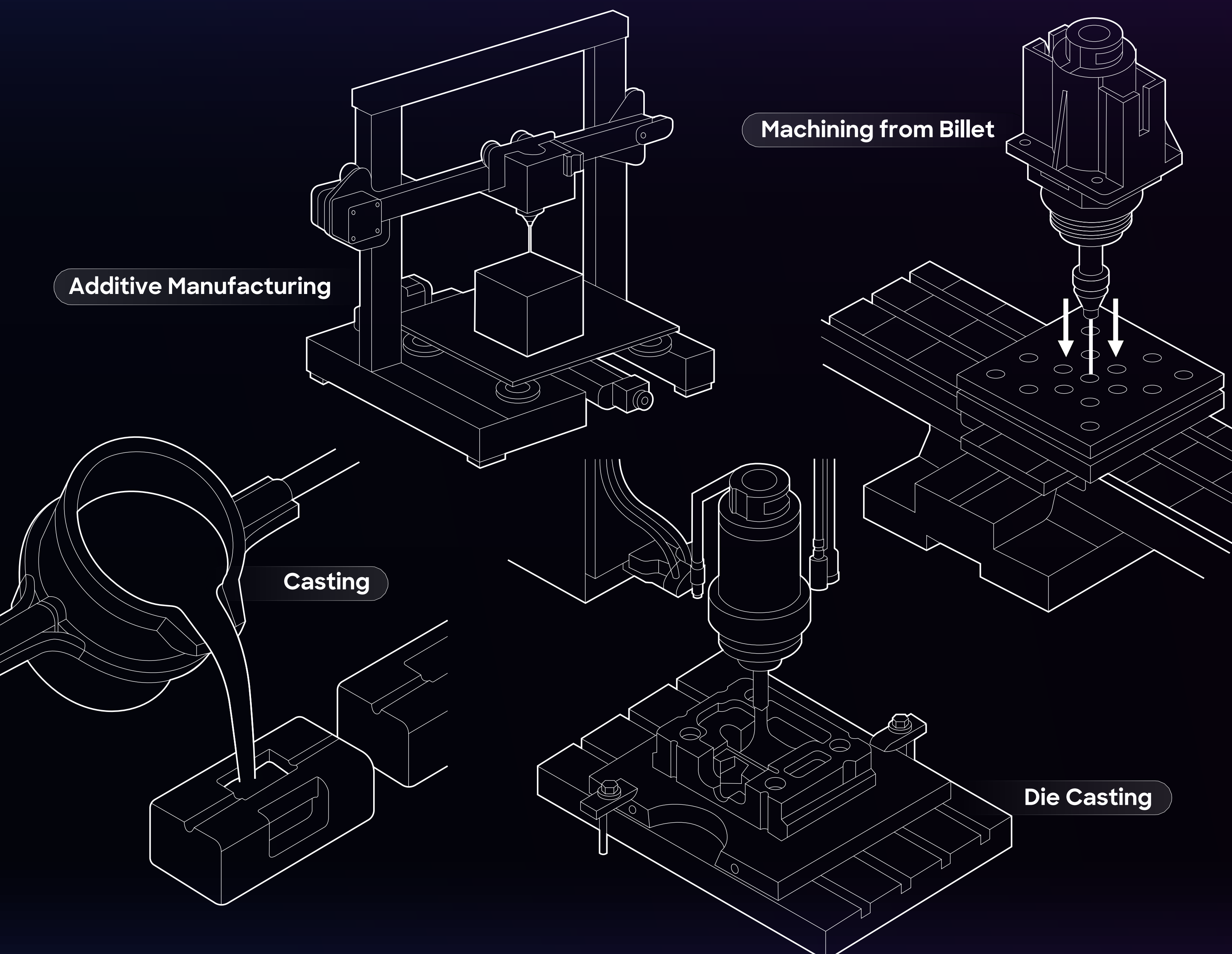
COLAB

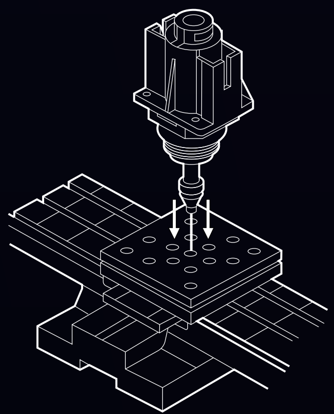
The Tradeoff

Selecting the right manufacturing process for a solid metal part



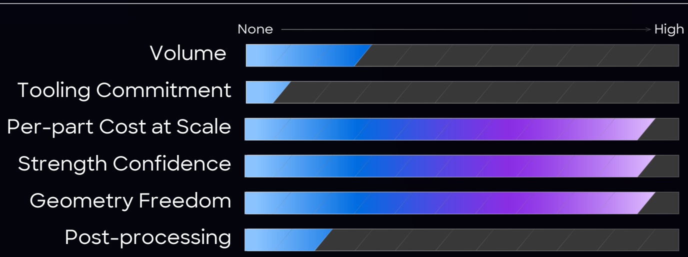
Selecting the right manufacturing process for solid metal parts

