Group 10 - A320 NH_3

The world is being irreversibly damaged due to gases such as CO_2 and NOx. The aviation industry is one of the largest sectors amplifying this problem. Worldwide, its contribution to carbon emissions is 2.5% and numbers add up to 7% when looking at The Netherlands only [1]. Despite this, the aviation industry is still experiencing growth to manage the demand. To counter the increase in the predicted growth of aviation and emissions, new fuels such as hydrogen, ammonia or alcohols bode promising alternatives in solving this problem. This can be a massive challenge but, as David Attenborough stated at the 2021 Glasgow climate summit: "We are, after all, the greatest problem solvers to have ever existed on Earth. If working apart, we are a force powerful enough to destabilize our planet. Surely working together, we are powerful enough to save it"[2]. This project aims to evince this statement.

Mission Objective

In order to keep the growth within the air industry sustainable, new innovations that promise a reduction in the environmental footprint are necessary in the future. Therefore, the objective of this study is to show that commonly used aircraft, the A320neo in this case, can be re-designed to reduce the contribution to climate change by 50%. This goal could be attained by using hydrogen to propel the aircraft, but employing hydrogen as fuel generates difficulties. This is why ammonia could be the solution. When using ammonia as an energy carrier the main challenge is the efficient and feasible conversion to hydrogen. Since ammonia is produced worldwide and the required infrastructure looks particularly similar to that of kerosene, this could offer a starting foundation that can be beneficial for faster applications. Hence, implementing a redesigned aircraft in the aviation sector could be achieved by 2035. In order to reach this fast application the A320-NH_3 will be introduced.

System Design

The design of the A320-NH_3 will be derived from the current A320neo configuration. The largest design change is the new fuel (ammonia) carried onboard, which will require a cracking system that converts ammonia (NH_3) to hydrogen (H_2) before combustion, something that has never been done before! Plasma and thermal cracking is studied. Ammonia has a lower energy density than kerosene which, together with the additional systems, results in a larger fuel required volume and a significant change in the fuel weight. An increase in the total weight of the aircraft requires more powerful engines to provide enough take-off thrust. To deliver more thrust, an inter-stage turbine burner is installed in the engine, which re-burns combustion chamber products and decreases NOx emissions. Furthermore, the weight and volume increase led to a change in wing size, which resulted in a larger fuel capacity and lift generated by the wing. The remaining required fuel has been placed below the passenger cabin, which reduced cargo capacity. Because of this, passenger rows have been removed in the back to store the cargo in the tail cone. Additionally, storing ammonia requires cooling of the fuel tanks. This is achieved by applying active cooling as well as insulating the tanks. Using a iterative system which optimizes the aircraft emmisions the final A320-NH_3 will be able to carry 150 passengers, have a design range of 4000 km, reduce the environmental impact by 50% and remove all operating carbon emissions.

[1] https://ourworldindata.org/co2-emissions-from-aviation, 08/06/2022

[2] https://indianexpress.com/article/world/climate-change/cop26-climate-change-summit-top-quotes-7602912/: :text=%E2%80%9CGlasgow%20must%20be%20the%20start,a%20choice%20to%20do%20it.%E2%80%9D