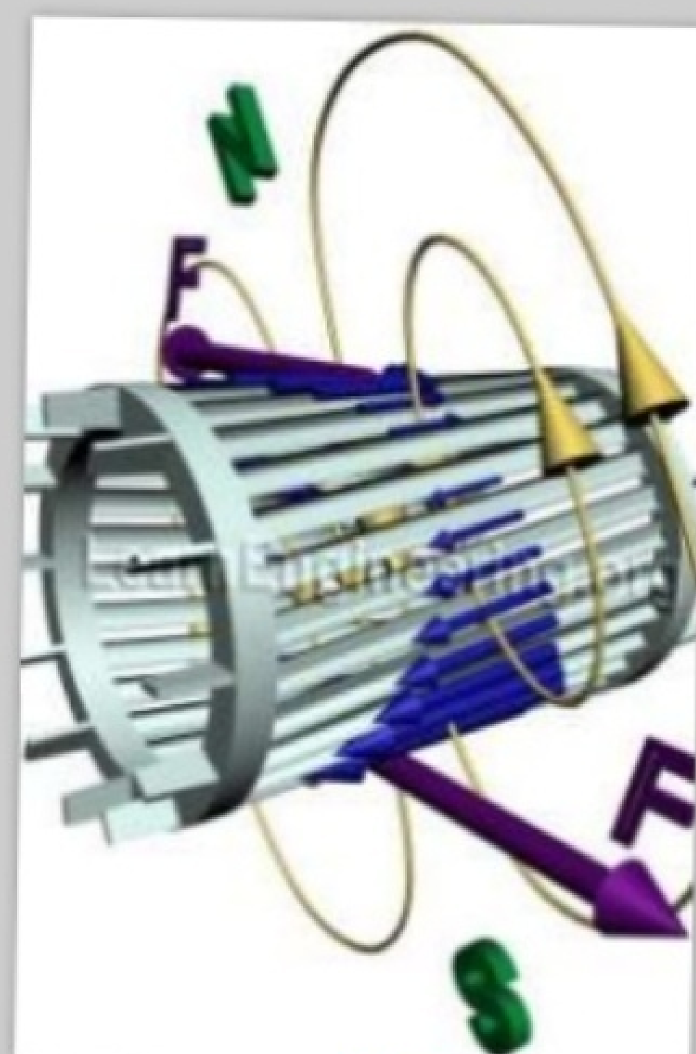
RMF produces a torque on rotor as in the simple winding case.



Poles and speed

- Every ac induction motor has poles, just like a magnet. However, unlike a simple magnet, these poles are formed by bundles of magnet wire (windings) wound together in slots of the stator core.In most cases, you can look inside the motor and count the number of poles in the winding; they are distinct bundles of wire evenly spaced around the stator core.

- The number of poles, combined with the ac line frequency (Hertz, Hz), are all that determine the no-load revolutions per minute (rpm) of the motor. So, all four-pole motors will run at the same speed under no-load conditions, all six-pole motors will run at the same speed, and so on.

- The mathematical formula to remember in helping make this calculation is the number of cycles (Hz) times 60 (for seconds in a minute) times two (for the positive and negative pulses in the cycle) divided by the number of poles.

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- *Therefore, for a 60-Hz system, the formula would be:*
  60 x 60 x 2 = 7,200 no-load rpm Ã· number of poles.
- *For a 50-Hz system, the formula would be:*
  50 x 60 x 2 = 6,000 no-load rpm Ã· number of poles.
- Using this formula, you can see that a four-pole motor operating on the bench under no-load conditions runs at 1,800 rpm (7,200 Ã· 4 poles). Note that when an ac motor is loaded, the spinning magnetic field in the stator does not change speed. Instead, the rotor or moving part of the motor is restrained by the load from “catching up” to the field speed.
- The difference between the field speed of 1,800 rpm in this example and the rotor speed of approximately 1,725 rpm is called the “slip.” Slip varies with the load over a narrow operating range for each motor design.

