



ASSURANCE

*Quality
Assurance and
Non-Destructive
Testing in*
**Investment
Casting**

Impro

800-800-9756 | sales@improusa.com

www.improprecision.com

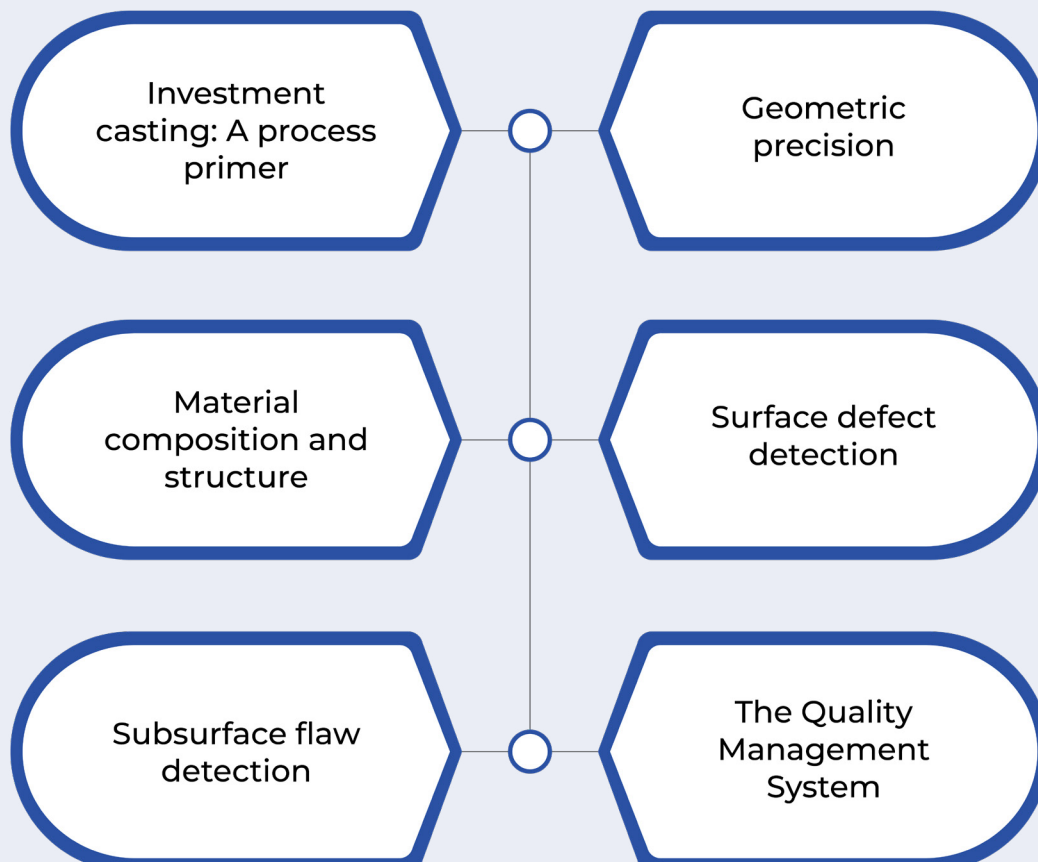
Investment casting is used to create complex metal parts with tight tolerances and thin walls. These are often cast in high-value alloys and go into demanding applications. Many investment cast parts are deployed in environments with high temperatures, corrosive atmospheres, and high loads.

In applications like these the consequences of failure could be catastrophic. A turbine might disintegrate, a pump could fail, and a bracket could shear off. Any of these could be extremely costly, and cause

significant reputational harm to the product manufacturer. To avoid these such parts must be free from all surface and internal defects.

Impro builds quality into investment cast parts through rigorous adherence to a demanding Quality Assurance (QA) system, reinforced by an extensive array of measurement, inspection and analytical equipment. As a leader in investment casting, we believe that what we do to ensure the products leaving our foundries set the standard for the industry.

