PERMANENT MOLD PROCESS

PERMANENT MOLD CASTING

Permanent Mold refers to the tooling used to produce the castings. The molds or dies are usually made of high alloy iron or steel (both very dense) and have a production life of 100,000 + castings.

HOW IT WORKS

The cavity surfaces of the mold are coated with a thin layer of heat resistant material such as clay or sodium sulfate.

The metal molds that consist of two or more parts are then assembled.

The molds are preheated to a set temperature and through the use of water-cooling and other radiation techniques a very close thermal balance is maintained.

Once to temperature the molten metal is poured into a sprue at the top of the mold.

The metal flows into the mold cavity through the runner system by the pressure and velocity induced by gravity.

When the metal has solidified, the mold is opened and the casting is removed.

The gating system is then trimmed from the casting; it is ground and prepared for shipping.

Subsequently, another casting is poured in the same mold cavity.

SEMI-PERMANENT MOLD

Semi-Permanent Mold refers to a casting produced using a sand core to form an internal passage. As the metal flows into the mold it surrounds the sand core while filling the mold cavity. When the casting is removed from the mold the sand core is removed from the casting leaving an internal passage in the casting.

For more information or a competitive quote please contact:

TOM CLARK

McCann Sales, Inc. Ph: 207-439-3747

E-mail: tclark@maine.rr.com

PERMANENT MOLD CASTING

TILT POURING

The tilt pouring process was developed to eliminate top pouring and pouring down vertical gating systems that could generate dross in the casting.

In the tilt-pour process, with the parting line of the mold in the horizontal position, molten aluminum is ladled into a 'pour cup' attached to the mold. The tilt-pour casting machine then rotates 90 degrees at a slow and controlled rate. As the metal travels down the runner system, it enters the mold cavity smoothly reducing turbulence and oxide.

LOW PRESSURE PERMANENT MOLD

This process automatically or semi automatically supplies liquid metal from a furnace, under pressure, up to 1 atmosphere, to a mold or die. This allows the metal to not only fill the contours of the casting shape but to feed the shrinkage while the solidification of the casting progresses to completion. Compared to the traditional permanent mold process low-pressure permanent mold yields mechanical properties approximately 5% superior. The yield is generally greater and thinner walls can also be produced.

THE CASTING PROPERTIES

Due to the chilling nature of the steel tooling the castings are very sound. This lends the process to parts that need to be pressure tight and that need to have very little porosity.

For more information or a competitive quote please contact:
TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

PERMANENT MOLD CASTING

The Permanent Mold Process offers:

- High mechanical properties
- Dimensional repeatability
- Good surface finish
- Reduced machining for a total lower cost

Typical parts:

- Gears
- Gear Housings
- Splines
- Fittings
- Ornamental Work
- Hardware Items

Other Permanent Mold Castings:

- Slush Casting
- Corthias Casting
- Vacuum Permanent Mold Casting

For more information or a competitive quote please contact:

TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

MECHANICAL PROPERTY LIMITS FOR COMMONLY USED PERMANENT MOLD CASTING ALLOYS

Alloy	Temper	Ultimate (ksi)	Yield (ksi)	% Elongation	Hardness
		1000 PSI	.2% offset		Brinell
356	F	19	- -	2	40 - 70
356	T51	23	16	- -	45 - 75
356	T6	30	20	3	55 - 90
A356	T6	34	24	3.5	70 - 105
319	F	23	13	1.5	55 - 85
319	T5	25	- -	- -	65 - 95
319	T6	31	20	1.5	65 - 95
535	T5	35	18	9	60 - 90

Note: The above properties are believed to be correct, but are not warranted in any way by McCann Sales, Inc. "F" as cast condition

GENERAL DESIGN DATA

SIZE RANGE: Up to 100 lbs.

METALS: Al, Bz, Iron, Lead

TOLERANCES: +/- .015" for 1" then add +/- .002 inches/inch

PARTING LINE SHIFT: +/- .010 to .030"

AVERAGE TOOLING COST: $ 5,000 to $ 15,000

TYPICAL ORDER QUANTITY: 500 +

AVERAGE TOOLING LEADTIME: 8 to 20 weeks

SURFACE FINISH: 150 to 300 RMS

MINIMUM SECTION THICKNESS: .125 " premium / .187" average

MINIMUM DRAFT REQUIRED: 2 to 4 Degrees

Note: The above information is meant to be a basic guideline for comparison purposes only.

For more information or a competitive quote please contact:

TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

GRAPHITE PERMANENT MOLD PROCESS

WHERE IT STARTED

The Graphite Permanent Mold Process was developed in Canada by Frank Cash and is now owned by Ligon Industries. Due to its proprietary nature the specific details of the process cannot be discussed. However, just like Steel Die Permanent Mold, metal is poured into a mold and the casting cavity is filled by the pressure and velocity induced by gravity. Please review the following information when designing your casting.