Machining from Billet

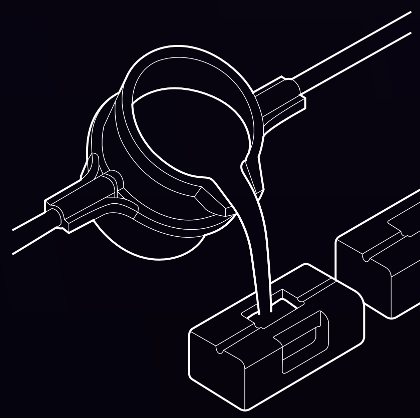


Best when

- ✓ Design is evolving
- ✓ Strength is critical
- ✓ Tooling risk needs to be minimized

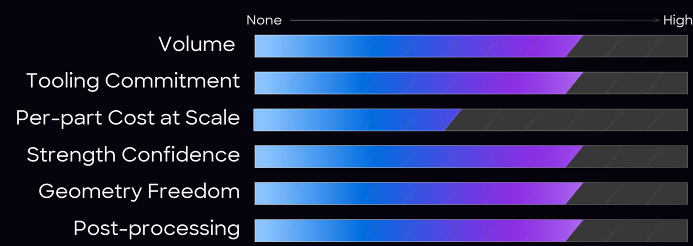


Casting

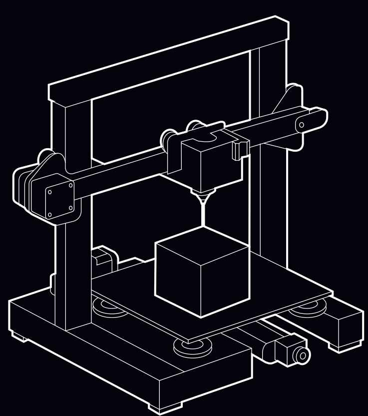


Best when

- ✓ Production volume is moving beyond prototyping
- ✓ Per-part cost must be reduced
- ✓ Design is stable enough to introduce tooling

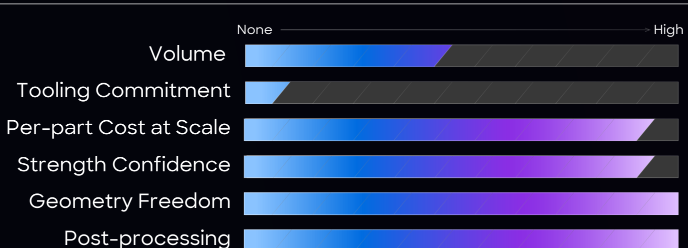


Additive Manufacturing

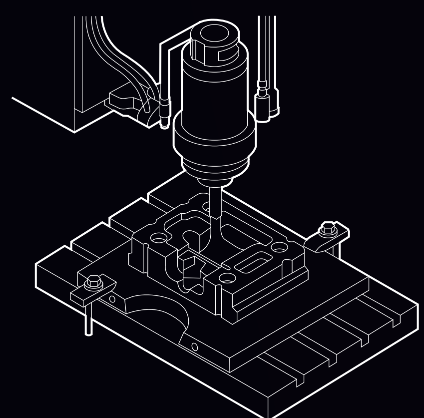


Best when

- ✓ Geometry is highly complex
- ✓ Internal channels or lightweight structures are required
- ✓ Low-volume or specialty production

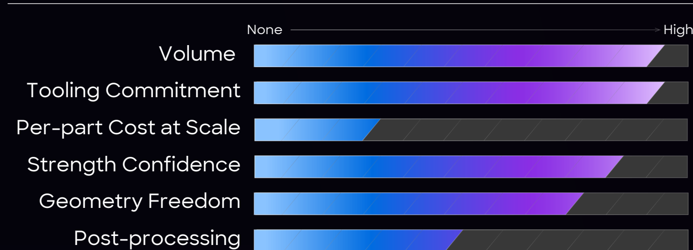


Die Casting



Best when

- ✓ Demand is stable and high
- ✓ Design is finalized
- ✓ Maximum production efficiency is a priority



A closer look at each manufacturing process

Machining from Billet

Machining from billet requires no tooling and offers the most flexibility early in the design process. It is best suited to prototyping and low production volumes.

Parts can be iterated quickly, tolerances are tight, and material properties are consistent. For load-bearing parts where strength in critical areas matters, machining provides higher structural confidence because it is cut from solid stock and avoids porosity-related risk.

Machining also gives engineers more freedom in geometry. For example, machined parts can tolerate sharp internal corners and variable wall thickness. In many cases, what comes off the CNC machine is the finished part, with no additional processes required.

The tradeoff is cost and efficiency. Cycle times are longer, material waste is higher, and per-part cost remains relatively high as volume increases. Teams often begin to consider a transition in the middle ground where volumes are too high for prototype machining but too low to justify hard tooling.

Casting

Casting introduces tooling, but reduces per-part cost once production volume increases. Material utilization improves and cycle times drop compared to machining. It is best suited for moderate production volumes when cost pressure begins to outweigh the flexibility of machining.

The shift to casting usually occurs at a threshold that depends on geometry, material, tolerances, and confidence in future demand. The decision often comes before volume is fully guaranteed, which makes the commitment more difficult.

