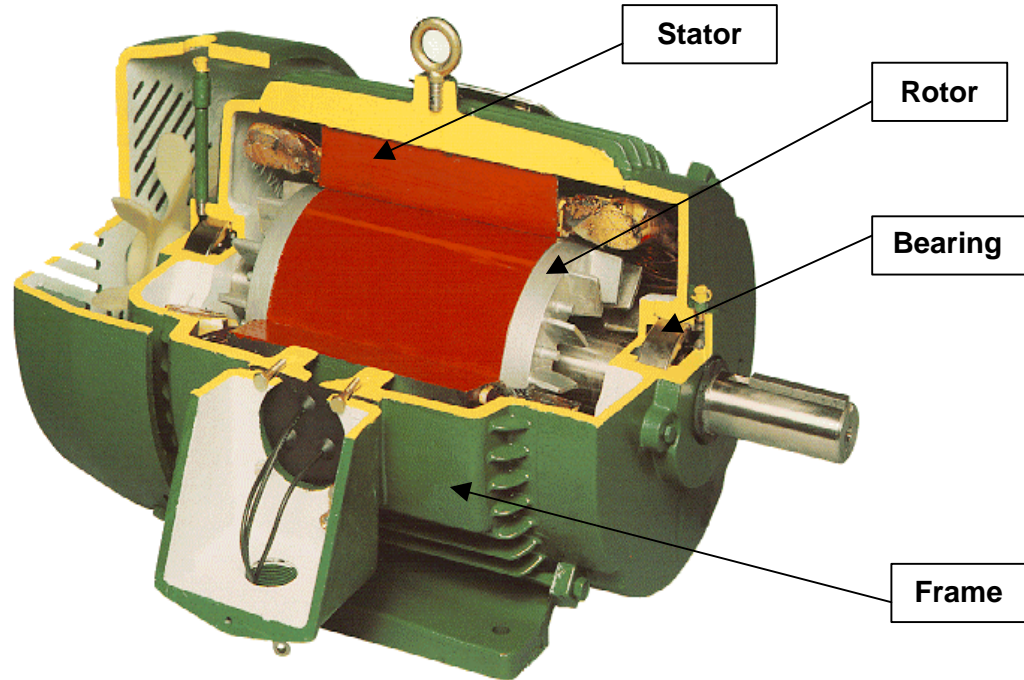


## Basic Squirrel Cage Induction Motor (SCIM) Overview

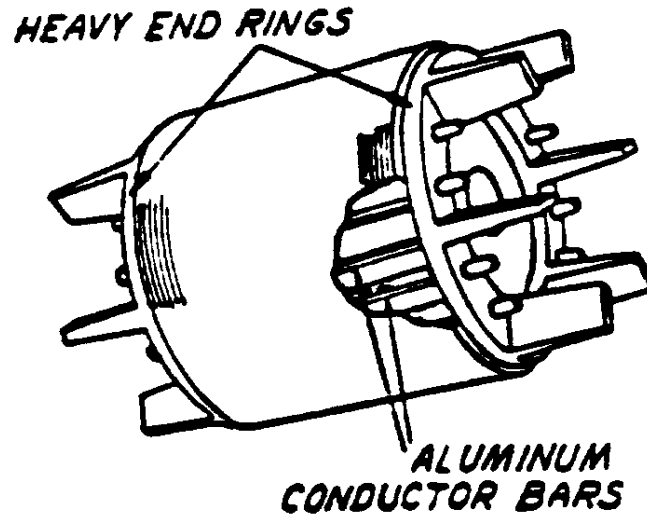
- A Squirrel Cage Induction Motor is the most common 3 phase motor found in a mill or plant. It is both rugged and simple in design, making it both economical and reliable.
- The SCIM has 2 basic components, a stator (the stationary component) and a rotor (the rotating element). In addition, a motor has bearings that allow the rotor to freely rotate plus a frame to hold everything in place.