WHAT MAKES US UNIQUE

In the Graphite Permanent Mold Process, we are capable of utilizing soft tooling to produce tight tolerance, thin wall castings. Typically, we can have first article in 4 weeks. Since our tooling is soft, we are capable
of quick changes at the lowest possible cost.

Due to our unique molding method, we are able to produce casting to .090 wall thickness with superior finishes and excellent metallurgy.

Our team of experts is dedicated to creating solutions to satisfy your casting demands. We constantly strive to challenge our organization to understand and meet the requirements of an ever-changing marketplace.

For more information or a competitive quote please contact:

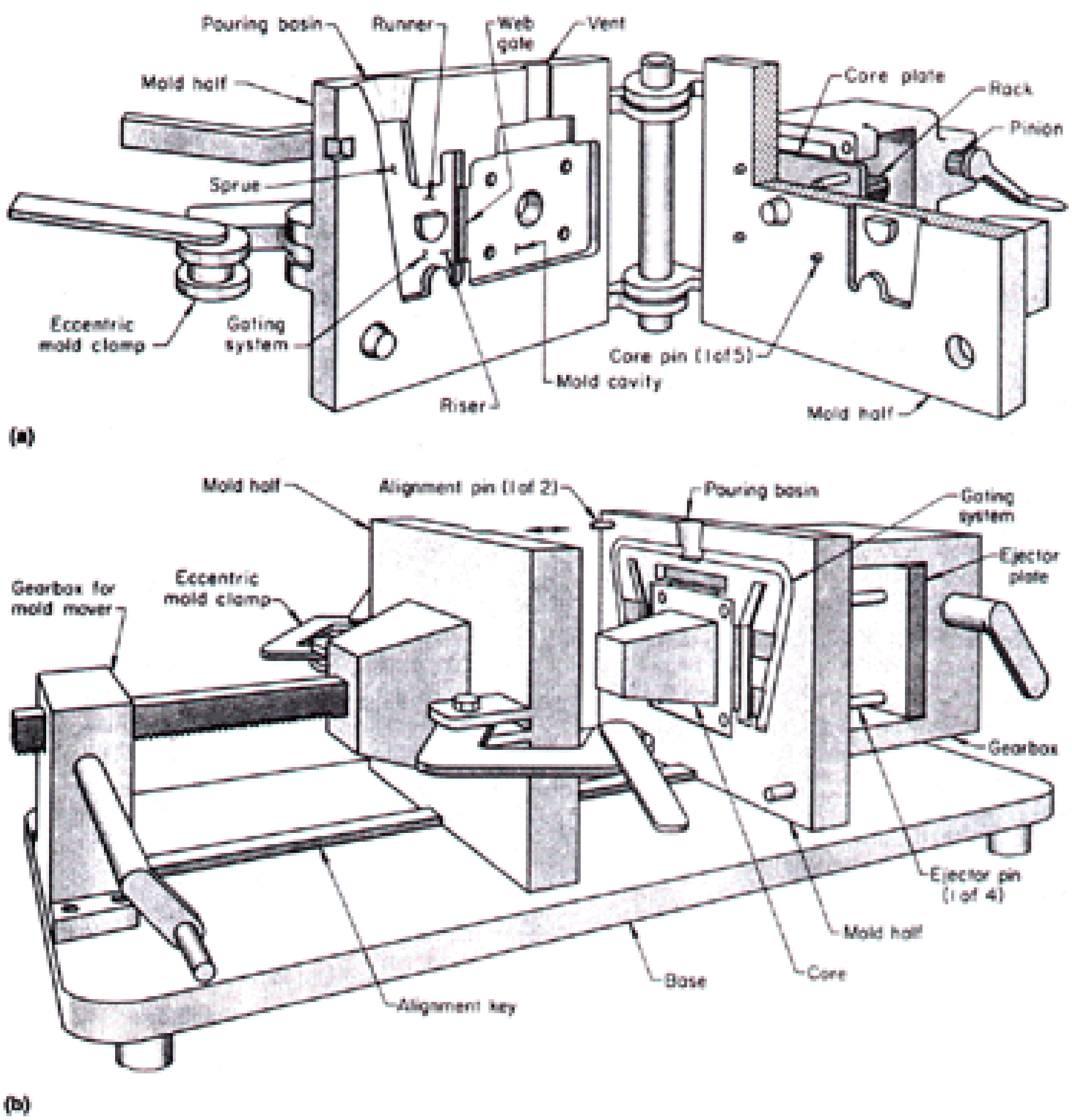
TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

GRAPHITE PERMANENT MOLD

The Graphite Permanent Mold process has been utilizing ZA-8, ZA-12 and ZA-27 to produce high quality, precision castings with very good surface quality for years. RECENTLY K CAST HAS DEVELOPED A PROPRIETARY PROCESS IN WHICH THEY CAN POUR ALUMINUM ON A PRODUCTION BASIS INTO THE CARBON BASED MOLD MATERIAL.

