AC Induction Motors

- Simplest and most rugged electric motor
- Consists of _____ and _____
- AC in the primary member (stator) produces a _____ field
- The magnetic field induces _____ in the secondary member (rotor) $\Rightarrow$ another _____
- Combined fields produce the force (torque) to create rotation.

AC Induction Motors

- Rotors typically consist of a laminated, cylindrical iron core with slots for receiving the conductors.
- Common type of rotor has cast-aluminum conductors and short-circuiting end rings.

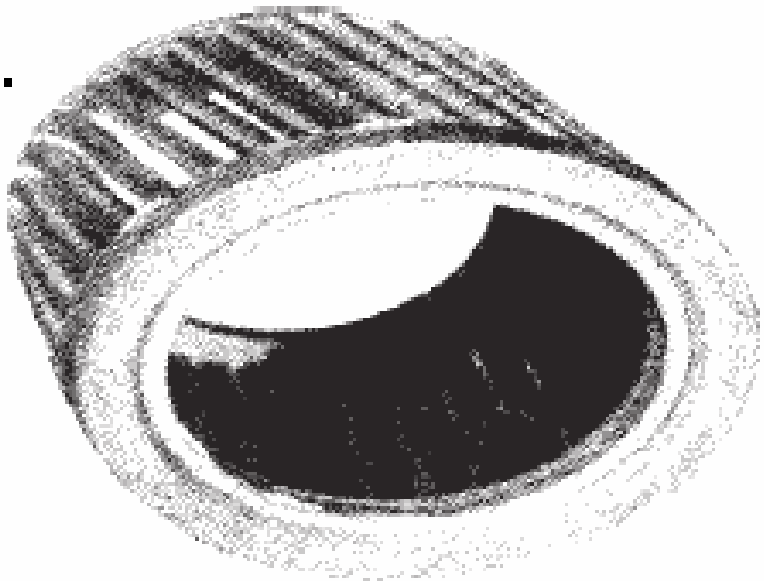
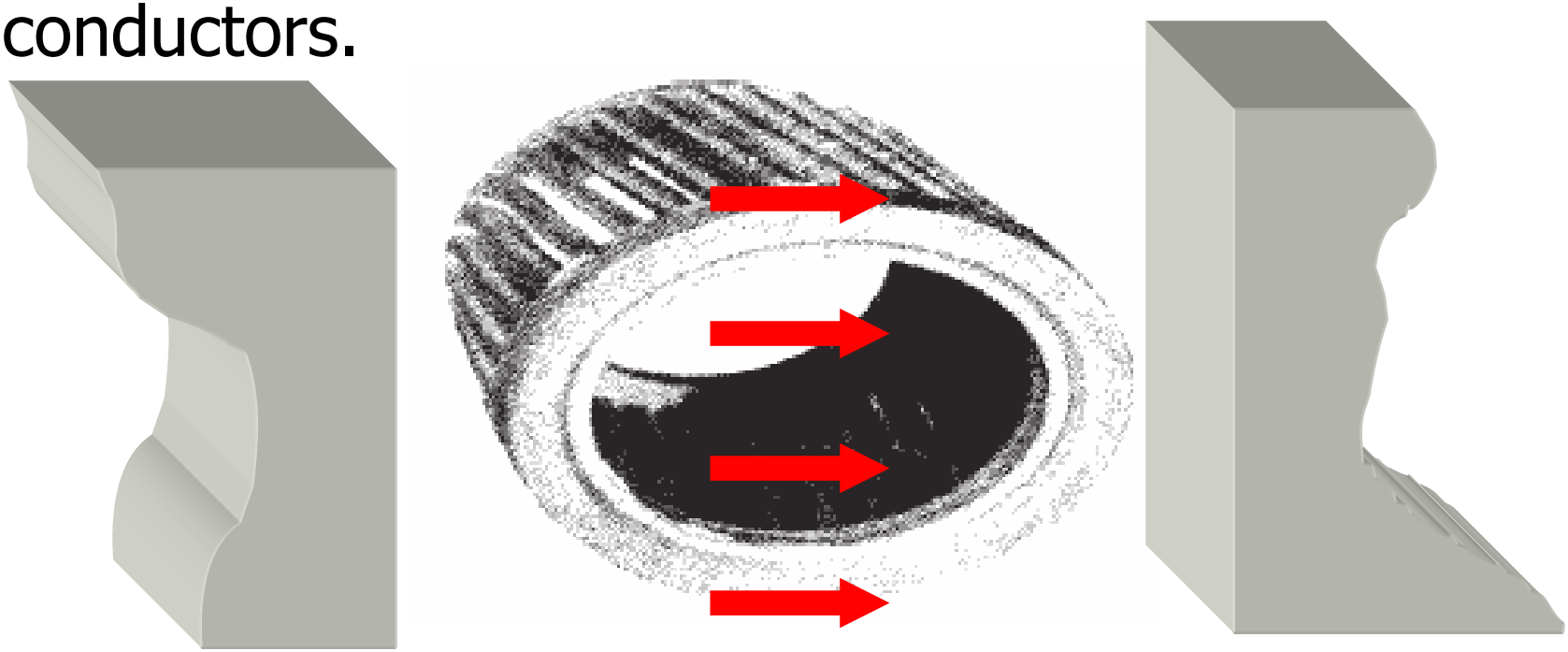


