Introduction to Electrical Circuits

Final Term
Lecture – 11

Reference Book:

[1] A Textbook of Electrical Technology , Volume- II, - B.L. Theraja, A.K. Theraja

[2] Principles of Electrical Machines -V.K. Mehta, Rohit Mehta

CONTENT

Week No.	Class No.	Chapter No.	Article No., Name and Contents
W13	FC11		**Introduction to Universal Motor, Servo Motor, Permanent-magnet Synchronous motor:** Basic principles, characteristics curve, application, limitations of a universal motor, Mathematical explanation (36.4, 36.5), purpose of governor, servo motor control system, different types of magnet

Universal Motor

- A universal motor is defined as a motor which may be operated either on direct or single-phase a.c. supply at approximately the same speed and output. In fact, it is a smaller version (5 to 150 W) of the a.c. series motor.

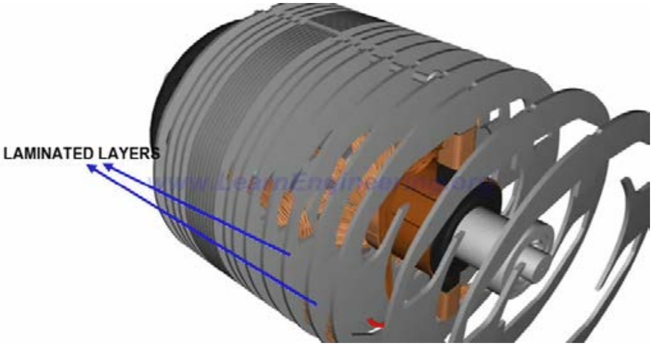
- Being a series-wound motor, it has high starting torque and a variable speed characteristic. It runs at dangerously high speed on no-load. That is why such motors are usually built into the device they drive.

- Generally, universal motors are manufactured in two types:

1. concentrated-pole, non-compensated type (low power rating)
2. distributed-field compensated type (high power rating)

They are commonly used in portable power tools and equipment, as well as many household appliances.

Universal motor.



Operation of Universal Motor

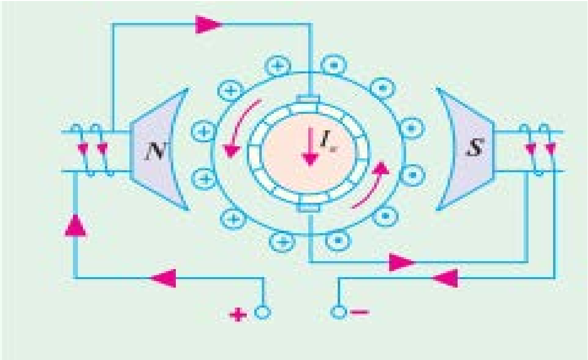


Fig. 1

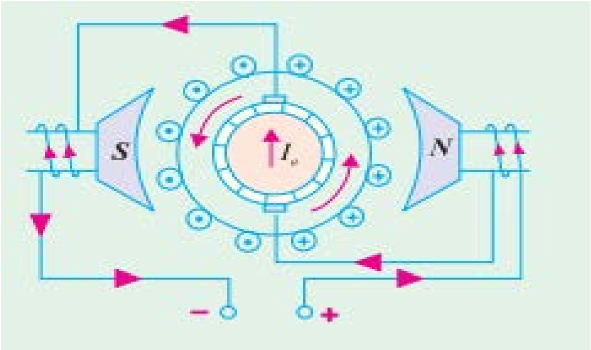
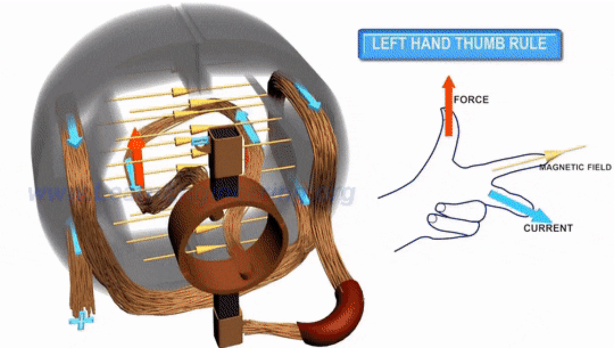


