



Precision Machining – A Materials Guide

Table of Contents

Polyoxymethylene materials (also known as Delrin® and Acetal)	3
Titanium-based alloys	4
Nickel-based alloys (e.g., Inconel® alloys)	5
Duplex stainless steel	6
Super duplex stainless steel	7
Oxygen-free copper	8
Hastelloy®	9
Vanadium	10
About Hi-Tech and GCM	11

Hi-Tech Manufacturing, LLC – Experts at Machining Polyoxymethylene Materials (also known as Delrin® and Acetal)

Hi-Tech Manufacturing and its subsidiary Global Contract Manufacturing (GCM) have the experience and expertise to machine components with polyoxymethylene materials such as Delrin®.

From small to large components, prototype runs to long run production orders, we have the experience to manufacture your components to your exact requirements.

Technical data

Delrin® and other polyoxymethylene materials are characterized by their high strength, hardness and rigidity at temperatures as low as -40°C. While Delrin® is intrinsically opaque white due to its high crystalline composition, it is available in other colors including black. Delrin® and other polyoxymethylene materials offer excellent resistance to abrasion and heat, low water absorption, a very low coefficient of friction, and excellent electrical and dielectrical properties.

Applications

Due to its excellent physical properties and stability at cryogenic temperatures, Delrin®, and polyoxymethylene materials in general, are used in the oil and gas industry for exploration and production equipment, and in the medical industry for mechanical components in radiology, hematology and urinalysis equipment. Other applications include mechanical gears, sliding and guiding elements, housing parts, and valve bodies. In addition, the Food and Drug Administration has approved Delrin® for use in the food industry.

We machine all grades of Delrin®

A sample of the grades we work with:

- 300CP
- 100PE, 300PE, 500PE
- 100STE, 100TE, 300TE, and 500TE

Delrin® is a registered trademark of Du Pont

Hi-Tech Manufacturing, LLC – Experts at Machining Titanium-based Alloys

Hi-Tech Manufacturing and its subsidiary Global Contract Manufacturing (GCM) have the experience and expertise to machine components with titanium-based alloys.

From small to large components, prototype runs to long run production orders, we have the experience to machine your Titanium-based alloy components to your exact requirements.

Technical data

Titanium-based alloys offer excellent strength, a high strength-to-weight ratio and outstanding corrosion resistance. These alloys are stronger than pure titanium and reliably address the requirements of a broad range of applications. Components fabricated using titanium-based alloys substantially exceed performance and service life expectations, and at a lower overall cost, compared to those fabricated using traditional materials.

Applications

Titanium-based alloys are used for the aerospace, automotive, marine equipment and medical industries. Ti6Al4V is the most widely-used titanium alloy. It offers good machinability, excellent mechanical properties, the best all-round performance for a variety of weight reduction applications, and excellent biocompatibility. Ti6Al4V has numerous applications in the aerospace, automotive, power generation, oil and gas production, sports and other major industries. Its inherent properties have also led to a wide and diversified range of successful applications in surgery and medicine, where biocompatibility with soft tissues and bone is required.

Machining titanium-based alloys

Machining titanium-based alloys can be difficult using traditional machining techniques, as heat does not dissipate easily from the tool-chip interface due to the alloy's low thermal conductivity. Furthermore, because of the strong tendency of titanium to gall and smear, machining should never be stopped while the tool and work piece are in moving contact. Consequently, the tool heats up quickly, which leads to lower tool life. To improve efficiencies, Hi-Tech Manufacturing uses the latest in cutting technologies, such as abrasion- and heat-resistant cutting tools, special fixtures to increase the rigidity of the entire system, and sharp, properly shaped cutting tools.

We work with various grades of titanium

A sample of the titanium-based alloys we work with:

- Titanium 6Al/4V Grade 5 (annealed)
- Titanium 6Al/4V ELI Grade 23 (solution-annealed)
- C.P. Titanium Grade 2 Plate (annealed)



A HI-TECH Manufacturing, LLC Company

Hi-Tech Manufacturing, LLC – Experts at Machining Nickel-based Alloys

Hi-Tech Manufacturing and its subsidiary Global Contract Manufacturing (GCM) have extensive experience and expertise in machining nickel-based alloys (e.g., Inconel® alloys).

From small to large components, prototype runs to long run production orders, we have the experience to machine your nickel-based alloy component to your exact requirements.