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- Motor Speeds, Both Loaded and Unloaded
- Our spinning **four-pole motor**, then, operates at 1,800 rpm in this example under no-load conditions and approximately 1,725 rpm under load. Motors of this speed are commonly found in belted applications such as blowers, fans, air-handling equipment, compressors, and some conveyors .**A two-pole motor** operates at 3,600 rpm (7,200 rpm Ã · 2) unloaded, and approximately 3,450 under load. Two-pole motors often are found in pump applications, such as sump pumps, swimming pool pumps, and water re circulating equipment.
- One thing for the service technician to keep in mind in the field is that the higher the rpm, the noisier a motor may sound to the untrained ear. It is beneficial to become aware of the different speed-related sounds motors make. 16
- found in ceiling fans.

- **Six-pole motors** run at 1,200 rpm unloaded (7,200 Ã·6) and between 1,050 and 1,175 rpm loaded. They are often used for air-handling equipment, direct-drive applications, window fans, furnace blowers, room air conditioners, heat pumps, and other equipment where the relatively slower motor speed makes for quieter operation. All can come in either totally open, totally enclosed, or combination models, adding to their versatility.
- To satisfy consumers' desires for quieter motors, manufacturers have developed **eight-pole motors**. These operate at 900 rpm (unloaded) and approximately 800 rpm under load. They are being used in applications where customers expect quieter operation, such as room air conditioners and outdoor heat pump applications.
- Less-common pole configurations include **12-pole motors** (600 rpm) that are used in applications requiring slow speeds, such as washing machines, and **16-pole motors** (450 rpm unloaded), often found in

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electricity is induced in rotor by magnetic induction rather than direct electric connection , That's why the name *induction motor* is used.

To aid such electromagnetic induction, insulated iron core lamina are packed inside the rotor.

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The Speed of Rotation of a Rotor

- Both the magnetic field and rotor are rotating.
- To find the speed of the rotor let's consider different cases.

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- Consider a case where the rotor speed is same as the magnetic field speed.

- Since both the magnetic field and the rotor are rotating at same speed, relative to the rotor, the magnetic field is stationary.

- The rotor will experience a constant magnetic field, so there won't be any induced e.m.f and current. This means zero force on the rotor bars, so the rotor will gradually slow down.

- But as it slows down, the rotor loops will experience a varying magnetic field, so induced current and force will rise again and the rotor will speed up.

- In short, the rotor will never be able to catch up with the speed of the magnetic field. It rotates at a specific speed which is slightly less than synchronous speed.

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Slip

- The difference between the flux (N_s) and the rotor speed (N) is called slip.

- % Slip = $(N_s - N) \times 100$

- Slip speed = $N_s - N$

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Energy Transfer in the Motor

- In an induction motor, electrical energy is enters via the Stator and output from the rotor, the mechanical rotation is received from the rotor.
- But between the power input and output, there will be numerous energy losses associated with the motor. Various components of these losses are friction loss, copper loss, eddy current and hysteresis loss.
- Such energy loss during the motor operation is dissipated as heat, so a fan at the other end helps in cooling down the motor.


A cooling fan is used to remove heat liberated by motor
COOLNG FAN
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SPEED CONTROL OF AN INDUCTION MOTOR

- The speed of an induction motor can be easily controlled by varying the frequency of the 3-phase supply.
- To maintain a constant (rated) flux density, the applied voltage must also be changed in the same proportion as the frequency (as dictated by Faraday's law).
- This speed control method is known as Volts per Hz.
- Above rated speed, the applied voltage is usually kept constant at rated value; this operation is referred to as constant HP. At low frequencies (i.e. speeds), the voltage must be boosted in order to compensate for the effects of the stator resistance.

