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Introduction: UAV Propulsion Systems

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## CHAPTER 1

### Achieving Reliable Cold Starts in a Stepped Piston Engine **1**

Researchers performed dynamometer testing on a spark ignition UAV engine operating on heavy fuel. The engine was a segregated scavenging two-stroke engine with air charge delivery by means of integral stepped pistons overcoming the durability issues of conventional crankcase scavenged engines. Additionally, the engine utilized an integrated recirculatory lubrication system to circumvent the lubrication challenges normally associated with crankcase scavenged two-stroke engines. The chapter focuses on addressing the need for repeatable cold start on low volatility fuel in the attempts to eliminate gasoline from UAV theatres of deployment.

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A series hybrid-electric propulsion system was designed for small, rapid-response UAVs with the intent of improving performance, providing flexible and responsive electric propulsion, and enabling heavy fuel usage. The motor-driven propeller is powered by a battery bank, which is recharged by an engine-driven generator. The engine design focused on a custom, two-stroke, lean-burn, compression ignition engine which has an integrated starter alternator to provide electrical power. This chapter focuses on how the series hybrid configuration allowed the engine to be mechanically decoupled from the propeller, enabling the engine to be operated at the load/speed condition for peak fuel-conversion efficiency.

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Synergies between an integrated airframe, distributed propulsion, and power management system affect the integrated system power requirement, production, and distribution. Researchers carried out a design space exploration to assess the influence of distributing motor-driven fans on three different airframes: a tube-and-wing, a triple-fuselage, and a blended wing-body. What was found was a drop in specific fuel consumption due to the engine design point change—from nearly flat to a 25%-increase in maximum endurance when moving towards heavier takeoff masses. This chapter discusses the improved endurance of a blended-wing-body design for the given distributed propulsion system.

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A prototype four-chamber, Otto-cycle rotary engine—named the Szorenyi engine—was constructed and tested in 2008. The stator of the Szorenyi engine shares similarities with the Wankel engine; however, the geometric shape of the rotor is a rhombus, which deforms as it rotates inside the contour of the rotor. The result is a rotary engine with four combustion chambers. Unlike the Wankel, which is rev limited due to excessive crankshaft bending from the centrifugal forces of the eccentric rotor, the Szorenyi rotor is balanced and is not rev-limited. This chapter discusses the development and testing of this new stator and rotor design.

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The dielectric barrier discharge (DBD) has been studied significantly over the past two decades. Recently, researchers have proposed utilizing DBD in various configurations to act as viable propulsion systems for micro- and nano-UAVs. DBD produces stable atmospheric-pressure non-thermal plasma in a thin sheet with a preferred direction of flow. Driven by electrohydrodynamic body forces, the plasma flow entrains the quiescent air around it and develops into a low speed jet. This chapter investigates two-dimensional duct flows for applications in micro plasma thrusters.

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