A Look at Global Metallic Fastener Development in Two Airliner Manufacturing Giants, Boeing & Airbus

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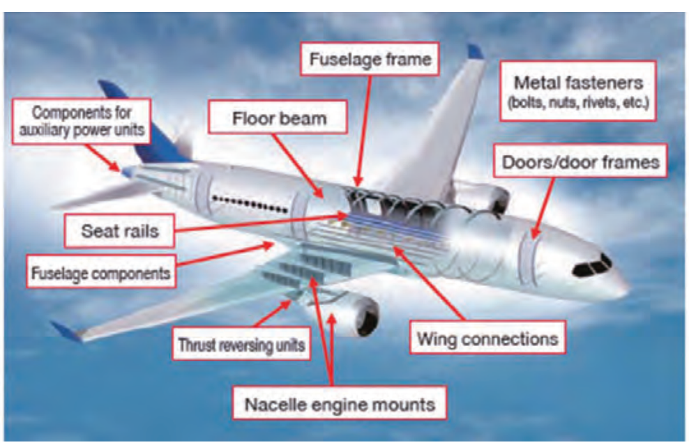
The aviation industry of the world started to recover after 2002 and the Boeing Company and Airbus tried to outdo each other and did market research on their own. Boeing focuses on manufacturing lighter, more fuel-efficient mid-sized jets to meet the increased demand for point-to-point air travel jets; in contrast, Airbus fabricates both lighter and large-sized, double-decker airliners to meet the increased demand for travel among airports.

Because titanium alloys are lighter and can withstand higher temperatures and corrosive chemicals, they have gradually replaced aluminum alloys in the aviation industry. Other new types of materials used in the aviation industry include carbon fiber, nickel-based alloys and various kinds of alloys of titanium and aluminum. Two reasons for such replacement are the fact that aluminum alloys are not light enough and the fact that aluminum alloys are inferior to these new types of alloys in terms of damage tolerance. Moreover, heavy loads of passengers can render airplanes made of aluminum alloys quite susceptible to metal fatigue. Therefore, to eliminate the disadvantages of aluminum alloys, airliner manufacturers have to switch to these new types of alloys.

In addition, the reason that we focus on titanium alloys is because they can be used for all parts and components of an airliner. **Fig. 1** illustrates an airliner's parts and components that titanium may be used for.

Fig. 1. Airliner's parts and components that titanium may be used for

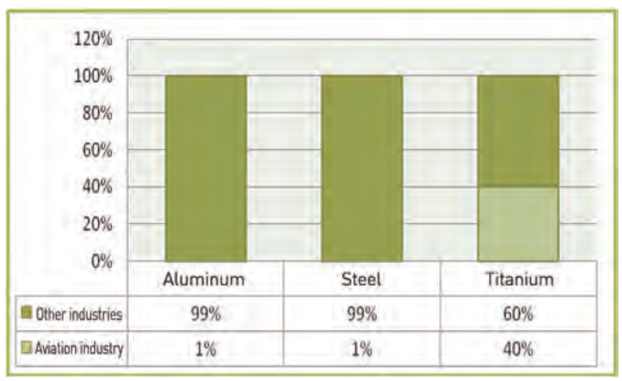


Source: Osaka Titanium Technologies 2013 Report. Compiled by MIRDC / 2014.04

From **Fig. 1**, besides the components that should be made of specific types of metals due to the considerations of cost and density, all other components and parts (such as fuselage, fasteners and key components) that have been conventionally made of steel, copper and aluminum may be made of titanium alloys.

Table 1 illustrates titanium and other metals used in the aviation industry and non-aviation industries in terms of percentage. Other metals have been widely and heavily used in other industries. In contrast, titanium, with its outstanding physical and chemical properties and its moderate price, has been highly valued by the high-end airliner manufacturers. **Table 2** illustrates the amounts of titanium used by or in airliners, the national defense industry and general titanium industries from 2012 to 2017. In the next three years, the amount of titanium demanded by airliner manufacturers will see an increase greater than that by the national defense industry and general titanium industries.