HOW IT WORKS

You first start with a block of graphite, which is used for the mold medium. Once the casting design is finalized the graphite is CNC machined to form the pattern tooling. Once the pattern is complete it is mounted in a molding machine something like the one shown below.



For more information or a competitive quote please contact:

TOM CLARK

McCann Sales, Inc. Ph: 207-439-3747

E-mail: tclark@maine.rr.com

GRAPHITE PERMANENT MOLD

Once mounted the mold is then heated and maintained at a specific temperature. The reason that the mold is heated is so that the metal solidifies more slowly. By slowing down solidification and controlling metal flow through our gating system, the process is able to yield very good grain structures and mechanical properties. Once the metal has solidified, the mold is opened and ejector pins push the casting out. Although the process if able to achieve CLOSE TO DIE CAST TOLERANCES because of slower fill time and lower metal pressure the process can not:

Produce the very thin walls that are possible with die-casting.
Produce the same out of mold surface finishes that are possible with die-casting.
Produce as the high volumes that are possible with die-casting.

However, Graphite Permanent Mold castings do have their advantages:

ADVANTAGES

- The KCAST Process utilizes special soft tooling which allows the use of CAD models to produce finished castings in less than 4 weeks.
- The KCAST Process allows virtual duplication of die cast parts. The tolerances are typically equal to NADC standards.
- The KCAST Process allows thick and thin wall castings to be produced. Walls can typically be made to .090”.
- The KCAST Process allows smooth flow of the aluminum and yields a fine finish – usually 50 to 90 RMS.
- Because of the unique KCAST Process, changes can be easily made to the design. A sample of the revised part can typically be made within 72 hours of receipt of a good CAD file.
- The KCAST Process is cost-effective for up to 10,000 castings.
- Part-to-part repeatability is very close to those attained by Die Casting.
- Unlimited Tool Life.
- The advantages of graphite are its high thermal conductivity, stability and minimal expansion.

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TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

DESIGN DATA – DRAFT REQUIREMENTS

DRAFT REQUIREMENTS **KP-E2**

All walls on castings that are perpendicular to the parting line require draft or taper. This draft is not constant. It will vary with the length of draw (l).

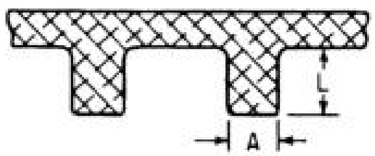


Fig. 1

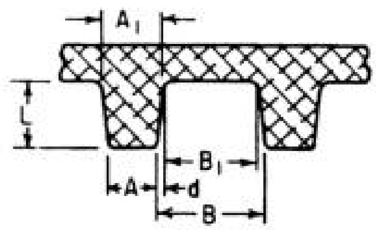


Fig. 2

Normally the drawing does not show draft (fig.1) standard foundry practice is to add draft to the part. To avoid misunderstanding, this is synonymous with saying it will add metal to the casting, thereby adding mass.
Draft D will be added to A increasing its size to A1 . Note that added draft affects dimension by decreasing its size to B1. This is shown in figure 2.

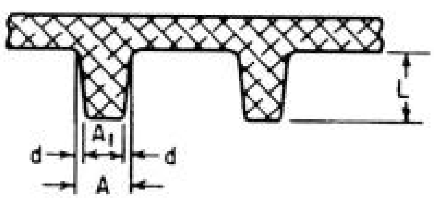


Fig. 3

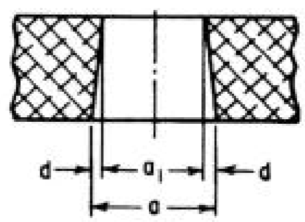


Fig. 4

Draft may be removed if desired but must be specified on drawing, as shown in figure 3. In holes draft will be added to A decreasing its size to A1, (see figure 4). When the designer desires a hole dimension to become larger for reasons such as clearance, he should specify.

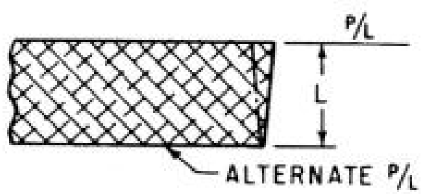


Fig. 5

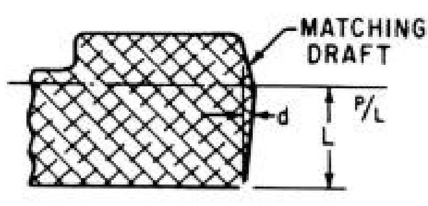


Fig. 6

The direction in which draft is applied is governed by location of parting line and will be at KCAST Pattern's discretion unless otherwise specified. Figure 5. And figure 6.

