World Academy of Science, Engineering and Technology
International Journal of Energy and Environmental Engineering
Vol:14, No:03, 2020

Evaluation of the Energy Performance and Emissions of an Aircraft Engine: J69 Using Fuel Blends of Jet A1 and Biodiesel

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Abstract : The substitution of conventional aviation fuels with biomass-derived alternative fuels is an emerging field of study in the aviation transport, mainly due to its energy consumption, the contribution to the global Greenhouse Gas - GHG emissions and the fossil fuel price fluctuations. Nevertheless, several challenges remain as the biofuel production cost and its degradative effect over the fuel systems that alter the operating safety. Moreover, experimentation on full-scale aeronautic turbines are expensive and complex, leading to most of the research to the testing of small-size turbojets with a major absence of information regarding the effects in the energy performance and the emissions. The main purpose of the current study is to present the results of experimentation in a full-scale military turbojet engine J69-T-25A (presented in Fig. 1) with 640 kW of power rating and using blends of Jet A1 with oil palm biodiesel. The main findings are related to the thrust specific fuel consumption – TSFC, the engine global efficiency – η, the air/fuel ratio – AFR and the volume fractions of O2, CO2, CO, and HC. Two fuels are used in the present study: a commercial Jet A1 and a Colombian palm oil biodiesel. The experimental plan is conducted using the biodiesel volume contents - w_BD from 0 % (B0) to 50 % (B50). The engine operating regimes are set to Idle, Cruise, and Take-off conditions. The turbojet engine J69 is used by the Colombian Air Force and it is installed in a testing bench with the instrumentation that corresponds to the technical manual of the engine. The increment of w_BD from 0 % to 50 % reduces the η near 3,3 % and the thrust force in a 26,6 % at Idle regime. These variations are related to the reduction of the □HHV□_ad of the fuel blend. The evolved CO and HC tend to be reduced in all the operating conditions when increasing w_BD. Furthermore, a reduction of the atomization angle is presented in Fig. 2, indicating a poor atomization in the fuel nozzle injectors when using a higher biodiesel content as the viscosity of fuel blend increases. An evolution of cloudiness is also observed during the shutdown procedure as presented in Fig. 3a, particularly after 20 % of biodiesel content in the fuel blend. This promotes the contamination of some components of the combustion chamber of the J69 engine with soot and unburned matter (Fig. 3). Thus, the substitution of biodiesel content above 20 % is not recommended in order to avoid a significant decrease of η and the thrust force. A more detail examination of the mechanical wearing of the main components of the engine is advised in further studies.

Keywords : aviation, air to fuel ratio, biodiesel, energy performance, fuel atomization, gas turbine
Conference Title : ICESA 2020 : International Conference on Energy Studies and Analysis
Conference Location : Paris, France
Conference Dates : March 26-27, 2020