Reusing Materials in the Aerospace Industry – A Research on Recyclable PEEK Material

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Abstract

This research explores the many material recycling methods used by the aerospace industry, with a particular focus on the materials used in aircraft. One of the most pressing issues facing this industry is the limited capacity for reusing and recycling materials. Aerospace materials are prone to physical degradation during repeated use, making them unsuitable for effective recycling. However, through an analysis of various other material mitigation strategies, it has become clear that several methods show promise for recycling aerospace materials back into usable forms. For example, polyetheretherketone (PEEK) and aluminum exhibit favorable properties after reprocessing, making them suitable for reintegration into new aerospace applications. By identifying promising recycling methods and implementing them effectively, the aerospace industry can help to meet its sustainability goals and reduce reliance on finite resources.

Introduction

In the next 20 years, tens of thousands of aircraft are expected to retire from service. “The timing of this MoU is important given that the rate of fleet renewal is expected to increase significantly over the coming years, with 18,000 currently in-service aircraft expected to be retired from operations by 2030,” noted Dr. Olumuyiwa Benard Aliu, President of The International Civil Aviation Organization (ICAO) Council [1].To address this issue, aircraft manufacturers have been working closely with the recycling industry to ensure that retired planes are dismantled in a sustainable and environmentally friendly manner. This paper aims to find ways to improve recycling within the aerospace industry, analyze PEEK and polymer materials as well as current methods for their suitability towards meeting these needs with minimal environmental impact.

Materials

The following figure 1 shows how many Boeing aircrafts have been delivered as of August 2022 based on their official order delivery database. The Boeing 737 is a popular jet aircraft that can be found all over the world based on the deliverables out there. The fuselage is made from aluminum alloys and steel wrapped around its core. The wings are made out of aluminum and covered with cloth material, while its body consists primarily from high-quality steel alloy which gives it strength for durability in flight conditions. The Boeing 787 and 777x are all made with a variety of materials that have different properties that include composites and aluminum according to Figure 2. According to the Environmental Assurance (EA) report, the EPA (the U.S Environmental Protection Agency) uses the term "hazardous waste" to identify wastes that could be harmful to human health and the environment [4]. Some aircraft structures that contain carbon fiber composites coated with hexavalent chromium primer. These types of hazardous waste may not go down on land due to possible leaching into the ground if it's not properly disposed of or recycled.

Materials: Polymers

There are a number of different polymers that are used in the aviation industry besides composites or aluminum materials. Polymers are used in a variety of applications, from airframes to engines. Some of the most common ones include polyetheretherketone (PEEK), polyamides (PA), and polytetrafluoroethylene (PTFE). Each of these polymers has different properties that make it suitable for a particular application. For example, PEEK is a high-performance polymer that is resistant to heat and chemicals. This makes it ideal for use in airframes and other components that are exposed to extreme conditions. The modulus of PEEK at operating temperatures is typically ~3.5GPa, compared to ~4.7GPa for a typical aerospace epoxy such as the Hexcel 8552 [5]. PA is a versatile polymer that can be used in various applications, including engines and hoses [6]. PTFE is known for its high resistance to corrosion and wear [7]. It is often used in seals and gaskets. In general, polymers with more monomer units will have higher performance levels.

