Robotic Shell and Core Removal Emerges as Viable Option Among Investment Casters

by Mark Handelsman
KMT Robotic Solutions

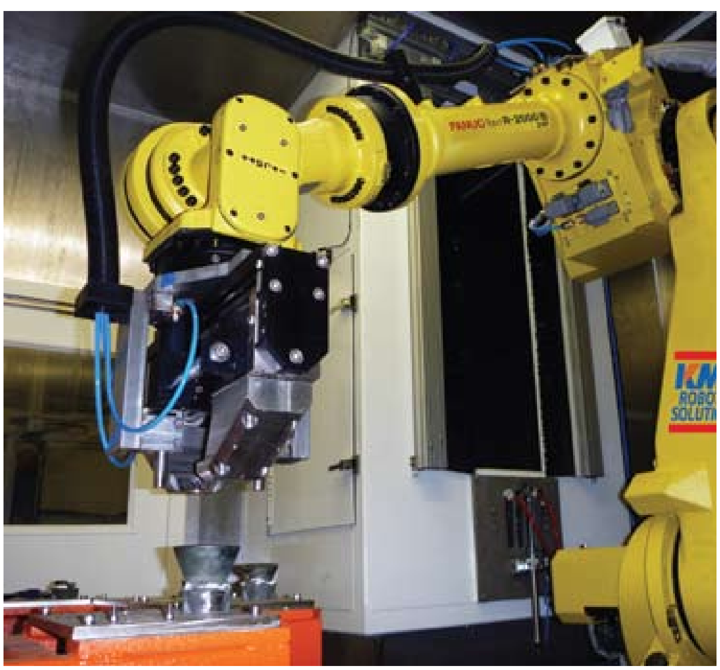
Robotics has become an established solution for several investment casting processes including wax assembly, grinding, and in particular shell preparation, but until recently there had been minimal use of robotics for shell and core removal. This is quickly beginning to change. Why? For the same reasoning that drove robotic automation to become widespread in the shell room. To address the constant need to reduce per part production costs and improve competitiveness.

"A common element in all of these systems is taking full advantage of the robot's ability to precisely control a high-pressure waterjet stream."

Traditionally, several different methods have been used for shell and core removal, each with their unique challenges and issues.

Investment casting foundries that rely on operators to blast parts with high pressure water, knock out the shell material with hammers, or other manual operations are subject to the variability that is inherent in all manual operations. This is particularly an issue in the back end of the foundry where this variability can back up the entire line or create large backlogs of work-in-progress (WIP) inventory.

Those investment casters that use hard automation water blast booths are typically able to remove 95% of the shell material, but struggle with parts that have more complex geometries or have deeper pockets. Water blast booths are also inherently inefficient, using far more water an energy that is required to compensate for the lack of flexibility.



Robot picks up trees and manipulates them in front of cleaning nozzles in the enclosure in the back corner of the booth

Caustic baths or shot blasting are effective in removing the shell material that hard automation water blast booths can not remove, but these solutions also have issues. The cost of the caustics or shot media, including disposal can be expensive. Caustic baths also have the disadvantage that they require a larger work in process inventory of parts.

A common concern for all of these shell and core removal alternatives is high running costs. From direct labor, to high water usage, to the cost of caustics or blast media, to disposal costs, to energy usage, all of these alternatives have some component that contributes to their relatively high running costs. It is not uncommon for the running costs to be as high as several dollars per part. For larger structural parts the shell and core removal costs can be even higher.

Despite their limitations, these non-robotic cleaning technologies get the job done and are the accepted approaches in most investment casting foundries. Shell and core removal have not traditionally received much attention, thus making it more challenging to implement new approaches. But the momentum to continue with the status quo cannot overcome the economic advantages that robotic shell and core removal has begun to be proven out.

So why has robotic shell and core removal only recently taken off? There is no overriding reason, but rather a combination of advances that have made robotic shell and core removal a viable solution.

In fact, some well known investment casting foundries built their own robotic shell and core removal systems, and have had these systems in operation for several years. Wanting to maintain a competitive advantage, these foundries used their in-house engineering staff to implement and support their robotic shell and core removal systems, and were not interested in selling their solution to other foundries.

Simultaneously, robotic systems integrators were successfully applying robotic waterjet based cleaning systems for stripping, deburring

Trees loaded by operators are indexed into the robotic cleaning booth for robotic cleaning.

This system is for shell and core removal of large structural parts loaded by crane.

and other cleaning processes outside of investment casting. This helped to advance the technology and know-how and reduce the system cost.

Things started to change within the last several years led by some investment casting foundries that partnered with robotic system integrators to implement waterjet based shell and core removal systems. These foundries were motivated to implement robotic cleaning by a variety of factors, including cost, safety or part damage issues associated with caustic baths, expansion needs that required additional cleaning capacity, or a desire to have greater consistency in their finishing area. Being an early adaptor can be a little scary, so all of these companies developed close relationships with their robotic systems integrators to make sure that they would work through any issues that came up during the installation.

