Key Liquidmetal technology process attributes include precision, strength, surface finish, corrosion resistance, hardness, and high elasticity. These attributes result in a broad range of automotive application categories that could benefit from the technology. Among them include engine timing systems, fuel injection, interior and exterior decorative components, passenger safety components, pumps, sensors, severe duty connectors, and many others.

Like any manufacturing process, leveraging the full benefits of Liquidmetal technology is achieved by developing application designs intended for the process. While there are many success stories about parts that have been converted from one process to another, experiencing the best economics and performance is always a result of having the part-design freedom. This design liberty is necessary to address all of the requirements of the manufacturing process used to produce them.
Finding the right fit

Liquidmetal technology has its own set of characteristics, some of which overlap other metalworking technologies, making it a valuable manufacturing alternative. If you need three or more of the attributes to the right, Liquidmetal technology is a likely solution for your automotive application.

Liquidmetal alloy has many notable capabilities, but one in particular stands out; dimensional precision and repeatability. Because the process generates all of the final material characteristics in the molding process step with little to no shrinkage (0.4%), part geometries are very stable. Additionally, there is no phase change that occurs in the material from its molten state at the beginning of the injection cycle to the material’s solid state in the mold after cooling. Low shrinkage and a lack of phase change allow the material to mimic the mold cavity with high precision and repeatability.
Potential Applications

**Brushless DC Drive**
- Key attribute: Surface Finish
- Key attributes:
  - Strength
  - Precision
  - Elasticity
  - Corrosion
  - Surface Finish

**Port Fuel Injection**
- Key attribute: Corrosion Resistance
- Key attributes:
  - Strength
  - Precision
  - Elasticity
  - Corrosion
  - Surface Finish

**Nozzle**
- Key attribute: Precision
- Key attributes:
  - Strength
  - Precision
  - Elasticity
  - Corrosion
  - Surface Finish

**Ignition Systems**
- Key attribute: Precision
- Key attributes:
  - Strength
  - Precision
  - Elasticity
  - Corrosion
  - Surface Finish
Precision

To gain a better understanding of Liquidmetal alloy’s capabilities, a gauge capability study was conducted on a 32-piece sample using a coordinate measuring machine. In the histogram that follows, two dotted lines represent the gauge repeatability for the two dimensions measured, and the solid lines represent six standard deviations for the part dimensions.

To summarize the results, the Liquidmetal process may be even more precise than previously thought. The minimal difference between the dotted and solid lines signify that the CMM, with gauge error considered, performs marginally better than the actual part to part variance for the sample. Additionally, no two parts varied more than 2.5 µm for one dimension, and 2.4 µm for the other. These results confirm the incredible precision of the Liquidmetal process, and often beat even the most conservative repeatability ranges for other manufacturing processes, like CNC machining.

Automotive applications requiring dimensional tolerances common to CNC machining are candidates for the Liquidmetal process. There are a number of components in a broad range of assemblies that meet this criteria, such as fuel injection components, engine timing and variable valve applications, fluid control valves, and sensors.
Combining excellent corrosion resistance, brilliant surface finish, and high hardness, Liquidmetal alloy is an excellent solution for decorative components. This is particularly true for high-end automobile applications where the look and feel of chrome plated plastic does not match that of a real metal surface. Testing has shown Liquidmetal alloys can outperform 316 stainless steel in highly corrosive environments.

As-molded surface finish for Liquidmetal alloy is comparable to lapping and superfinishing polishing techniques. This capability allows for reduced post processing cost on cosmetic surfaces of decorative components.
Applications such as instrument bezels, nameplates, key fobs, handles, and other touch points where the feel of metal exhibits high quality are all great candidates. They will especially benefit from the processes’ unique ability to provide fine surface finish and corrosion resistance.

**Elasticity**

The unusually high elastic limit of Liquidmetal alloys provides a particularly good alternative to 17-4 PH and 316 stainless steel for pressure sensors. These common materials used in pressure sensors are subject to physical deformation, embrittlement, and property changes over time. Burst failure, caused by pressure spikes, along with corrosion are common causes of failure with these alloys. Stainless steels also have to protect electronics from the damaging effects of exposure to the liquids and/or gases for which they are monitoring. Both are challenging requirements because these materials experience cyclical stress, which can lead to micro-fractures thus allowing fluids and gases to penetrate the sensing device.
A well built pressure sensor requires the mechanical properties of its diaphragm to be maintained over hundreds of millions of cycles and decades of use to achieve accurate results over the lifetime of the sensor. Membranes made from Liquidmetal alloy are extremely stable, exhibiting consistent elastic deflection with extensive use, thus making the alloy a great candidate for sensors.

**Conclusion**

The automotive application possibilities are endless. High precision, corrosion resistance, surface finish, strength hardness, elasticity, and the other characteristics of Liquidmetal alloy are all achieved by a single step molding process. No post processing, such as heat treating, is required to achieve final material properties.