Hybrid Gas-Electric Multi-Engine Testbed – Results of Research

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Abstract:

The significant increase of interest in the green aviation, therefore in the alternative propulsion systems is surely caused by the concern for the environment but mainly due to limitations and restrictions arising from declarations and legal acts of governments and aviation institutions. The main impact of reducing the emission of greenhouse gasses is expected to be achieved by the civil aviation, due to the constant growth of the air traffic passenger demand. Even though many well-known companies, small start-ups as well as great consortiums attempt to design, create, test and certify at least a regional hybrid gas-electric aircraft, which is one of many examined environment-friendly ideas, projects face many issues such as: insufficient technology of batteries, complicated design of a Power Management Unit, necessity of applying a complex cryogenic cooling system as well as safety concerns. And therefore, the Warsaw University of Technology team decided to gain knowledge regarding the hybrid gas-electric multi-engine solution and adapt this kind of propulsion system to one of the Warsaw University of Technology motor gliders in an aerobatic configuration called PW6.

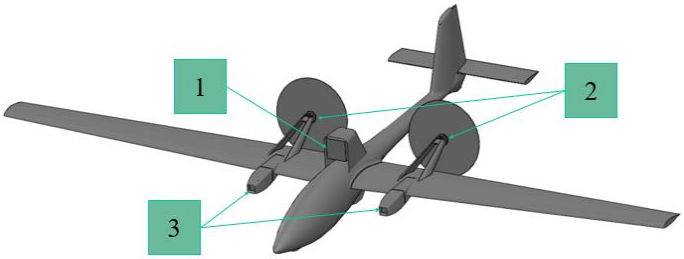

Figure 1 The visualization of the PW6-X20 motor glider with the hybrid gas-electric twin-engine propulsion

The propulsion system was designed in such manner that as few as possible adjustments in the PW6 aircraft's structure had to be made in order to install the hybrid propulsion system in the serial configuration on the structure. The idea was to mount the generator set (including an Internal Combustion Engine and an electric motor as a power generator) at the top of the fuselage (Fig. 1 no. 1), two electric motors with propellers behind the trailing edge of the wing (Fig. 1 no. 2) and two sets of batteries in the nacelles in front of the leading edge in line with motors (Fig. 1 no. 3). However, before the propulsion can be installed on the real aircraft, it should be tested on the ground, thus the propulsion system was firstly prepared as a testbed, in which the battery sets where replaced with the power supply (see Fig. 2).

Figure 2 The ground testbed during the research campaign

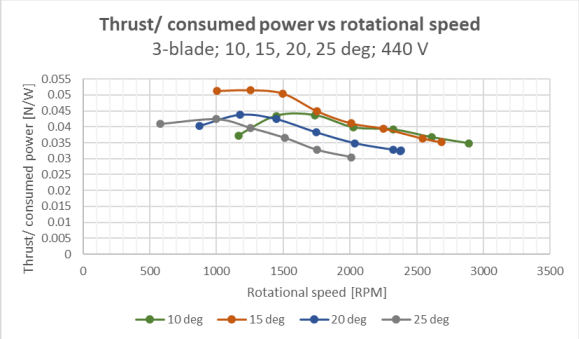

Figure 4 Example of the graph of the thrust over the consumed power vs the rotational speed

During the test campaign two aspects were examined: the evaluation of the performance of the propellers' and the power generator. The goal of the propellers' performance evaluation was to obtain aerodynamic characteristics of 2- and 3-blade propellers and determine the optimal operating point for each propeller driven by the motor. Different supply voltage and propeller's pitch angles were examined (see Fig. 3).

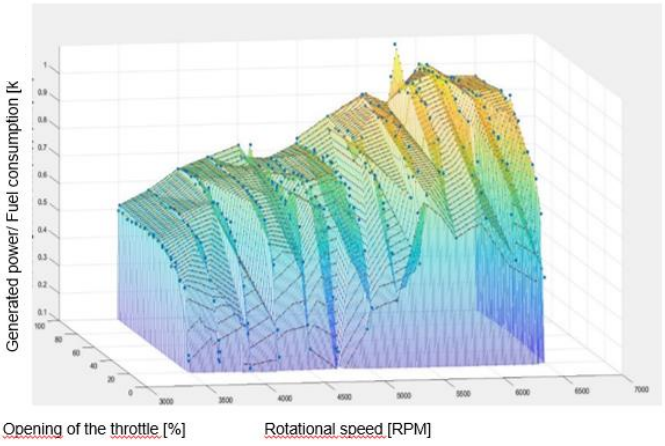

Figure 3 The map of the generated power over the fuel consumption vs opening of the throttle and the rotational speed of the power generator

The second aspect of the research concerned the common work of the Internal Combustion Engine and the electric motor as the generator. The main goal of these studies was to create the map of the power generated by the power generator regards to the fuel consumption. It was expected that the optimal operating conditions (the maximal ratio of the generated power over the consumed fuel) should occur as a range of rotational speed and opening of the throttle. It was confirmed during the test campaign (see Fig. 4). The variables taken into account during the power generator evaluation included the rotational speed and the throttle opening of the Internal Combustion Engine.

Many interesting facts and conclusions were drawn from the studies, but also some issues were revealed. Our team is eager to share these details with you during the Research and Education in Aircraft Design conference.