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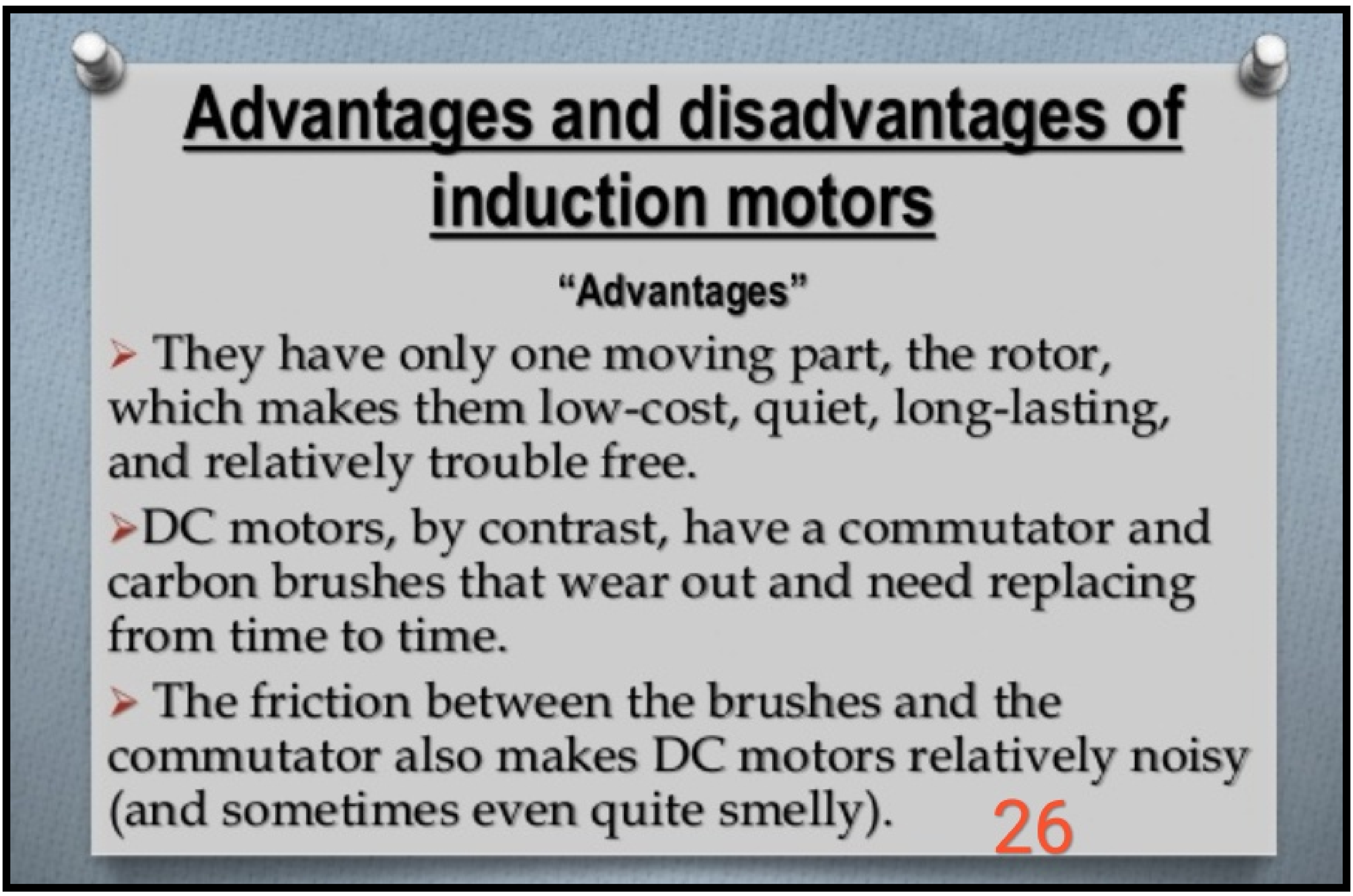
Advantages and disadvantages of induction motors
"Advantages"
➢ They have only one moving part, the rotor, which makes them low-cost, quiet, long-lasting, and relatively trouble free.
➢DC motors, by contrast, have a commutator and carbon brushes that wear out and need replacing from time to time.
➢ The friction between the brushes and the commutator also makes DC motors relatively noisy (and sometimes even quite smelly).
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“Disadvantages”

- Since the speed of an induction motor depends on the frequency of the alternating current that drives it, it turns at a constant speed unless you use a variable-frequency drive.
- the speed of DC motors is much easier to control simply by turning the supply voltage up or down.
- Induction motors can be fairly heavy because of their coil windings.
- Unlike DC motors, they can't be driven from batteries or any other source of DC power without using an inverter. That's because they need a changing magnetic field to turn the rotor.

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