**Motor Cutaway showing Rotor, Stator, Bearings and Frame.**

- The Stator consists of a core of thin, insulated laminations made of silicon steel. These laminations are stacked and compressed and held in place by either banding or welding beads along the length of the stack. The Stator has slots into which copper wire is inserted. Leads are connected to the windings and brought out to a junction box to connect to three-phase power.
- The Stator produces a rotating magnetic field. The speed of rotation of this magnetic field is a function of the number of poles where:  
$$\text{RPM} = (120 \times \text{Hz}) \div \text{Number of Poles}$$

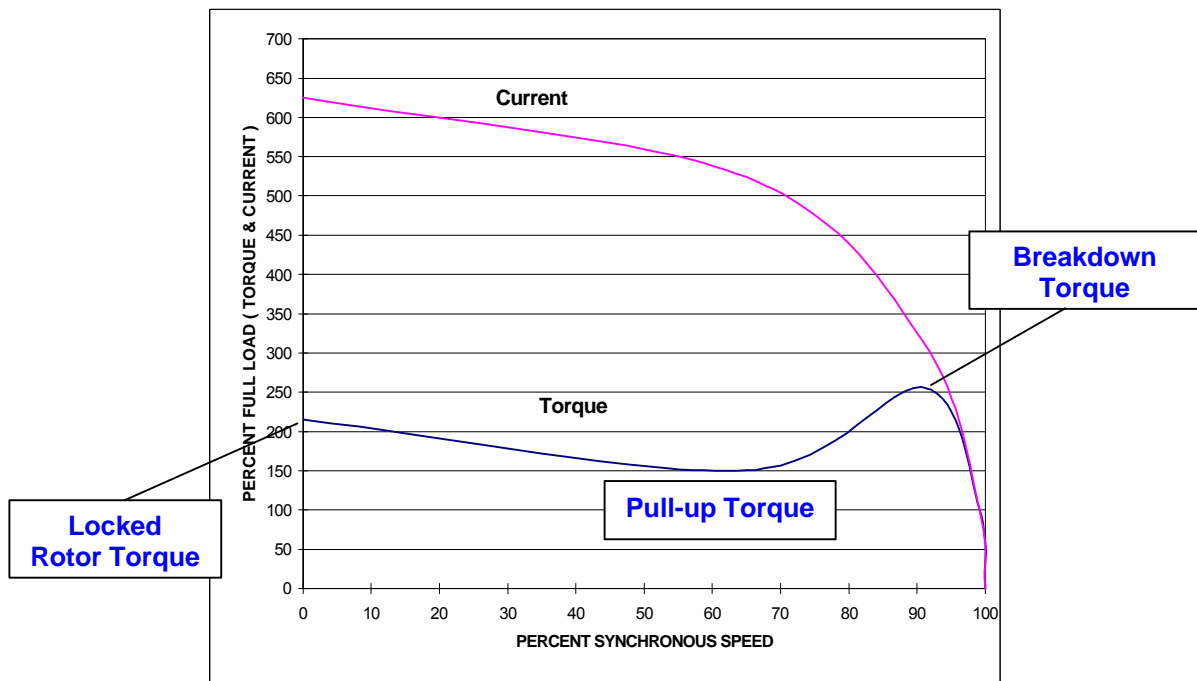
- The Rotor consists of a core made of the same thin laminations of silicon steel that the stator uses, but instead of copper windings has several bars which run along its length which are connected to end rings. If the steel laminations were to be removed, these bars look like a squirrel cage, hence the name, Squirrel Cage Induction Motor (SCIM).



**Sketch of Die Cast Aluminum Rotor**

- The rotating magnetic field from the stator “cuts” through the rotor bars and induces current in them. The current flows through the bars to one of the end rings, through the bar on the opposite side of the rotor then returns through the other end ring etc.
- The current flowing through the rotor bar creates a magnetic field in the rotor that follows the stator’s magnetic field.
- The difference in speed between the rotor and the stator’s rotating magnetic field determines how many lines of magnetic flux cut through the rotor bar. The greater the difference in speed, the more current that is induced.
- During starting, the rotor is completely stationary, therefore the maximum amount of current is induced into the rotor.
- This maximum current causes a tremendous amount of current to be induced in the rotor, which generates the “Starting” or “Locked rotor” torque. This very large amount of current produces a high amount of  $I^2R$  heating in the rotor. (This is why a motor that has been stalled for too long often shows damage or partial damage to the rotor.) The stator also sees a large amount of current.
- Almost instantly after power is applied, the rotor starts to rotate, current starts to drop and torque typically starts to drop slightly. Torque reaches a minimum value that is referred to as “Pull-up” torque.
- When the motor gets closer to full rated speed torque increases to a peak value referred to as “Breakdown” torque.
- When a SCIM reaches full speed and is running at no load, the rotor runs at very close to its rated speed. During this condition, very few lines of magnetic force cut through the rotor bars and therefore a minimal amount of current is induced in the rotor.