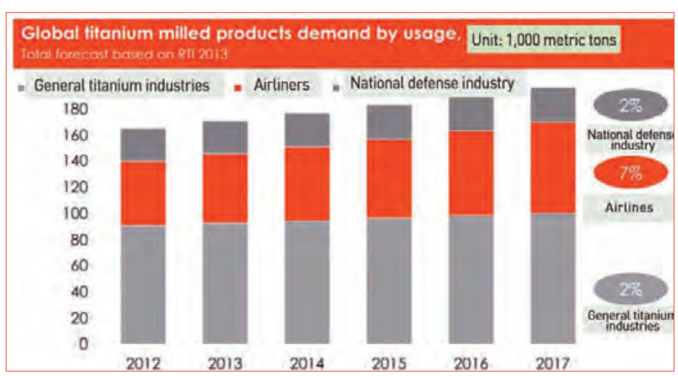
Table 1. Titanium and other metals used in the aviation industry and other industries in terms of percentage



	Aluminum	Steel	Titanium
Other industries	99%	99%	60%
Aviation industry	1%	1%	40%

Source: Titanium Europe 2013, compiled by MIRDC / 2014.04

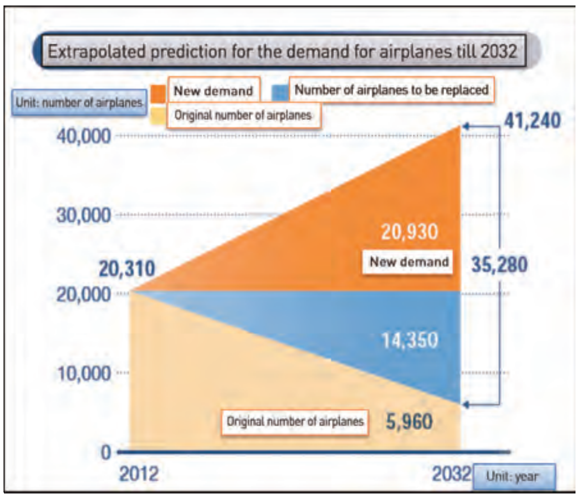
Table 2. The amount of titanium used by or in airliners, the national defense industry and other industries from 2012 to 2017



Source: RTI 2013

Boeing 787 Dreamliner is the world's first airliner model that fully utilizes the outstanding properties of new types of alloys. 50% of it is made of these alloys (38% more than Boeing 777). Both Boeing and Airbus have used more amount of titanium to build their planes. We can see that the demand for titanium alloys will continue to grow in the future. **Table 3** illustrates the demand for airplanes from 2012 to 2032, indicating a prosperous future for the airplane manufacturing industry in the next few years.

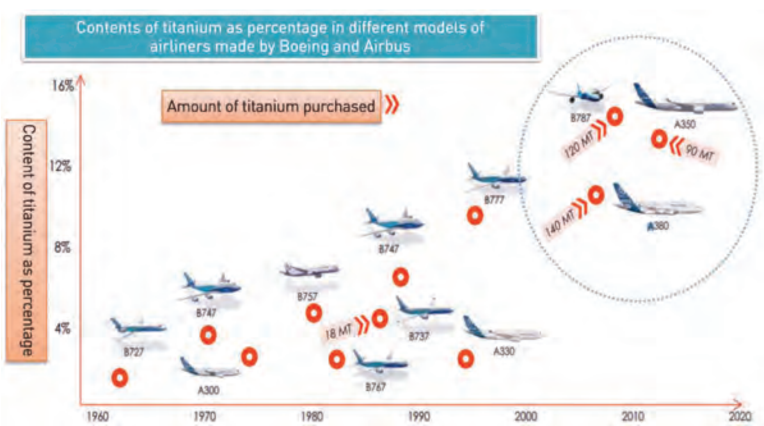
Table 3. An extrapolated prediction for the demand for airplanes till 2032



Source: Osaka Titanium Technologies 2013 report. Compiled by the MIRDC/ 2014.04

Fig. 2 illustrates the contents of titanium as percentage in different models of airliners made by Boeing and Airbus. As of now, Boeing 787 Dreamliner and Airbus 350/380 are the models with the highest contents of titanium.

Fig. 2. Contents of titanium as percentage in different models of airliners made by Boeing and Airbus have exhibited a growing pattern

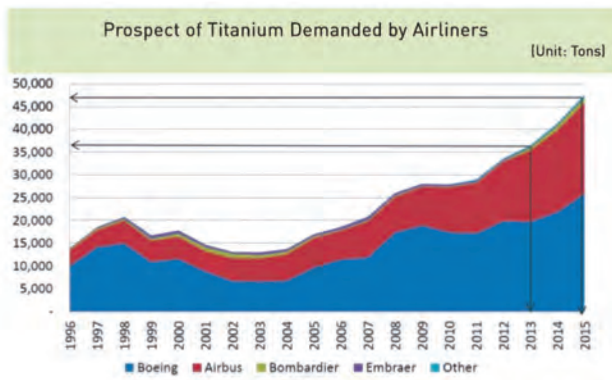


Source: Roskil 2010. Compiled by MIRDC / 2014.04

Boeing and Airbus SAS have been the leading manufacturers of airliners in the world, producing more than 1,100 airliners in 2012 (nearly 100 airliners per month). As the economic conditions of the US and Europe have recovered, demand for air travel becomes more frequent and keeps increasing. The two giants received orders for 9,000 airliners in 2012. To deliver them on time and ensure high quality, they have to devise fabrication plans.

