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11. Green Initiatives in Aerospace Industry

Daksh Goswami, Muhammed Sameel, Rajdeep Singh, Agnik Ray, Jeeban Prasad Gewali

School of Mechanical Engineering,
Lovely Professional University,
Phagwara.

Abstract:

Driven by the imperative of environmental stewardship, the aerospace industry is embarking on a radical transformation. Fuel-guzzling behemoths are giving way to eco-conscious designs, while rocket trails blaze a path towards sustainable space exploration.

This chapter delves into the challenges and opportunities of green initiatives in aerospace, from fuel-efficient aircraft to electrifying propulsion systems. We'll explore how lightweight materials, cutting-edge research, and multidisciplinary thinking are paving the way for a greener future, where innovation takes flight in harmony with the environment.

Keywords:

Green Initiative, Propulsion, Aerospace Industry, Sustainable Fuel Aviation

11.1 Introduction:

For generations, the aerospace industry has captivated our imaginations with feats of aeronautic engineering and daring explorations of the cosmos. But as the clouds of environmental concern gather, a new kind of flight is taking wing - one fueled by a commitment to sustainability. The once-distant rumble of rocket engines now gives way to the whisper of a changing tide, as the aerospace sector undergoes a transformative shift towards eco-friendly practices and green technologies. The aerospace industry, known for its groundbreaking innovations in aviation and space exploration, is undergoing a transformative shift towards sustainability. In the wake of environmental concerns and the imperative to mitigate climate change, the aerospace sector is increasingly recognizing the need for eco-friendly practices and green technologies.

During our pursuit of knowledge in aerospace engineering, we are compelled to explore and understand the various facets of green initiatives within this dynamic industry. From designing more fuel-efficient aircraft to developing sustainable propulsion systems, the aerospace community is at the forefront of engineering solutions that aim to minimize environmental impact. In this article, we will unravel the challenges and opportunities presented by green initiatives in aerospace. We will delve into cutting-edge research and technologies that promise to revolutionize the way we think about the air travel and space exploration. From lightweight materials to advanced propulsion systems, our exploration will encompass the multidisciplinary nature of aerospace engineering and its intersection with environmental sustainability.

11.2 *Hindrances to Takeoff:* Challenges and Opportunities for a Sustainable Aerospace Industry

Implementing green initiatives in the aviation industry faces multifaceted challenges. Technological complexities and the high costs associated with developing eco-friendly solutions present formidable obstacles. Existing infrastructure may lack support for sustainable practices, while stringent regulations and a lack of incentives hinder progress. Balancing the financial burden of initial investments in green technologies further complicates the equation. Public perception, global collaboration difficulties, and the limited availability of renewable resources add layers of complexity. Additionally, the potential risks associated with new technologies and the challenges of transitioning from traditional practices contribute to the intricate landscape of adopting environmentally friendly measures in aviation. Navigating these hurdles requires strategic planning, international cooperation, and innovative solutions to ensure a sustainable future for the industry.

- **Technological Challenges**: Developing and implementing eco-friendly technologies in aviation can be complex and expensive, posing a barrier to widespread adoption.
- **Infrastructure Limitations**: Existing airports and facilities may lack the necessary infrastructure for sustainable practices, such as efficient waste management or renewable energy sources.
- **Regulatory Hurdles**: Stringent aviation regulations may make it difficult for airlines to adopt green initiatives without clear guidelines or incentives from governing bodies.

- **Cost Pressures**: The initial investment required for green technologies, such as biofuels or energy-efficient aircraft, may be substantial, impacting the financial viability for airlines.
- **Public Perception and Acceptance**: There might be resistance from passengers or stakeholders if they perceive green initiatives as inconvenient or if there is a lack of awareness about the benefits.
- **Global Collaboration**: Coordinating efforts on an international scale is essential for effective green initiatives in aviation, but achieving consensus and collaboration among diverse stakeholders can be challenging.
- **Limited Renewable Resources**: Dependence on limited renewable resources, like sustainable biofuels, can lead to competition with other industries and potential supply chain issues.
- **Technological Risks**: The development of new technologies comes with inherent risks, such as unexpected technical challenges or safety concerns, which can impede the progress of green initiatives.
- **Transition Period Challenges**: Transitioning from traditional practices to green initiatives may require substantial time and effort, causing disruptions and resistance during the adjustment period.
- **Economic Viability**: The economic feasibility of green initiatives, such as carbon offset programs, may be uncertain, and businesses might be reluctant to invest without clear returns on investment.

