TPi ARCADE
a LIGON company

Technical Guide

Updated October 8, 2019

The following pages contain some considerations and recommendations for designing V-Process castings to be produced at TPi Arcade, llc. When in doubt, it is important to email a drawing or model (sales@tpicast.com) for some direction in the design process.

When any casting design is being considered, it is important to involve the foundry as early in the design process as possible. Even if the specific type of casting (sand, die, V-Process, etc.) has not been determined, working with one or more foundries will always be beneficial to determine the best casting process for the application. TPi Arcade llc. has the turnkey experience and supply chain to assist customers in achieving the desired results in the final finished part.

TPi Arcade llc. utilizes Project Engineers dedicated to each and every customer and their programs. These individuals work to ensure precise and punctual coordination and communication between the customer, supply chain, sale representatives and internal personnel. TPi's Project Engineers manage customer's programs from day one until the final shipment to ensure a successful program.

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WALL SECTION THICKNESS

TPi Arcade can typically produce walls .125” thick. Walls can be cast as thin as .090” with TPi engineering approval. If a core is needed, walls need to be approx. .150” thick.

As a general rule of thumb, thinner wall sections can be cast on smaller parts but this is not always true. Other factors determining minimum wall section are the alloy (A356 is ideal), ability to flow the metal into the thin section and the amount of thick/thin section transitions.

There is no upper limit to the wall section that TPi Arcade can pour.

MOLD SIZES

At TPi Arcade llc., V-Process castings are produced in molds 36” wide x 36” long x 18” tall (9” in the cope & 9” in the drag)

The part needs to fit in a cube 32” wide x 32” long x 12”-15” tall. This is strictly dependent on part geometry. TPi also has a sister facility with a larger flask size.

When in doubt, do not assume a part will fit or not fit. Please email (sales@tpicast.com) the model for a layout and evaluation.

On higher volume programs, this footprint can be multiple impression or cavities to lower the price per unit. The number of impressions that can fit determined by the size of the part and the gating system required. Again, when in doubt, do not assume a part will fit. Please email (sales@tpicast.com) the model for evaluation.

TOLERANCES

V-Process linear tolerances are as follows:

a) ± .010 inch for the first inch
b) ± .002 inch for each additional inch
c) Additional ± .010 inch across the parting line
d) Flatness tolerance of .003 inch per linear inch
e) Additional tolerances may apply in cored areas

The size and shape of the core determine the amount of additional tolerance required for cored areas.

Flatness may be improved upon the stated tolerance but this depends on the design of the part (how thick is the part, stiffening ribs, etc.). Please note that the flatter an as cast surface is needed, the more straightening and inspection is needed thus increasing cost.

Please consider parting line placement during the design stage. A customer’s understanding of this variable is critical to assessing repeatability in casting and machining design and functionality. Although not always possible, it is best practice to avoid parting lines on cosmetic surfaces.

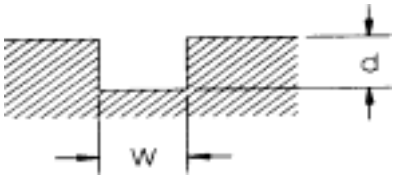
FILM STRETCH

The first step in producing a V-Process mold is the vacuum forming of a thin sheet of heated plastic film over the V-Process pattern. The film can only stretch so far. Film stretch or draw is the amount the plastic film needs to stretch over or into the pattern to form features.

The general safe limit for the film stretch ratio (depth of feature to width) is 1 to 1. That is the amount that the film will need to stretch when it is drawn over the pattern.

This comes into play when the film is drawn into features such as cast holes, lightener pockets and/or heatsink fins.

The calculations to determine the film stretch ratio are explained below.



The above information is a design guide only. There may be situations where this ratio can be exceeded based on the total design of the part or utilizing proprietary film stretching tools. When in doubt, please email a model for review (sales@tpicast.com).

CORES AND LOOSE PIECES (SLIDES)

The V-Process can use cores that are similar to a sand casting core. Cores can form undercuts, reentrant shapes, wire / oil passageways, thinner cast sections, heat sinks and other features. Cores add cost but are sometimes unavoidable due to part functionality.

