(Un)Stoppable Automation for the Mold Shop

Rexam’s new MegaCell is designed to maximize lights-out production of mold inserts and electrodes in its fully automated mode, yet it easily accommodates “custom” work in the manual mode.

BY MARK ALBERT
“W"e knew the MegaCell had to be designed for complete flexibility from the start,” says Len Graham, the business unit manager at Rexam Mold Manufacturing (RMM), a division of Rexam Healthcare, in Buffalo Grove, Illinois, a northern suburb of Chicago. MegaCell is the name given by RMM’s Automation Engineering Team to an ambitious implementation of robotically tended production cells that will automate the entire mold manufacturing process. The MegaCell is being constructed in phases.

Rail 1, the first phase of construction, is complete. This sub cell, which consists of machining centers and EDM units arranged on both sides of a track-mounted robot, is designed to streamline the production of graphite EDM electrodes and hardened tool steel mold inserts. Plans call for adding more sub cells end-to-end with the existing robot track, eventually creating an integrated, fully automated production line that covers virtually the entire mold manufacturing process.

The MegaCell embodies a number of bold design and operational features, many of which are incorporated in Rail 1. “This first sub cell is a prototype for future extensions. It follows and proves out key principles for flexible automation that we’re pioneering in the MegaCell,” Mr. Graham says.

By “flexible,” however, Mr. Graham means that the cell can not only produce a wide range of electrode or insert types, but also can operate in either a lights-out, unattended mode or in a manual mode for custom work. Provisions for manual operation were a critical requirement when Mr. Graham and his team began the conceptual development of the MegaCell. Although several of the cell’s concepts are innovative and original, its dual-mode capacity may be the most significant because it reflects insights into the special nature of mold production and the kind of automation that suits it.

Mr. Graham explains that most mold shops like RMM have to accommodate work that doesn’t normally fit automated processing. This “custom” work includes mold components that need repair, don’t fit standard pallets or require urgent processing. “It’s not practical or affordable for a mold manufacturer to maintain an automated system that duplicates conventional, manual capability or vice versa. Not having dual-mode capability makes it almost impossible to justify

(Facing  Page) This view of Rail 1 is representative of how the rest of the cell is arranged. It shows one of the EDMs with its side to the robot track. The side of a graphite mill is visible on the opposite side of the track. One of the cell’s storage carousels is at the far left.

A Workmaster robot serves all of the machine tools and other equipment in the cell, but it does not interfere with operators handling custom work on off-line machines.
the investment in automation or makes the automation incompatible with the realities of mold production,” Mr. Graham says. By design then, any machine tool in Rail 1 can be taken off-line and operated like an ordinary, stand-alone CNC machining center or EDM. A CMM integrated in Rail 1 is also set up in the same fashion. Regardless of the equipment in off-line status, the rest of the cell can continue to operate safely and efficiently in the automated mode. Jobs already scheduled for an off-line machine are put on hold by the cell’s master control system. When the operator has completed the custom, offline work, a press of a button resumes automated production exactly where it left off.

“Because the cell has dual-mode capability, it can supply virtually all of the electrode machining to support the rest of the mold shop,” Mr. Graham says. “Whether we need 100 pieces or only one, Rail 1 can handle it.” He adds that this sub cell delivers precision to ± 0.0001 inch or better, regardless of its operational mode.

**MOLD PRODUCTION FOR THE WORLD**

Rexam is a London, England-based global supplier of consumer packaging. It is best known as the world’s largest producer of beverage cans. Chances are that if you had a drink from an aluminum can at lunch today, that can was made by Rexam. Accounting for about 10 percent of its revenue, the company’s Healthcare unit is a leading supplier of rigid packaging for pharmaceuticals and manufacturer of other plastic medical devices.

Rexam Healthcare has 14 production plants on three continents. The Rexam Mold Manufacturing (RMM) facility in Buffalo Grove provides mold making services for all of these plants. Tooling from RMM includes high-precision, high-cavitation plastic injection molds in single-face, stack, unscrewing, multi-material and rotary cube configurations, among others. RMM also supplies plastic injection molds to a host of outside customers in the medical, pharmaceutical, general enclosure, personal products and home care markets.

Today, RMM’s facility consists of close to 100,000 square feet of space for mold design and

This view of Rail 1 shows the side of the cell with two sinker EDMs and the load/unload station. Two machining centers and a CMM are on the other side.
production; a Product Development Center for mold qualification and short test runs; and a suite of offices for administration, training and meetings. Manufacturing capabilities include wire and sinker EDM, CNC hard milling, various types of grinding (jig, surface, ID/OD), five-axis multitasking, and laser engraving. Around 80 mold manufacturing specialists and their leaders are employed there.

Mr. Graham joined Rexam in late 2011 after eight years as a consultant in the design and installation of automated mold manufacturing systems. A spectacular but short lived implementation of cellular mold production designed by Mr. Graham attracted considerable attention in 2003. Many of his ideas for automated mold manufacturing were developed for that installation. “What attracted me to Rexam was an opportunity to advance mold manufacturing to a new level of flexibility and productivity. I also like the team-based approach to mold manufacturing that is a hallmark of Rexam’s manufacturing culture,” Mr. Graham says.

