ENERGY POWER CONSERVATION IN MOTOR APPLICATIONS

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ELECTRICAL

With the ever increasing pressure to keep running costs from going up, there has been an influx of various kinds of energy management equipment on the market recently. One such piece of equipment is the PowerBoss, aimed primarily at the low voltage induction motor user. To understand what impact the PowerBoss can have on your plant, one firstly needs to understand some of the characteristics of an induction motor.

We will first consider the characteristics of induction motors, including their inherent inefficiencies. We will consider iron losses, frictional losses and stray load losses.

Finally, we will consider real and apparent power and the power triangle, and how we can improve the efficiency of a motor.

Motor characteristics

Here we consider the load and speed characteristics of an induction motor.

Static loads

This results in very high starting currents; the motor demands the right amount of energy to overcome the stationary load - the motor must be built to deal with this load.

Speed

Induction motors run at a constant speed, very nearly irrespective of load.

Moving load

Usually once started and the motor has gained full speed, the current drawn from the supply falls. However, this 'running' level of current is still too high and the energy is manifested as heat, vibration and noise as well as the movement of the load. This represents a waste of energy.

Inefficiencies of electrical motors

All induction motors are characterised by:

- iron losses
- copper losses
- friction losses
- stray load losses

These add up to give the total power loss, as shown in Figure 1.

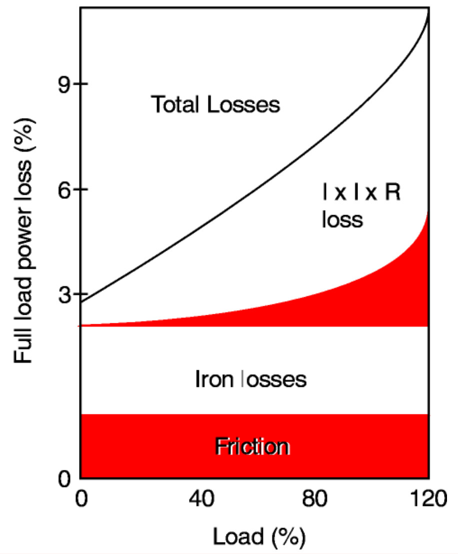

Figure 1. Graph of power losses in electric motors

Iron losses (Fe)

Also called the magnetising losses - these are voltage related and therefore are constant for any given load.

The magnetising losses are comprised of the hysteresis losses and the eddy current losses. The magnitude of these losses is determined by the constriction of the motor and the type of steel. At low load, Fe losses predominate and produce the poor power factor.

Copper losses

These are also called the 12R losses and are proportional to the square of the load current.

Friction losses

These are also called mechanical losses - bearings, windings, windage.

Stray load losses

Disturbance of the magnetic field due to the change in load.

Electric power and the power triangle

In this section, we will consider real (resistive) power, and reactive power. We will also consider the power triangle, as this is a visual way of better understanding power factor (pf).

Real (resistive) power

As can be seen from Figure 2, if V and I are in phase, we have a purely resistive load: Real power = V x I (kW)

In the general case, when there is a phase displacement between V and I of ø then real power = V x I x cos ø

We refer to cos ø as the power factor.

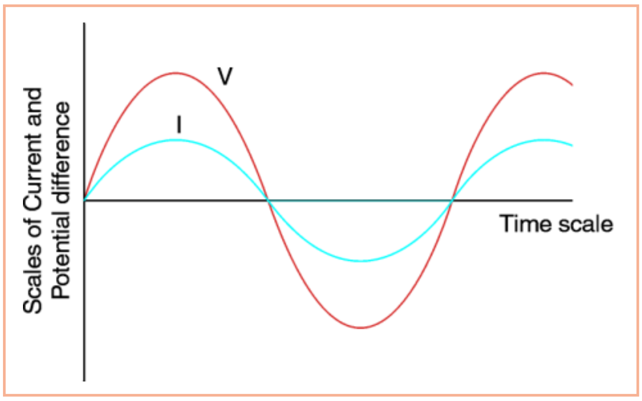

Figure 2. V and I are in phase for a purely resistive load.