Technical data

Nickel-based alloys offer a combination of strength, tolerance to extreme temperatures, and resistance to corrosion and oxidation. Depending on the specific alloy, acceptable surface temperatures range from cryogenic levels to as high as 1800°F (982°C).

Applications

Nickel-based alloys are typically used in extreme environment applications, including the energy sector, due to their high strength and corrosion resistance. In the aerospace industry, nickel-based alloys are used for components such as gas turbine blades, seals and combustors, and turbocharger rotors. Other applications include high-temperature fasteners, chemical processing and pressure vessels, heat exchanger tubing and steam generators used in nuclear pressurized water reactors.

Machining nickel-based alloys

Machining nickel-based alloys requires expertise and a thorough understanding of their properties. Traditional techniques utilizing high pressures can result in a stressed work-hardened layer of

deformed metal on the surface of the component, making machining laborious. Hi-Tech Manufacturing has the expertise and capabilities to machine age-hardened nickel-based alloys, such as alloy 718, and solution-annealed alloys. We use techniques that avoid stresses and excessive work hardening during machining, and in the case of solution-annealed alloys we perform the final steps after allowing the alloy to stabilize.

Hi-Tech Manufacturing offers the latest in cutting technologies, including new reinforced ceramic cutters that can be used to machine nickel-based alloys such as Inconel® up to 8 times faster than traditional carbide cutters.

We work with all grades of Inconel®

A sample of the nickel-based alloys we work with:

- Inconel® 718 nickel-chromium
UNS N07718 (solution-annealed and age-hardened condition)
- Inconel® 600I nickel-chromium-iron
UNS N06600 (solution-annealed)
- Inconel® 625 nickel-chromium
UNS N06625 (solution-annealed)

Inconel® is a registered trademark of Special Metals Corporation



A HI-TECH Manufacturing, LLC Company

Hi-Tech Manufacturing, LLC – Experts at Machining Duplex Stainless Steel

Hi-Tech Manufacturing and its subsidiary Global Contract Manufacturing (GCM) have extensive experience and expertise in machining duplex stainless steels.

From small to large components, prototype runs to long run production orders, we have the experience to manufacture your duplex stainless steel components to your exact requirements.

Technical data

Duplex stainless steels combine many of the beneficial properties of ferritic and austenitic materials to provide high strength and good corrosion resistance. Due to their duplex structure and high chromium, molybdenum and nitrogen content, these steels offer many benefits in comparison to 300-series austenitic grades. Duplex stainless steels offer high strength (roughly twice that of austenitic steels), excellent resistance to stress-corrosion cracking, good resistance to pitting, crevice corrosion, erosion and fatigue, good weldability and heat transfer. In addition to these advantageous properties, its lower nickel content compared with austenitic grades results in greater price stability.

Applications

Due to their high strength and corrosion resistance, duplex stainless steels are used in the oil and gas, mining, food nuclear, biofuel and other industries. Components fabricated using duplex stainless steels include rotors, impellers, shafts, pressure vessels, reactor tanks and heat exchangers. Other applications include water transmission pipes, desalination plants and seawater systems, and stock washers and other equipment for the pulp and paper industry and biofuel plants.

We machine various grades of duplex stainless steel

A sample of the duplex stainless steels we work with:

- Duplex LDX 2101
- 2304
- 2205

Hi-Tech Manufacturing, LLC – Experts at Machining Super Duplex Stainless Steel

Hi-Tech Manufacturing and its subsidiary Global Contract Manufacturing (GCM) have extensive experience and expertise in machining super duplex stainless steels.

From small to large components, prototype runs to long run production orders, we have the experience to manufacture your super duplex stainless steel components to your exact requirements.

Technical data

Super duplex stainless steels offer excellent impact strength and thermal conductivity, a low coefficient of thermal expansion, and excellent resistance to chloride stress corrosion. The high chromium, molybdenum, and nickel levels provide excellent resistance to pitting, crevices, and corrosion. Alloy 2507 is the most frequently used super duplex stainless steel. It contains 25% chromium, 4% molybdenum and 7% nickel, and is designed for demanding applications that require exceptional strength and corrosion resistance.

Applications

Super duplex stainless steels are used in the oil and gas, chemical processing and power industries. Equipment fabricated using super duplex stainless steels includes offshore platforms, heat exchangers, process and service water systems, fire-fighting systems, injection and ballast water systems, vessels, piping, FGD systems, utility and industrial scrubber systems, absorber towers and ducting. Other applications include desalination plants, seawater piping and high pressure RO plants.