- During normal running conditions, when the motor load increases, the rotor slows down, more lines of magnetic force cut through the rotor bars and hence, generate more torque (to a point).
- As current rises, the rotor and/or the stator starts to saturate and the amount of torque generated per amp starts to diminish. For example, at 100% load torque, the motor draws 100% rated current. At 250% torque, the motor example in fig.1 draws approx. 300% of rated current. If the load torque increases past the breakdown torque point, current continues to increase but torque starts to go down. When this occurs, the motor stalls, the rotor heats up and will potentially be damaged unless tripped off line in time. (The higher a motor's breakdown torque, the less likely it will stall.)



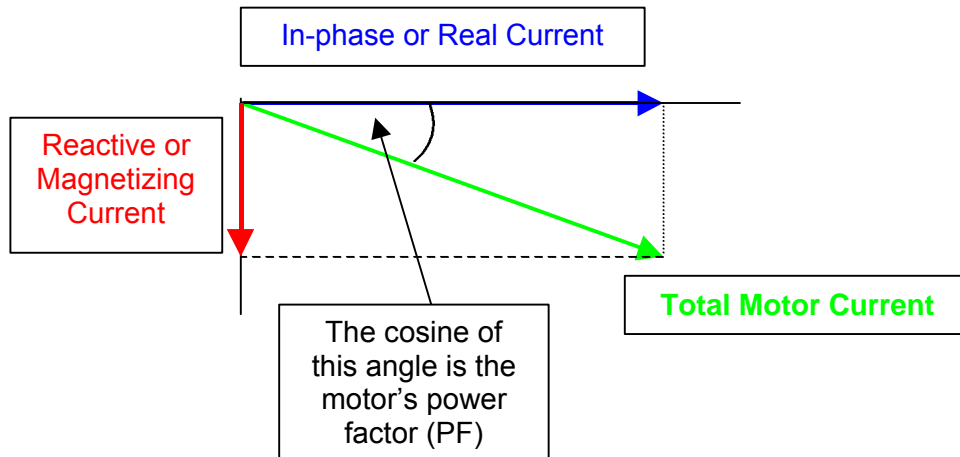
**Fig.1 Sample Torque & Current versus Speed Curve**

One interesting characteristic of motor torque is that it is quite linear with respect to speed until the motor nears its breakdown torque point. This means that if you want to determine the actual motor load, a fairly accurate method is to measure the shaft speed with a tachometer. The following formula can then be used to determine the % load.

$$\frac{\text{Nominal RPM} - \text{Actual RPM}}{\text{Nominal RPM} - \text{Full Load RPM}} \approx \% \text{ of Full load.}$$

**(Note - A high-resolution tachometer must be used to obtain accurate results.)**  
 (Measuring the current and comparing it to full load current is not a linear comparison method of determining percentage loading since efficiency and PF change with load. This impacts the current that the motor draws. For example, a Toshiba 7.5HP, 1800RPM EQPIII, 575V motor draws 2.9A at no load, 4.5A at ½ load and 7.4A at full load. If however, the PF and efficiency are known at various load points, a non-linear, load versus current curve can be drawn which will provide an accurate correlation between load and current.)

Motors draw two components of current. One component is in-phase or real current. The other component is reactive or inductive current that is sometimes referred to as magnetizing current. The cosine of the angle between these two components of current is called the power factor.



As load goes down, the in-phase component shrinks faster than the magnetizing component therefore the phase angle gets larger and the PF gets lower.

