Titanium-Strength, Corrosion Properties And Uses

How do you consider Titanium, as an unusual material described for powerful jet engines? A costly metal that is discovered on the outer walls of a popular museum in Spain? A strong and new metal for use in jewelry, sports and mountain bikes?

If it is then you are just somehow right.

Titanium is undoubtedly utilized in the whole of above stated applications but it is not an unusual material actually it is found in several ordinary places that we usually consider. Titanium is definitely a global material for choosing in construction of jet engine components. It is utilized in the architectural materials in several consumer products. The designers and engineers across the globe use titanium for the leading industries applications. Using this high functional metal we fly higher and more quickly, enjoy games, trust on electricity without any concern, prepare chemicals, oil and gas we need at a more affordable price, making our house's ceiling stronger and last longer and consume medicines to cure several diseases. Titanium enhances products and services and overall our quality life in the unlimited ways in the daily routine.

Titanium is an outstanding metal that has applications almost in all sorts of industries. It is energy intensive to manufacture, extremely reactive and offers exceptional corrosion resistance. The properties and applications of this unique metal are summarized in this post.

Titanium resource

Titanium is a significant and lightweight metal of silver color. It is the 4th most abundantly available metal on this earth. So a question comes into mind, why it is still expensive? To a large level, the costs are involved in receiving it. The whole base metals are received as a metal oxide. Titanium is also found in its oxide form, titanium dioxide, TiO2 that is named rutile and ilmenite (FeTiO3). These minerals are the most popular and commercially available. Other ores found are leucoxene, a natural modification of ilmenite, anatasem a naturally occurring ore of titanium dioxide & pervoskite (CaTiO3). Several processes are included in the extraction of titanium from its oxide which make it a costly material.

Metallurgical characteristics

However titanium is widely popular as a mineral, its metallurgical properties make it an exclusive and more accurately, its set of characteristics, make it unique- the synergy of intrinsic properties increase its commercial use.

Titanium has strength similar to steel however its density is just 56 percent as of steel. Therefore it offers the largest strength to weight ratio amongst all structural metals in the modern time. To manufacture structures of identical strength, very small titanium is needed as compare to other metallic materials. If same weight **titanium plates** are need to be made, these will be double times larger in size than copper plate whilst 75 % larger than stainless steel.

About titanium

Titanium has atomic number 22 in the periodic table, positioned near iron, nickel and copper. The significant metallurgical and physical properties are advantageous for demanding industrial and commercial operations in the global markets. It is most commonly used when the initial design describes its exclusive properties instead only replacing the other metals. In few demanding applications such as jet engines and medical implantation, titanium offers the components to utilize its highest strength.

In few cases, titanium introduces significantly enhanced functionality, it is expensive that is little more than a challenging material. For instance it is used in golf clubs where people wish to pay higher for the premium titanium sports materials that offer enhanced playing experience.

In chemical processing and marine conditions, titanium offers longer life that makes it a dominating choice over other metals while its main cost may be larger; its overall lifecycles is smaller. In few applications, use of titanium can influence the overall design, making it more competent and economical. It is the case in offshore oil and gas platforms where titanium pipe below the sea surface saves three times its weight in the apparent structure and anchoring system.

Properties

Titanium is a reactive metal having a standard potential of -1.63 volts, around 4 times more negative than negative potential of iron. But this very ignoble metal treats in an inert way that the titanium dioxide layer offers outstanding security. Titanium is very reactive that its oxide layer produces immediately when it comes in contact of air even in absence of water. On the other hand, iron needs humidity and air both to produce oxide. Hence iron is an active instead a reactive metal.

The general characteristics of titanium are stated as following:

1. Very small density
2. Excellent corrosion resistance
3. High erosion resistance
4. Great heat conductivity
5. Suitable strength to weight ratio
6. Small thermal expansion
7. Attractive look

8. Rough smooth oxide layer

The oxide layer strongly prevents the deposit of dirt and encourages condensation to create drops, an essential factor in the suitable functioning of condensers and heat exchangers. The properties such as small density, high mechanical strength and corrosion resistance are crucial factors that will rapidly state the use of this metal. In the previous 50 years, titanium has proved to become a specifically suitable option of material in salt, brackish and contaminated water. Over 150 million meters of condenser tubes with guaranteed life of around 40 years have been successfully installed across the globe in the electricity production plants, and no damages have been noticed.

The fire extinguishing systems and cooling apparatus on the offshore plants were constructed with carbon steel secured by different types of coatings. Since the damage is retained by such coatings, the carbon steel was immediately replaced by cupronickel however it is also susceptible to pitting corrosion and erosion in the contaminated water. The metallurgists then attempted to overcome these issues by increasing the wall thickness and decreasing the water speeds. It resulted into reduced flow rate, the negative results of which were bigger pipe diameters, larger bend angles and extensive increase in cost and pipe weights that even took lot of space.