Sometimes, loose pieces or slides can be placed into the pattern to avoid using a core. The placement of these features depends on part geometry.

DATUMS

When creating drawings, TPi Arcade strongly recommends customers use the 3-2-1 datum system. This system will help coordinate inspections of both the machined and raw castings between TPi, the machinist and the customer.

TPi recommends separate casting and machining drawings but this is not necessary. TPi's project engineers work directly with the customer and the machine shop to determine which features will remain as cast and which will need secondary machining.

ALLOYS

TPi Arcade pours A356 aluminum alloy. This is comparable to 6061 billet aluminum. A356 is cast at TPi with a robot to ensure consistent pouring flow rates and extremely repeatable cast material.

Most castings undergo a post heat treatment process to ensure dimensional stability and achieve higher mechanical properties. T51 and T6 are the most common heat treatments performed in house at TPi. T71 and T77 heat treatments can also be provided.

TPi conforms to the Aluminum Association's Standards for Sand and Permanent Mold Castings. This specification is extremely comparable to the casting specifications for the Military (MIL-2175) and Aerospace (ASTM B26).

DRAFT ALLOWANCES

The V-Process is extremely unique in that *it does not require any draft angle*. The first step in the V-Process is to coat the pattern in a thin Surlyn plastic film. This allows enough friction loss between the pattern and the mold to cast vertical, straight walls. This attribute is ideal when converting 100% machined parts to near net shape castings.

A few advantages of the zero-degree draft capabilities are as follows:

- Uniform Wall Thickness: This reduces weight and has aesthetic appeal.
- Elimination of Machining: Sometimes, draft angles need to be machined off to ensure clearance for mating parts and assemblies. Vertical walls eliminate this requirement.
- Allows for Simpler and More Accurate Machining and Inspection Fixtures: Fixtures can be constructed without considering draft angles.
- More Accurate Casting: Tolerance range remains for the actual feature, not the feature plus draft. Draft does not use up the tolerance.
- Simplified Casting Design: Since there is no draft, the design is less complex. Calculations and depictions are more straightforward.

POROSITY

There is not a casting process that can insure parts produced are always free of casting imperfections or porosity. These imperfections are inherent to the melting and solidifying metal. Porosity risks can be minimized utilizing a multitude of factors.

All other factors being equal, the V-Process will tend to produce a part with a minimum amount of porosity. This is because a dry sand is used. Traditional sand casting processes add chemicals and/or moisture to the sand in order to hold the sand together. These mold binders react with molten metal when it is poured into the sand. This reaction produces gases which can be imbedded into the casting and become visible during x-ray or machining.

In the V-Process, a vacuum holds the sand in shape in place of chemicals. Since there are no chemicals, there is no reaction when the metal is poured resulting in a denser metal and less porosity.

Finally, TPi has in house mold solidification software and solidification simulations are performed on all programs prior to tooling construction. This reduces the learning curve and ensures parts are corrected and shipped on time.

SURFACE FINISH

The V-Process provides a more cosmetic surface finish than a typical sand or permanent mold casting. When measuring surface finishes on a profilometer, V-Process will produce a 125-150 RMS reading while a sand or permanent mold process will produce a 250-500 RMS reading. This V-Process attribute is ideal for castings with high cosmetic requirements.

RADII

Good casting practice requires the use of fillets in castings. Fillets improve structural support and assist metal flow. Fillets are commonly .060” radius.

TYPICAL COST DRIVERS

The following describes customer-controlled items that can affect the price of a casting.

