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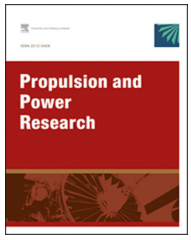

ORIGINAL ARTICLE

Study on effects of the secondary fuel manifold unfold pressure on engine starting performance

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Abstract The fuel manifold is an import accessory through which the fuel enters in combustor, after measuring in fuel control system. The component test results of fuel manifolds show that, when the starting fuel supply is given and the primary fuel manifold relative unfold pressure is at constant, the adjustment of the secondary fuel manifold turn-on pressure has effects on fuel flow through the secondary fuel manifold and the time of fuel into the combustion chamber. The verification test of the secondary fuel manifold unfold pressure influence on engine starting performance has been conducted, showing that the unfold pressure variation of the secondary fuel manifold has great influence on the engine start performance. The test research results have important guidance and reference meaning for confirming the secondary fuel manifold unfolds pressure.

1. Introduction

The in-service turbo-shaft engine usually supplies fuel to the combustor by employing the fuel divider plus fuel manifold form, and the number of the fuel manifold exerts great influence on the engine starting [1,2]. According to the present literature, the fuel manifold of some engine only uses one manifold, like Russian TV-117BM, and some uses two manifolds like Canadian PT6T-6 and a certain in-service turbo-shaft engine in China. The unfold pressure of the fuel divider connecting with the engine fuel manifolds determines whether the fuel could pass the fuel manifold and enter the combustor, therefore, it has significant influences on rapid and reliable engine starting [3,4].

According to the statistics, when different turbo-shaft engines employ dual fuel manifolds to supply fuel, the unfold pressure of the first fuel manifold is 0.04–0.1 MPa,

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while the unfold pressure of the second one varies according to the self-characteristics of the engines.

The relative unfold pressure of the first fuel manifold of engine is quite low, therefore no specific research is carried out on the first fuel manifold in this paper. This paper focuses on the influence that the changes of the relative unfold pressures of the second fuel manifold have on the starting features of the engine in normal temperature and low temperature (−20 °C) [5].

2. The operating principle of engine fuel manifold

When the engine is at work, the fuel metered by the measuring oil needle of the fuel measuring device in the fuel control system would enter and burst in the fuel atomizer in the combustor after passing the fuel divider and the dual manifolds [6]. The oil-way of the engine is shown in Figure 1, and the structure principle of fuel divider is shown in Figure 2.

In starting, when the pressure of the high pressure fuel measured by the measuring oil needle of the fuel measuring device in the fuel control system is too low to overcome the power of large spring in the fuel distributor, the large valve would seal off the oil mouth of the first oil-way, so that the fuel oil cannot enter the first oil-way of the fuel manifold. When the high measured fuel reaches a certain flow rate, the corresponding fuel pressure would be higher than that of the first oil-way of the fuel divider, but lower than that of the second the oil-way, and the fuel pressure would overcome the power of the small spring and the friction between small valve and big valve. Now, the fuel could pass through the first manifold and primary atomizer, burning and speeding up the engine, and this increase the flow rate in return [7]. The small vale moves forward and over the second oil-way afterwards, and the fuel enters the second fuel atomizer to burn [8], so both primary and secondary fuel manifold are unfolded.

After the engine is started and operates above the idling state, the fuel would burn in the fuel nozzle after passing the first and second fuel manifolds. The available power generated by the fuel generator would be absorbed by the turbo-shaft in the power turbine and decelerated by the main speed reducer in the helicopter and to drive the main rotor and tail rotor, so as to satisfy the helicopter's power need for fly. When the engine stops, the fuel divider would

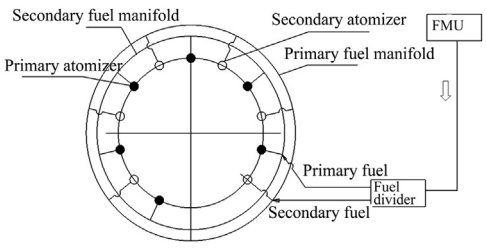

Figure 1 Flow chart of the engine fuel system.

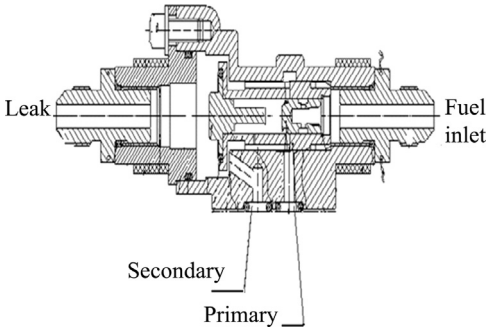

Figure 2 Principle of the fuel flow divider.

shut down the second and first fuel manifold successively, and the redundant fuel would be exhausted outside the engine by the specific fuel leaking outlet.

3. Testing situation for the fuel distribution components of the two fuel manifolds

To obtain precisely the mathematical model when the fuel fills the fuel manifolds, the fuel flow changes in the two oil-ways of the fuel manifold are needed to be known when the fuel supply for the engine is fixed [9,10]. Therefore, the fuel divider, fuel manifold with two oil-ways and fuel nozzle are installed in the engine and go through the fuel flow feature testing. In the flow feature testing, the relative unfold pressure of the first oil-way in the fuel distributor is adjusted in a certain value, and adjusts the relative unfold pressure of the second oil-way in three different pressure values by adjusting the power of small spring controlling the closing of the second oil-way of the fuel manifold in the fuel divider, and the three design pressure values are A MPa, A-0.02, and A+0.02 MPa. The distribution situation for starting fuel oil supply in two oil-ways of fuel manifold in the engine is obtained, and the testing results are shown in Figure 3.

It can be seen from Figure 3, when the fuel supply for engine start is fixed, and the relative unfold pressure of the first oil-way in fuel distributor is unchanged, the adjustment of relative unfold pressure of the second oil-way has no influence on the fuel supply of the first oil-way. When the unfold pressure of the second oil-way is low, the fuel flow into the second oil-way is advanced, so the ignition and combustion of fuel is earlier, leading to earlier power generation. In addition, when the open pressure of second oil way is above 0.264 MPa, the unfold pressure of the second oil-way has no longer effect on the total fuel flow.

4. Mathematical model for fuel filling fuel manifold

When the unfold pressure of the first oil-way is fixed, the adjustment of relative unfold pressure of the second oil-way exerts no influence on the fuel supply for starting in the first