Reactive power

As we can see from Figure 3, if V and I are shifted by 96˚ (ie ø = 90˚):

reactive power = V x (kvar)

In the general case, the reactive power is given by:

reactive power = V x I x sin ø

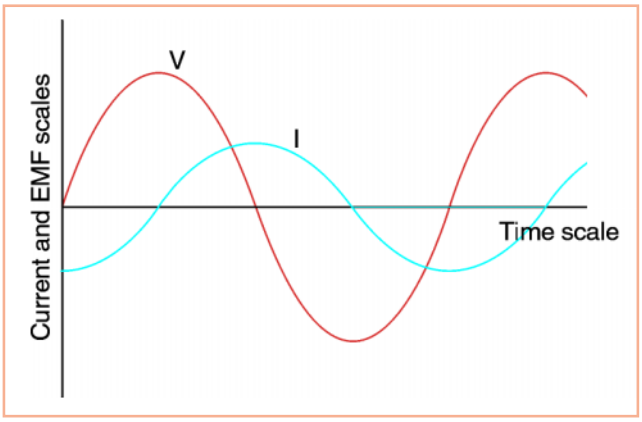

Figure 3. V and I are shifted by 90˚

The power triangle

The combination of power due to the resistive elements and apparent power due to the presence of the reactive power need to be combined. This can only be done using vector addition.

In order to add the in phase (resistive) (Figure 2) and quadrature (reactive) (Figure 3) elements they have to be added using vectors. This is the technique which takes into account both the magnitude and the angular displacement of the elements, and is shown in Figure 4.

Power factor is the cosine of the angle between the resistive power and the apparent power. The ideal pf is unity or 1, however in an induction motor it is usually less than unity or 1 and might typically be 0,78. The power factor is only present when reactive power exists and therefore is caused wholly by the inductive characteristics of the induction motor and as we have seen, this is caused by the iron losses in the motor.

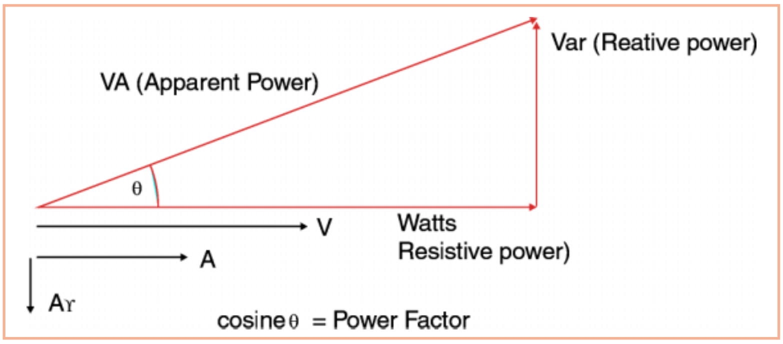

Figure 4. The power triangle.

How can we save?

PowerBoss will save energy by working on the inductive reactive component of the waste which exists in an induction motor. In so doing, it improves power factor by reducing the waste of energy. PowerBoss will eliminate the need for power factor correction at the source of input, by reducing incremental the effect of inductive reactance at the point or origin, ie the ac induction motor.

The idea behind the PowerBoss is not a big secret, but the technology used to make it possible is. PowerBoss takes the 50 Hz sinewave and reduces the area under the sinewave. The height of the sinewave and the zero crossover points on the horizontal axis do not change. Hence, the motor does not lose its speed (rpm) due to momentum. But it does have a reduction in voltage and current, which is power. Figure 5 shows a typical example of a sinewave before and after the PowerBoss principle has been applied. The shape of the graphs are not accurate due to every motor having its own characteristics.