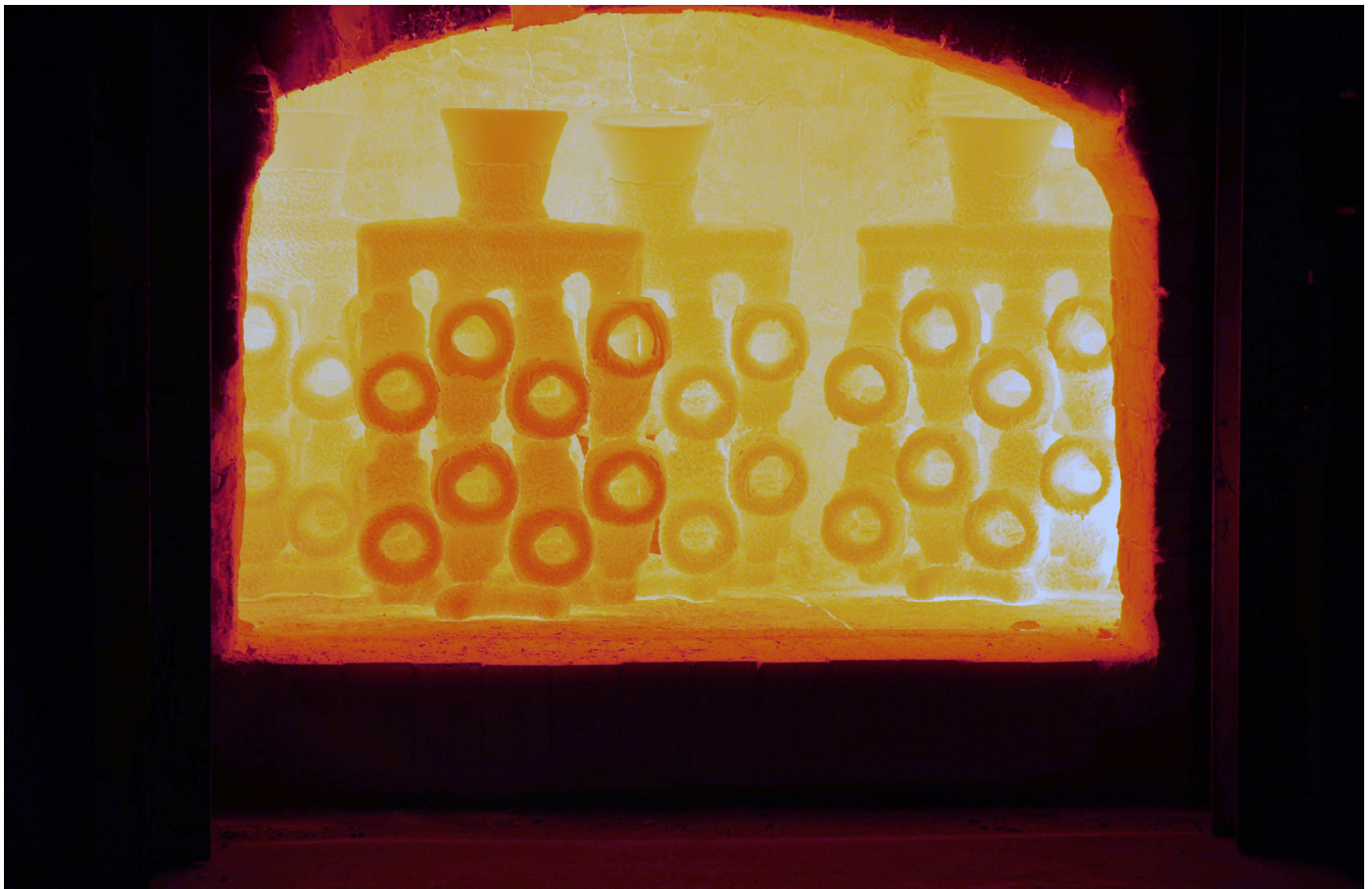
This eBook details what's involved. Individual sections address:



Investment Casting: A Process Primer

In the context of casting, “investment” refers to applying an outer layer or coating over a wax pattern. This coating is dried to form a hard shell and the wax melted out to leave a cavity for metal to be poured into.

Once the metal has solidified the shell is broken apart to release the metal part, along with the metal feeding system.



This process allows the casting of complex features, including re-entrants. It yields excellent surface finishes and is capable of maintaining tight tolerances and producing thin sections. It also avoids parting lines and the need for draft angles on vertical surfaces.

However, the single use nature of both pattern and mold mean it's a complex process. In general, investment casting is reserved for applications maximizing the benefits of reduced machining and assembly.

Geometric Precision

As the wax pattern determines part dimensions, this has to be correct. “Correct” in this context includes allowances for metal shrinkage. Other than for small quantity production, these patterns are injection molded. Initial patterns are inspected on a CMM but once the mold tool is accepted additional checks are unnecessary. Visual inspection is still performed though to check for nonfills or other pattern faults.

As with the pattern, initial castings undergo thorough dimension inspection to verify conformance to print. This is done on a CMM and may require the part to be sectioned to provide access to internal features.



The results of the inspections of the first cast parts are used to refine the pattern and pattern mold tool. Once the cast parts are correct in every dimension there is no need for ongoing dimensional checks, other than on a sampling or audit basis.

Material Composition and Structure

The alloys used to investment cast high quality parts are sourced from reputable vendors and supplied with certificates confirming their composition meets the relevant standards. However, for additional verification Impro maintains in-house analytical capabilities. These include equipment to determine the composition of casting alloys.