Fig. 2-8: Aluminum conductors in an AC induction rotor. The steel laminations have been removed to illustrate the "squirrel cage" form of the cast aluminum conductors.

AC Induction Motors

- The "squirrel cage" rotates when the moving magnetic field induces a current in the shorted conductors.



AC Motor Speed

- The magnetic field rotates at the _____ speed of the motor
- Determined by the number of _____ in the stator and the frequency of the AC power

n_s = synchronous speed (in RPM),

f = frequency (in Hz), and

p = the number of poles

AC Motor Speed

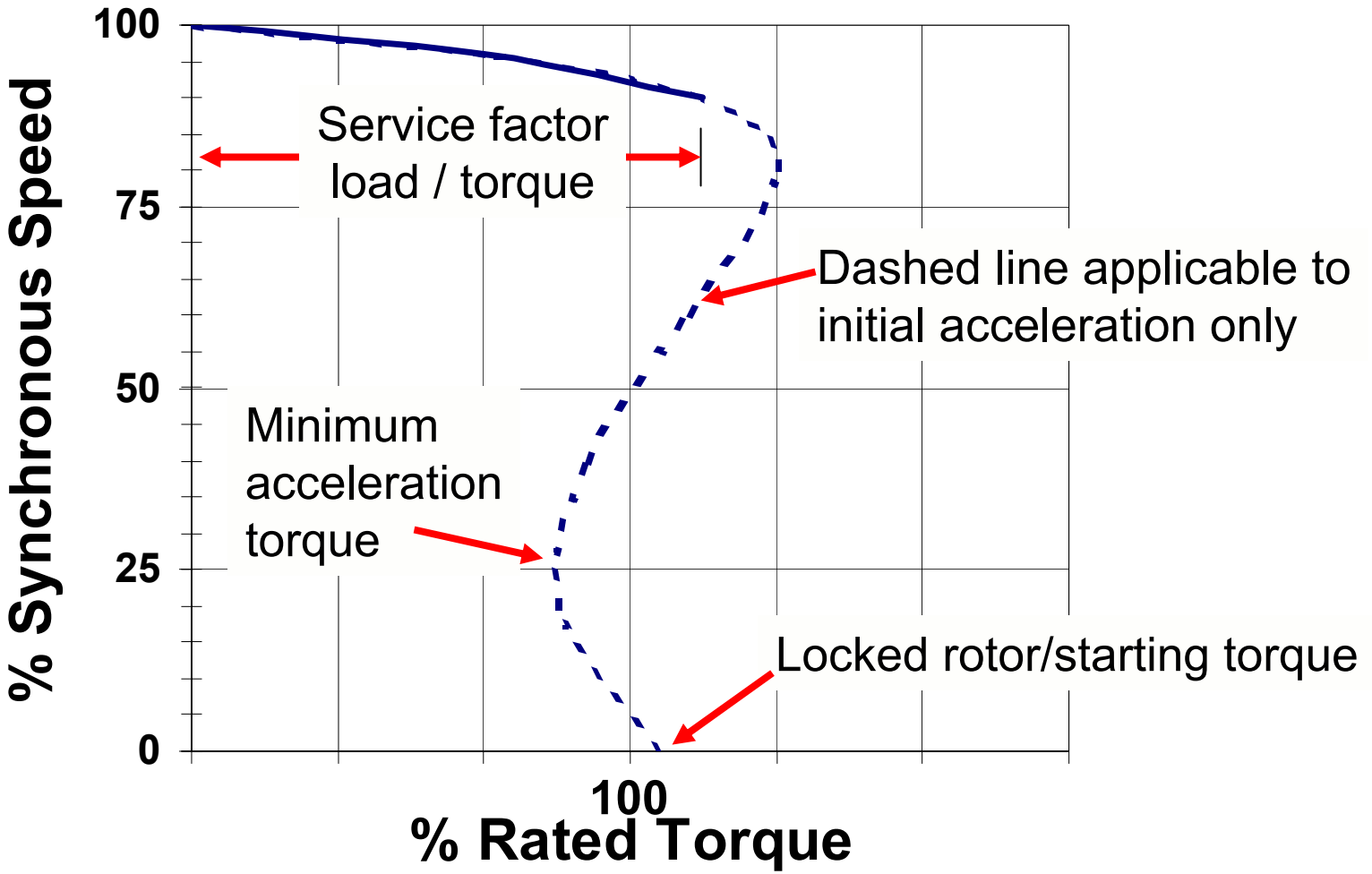
- Synchronous speed is the absolute upper limit of motor speed.
- When running, the rotor always rotates _____ than the magnetic field (or no torque!)
- The speed difference, or ____, is normally referred to as a % of synchronous speed:

s = slip (in %),

n_s = synchronous speed

n_a = actual speed

AC Motor - Speed vs. Torque

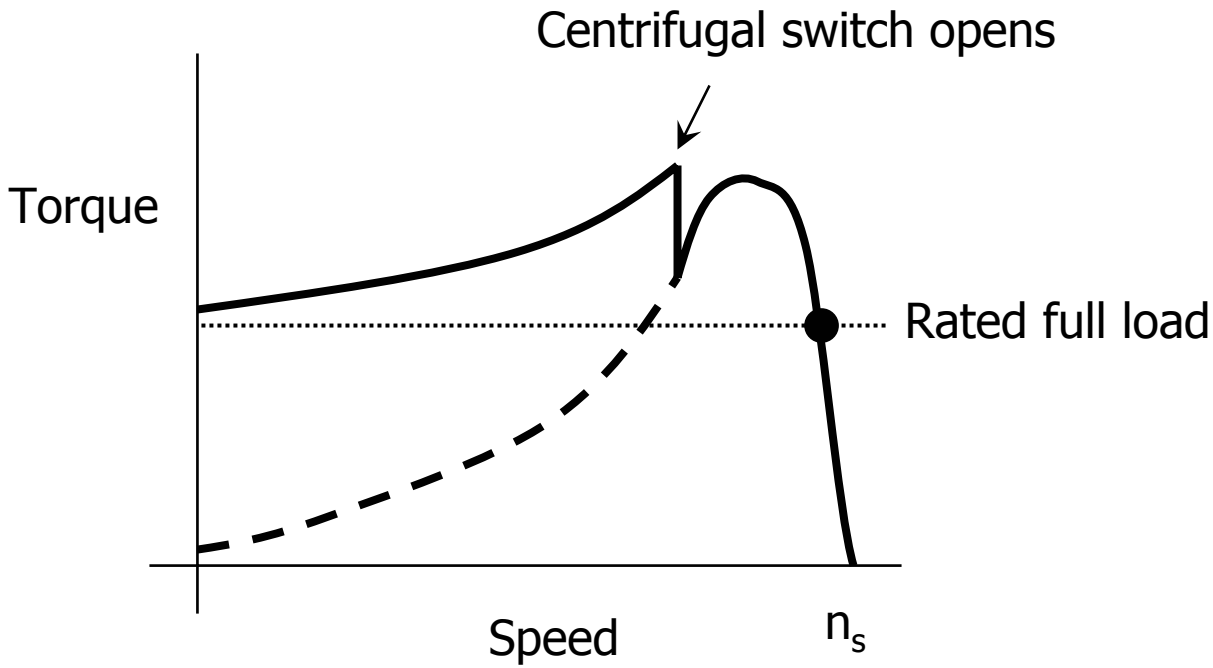


Single-phase AC Motors

- Single phase AC motors require a "trick" to generate a 2nd "phase" to develop starting torque
- Three common methods:
  - split-phase (auxiliary winding is rotated 90°)
  - capacitor
  - shaded-pole

