

The Theory of Induction Motors

1. When a voltage is applied to the stator of an induction motor, a magnetic field begins to rotate in the stator. For example, this rotating magnetic field may be 1800 RPM. When the rotor is at a stand still (0 RPM) the rotating magnetic field of the stator cuts the conductors of the rotor at a maximum rate, inducing maximum voltage and current in the rotor's conductors.
2. As the rotor gains speed, 600 RPM for example, the conductors of the rotor are being cut by the stator's magnetic field at a slower rate since the rotor's RPM is catching up to the magnetic field's RPM. ($1800 \text{ RPM} - 600 \text{ RPM} = 1200 \text{ RPM}$) This causes less voltage and current to be induced in the rotor's conductors.
3. When the rotor reaches full speed (assuming no mechanical load is present) the rotor conductors are being cut at the slowest rate. Assuming the speed of the rotor is 1750 RPM and the stator's magnetic field is rotating at 1800 RPM, the rotor conductors are now being cut at a rate of 50 RPM. This slow rate of cutting action induces the smallest amount of voltage and current into the rotor's conductors.

NOTE: The rotor of an induction motor can never reach synchronous speed (the speed of the rotating magnetic field in the stator windings). If the rotor's speed equals 1800 RPM then the rotor conductors would be cut at a rate of 0 RPM. This would result in no induced voltage, no current, without current there would be no magnetic field and therefore no torque.

4. When a mechanical load is applied to the motor, the rotor slows down from full speed, 1400 RPM for example. The rotor conductors are now being cut at a rate of 400 RPM ($1800 \text{ RPM} - 1400 \text{ RPM} = 400 \text{ RPM}$). This is obviously much faster than the 50 RPM rate at full speed. This would cause the induced voltage and current in the rotor to increase as well as the magnetic field in the rotor conductors.

Now let's take a look at what happens to the stator windings.

If we look at the situation in step 1, the rotor is starting from a stand-still and has 0 RPM from the start. The lack of rotation of the rotor also means the lack of induced voltage back into the stator. This means minimal CEMF opposing the line voltage and maximum line current.

As the speed of the rotor increases, such as in steps 2 and 3, more of the stator's conductors are being cut by the rotor's magnetic field. This induces more voltage into the stator windings. More induced voltage means more CEMF and less line current.

As a mechanical load is added to the motor as in step 4, the rotor slows down. This reduction in speed means the stator's conductors are being cut at a slower rate. Less voltage is induced into the stator windings causing less CEMF and a larger amount of line current to overcome the mechanical load.