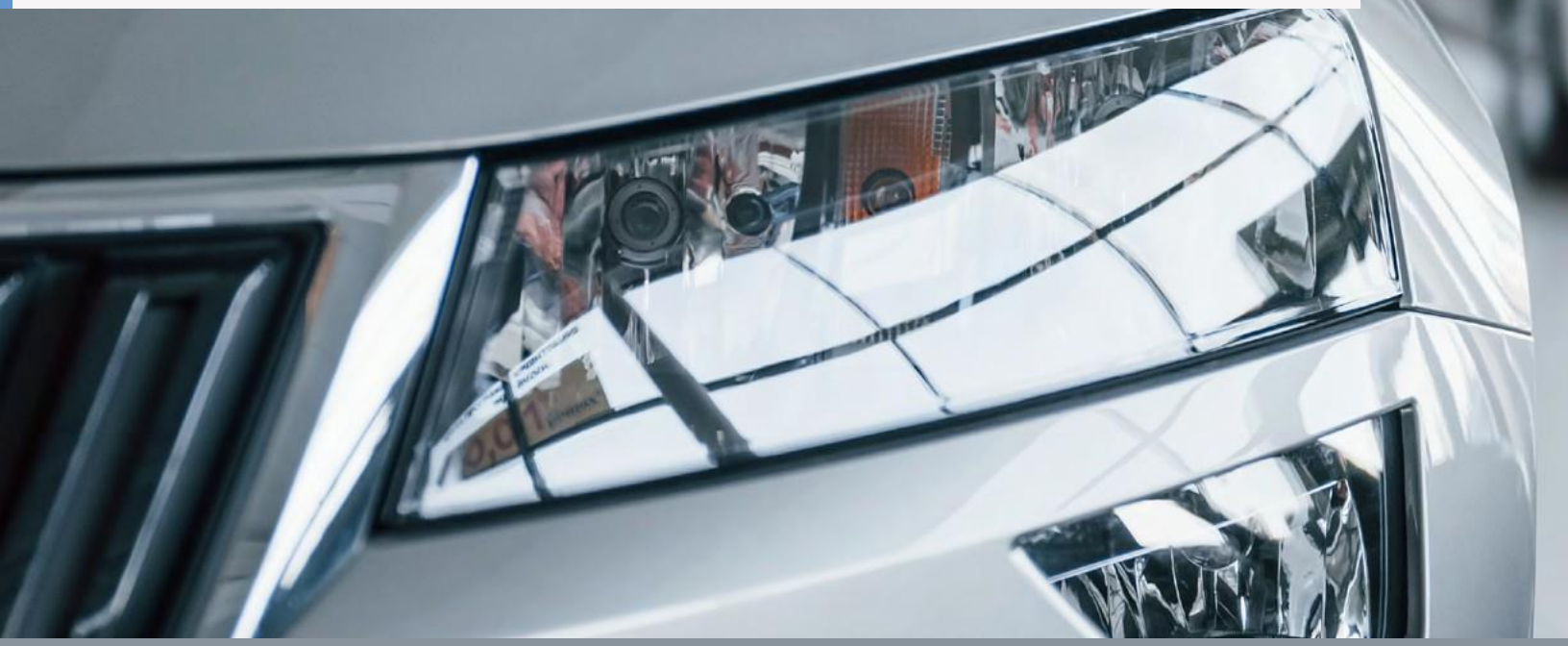
Impro: A Complete Guide to Titanium Investment Casting Solutions



Impro

Titanium offers many unique physical and metallurgical characteristics that make it a suitable material for demanding and high-performance industrial components, particularly within the aerospace, defense, medical, industrial, and consumer markets.

High strength-to-density ratio, corrosion resistance, biocompatibility, and the ability to withstand extreme, high-temperature conditions are key advantages to choosing titanium. While it does come at a higher price point in comparison to alternative metals such as aluminum and steel, titanium is compatible with a broad range of shapes and forms, such as sheet, plate, bar, tubing, and other custom specifications. Also a multitude of manufacturing processes — including casting, forging, molding, and additive methods — are compatible with titanium.

As industrial technologies and operational demands advance, it is anticipated that the titanium market will grow rapidly to accommodate these changes.

The following eBook will provide you with insights on the main advantages and properties of titanium, titanium investment casting opportunities available for industrial and consumer markets, as well as anticipated future growth data for titanium and titanium castings.