Fig. 2

- Such motors develop unidirectional torque, regardless of whether they operate on d.c. or a.c. supply.
- The production of unidirectional torque, when the motor runs on a.c. supply can be easily understood from Fig. 1.
- The motor works on the same principle as a d.c. motor i.e. force between the main pole flux and the current-carrying armature conductors.
- This is true regardless of whether the current is alternating or direct (Fig. 2).



Characteristic Curve

- The speed of a universal motor varies just like that of a d.c. series motor *i.e*. low at full-load and high on no-load (about 20,000 r.p.m. in some cases).
- In fact, on no-load the speed is limited only by its own friction and windage load.
- Fig. 3 shows typical torque characteristics of a universal motor both for d.c. and a.c. supply.
- Usually, gear trains are used to reduce the actual load speeds to proper values.

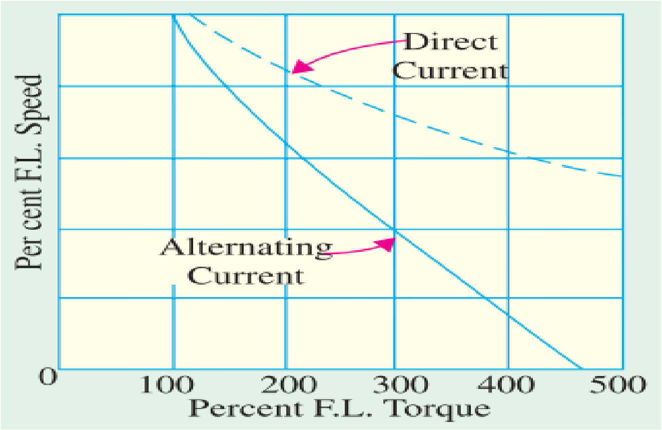


Figure 3

Limitation of Universal Motor

No piece of equipment is perfect and universal electric motors are no exception. There are a couple downsides to having the unique versatility and high-speed power of universal motors. Which are:

- They are not meant to run continuously.

- In addition, they tend to have shorter lifespans due to problems with the commutator along with EMI issues. If the motors are used intermittently, less maintenance will have to be done thus pushing out the life span of the motor.

- The last downside to universal electric motors is that they are typically noisy. Although they are noisy, they make up for it in their compact size and flexibility.

Example 36.4. *A 250-W, single-phase, 50-Hz, 220-V universal motor runs at 2000 rpm and takes 1.0 A when supplied from a 220-V dc. supply. If the motor is connected to 220-V ac supply and takes 1.0 A (r.m.s), calculate the speed, torque and power factor. Assume $R_a = 20\,\Omega$ and $L_a = 0.4$ H.*

Solution. DC Operation : $E_{b.dc} = V - I_a R_a$

$$= 220 - 20 \times 1 = 200 \text{ V}$$

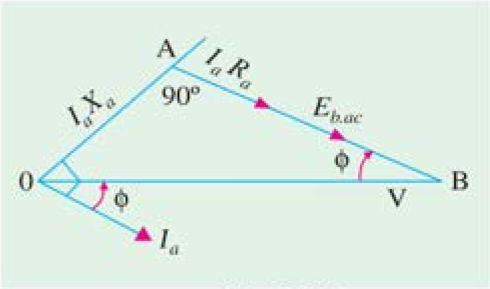


Fig. 36.53

AC Operation

$$X_a = 2\pi \times 50 \times 0.4 = 125.7\,\Omega.$$

As seen from Fig.36.53.

