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High-Tech Material Utilization Trend in the Aviation Industry

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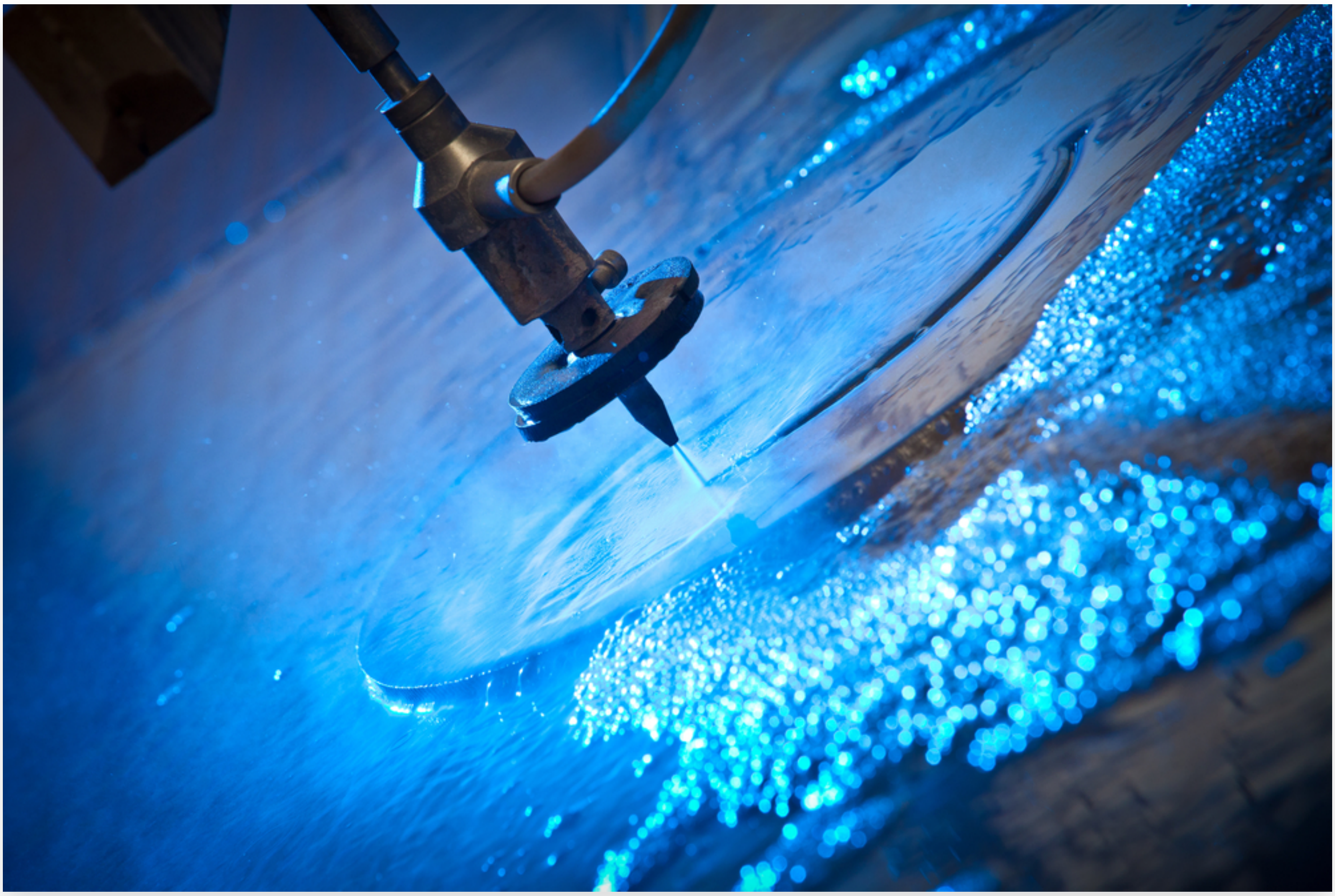

The aviation industry is still growing even in the midst of the relative global recession due to the impact of an increased demand to fly. According to the International Air Transport Association (IATA) it is has been stated that 8.2 Billion people are expected to fly in 2037 (ICAO, 2016) whereas almost 4.5 Billion travelled by plane in 2019 (Statista, 2019). It means the number of passengers boarding will almost double through the next two decades. While we are talking about passenger demand it should be emphasized that the main driver of the expanding aviation industry is due to an increase in air freight. While the aviation industry expands what are the impacts of the aviation industry on the environment? It is clear that aircraft create an desirable impact on the environment. Consumers can change their habits and technical teams can design cleaner and more efficient technologies. All these factors are being realized at present. Since the 1970's, the early days of environmentalism, many aspects have gotten better in the name of the aviation industry, but unfortunately a lot of environmental impacts have also become worse as well. The main pollutants emitted by aircraft engines in operations are Carbon Dioxide (CO2), Nitrogen Oxides (NOX), Sulphur Oxides (SOX), Unburnt Hydrocarbons (HC), Carbon Monoxide (CO), Particulate Matter (PM) and soot. In accordance with the 2019 European Aviation Environmental Report, two main impact drivers were CO2 emissions which were recorded to be163 million tons in 2017 and it is estimated that it will reach 224 million tons in 2040 while hydrocarbons (HC) were recorded to be 57 thousand tons in 2017 and it is estimated that it will reach 58 thousand tons in 2040. The aviation industry is mainly responsible for approximately 2-3% of worldwide Carbon Dioxide (CO2) emissions and based on the most current growth forecasts, this figure is expected to double by 2050 (Penner E,2000). Meanwhile, the maritime impact is worse than aviation industry. The environmental impacts of an aircraft operation are categorized in seven groups as depicted in Figure 1 With a closer at a one-hour-flight with narrow-body aircraft with the full crew and 150 passengers on board, it can be observed that the amount of emissions are huge comparatively to air breathed. The Federal Office of Civil Aviation (FOCA) depicted the figure of a one-hour-flight with the perspective of inhaled air and exhaled emissions which are demonstrated in Figure 2. There are numerous studies and research work focused on reducing aviation emissions. There's a chicken-egg relation between the studies and the robustness of aviation companies. The more powerful aviation companies are, the more powerful their research studies become. More fuel-efficient and less polluting turboprop and turbofan engines have been designed, developed and manufactured with the rise of novel technologies such as additive manufacturing techniques. Hybrid and electrically powered aircraft are being developed and prototypes are showing up in the theater. But it must be kept in mind that, none of this research would be possible if the aviation industry was in a permanent recession. Quite obviously it requires investments to carry out emission reducing research. The funds for research and development are channeled from the profits of robust companies. As mentioned prior, direct emission from aviation is about 2-3% of overall global emissions. But, with this point it should be emphasized that maritime transportation has a more severe