For more information or a competitive quote please contact:
TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

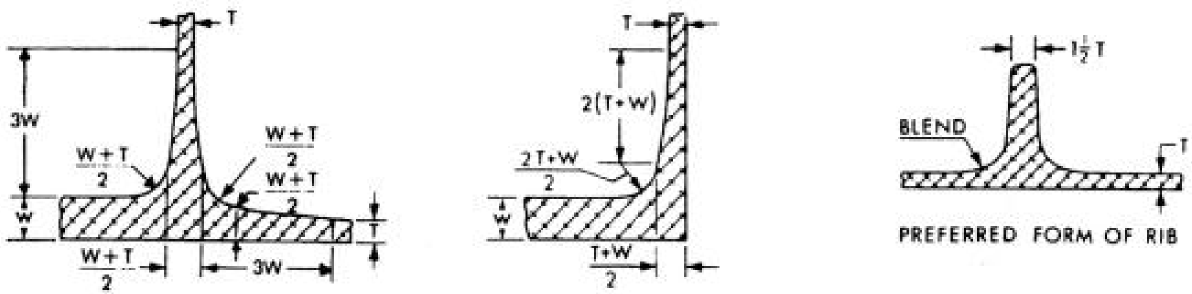
DESIGN DATA – WALLS AND RIBS

WALLS AND RIBS

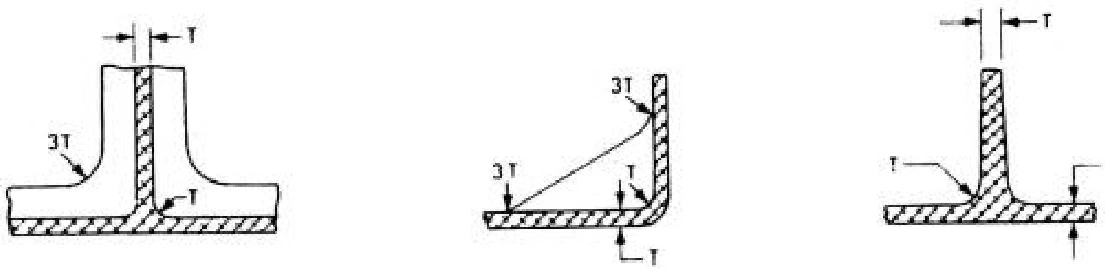
NOTE: The following is not to be considered an Engineering Standard but rather a guide to good casting design.

A production problem of fundamental importance to foundries is establishing a sequence of progressive solidification that will compensate for the change in unit volume as the cast shape solidifies. The designer should,wherever possible, use sections that are tapered to increase in thickness toward points accessible to feed metal. If it is necessary to join light and heavy sections, a gradual increase in thickness is most desirable. If tapered sections are not practical or the increased expense of building the pattern or mold is not warranted, a uniform section should be maintained. Intersecting surfaces forming junctions of metal thickness should be joined with fillets in order to obtain improved foundry characteristics and a more uniform distribution of stress in service.

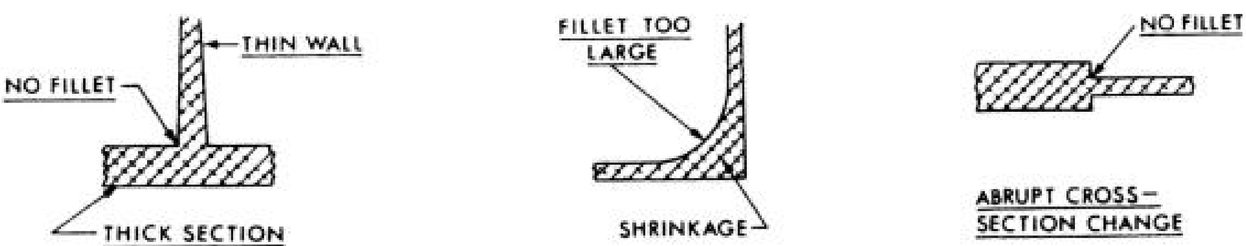
RECOMMENDED DESIGN



GOOD DESIGN



POOR DESIGN



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TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

