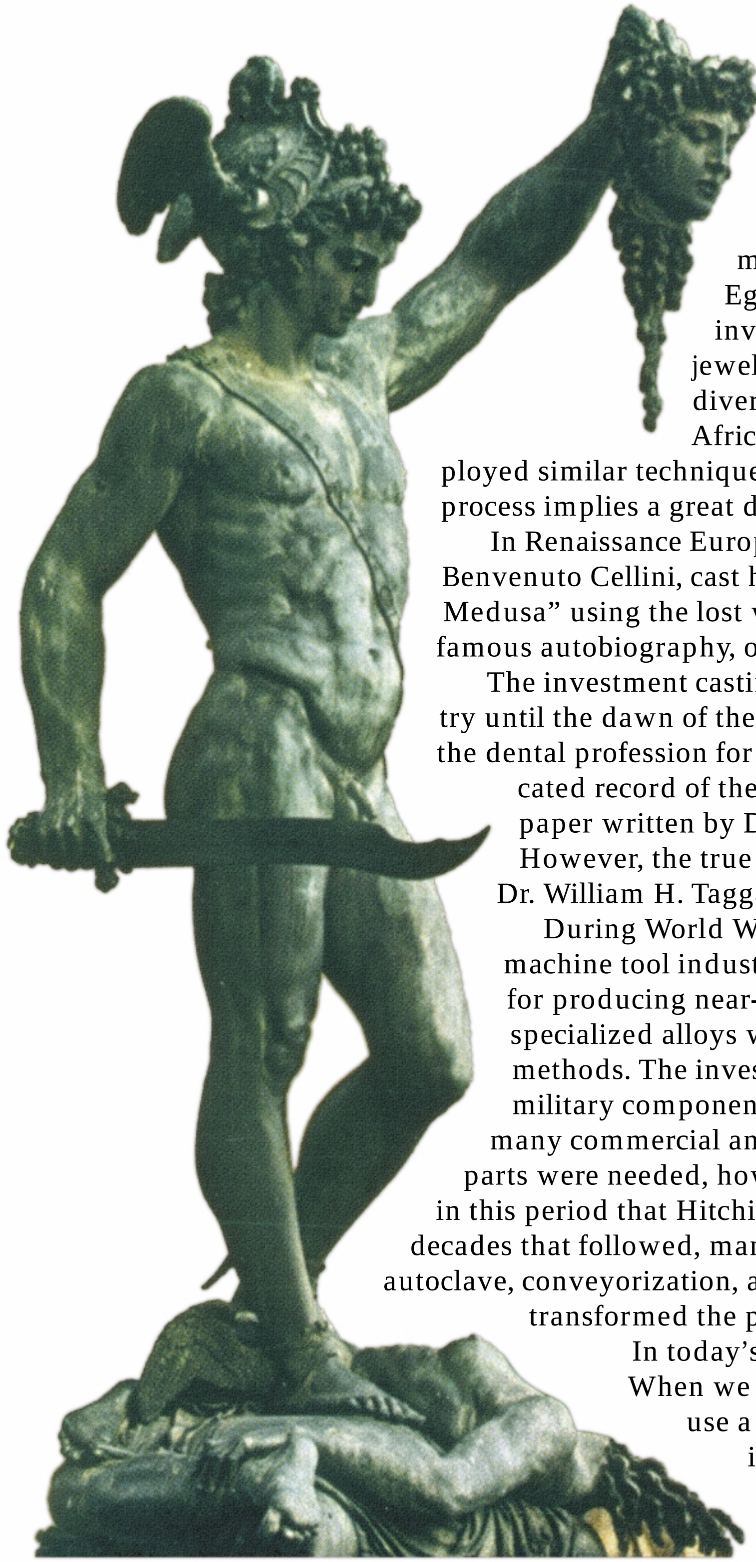
An Introduction to the Investment Casting Process



Cellini's three and one half ton statue of Perseus and the Head of Medusa.

The technique of investment casting is both one of the oldest and most advanced of the metallurgical arts. Investment castings are at work in the fiery combustion chambers of jet aircraft and in the sub-zero vacuum of space. Yet, the root of this technology, the cire perdue or "lost wax" method dates back to at least the fourth millennium B.C. The artists and sculptors of ancient Egypt and Mesopotamia used the rudiments of the investment casting process to create intricately detailed jewelry, pectorals and idols. Remarkably, civilizations as diverse as China's Han Dynasty, the Benin Kingdom in Africa and the Aztecs of pre-Columbian Mexico employed similar techniques. The cross-cultural adoption of this complex process implies a great degree of commerce and communication in antiquity.