A common element in all of these systems is taking full advantage of the robot's ability to precisely control a high pressure waterjet stream. Unlike hard automation waterblast systems, a robot can control the stand-off distance, angle of orientation, feed rate, and water pressure. Plus, these parameters can be setup for each tree or part style. A robotic waterjet cleaning system can also use a combination of nozzles, one for gross shell or higher volume removal, and one for fine removal in pockets or other hard to get at areas. With this combination of gross and fine shell removal, a typical cycle times to clean a tree range from 4 to 8 minutes.

"Since every foundry has unique requirements, there is no one size fits all solution for robotic shell and core removal."

Another common element is the use of straight city water for all cleaning needs. Robotic shell and core removal systems rely strictly on the mechanical energy of the water stream impinging on the shell or core material. No special additives or chemistry is required. Also, no hot water or other special energy consuming equipment is required.

Since the robot precisely controls the jet stream, water use is significantly lower than a hard automation blast system. Some customers that are faced with high water and sewage rates have taken the additional step to implement a closed loop systems to reduce their water requirements to the bare minimum.

Since every foundry has unique requirements, there is no one size fits all solution for robotic shell and core removal. This especially holds true for how trees or individual parts are presented to and handled by the robot. For small trees with shorter cleaning cycle times, a common approach is to have the robot pick up trees by the pour cup and manipulate them about fixed nozzles. This approach has the added advantage that since the robot is holding the tree or part it can perform other operations such as gate cutoff.

For larger trees or for trees that are not easily held by the robot, the most common solution is for the robot to hold the nozzle or nozzles and guide them along a defined path around the parts to be cleaned. Trees are indexed into the robot's cleaning cabinet on a two-position turn table. On the outside of the turn table, trees are loaded and unloaded by operators while on the inside of the cleaning cabinet, the robot cleans the previously loaded part.

Structural or other large parts with long cleaning cycles can be directly loaded onto a turn table inside of the robotic cleaning booth. The turntable rotates the part in front of the robot holding the nozzles so that all areas can be accessed and cleaned. One disadvantage of this approach is that the system is not available for cleaning while parts are being loaded or unloaded, so it is typically only viable for parts with longer cleaning cycles where the loading and unloading is a small portion of the overall cycle time.

Regardless of what type of system is implemented, the return on investment turns out to be very similar. For investment casting foundries that produce a couple of hundred or more trees per day any savings in the running costs will quickly pay for the initial investment and start up costs. The savings includes:

- Direct labor costs
- Water and sewage savings
- Energy savings
- Elimination of caustics and their disposal
- Elimination of shot media and their disposal
- Reduction of Work in Process inventory and associated cost savings
- Avoidance of bottlenecks associated with more variable processes
- Avoidance of separate process steps for aluminum parts
- Reduction in the number of steps to clean parts

"Robotic shell and core removal is not necessarily a good fit for all foundries."

A good example of an investment caster that benefited from these savings is a foundry that does work for a mix of industries that was interested in expanding its automotive business. They were bidding on a new opportunity and wanted to reduce their per-part cleaning costs to better position themselves to win this new contract. This new part had particularly demanding cleanliness requirements. Because of this they would have used a vibratory knock out and a caustic bath to remove the shell material. Adding up all of the running costs including consumables, disposal, utilities and labor, the cost to clean each part would be approximately \$2.50. The running costs to clean the same part robotically would be approximately \$0.35 for a savings of about 85%. This was a rather large contract, but capacity would be available to run other parts as well. They decided that if they won the contract they would invest in a robotic cleaning system and use the savings to pay for the system.

Their aggressive approach paid off and they were able to win this new contract and implement a new robotic shell removal system. In addition to the new contract, this foundry runs about 150 different part styles and has implemented a number of these other higher volume part models on their robotic cleaning system.

Those investment casting foundries that have implemented robotics for their shell and core removal have had good results and some are already moving forward with additional systems.

Even so, robotic shell and core removal is not necessarily a good fit for all foundries. Some of the common elements where robot shell and core removal is a good fit include:

□ Common feature on or near the poor cup or part for locating

□ Reasonable repeatability of part molds on the trees

□ Higher volume part models to focus on initially

□ No more than 300 trees/day based on a three-shift operation

□ No blind holes or other areas where there is no direct line of sight to access shell or core material

□ Some experience with robots in the shell room or other operations is a plus

For those that have implemented robotic automation in their shell room or in other areas of their foundry wonder how they ever got along before they automated. It may not be too long before investment casting foundries are wondering how they ever got along without robotic core and shell removal.

About the Author

Mark Handelsman, advanced technology product manager at KMT Robotic Solutions, can be reached at: 1-248-829-2834; e-mail mark.handelsman@kmtrobotic.com.