DESIGN DATA – FLATNESS / STRAIGHTNESS

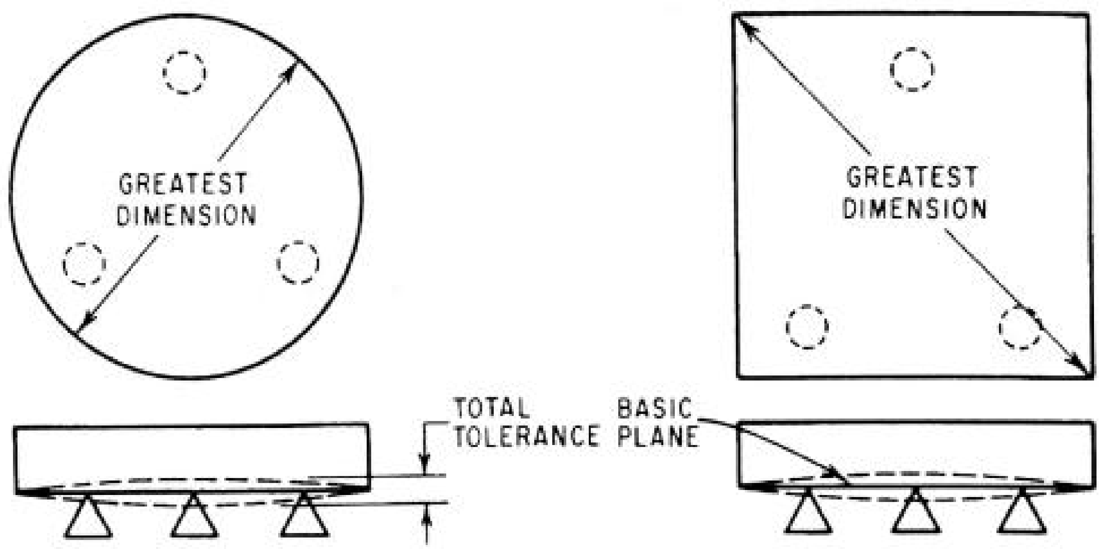
FLATNESS
STRAIGHTNESS

KP ES-10

Flatness: Flatness is the condition which exists when all points on a surface lie in the same plane. The surface of castings can be measured for flatness by supporting the surface in question by three widely separated points to establish the basic plane. The flatness variation is the deviation from the plane as measured by coordinate measuring machine or dial indicator.

Flatness Tolerance: a flatness tolerance is the total deviation permitted from a plane and consists of the distance between two parallel planes within which the entire surface must lie.

Straightness: Straightness is that condition which, when matched with a straight edge of a true flat surface, will permit full line contact along the full length.



GREATEST DIMENSION	CASTING TOLERANCE
0 THRU 3 INCHES	.005
EACH ADDITIONAL INCH	.003

Tolerances closer than the above are obtainable but may require gauges or fixtures at an additional cost.

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McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

MECHANICAL PROPERTY LIMITS FOR COMMONLY USED PERMANENT MOLD CASTING ALLOYS

Alloy	Temper	Ultimate (ksi)	Yield (ksi)	% Elongation	Hardness
		1000 PSI	.2% offset		Brinell
356	F	19	- -	2	40 - 70
356	T51	23	16	- -	45 - 75
356	T6	30	20	3	55 - 90
A356	T6	34	24	3.5	70 - 105
319	F	23	13	1.5	55 - 85
319	T5	25	- -	- -	65 - 95
319	T6	31	20	1.5	65 - 95
535	T5	35	18	9	60 - 90

Note: The above properties are believed to be correct, but are not warranted in any way by McCann Sales, Inc. “F” as cast condition

GENERAL DESIGN DATA

SIZE RANGE: Up to 6 lbs.

METALS: Al 356, Al 319, ZA-12, ZA-27

TOLERANCES: +/- .005” for 1” then add +/- .002 inches/inch

PARTING LINE SHIFT: +/- .005”

RADII: Min. requirement .101”

AVERAGE TOOLING COST: $ 3,000 to $ 9,000

TYPICAL ORDER QUANTITY: All

AVERAGE TOOLING LEADTIME: 2 to 4 weeks

SURFACE FINISH: 63 to 90 RMS

MINIMUM SECTION THICKNESS: .090 “ premium / .120” average

MINIMUM DRAFT REQUIRED: 1 Degree

HOLES: Minimum holes size .125”

SLIDE AREAS: Up to 5 square inches add +/- .005” for 1” and add .003” inches/inch thereafter.

Note: The above information is meant to be a basic guideline for comparison purposes only.

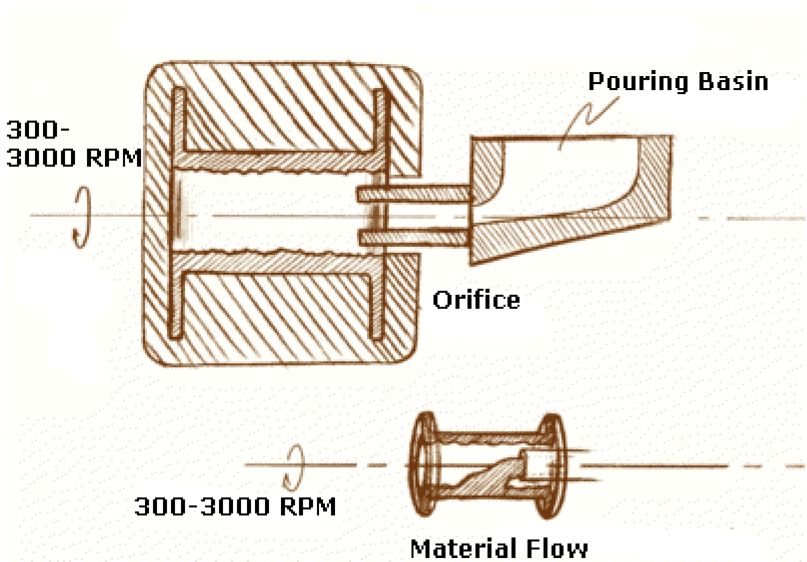
For more information or a competitive quote please contact:

TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

CENTRIFUGAL CASTING PROCESS

CENTRIFUGAL CASTINGS

Centrifugal Castings are produced by pouring molten metal into a permanent mold that is rotated about its axis at high speeds (300 to 3000 rpm). The molten metal is centrifugally thrown towards the inside mold wall, where it solidifies after cooling. The axis of rotation may be horizontal or inclined at any angle up to the vertical position. The speed of rotation and metal pouring rate vary with the alloy and size and shape being cast. The casting is usually a fine grain casting with a very fine-grained outer diameter, which is resistant to atmospheric corrosion, a typical situation with pipes. The inside diameter has more impurities and inclusions, which can be machined away.



CENTRIFUGAL CASTING

The uniformity and density of centrifugal castings approaches that of wrought material, with the added advantages that the mechanical properties are nearly equal in all directions. Since no gates and risers are used, the yield or ratio of casting weight-to weight of metal poured is high.

The mold may be made of cast iron or steel, copper, graphite, ceramic, or dry sand. Only cylindrical shapes can be produced with this process. Size limits are up to 10 feet diameter and 50 feet length ranging from ounces to 50,000 pounds.

For more information or a competitive quote please contact:
TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

CENTRIFUGAL CASTINGS

Wall thickness can be 0.1 - 5.0 in. The tolerances that can be held on the OD can be as good as 0.1 in and on the ID can be 0.15 in.

TYPICAL MATERIALS:

1. IRON
2. STEEL
3. STAINLESS STEELS
4. ALUMINUM
5. COPPER
6. NICKEL

TYPICAL PARTS:

1. PIPES
2. BOILERS
3. PRESSURE VESSELS
4. FLYWHEELS
5. CYLINDER LINERS
6. PARTS THAT ARE AXIS-SYMMETRIC

For more information or a competitive quote please contact:

TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

LOST
FOAM
PROCESS

Lost Foam

Pre-forms of the parts to be cast are molded in expanded polystyrene (or other expandable polymers) using aluminum tooling. Gluing EPS moldings together can form complex shapes. The pre-forms are assembled into a cluster around a sprue then coated with a refractory paint. The cluster is invested in dry sand in a simple molding box and the sand compacted by vibration. Metal is poured, vaporizing the EPS pre-form and replacing it to form the casting.

SPECIAL CHARACTERISTICS OF LOST FOAM CASTING

High production rates are possible

High dimensional accuracy is achieved

No cores are needed

Complex shapes can be cast

Machining can be eliminated

Expensive tooling restricts the process to long run castings

Long lead times are needed to develop new castings

For more information or a competitive quote please contact:
TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

CERAMIC MOLD PROCESS

CERAMIC MOLD CASTING

The CERAMIC MOLD CASTING uses permanent patterns made of plaster, plastic, wood, metal or rubber and utilizes fine grain zircon and calcined, high-alumina mullite slurries for molding. These slurries are comparable in composition to those used in investment castings. Like investment molds, ceramic molds are expendable. However, unlike the monolithic molds obtained in investment castings, ceramic molds consist of a cope and a drag setup.

How it Works

1. The ceramic slurry is poured over the pattern.
2. It hardens rapidly to the consistency of rubber.
3. It is then peeled from the pattern and reassembled as a mold.
4. The volatiles are removed using a flame torch or in a low temperature oven.
5. It is then baked in a furnace at about 1000 degrees Celsius or 1832 degrees farenheight yielding a ceramic mold.
6. The mold is now capable of high temperature pours.

The process is expensive but can produce castings with fine detail, smooth surfaces and a high degree of dimensional accuracy.

MINIMUM SECTION THICKNESS: .050”

SIZE RANGE: Ounces to tons

DRAFT ALLOWANCE: 1 Degree

PARTING LINE SHIFT: .012”

For more information or a competitive quote please contact:

TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

CERAMIC MOLD CASTING

TYPICAL MATERIALS:

7. STEEL
8. STAINLESS STEELS
9. BRONZE

TYPICAL PARTS:

7. IMPELLERS
8. COMPLEX CUTTING TOOLS
9. PRECISION PARTS

CERAMIC MOLDING is used for the production of precision castings to large for the investment process. It is also used for lower quantities and for quick turnaround parts on a low volume basis.