Casting typically produces a near-net shape part that requires secondary machining operations. It also introduces design constraints.

Wall thickness must be controlled, and draft angles are required. Features such as ribbing are frequently introduced to meet casting requirements. If these constraints are identified late, redesign is often necessary.

Porosity risk depends on geometry and process control. It is not uniformly distributed and can become a concern in load-bearing regions or thin sections. A part may perform well in most areas and still fail due to a localized defect. For non-structural parts, this risk may be acceptable. In structural applications requiring strength in critical areas, the tradeoff must be evaluated carefully.

Casting is often the first step away from machining as volume increases and the design begins to stabilize, even if demand is not yet fully stable. It reduces per-part cost without the full tooling commitment associated with die casting.

A closer look at each manufacturing process

Additive Manufacturing

Like machining, additive manufacturing requires no tooling. This reduces upfront commitment and makes additive well suited for low production volumes and specialty variants.

Additive supports highly complex geometries, including closed internal channels and lightweight structures that cannot be produced by other processes. If done properly, additive parts can be fully densified and offer material properties comparable to machined parts. However, parts come off the machine with rougher surface finish and often include support structures that must be removed. Heat treatment, surface finishing, and secondary machining are typically required.

Additive is not optimized for high-volume production, and per-part cost remains relatively high. It may make sense for a few hundred specialty automotive components annually, but it is unlikely to replace die casting for parts produced in the tens of thousands.

Die Casting

Die casting requires significant upfront tooling investment, and is selected when demand is stable and the design is largely finalized. It is best suited for high-volume production, delivering short cycle times.

Compared to casting, tooling is more expensive and specific, and design changes are costly once the tool is cut. Committing too early can lead to sunk cost if volumes do not materialize, which is why teams choose die casting when they are confident the volume will justify the investment.

Die casting is most commonly used with materials such as aluminum and zinc alloys. Steel is not typically die cast, so material choice can narrow the available process options.

Like casting, die casting imposes geometric requirements such as draft angles, controlled wall thickness, and ribbing. While die casting generally achieves tighter tolerances than conventional casting, post-processing is still required. Flash must be trimmed, and parts undergo selective machining.

Die casting can reduce porosity risk compared to casting because the metal is injected under high pressure rather than relying on gravity fill. As a result, die cast parts offer higher strength confidence than casting, though performance still depends on process control and geometry.

Die casting offers the least flexibility of the methods discussed, but the payoff is repeatability

Manufacturing process selection for real-world applications

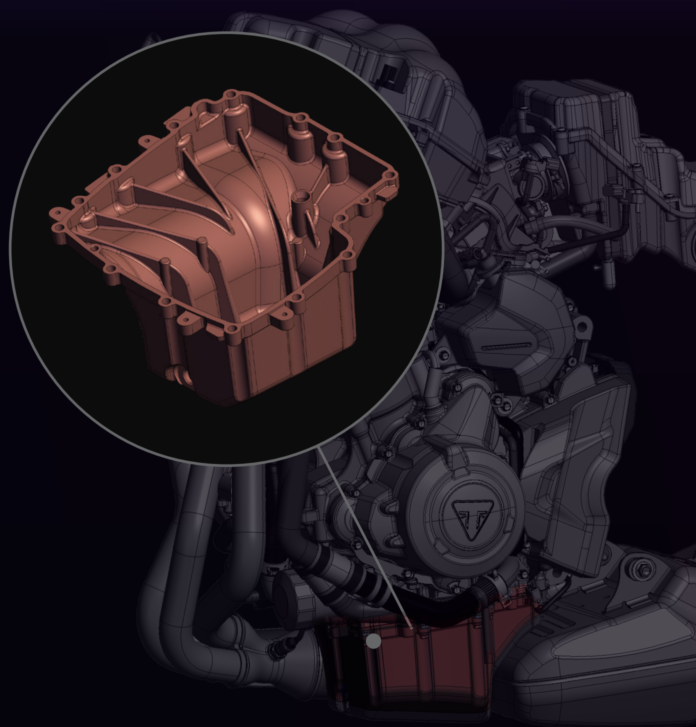
The following examples show how the decision framework applies to real components.

Motorcycle Sump

Volume-Driven Process Change

At low production volumes, this sump would be machined from billet aluminum to avoid tooling cost while preserving flexibility during early development. As volume increases, investing in tooling for casting reduces cycle time and material waste, lowering per-part cost. The design is adjusted to meet casting requirements.

Decision: In this case, volume drives the decision. Once demand justifies tooling investment, casting becomes the appropriate choice.



Rear Footrest Bracket

When Strength Overrides Cost

The rear footrest bracket operates in a high-vibration, load-bearing environment. In testing, the part cracked under tip-over simulation. Analysis showed stress concentrations in areas that could not tolerate material variability. When manufactured using casting, porosity introduced a weakness that would not have been present in a fully dense machined part.

Decision: Machining from billet would provide greater structural confidence and more consistent material properties. For components operating in critical load paths, strength outweighs cost savings. In this scenario, the correct design decision would be to specify machining rather than casting.