Process parameters and desirable end-use properties

Five speakers presented their research activities on the identification of process parameters and desirable end-use properties of SAF in the second online seminar of AMF Task 66. First, **Susan van Dyk (SVD Consulting)** provided an overview on SAF production technologies, key challenges and opportunities. Subsequently, **Robert McCormick (NREL)** elaborated on fuel property measurements at jet engine relevant conditions. Next, **Isaac Ekoto (Sandia)** presented insights on measurements and simulations used to elucidate fuel specific soot and contrail formation processes. The following speaker **Florian Kleissner (TU Vienna)** elaborated on the application of SAF in compression-ignition aircraft engines. Lastly, **Bernd Reiter (AVL)** presented insights from the demonstration of a Co-SOEC-based Power-to-Liquid plant.

Introduction

To reach the IEA´s net-zero target by 2050, more than 500 Mt/a of SAF will be required. The current production is less than 1% of this target. These volumes are mainly provided by the only fully commercial pathway HEFA, which is expected to be the main source of SAF until 2030. It is critical that at least some of the other pathways (11 pathways ASTM approved, many more under investigation), such as Alcohol-to-Jet or Gasification Fischer-Tropsch reach commercial maturity to provide sufficient amounts for reaching the net-zero by 2050 target.

ASTM approval focuses on operability and flight risk (e.g. lean blowout, altitude relight, cold ignition), it does not indicate if a pathway is commercially available. The evaluation process of new SATF (synthetic aviation turbine fuels) is streamlined by the National Jet Fuels Combustion Program (NJFCP). The ASTM qualification process of new SATF is expensive and time-consuming. It requires a lot of fuel for tests, which is a challenge for early-stage and small-scale technologies.

Fuel property measurements and simulations

To mitigate the scale-up and qualification risks, a combined experimental and computational approach can be applied to predict fuel property effects on aviation turbine combustor performance, with smaller fuel quantities. Relevant properties measured are viscosity, density and surface tension for fuel atomization, heat capacity, distillation behavior and vapor pressure impacting fuel spray and evaporation. Fuel property impacts on combustor performance can be simulated, supported by measuring fuel properties at turbine relevant conditions along with fuel property prediction models. Applying these models can accelerate SAF introduction.

Measurements and simulations are also conducted to explore end-use-related properties, such as soot and contrail formation processes. Using SAF is expected to be beneficial in terms of non-CO2 effects. However, there are still research gaps regarding e.g. soot property prediction, soot microphysics, particle growth and transport mechanisms, which are addressed by, among others, the DOE VTO combustion program.

SAF in compression-ignition aircraft engines

While large aircraft use turbines, smaller aircraft use compression-ignition engines, and these need to operate on the same kerosene as large aircraft. The suitability and potential thermal efficiency increase of SAF in compression-ignition (CI) aviation engines is investigated, using cylinder pressure-based combustion control in flight investigations. Most relevant fuel parameters when using SAF in CI engines are aromatics content, density, energy content of the fuel and cetane number. Test flights have been conducted with fossil jet fuel, and different HEFA blends up to 100%. The aromatics content of 100% HEFA is significantly lower compared to fossil jet fuel and thus, the density of the fuel is lower as well. Due to higher hydrogen content, the energy content of HEFA is higher. The cetane number, which is an indicator for the ignition delay, is higher in case of HEFA due to longer chain lengths.

Power-to-Liquid (PtL) SAF production

The production of PtL or e-SAF will also contribute to reach the net-zero target in the long term. The TRL of e-SAF production is low, but AVL operates a demonstration plant for high temperature electrolysis (SOEC - solid oxide electrolyser cell). The plant demonstrates continuous and stable operation as well as efficiency gain. In comparison to low temperature electrolysis, the potential for efficiency increase lies between 15-20%.

Research gaps

- To facilitate the ASTM approval process, it is required to better understand the performance of new SATF in engines and all related processes. This will require still a lot of effort.
- From the end-use perspective it must be proven that SAF can be utilized safely in compression-ignition aviation engines. When certified SAF is bought, the fuel specifications can vary due to different blends. This is especially critical in terms of the cetane range.

The content of this seminar was summarized by Doris Matschegg.