# Titanium: Available and affordable material of construction for industrial applications

When you hear the word 'titanium', what do you think? Most people would think aerospace and airplane applications, when it is much more than that. Many also associate the word titanium with 'expensive', when in reality, it is actually cost effective. Many would also think 'unobtainable', when it is readily available.

While a majority of the titanium used today goes into the aerospace industry, there has been much progress made in the use of titanium in the corrosion control market – in chemical processing, refining, offshore, and other industrial markets. In fact, the use of titanium continues to grow as more and more design engineers, process engineers, reliability engineers, plant engineers, and company executives understand the value of this metal and its alloys, and specify its use for their projects that require corrosion resistance.

***By Charles Young, Metallurgist and Business Development Manager, Tricor Metals***

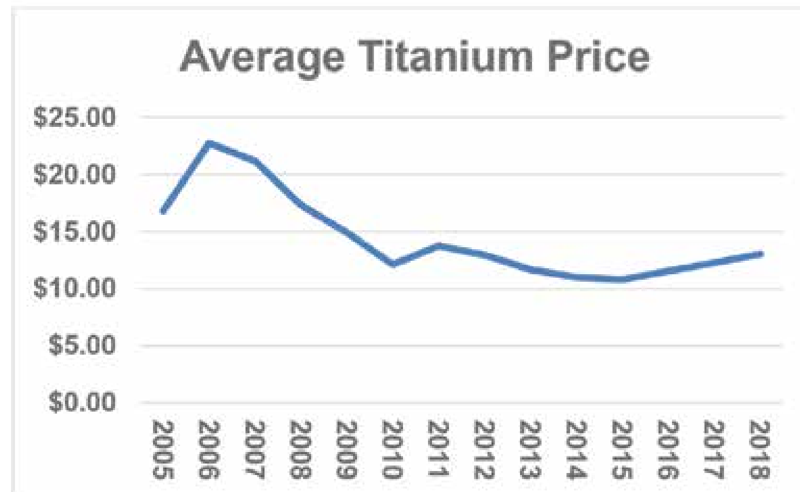


*Figure 1: The average, annual price of titanium per pound.*

Titanium has been used for more than 60 years to prevent corrosion in a wide variety of industrial applications. One of the first, most widely used, applications was in seawater surface condensers for nuclear power plants. Titanium in these applications often lasted longer than the life of these plants, which was more than 50 to 60 years in some cases. Early on, the pulp and paper industry also saw the value of titanium to prevent corrosion in bleaching systems, while the plastics industry used titanium's corrosion resistance in a wide variety of chlorine and chlorine chemical plants. One such example is a titanium vessel that was used in a chemical plant which was only recently replaced in 2017, after more than 50 years of service.

Part of the problem, which is related to the lack of knowledge about titanium in industrial applications, is the titanium industry's historical focus on aerospace, as well as the ups and downs in the titanium price and supply, created by fluctuations in the aerospace market. These wide variations in pricing and shortages of supply meant that the industrial market could not rely on titanium when it was needed and, therefore, there was little reason for chemical processing industry (CPI) engineers to design titanium into their systems. In addition, with the titanium industry's focus on aerospace, there was very little titanium marketing and research done to support the growing number of potential uses in the industrial market. However, all of this has changed in the past 10 to 15 years, and titanium is now recognized as another competitive corrosion-resistant material of construction.

## A change in the industry

Throughout the past 10 years, the titanium industry has become more focused in its support of the industrial market, and the overall price of titanium has remained fairly stable (as shown in Figure 1). This is especially true when compared to other corrosion resistant alloys (CRAs) including stainless steel, nickel alloys and copper alloys, all of which have seen drastic price fluctuations in the past 10 to 15 years, due to geo-political and other supply issues. Since 2009, the annual average price of titanium has remained almost flat.

While the average price per pound of titanium has been, and continues to be, relatively stable, comparison of the price per pound against stainless and nickel alloys may result in an inaccurate conclusion. This is because titanium has half of the density of these other materials of construction (MOCs); the same sized piece of titanium weighs half as much as a piece of these other alloys. Figure 3, developed by Tricor Metals, takes into account this difference in density, as well as differences in strength levels between the various alloys, to show a 'normalized cost comparison'. Titanium grade 2, the workhorse of the industrial market, is remarkably less expensive than the high-nickel alloys, and the 90/10 copper-nickel alloy, when this type of comparison is done.

## Checking costs

When engineers in the CPI also use 'life cycle costing' in their analysis of what material to use for corrosion resistance in their project, the advantage of titanium's superior corrosion resistance in a wide variety of applications becomes readily apparent. Comparing the life cycle cost of titanium to some non-metallic materials for headers and piping systems in the chlorine-producing industry shows that titanium should be the material of choice – if low maintenance and long life is the desired goal. This is also true when comparing titanium to some stainless and nickel alloys.