Unlike other aerospace sectors, the aviation industry has one of the highest impacts on most people's personal life. The International Civil Aviation Organization reports that 3.5 billion passengers buckled up for takeoff in 2015[(1)] and this value is expected to increase every year. That is about 46% of the population in 2015.This has a direct impact on the carbon emissions. In 2016 alone, civil aviation as a whole emitted around 814 million tons of CO_2 which is roughly 2% of manmade carbon emission [(2)]. Hence initiating a green revolution in the industry cannot be overstated.

Figure 11.1: Sustainable Fuel Aviation [(3)]

11.3 *Green Wings: Transforming Flight*

Most green initiatives in this industry have been focused towards developing **Sustainable Fuel Aviation** (SAF) and reducing fuel consumption by optimizing design and operational procedures. We will look into a major initiative taken by Civil aviation authorities like **IATA** (International Air Transport Association) and **ICAO** (International Civil Aviation Organization), and one of the major contributors to sustainability in aviation industry: SAF (sustainable aviation fuel).

11.4 IATA's Four Pillar Strategy:

IATA had stated that aviation is approaching the challenge of achieving its climate goals through a four-pillar strategy in its paper **"Carbon offsetting for international aviation"** [(3)]. The four pillars as stated by IATA are:

- "The development of new, more efficient aircraft and engines can substantially decrease CO_2 emissions. New technology aircraft are, on average, around 15-20% more fuel-efficient than the models they replace. Sustainable aviation fuels, which are already being used on certain commercial flights, will have the potential to cut emissions by up to 80%.
- Operational measures include identifying weight savings in the current fleet, allowing the aircraft to burn less fuel. Airlines have been investing in lightweight seats and cabin equipment and even replacing heavy pilot manuals with tablet computers. Other operational measures include single-engine taxiing, idle reverse thrust, and ATC procedures such as continuous descents into airports and traffic flow management that prevent unnecessary airborne holding.
- The 'infrastructure' pillar of the strategy relates mainly to navigational improvements, making better use of airspace and streamlining the routes taken by aircraft to cut down on flight time, and optimizing airport layout to improve throughput and prevent unnecessary holding.
- The industry remains confident that technology, operational measures and better infrastructure will provide long term solutions to ensure the sustainable growth of the aviation industry through partnership between industry and government. However, it is also acknowledged that a global market-based measure is needed to fill any remaining emissions gap until those other measures have taken full effect". [(4)]

These 4 pillars can be summarized as:

- Technology Improvement
- Operational efficiency
- Infrastructural efficiency
- Positive economic efficiency

This strategy was developed to meet three goals set during the high-level meeting on international aviation and climate change by ICAO (International Civil Aviation Organization) in 2009 [(5)]:

- A short-term target to improve fuel efficiency by 1.5% annually from 2009 to 2020. [6]
- Set a cap on carbon dioxide emissions from year 2020. [7]
- A long-term target to reduce CO2 emissions to 50% of CO2 emissions in the year 2050 when compared to 2005. [8]

These sum up some of the major initiatives and goals set by the major aviation authorities to control the Carbon emissions, and to make the industry carbon neutral.

Without the will power of Industry participants, it is impossible for the aviation industry to achieve carbon neutral growth, so let us delve into some initiatives taken by the industry participants to follow the given set of goals.

First, we will discuss SAF (Sustainable Aviation fuel) as according to IATA, SAF could contribute around 65% of the reduction in emission needed by aviation to reach net-zero by 2050[9]

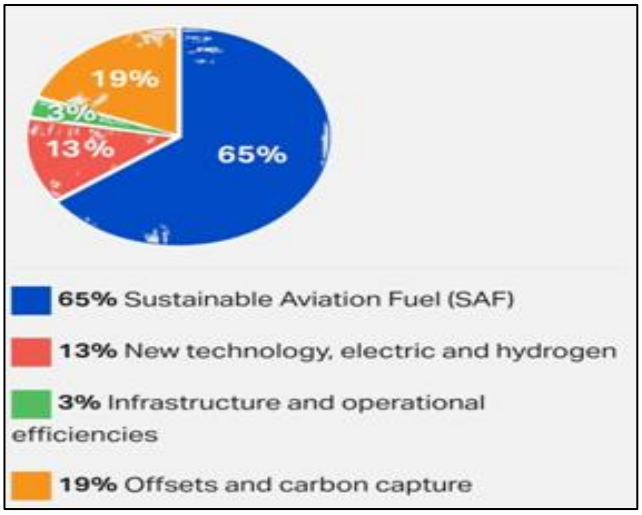

Figure 11.2: Pie chart showing percentage contribution of various factors for achieving net zero [10]

What is SAF?

