

Robots beat the clock

Unloading injection-moulding machines and assembling automotive components within 16 seconds

BY ANDRÉ BEAUREGARD

Automated production is nothing new for Camoplast Inc. of Sherbrooke, QC.

A supplier of injection-moulded and blow-moulded products for customers like General Motors, Delphi Automotive Systems and Johnson Controls – as well as manufacturers of recreational vehicles and office-equipment industries – Camoplast now operates 11 production plants throughout Canada, the United States and Europe. After 30 years in business, the company is now diversified into three groups – traction, composite and thermoplastics.

Two years ago, Camoplast contacted Quebec systems integrator, Groupe CADEC, to solve some technological problems. Groupe CADEC is a Quebec-based firm that specializes in the design and fabrication of industrial equipment, industrial computer programming, automated robotic systems and control panels. Camoplast wanted to develop a fully automated line for unloading two injection-moulding machines and assembling five different components, in order to deliver 1,000,000 parts per year to General Motors.

The first design steps were undertaken in June 1999 to fabricate and implement an automatic cell to assemble the product. Various customized automated systems were developed to handle forming, pre-assembly, conveying inserts to the equipment, inserting components, hot stamping, bonding foam, inspection of finished parts and routing to output conveyors. Cover indexing and positioning for each machine were achieved by synchronizing the two 6-axis articulated robots and conveyors.

The "MousseFinder"

One materials handling step, in which a protective paper covering on foam had to be removed, was especially problematic. At that time, there were no systems, mechanical assemblies, automation, or even repetitive operational principles, to carry out this type of operation. Furthermore, the material's complex shape, non-repeatability and flexibility appeared to eliminate one or more of the various solutions to automate the operation. One part of the research and development process, therefore, focused on determining if the protective paper liner could be removed automatically.

In order to meet the mechanical requirements of this research project, Groupe CADEC joined forces with Verbom Inc., Eastern Canada's largest manufacturer of punch and

dies. For 20 years, Verbom has been offering consulting services in design, tool fabrication, and inspection as well as manufacturing prototype parts. Under this R&D project, four prototypes were developed and manufactured to carry out operational tests and validate our concepts. The final theory of operation is effective, fast and repetitive, while allowing controlled variations in the foam that have no impact on system reliability.

The "MousseFinder" is equipped with a device developed specifically to remove the protective paper liner from foam parts. It includes a carousel with eight positions indexable at variable speeds to a 1/2-HIP, 600-volt Allen-Bradley Series 1305 variable-speed AC drive, and to pick-and-place systems with two-axis linear drives.

Robot A cell

This system is able to empty two 750-ton injection-moulding machines with a single robot. The standard configuration has the robot handling the output directly with the machine. The six-axis robot used on its own base (with a 80-kg payload, a normal reach of 2643 mm, and an RJ5 controller) delivers high flexibility in rapidly and accurately accomplishing its tasks.

A 750-mm hand extension was added to the robot's wrist to enable it to reach the injection-moulding machines. The hand was designed and fabricated with dedicated robotics components in order to increase accuracy and hold down manufacturing costs. With its dedicated hand, Robot A has a reach of 3.3 metres (10 feet), enabling it to attain the five load and unload points in Cell A.

In order to better govern the injection process, Robot A picks up a plastic cover from first one, then the other injection-moulding machines, as soon as the injection cycle is completed, making it possible to maintain a specific machine cycle rate. The robot then places the part in the assembling press if it is ready, or, if not, behind the cell in a buffer zone.

Managing with PLCs

Constant communication between the robot and each section of the machine takes place via a robot interface (SPI) link in the case of injection-moulding machines, and an Allen-Bradley Remote I/O for communicating with the master programmable logic controller (PLC). When the moulding cycle has ended, the injection-moulding machine signals to the main PLC that the press is open. The PLC



A single robot can empty two 750-ton injection-moulding machines.

authorizes the robot to move between the moulds to get into position to pick up the part. The robot signals that it is ready. The PLC signals the machine to eject the part and the robot picks it up and moves off. The robot signals that it has withdrawn from the machine. The PLC then authorizes the machine to close to restart the moulding cycle. In this operating mode, the master PLC (Allen Bradley SLC500, CPU5/03) manages the tasks carried out by the robot, and the moulding machines and conveyors act as slaves.