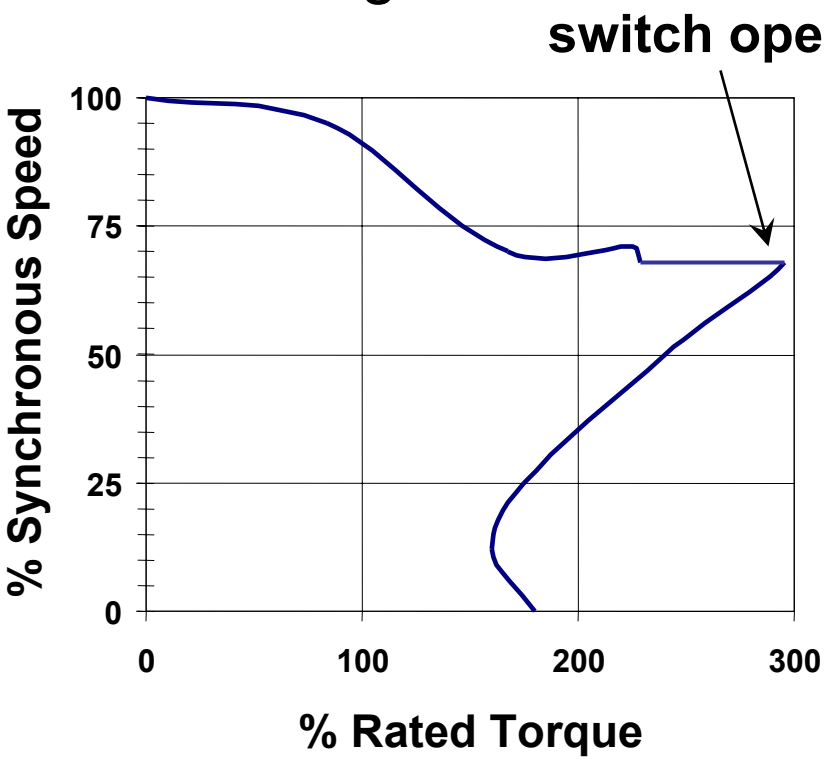
Split-Phase AC Motor

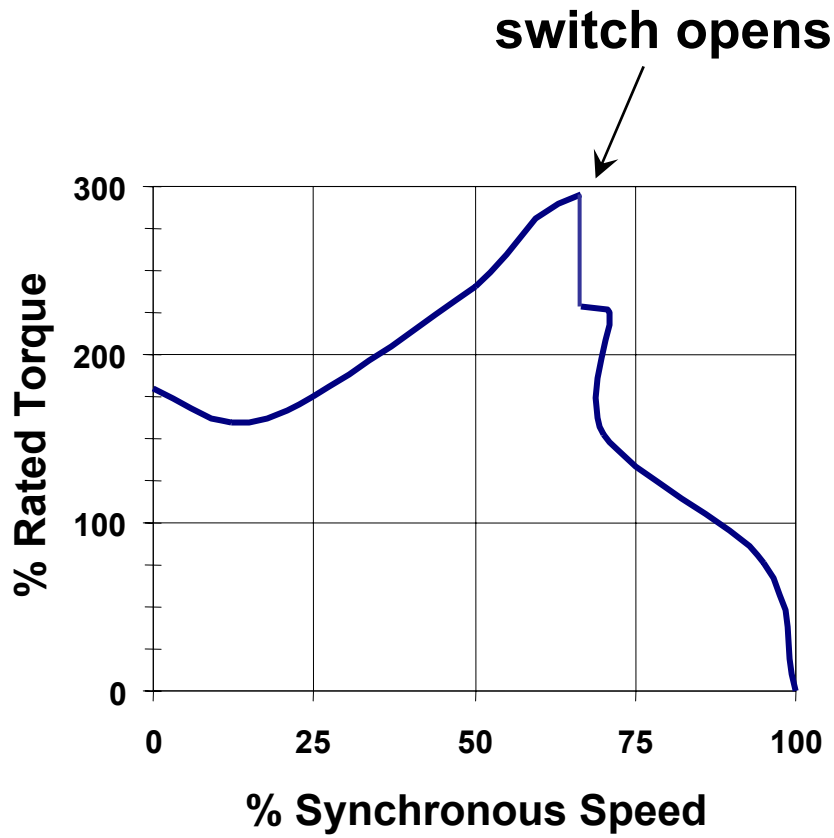
- Motor starts with both main and auxiliary winding
- A centrifugal switch opens and removes the auxiliary winding