We machine and weld various grades of super duplex stainless steel

A sample of the super duplex stainless steels we work with:

- 2507
- Ferralium 255



A HI-TECH Manufacturing, LLC Company

Hi-Tech Manufacturing, LLC – Experts with Oxygen-free Copper

Hi-Tech Manufacturing and its subsidiary Global Contract Manufacturing (GCM) have the experience and expertise to fabricate components with oxygen-free copper.

Technical data

Oxygen-free copper is produced by electrolytically refining and then casting copper under non-oxidizing conditions. It contains few impurities, almost no oxygen, and certified electronic grade oxygen-free copper contains at least 99.99% copper.

Oxygen-free copper offers exceptional electrical conductivity above 100% IACS (typically up to 102% of IACS); high thermal conductivity and ductility; resistance to deformation and corrosion; and resistance to hydrogen embrittlement for secure welding and brazing. It is suitable for use in vacuum and non-vacuum environments, at high and cryogenic temperatures and can be used for machining, welding, brazing and sputtering processes.

Applications

Oxygen-free copper is used for components in the electronics, medical, electrical and scientific industries. Examples include printed circuit boards, transmitter tubes, waveguide tubes, linear accelerators, glass-to-metal seals, X-ray tubes, vacuum interrupters and scientific

instruments. Other applications include superconducting wires, laser mirrors, coils for induction furnaces and electrical magnets, and heat sinks for semiconductor bases. Tuyères for steelmaking blast furnaces are also fabricated from oxygen-free copper.

Using oxygen-free copper

We have the expertise and capabilities to fabricate and braze your components using oxygen-free copper. Expertise and quality control are critical factors in the delivery of high-quality components for demanding environments and applications. Hi-Tech Manufacturing and [Global Contract Manufacturing \(GCM\)](#) are both ISO 9001 and ISO 13485 certified, with robust quality control processes in place for timely delivery of high-quality components containing oxygen-free copper.

We work with oxygen-free copper

Oxygen-free coppers we work with:

- C10100 (OFE - electronic grade)
- C10200 (OF)
- C10300



A HI-TECH Manufacturing, LLC Company

Hi-Tech Manufacturing, LLC – Experience and Expertise in Machining Hastelloy® *

Hi-Tech Manufacturing and its subsidiary Global Contract Manufacturing (GCM) have the experience and expertise to machine Hastelloy®.

Technical data

Hastelloy® is a registered trademark for a family of nickel-based “superalloys” with a high content of chromium and/or molybdenum, the mix depending on the specific alloy. Hastelloy® alloys offer resistance to corrosive pitting, stress cracking and crevicing. They are typically used for components destined for demanding environments where high strength and resistance to chemicals, corrosion and oxidation are required, together with excellent physical properties at high temperatures and low thermal expansion. Various Hastelloy® alloys are resistant to hydrogen sulphide; hydrofluoride; ferric ions; chlorine; bromine; formic, acetic, nitric, sulphuric and hydrofluoric acids; and other challenging chemicals. Oxidation resistance to around 2000°F (1095°C) can be attained with Hastelloy®.

Applications

Hastelloy® is frequently used in the aerospace and gas turbine industries for combustors, casings, seal rings and transition ducts.

Other applications include reactors, pumps and bellows in chemical processing, bellows in the pharmaceutical industry, components in sour gas wells, heat exchangers and diaphragm valves, pressure regulators and tubing in the semiconductor industry.

Machining Hastelloy®

Machining Hastelloy® alloys requires expertise and a thorough understanding of their properties. Traditional techniques can result in stresses and degradation of these materials, and rapid work hardening makes machining laborious. Hi-Tech Manufacturing and [Global Contract Manufacturing \(GCM\)](#) have the capabilities to turn, mill and cut Hastelloy® in its solution-annealed state. We use techniques that avoid stresses, degradation and excessive work hardening, and then finish components after allowing the alloy to stabilize. Waterjet cutting of Hastelloy® is also an option.

Achieving accurate, durable results with no degradation can be difficult when machining Hastelloy®. This makes expertise and quality control critical factors in the delivery of high-quality components within tolerances. Hi-Tech Manufacturing is ISO 9001 and ISO 13485 certified, with robust quality control processes in place for timely delivery of high-quality Hastelloy® components to our customers.