Sustainable aviation fuel (SAF) is the main term used for alternative sources of fuel to conventional (mainly fossil fuels) in the aviation industry.

When compared to fossil fuels they result in reduced overall CO_2 production throughout their life cycle (i.e. from production to consumption). CO_2 consumed by plants during their growth is approximately equal to the amount of CO_2 produced during the combustion of SAF in engines. This allows SAF to be carbon neutral, but when their production, transportation, etc. are taken into account, the CO_2 emissions from these processes add up. When these elements are taken into account, the use of SAF has shown significant reduction in CO_2 emission as compared to fossil fuel, (in some cases 80%) [11]

The SAF is developed in such a way that its physical and chemical characteristics allow it to be mixed with fossil fuels (in varying degrees), so that they can be used in aviation engines without any modification. Fuels with these properties are called **"drop-in fuels"** (Fuels that can be incorporated into existing airport fueling systems). [12]

To be classified as SAF, a fuel type must meet three key elements:

- **Sustainability**: Must be consistent with economic,social,and environmental aims and must conserve the environment without the depletion of natural resources[13]
- **Alternative feedstock to Crude oil**: Feedstock means the raw material from which the fuels are produced. Feedstocks for SAF are varied ranging from cooking oil, municipal waste, wastegases, agricultural residues etc. [14]
- **Fuel**: Means fuel that meets technical requirements for use in commercial aircraft [15]

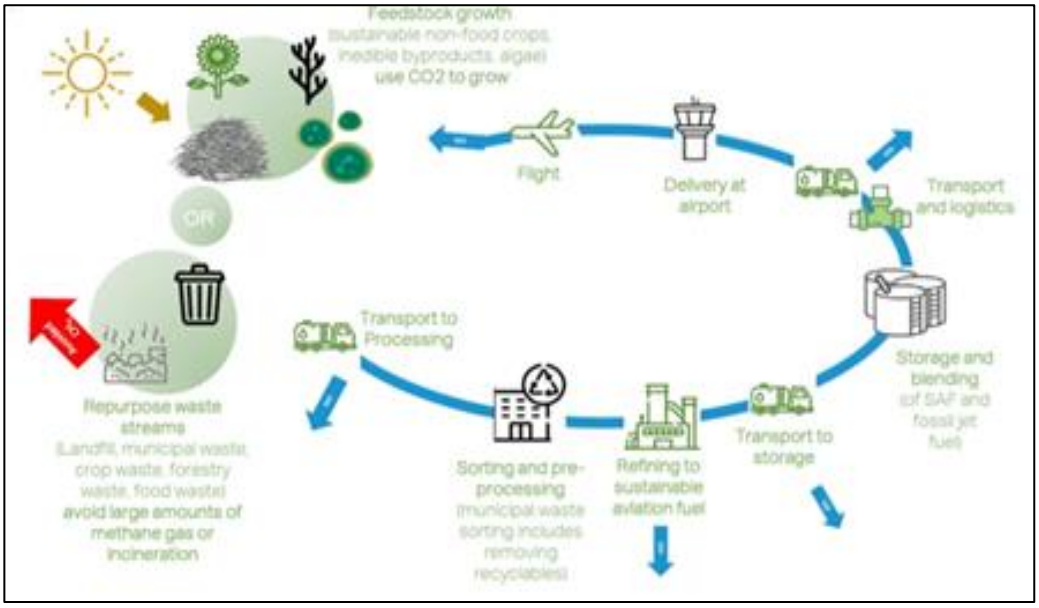

Figure 11.3: Developing Sustainable Aviation Fuel [9]

Some examples of SAF are Hydro processed Esters and Fatty Acids –Synthetic Paraffinic Kerosine (HEFA-SPK, basically hydrotreated vegetable fuel oil), Fischer-Tropsch Synthetic paraffinic kerosene (FT-SPK, processing solid biomass using pyrolysis to produce oil), and Alchohol-to-jet Synthetic paraffinic kerosene (ATJ-SPK, deoxygenating and processing ethanol or butanol to convert them into jet fuels). [16]

Many companies have adopted the usage of SAF as substitute for fossil fuels. For example, Airbus, an aircraft manufacturer had done series of tests (One engine 100% SAF, both engine 100% SAF,etc.) for aircrafts including commercial, military, and rotorcrafts on SAF from 2021 to 2023[17].