Instead of all of the above steps, in the long term race, different limitations occurred and it became clear that a radical change of course in terms of material selection and a new approach to material design were essential. Several latest designs need not just cost and weight cut down even also highly reliable materials that make it feasible to transfer liquids at the larger speeds through popes with small diameters. To initialize with austenitic stainless steels containing around 6% molybdenum and later super duplex stainless steel grades that have achieved more popularity by providing better functionality, these grades gave much better functionality than cupronickel however still it was tough to obtain the required outcomes and additionally shown the apparent problems while the production. The outstanding and exclusive corrosion inhibition by titanium gave new viewpoints for these applications. It was hence not wondering that titanium these days is selected most commonly for the production of seawater quenched heat exchangers and pipes and as a condenser material in electricity power plants and different kinds of equipment on ships like handling systems. In the modern generation, it has turned out that using titanium guarantees an effective solution to corrosion issues in specific media. Titanium should be considered, in both onshore and offshore conditions in chloride based conditions containing sulfur compounds or hydrocarbon compounds.

Corrosion resistance properties

An exceptional property of titanium is prevention of corrosion. To a large limit, this recompenses its lower heat conductivity.

Titanium offers natural resistance to acids, alkalis, salt water and polluted waters. Even its resistance to seawater is similar to platinum. However since titanium is a reactive metal, it produces hard security oxide layer in contact of oxygen, air or water. If the security layer is damaged, the metal quickly recovers itself in the presence of oxygen.

The naturally producing oxide layer also offers the metal an exclusive appearance. With increasing the thickness, its look changes in a range of colors.

Titanium has small elastic modulus, around half of steel. It offers outstanding flexibility. It is the highly biocompatible metal among all materials. It is poison-free, prevents corrosion due to body fluids and its versatility is similar to human bone.

Biocompatible Titanium is received from the abundant natural resource that is mined with the lowest impact. No harmful side products are produced in its production and as high value in the market, 95 % of titanium scrap is recycled.

Applications

Titanium is utilized in several construction applications of industrial apparatus like in heat exchangers or piping equipments in the chemical or offshore industries and in process instrumentation like pumps and valves. The material is also used in aircraft make, medical implants, sport products like tennis rackets and golf clubs, scenery frames, jewelry, paint pigmentation paper and others. The popular applications include chlorine production through membrane electrolysis and PTA.

<u>Marine and atmospheric media</u>

The titanium products provide regular service in the marine conditions for about 40 years without the need to care for corrosion. By titanium cladding in building's facades or ceiling assure security for around 100 years. Endless examples of titanium cladding in Japan can be seen.

Titanium's security oxide layer is also highly resistant to erosion. In the large velocity process streams and in quickly running seawater, it offers around 20 times higher resistance to erosion than cupronickel alloys.

Titanium is the only fully resistant metal to microbiological induced corrosion or MIC in marine water.

<u>Titanium for alloys</u>

Titanium is a suitable alloying agent for example in stainless steel and also in nickel alloys and others. A common application is when titanium is utilized as a stabilizer in the stainless steel grades with a large carbon %. Titanium offers very high affinity with carbon to produce a compound at the elevated temperatures, hence it is feasible to avoid deleterious chromium carbides production in,

for instance, heat affected region while welding. A common example is Stainless steel 316 that is utilized in Germany. However it is not mostly used nowadays because of feasibility to produce a low carbon grade steel which prevents the need for a titanium inclusion, in fact the risk of deleterious chromium carbides production also prevented. But it doesn't refer to insignificant contribution of titanium in enhancing the mechanical properties of austenitic stainless steels. Therefore, titanium based material is normally more recommended than low carbon steels for constructing pressure vessels.

Aerospace applications

No aircrafts without Titanium

As it is a lightweight, powerful, corrosion resistant and has outstanding high temperature properties, titanium has the largest applications in the production of commercial jet engines where it is used for fan blades, compressors, discs and crucial rotating materials. In the standard gas turbine engine, titanium is used in 30% of jet's weight. Overall, it is estimated that jet engines are used by 42% in US market and 37% in the European market.

Titanium is also utilized in airframes, in components varying from bulk forged wing structures and landing gears to crucially small fasteners, springs and hydraulic tubes. The future generation may use around 100 tons of titanium in each jet plane including engine, around 17% of aircraft's weight.

Following the current industry, estimates of American titanium producer, global commercial aerospace industry's need for titanium is around 120 million pounds of mill product shipments in 2015.

Titanium has been an aircraft metal since 60 years. It is popular as a solution to the high speed design challenges. In army aircrafts, the titanium % has rapidly increased with the technological upgrade. It is also used in spacecrafts. A critical application in the modern time is in the international space station.

Automotive industry

The titanium industry is making crucial efforts in the emerging automotive applications as even a pound of titanium in every new car would makes it a major market than aerospace. The titanium valve train parts have shown that they can enhance a car's fuel efficiency by around 4%. The titanium suspension springs could offer weight cut down by 70% as compared to steel and full corrosion resistance. The titanium engine springs offer higher engine speeds and enhanced fuel efficiency.

The connecting rods in sports car made of titanium that decrease the car weight is sufficient that a turbocharger is not required to obtain high functionality. The concept car built using titanium is tested since 1956. The automotive racing industry utilizes titanium valves, valve springs, suspension springs, connecting rods and rocker arms.

