Description

Image

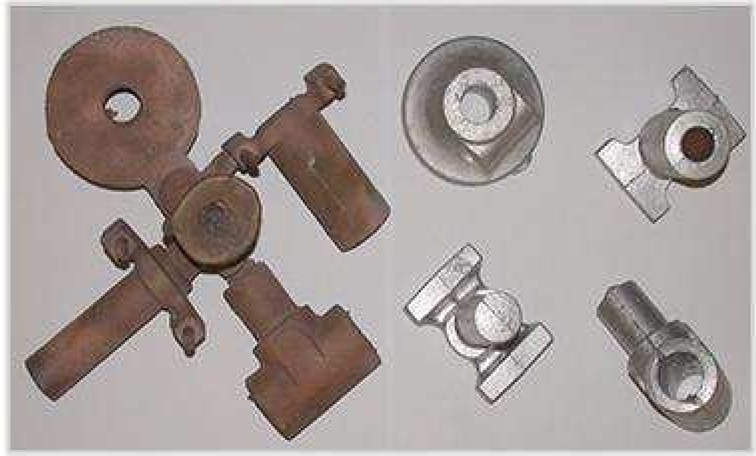


Image caption

(1) Making a building sign © MetalShaper at Wikimedia Commons (CC BY 3.0) (2) Two sets of castings (bronze and aluminium) from the sand mold © Glenn McKechnie at Wikimedia Commons (CC BY 2.0)

The process

SAND CASTING probably started on beaches -- every child knows how easy it is to make sand castles. Add a binder and much more complex shapes become possible. And sand is a refractory; even iron can be cast in it. In GREEN SAND CASTING, a mixture of sand and clay is compacted in the split mold around a pattern that has the shape of the desired casting. The pattern is removed to leave the cavity in which the metal is poured. Cheap wooden patterns, with gates and risers attached, are used when the batch size is small and the process is manual, but this is slow and labor intensive. Automated systems use aluminum patterns and automated compaction. The sand mold is referred to as 'green' when it is used in a moist condition. Dry sand molds are stronger and more rigid, and thus are used in making large heavy castings.
In CO2 /SILICATE SAND CASTING, a mixture of sand and sodium silicate binder is packed around a pattern as before and flooded with CO2 to seal the sodium silicate gel. The mold is, in principle, reusable, but deteriorates quickly. In EVAPORATIVE SAND CASTING, the pattern is made from polystyrene foam, and is first coated with a refractory coating and then embedded in dry, unbonded sand. When molten metal is poured into the mold, the polystyrene pattern vaporizes. Very complex shapes of undercuts at re-entrant angles are feasible without the use of cores. In SHELL CASTING, a mixture of fine-grained sand and thermosetting resin is applied to a heated metal pattern (aluminum or cast iron) and cured to form a shell. Two matching shells are then joined to form a complete mold which is then placed in a frame packed with sand. The process gives good surface finish and better dimensionality than conventional sand casting.

Process schematic

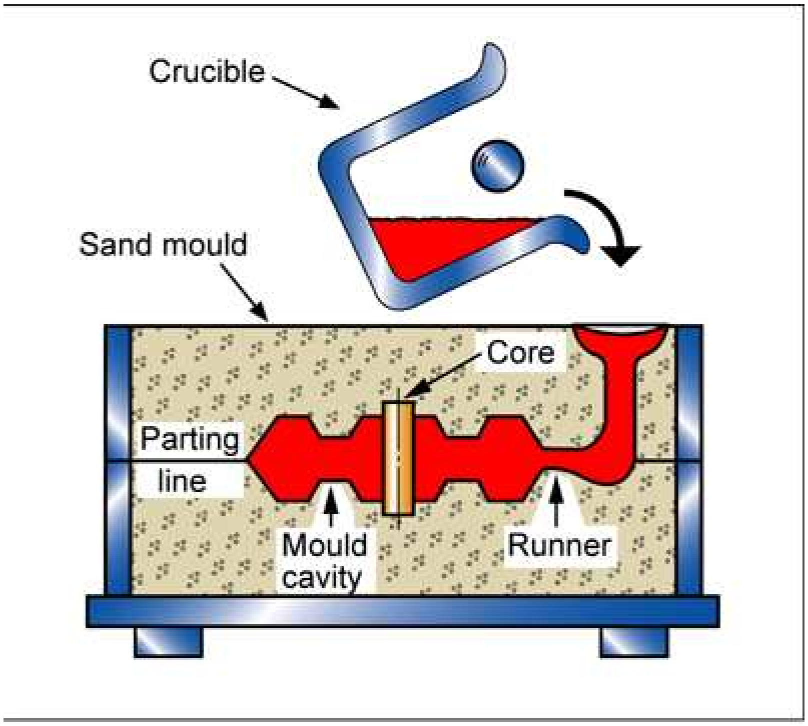


Figure caption

Green sand casting

Material compatibility

Metals - ferrous	✓
Metals - non-ferrous	✓

Shape

Circular prismatic	✓
Non-circular prismatic	✓
Solid 3-D	✓
Hollow 3-D	✓

Economic compatibility

Relative tooling cost	low			
Relative equipment cost	low			
Labor intensity	high			
Economic batch size (units)	1	-	1e5	

