The Investment Casting Process

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Background

- Originally developed by ancient Chinese and Egyptian culture to create artwork
- Primarily used for art until development of the jet turbine engine at the end of World War II
- Since that time it has become an enabling technology in today’s top industries
  - Aerospace and Defense
  - Power Generation
  - Automotive
  - Oil and Gas
  - Space Exploration
  - Medical / Orthopedics
  - Agriculture
  - Construction
  - Commercial and Consumer products
Some of the Benefits of Investment Casting

• Superior surface finish
• Wide range of alloys
• Complex, near net geometries
• Fine detail
The Investment Casting Process
Creating a Wax Pattern

• In today’s manufacturing world, wax patterns are typically made by injecting wax into a metal tool or “die”
  • With the evolution of Additive Manufacturing, patterns can be printed

• In the art community, one of a kind pieces are carved by the artist from wax blocks
  • For multiple castings, a silicon tool is usually made from the artist’s sculpture and wax is injected or poured into the resulting cavity
Wax Tree Assembly

• It is typically uneconomical to make small parts one at a time, so wax patterns are typically attached to a wax “sprue”

• The sprue serves two purposes
  1. Provides a mounting surface to assemble multiple patterns into a single mold, which will be later filled with alloy
  2. Provides a flow path for the molten alloy into the void created by the wax pattern(s)

• The wax between the pattern(s) and the sprue are called “Gates”, because they throttle the direction and flow of the alloy into the void made by the pattern
Shell Building

• The next step in the process is to build a ceramic shell around the wax tree
• This shell will eventually become the mold that metal is poured into
• To build the shell, the tree is dipped into a ceramic bath or “slurry”
• After dipping, fine sand or “stucco” is applied to the wet surface
• The mold is allowed to dry, and the process is repeated a number of times until a layered (or laminated) ceramic mold, capable to undergo the stresses of the casting process, has been built
Dewax / Burnout

• Before pouring metal into the mold, the wax is removed
• This is typically done using a steam-dewax autoclave, which is like a large, industrial pressure cooker
• Another method is the use of a flash fire oven, which melts and burns off the wax
• Many foundries use both methods in concert
  • Autoclave removes the majority of the wax, which can be reconditioned and reused
  • Flash fire burns off residual wax and cures the shell, readying it for casting
Metal Pouring

• Before the metal is poured into the ceramic mold or “shell”, the mold is preheated to a specific temperature to prevent the molten alloy from solidifying or “freezing off” before the entire mold is filled

• Alloy is melted in a ceramic cup (called a crucible) using a process known as induction melting
  • A high frequency electric current creates a magnetic field around the alloy, generating electric fields inside the metal (eddy currents)
  • The eddy currents heat the alloy due to the material’s electrical resistance

• When the alloy reaches its specified temperature, it is poured into the mold, and the mold is allowed to cool
Shell Knock Off

• Once cool, the shell material is removed from the metal
• This is typically done via mechanical means
  • Hammer
  • High Pressure Water Blast
  • Vibratory Table
• Shell removal can also be accomplished chemically, using a heated caustic solution of either potassium hydroxide or sodium hydroxide, but this approach is being phased out due to environmental and health concerns
Cut Off

• Once the shell material has been removed, the parts are cut off the sprue and the gates are ground off

• Part cut off can be done manually
  • Chop saw
  • Torch
  • Laser (limited applications)

• Parts can also be cut off using automation, that is, the mold can be secured using a fixture on a programmable cut off saw
Individual Castings

• Once the parts are removed from the sprue, and the gates removed, the surface can be finished via a number of means
  • Vibratory/Media finishing
  • Belting or hand grinding
  • Polishing

• Finishing can be done by hand, but in many cases it is automated

• Parts are then inspected, marked (if required), packaged and shipped

• Depending on the application, the parts can be used in their “net shape” or undergo machining for precision mating surfaces
Summary

• From Egypt and China to modern day manufacturing, investment casting has evolved from an art to a high technology enabler

• In our everyday lives, investment castings can be found all around us
Questions?

Call the Investment Casting Institute at 201-573-9770.