For more information or a competitive quote please contact:
TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

PLASTER
MOLD
PROCESS

Plaster Mold

The plaster mold casting process is a specialized process used typically for short run and prototype castings. The plaster molds are made from a mixture of metal casting plaster, talc or other refactory materials and water, once combined they form a slurry.

The slurry is poured manually from the mixer into a flask containing the pattern. The slurry takes less than 15 minutes to set and form the mold. The mold is then vented and removed from the pattern. To prevent the mold from sticking to the pattern, a parting compound is applied, allowing for an easier release.

The molds must then be dried in an oven until there is no more moisture present. As a result, no gases or steam form when molten metal is poured into the mold.

The mold halves are then assembled along with any cores (Cores are used to form hollows and undercuts in the casting) that are needed to form the final mold that will produce the casting.

Metal is then poured into the molds and after the casting solidifies, the plaster is broken away and the cores are washed out. The gating system is then removed and the casting is finish ground.

ALLOYS

Only non-ferrous alloys can be poured with the plaster mold process. Typical alloys are Aluminum, Zinc, Brass, and Magnesium.

TOOLING

Both ridged and flexible patterns are used. Rigid patterns are usually sealed wood, metal or plastic. Flexible patterns, made from silicone rubber, are often used.

For more information or a competitive quote please contact:
TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

PLASTER MOLD

ADVANTAGES

The ability to produce complex shapes

The ability to produce thin section castings

The excellent replication of pattern detail

The ability to produce castings, which are dimensionally accurate

The ability to produce castings with good surface finish

DISADVANTAGES

Poor productivity due to lengthy processing problems

The need for multiple patterns to improve molding productivity

The requirement for close control of the production process

The need for special procedures to overcome the problems of poor mold permeability

The possibility of impaired mechanical properties arising as a result of slow cooling of the casting

The mold materials are not reclaimable

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TOM CLARK
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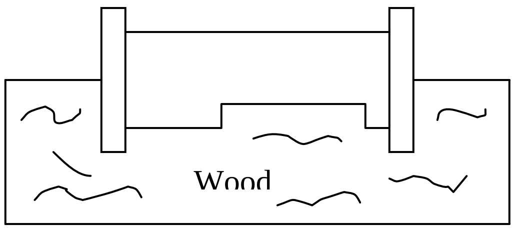
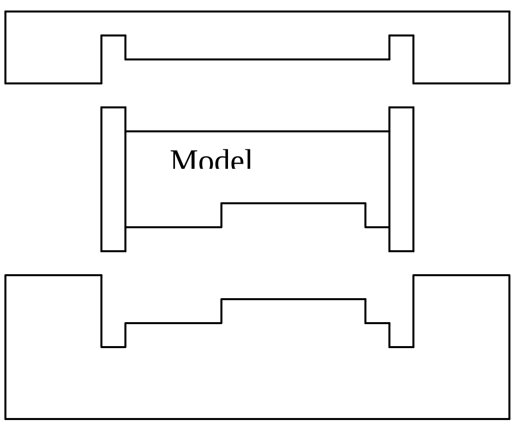
E-mail: tclark@maine.rr.com

Plaster Mold

1. MAKE MODEL: Materials can be wood, metal or plastic.

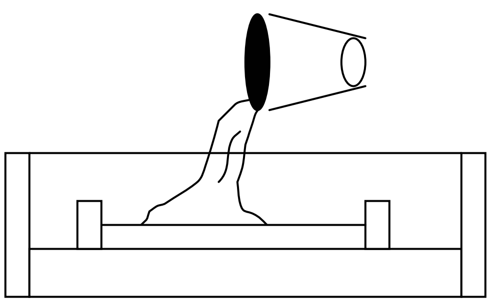


2. PARTING BOARD OR JOINT: Pattern can be run " loose" at this stage for small quantities.



3. MAKE RESIN NEGATIVES: Materials can be epoxy, urethane or plaster.

4. MAKE COPE AND DRAG PATTERN: Materials can be resin, urethane or rubber.



5. MAKE PLASTER MOLD: Pour the plaster, also known as liquid slurry.

6. BAKE MOLDS: Bake at 500^0 for 6 – 24 hours to remove moisture.
7. POUR CASTING: Use gravity or pressure of vacuum.
8. COOL CASTING: Wash off plaster, saw and grind gate.

For more information or a competitive quote please contact:
TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

PLASTER MOLD

GENERAL DESIGN DATA

SIZE RANGE: Up to 50 lbs.

METALS: Aluminum, zinc, magnesium, brass

TOLERANCES: +/- .005” for 2” then add +/- .002 inches/inch

PARTING LINE SHIFT: +/- .010”

TYPICAL ORDER QUANTITY: 1 – 250 pcs.

AVERAGE TOOLING COST: $ 2,000 to $ 5,000

AVERAGE TOOLING LEADTIME: 2 to 6 weeks

SURFACE FINISH: 63 to 125 RMS

MINIMUM SECTION THICKNESS: .060 “ premium / .080” average

MINIMUM DRAFT REQUIRED: ½ to 3 degrees

Note: The above information is meant to be a basic guideline for comparison purposes only.