In the recent time, titanium and its alloys are actively used in the production of different parts of automotives:

1. The need of lightweight components has become strictly vast to control the global warning by reducing the emission of carbon dioxide.
2. Significant progress has been made in the production of technology for the development of economical titanium.
3. The appealing look of titanium catches the attention of public.

Exhaust Pipes and mufflers

Besides of plain carbon steel and stainless steel and aluminum, titanium is also used for exhaust pipes and mufflers. Because these are large size components for auto-bodies, the effect of decreasing their weight is considerable, advantageous not only in cutting the fuel cost even also in the enhancement of engine functionality. Titanium is the best fit material for providing greater heat resistance than aluminum, it is most suitable as a material to attain the effect of weight reduction in light since these components are subjected to the elevated temperatures above 400oC in contact with exhaust gas. For instance, weight of two wheeler can be cut down by 3 kg and four wheeler can be reduced by 8kg if titanium is used instead steel.

Now, because titanium has lower coefficient of thermal expansion and young modulus than steel, it may even decrease the strain caused by size change.

Engine Valves

The weight loss in the engine components is more suitable than the other components in terms of fuel use, decreasing the noise release and providing higher efficiency. In specifically, the effect is considerable in the engine valves and the titanium applications have been analyzed.

Exhaust valves

For the exhaust valves that are subjected to the elevated temperatures, the titanium heat resistant alloys are used in the several conditions.

Commercial applications make Titanium a daily material

Titanium eyeglass frames loss of light, cozy, striking and if they are deformed, they resume their original shape. The camera cases of titanium are powerful, corrosion resistant, dent – resistant and light, non-stick titanium coatings on cooking utensils are corrosion and scratch resistant.

The first and foremost use of titanium was in marine for condenser tubing, power production plants as it provides outstanding corrosion resistance. In the modern century, it is used in the endless global industrial applications. Titanium pipes are used on the vast scale in the desalination plants in Saudi Arabia for water purification units, desalination evaporation units for the heat recovery and input stages and in the more crucial exit stages.

In the chemical plants, titanium is used in the production of heat exchangers, vessels, pipe, tubing etc that operate in the severe oxidizing acidic and chloride solutions, high temperatures and pressures.

For general marine applications, titanium is resistant to corrosion in the natural and polluted seawater where copper and stainless steels are sensitive to attack. Therefore higher strength titanium is used in screw propellers to shipboard sprinkling apparatus. Titanium offers outstanding functionality its performance is many time warranted for around 100 years.

In production, natural resistance to corrosion, high strength, elastic modulus and aesthetically appealing look make it a popular metal in the market.

Titanium production

Pure titanium is found in two crystallographic forms – Alpha is stable up to 1620oF or 880oC at this limit, it converts to beta phase which is stable up to the melting point. Few alloying agents that are added in the pure titanium, they alter the temperature at which the phase transformation takes place and the amount of each phase present and hence the metal's properties.

The titanium alloys provide the complete range of strength features such as highly formable, lower to higher strength. Several alpha-beta and beta alloys can offer multiple strength-ductility combinations through alloy heat processing or/and chemistry. With the range of titanium alloys, a suitable alloy for a specific application environment can be possibly selected.

Melting is the chief step of producing titanium. It is performed in Vacuum Arc Remelt furnace to develop ingots usually utilized for aerospace applications or in a cold hearth furnace to fulfill industrial and specific aerospace requirements or to generate feedstock for a subsequent VAR melt. The ingots can weigh around 30,000 pounds.

For VAR, commonly used for aerospace applications, titanium sponge and alloys elements are pressed into briquettes that are welded together to produce an electrode. In the VAR furnace, the electrode is melted.

Cold hearth melting is a recommended method for the development of clean titanium for aerospace applications. The combined cold-hearth and VAR melts can prevent inclusions and flaws that even cannot be removed by triple VAR melting. Since the cold hearth melting uses a large percentage of low cost scrap, it can even develop economical titanium grades for industrial and commercial operations.

VAR ingots and cold heath melted cast slabs are pressed or rotary forged into slabs or billets. The common processing methods develop mill products such as bar, plate, sheet, tubing, billets and more which are industrial and structural shapes offering the required characteristics that increase the metal utility. The mill products are introduced in the range of alloys and grades in the whole major global markets.

Casting is a latest production technique that is used in the production of almost overall shapes. It delivers greater design privilege and considerably decreases the need for costly machining or forming to receive the required shape. The investment casting can be followed to develop large, tolerance critical components like heat shields, fan frames and missile parts and smaller components for example valves.

The commercial casting started in 1960 and in the modern time, the technology has been advanced to daily supply the crucial parts for gas turbine engines, air frames, chemical units, medical equipments and marine systems.

The traditional metal processing tools and production methods can be implemented to fabricate, machine and weld titanium and its workability is similar to stainless steel.

Heanjia Super-Metals produces Titanium in the forms – Wire, Sheet, Strip, Pipe, Tubing, Tube, Ribbon, Tape, Mesh, Flanges, Plate and various other forms.