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Ultrasonic Atomizer for Turbojet Engines

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Abstract : This paper suggests a new and more efficient method of atomization of fuel in a combustor nozzle of a high bypass turbofan engine, using ultrasonic vibrations. Since atomization of fuel just before the fuel spray is injected into the combustion chamber is an important and crucial aspect related to functioning of a propulsion system, the technology suggested by this paper and the experimental analysis on the system components eventually proves to assist in complete and rapid combustion of the fuel in the combustor module of the engine. Current propulsion systems use carburetors, atomization nozzles and apertures in air intake pipes for atomization. The idea of this paper is to deploy new age hybrid technology, namely the Ultrasound Field Effect (UFE) to effectively atomize fuel before it enters the combustion chamber, as a viable and effective method to increase efficiency and improve upon existing designs. The Ultrasound Field Effect is applied axially, on diametrically opposite ends of an atomizer tube that gloves onto the combustor nozzle, where the fuel enters and exits under a pre-defined pressure. The Ultrasound energy vibrates the fuel particles to a breakup frequency. At reaching this frequency, the fuel particles start disintegrating into smaller diameter particles perpendicular to the axis of application of the field from the parent boundary layer of fuel flow over the baseplate. These broken up fuel droplets then undergo swirling effect as per the original nozzle design, with a higher breakup ratio than before. A significant reduction of the size of fuel particles eventually results in an increment in the propulsive efficiency of the engine. Moreover, the Ultrasound atomizer operates within a control frequency such that effects of overheating and induced vibrations are least felt on the overall performance of the engine. The design of an electrical manifold for the multiple-nozzle system over a typical can-annular combustor is developed along with this study, such that the product can be installed and removed easily for maintenance and repairing, can allow for easy access for inspections and transmits least amount of vibrational energy to the surface of the combustor. Since near-field ultrasound is used, the vibrations are easily controlled, thereby successfully reducing vibrations on the outer shell of the combustor. Experimental analysis is carried out on the effect of ultrasonic vibrations on flowing jet turbine fuel using an ultrasound generator probe and results of an effective decrease in droplet size across a constant diameter, away from the boundary layer of flow is noted using visual aid by observing under ultraviolet light. The choice of material for the Ultrasound inducer tube and crystal along with the operating range of temperatures, pressures, and frequencies of the Ultrasound field effect are also studied in this paper, while taking into account the losses incurred due to constant vibrations and thermal loads on the tube surface.

Keywords : atomization, ultrasound field effect, titanium mesh, breakup frequency, parent boundary layer, baseplate, propulsive efficiency, jet turbine fuel, induced vibrations
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