In life cycle costing, the initial cost of the components is considered along with any additional considerations that must be made to accommodate the use of each material. These considerations include the weight of components, number of pipe supports necessary, and ease of installation (welding versus flanged joints, etc.). In addition, maintenance costs and associated downtime throughout the life of the installation need to be considered. With titanium's life in these applications in the 20- to 30-year range, with little or no maintenance, it soon becomes overwhelmingly apparent that titanium should be the material of choice – for a long life, maintenance-free operation.

Stable titanium pricing and adequate supply of titanium now allow the chemical and refining industries to incorporate the use of titanium into their large, long-term projects. This pricing also allows the industries to consider using titanium during repairs, or for the modification of equipment as an upgrade in corrosion resistance to other MOCs, which often offer shorter corrosion-resistant life spans. With cost comparisons as shown in Figure 2, as well as life cycle cost analyses, titanium compares favorably to other corrosion resistant alloys used in the industrial market.

*An American Society of Mechanical Engineers (ASME) Code tank, made from 0.875-inch thick titanium, grade 2.*

*A titanium wastewater treatment tank.*

*A titanium bleach reactor.*

## The application of titanium

Titanium is being used today in a wide variety of industrial applications. The chemical industry, in particular the chlorine-producing sector, uses titanium for a majority of the equipment, including headers, piping, heat exchangers and vessels. Refineries use titanium for overhead condensers and other heat exchangers that use brackish or contaminated river water or seawater for cooling, because titanium is immune to microbiological influenced corrosion (MIC corrosion). The terephthalic acid (TPA) industry, which manufactures the precursor to the plastic used in disposable soda and water bottles, uses titanium in heat exchangers, pressure vessels and piping as well, due to its overall corrosion resistance. Industries that use chlorine as one of the input materials to manufacture various plastics also use titanium in all of these forms. The oil and gas industry, more specifically the offshore sector, uses titanium because of its excellent resistance to seawater, and low density, which allows for lighter equipment. In addition, thermal desalination plants, as well as wastewater treatment plants use titanium for its resistance to chloride environments and other water-cleaning chemicals.

The titanium industry has also been aggressive in adding upgraded titanium alloys into the American Society of Mechanical Engineers (ASME) Code. This will allow for the use of thinner walls on vessels and exchangers, and would effectively decrease the cost of this equipment, which would make titanium even more cost-competitive.

Titanium grade 2H, with an ultimate tensile strength (UTS) of 58 thousand pounds per square-inch (ksi), was approved for use in ASME Division VIII, Section 1 in 2008 and a Code case is being developed to allow the use of this titanium grade in ASME Section VIII, Division 2, Class 2. This new code case has the potential to further reduce the cost of a titanium vessels by as much as 14% to 16%. When this is completed, the chemical industry will be able to use titanium for even more vessels, at a reduced overall cost. The chemical industry operations will become more cost-effective and sustainable as less maintenance and a longer lifespan can be expected from titanium. This will result in overall cost benefits to chemical companies, their customers, and to consumers of the end use products.

In summary, titanium has been used in industrial applications for more than 60 years. With stable pricing and with the titanium industry gearing its focus on the industrial market, the material's industrial uses will be further recognized, and its use will continue to increase into a wider array of applications, where it will provide cost-effective corrosion control for many years to come.

Titanium's pricing is stable; titanium is readily available; and titanium should now be considered as a standard material of construction in the chemical process industry, as well as other industrial markets.




| Metal | Density (Lbs/In³) | Yield Strength | Price/lb | Price/Sq Ft | Price/Sq Ft Normalized |
|---|---|---|---|---|---|
| 2205 | 0.29 | 65,000 | $3.70 | $39 | $24 |
| 316L | 0.29 | 25,000 | $3.22 | $34 | $54 |
| Ti2 | 0.163 | 40,000 | $13.34 | $78 | $78 |
| 625 | 0.305 | 55,000 | $15.59 | $171 | $124 |
| C276 | 0.32 | 41,000 | $13.35 | $154 | $150 |
| CuNi 90-10 | 0.323 | 15,000 | $7.73 | $90 | $240 |
| Ti16 | 0.163 | 40,000 | $48.25 | $283 | $283 |
| Ti7 | 0.163 | 40,000 | $71.52 | $420 | $420 |
| Zr | 0.234 | 30,000 | $43.27 | $364 | $486 |

*Normalized cost comparison. Image courtesy of Tricor Metals*

### About the author

Charles (Chuck) Young is the Metallurgist and Business Development Manager for Tricor Metals in Wooster, Ohio, U.S.A. He has Bachelor of Science, and Master of Science degrees in Metallurgy & Materials Science from Carnegie-Mellon University in Pittsburgh, PA, and a Master of Business Administration from Ashland University in Ashland, OH. Young has more than 45 years of experience in technical sales and marketing in metals industries, specializing in the uses of corrosion-resistant materials. Young has been with Tricor Metals for more than 10 years, and has additional experience in the titanium, specialty metal, clad metal, copper flat roll and tubing, as well as the zinc, and galvanizing industries.