Why Ti? Advantageous Properties of Titanium

Some of the key advantages of titanium include:

- **High strength-to-density ratio.** Titanium is an ideal choice for products and systems that require high strength without excessive weight. Additionally, when applied within engine component and mobile equipment manufacturing processes, titanium's lighter weight translates to better fuel efficiency.

- **Superior corrosion resistance.** When exposed to oxygen, titanium creates a protective oxide film that resists corrosive and erosive compounds with pH levels between 3 and 12, including chemical media, seawater, and solutions containing carbonates, chlorides, nitrates, phosphates, sulfates, silicates, and more. The oxide layer helps end products retain their surface finish. These qualities make titanium ideal for use in operations involving desalination, LNG liquefaction, offshore operations, petroleum refining, and power generation.

- **Excellent biocompatibility.** Due to the material's biocompatibility, titanium is non-toxic and non-reactive within the human body, making it suitable for medical devices and instruments.

- **High temperature resistance.** Titanium is able to withstand higher operating temperatures without incurring damage. Additionally, its heat transfer characteristics allow for more efficient and sustained heat transfer that both conserves energy and reduces process cycle times.

Titanium vs. Alternative Metals

While low-cost alternatives are available, titanium remains an excellent option for critical applications that require superior strength and corrosion resistance. Here is how it compares to some common alternatives:

- **Compared to steel:** Titanium has comparable strength with only 60% of the material density, as well as a higher melting point, temperature resistance, and creep resistance.
- **Compared to aluminum:** Titanium has a material density that is 60% greater, but with twice the strength of aluminum.
- **Compared to stainless steel:** Titanium offers greater stress corrosion resistance when exposed to chlorides.
- **Compared to typical metals of similar strength:** Titanium features a higher degree of flexibility due to its low elastic modulus.

Investment Casting with Titanium

Although titanium accommodates a wide range of manufacturing processes, it is particularly well-suited for use in investment casting operations (given the proper working conditions—i.e., specialized equipment in a vacuum or an inert gas environment that minimizes the risk of unintended reactions during melting and casting). When used for investment casting, titanium offers:

- Greater part complexity
- Higher surface quality
- Better mechanical and physical properties
- Broader compatibility with graphite fiber reinforced polymeric composites
- Increased high temperature applications in the form of titanium aluminides