Split-Phase AC Motor

Motor starts with both main and auxiliary winding
A centrifugal switch opens and removes the aux winding





Split-Phase AC Motor

Advantages

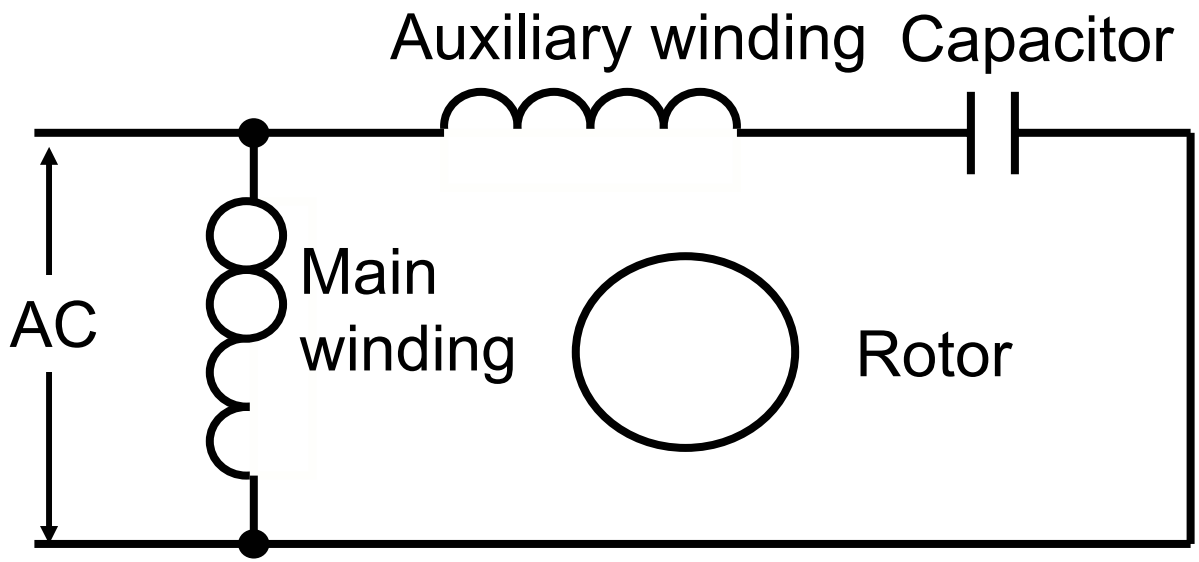
- Operate at ~ constant speed, 4 pole, 60 Hz:
  - 1780 RPM (no load)
  - 1700/1725 RPM at full load
- Reversible at low speed
- Rapid acceleration
- Relatively low cost

Disadvantages

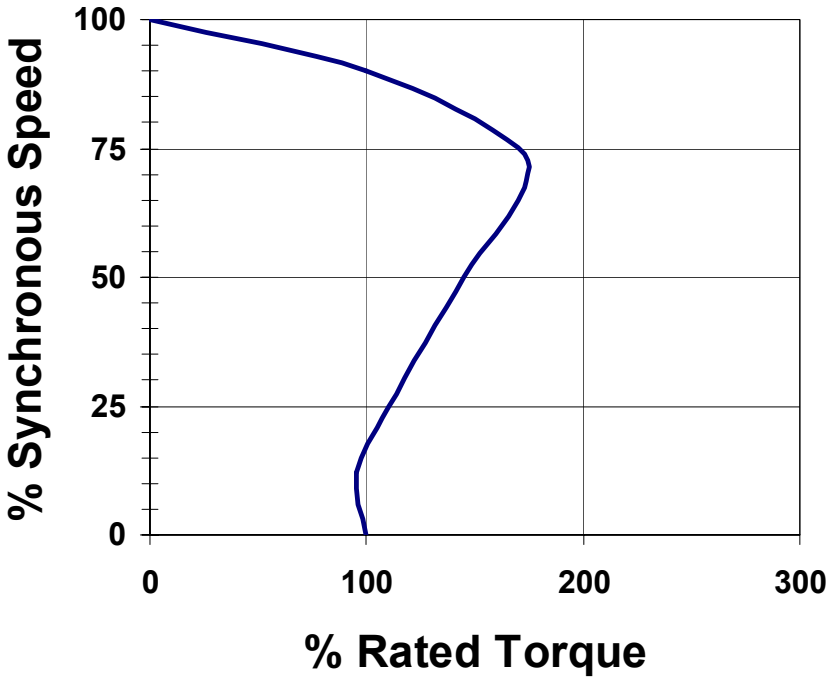
- Repeated start/stop cycles heat the windings (high start resistance)
- Less useful for large inertial loads
- Requires large wiring to handle starting currents