$$V^2 = (E_{b.ac} + I_a R_a)^2 + (I_a \times X_a)^2$$

$$\therefore \quad E_{b.ac} = -I_a R_a + \sqrt{V^2 - (I_a X_a)^2}$$

$$= -1 \times 20 + \sqrt{220^2 - (125.7 \times 1)^2} = 160.5 \text{ V}$$

Since armature current is the same for both dc and ac excitations, hence

$$\frac{E_{b.dc}}{E_{b.ac}} = \frac{N_{dc}}{N_{ac}}; \qquad \therefore \quad N_{ac} = 2000 \times \frac{160.5}{200} = 1605 \text{ rpm}$$

$$\cos\phi = AB/OB = (E_{b.ac} + I_a R_a)/V = (160.5 + 20)/220 = 0.82 \text{ lag}$$

$$P_{mech} = E_{b.ac} \,.\, I_a = 160.5 \times 1 = 160.5 \text{ W}$$

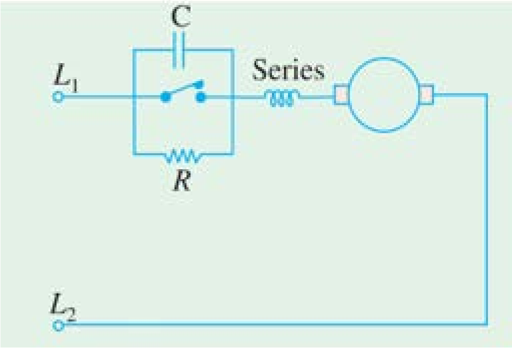
$$T = 9.55 \times 160.5/1605 = \mathbf{0.955\ N\text{-}m}$$

Purpose of Governor

A **governor**, or speed limiter or controller, is a device used to measure and regulate the speed of a machine.

- Universal motors, particularly those used for home food and drink mixers, have a number of speeds.
- Selection is made by a centrifugal device located inside the motor and connected.
- The switch is adjustable by means of an external lever.
- If the motor speed rises above that set by the lever, the centrifugal device opens two contacts and inserts resistance *R* in the circuit, which causes the motor speed to decrease.
- When motor runs slow, the two contacts close and short-circuit the resistance, so that the motor speed rises.
- This process is repeated so rapidly that variations in speed are not noticeable.

The resistance R and capacitor C is used across the contact points in order to reduce sparking produced due to the opening and closing of these points. Moreover, it prevents the pitting of contacts.



Servomotors and its Control System

- They are also called control motors and have high-torque capabilities.
- Unlike large industrial motors, they are not used for continuous energy conversion but only for precise speed and precise position control at high torques.
- Their power ratings vary from a fraction of a watt upto a few 100 W.
- Due to their low-inertia, they have high speed of response.
- That is why they are smaller in diameter but longer in length.
- They generally operate at vary low speeds or sometimes zero speed.
- They find wide applications in radar, tracking and guidance systems, process controllers, computers and machine tools.
- Both DC and AC (2-phase and 3-phase) servomotors are used at present.

Fig. 4. DC servo motor

- ✓ Servo motors work on servo mechanism that uses position feedback to control the speed and final position of the motor.
- ✓ Internally, a servo motor combines a motor, feedback circuit, controller and other electronic circuit.
- ✓ It uses encoder or speed sensor to provide speed feedback and position.
- ✓ This feedback signal is compared with input command position (desired position of the motor corresponding to a load) and produces the error signal (if there exist a difference between them).
- ✓ The error signal available at the output of error detector is not enough to drive the motor.
- ✓ So the error detector followed by a servo amplifier raises the voltage and power level of the error signal and then turns the shaft of the motor to desired position.

Magnets

- Permanent Magnets
- Temporary Magnets
- Electromagnets
- Rare earth magnets(Neodymium Iron Boron and the Samarium Cobalt magnets)

https://www.coolmagnetman.com/magtypes.htm


THE END