Can Sustainable Fuels Propel Us to Greener Skies?

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The aviation industry is under increasing pressure to mitigate its environmental impact, particularly concerning greenhouse gas emissions. One solution for this is using sustainable aviation fuel.

The need for sustainable and environmentally friendly fuels in existing engines is significant. More research is needed, as it is crucial to first understand these fuels complete combustion behavior and parameters. Currently, certain sustainable aviation fuels are approved for use in a 50/50 mixture with conventional fuel, as this has been proven to work well. These fuels are expensive to produce, and to gain approval for mixtures exceeding 50/50, two steps are necessary: testing different mixtures to observe their behavior and also finding a way to produce more of these fuels. As experiments are both expensive and time-consuming, it can be complementary to use quick, inexpensive, and flexible computer simulations. We have conducted computer simulations based on Computational Fluid Dynamics to identify the best existing models for predicting combustion in aircraft engines, in the commercial software STAR-CCM+. In this comparative study, four different combustion models were evaluated across distinct turbulence modeling frameworks, notably including Reynolds-Averaged Navier-Stokes and the computationally intensive Large Eddy Simulation. One notable discovery pertains to the suitability of the combustion model Eddy Dissipation Concept. While it proves to be an appropriate choice for Reynolds-Averaged Navier-Stokes simulations, its performance worsen when applied in Large Eddy Simulation. This is caused by poor software implementation of the model. Furthermore, the investigation uncovers intriguing insights into the environmental impact of different aviation fuels. Surprisingly, the sustainable aviation fuel C1 exhibits a higher propensity for nitrogen oxide, NOx, emissions compared to the conventional Jet A fuel A2. Further studies are needed to validate this, as the amount of fuel being combusted is higher for C1 than A2. Another significant revelation pertains to the computational trade-offs involved in incorporating thermal radiation into simulations. While enabling this feature enlarges the computational costs, the payoff is substantial, especially when analyzing temperature distributions or NOx emissions. Moreover, these findings serve as a springboard for future explorations within the realm of STAR-CCM+. They provide a solid foundation for researchers to delve deeper into combustion models and reaction mechanisms.