Reactive Power Management System Provides Better Power Factor and Lower Operating Costs

Michael Flood, P.Eng.
Monroe Automotive Equipment Co. of Canada, Owen Sound, Ontario

Power factor for the plant had historically averaged about 0.72 to 0.78, resulting in substantial penalty from the local utility...ongoing failure of the inverter drives for the CNC machines...was strongly suspected of being related to poor power factor

As the sole North American manufacturer of automotive strut rods, Monroe Automotive Equipment's 292,000-square foot plant in Owen Sound, Ontario, produces 7.5 million rods per year. It's a process that involves Computer Numerical Control (CNC) equipment, induction hardening and chrome plating—all having heavy reactive demand. As an added challenge, the dynamic behavior of these loads results in a reactive power demand that is variable throughout the cycle or process, making correction through mechanically switched capacitors inadequate.

Power factor for the plant had historically averaged about 0.72 to 0.78, resulting in substantial penalty from the local utility. At the same time, ongoing failure of the inverter drives for the CNC machines that thread the strut rods was strongly suspected of being related to poor power factor.

Plant Electrical System

The plant's demand load of roughly 5 MW is supplied from a main outdoor distribution station, half of which flows through a station transformer that drops the voltage from 44 kV to 4.16 kV. The reactive compensation equipment is installed in an indoor substation on two transformers further stepping down the voltage from 4.16 kV to 480 V, with two identical reactive compensation units installed on the 480 V sides.

The reactive loading being compensated for includes rectifiers for the chrome platers rated at 3,000A, the induction heating equipment used to harden and temper the strut rods, and the inverters for the CNC machines. Converting DC back to AC at variable frequency, the controls for the inverters are electronic switches, designed to operate at the zero crossing of the AC waveform.

However, with poor power factor, the current lags the voltage, and is therefore not at zero during switching. The result is increased heating and stress on the components, often causing premature failure.

A second indoor substation contains a previously installed 1MVAR static capacitor bank that ties into distribution panels supplied by two 44kV/480V transformers. However, the dynamic nature of the load conditions has rendered these static capacitors incapable of controlling the power factor to any degree. Considering this and the sensitivity of the inverter controls a more sophisticated approach was necessary.

Solid State Capacitor Switching

The two units recently chosen are manufactured by Toronto-based Haefely Trench and are called Adaptive Var Compensators (AVCs). They combine microprocessor controls and solid-state switching with traditional large-scale capacitors. Microprocessor control and solid state switches allow the AVC to closely follow the varying reactive power demands of the load. The capacitors are kept precharged and are inserted into the circuit at a natural zero crossing of the current, thereby avoiding the generation of voltage transients. Each phase is compensated independently, helping to improve unbalanced conditions.

Based on a site evaluation, each of the two AVCs was installed with ratings of 750 kVAR and a resolution of 18 kVAR/phase—the smallest amount of capacitance that can be switched in or out at any time. Each unit is contained in a 3' x 6' x 8'-high metal clad enclosure with capacitors stacked in trays down the left side and controls accessible through a door on the right.

As a result of the harmonics present in Monroe's system (21 to 22% THD), each AVC has been equipped with reactors providing harmonic mitigation and eliminating the possibility of resonance related problems.

Utility Monitoring

In cooperation with Ontario Hydro, the provincially-run regional utility, monitoring equipment was put in place to allow data capture for two months prior to and following installation. Monitoring points included the billing meter cabinet of the outdoor distribution station, and at the distribution panels of the indoor substation housing the AVC units. Data captured included voltage, current, power, power factor and system transients. The log interval was set at 30 seconds, resulting in a comprehensive profile of electrical load to allow detailed performance comparisons.

