Cycle Analysis of a Hybrid Engine Concept for a Multi-fuel Blended Wing Body Aircraft

Background
The air traffic increase will inevitably result in the increment of the aviation emissions. Therefore, the Advisory Council for Aeronautics Research in Europe (ACARE) has set ambitious goals as presented in Fig. 1 to reduce emissions. This reduction is to be achieved by a combined improvement in the aircraft, propulsion system and air traffic management system.

The Multi-fuel BWB & Hybrid Engine Concept
To meet the ACARE goals, a hybrid engine concept is proposed for a multi-fuel BWB as shown in Fig. 2. The Schematic of hybrid engine concept is shown in Fig. 3. It is a separated flow turbofan engine with several novel techniques introduced briefly in Fig.3 as well.

Parametric Analysis
Fig. 4 presents the variation of the specific fuel consumption (sfc) with the Fan Pressure Ratio (FPR) for various Bypass Ratio (BPR). It can be observed that the sfc reduces with increasing BPR. Moreover, the optimal FPR is lower for a higher BPR.

Optimization and comparison:
Genetic algorithms have been used to optimize the engine design parameters at the reference point (cruise). The optimum engine parameters and performance are achieved. A comparison of the Specific Thrust (ST), Specific Fuel Consumption (SFC), kerosene equivalent, Specific Energy Consumption (SEC) and CO2 emission at the reference point between the hybrid engine using LNG/LH2 and the baseline engine (PW4056) can be seen in Fig. 7.

Fig. 1 The ACARE vision for Europe

Fig. 2 Schematic of the multi-fuel BWB.

Fig. 3 Schematic of the hybrid engine

Contra Rotating Fans:
• Good for BU
• Improve s propulsive efficiency

Cryogenic fuel Combustor:
• Burns LNG/LH2
• Reduces CO2 emission

Flameless Combustion:
• Burns kerosene Biofuel
• Reduces NOx emission

Fig. 4 Variation of sfc with FPR for various BPR.

Fig. 5 Variation of sfc and FN w.r.t. OPR and TT4.

Fig. 6 Variation of sfc and FN w.r.t. TT46 and TT4.

Fig. 7 Comparison of the hybrid engine to PW4056
Compared to the PW4056 engine, the hybrid engine is able to reduce CO2 emission by 33% and 90% using LNG and LH2 respectively. Furthermore, the SFC of the hybrid engine is decreased about 20% due to the higher engine efficiency. However, the ST of the hybrid engine is slightly lower than the PW4056.

One more comparison has been made between the hybrid engine and GE90-94B in Fig. 8.

Fig. 8 Comparison of the hybrid engine to GE90-94B.
Compared to the GE90-94B engine, the hybrid engine also reduces CO2 emission and SFC. Additionally, the ST of the hybrid engine is higher by 7% than the GE90-94B engine.

Progress and Objectives
The research was mainly about modeling, architecture definition and design performance analysis of the multi-fuel hybrid engine concept.
A 2-D thermodynamic model has been created and applied for analyzing the engine performance. Accordingly, an in-house optimization tool was executed to optimize the engine performance. On the basis of the optimization results, the hybrid engine has the substantial potential to reduce the CO2 emission using the alternative fuels.
Further analysis will be performed to study the engine off-design performance and a multi-points design method will be considered.

Publications