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Filter-based power conditioners boost productivity at glass plant

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Making precision-contoured car and truck windshields is an intricate process—part art, part science, and part basic manufacturing. Still, the automating of certain key stages of cutting and handling holds strong promise for gains in productivity, faster production changeover from one design to another, and easier development of new designs. At Ford Motor Company of Canada's Niagara Falls Glass Plant, however, turning this promise into reality stumbled on the common problem of erratic plant electrical power.

Instead of higher productivity, the plant initially found itself with more downtime and a new category of expense—replacement costs for electronic circuit boards. The solution, as detailed in this article, turned out to be a three-phase power conditioner.

Making auto glass

As one of four Ford windshield plants in North America—and the first of them to qualify under Ford's "Q-1" quality program in 1988—the Niagara Falls plant produces more than five million glass items per year, including windshields, backlites (rear windows) and body glass. The 258,000 sq ft facility annually processes more than 31 million sq ft of float glass purchased from outside suppliers.

No plant function is more complex than the production of contoured windshields. These start out as two flat halves—a *long* form for the outer layer and a slightly smaller *short* form for the inner layer. The two layers are put together with a layer of polyvinylbutylate (PVB) sandwiched between them, which creates the familiar shatterproof safety glass unit. The size difference between the layers is calculated to assure a dimensional match after the two halves are bent to the required design shape.

Long and short forms are cut from rectangular sheets of commercial float glass ranging from 0.07 to 0.09 inch thick, and up to 36 × 70 inches in size. Their desired shapes are scored into the glass with a wheel-type cutter, but the shapes do not separate until the scored glass sheet passes over a flame strip-out station. Here, heat from gas

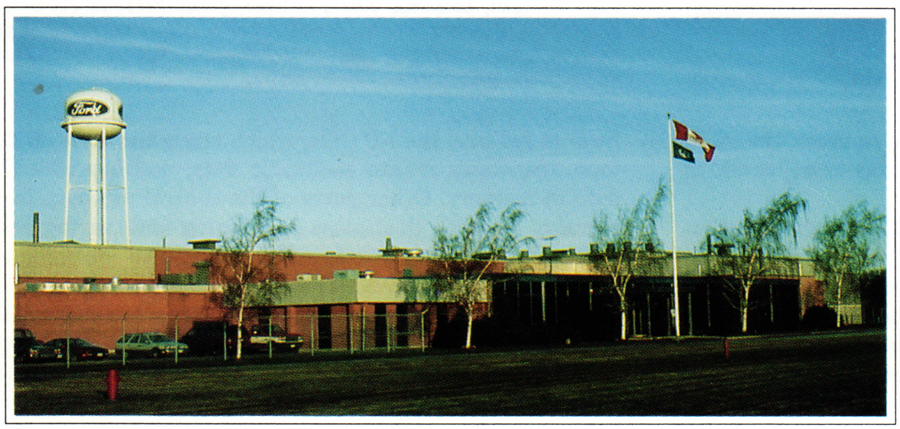

Fig. 1 (top): Ford Motor Company of Canada's Niagara Glass Plant is the first of Ford's four glass plants to fly the company's Q-1 flag.

Fig. 2 (extreme left): The author watches the NC glass cutter initiate a cutting pattern from punched tape instructions. The FilTrac power conditioner is mounted atop the control cabinet in a NEMA 12 enclosure.

Fig. 3 (left): The author examines a control board that earlier required repeated replacement due to damage from electrical noise and spikes.

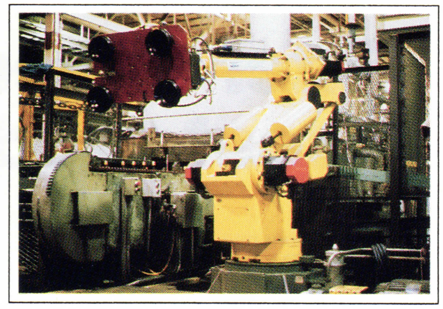

Fig. 4 (above): Staying one shift ahead of the bending lehr, a variety of flat windshield forms wait on wheeled carts. Any downtime in the NC cutter usually requires that a one-shift "cushion" be made up on an overtime basis.

Fig. 5 (right, top): This GMF robot had frequent power problems until power conditioners eliminated PC board failures.