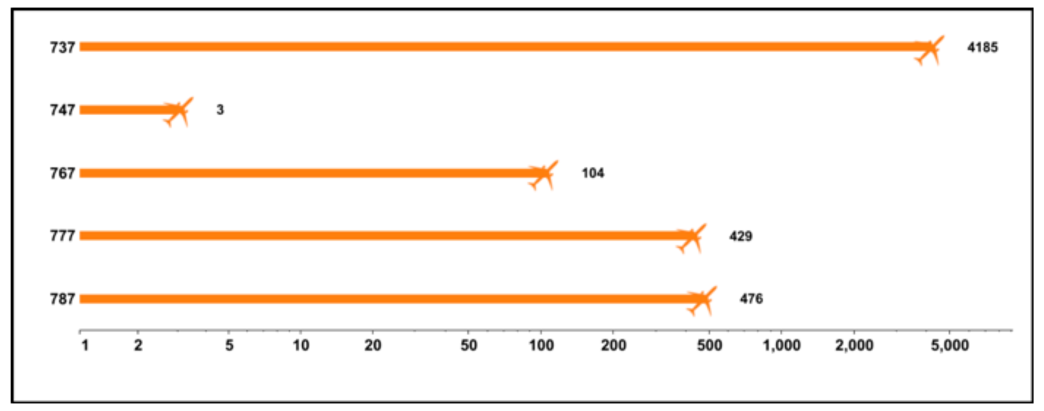

Figure 1. *Boeing Aircraft Deliveries Database [2].*

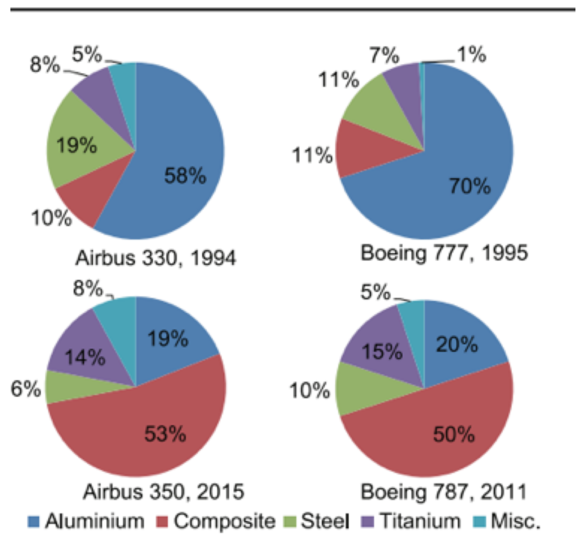

Figure 2. *Material comparison between Airbus & Boeing [3].*

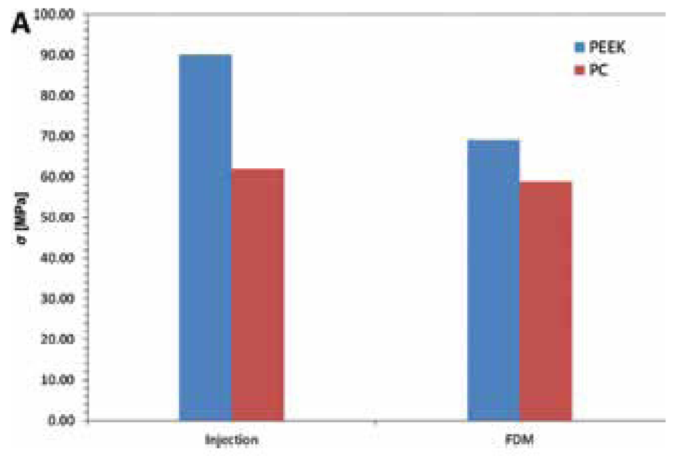

Figure 3a. *Tensile Strength Comparison between PEEK & PC [8].*

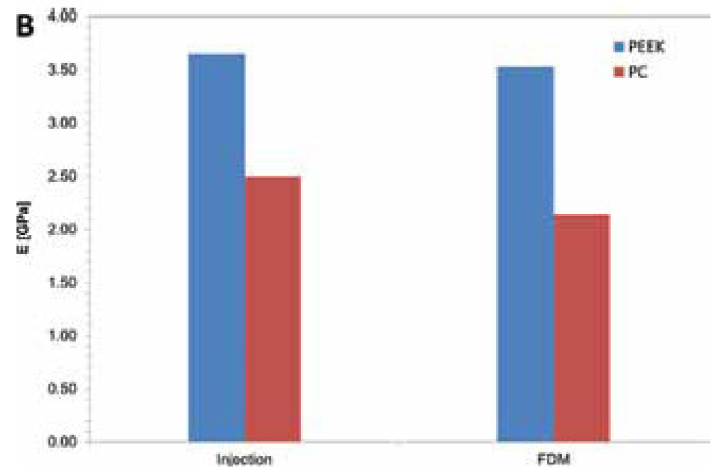

Figure 3b. *Elastic Modulus Comparison between PEEK & PC [8].*

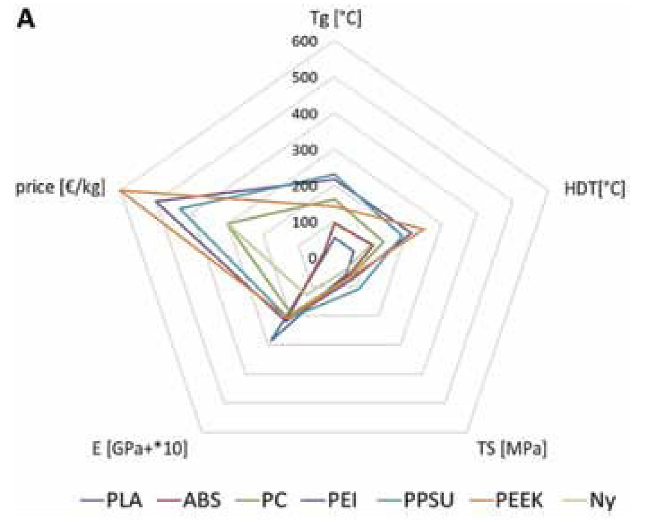

Figure 4a. *Comparison of properties of Stratasys & PEEK [8].*

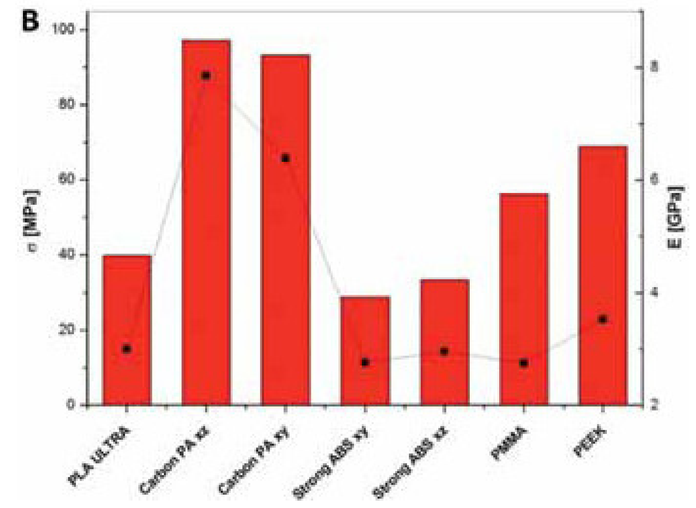

Figure 4b. *Comparison of the tensile mechanical properties of PEEK & Composites [8].*

Analysis on PEEK

The use of 3D printed PEEK in the medical, chemical, and electrical fields has been investigated by various researchers and companies. 3D printed PEEK can be used to make a wide variety of different components in the aircraft instead of metal or some of the composites or could be layered with aluminum. Since the material is lightweight, durable, and heat resistant, making it well-suited to applications where performance and safety are critical. This material can be used to build fuel tanks and other inner parts of an aircraft's fuselage that must withstand high temperatures during flight. Additionally, PEEK can be used for jet engines and other sensitive equipment that may require superior insulation from heat and pressure. Based on Figure 3a and 3b, these lab tests on PEEK and PC revealed that PEEK has very favorable properties, including excellent mechanical properties compared with other filament materials. According to Figure 4a and 4b, the comparison showed that PEEK with its Heat Distortion Temperature (HDT) of 250°C offers similar or even higher mechanical properties than other materials like PPSU, PEI and PC. Mentioning the superiority of this material clearly demonstrates how it stands out from all others which are either less durable or more brittle. Companies and consumers rely on the properties of polymers to ensure the safety and reliability of aviation products. By choosing the right polymer for the job, manufacturers can create products that meet or exceed the expectations of consumers.

Conclusion

According to ICAO Assembly- 40th session executive committee meeting where they talked about artificial Intelligence and digitalization in aviation. In their working paper they summarized the meeting that “AI and digitalization will deeply impact the competencies of aviation professionals, and there is a need for the whole aviation sector to prepare for this significant change”. The aviation industry is in for some major changes with the introduction of artificial Intelligence and digitalization. Furthermore it's possible innovations could push scientific boundaries even further! In conclusion, 3d printed parts made from PEEK might offer many advantages over their traditionally manufactured counterparts; these include higher performance specifications at reduced weight which will reduce costs on aircrafts flying today as well as improved sustainability due to lower production volumes requiring less energy consumption during manufacturing processes.

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