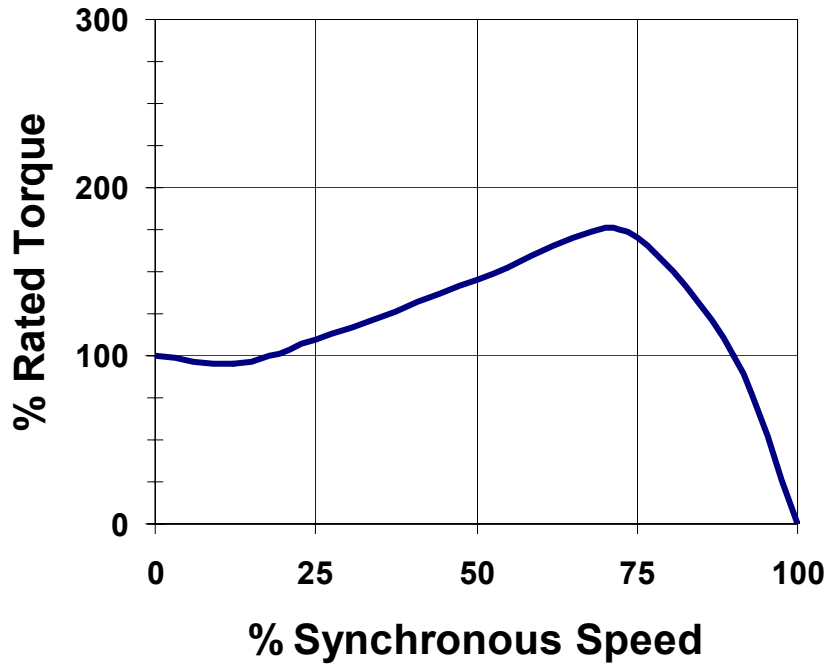
Single-Phase Capacitor Motors

- Permanent split capacitor (PSC)
- Capacitor-start (later switched out)
- Start-capacitor, run-capacitor (switched)



Permanent Split Capacitor (PSC)





Permanent Split Capacitor (PSC)