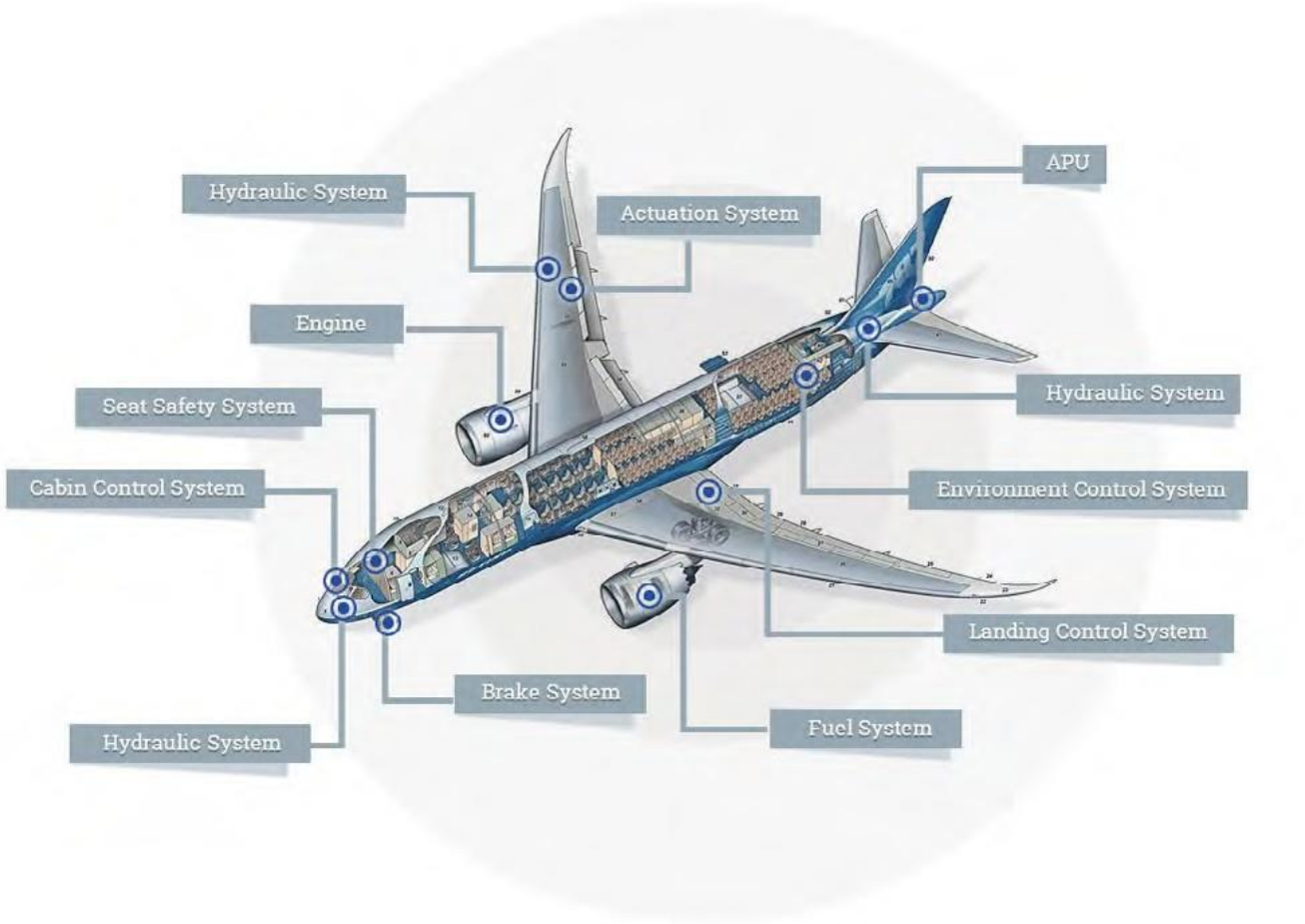
In regard to the two latter points, titanium mixed with carbon composite or mixed with aluminum to produce titanium aluminides have additional advantages. For example:

- **When joined with carbon composite:** minimizes the risk of galvanic corrosion.
- **When mixed with aluminum to produce titanium aluminides:** increased durability of rotating and reciprocating components, as well as superior high-temperature performance, lower weight, and reduced fuel consumption and emissions production.

Industrial Applications of Titanium

Titanium castings find application in a diverse set of industries, including the following:

Aerospace



Since the 1950s, aerospace companies have utilized titanium to manufacture structural and auxiliary elements for commercial aircraft (e.g., Boeing 707 Dreamliner), vehicles, and equipment. Typical parts and products made from titanium include rotating and static components, such as frames, rotors, blades, and landing gears. Due to the material's strength-to-weight ratio translating to a better thrust-to-weight ratio, critical parts—such as jet engines—have increasingly incorporated more titanium. For example, modern designs for jet engines contain two to three times as much titanium when compared to older models. The aerospace industry is a key contributor to the growth of titanium demand, as it currently consumes two-thirds of all titanium used across industries.

Military and Defense

In the military and defense industries, the first titanium applications date back to the 1950s and 1960s, when the United States and the Soviet Union used the material to manufacture aircraft and submarines. Today, titanium continues to serve as a construction material in many modern military systems and products due to its superior strength-to-weight ratio, durability, corrosion resistance, manufacturability, and heat transfer characteristics. Titanium uses in the military industry include:

- Armored weaponry
- Battlefield tanks
- Missiles
- Naval seawater piping
- Tank armor

Power Generation and Marine Power

Titanium can be found in many modern power generation and marine power systems, such as aeroderivative gas turbines and microsteam turbine power systems. Several examples:

- **Combined heat and power (CHP) technology:** Titanium's strength and durability make it ideal for critical components in CHP systems.
- **Engines:** The metal's lighter weight promotes fuel efficiency.
- **Nuclear power equipment:** The advantageous heat transfer characteristics of titanium facilitate efficient operations of condensers and heat exchangers.
- **Steam engines:** Titanium's corrosion resistance is a sought-after property when it comes to the manufacture of components exposed to geothermal steam, which contains corrosive or erosive compounds.

Oil and Gas

Offshore and undersea oil and gas rigs typically require many types of castings, including valves. Titanium is an excellent opportunity for extraction and processing operations.

