Continuing Advances in Vacuum Impregnation Systems

Progress in design has increased productivity, quality, and throughput, and reduced operating costs. Along with improved operator safety, these developments have driven a revival for in-house vacuum impregnation.

By Andy Marin

The beginning of the 21st century was a turning point for vacuum impregnation safety and production quality, and in less than two decades there have been significant improvements in that technology, a process that had been essentially unchanged since the 1950s.

What is vacuum impregnation? — Vacuum impregnation seals defects that form during the casting or molding of metal parts, defects that include microscopic pores and leak paths in the casting wall. The technique seals the defects without changing the casting's dimensional or functional characteristics, with the result that parts that otherwise would be scrapped can be used for the design purpose.

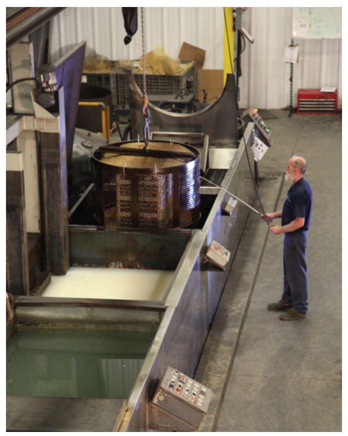
Advanced vacuum impregnation systems that incorporate robotic handling reduce cycle times and improve overall part quality.

Developed in the 1950s, the process was adopted quickly in various industries, particularly in automotive and aerospace sectors, and it became the preferred method to prevent leakage of fluid or gases under pressure.

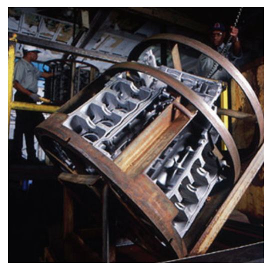
Until the mid-1980s, most automotive OEMs handled the vacuum impregnation process in-house. They used batch systems, in which workers would load multiple parts into large baskets for processing. This approach typically had a cycle time of 30-40 minutes. To increase productivity the operators would increase the size of the process equipment, but this was accompanied by a reduction in finished product quality and process safety.

In the course of sealing castings against porosity, the parts would be processed through the following stations:

- An impregnation chamber. The operator would seal the chamber and draw a vacuum. This would remove air in the porosity and leak path in the casting wall. Then, the parts would be covered with sealant and a positive pressure applied. More energy would be required to penetrate the porosity with sealant than to evacuate the air. The operator then would release the pressure and drain the chamber.
- Excess sealant recovery. The operator would remove excess sealant through gravity, rotation, or centrifugal force.
- Wash/rinse station. Next, the operator would wash residual sealant from the part's internal passages, taps, pockets, and features.
- Cure station. Finally, the operator would polymerize the impregnated sealant in the leak path.



In manually operated impregnation systems, process equipment like overhead hoist cranes could injure the operator.



Manually operated systems may require an operator to move heavy, unwieldy baskets that can impart stress or injury to the operator.

Safety concerns — Over the years that vacuum impregnation became standardized, other manufacturing operations (e.g., machining, pressure testing, and assembly) had been modernized. They became more cellular, more automated, more ergonomically sound and safer for operators, and in general more efficient. Vacuum impregnation, however, remained a manual process with significant safety concerns.

Among the safety concerns were:

- Open modules would jeopardize operator safety. For example, an operator could be splashed with sealant or fall into an open, 800-gallon container of 195°F water.
- Open tanks would emit hot vapor with elevated VOC levels, which could cause health problems.
- System components like overhead hoist chains, actuating tank lids, locking rings and chain drives could cause injuries.
- Part baskets were bulky and heavy and moving them could create stress on the operator's body or cause injury if mishandled.

Issues with quality — Batch impregnations systems are prone to quality issues, too. These include:

- Complex castings are difficult to impregnate. Large batches cannot be washed and rinsed adequately, increasing sealant contamination, which renders many parts unusable or jeopardized their use in assembly.
- There is a high probability of human error. Due to manual control, the operator might pack the basket incorrectly or skip processing steps, potentially damaging parts. With the poor safety record of batch systems, many OEMs began to outsource the process to third-party providers. This allowed OEMs to alleviate risk and focus on their core competencies.

Re-imagining vacuum impregnation

In the early 2000s, many OEMs brought vacuum impregnation in-house, intending to meet the volume demand for lighter, aluminum parts that increased in volume following the introduction of the Corporate Average Fuel Economy (CAFE) standards, and subsequent pressure to produce more fuel-efficient vehicles.

Systems were modernized to meet the demands of the new manufacturing environment. Rather than large, top-loading batch systems new equipment was designed to be front-loading and to process just single pieces or a small number of castings.

Modular vacuum impregnation, like this unit designed by Godfrey & Wing, can be integrated with the overall production process.

Incorporating robotic handling allowed parts to move continuously between each station. The robotics reduced cycle times and improved overall cycle time and production volumes.

Automated impregnation technology then expanded to compact, manually operated systems. This allowed OEMs to bring vacuum impregnation in-house at a fraction of the cost. These new systems were smaller than batch systems and the modular design enabled them to integrate with other production operations.

Now, the operator were safer than ever before as self-contained modules protected them from contact with sealant and hot fluids; mist eliminators collected water vapor in the exhaust and return it through a drain line for re-use and better ergonomics allowed the operator to simply slide a lightweight fixture onto the platform for each module, eliminating the risk of injury.

Improved productivity, quality — The redesign of modern vacuum impregnation systems also has improved recovery rates and cycle times. The old economies of scale have given way to smaller, more efficient systems, which have yielded greater productivity and quality.

New equipment has been designed to function with an automated and repeatable process. With robotics, parts can be impregnated automatically, which reduces the possibility of human error. Stations can contain operator demands of the new manufacturing environment. Rather than large, top-loading batch systems, new equipment is designed to be front-loading and to process just single pieces or a small number of castings.

Robotic handling is incorporated and the use of robotic arms allows parts to move continuously between each station. The robotics reduce cycle times and improve overall cycle time and production volumes.

The next evolution of automated impregnation technology was compact, manually operated HMI and cycle status lights that present real-time process data and fault diagnostics.

As the 21st Century proceeds companies will continue to wrestle with challenging design standards, fewer resources and shorter cycle times. Those that thrive will do so by increasing productivity, quality, throughput and cost reduction.

Ergonomically designed processes include baskets that allow parts to be moved safely between process modules.

The repeatability of modern vacuum impregnation equipment, including the use of robotic handling, eliminates many quality deficiencies of earlier-generation systems for sealing porosity.

The vacuum impregnation systems of the past are no longer competitive, and the most competitive newer systems are those that will continue to offer safety to the operators, with increasing production volumes and the continuing effectiveness at eliminating casting defects.

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