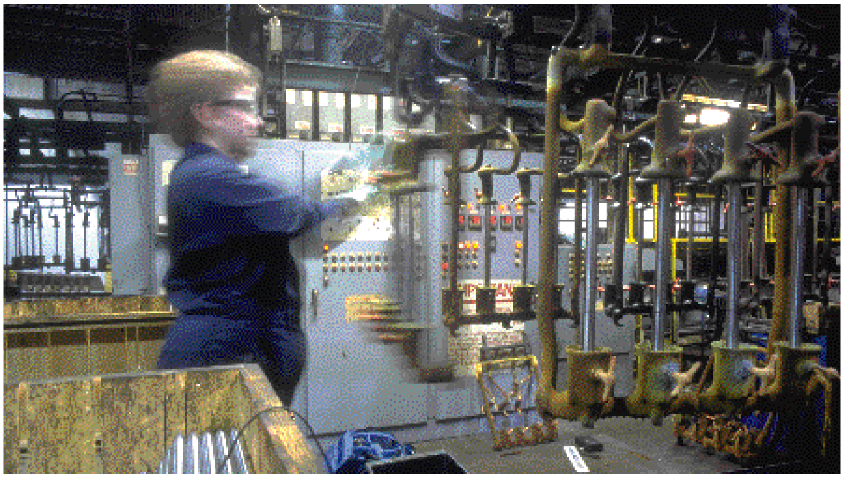

Figure 1 shows a typical daily power factor report before installation, with power factor ranging from 0.72 to 0.78; Figure 2 represents another typical daily power factor report after the AVCs were installed—power factor is close to unity.

Figure 3 shows electrical energy consumption and power factor for the whole plant after AVC installation. With the plant power factor now ranging from 0.92 to 0.96, annual power factor penalties have since been eliminated.

Multiple Benefits

After installation of a reactive compensation system in January 1994 that adapts its output to the load requirement and compensates on a cycle-by-cycle basis, plant power factor has climbed to a range of 0.92 to 0.96. Although not the prime reason for the project, the system has also reduced inverter drive failures from an average of one per month to one per year. Payback was less than one year on an installation cost of roughly $110,000, taking into account power factor penalty savings, consumptive savings and equipment failure savings.

Also, although production of strut rods rose 14 percent shortly after installation of the system, this was not reflected in energy billing. While not all the efficiency improvement may be attributed to the AVCs, there has been less energy losses as a result of their installation. ■

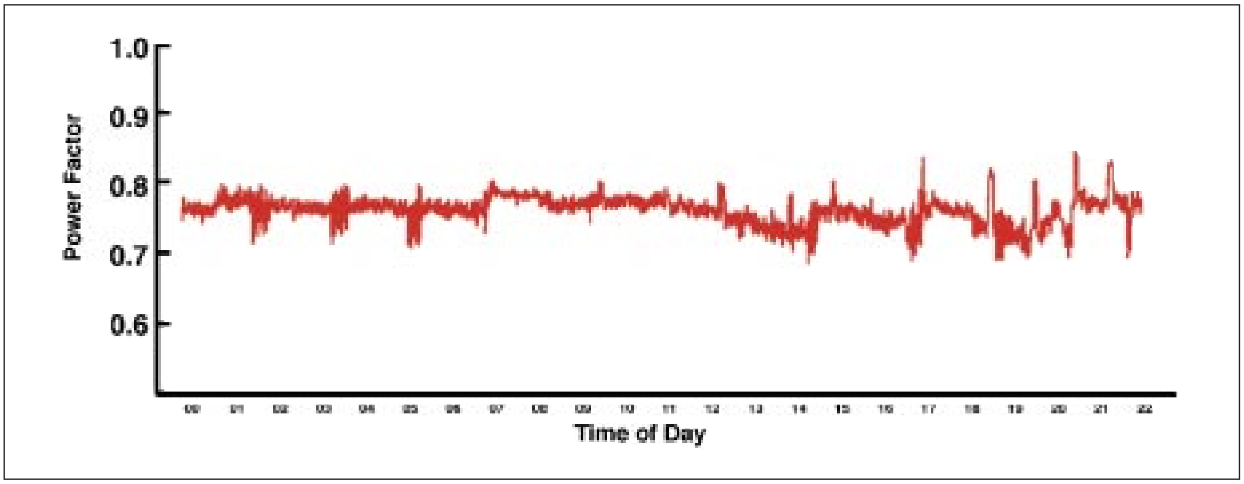

Figure 1. Typical Daily Power Factor Profile Before Installation of the Adaptive VAR Compensator.

