Energy Saving with Electronic Reduced Voltage Starters

Question: Is "Energy Saving" with a reduced voltage starter (RVS) possible?

Answer: “Possibly...but!”

EASI is frequently asked for advice on whether reduced voltage motor starters, or so-called “Power Factor Controllers” actually save money on billed electricity consumption. Our answer is simply to relate the history of these devices, and to point out some clear electrical principles regarding their use.

HISTORY

The concept of energy saving with electric motors is widely publicized as a spin-off from the NASA space program in the 1980’s, and is incorporated in a wide variety of products being marketed today by as many as 50 different manufacturers world wide.

The power factor controller is claimed to sense the amount of power needed by an electric motor, and to then vary the power according to the need. Laboratory tests are often cited that show these controllers can trim power usage by 6 to 8 percent under normal demand conditions, and by as much as 65 percent when a motor is idling.

Invented by now-retired NASA engineer Frank Nola for the space program in the early 1980s at NASA's Marshall Space Flight Center in Huntsville, Alabama, the power factor controller, with its widely anticipated potential for energy savings, quickly became one of NASA's most widely adopted "spinoff" technologies. And, it was quickly incorporated into a wide variety of that era’s machines, ranging from household refrigerators and washing machines to typewriters, kidney dialysis and industrial drilling machines, as well as scores of other commercial products.

Numerous devices have been developed and sold as "Power Factor Controllers", with a great many energy savings claims attributed to them. These devices have largely developed into the "Electronic Reduced Voltage Starter" (or “soft start”) that we are familiar with today. Many manufacturers still claim an "energy saving" function with their RVS's. What we will explore here is if this function is real, calculable, and beneficial or just an overemphasized marketing tool.

How it Works

An induction motor draws current from the supply in order to magnetize the core. At rated load, full magnetizing flux is needed for the machine to operate satisfactorily. At part loads however, full flux is not required but is still maintained if the terminal voltage is held at the nominal level.

Therefore, for a motor operating at light load, the losses associated with maintaining full flux will be a significant proportion of the motor demand, hence the motor runs with a lower efficiency.

In simple terms, when a motor is lightly loaded, its efficiency is lower and it wastes power.

However, it is worth noting that, although this waste is high as a percentage of power being drawn, it is quite low when expressed as a percentage of full load power - a key point often glossed over by companies bent on marketing their “energy saving” motor controllers.

Phase Angle Control

There are several different methods of motor control, with one being to measure the phase angle of motor voltage and current. As load reduces, the phase angle increases. When a certain level is reached, the firing angle of an SCR in the control device is reduced and the motor terminal voltage is reduced.

This reduction in voltage causes the motor's magnetizing current to reduce, with a corresponding improvement in power factor, and the actual energy consumed is indeed reduced for an extremely lightly loaded motor.

The motor flux is reduced, which decreases the iron and stator copper losses. But importantly, the rotor I_2R heating losses actually increase due to increased slip.

Current Control

A simpler control strategy often adopted for ease of implementation by RVS manufacturers is simply to monitor the current (once a start is completed). As current reduces below an adjusted set point, the SCR firing angle is reduced. The complication with this method is that incorrect adjustment or a poor control philosophy can cause motor instability.

Also, as cost is a major consideration, the control techniques are often rather crude. To avoid instability, fairly long response rates are used. This complicates the situation in that when load is applied very rapidly, as in a compressor, the voltage response is quite slow. This means the motor actually can be significantly underfluxed until the SCR firing angle is increased back to 100%.

The net result is to increase motor heating (losses) and in many situations to actually increase the total power consumed. Obviously, over time this also impacts motor bearing and insulation deterioration, as well.

Harmonics

Another point often overlooked in the past is the harmonic contribution of this control circuitry. As the SCR firing angle is reduced, current is drawn over a smaller portion of the sinewave. This effectively distorts the facility's power and shows up as increased losses not only in the motor, but also throughout the whole system. Calculation of this loss is difficult in the extreme as it depends on many variables such as the specific motor design details and the system impedance.

Actual measurement of this harmonic loss is also difficult without specialized equipment, usually not available to all but the best equipped of laboratories.

Standing Losses

Another important consideration is the standing loss introduced by the SCR itself. Typical voltage drops across these devices are 1.5 volts per phase. Multiply this by the full load current, and the soft starter (or "power factor corrector") installed purely on the grounds of energy saving would actually cost money in most installations.

Duty Ratio

Unless the variation between light load and full load is very large, with the duration of full load being extremely short in comparison to light load, "energy savings" with a soft starter may actually be energy wasting.

Conclusion

Confused? Rightfully so. Energy savings with a soft starter is theoretically possible, but actual calculation of the amount saved is difficult and there is the distinct possibility of actually wasting more energy.

Because of the above complications, the poor performance of most "energy saving RVS's," and the fact that most end customers truly do not fully understand these devices, EASI has resisted the temptation to incorporate these "Energy Saving" motor controllers into its range of recommended technologies to date.

EASI frequently encounters customers who already have these RVS systems installed on facility motors, and most of these customers are quite pleased with the savings they believe are being generated by these units, frequently noting measured wattage reductions and reduced motor operating temperatures as proof of their savings.

EASI has long mastered the technologies of applying fast switching triacs or SCR’s for voltage wave notching, and we apply this technology regularly to many types of lighting systems as an energy saving technique. However, we absolutely refuse to apply such waveform chopping power control to a rotating inductive load. The damages to a motor from always undertaking new mechanical load in an underfluxed condition are more important to us than offering customers the allure of a “dramatic energy savings.” We believe we have a responsibility to consider all effects of our recommended savings technologies, including any reductions in motor operating lifetime, as this directly effects motor maintenance intervals and production reliability.

When we encounter a customer installation of these RVS devices, we gently recommend that they be removed. If this advice is not effective, it is a simple matter to apply our EasiLiner™ or PowerLiner™ technology in combination with the RVS, and gain an additional 8% to 12% cost savings, while the motor is under any load, including its maximum operating load condition, where the RVS has little or no ability to provide savings.

In very carefully identified circumstances involving extremely lightly loaded motors, the application of RVS's will show the biggest benefit when applied for reasons of reducing mechanical shock loading and reducing electrical disturbance at the instant of motor starting.

However, EASI does not advocate the use of these systems for the purpose of reducing billed electrical consumption costs.