When developing a new design, designers of metal components must always consider the manufacturing methods available to them. At the same time, they must consider the geometric possibilities and material characteristic needs for the particular functional and performance requirements of the application they are designing for. This is not always a simple task.

**Other manufacturing options**

If dimensional precision is needed, CNC machining could be the solution. While precision is certainly available with this process, it generally comes with elevated cost - particularly when high levels of part complexity are also needed. Investment casting, die-casting, and metal injection molding (MIM) all provide good levels of part complexity, but each has a limitation that designers need to consider.

Investment casting, for example, yields higher levels of dimensional variation (in the range of +/- 0.5% of a given feature size). However, it also produces generally rough surface finishes and is limited in the feature details it can provide on small, complex parts. Often, investment cast parts are machined to achieve fine feature details, tolerances, and surface finish needs. These operations all add incremental costs to the final product. Investment cast parts are also subject to internal voids, which can negatively impact process yields.
Die-casting provides excellent part complexity, but is limited to a small range of metals - all of which have inferior physical properties in comparison to most stainless and low alloy steels. Excessive flash is also common among die-cast components. As a result, secondary finishing operations are frequently required. Dimensional control is better with die-casting than investment casting, but not nearly as good as production machining processes. For many applications, secondary machining operations are required.

MIM offers significant part complexity in a wide range of metal alloys, but the early promise of it becoming a true net-shape process has not been met. Dimensional control with MIM is also better than investment casting, but cannot compete with discrete machining processes. Furthermore, dimensional variation increases with part dimension size. This is primarily due to the multiple process steps required to produce MIM parts. Compounding metal powders with polymer binders for injection molding, debinding to remove the sacrificial binders, and sintering to consolidate the metal powders into the final desired part shape are the primary sources of variation. The large percentage of shrinkage that occurs from the molded part size to the as-sintered, or final, part size, combined with the effects of gravity and surface tension during the large size transition in sintering, contribute unique dimensional control and shape retention challenges. Part-to-part consistency varies enough that a large percentage of MIM parts require secondary operations to achieve required final dimensions and part shape.

The list of metalworking technologies is long and goes well beyond the three processes mentioned. Others include Swiss screw machining, stamping, fine blanking, cold heading, roll forming, powdered metal, forging, spray forming and many others.

Why choose the Liquidmetal process?

The Liquidmetal process is a combination of an unusual metal alloy with highly useful properties, and a shape forming process common to plastic components. This provides a new set of possibilities for metal parts fabrication and component designs not previously possible with other metalworking technologies. The basic capabilities of Liquidmetal alloy are below, if you need three or more, you likely have a Liquidmetal application:

- Exceptional dimensional control and repeatability
- Excellent corrosion resistance
- Brilliant surface finish
- High Strength
- High Elastic limit
- High hardness, scratch & wear resistance
- Non-magnetic
- Complex shapes that can be molded
Precision

With the Liquidmetal process, there is finally a production metal forming technology with dimensional control and repeatability that rivals production machining processes, without the associated costs and material scrap. Liquidmetal alloy LM105 features a molding process with an incredibly small amount of shrinkage (0.4%).

In a recent study, a hollow five-sided box was used to evaluate dimensional repeatability. The part, represented in the photo below, measures 45.63mm for the A-B dimension, and 28.70mm C-D dimension.

A gage capability study was conducted on a coordinate measuring machine, which evaluated a 32-piece sample. In the histogram that follows, two dotted lines represent the gage repeatability for the two dimensions measured, and the solid lines represent six standard deviations for the part dimensions.

Having excellent dimensional control provides many advantages to the metal part designer. Those advantages include: greater design flexibility, better fit between assembled components, more precise part performance, improved overall product performance, ability to insert mold reliably for downstream conjoining of materials, and reduced stack-up tolerances among parts in an assembly.

Corrosion Resistance

The unique Liquidmetal LM105 alloy provides impressive corrosion resistance compared to materials like 316 Stainless Steel, traditionally thought of as go-to materials for applications in corrosive environments. When tested against 316 SS in hydrochloric acid and sulfuric acid solutions, LM105 significantly outperformed 316 SS in both cases.

The superior corrosion resistance of Liquidmetal alloys is advantageous in a variety of markets and industries. Possible applications include: automotive decorative and harsh environment applications, aerospace, defense applications, dental, industrial equipment, food processing equipment components, marine, medical devices, sporting equipment components for outdoor applications, and more.
Liquidmetal alloys are particularly useful in medical device applications as shown in the biocompatibility test results displayed in the following table.

However, Liquidmetal alloys can also be polished, but see unique results due to its amorphous structure. The material does not have a crystalline structure like all other metal alloys, so inherent material characteristics, such as grain boundaries, do not influence the reflective properties that can be achieved.

With Liquidmetal alloys, specifying excellent surface finish does not force any trade-offs. For example, you don’t need to give up dimensional control or corrosion resistance to achieve the desired surface finish. Liquidmetal alloys and the injection molding process allow all the properties to be taken advantage of simultaneously.

### Surface Finish

The Liquidmetal process produces a surface roughness down to 0.05 Ra μm, an equally impressive property. This value cannot be achieved through any other process without secondary operations, such as: superfinishing, lapping or polishing.

In some applications, reflective properties are important. The as-molded surface finish of Liquidmetal alloys provides good specular reflection.
Elasticity, strength, hardness, and magnetism

As shown to the right, the properties of LM105 are comparable or superior to the properties of a variety of other materials from varying process technologies.

With Liquidmetal alloys, now you can combine the strength of heat-treated 420 Stainless Steel, with the corrosion resistance of 316 Stainless Steel, a surface finish of 0.05 Ra μm, and a 20% reduction in mass over stainless or steel alloys – with no trade-offs.

A particularly unique property of Liquidmetal LM105 is its high level of elasticity (1.8%, as a percentage of its original shape). This property can provide particular advantages in certain applications that other materials cannot. Examples include:

- A medical device could flex under stress, but not plastically deform.
- A pressure transducer housing that requires repeated flexure without plastic deformation or work-hardening.
- A precision spring that requires a highly repeatable force when stressed to a given dimension.

These applications are made possible by Liquidmetal alloys - a new material that can provide new solutions or solve problems where a solution did not previously exist.

Not to be forgotten, LM105’s as-molded hardness (53 Rockwell C) is competitive with post-processed and heat-treated stainless steels. Distinct to Liquidmetal alloys, the hardness value is consistent through the material, not just on the surface. As a result, applications of wear, or components requiring scratch resistance can benefit from Liquidmetal alloys.
Liquidmetal alloys are classified as non-magnetic and behave like paramagnetic materials. They are very weakly attracted to a magnetic force as can be seen from the minimal paramagnetic signature shown below.

![Graph showing minimal paramagnetic signature](image)

Conclusion

The broad range of valuable material properties creates an even greater range of application opportunities from Liquidmetal alloys. Part geometry sophistication is not always needed with the expansive material properties available. With a process developed around an advanced injection molding technology, part applications are nearly limitless.

Part complexity similar to plastic components with impressive material properties gives design engineers options previously unavailable, impossible, or economically impractical with metal parts production.

Liquidmetal alloys cannot be magnetized and cannot be caused to retain any magnetism they may be exposed to. Housings for magnetic switch applications, components in MRI equipment, or applications involving high RF power are applications that could benefit from this property.

Wondering how Liquidmetal alloys might work for your application? We invite you to download our design guide and speak with Liquidmetal scientists and engineers. We are challenging everything you know about metal parts processing. Why not challenge us?

Talk to the experts.

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