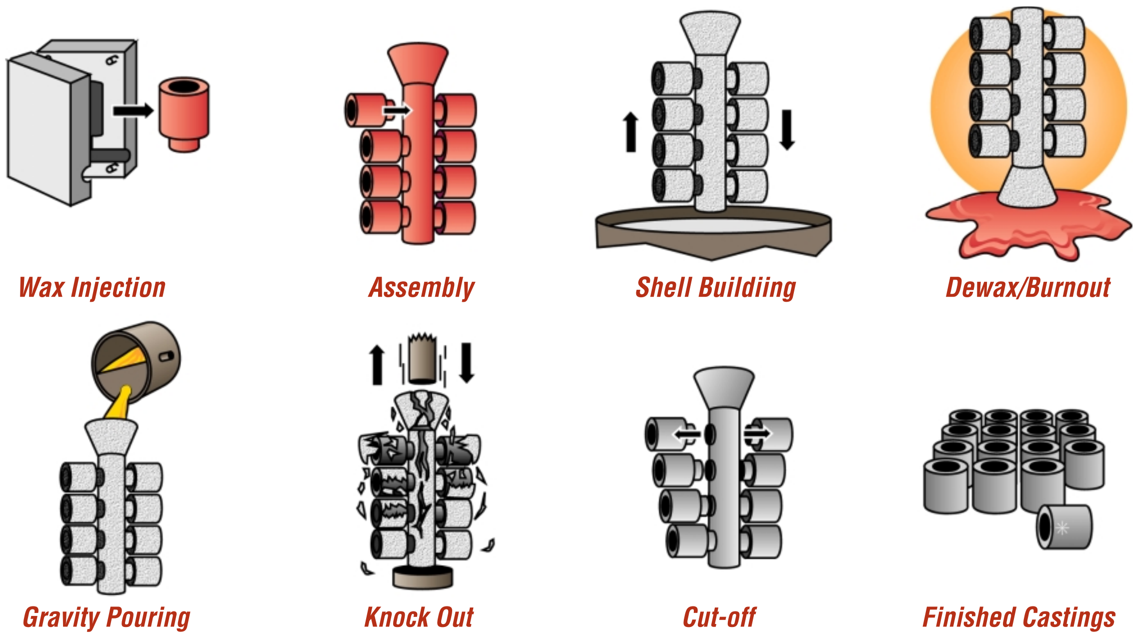
In Renaissance Europe, the Italian Sculptor, goldsmith and author, Benvenuto Cellini, cast his bronze masterpiece "Perseus and the head of Medusa" using the lost wax process. Cellini detailed his achievement in his famous autobiography, one of the classics of world literature.

The investment casting technique was largely ignored by modern industry until the dawn of the twentieth century, when it was "rediscovered" by the dental profession for producing crowns and inlays. The first authenticated record of the use of investment casting in dentistry appears in a paper written by Dr. D. Philbrook of Council Bluffs, Iowa in 1897. However, the true significance of this process was not realized until Dr. William H. Taggart of Chicago published his research in 1907.

During World War II, with urgent military demands overtaxing the machine tool industry, the art of investment casting provided a shortcut for producing near-net-shape precision parts and allowed the use of specialized alloys which could not readily be formed by alternative methods. The investment casting process proved practical for many military components—and during the postwar period it expanded into many commercial and industrial applications where complex metal parts were needed, however, the process was still relatively obscure. It was in this period that Hitchiner Manufacturing Co., Inc. was founded. In the decades that followed, many innovations such as the shell process, the steam autoclave, conveyorization, automation, and robotics have modernized and transformed the process.

In today's world, investment castings touch all of our lives. When we fly on an airplane, drive an automobile, play golf, use a utility tool, power tool or hand tool, we are using investment castings. Once thought of as suitable only for low volume, high cost applications, investment casting has evolved into a technology capable of producing quantities of millions of pieces per year, at costs rivaling those of less flexible and desirable methods.

The Basic Steps in the Investment Casting Process



The investment casting process begins with the production of wax replicas of the desired castings. These replicas, called patterns, are injection molded in metal dies. A pattern must be manufactured for each casting to be produced.

A number of patterns (depending on size and complexity) are attached to a central wax stick, or sprue, to form a casting cluster, or assembly.

After some initial pre-dips, which thoroughly clean the wax, the assemblies are immersed, or “invested,” into a liquid ceramic slurry, and then into a bed of extremely fine sand to form a shell. The first critical layers are often applied by hand. Between each layer the ceramic is allowed to dry. The later, heavier layers are often applied by automated equipment or special shell building robots. Enough layers must be applied to build a shell strong enough to withstand subsequent operations. After the shell is completely dry, the wax is melted out in a high pressure steam autoclave, leaving a hollow void within the mold, which exactly matches the shape of the assembly.

Prior to casting, the shells are fired in an oven where intense heat burns out any remaining wax residue and prepares the mold for the molten metal.

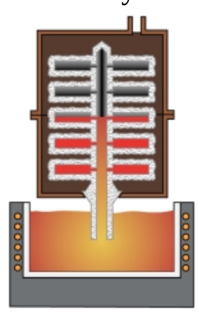
In the conventional gravity pouring method, metal is poured into the shell through a funnel-shaped pour cup and flows by gravity down the sprue channel, through the gates and into the part cavities. As the metal cools, the parts, gates, sprue and pouring cup become one solid casting. After the casting has cooled, the ceramic shell is broken off and the parts are cut from the sprue using a high speed friction saw.

After minor finishing operations, the castings, which are identical in configuration to the wax patterns which shaped them, are ready for certification and shipment to the customer.

Countergravity Casting

Countergravity casting is an innovation pioneered by Hitchiner Manufacturing Co., Inc. In the basic countergravity process, metal is drawn up into the mold by vacuum. After a brief hold time, allowing the parts and a portion of the gate to solidify, the vacuum is released and the metal in the central sprue flows back into the melt. Only a short, easily machined gate stub remains on the casting. Countergravity casting methods have enhanced Hitchiner’s ability to produce high quality, thin-walled castings (Technical Update 2D5).

Many variations of the basic process exist to accommodate specific applications. Countergravity processes provide distinct cost and quality advantages over gravity poured castings. Some of the advantages of countergravity casting are: Improved grain structure, better machining due to fewer inclusions, increased sprue loading, and better mold fill-out, especially in thin sections.



Countergravity Casting