02 - Hydrogen Powered Regional Aircraft

With climate change becoming a bigger concern for the general public, the impact that commercial aviation has on the environment, has persuaded people to consider greener alternatives to air travel. This "flight shame" could jeopardise the future of the commercial aviation industry. For this industry to stay competitive and reduce its influence on carbon emissions, there needs to be a more sustainable alternative to conventional fossil fuel powered aircraft. Hydrogen seems to be the solution as its combustion produces no CO$_2$, CO, soot or unburned hydrocarbons. In addition, liquid hydrogen is three times lighter than kerosene for the same amount of energy, yet it requires four times the volume at cryogenic temperatures, which corresponds to the main design challenge.

--- Mission Objective ---

Thus, the market desires an aircraft which can "Provide sustainable and zero emission commercial regional air travel and counter flight shame". This aircraft shall have zero emissions, be 90% recyclable by weight, carry 236 passengers from Norway to Cyprus, and should have operational and production costs comparable to its competitors. Therefore, our objective was to prove the feasibility of this hydrogen powered regional aircraft: The Hydrojet. For this, we had to design an entire aircraft including its subsystems (Planform, Power and Propulsion, Landing gear) and the corresponding ground facilities.

--- System Design ---

After a conceptual design study, the blended wing body configuration combined with a turbofan engine were deemed most suitable for the requirements. The blended wing body results in a high aerodynamic efficiency, provides sufficient room for fuel tank integration and allows for a light weight structure. Next, the turbofan engine is relatively inexpensive, has a great technology readiness level and is rather light weight. Additionally, a fuel cell was incorporated to function as the APU and to power the nosewheel motor, adopted for pushback and taxi in order to eliminate NO$_x$ emissions on ground, where they are the most harmful to the environment.

During the subsystem design phase, first a mass estimation was performed and the cabin and tank layout was established. This was followed by the construction of the planform shape based on aerodynamic and stability analysis. Next, a flight performance study gave the required thrust that needs to be provided by the propulsion system. The power and propulsion system was then designed for minimal emissions and the materials for the structural components were selected to maximise the recyclability. Lastly, the ground facilities, which supply fuel to the Hydrojets, were designed to produce green hydrogen and to store the hydrogen in a sustainable way.

The final outcome of this project is a feasible aircraft design with a 99% reduction of the total emissions and a recyclability of 90% by weight. Due to the clever blended wing body design, a great lift-over-drag ratio of 25.68 is achieved, resulting in a range of 4500 km. Finally, by also producing the hydrogen from wind powered PEM electrolysis, the Hydrojet is truly sustainable and flight shame proof.

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1K. Seeckt, and D. Scholz, "Jet Versus Prop, Hydrogen Versus Kerosene for a Regional Freighter Aircraft", Hamburg University of Applied Sciences