Physical and quality attributes

Mass range	0.022	-	2.2e4	lb
Range of section thickness	118	-	3.93e4	mil
Tolerance	31.5	-	118	mil
Roughness	0.787	-	7.87	mil

Surface roughness (A=v. smooth)	C

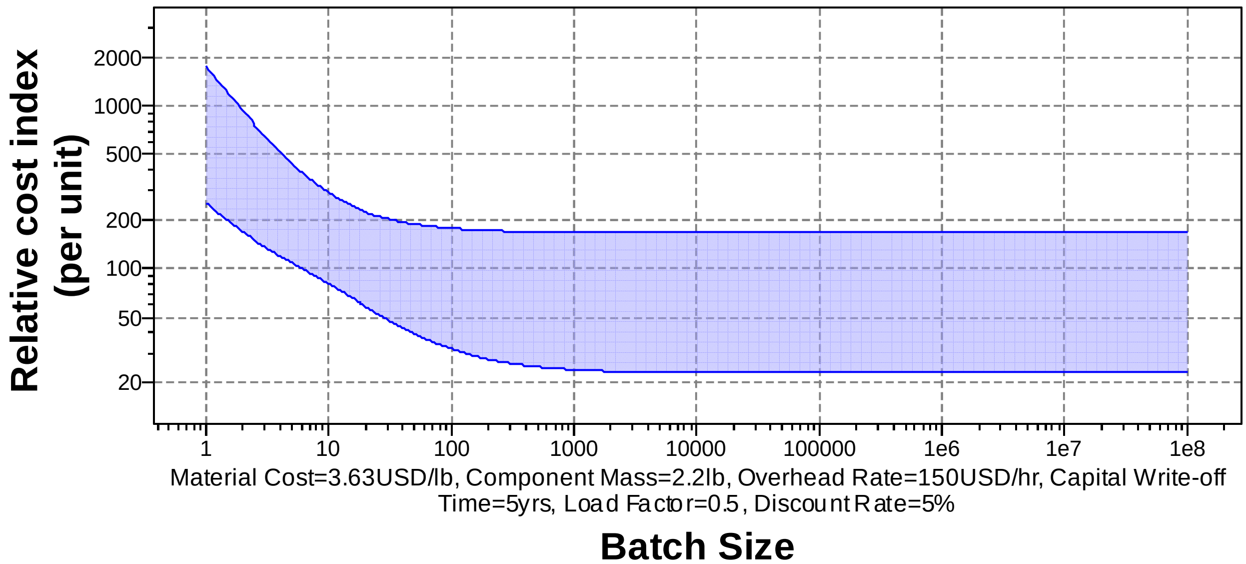
Process characteristics

Primary shaping processes	✓
Discrete	✓
Prototyping	✓

Cost model and defaults

Relative cost index (per unit)	* 23.7	-	167

Parameters: Material Cost = 3.63USD/lb, Component Mass = 2.2lb, Batch Size = 1e3, Overhead Rate = 150USD/hr, Discount Rate = 5%, Capital Write-off Time = 5yrs, Load Factor = 0.5



Capital cost	* 1.64e3	-	8.2e3	USD
Material utilization fraction	* 0.6	-	0.8	
Production rate (units)	1	-	20	/hr
Tooling cost	* 164	-	1.64e3	USD
Tool life (units)	* 100	-	1e3	

Supporting information

Design guidelines

Few processes are as cheap and versatile as sand casting for shaping metals. It allows very complex shapes, but the surface is rough and the surface detail is poor. The process has particular advantages for complicated castings with varying section thickness. Bosses, undercuts, inserts and hollow sections are all practical. Evaporative pattern casting leaves no parting lines, reducing finishing requirements. The minimum wall thickness is typically 3mm for light alloys, and 6mm for ferrous alloys.

Technical notes

In principle, any non-reactive, non-refractory metal (one melting at less than 1800 C) can be sand cast. In particular, aluminum alloys, copper alloys, cast irons and steels are routinely shaped in this way. Lead, zinc and tin can be cast in dry sand, but melt at too low a temperature to evaporate the foam pattern in evaporative pattern casting.

Typical uses

Machine tool basis, structures, compounds, auto engine blocks, cylinder heads, transmission cases, gear blanks, crankshafts, connecting rods. Evaporative pattern casting: manifolds, heat exchangers, pipe fittings, valve casings, other engine parts.

The economics

Capital and tooling costs for manual sand casting are low, making the process attractive for small batches. Automated systems are expensive, but capable of producing very complex castings.

The environment

Fine silica dust and organic additives may create a health hazard, requiring proper ventilation. The mold materials, in many cases, can be reused.

Links

MaterialUniverse

Reference