Chemical and Hydrocarbon Processing

Corrosion resistance is essential for equipment used in chemical and hydrocarbon processing operations. For this reason, titanium is used for the manufacture of critical parts such as impellers, pumps, and valves for metal finishing and recovery, hydrocarbon processing, and plastic manufacturing systems.

Marine

In the marine industry, titanium serves as an ideal construction material due to its strength-to-weight ratio, durability, and corrosion and erosion resistance properties. These qualities, among others, have led to its use in everything from ball valves and heat exchangers to tidal zone protection components and yacht fittings.

Medical

As titanium demonstrates biocompatibility and the ability to osseointegrate, medical equipment manufacturers often use it to create medical instruments and devices, such as surgical tools and implants. Titanium's strength makes it appropriate for the manufacture of products such as crutches and wheelchairs, and it is highly suitable for custom-tailored patient products.

Desalination

For desalination facilities, titanium's corrosion and erosion resistance to salt — coupled with its high condensation efficiency — makes it a natural choice as a construction material for critical plant components.

Heating, Ventilation, and Air Conditioning (HVAC)

In the HVAC industry, corrosion resistance is key. Titanium resists damage due to corrosive compounds, including common cooling mediums used in HVAC heat transfer applications such as brackish water, polluted water, or seawater. For these applications, the metal offers superior cost-effectiveness during installation and throughout the service life of the product.

Automotive and Motorcycle

For automobile and motorcycle manufacturers that are looking for new ways to increase the safety and fuel efficiency of vehicles, look no further than titanium. Titanium is able to achieve each of these end goals, as it has a high strength-to-weight ratio, which enables resulting components to maintain their integrity without adding too much weight. Typical examples of automobile and motorcycle parts that can be produced with titanium include connecting rods, rocker arms, turbocharger components, and valves.

Additional Industrial & Consumer Applications

In addition to the industries mentioned above, investment cast parts made from titanium also play a role in the following:

- **Food and beverage and brewery industries.** Durable and corrosion-resistant titanium components offer easy maintenance of health and safety standards.
- **Mining industry.** Corrosive and erosive resistant titanium parts such as valves for slurry pumping systems are frequently requested.
- **Pharmaceutical industry.** Biocompatible and corrosion-resistant titanium parts facilitate longer life and reduced contamination.
- **Pulp and paper industry.** Reliable and durable equipment for waste fluid management is made possible with titanium.

In the consumer sector, the demand for titanium investment castings is growing for:

- Hand and power tools, such as crowbars, grips, and hammers
- Sporting goods, such as bicycles, camping gear, fishing reels, and hunting equipment

Anticipated Market Growth for Titanium & Titanium Castings

According to a report released by Fior Markets, from 2017 to 2025, the global titanium alloy industry is expected to grow to USD 6.87 billion at a compound annual growth rate (CAGR) of 4.13% between 2018 and 2025. The two markets that will lead this industry growth are aerospace and industrial—they are first and second largest, respectively.

After the aerospace market, the industrial market makes up less than 20% of the overall industry. However, it is currently expanding at a rate of between 6 to 7% each year. Some of the most significant current or anticipated trends include:

- Approximate 6-7% growth in titanium investment casting operations
- Increased usage of titanium in high-end vehicles, such as bicycles, cars, and motorcycles as a result of combining titanium with carbon fiber composites
- Use of titanium in low-volume additive manufacturing operations
- Accelerated growth in the chemical, shipping, and desalination industries, as well as favorable developments for the power and automotive sectors

Comprehensive Titanium Investment Casting Solutions at Impro

The titanium investment casting market will continue to grow rapidly, as there are many opportunities and benefits to implementing titanium. It is an excellent choice when seeking an incredibly long-lasting, strong, and lightweight material for critical components.

At Impro, we are a one-stop solutions provider with comprehensive precision component solutions. We offer titanium investing casting services tailored to the customer's specifications, as well as a range of additional casting services including, but not limited to, prototype development, secondary machining, and finishing.

If you would like to learn more about our investment casting services and capabilities, visit our website or contact our team today.

About Impro

Impro is a global leading manufacturer of high-precision, high-complexity, mission-critical casting and machined components for diverse end-markets. We supply customized casting and machined products and provide surface treatment services to a well-diversified global customer base. Our global leading position is underpinned by our integrated business model with comprehensive capabilities of offering one-stop solutions to our customers.

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