rotor is made up of separated discs and flux is allowed to enter through the faces. This construction has better use of active material and the inertia is considerably reduced. The rotor of a typical hysteresis motor is shown in Fig. 2 . The rotor has no winding and teeth. The rotor has hysteresis ring made up of magnetic material like chrome. The ring is mounted on a cylinder of non-magnetic material like aluminium.

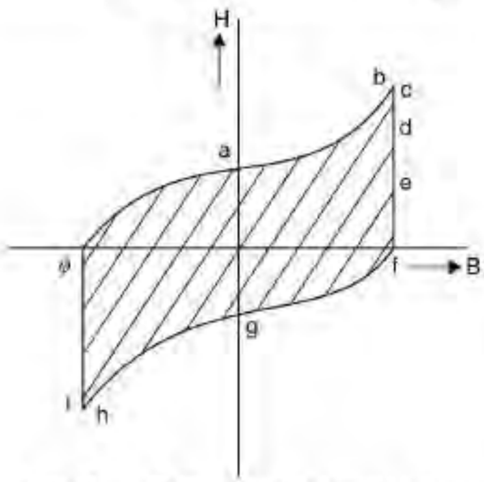

Fig. 1 B–H loop of hysteresis motor

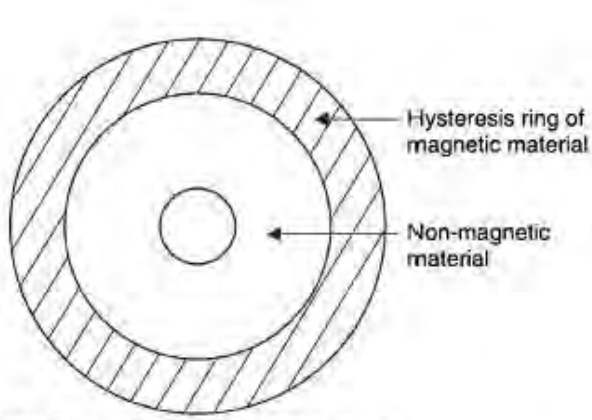

Fig. 2 Rotor of a hysteresis motor

When the stator winding is connected to single-phase AC supply, a sinusoidal magnetic field is established. The stator mmf F_s is shown in Fig. 3. This mmf produces a rotor flux density B_r which is distributed as shown in Fig. 3. F_s and B_r are displaced by angle δ. This mmf and flux density produce a torque and rotor moves. It may be noted that there is no rotor current. The torque depends on angle δ, and up to synchronous speed, it is independent of speed. In Fig. 3, the points marked correspond to points in Fig. 1.

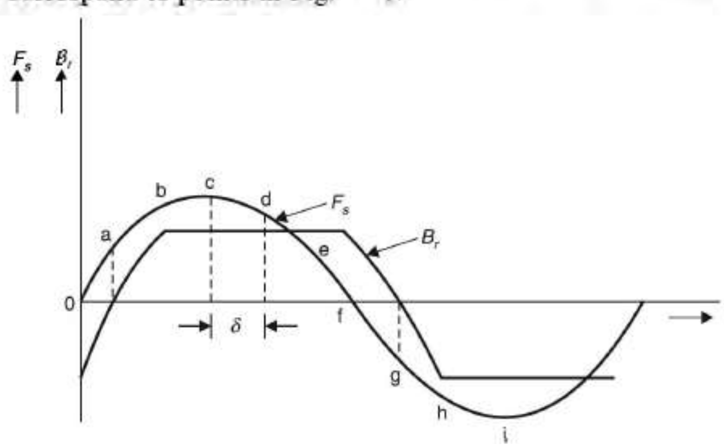

Fig. 3 MMF and flux density wave forms of hysteresis motor

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The torque developed is given by

$$T = \frac{k_h f \ B_r^{1.6}}{\omega_s}$$

where

k_h = hysteresis coefficient
f = frequency of supply
B_r = flux density (maximum)
ω_s = synchronous speed

As all these values are constants for a given frequency and flux density, T is a constant.

The torque–speed characteristics of hysteresis motor are shown in Fig. :4. For comparison, the torque–speed characteristics of a single-phase induction motor of same rating are also shown.

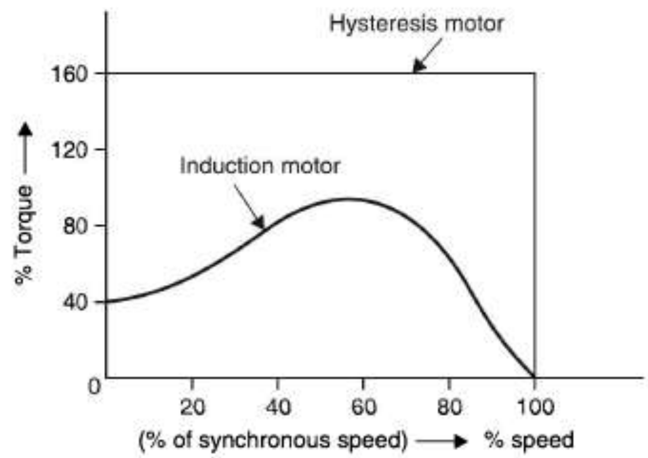

Fig. 4 Torque–speed characteristics of hysteresis motor

Thus, a hysteresis motor has the following unique features:

(i) As the motor has constant torque from zero to synchronous speed, it can synchronise to any load and can be accelerated with load.
(ii) As the rotor is smooth, it operates quietly and has no magnetic pulsation.
(iii) Free from mechanical and magnetic vibrations.

The major applications of hysteresis motor are in electric clocks and other precise timing devices. It is used to drive tapedecks, turntables and other precision audio equipment. The constant speed operation and the low inertia of the hysteresis motor make them very popular in applications where fast synchronism is essential. Vibration-free operation is another favourable property of hysteresis motor for its use in turntable audio equipments.

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Example:

A 50 Hz, 32-pole hysteresis motor needs 0.8 J to complete one revolution. Find (a) pull-in and pull-out torque, (b) maximum output power before stalling, (c) rotor losses when the motor stalls and (d) rotor loss when it runs at synchronous speed.

Solution

Given:

Number of poles, $P = 32$

Frequency, $f = 50$ Hz

Power input = 0.8 J

(a) In hysteresis motor, the hysteresis loss in the rotor is used for rotation. The pull-in and pull-out torques are equal for hysteresis motor.

$$\therefore \quad \text{Pull-in torque} = \text{Pull-out torque} = \frac{0.8}{2\pi} = 0.127 \text{ N-m}$$

(b) Synchronous speed,

$$N_s = \frac{120f}{P} = \frac{120 \times 50}{32} = 187.5 \text{ rpm}$$

$$\text{Maximum power} = \frac{187.5 \times 0.127}{9.55} = 2.493 \text{ W}$$

(c) When the motor stalls, the power losses in the rotor is

$$= \frac{187.5 \times 0.8}{60} = 2.5 \text{ W}$$

(d) At synchronous speed rotor loss is zero.