The metallurgical structure of the cast part plays a major role in providing the strength and fatigue resistance needed. Cooling and solidification rates determine structure, and these are strongly influenced by the thickness of the shell formed around the pattern. With the traditional dipping process, a foundry didn't have the ability to selectively vary thickness, but that

has changed with modern robotic spraying methods. Thus, by varying shell thickness, it's possible to create local variations in the structure.

Developing a coating process for a specific part therefore requires extensive metallurgical analysis. This includes using tensile testing tools and high resolution metallurgical microscopes.



Once the casting process has been optimized for a specific part there is no need for further rigorous testing. However, audit checks verify the alloy and microstructure remain as in the initial samples that the customer approved.

Surface Defect Detection

The investment casting mold includes channels that take the liquid metal to the mold cavity. The cross-section of these channels determines how quickly the cavity fills. Filling faster increases turbulence in the metal, which risks creating more defects, both internally and on the surface. Fill too slowly though and the metal will start to solidify before the cavity is full.

The most common surface defects are nonfills and cold shuts, (where metal has flowed together from different directions but doesn't fuse because of oxide skins on the approaching metal fronts). A third type of surface defect is cracking. This results from metal shrinkage and is most common around changes in part cross-section.

Nonfills and cold shuts are found by visual inspection. As the investment casting process is developed for a particular part the engineering team look for improvements that will stop these flaws occurring. This isn't always 100% possible, but over time technicians learn which areas of the part are most troublesome, and direct their attention accordingly.

Cracks and cold shuts are often too small for easy detection by the unaided human eye. Consequently, two techniques are used to increase contrast and thereby improve detectability: magnetic particle inspection (MPI), and fluorescent particle inspection (FPI).

MPI is used with non-austenitic, ferrous alloys while FPI is employed elsewhere. The principles are very similar.

In FPI a low viscosity liquid is applied to the surface and drawn in to any cracks present by capillary action. The liquid contains a dye that fluoresces under ultraviolet (UV) light. After cleaning the surface, the technician scans the surface under UV light for evidence of cracks.

In MPI the sample or part being inspected is magnetized, typically by placing it within a magnetic field. This creates a magnetic flux inside the part that gets directed outwards by local discontinuities.

With the part in the magnetic field, a technician coats the surface with a liquid containing ferrous particles. These flow over the surface and are attracted to places where the flux extends outside, accentuating the visibility of surface-breaking cracks.

Subsurface Flaw Detection

While optimizing the investment casting process for a specific part, castings are frequently sectioned for inspection of internal features. This isn't an option once the part has entered production, other than on a sampling basis, so the alternative is to take x-ray images of key features.



Industrial x-ray systems are expensive, largely because of the power needed to get a beam through thick metal. In addition, image evaluation requires a skilled technician.

An advance on 2-dimensional x-ray imaging is computerized tomography

(CT) imaging. This slow and costly process creates 3d images that reveal internal features and, with sufficient resolution, internal defects. Lack of speed and the expense of the equipment means CT inspection of castings is reserved for inspection of the most critical parts, usually on a sample basis.

The Quality Management System

As it's difficult to find internal flaws in cast parts a better approach is to ensure they can't arise. This is achieved by following detailed procedures defined in a Quality Management System (QMS), and ensuring those responsible for process control and product quality have been trained appropriately.



To ensure a QMS has sufficient rigor it's usually measured against a formal, internationally recognized standard, like ISO 9001. Foundries supplying automotive customers often seek certification to the IATF 16949 standard. Those supplying aerospace and defense companies typically follow the National Aerospace and Defense Contractors Accreditation Program (NADCAP).

In addition, foundries that operate rigorous QA systems and conduct extensive NDT inspections ensure their Quality technicians are trained appropriately.

Level 2 NDT certification
shows a technician has the knowledge and skills
needed to carry out NDT work,

while Level 3, the highest
shows a technician can interpret test results, perform
NDT-related problem-solving, and act as an authorized
signatory on test certificates.

A Commitment to Quality

Investment casting is typically used to produce complex, high-value parts, often for challenging, high-stress environments. Avoiding failure requires these parts to be dimensionally correct and free of defects. Inspection and NDT are the main tools, but these must be underpinned by a formal QA system that minimizes deviations from defined practices and procedures.



As an investment casting leader, Impro has committed significant resources to test and analytical capabilities, along with employee training and development and maintenance of a strict QMS. Evidence of this is shown in the form of the many certifications our facilities have earned.



Reliable • Flexible • Global



Contact us Now

800-800-9756 | sales@improusa.com

www.improprecision.com

