

# INVESTMENT CASTING VS. CLOSED-DIE FORGING

*A Process Selection Guide for High-Stress Alloys by ForceBeyond*

When manufacturing mission-critical components from high-stress alloys—such as Inconel 718, Titanium Ti-6Al-4V, and 17-4 PH Stainless Steel—engineers face a crucial decision: should the part be investment cast or closed-die forged? Both processes are highly capable, but they yield fundamentally different mechanical properties, geometric limitations, and cost structures.

Selecting the optimal manufacturing route depends heavily on the component's operating environment, required fatigue life, production volume, and geometric complexity. This guide explores the engineering trade-offs between investment casting and closed-die forging to help you optimize performance and unit economics.

## 1. Investment Casting: The Precision Approach

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Investment casting, or "lost-wax casting," involves creating a wax pattern, coating it in a ceramic shell, melting out the wax, and pouring molten metal into the resulting cavity. It is highly valued for its ability to produce intricate, near-net-shape components.

### Advantages of Casting

- **Unmatched Geometric Freedom:** Casting allows for complex internal cavities (using ceramic cores), thin walls, and intricate undercuts that are impossible to forge.
- **Reduced Machining Time:** Because casting produces a near-net shape, the amount of secondary CNC machining required is vastly reduced, saving time and extending tool life.
- **Lower Initial Tooling Costs:** Wax injection dies are typically machined from aluminum and are significantly less expensive than the hardened steel dies required for forging.

## 2. Closed-Die Forging: The Strength Approach

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Closed-die forging shapes a heated billet of metal under immense compressive forces, pressing it between two custom-machined steel dies. This process physically deforms the metal into the desired shape.

## Advantages of Forging

- **Superior Mechanical Properties:** The massive compressive forces refine the internal grain structure of the metal. More importantly, forging aligns the material's grain flow to follow the contours of the part, maximizing tensile strength, ductility, and fatigue resistance.
- **Zero Internal Porosity:** Because the metal is never fully melted, there is no risk of gas porosity or shrinkage voids, ensuring 100% structural density.
- **High Production Efficiency:** Once tooling is established, forging is a highly repeatable and exceptionally fast production method, making it ideal for high-volume runs.

## 3. Direct Comparison: Making the Decision

| Factor                       | Investment Casting                        | Closed-Die Forging                            |
|------------------------------|-------------------------------------------|-----------------------------------------------|
| Mechanical Strength          | Good (Isotropic properties)               | Excellent (Directional grain flow)            |
| Geometric Complexity         | High (Internal cavities, undercuts)       | Moderate (Requires draft angles, no cavities) |
| Tooling Cost                 | Lower (Aluminum wax dies)                 | Higher (Hardened tool steel dies)             |
| Production Volume Sweet Spot | Low to Medium (Prototyping to steady run) | Medium to High (Amortizes tooling cost)       |
| Material Yield               | High (Near-net shape, less waste)         | Moderate (Flash removal, heavy machining)     |

### Design for Manufacturability (DFM) Support

The optimal manufacturing process is rarely a simple choice. By engaging with **ForceBeyond's** metallurgical and manufacturing engineers early in your design phase, we can evaluate your CAD models, structural requirements, and volume projections to recommend the most cost-effective and structurally sound process.

Request an Engineering Review & Quote