Fig. 6 (right, bottom): The smallest of the FilTrac FA series power conditioners is rated for 30 A per phase. This filter-based design reduces weight, cost, and footprint requirements compared with transformer-based units.

jet flames is applied at strategic points to crack the glass along the scored line. The excess falls away as cullet and is sold to outside reclamation firms.

The shaped forms next pass through a grinding station where their razor-sharp edges are blunted, then to a washing station, and (when design specification requires) to a painting station, where decorative borders are applied with a silkscreen process. After these preparatory steps, the long and short forms are paired and laid flat on contoured molds, then conveyed through a bending lehr (a tunnel-like furnace) that heats the paired forms to around 1300°F for about nine minutes, allowing them to soften and sag simultaneously into their mold shapes.

With their contours identically mated, the two halves are cooled and separated, the PVB film is inserted, and the resulting sandwich is temporarily unified in a "tacking" oven. These tacked units are stacked in tubs, submerged in oil, and autoclaved at temperatures and pressures in excess of 250°F and 250 psig, respectively, which permanently bonds each sandwich together into a finished windshield.

Glass cutting automated first

The first step in automating the Niagara Falls plant was the addition of a Bystronic numerically controlled (NC) cutter at the head end of the windshield line. This unit's computerized control system receives design information for a specific windshield configuration from a library of punched tapes containing data for about 240 windshield designs.

Prepared on-site by engineering department computers, punched-tape NC cutting instructions currently initiate about 85% of the plant's windshield production, at a typical rate of five or six units per minute.

For each design, a separate tape for either long or short form is fed into the NC unit, which reads the code on the tape, translates it into electronic data, and captures the data in memory. Other parts of the control use data from memory to guide float-glass positioning and cutting head movement, and to verify actual machine movements against design instructions as they take place. The controller contains a total of eight PC boards, including two memory boards, a central processing unit (CPU) board, X-Y coordinate boards, and a main control board that interfaces the CPU with the other boards and controls the voltage levels fed to the other boards.

PC board failures flag power problems

Right from the start, the computerized cutter encountered serious control problems with power-line spikes and noise. For a while, we didn't realize the source of the problem. Before we began using electronic controls, our electrical equipment had never given any indication of anything wrong with our power. But with the NC cutter, we found ourselves continually changing PC boards because of unexplainable failures. Between failures, we'd see data transmission errors, such as glass not being positioned properly.

Replacing a PC board wasn't difficult, but determining which board to replace could be. If a specific machine movement malfunctioned or quit, its identity would usually guide us to the damaged circuit. But often a larger group of functions was affected and the entire machine went down. When this happened, it would take hours of testing with an oscilloscope to determine where the problem was.

Board replacement was costly: up to $1,400 per board. Sometimes four or five boards had to be replaced.

Such downtime usually isn't a production problem, because cutting is paced to stay at least one shift ahead of the bending lehr. In our business, bending is the main measure of production, and our lehr is kept busy three shifts around the clock, six days a week. However, cutter downtime that eats into the one-shift cushion must be made up at higher cost on an overtime basis, eroding plant productivity.

Couldn't keep new robot running

Late in 1989 the plant took another step into automation with the addition of a GMF robot that transfers finished windshields from the autoclave tubs to a conveyor for washing and final inspection. This was possibly the worst manual task in the plant, because finished windshields are heavy, and dripping with autoclave oil. The robot, which is a floor-mounted articulated arm that grips each windshield with suction cups, is located at the end of a U-shaped production line, only about 50 ft away from the NC cutter.

We just couldn't keep the robot running. We had so many PC board failures that at one point we had depleted GMF's entire U.S. replacement board inventory.

Studying power quality

Even before installing the robot, we had commissioned a two-month investigation into the quality of our electrical power, convening a team of Ford engineers and independent consultants, with assistance from the electrical utilities Ontario Hydro and Niagara Falls Hydro. Virtually all areas of the plant were monitored and analyzed for power quality. What we found was a mixture of very high pulses (up to 1400 V peak on a 480 V system, with energy levels of up to 400 mJ), high THD (total harmonic distortion) in both currents and voltages, resonance-amplified currents, voltage surges and sags, poor power factor, and other problems.