We work with Hastelloy® alloys

A sample of the Hastelloy® alloys we work with:

- HASTELLOY® S alloy
- HASTELLOY® X alloy
- HASTELLOY® B4
- HASTELLOY® C-22HS, C 276 and C3
- HASTELLOY® G-50® and G-30

*Registered trademark of Haynes International Inc.



A HI-TECH Manufacturing, LLC Company

Hi-Tech Manufacturing, LLC – Experts with Alloys Containing Vanadium

Hi-Tech Manufacturing and its subsidiary Global Contract Manufacturing (GCM) have the experience and expertise to fabricate components with vanadium steel and titanium.

Technical data

Vanadium occurs naturally, however the majority of vanadium used is produced as a by-product during oil and during mineral operations. It is largely used in steel alloys, and is also used in titanium alloys. The vanadium content in steel alloys can range from 0.03% to > 4%, depending on the application. High-strength low-alloy (HSLA) steels typically contain <0.15% vanadium and up to 0.20% and account for the greatest use of vanadium. Alloys containing vanadium are used for components when exceptional strength, strength-to-weight ratios, toughness, high ductility, and resistance to corrosion, wear, shock and vibration are required. A strength of 550 MPa is typical for HSLA grades. Vanadium steel is resistant to salt water, hydrochloric and sulfuric acids. It also offers improved machinability and weldability, and high temperature and low neutron-absorbing properties. The alloys are suitable for use in pressure and non-pressure environments, at high temperatures and can be used for machining, welding and brazing processes.

Applications

Vanadium is used for the energy, aerospace, automotive, medical and construction industries. Titanium alloys containing vanadium are used for high-speed airframes and jet engines. Chromium-vanadium steel alloys are used for ball and roller bearings. Examples of vanadium steel components include axles, crankshafts, gears, piston rods,

connecting rods, automotive chassis, high-strength fasteners, tooling and dies. Other applications include engine turbines, surgical instruments, joists and girders in construction, armour plating, pressure vessels and in nuclear reactors.

Using alloys containing vanadium

We have the expertise and capabilities to fabricate and braze your components using alloys containing vanadium. Expertise and quality control are critical factors in the delivery of high-quality components for demanding environments and applications. Hi-Tech Manufacturing and [Global Contract Manufacturing \(GCM\)](#) are both ISO 9001 and ISO 13485 certified, with robust quality control processes in place for timely delivery of high-quality components fabricated using alloys containing vanadium.

We work with alloys containing vanadium

A sample of the alloys containing vanadium we work with:

- Grade 8620 (HSLA-V)
- Grade 6150
- Grade 4330V
- Grade 5655A
- Grade 616
- Lescalloy BG 42



A HI-TECH Manufacturing, LLC Company

About Hi-Tech

Hi-Tech is a world-class manufacturer of low-to-medium volume, mission-critical precision machined components and assemblies. Based near Chicago's O'Hare airport, the company serves large, market-leading customers in the MedTech, scientific laboratory, diversified industrial, aerospace, space flight systems, and energy markets. The company is regarded as the preferred contract manufacturer for its customers' most critical, tight tolerance and difficult-to-manufacture components.

About GCM

Headquartered in Union City, California, with a second facility in Dongguan, China, GCM is a preferred supplier of contract manufacturing services to leading OEMs in the medical, industrial, transportation, and aerospace sectors. GCM offers precision machining, sheet metal fabrication, EDM, Swiss machining, furnace brazing, electro-mechanical assembly and clean room integration as core service solutions. GCM also provides value-added services to its customers including rapid-prototyping/new product introduction, supply chain management, and low cost region manufacturing through its wholly-owned subsidiary in China. For more information on GCM, please [visit www.gcmfg.com](http://www.gcmfg.com).



For more information on Hi-Tech Manufacturing, LLC or GCM please visit our Websites at www.hi-tech-mfg.com and www.gcmfg.com or contact Aldo Eagle, Vice President of Business Development, at 918-804-2701, aeagle@hi-tech-mfg.com.

Tim Weaver, CEO 847-752-3244
tweaver@hi-tech-mfg.com



Hi-Tech Manufacturing, LLC
9815 Leland Avenue
Schiller Park, IL 60176
847-678-1616
www.hi-tech-mfg.com