CASTING

a) **Casting Size**: The size of casting dictates how many pieces can be poured per mold. Pricing is reduced when more cavities can fit into the mold and more parts per pour are produced.
b) **Cores**: These form undercuts in the casting but add cost. A core is used once and then destroyed on every casting. If an area can be filled solid or possibly machined in, this can save cost.
c) **Surface Finish (Grinding or Buffing) Required**: Grinding is necessary on all castings. This removes flash and gating systems. Cosmetic parts require more handwork thus driving costs.
d) **Weight:** Aluminum material costs are based per pound. Weight can also dictate the numbers of parts produced per pour.
e) **Heat Treatment**: The 2 most common heat treatments at TPi are T51 and T6. Both involve a straightening process. T6 requires more straightening and thus increased costs. TPi recommends a T51 heat treatment unless the part's application dictates the need for T6.
f) **Parting Line Design**: Parting lines can be developed to reduce grinding and thus costs. TPi's engineers are always able to assist customers on casting design.

MACHINING

a) **Tolerances Required**: Tighter tolerances drive costs in both machining time and inspection. Typical machining tolerances are +/-.005".
b) **Flatness Callouts**: While this can vary based on part geometry, flatness requirements can drive costs.
c) **Surface Finish**: A typical machined surface finish is 32 RMS. Finish requirements more stringent than this add cost.
d) **Hardware Required**: Hardware adds material and assembly costs.
e) **Size and Depth of Machining Cuts**: Smaller machined features require smaller tools with limited reach. If a machine feature is a less than desirable distance from the spindle and smaller, the smaller tool needs to be slowed to accommodate this depth.
f) **Complexity of Machining Needed**: Machining that needs to be performed in several different planes or orientations adds cost.

FINISHING

a) **Chromate**: This is a chemical conversion that prevents corrosion on the casting. A typical callout is ROHS chromate. ROHS is a European Union designation that chromium is not present.
b) **Anodize**: Anodize is a chemical conversion that is typically a functional application in the casting industry and is commonly dyed black.
c) **Paint or Powder Coating**: Since V-Process offers a highly cosmetic surface finish, paint or powder coating are the 2 most common finishing applications performed. The texture of the paint or powder coating can drive costs. A rougher texture is more forgiving on the cast surface than a smoother texture. Generally, the smoother the texture allows for more handwork and prepping by the finisher.

TYPICAL COST DRIVERS (cont.)

MISCELANIOUS

a) **X-Ray Specification:** Depending on the drawing's x-ray callout, independent film x-ray may be needed. This adds cost. TPi has in house digital real time x-ray but is not able to certify as per industry requirements. TPi typically produces a grade D x-ray specification based on part geometry.

b) **Quality Specifications:** Testing such as Brinell Harness or liquid penetrant will add cost.

c) **Packaging:** Basic packaging is included in the piece price. Any special packaging requirements adds cost.

DRAWING CONSIDERATIONS FOR ALUMINUM CASTINGS

While not necessary, TPi recommends a drawing representative of the casting and one of the machining. Some customers create 2 separate part numbers and drawings, some add a page to the machining print detailing the casting while other do not provide a casting drawing at all. This work is performed by and solely to the discretion of the customer.

Drawings typically have a cast and machine datum structure and utilize Geometric Dimensioning and Tolerances (GD&T).

A casting is usually a framework or platform to machine in accurate features that mate with assemblies. How these machined features relate to the casting is imperative to how the machined casting functions and detrimental to the success of the design. TPi utilizes touch probes and creates centerlines when locating machined to each casting. This reduces the tolerances and thus variation to ensure the machining location is optimized on each casting.

Since drawing tolerances depend on parting lines, cored features and other items, TPi recommends customers work directly with our in-house experienced engineers and the machinist during the drawing creation to assist in establishing datum structures and tolerances.

About TPi Arcade,

TPi Arcade is the most advanced aluminum V-Process casting facility in the US. We provide turnkey aluminum cast product solutions including casting, machining, finishing and sub-assembly. V-Process is an innovative method that places molds under vacuum; compared to traditional sand casting it allows us to create castings with smoother surface finish, near net shape and thinner walls. V-Process also has the added benefit of unlimited pattern life because the pattern never actually touches the sand.

TPi is optimized to provide a cast sample in as little as 2 weeks and production parts a week after sample approval. We can provide anything from prototypes to low volume production to raw castings to turnkey programs for a single source solution.

Visit us at https://tpicast.com to find out more.

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