Among the major sources of these problems were the welding activities involved in maintenance and equipment installations, plus the operation of four 600 hp blower motors with variable-speed drives, a coating system controlled by five 250 A SCRs, and a painting oven controlled by 14 back-to-back thyristors ranging from 75 to 400 amps. Even the robot itself was observed to create a 300 V spike every time its arm moved.

Surge suppressors prove inadequate

One of the recommendations from the study was the use of surge suppressors. After trying conventional surge suppression on the robot and finding it inadequate, we contacted ONCA Systems, Inc. the Canadian representative of ONEAC Corp. (Libertyville, IL), a producer of low-impedance power conditioners. ONCA recommended a new filter-based three-phase industrial power conditioner recently introduced by ONEAC. The conditioner was appropriate for both the NC cutter and the GMF robot because both are 3-phase systems in which drives and controls share the same electrical service line. The cutter represents a 12 kVA load and the robot draws 7 kVA, both with delta input.

Known as the FilTrac™ power conditioner, this filter-based, low-impedance design supports loads of up to 200 A per phase, and is made for applications that require no voltage step-down. Filter-based power conditioning for our applications ended up costing us about 50% less than comparably rated transformer types. The fact that cutter and robot motors presented relatively low-current loads, combined with the difficulties that would be encountered in rewiring separate electrical feeds for motors and controls, made the FilTrac alternative especially attractive for us.

The power conditioner's noise rejection, tested under power to the 6000 V ANSI/IEEE C62.41 Category A specification, is rated for let-through of less than 20 V in both normal mode and common mode. Surge voltage withstand capability also complies with ANSI/IEEE C62.41 standards (Category A – 6000 V/200 A, 0.5 μs rise time, 100 kHz decay; Category B – 6000 V/500 A, 0.5 μs rise time, 100 kHz decay, 6000 V/3000 A, 1.2 × 50 μs and 8 × 20 μs voltage/current surge). For virtually any input spike amplitude and dv/dt (rise time), the conditioner's maximum output dv/dt is 20 V/μs or less.

Low impedance benefits seen

A particularly important characteristic of the FilTrac's design is its low forward transfer impedance (FTI) of < 1 Ω at 1 kHz. While this does not serve a power conditioning function, it allows the conditioner to furnish the high-pulsed *current on demand* required by both the switch-mode power supplies (SMPSs) that drive microelectronic circuits, and the fast-switching power electronics controlling the motors. This helps the SMPS run cooler and more efficiently, with longer service life. With low FTI, the FilTrac design eliminates the need to oversize the conditioner, as is usually required with conventional ferroresonant designs.

The design blocks load-generated electrical noise from passing back onto the line, and also blocks line-to-load disturbances. In addition, its extremely low output impedance (< 0.5 Ω at 100 kHz) prevents load-generated noise from reflecting back into the protected system's electronics.

The two 30 A FilTracs are contained in a NEMA 12 enclosure measuring 16 in. wide × 24 in. high × 9 in. deep. Because the conditioners weigh only 85 lbs, much less than transformer based conditioners, we were able to mount them atop the robot and NC cutter control cabinets.

Board replacement ceases

In August, 1990, we agreed to a trial installation of the 30 A power conditioners on the controls for both the NC cutter and GMF robot. To date, we have experienced no further power-related PC board failures or malfunctions. This is a dramatic contrast with the previous year, when we suffered 20-plus board replacements at a total cost of around $25,000. At that rate, the power conditioners paid for themselves in about four months.

In order to document the role that improved power plays in cost reduction and increased system uptime, we invited ONCA representatives to install ONEAC's ONEGraph power line monitors around each power conditioner. Two monitors were set up to measure continuously, for a 19-day period, common mode noise between Line #1 and ground on both the input and output sides of the conditioner.

Bar-graph printouts from the input-side ONEGraph showed that common mode noise was fairly constant in the 30-to-70 volt range, with 11 pulses of 100 to 550 volts during the test period. Matching bar-graph printouts from the output-side ONEGraph showed common mode noise at harmless levels of less than 20 volts.

To keep our qualification for the Ford Q-1 program, our plant must demonstrate a commitment to continuous improvement. With a measurable increase in productivity and reduction in board replacement costs, the power conditioners have made a solid contribution to our efforts. ■