Considerations Related to the Past, Present and Future of use of Aluminum Alloys in the Aeronautical Industry

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Abstract: *The present paper is meant to be a short presentation of the history of using aluminum alloys in the aerospace industry. The author shows some theoretical consideration regarding the apparition of aluminum alloys and presents examples of the used alloys in various places. Also, here we will see some statistics from WWI and the material used in current aeronautical industry.*

Keywords: *aerospace, aircraft, alloy, aluminum, composite, steel.*

1. INTRODUCTION

The most widespread metal on earth occupying almost 8% of the crust, is aluminum which was only discovered in 1825 by the Danish physicist H.C. Orested.

However, 20 years passed until the German chemist Friederich Wohler obtained some grains of aluminum, finding that they had metallic properties and were three times lighter than iron. In 1881, the French chemist Henri Deville discovered a new process for obtaining aluminum, something cheaper, arousing the interest of Emperor Napoleon II.

However, the large-scale production of aluminum had to wait, even if the new metal was abundant on Earth and had special physical-mechanical properties. Aluminum is not found free in nature, but in the form of an ore called bauxite that cannot be reduced with coal as in the case of other metals, because it melts very hard, it reaches 2000° Celsius.

The electrical method that is still used today, was discovered on February 23-1886 by a young man of only 22 years from Oberlin, Ohio, Charles Martin Hall, in the woodshed behind the house where he had set up a rudimentary laboratory. young Hall was a student at the local college and his chemistry teacher challenged his students, talking about the fact that the one who discovers a new efficient method of obtaining aluminum will be covered with glory. This idea fascinated Hall who set up a laboratory in the woodshed. There he brought batteries from college, alumina (aluminum oxide), cryolite and crucibles that he had bought.

Because the usual chemical processes could not be used to obtain aluminum, Hall thought that the only efficient method might be the electrolytic one. For this, he had to melt alumina, a difficult thing to achieve, however, because it melts at over 2000° Celsius. He mixed alumina with cryolite and after several attempts he managed to melt the mixture at only 1000° Celsius. He connected the fuse to the electric batteries and after only two attempts he succeeded. After two hours of waiting, searching in the crucible, he found the aluminum balls with which, still warm, he ran to his teacher.

Young Hall's enthusiasm was justified. He had really managed to discover the process of obtaining aluminum which, with rigorous improvements, is still used today. [1]

2. THE USE OF ALUMINIUM - HISTORY

The first large and significant use of aluminum was in the cookware and household goods industry. Knives, forks, spoons, and plates were processed from aluminum. Aluminum objects were more precious than gold or silver ones.

The second most important use of aluminum was on December 17, 1903, when the Wright brothers made the world's first human flight with their airplane, the Wright Flyer. At the time, automobile engines were very heavy and did not provide enough power to achieve takeoff, so the Wright brothers built a special engine in which the cylinder block and other parts were made of aluminum.

Since aluminum was not widely available and expensive, the plane itself was made from a frame of Sitka spruce and bamboo covered with canvas. Due to the aircraft's low speed and limited ability to generate lift, keeping the frame extremely light was essential, and wood was the only feasible material, light enough to fly but strong enough to carry the required load. It took more than a decade for the use of aluminum to become more widespread.

Wooden airplanes made their mark in the early days of aviation, but during World War I, lightweight aluminum began to replace wood as an essential component for aerospace manufacturing.

In 1915, German aircraft designer Hugo Junkers built the world's first all-metal airplane, the Junkers J-1 monoplane. Its fuselage was made from an aluminum alloy that included copper, magnesium, and manganese.

The use of aluminum in aircraft construction had a major impact during World War I, contributing to the technological advancement of the aeronautical industry and improving the performance of military aircraft.

The first all-aluminum fighter plane used in World War I was the Albatros D.I, a German aircraft. It was developed by the Albatros Flugzeugwerke and entered combat in 1916.

The Albatros D.I was a single-seat monoplane fighter. Its structure was built entirely of aluminum, making it lighter and faster than most contemporary

aircraft. The Albatros D.I was known for its superior the aluminum structure.