The MegaCell, which will consist of four other cells similar to Rail 1, will be the centerpiece of RMM’s push to state-of-the-art mold manufacturing technology. “It’s cutting edge on many levels,” Mr. Graham explains, “but the dual-mode operational capability is an especially important strength.” That’s because, he says, dual-mode capability addresses and resolves one of the main dilemmas mold shops confront when evaluating the jump to an automated system—how to get high production without giving up flexibility. “The successful mold manufacturer has to have both,” Mr. Graham declares.

CUSTOMIZED FOR CUSTOM WORK

At first glance, Rail 1 may not appear conspicuously different from other machining cells. On one side of the rail-guided robot carrier are two sinker

Identical pallet receivers on the machine tools and CMM ensure precise and repeatable location, whether the robot or the operator loads the pallet.
EDM units, one from Mitsubishi EDM and one from GF AgieCharmilles. On the other side are two Makino CNC machining centers, one for graphite/copper graphite milling and hard milling of inserts and one for graphite milling only. Two 250-position, carousel-style System 3R Macro pallet storage units are located on one end. A Zeiss CMM and a System 3R Dynafix bookshelf-style load station are located at the other end.

Installation of this sub cell began in September 2012. By March 2013, all of the machines and equipment were in place and in operation. A closer look at the cell’s configuration reveals numerous built-in provisions for dual-mode operation.

For example, all of the machine tools interface with the robot from the side so that the operator can freely access the front of the machine and its control panel from the aisle. It is impossible for the robot to enter space that might be occupied by the operator. Safety interlocks prevent the side door for the robot and front door for the operator from being opened at the same time. A pressure pad has been installed as a further safety measure in front of one of the EDMs because the rise-and-fall tank does not fully bar the robot arm from entering the work area. Stepping on the pad blocks the robot from the work area. Stepping off the pad automatically unblocks the robot, so there is no unintended loss of machine cut time.

All of the machines face the same direction. This makes the presence and activity of the operators more visible to cell supervisors and observers. Thus, the two EDMs on the right side are tended by the robot from the left, and the two machining centers on the left side are tended from the right. Chillers, filters, hydraulic systems and other auxiliary equipment are located on the aisle side of the machines to facilitate inspection and maintenance.

Because the CMM is gantry style, it is situated with its front open to the aisle for the operator and its back open to the track for the robot. A light curtain protects the operator’s area when the robot is in motion. The load/unload station for the cell is located on the other side of the robotic track and is similarly protected by interlocks and a light curtain.

The four machine tools, the CMM and the load/unload station are outfitted with identical receivers for System 3R’s Dynafix pallets. These receivers serve as the universal workholding interface. Fully palletizing the cell ensures that workpiece location can be precisely established on the CMM and maintained within ± 0.0001 inch as the
pallet moves from or returns to any pallet receiver in this sub cell. Smaller pallets such as System 3R Macro or Magnum can be mounted on the larger Dynafix pallets for extended machining cycles. RFID chips installed on all pallets enable the robot to make positive identification when retrieving or storing a pallet.

**A VITAL BRIDGE**

Devising a system so custom work could take advantage of palletization yet be compatible with flexible, manual operation was a challenge for the MegaCell design team, Mr. Graham says. The solution was adopting special magnetic chucks developed by The Hermann Schmidt Co. (South Windsor, Connecticut) that interface with the 3R pallet receivers. These magnetic chucks are equipped with precision-ground, precisely located side rails that establish repeatable workpiece orientation.

The magnetic chucks serve as the bridge between automated, untended operation of the sub cell and manual operation for custom work, Mr. Graham explains. “The goal is always to have enough work in the regular pallets to keep the machines in the cell running around the clock in the automated mode. In the meantime, custom work can be fixtured at the bench on the magnetic chucks, and then either entered for robotic delivery or loaded by hand after the machine is taken off-line,” he says.

The magnetic chucks enable a variety of clamping units to be mounted singly or in multiples. These clamping units, all affixed to the System 3R Dynafix palletizing system, include the smaller Mini and Magnum pallets or other types of convenient workholding devices. When set up, a magnetic chuck can be entered at the sub cell’s load/unload station, sent to the CMM to verify all workpiece positions, then delivered to the appropriate machining center or EDM, where an operator is expecting it. Any other Dynafix-mounted workholding unit can be handled in the same way.

The magnetic chucks are not used exclusively for custom work, however. Workpieces such as pins or bushings that can’t be clamped in palletable System 3R fixtures can be held in V-blocks or vises for mounting on the magnetic chucks. Thus, the magnetic chucks enhance both automated and manual operations on the sub cell.

Mr. Graham stresses that, regardless of the mode of operation, a key component in the sub cell’s effectiveness is consistent reliance on the master gage balls assigned to each workstation. These master gage balls are used to locate any item to a common, known reference point. Coordinate positioning (X, Y and Z) and machine offsets are always established in relation to the master gage ball, whether the work is mounted on the magnet, a fixture on the magnet, or a Dynafix-mounted Macro or Magnum pallet.