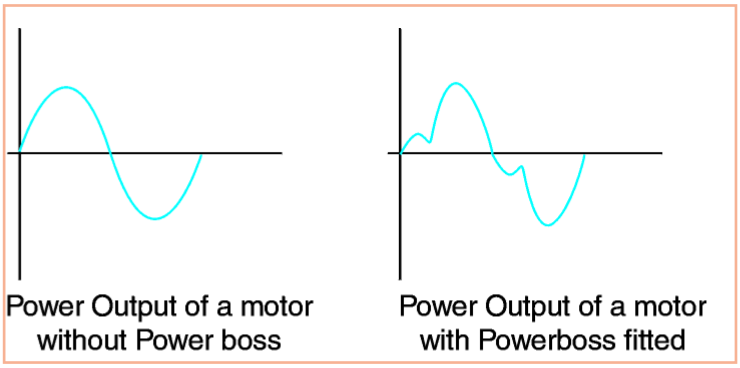

Figure 5. Energy saving.

PowerBoss manages the electrical energy demanded by the load, via the motor, from the supply, as suggested in Figure 6. It does this by regulating the voltage at the motor terminals in such a way as to provide just sufficient energy to provide enough magnetising forces to meet the driven load demand. Hence PowerBoss reduces the effect of Fe (iron) losses.

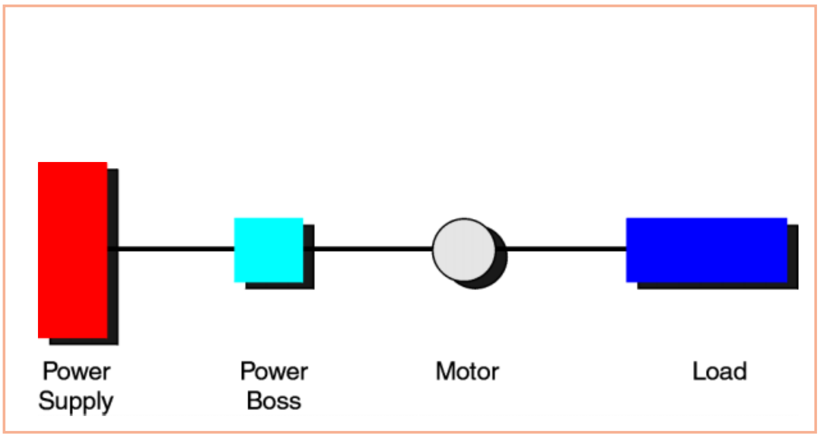

Figure 6. the PowerBoss in line with the load.

PowerBoss 'looks' through the motor at the load and adjusts the incoming power to satisfy the load requirements.

Integration of computer and digital switching technology is married to power electronics. Micro controllers control the switching of triacs or thyristors. Feedback about the load is collected via the neutral line in single phase or the 2 'non-firing' thyristors in 3 phase.

Optimisation

During the learn cycle, PowerBoss reduces the voltage to a point just above the motor stall speed - no actual reduction in speed occurs, it then optimises the energy supplied to maintain that reference point. At no time has the speed of the motor changed.

Usually, PowerBoss is operated in an automatic optimisation mode, but for certain applications, it is necessary to control the level of voltage reduction. Therefore, a semi-automatic mode of operation is available. Any load increase or decrease is automatically compensated for by PowerBoss.

Soft start

In order to reduce the high in-rush current which can be as high as 8-12 times the normal operating current, the 3 phase PowerBoss provides a soft start option. This is achieved by setting the initial start voltage level (pedestal voltage) and then allowing the voltage to rise to full voltage over a given time period (ramp time). This is a strong feature of the 3 phase PowerBoss as it has no limit to the number of starts that may be demanded by the system. Used to replace Star/delta starters, resistor load starters and transformer starters, soft start reduces the wear and tear in the drive systems to which the motor is connected. No more screaming drive belts, sheared pinion drives, stretched chain drives, etc. Good for peak demand energy management.

Conclusion

It can be seen that, by reducing the VA, improving the power factor and eliminating the high in-rush currents associated with the starting of induction motors, you reduce the three factors evident in the electricity billing calculation. Furthermore, by reducing the input current, but not the rpm, you automatically reduce stress and improve the cooling of the motor, resulting in lower maintenance costs and breakdowns. All these factors exhibit a running cost saving, resulting in the PowerBoss paying for itself over a period of time. Thereafter, you will be experiencing real saving in your plant.

The concepts in this article are based on research carried out by Australian-based energy power conservation and the Western Australian power utility.