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TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com

THE
SHELL MOLD
PROCESS

SHELL MOLD CASTING

A metal pattern is produced first, and the metal used must have good heat capacity and thermal conductivity, as well as a good surface finish and the ability to withstand the abrasion of sand mixes. A shell mold is formed by heating the metal pattern and then bringing a sand and resin mixture into contact with the pattern. The heat from the pattern cures the resin in the mixture for a predetermined time, and any further curing needed is carried out in an oven. When fully cured, the rigid shell is ejected from the pattern plate.

Cope and drag shell sections are made for each mold, and they are joined together with bonding resin or clamps to form the complete mold. Any cores required are placed inside the cope and drag before they are joined. When heavy castings are being produced, the thin shell mold is usually supported with metal shot or other back-up material. Shells for light castings do not require support.

The process is good for producing parts requiring:

- Thin Sections
- Intricate Details
- Close Dimensional Tolerances
- Excellent Surface Finish
- High Volumes

Typical alloys cast in this process are:

- Cast Iron
- Carbon Steel
- Alloy Steel
- Stainless Steel
- Aluminum Alloys
- Copper Alloys

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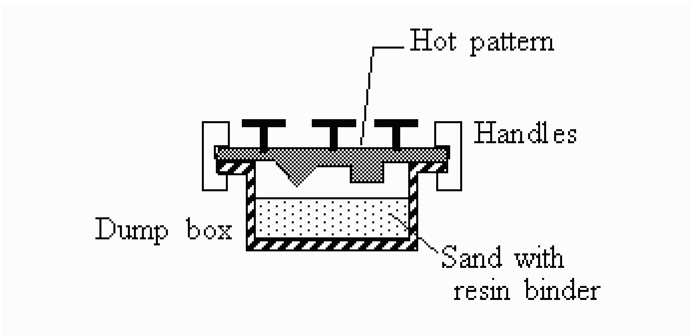
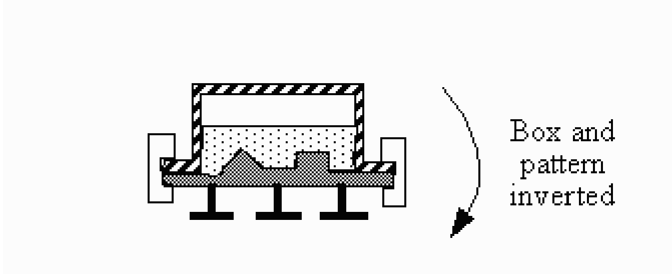
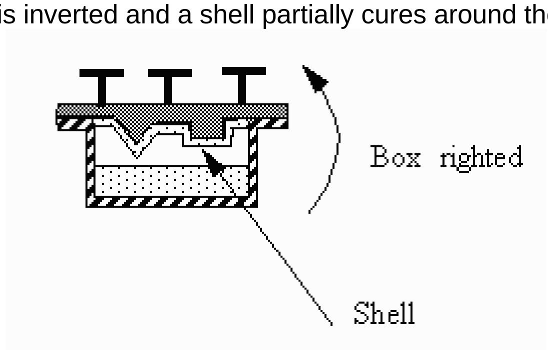
THE PROCESS



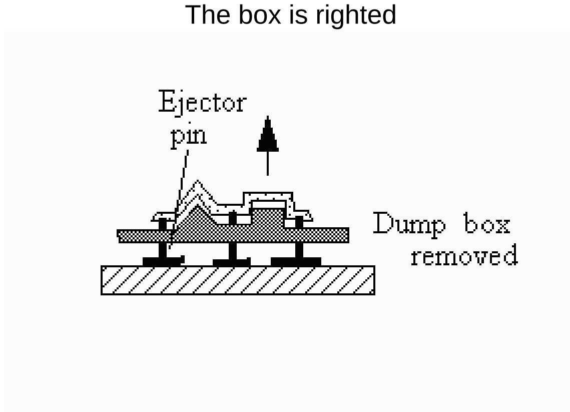
Heated pattern placed over a dump box containing a sand and resin mixture.



The box is inverted and a shell partially cures around the pattern.



The box is righted



The top is removed and the shell is further cured and is finally stripped from the pattern

After the other half of the mold has been made, shells are clamped together and shell mold is ready to receive molten metal. Once the metal solidifies, the shell is broken.

SHELL MOLD CASTING

MINIMUM SECTION THICKNESS: .062”

SIZE RANGE: Ounces to around 25 #

TYPICAL PARTS:

- CONNECTING RODS
- GEAR HOUSINGS
- LEVERARMS

For more information or a competitive quote please contact:

TOM CLARK
McCann Sales, Inc. Ph: 207-439-3747
E-mail: tclark@maine.rr.com