**CUSTOMIZED CELL/MACHINE CONTROL**

Some of the most important provisions for accommodating custom work are not visible in a tour of...
the cell. These pertain to modifications to the cell control software or its CAM programming system. For example, the basis for the cell’s overall control is System 3R’s Workshop Manager. This software is designed to coordinate the operation of an automated cell by queuing work according to schedule, tracking the whereabouts of every pallet, moving pallets to and from machining stations and so on.

This system was modified by the supplier for RMM so that an operator can interrupt automated operation with a command from any machine’s CNC. The CNC system on each machine also required modification to enable it to disengage and re-engage with the Workshop Manager interface. In practice, the operator usually picks a convenient stopping point, such as the completion of the current pallet, to switch modes. When switching to manual operation, the robot removes the current pallet and takes it to the storage carousel for holding.

The robot either returns with the pallet identified via RFID for custom work (usually on a magnetic chuck) or activates the interlock to enable the operator the open the machine doors. From that point, the operator runs the machine in the conventional manner as if it were stand-alone unit on the shop floor. When the custom work is completed, the cell technician transmits a return-to-automated-mode signal to re-engage control of the machine by the Workshop Manager system.

Mr. Graham reports that the machines in the cell typically run off-line in manual mode about 4 to 6 hours a day. They run unattended for 80 percent of the remaining hours, depending on jobs available in the work schedule. The goal for each machine is to have it engaged in a workpiece for at least 125 hours per week. “We consider that to be the most cutting time that is reasonably achievable, given that allowances have to be made for first-article inspection and 100-percent component verification,” Mr. Graham explains. “Reaching this goal for each machine and CMM in the cell helps our customers benefit from reduced lead times, improved overall quality, and ultimately, lower mold costs.”

**THE MEGACELL IS “ MEGA SMART”**

Although Rail 1 of the MegaCell is fully operational, not all of its features and capabilities are in place. RMM’s Automation Engineering Team maintains a list of refinements and enhancements that are now nearing completion, under implementation or in development. “Rail 1 is a working laboratory that will help us make the MegaCell the most intelligent system for automating mold manufacturing,” Mr. Graham proclaims. He is fond of saying that the MegaCell is “mega smart.”

Some of the action items for further improvement of Rail 1’s capability include:

- Job schedule lookahead that will enable the robot to move into position at a workstation in anticipation of a load or unload activity. This will eliminate production delays for robot travel time.
- Provisions to enable customers to view jobs in progress remotely via a wireless video streaming to the Internet. Cell supervisors currently have remote video monitoring and remote production control. They can run the sub cell and check in-process inspection reports from mobile devices at home.
- Concurrent programming. This will be seamless with Delcam’s PowerSHAPE, PowerMILL and PowerINSPECT. The concept is to create a “one-stop” programming session, starting with a Solid-Works 3D CAD mold design. Before the programmer creates the tool path for a graphite electrode, he uses PowerSHAPE to create the electrode model and associated EDM programs. He also tags “critical to function” dimensions. He then uses the model of the electrode to create the
Milling program with PowerMILL. The cell technician then uses PowerINSPECT to ensure the needed critical-to-function requirements are satisfied when the machined electrode is inspected at the CMM.

- In-process correction of machining operations based on CMM inspection data. For example, when the CMM detects a slightly undersized electrode, it signals the EDM to adjust the orbiting parameters programmed for the finish burn of that electrode. New offsets are automatically downloaded to update the original program settings. The RFID chip in the pallet holding that electrode identifies it as the one for which the adjusted program is intended.

- Automatic sorting of electrodes by size to optimize EDMing time. The strategy is to match electrodes to roughing or finishing steps according to their as-machined dimensions. Electrodes nearer the upper limit are best for the high wear conditions encountered in roughing. Those nearer the lower limit can be applied to fine finishing with adjustments to the orbiting routine.

Construction of the next sub cell, Rail 2, is scheduled to begin in the first quarter of 2014. This sub cell will consist of a five-axis machining center, surface and ID/OD grinders, and a lathe with live tooling for hard turning. It will also have a CMM and robot. A transfer carousel at the junction of Rail 1 and Rail 2 will enable pallets to move between the sub cells. Rail 5, the last sub cell to be constructed, will be a separate unit located on the opposite side of the shop floor. It will consist of horizontal machining centers for production of mold plates and bases.

Plans call for one new cell to be installed each year. The MegaCell is scheduled for completion by the end of 2017.

NO DUEL BETWEEN MODES

Mr. Graham says the dual mode capacity of the MegaCell concept embodies an important lesson about mold manufacturing. “What matters isn’t the level of automation, but the level of utilization,” he points out. In other words, running the sub cell in manual mode doesn’t represent a lesser use of its advanced technology, but rather a fuller use of its potential productivity. The cell’s capacity to handle custom work adds to its remarkable earning power, because the custom work flows almost as seamlessly as the palletized work. The modes are complementary by design and out of necessity, he says.

“Maximizing the time each machine spends with its tool engaged is the key,” Mr. Graham says. Ultimately, it makes little difference whether the operator or the robot keeps the machines busy making parts, as long as the machines are as busy as possible.”