It had a higher top speed and a better rate of climb compared to Allied aircraft at the time. It was used primarily as a fighter to intercept Allied aircraft and support the German air effort. However, it was not without problems, being prone to structural problems and prone to wing breaks.

The Albatros D.I was the basis for a series of later variants, such as the Albatros D.II and Albatros D.III, which attempted to solve the problems encountered and improve performance.

Although the Albatros D.I had significant successes, the aircraft of the time were still in the process of constant development and improvement process of constant development and improvement. The use of aluminum in aircraft construction became an increasingly common practice as metalworking technology advanced, having a significant impact on the weight and performance of World War I aircraft.[3]

3. THE PRODUCTION OF AIRCRAFT USING ALUMINIUM ALLOYS

During World War I, the industry of aluminium aircraft exploded. There was a need for light aircraft to rise up and win the battles from the sky. From the presented figures (Figures 1 and 2) we can see that the French and Brits were leading the production of the lightweight aircrafts but in Figure we can see that also the lost were too high for them.

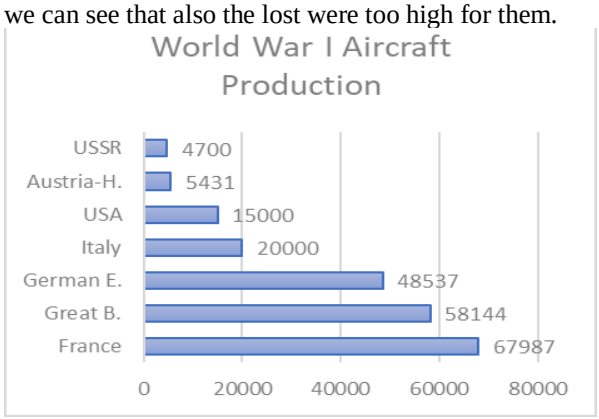

Figure 1. WWI aircraft production

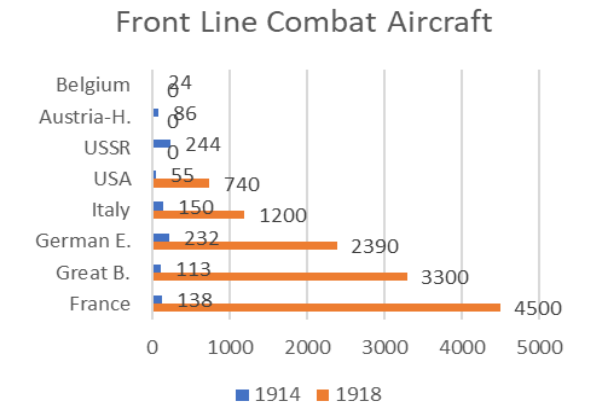

Figure 2. Front line combat aircraft

In the Figure 3 is presented the damaged aircrafts during WWI.

merability and speed, due to the light weight of

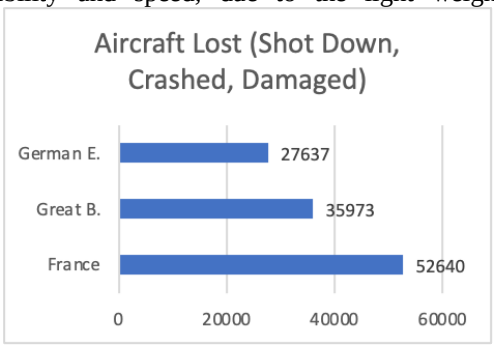

Figure 3. Aircraft Lost during WWI [3]

4. COMMERCIAL AVIATION – MATERIAL USED

In the 1960s and 1970s, most commercial aircraft were built with aluminum alloy structures, such as the Boeing 707 series, Boeing 727, Boeing 737, as well as the Airbus A300 and A310.

Aluminum was chosen for its strength, ease of processing and its ability to withstand varying atmospheric conditions. The share of aluminum use in aircraft construction can vary depending on the type and size of the aircraft, as well as the specific technology used in the industry. In general, the modern aviation industry uses a combination of materials, including aluminum, advanced alloys, composites, and metal matrix composite materials.