A number of airline companies that have taken test flights by using SAF is given below.

Carrier	Aircraft	Flight path	Date	Feedstock (Supplier)
KLM	B737	Amsterdam - Paris	22 June 2011	Used cooking oil (SkyNRG)
Lufthansa	A321	Hamburg - Frankfurt	15 July 2011	Mix of feedstocks (Neste Oil)
FINNAIR	A321	Amsterdam - Helsinki	18 July 2011	Used cooking oil (SkyNRG)
interjet	A320	Mexico City - Tuxtla Gutierrez	21 July 2011	Jatropha (ASA)
AEROMEXICO	B777	Mexico City - Madrid	1 August 2011	Jatropha (ASA)
IBERIA	A320	Madrid - Barcelona	3 October 2011	Camelina (ASA)
Thomson Airways	B757	Birmingham - Arrecife	6 October 2011	Used cooking oil (SkyNRG)
AIRFRANCE	A321	Toulouse - Paris	13 October 2011	Used cooking oil (SkyNRG)
UNITED	737-800	Houston - Chicago	7 November 2011	Algae (Solazyme)
Alaska Airlines	737s and Q400s	Seattle - Portland, Seattle - Washington	9 November 2011	Used cooking oil (SkyNRG)
THAI	777-200	Bangkok - Chiang Mai	22 December 2011	Used cooking oil (SkyNRG)
Lufthansa	747	Frankfurt - Washington DC	12 January 2012	Mix of foodstocks (Nestle Oil/Mi)
LAN	A320	Santiago - Concepcion, Chile	7 March 2012	Used cooking oil (SkyNRG)
QANTAS Spirit of Australia	A330	Sydney - Adelaide, Australia	13 April 2012	Used cooking oil (SkyNRG)
porter	Q400	Toronto City - Ottawa	17 April 2012	Used cooking oil (Honeywell/SkyNRG)
Jetstar	A320	Melbourne - Hobart	19 April 2012	Used cooking oil (SkyNRG)
porter	Q400	Montreal - Toronto	18 June 2012	Camelina
AIR CANADA	A319	Toronto - Mexico City	18 June 2012	Used cooking oil (SkyNRG)
AEROMEXICO	777	Mexico City - Sao Paulo	18 June 2012	Mix of feedstocks (ASA)
KLM	777	Amsterdam - Rio de Janeiro	19 June 2012	Used cooking oil (SkyNRG)

Figure 11.4: IATA'S Four Pillar Strategy [18]

Figure 11.5: TU-delft Flying [19]

11.5 Conclusion:

As we conclude our exploration of "Green Initiatives in Aerospace Industry", it becomes evident that the pursuit of sustainability in aerospace engineering is not merely a trend but a fundamental shift in our approach to technology and innovation. Throughout our journey, we have witnessed the industry's commitment to addressing environmental challenges and fostering an eco-friendlier future. The aerospace sector, renowned for its advancements in speed, efficiency, and exploration, is now embracing the responsibility of mitigating its

environmental footprint. From the adoption of cleaner propulsion technologies to the development of lightweight and eco-friendly materials, the industry is at the forefront of pioneering solutions that align with global environmental goals. Our foray into this topic has underscored the multidisciplinary nature of aerospace engineering. It requires collaboration among experts in aerodynamics, materials science, propulsion systems, and more to achieve meaningful progress. The challenges are substantial, but so are the opportunities for innovation and positive impact.

As budding aerospace engineers, we find ourselves at the threshold of a future where sustainability and technological progress go hand in hand. The imperative to reduce emissions, minimize resource consumption, and explore alternative energy sources challenges us to think creatively and critically. The solutions we develop today will shape the aircraft and spacecraft of tomorrow, influencing not only the industry but also the broader global effort towards a sustainable future.

In conclusion, the path ahead beckons us to be innovators, problem solvers, and advocates for sustainable practices in aerospace engineering. Together, let us forge a future where the skies and beyond are explored with a commitment to environmental harmony. Here's to a future of green skies and sustainable horizons!

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