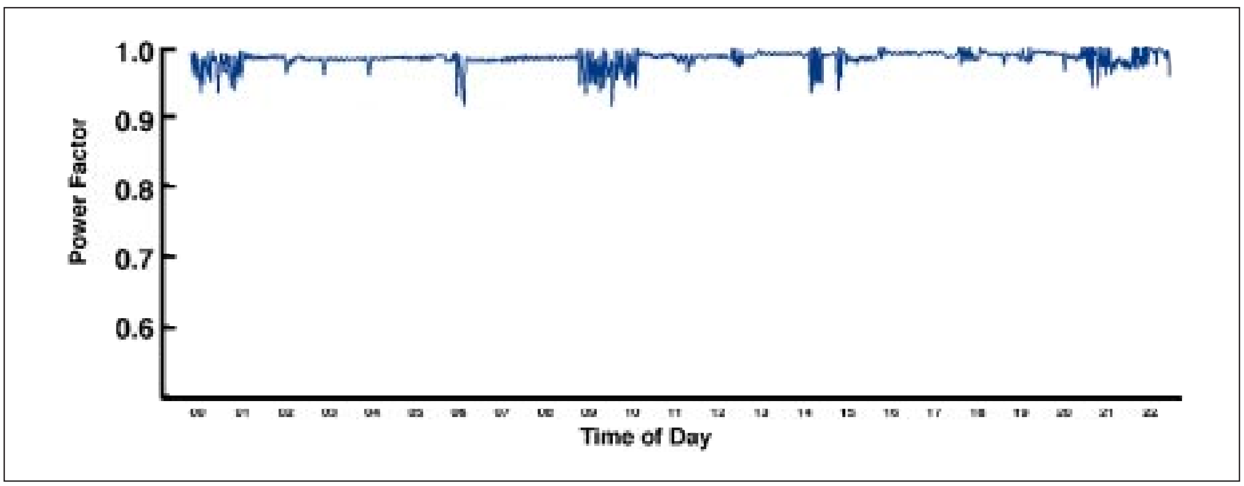

Figure 2. Typical Daily Power Factor Profile Following Installation of the AVC.

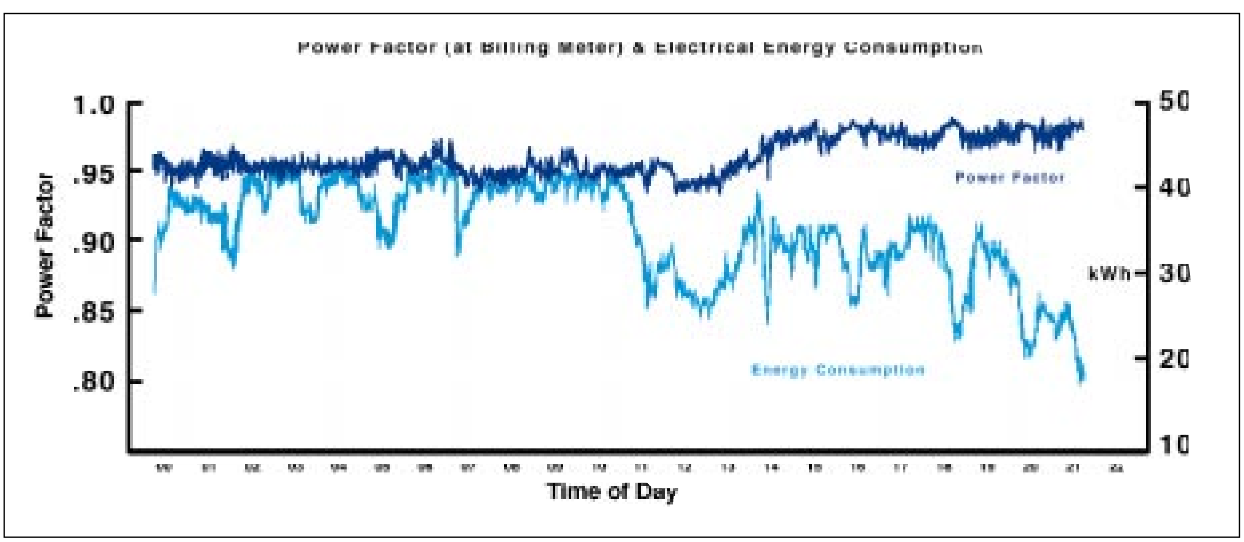

Figure 3. System Power Factor Now Ranges Between 0.92 and 0.96.