Aircraft wings are often constructed from lightweight aluminum alloys. Fuselage sections can be constructed from aluminium, aluminium-lithium or advanced alloys. Certain critical structural components can be made of aluminum or aluminum alloys to provide strength and durability. [2]

Elements such as seats, floors and other interior components may contain aluminum or aluminum alloys to provide strength and durability. It is important to emphasize that the exact proportion of aluminum use in aircraft construction may vary depending on the specific design and project of the aircraft, as well as the specific requirements of operators and manufacturers. Current trends indicate an increase in the use of composite materials, but aluminum remains an essential material in many aeronautical applications.

In conclusion, the use of aluminum in modern commercial aviation changed significantly after 1960, moving from its predominance to the use of composite materials and advanced alloys. However, aluminum remains an essential material in aircraft construction, still being used in certain parts of aircraft structures and components. [4]

2024 -Commonly used in aircraft skins, hoods, airframes. Also used for repair and restoration.

3003 -This aluminum sheet is widely used for hoods and baffle cladding.

5052 -Commonly used to make fuel tanks. 5052 has excellent corrosion resistance (especially in marine).

6061 -Commonly used for aircraft landing mats and many other non-aviation structural end uses.

7075 -Commonly used to strengthen aircraft structures. 7075 is a high strength alloy and is one of the most common grades used in the aviation industry [5]

5. THE FUTURE OF MATERIALS IN THE AERONAUTICAL INDUSTRY

The future of materials used in the aeronautical industry appears to be headed towards the continued development and adoption of increasingly advanced materials to improve aircraft efficiency, performance, and durability. Here are some key trends and aspects of materials in the aeronautical industry for the future:

1 Advanced Composite Materials

Composite materials such as carbon fiber will remain an essential element in aircraft construction. Continued development of compositions and manufacturing processes will lead to lighter yet stronger composite materials.

2 Nanomaterials

The use of nanomaterials such as carbon nanotubes and nanofibers could bring significant improvements in the strength and weight of materials used in aircraft. These materials can have superior mechanical and thermal properties.

3 Advanced Alloys

Continue to develop advanced alloys of aluminum, titanium, magnesium, and other light metals to improve the strength, durability, and weight of aircraft components.

4 Metal Matrix Composite Materials

Metal matrix composites (MMCs) combine the advantages of composite materials with those of metals, providing superior strength and durability. They can be used in various aircraft components.

5 Multifunctional Materials

Developing multifunctional materials that can perform multiple roles at the same time, such as providing structural strength and the ability to conduct electricity or absorb energy.

6 3D Printing of Advanced Materials

3D printing technology enables the production of complex and customized components. In the future, this could be used to print aeronautical components from advanced materials, reducing material loss and providing design flexibility.

7 Bio-inspired Materials

Taking inspiration from the structures and properties of materials in nature, such as bones or shellfish shells, researchers are exploring the development of lighter and stronger aeronautical materials.

8 Circular Economy and Recyclable Materials

Increasing concerns about sustainability and the environment could lead to an increase in the development of recyclable materials and circular economy practices in the aviation industry.

9 Smart Materials

The use of smart materials that can respond to changes in the environment or external demands, such as materials with shape memory or materials that can detect and repair damage.

The future of materials in the aeronautical industry is extremely dynamic, with continuous research and innovation. The new materials are expected to bring significant improvements in fuel efficiency, aircraft weight, safety, and durability. [6]

6. CONCLUSIONS

The use of aluminum in aircraft construction has been and remains an essential aspect of the aeronautical industry. Over the years, aluminum has made significant contributions to the development of aircraft, but technological evolution has also introduced other advanced materials in this field. Here are some conclusions regarding the use of aluminum in aircraft construction:

Advantages of using Aluminum:

Lightness and Corrosion Resistance: Aluminum is a lightweight metal, which helps reduce aircraft weight and improve fuel efficiency.

The corrosion resistance of aluminum contributes to the durability and reliability of aircraft under varied operating conditions.

Easy Processing: Aluminum can be easily machined and formed into various configurations, facilitating the manufacturing process of aircraft components.

Advanced Processing Technologies: Advances in aluminum processing technologies have allowed the development of special alloys, such as aluminum-lithium, which combine the benefits of reduced weight with increased strength. [7]

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