Systems were developed to handle forming, pre-assembly, conveying inserts, inserting components, hot stamping, bonding foam, inspection and routing to output conveyors

DeviceNet communication

All the commands are linked across a DeviceNet network, which makes the diagnostic mode and programming more versatile. The DeviceNet network also reduces the connections significantly in terms of number of cables and electrical conduit size, making the network even more efficient for this type of installation and programming. In addition, DeviceNet technology facilitates modular design, which makes local equipment connection possible. A 1747-SDN scanning module installed on the main chassis acts as the master over the DeviceNet FLEX I/O 1794-ADN units and the CompactBlock I/O 1791D, to which are connected the 300 I/Os divided into 10 nodes across the work cell.

Robot B cell

An assembling press is located between the Robot A and Robot B work cells. Robot A conveys the plastic cover to the assembling press, while Robot B – with a 16-kg payload and a normal reach of 1813 mm – picks up the cover once the

operations have been completed.

The pneumatic assembling press brings together a number of technologies, such as a hot-stamping system, three vibrating bowls, three hoppers for bowl autonomy, and four vibrating rails to ensure that materials are delivered to the pre-assembly and component-insertion devices. To ensure high precision and reduce part strain, the retaining jigs are machined out of 1,600-psi Delrin, according to the "math-data" 3D design.

Robot B removes the plastic cover from the assembling press using a compact prehensile hand designed for handling the cover. It then places the cover in the MousseFinder, which bonds the foam inside the cover. The robot next cleans up any imperfections in the logo with a dedicated brush. It then places the cover in the foam press, which ensures that the self-bonding foam adheres to the plastic by applying pressure for a short period of time.

Inspection and vision

Since requirements in the automotive sector limit rejects to a maximum of 25 parts per million, automating the final product inspection station was a critical concern. Camoplast teamed up with Groupe CADEC and Verbom to find reliable methods for measuring the exactitude and presence of components and subassemblies installed in the plastic cover. A DVT vision system checks that the paper is completely removed before full pressure is applied in the foam press. This vision system communicates results to the central PLC so that the part can be routed normally or rejected, as the case may be. After a six-point inspection, two-axes on a linear pneumatic manipulator route the part to a rejected or accepted product conveyor.

The information collected is sent to the PLC that manages the accepted/rejected parts counters, displaying a seven-point rejection report on the operator interface screen. The status of the sensors and inspection device is validated during every inspection cycle. An operator alarm is triggered immediately should a component become faulty.

Operator interface

The operator interface (an Allen-Bradley PanelView 900) enables the operator to troubleshoot machine shutdowns. Through the main menu, the operator has access to robot status, equipment activation and deactivation, various robots and cell controls, robot positions, machine status, production counters, a page providing the means for resetting sequences, and a current alarm history. One of the system's main features is production flexibility. The control system is equipped with by-pass mode so that assembly steps can be by-passed without affecting normal operation in other steps. This means that, if the machine runs out of a raw material like foam, the operator can deliberately by-pass the corresponding production step and continue producing the plastic parts exiting the injection-moulding machines. The OI is connected to the main PLC over a Remote I/O network.

Machine safety

The cell has a physical barrier to impede access to dangerous zones. Four accesses protected by positive-action safety switches restrict the entry of personnel within the perimeter. Because of the risks related to robot actions and movements, injection-moulding machine operation, and movement of the pneumatic cylinders (assembling press), these zones must be protected with adequate devices. The cell is therefore divided into two separate sections so that operators can intervene in specific places without impacting on the operation of the other section.

In order to protect operator safety, Groupe CADEC applies CSA-Z452-94, which relates to machine safety, and CSA-Z454-94, which deals with general requirements for industrial robots.

System security is provided by seven positive-action emergency buttons that shut down the cell. Three security modules for emergency shutdown controls with redundancy validate that the shutdown devices are working properly during each operating cycle. Furthermore, 17 key-coded door switches provide positive monitoring of access within the security perimeter.

Based on Camoplast's initial request to be able to create a final assembled product within 16 seconds, Groupe CADEC and the entire design team were officially mandated to fabricate an automated production line involving minimal human handling.

Groupe CADEC's André Beauregard is head of the machine automation project. He thanks Serge Rioux, Réjean Landry and Pierre Doucet (all with Groupe CADEC), and Jean-Pierre Lavallée, Camoplast's operational manager, for their assistance with this article. Beauregard can be reached through Email at editor@automationmag.com