The newest models of these two giants are Boeing 787 Dreamliner and Airbus 350/380, which have higher contents of titanium than those of previous models. In either model, many parts and components -- from fuselage to small but numerous fasteners – are made of titanium alloys. In **Table 4**, we can see that, from 2013 to 2015, Airbus' demand for titanium will be greater than Boeing's. This may be that Airbus, which puts more importance on long-haul flights, considers the weight reduction is more important. In addition, fuel has comprised 40 to 50% of the operation cost of any airline; therefore, a reduction in the fuel consumption can be an increase in the profit.

Table 4. Demand for titanium by the four major airliner manufacturers from 1996 to 2015



Source: Airline Monitor 2013 and relevant public statements. Compiled by the MIRDC / 2014.04

The fuselage and wings of Airbus 350 are made of carbon fiber and new types of alloys (such as titanium alloys). It is the first time that such materials have been used for any Airbus' model. Titanium may be used for or in fasteners, accessories, fuselage accessories and carbon fiber brackets. Especially, if carbon fiber is not suitable for a certain kind of fastener, titanium alloy would become the first alternative.

Table 5 illustrates the range of titanium usage in the parts and components of an airliner. These parts and components may be categorized into four types: (1) Main body: including landing gears, wings, fuselage and tail (including rudder, vertical stabilizer and horizontal stabilizers) – the content of titanium depends on various models (2) Key parts: such as hangers, accessories and cockpit cabin framework (3) Functional parts: including wings, hatch hangers and exposed parts of windows and accessories of hatches

– by utilizing the higher tolerance to high temperatures and corrosive chemicals (4) Fasteners and turbine blades: recently, GE has announced that gamma TiAl (titanium aluminide) low pressure turbine blades will be used on the engine that powers the Boeing 787 Dreamliner. This announcement has attracted a lot of attention and such turbine blade has been certified by US FAA as the world's first type of low pressure turbine blade that is made of titanium alloy. Though these fasteners and turbine blades do not have a high content of titanium, these fasteners and blades containing titanium have become more and more important because they are physically stronger and safer and last longer than their counterparts without any content of titanium (and hence enable airlines to greatly reduce maintenance fees in the future).

Table 5. The range of titanium usage in the parts and components of an airliner

	Main Body	Key Parts	Functional Parts	Fasteners and Turbine Blades
Titanium content	>50%	~30%	~20%	3%
Area or Size Containing Ti	Very large	Medium to small	Roughly small	Fasteners: small Turbine blades: medium to small
Applied Quantity	Small	Medium	Medium	Large
Applied Components Containing Ti	Landing gears, wings, fuselage and tail	Hangers, accessories and cockpit cabin framework	Hatch hangers and exposed parts of windows and accessories of hatch	Fasteners and turbine blades

Source: Norsk Titanium 2014. Compiled by MIRDC / 2014.04

Conclusion

When titanium alloys are used in a fuselage, they are strong enough to rival super-strength stainless steel. The fasteners of the landing gear and internal girder of both Boeing 777 and Airbus 350 are of the Ti-10-2-3 titanium alloy series, instead of super-strength stainless steel that was used previously. Because of the increased demand for air travel due to globalization and the hike of gasoline price, more and more titanium will be used for the fabrication of the fasteners of the Boeing 787 Dreamliner and Airbus 380. Because titanium alloys are lighter and can withstand higher temperatures, low pressure turbine blades made of gamma TiAl (titanium aluminide) have been used on GE's GEnx engine.

Conventionally, components near the hatch hanger are made of Ti-6242 by superplastic forming or thermoforming. Because new types of turbines have higher rpm, the components and fasteners near the hatch hanger must be able to withstand exhaust with higher temperatures. Therefore, airliner manufacturers would prefer a titanium alloy that is lighter and can withstand higher temperatures. For the time being, a super nickel-based alloy, which can withstand temperatures higher than titanium alloy, is and will be used until titanium alloy manufacturers can develop new types of titanium alloy fasteners that can withstand higher temperatures.

Reference

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