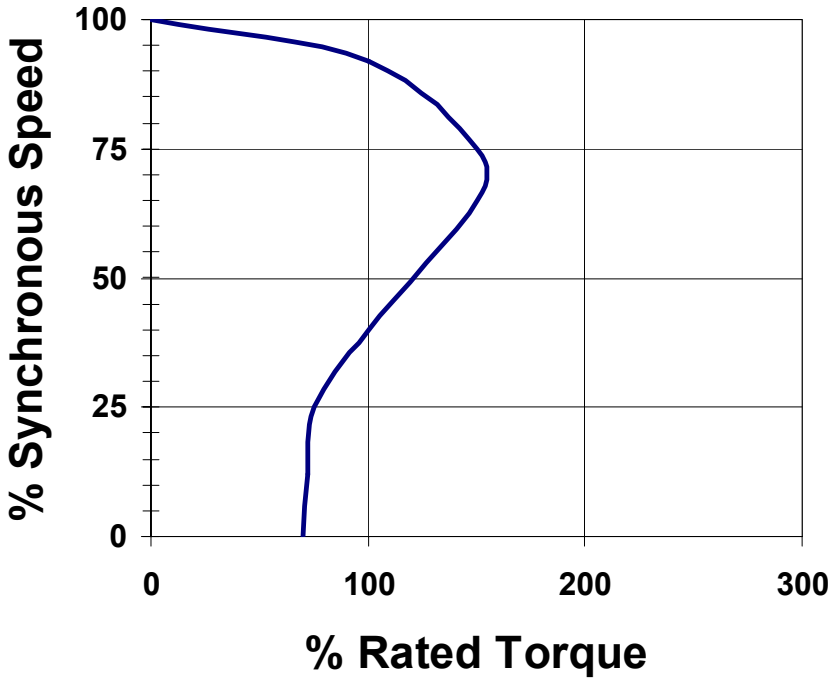
Advantages

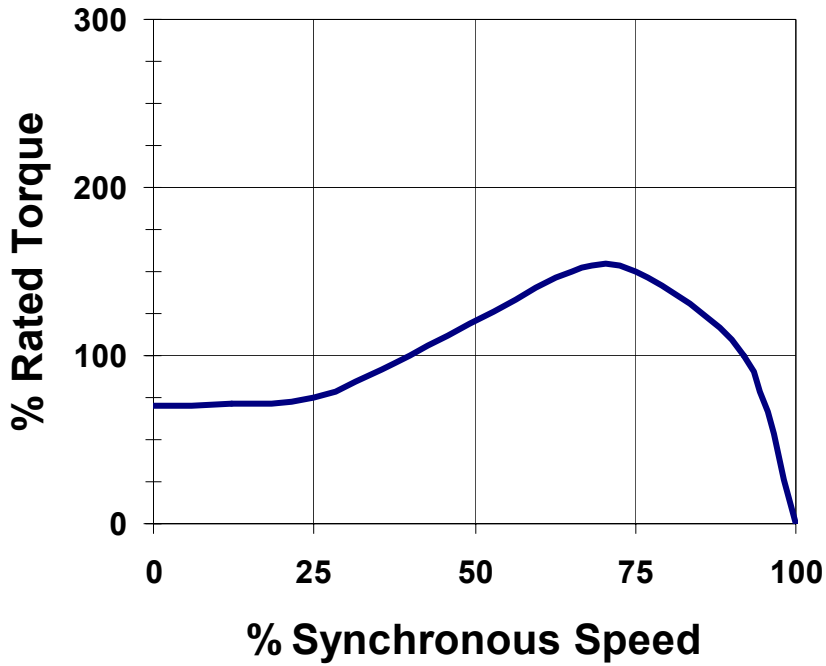
- Quieter, smoother than split phase
- Reduced starting current
  - Longer life
  - Higher reliability
- Capable of frequent start/stop cycles

Disadvantages

- More expensive for same HP
- Lower performance when starting
- Need to always use manufacturer's desired capacitor value

Shaded Pole AC Motor





Shaded Pole AC Motor

Advantages

- Simple in design and construction
- Suitable for low cost, high volume app's
- Relatively quiet and free from vibration
- "Fail safe" design - starts in only 1 direction

Disadvantages

- Low starting and running torque
- Low efficiency
- Available in sub-fractional to ~ 1/4 hp sizes

NEMA - National Electrical Manufacturers Association

NEMA is responsible for several electric motor industry "standards"

- Motor ratings (1/4 hp, 1/2 hp, 1 hp, etc.)
- Frame size
  - diameter, length, shaft size, etc.
- Service factors
- Housing/protection types and ratings

Service Factors

- A multiplier applied to the rated horsepower
- Indicate how much the motor can be overloaded without overheating
- Generally used for
  - handling a known, occasional overload
  - provide a factor of safety where environment or service condition is not well known

Motor Enclosures

- DP - dripproof
- DPFG - dripproof, fully guarded
- SP - splashproof
- FV - forced ventilation (separate/attached fan)
- TENV - totally enclosed, non-ventilated
- TEFC - totally enclosed, fan cooled
- TEUC - totally enclosed, unit cooled (heat-X)

AC Motor Efficiency

- Efficiency, η = _____
- Small universal motors have $\eta \sim$ ____
- Large 3-phase motors have $\eta \sim$ ____
- Depends on actual motor load vs. rated load
  - efficiency best near rated load
  - efficiency drops rapidly for both under- and over-load conditions