environmental impact than the aviation industry in accordance with the data provided by the International Maritime Organization (IMO) (IMO, 2019). According to the IMO's website information, shipping activities account for approximately 3.1% of annual global emissions which is greater than that of the aviation industry. In the aviation industry, the use of novel technologies is not directly related with environmental issues, more so it is a natural result of engaging in fierce competition. For example, a Boeing 747-400 which has a Maximum-Take-Off-Weight (MTOW) of 396,890 kg, reducing 1 kg in the MTOW results in 0.94 kg less CO2 emissions and for an Airbus A330-300 which has an MTOW of 242,000 kg, a reduction by 1 kg in the MTOW results in a reduction in CO2 emissions by 0.475 kg. Also, a reduction of 1 kg in carbon emissions can also save up to 0.3 kg in aviation fuel (Tsai, 2014) The usage of composite materials such as Carbon Fiber Reinforced Polymers (CFRP) has great benefits on reducing CO2 emissions. Composite materials feature a variety of benefits which include a high strength to weight ratio, an improved resistance to corrosion, advanced fatigue resistance and the low cost of maintenance (Justin Hale, 2006). The density of steel is about 7.7–8.0 gr/cm3 and aluminum's density is 2.7 gr/cm3 whereas typical CFRP material density is about 1.6 g/cm3 (Gorbatikh, L. Wardle, & V. Lomov, 2016). Even with just this comparison the popularity of CFRP usage can be understood. Previously, steel was converted to aluminum alloys and now composite materials are taking the place of aluminum materials. In Figure 3 the composite usage in the Boeing 787 Dreamliner is shown. It can be easily observed that composite material usage is over 50%. The other major aircraft manufacturer company Airbus plays a significant role in the industry and has a similar strategy regarding the use of aircraft materials. In Figure 4 the percentage of composite material used in the Airbus A350 XWB aircraft is depicted. After layering up the carbon and resin layers, and autoclave operations the most important stage of the whole manufacturing phase is to cut the materials with given End-of-Part (EOP) borderline (Hashish M. 2013). The Abrasive Water Jet (AWJ) is another novel technology used in the aviation industry for cutting the part with given EOP. In Figure 5 an AWJ machine in use is shown. This complicated cutting process gives advantages of cutting materials with high surface quality. With the benefit of advantages and capability of high quality surface AWJs have found a wide usage area in the aviation industry. Machining large parts like wings, tails and the skin of aircraft is an enlarging trend requisition in the aviation industry. The cutting of large composite materials as well as metallic ones makes the use of AWJs a popular technique. For example, Boeing makes a 5-axis AWJ machine a standard machine because during cutting operation, the AWJ prevents delamination, splitting and edge scratches (Shengxiong X, 2017). All technologies have their own pros and cons, as do CFRPs. Many engineering solution challenges are faced especially during the disposal and retirement phase in the name of life cycle management. Sooner or later, more novel technologies will be implemented in the aviation industry as it was in the past and it is at present. With the increase in new technologies weight reduction studies will also increase by two major forces. The first force is directly a result of fierce competition in the aviation industry and the second one is the pressure of addressing environmental impacts. For sure, in the near and far future, CFRP and CFRP-like materials will be seen more widely in facilities of aircraft manufacturer companies