Group 03 - Ultra-Efficient Hybrid Aircraft

The aviation industry contributes a significant share to travel caused air pollution. With the aviation industry predicted to expand further in the future, changes to aviation design and infrastructure must be made imminently in order for humans to continue to live in a healthy environment. Not only do aircraft produce CO_2 and NOx emissions, but they also emit ultra-fine particles (UFPs) that have a substantial impact on the health of airport workers and communities living in the vicinity of the airport. Research conducted by Schraufnagel and Kwon shows that increased exposure to particulate air pollution is associated with increased respiratory and cardiovascular health issues. With this in mind, the Low Emission Alternative Fuel, or LEAF, aircraft is designed such that harm to the surrounding population is minimised. In order to reduce these UFPs, the energy required by the aircraft must be minimised, and a clean energy source must be used during aircraft ground operations, take-off and landing.

Mission Objective

The objective of the mission is to design an aircraft that minimises the emission of ultra-fine particles at the airport, the energy consumption and the overall impact on the environment. This objective can be broken down further into the following top level requirements: aircraft pollution in the form of CO_2 and ultra-fine air particles emitted by the aircraft must be reduced by at least 30% and 80% respectively, as well as a 100% reduction of each during ground operations. Also, the aircraft should have comparable performance as an A320 and be operational by 2035.

System Design

In order to comply with the emission requirements it has been chosen to use liquid hydrogen as the secondary fuel for the LEAF aircraft. This liquid hydrogen is stored in a cryogenic hydrogen tank placed in the rear of the fuselage. 30% of the total energy required for the aircraft is stored in this tank and due to this tank the aircraft will be 7.5 metres longer than an A320. The aircraft has two hybrid turbofan engines that will combust hydrogen during take-off and landing, but will combust a mixture of hydrogen and kerosene during cruise.

To reduce the overall energy consumption, electric motors are placed in the main landing gear wheels in order to drive the aircraft around at the airport. The energy needed for this will come from regenerative braking of the aircraft during landing. The energy generated from this is stored in a battery on board. The rest of the energy needed to perform ground operations will come from the APU, which is a hydrogen fuel cell located in the rear of the fuselage.

The LEAF aircraft utilises riblet technology on the wing planform, which is designed to offset the start of the flow separation. This would mean that the aircraft can generate more lift for the same amount of drag and therefore be more energy efficient.

To have the lowest possible impact on the environment, 90% of the aircraft will be recycled at end-of-life and 5% of all parts will be reused.