Experimental Investigation of an Engine Quick-Start System with Compact Air Supply for Rotorcraft Application

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Long Abstract

Introduction

Helicopters of the light and medium weight class have usually two turboshaft engines installed due to safety reasons. However, this installed power is barely needed during most flight missions and thus, the engines are running mainly at part load. Anyway, turboshaft engines have low specific fuel consumption (SFC) at high engine loads. Accordingly, fuel efficiency is poor at engine part load. An operational strategy for fuel economy can be an intended controlled shutdown of one engine (ISEO). Simultaneously, the load of the remaining running engine is increasing whereby the SFC is shifted to better values and fuel can be saved. This saving can be used either for reducing mission-specific fuel consumption or for extending flight mission time. First flight tests of this operational strategy are discussed within the Bluecopter research project of Airbus Helicopters [1]. Due to safety and power required reasons, the intended operational engine usage strategy is limited to certain areas of the helicopter flight envelope. Due to maximum transmission or engine power, neither low or high speed flights nor steep climb flights are possible. The other constraint is the flight altitude. Flying with ISEO requires sufficient altitude margin for autorotation if the running engine fails. To reduce this height safety margin and to extend the ISEO flight envelope areas, the before controlled shutdown engine has to be quick-start capable since regular engine starts last too long until sufficient power can be provided by the engine. Such a quick-start system (QSS) for turboshaft engines was designed and tested at the Institute for Flight Propulsion. Similar systems were tested by Rodgers and Hull in the 1960s and 1980s [2, 3].

Content

The institutes QSS utilizes pressurized air for accelerating the gas generator during engine start-up. An air jet is directed to the trailing edges of the radial compressor of an Allison 250-C20B engine. For proof of concept, shop air of 13 bar(a) is used for the five Laval nozzles which are integrated in a new radial compressor casing. The performance of this system is shown in Figure 1. Acceleration time of the gas generator was reduced by approximately 90% to 2.4 seconds. After 8 seconds the engine delivers 20% of its maximum rated continuous power (see Figure 2).

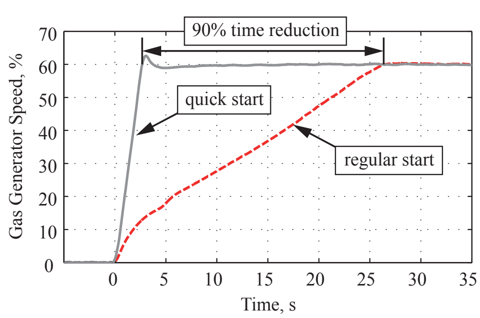

Figure 1: Ground idle start times of a regular engine start [4]

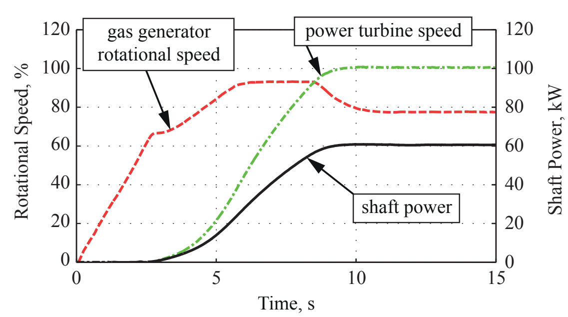

Figure 2: Power delivery curve after performing a quick-start to flight mode start. [4]

However, in a flying system like a helicopter, the usage of shop air is not possible. Thus, at the second development stage the required air mass flow is provided by lightweight compressed air bottles. This paper deals with experimental investigations of the quick-start system powered by compressed air bottles. This comprises in first case general identification of system parameters by numerical studies and experimental tests. The numerical studies are done with the simulation software ESPSS. Further information about ESPSS is given in [5] Therewith, the ideal count of nozzles is determined by adjusting a proper nozzle entry pressure. As pressurized air source, a compressed air cylinder bundle is used which provides sufficient mass flow at high pressure levels. A pressure reducer is used for providing a constant nozzle entry pressure. A quick operating high pressure magnet valve is incorporated for system operation activation. Afterwards, experimental engine quick-start performance tests are performed. Therefore, the compressed air cylinder bundle is replaced by a single compressed air bottle (see Figure 3). This QSS setup comes close to an airworthy one, which is described in [6] and shown in Figure 4.

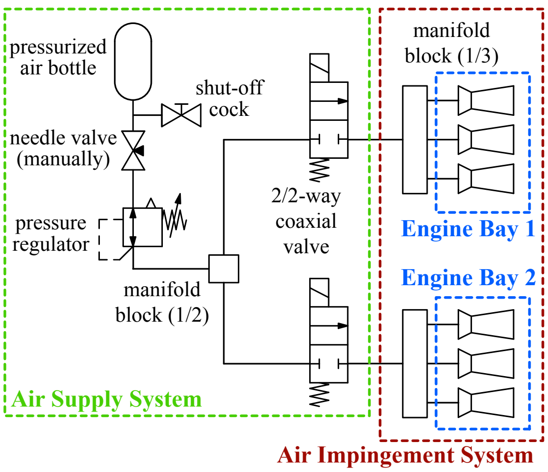

Figure 3: Scheme of an airworthy quick-start system for testbed application and helicopter integration

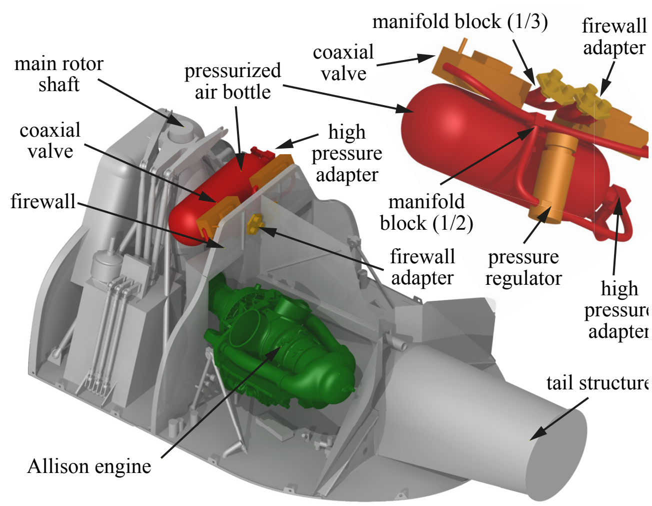

Figure 4: CAD model of a possible QSS arrangement within the BO 105 fuselage

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