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Failure analysis of an aircraft auxiliary power unit air intake door

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ABSTRACT

A remarkable number of auxiliary power unit (APU) air intake doors of the C27-J aircrafts consisting in A356-T6 casting aluminium alloy were found prematurely cracked during post-flight inspections. All the cracks were localized in correspondence of the inner side ribs and affected by extroversion. Examination of the fracture surfaces by using electron microscopy revealed the cracks propagated in accordance with a high cycle fatigue mechanism induced by in-service typical loads, such as vibrations and air turbulent flows. The doors were found to be confirmed to the chemical, metallographic and hardness requirements for the selected material. The stress induced by these loads was also locally increased by sub surface shrinkage cavities located in correspondence of the ribs. As a consequence of that, new doors, in terms of design as well as material, have been introduced, thus obtaining the necessary functional improvements.

1. Introduction

The APU, installed in the forward part of the left main landing gear (MLG) wheel well of the C27-J aircraft, is a gas turbine engine which provides power to drive the necessary accessories and to maintain safety operations (Fig. 1). The APU also supplies mechanical power to drive a 50/60 KAV generator fitted on the APU gearbox and provides compressed bleed air for main engine starting both on the ground and in flight and cabin air conditioning/pressurization. The APU air intake is composed of a NACA flush type inlet located on the forward upper skin of the landing gear fairing and an intake duct which connects the inlet to the APU inlet plenum. The inlet is provided with a three position inlet door (closed, for the APU not opening or APU fire, partially open for APU starting and fully open for APU available operation) driven by an electrical actuator (details in Figs. 2 and 3 a and b). The door in the closed position guarantees the aerodynamic continuity of the main landing gear fairing surface. On the opposite, the open one provides a continuous air flow to the equipment through the duct.

Many doors, specified to be a cast conforming to the aluminium alloy A356-T6, evidenced several cracks during post-flight inspections. In particular, the cracks, produced after about 50 flight hours, were localized along the inner side of the ribs, especially around the door hinge (Fig. 4). By using visual inspection, fracture surface observation as well as material characterization, a requested failure analysis investigation was carried out to determine the nature of the cracks.

The results showed the material was conforming to the drawing requirements. In addition, it was revealed that the cracks occurred by fatigue and the ribs originated them. Since the amount of the striations was significantly higher than the total flights/flight hours accumulated by the doors, it was concluded that the cracks were produced by typical in-service loads, such as vibrations and air turbulence. No interference occurred between the door and the internal duct. In addition, due to the nature of the casting, the presence of sub surface shrinkage cavities localized about 200 μm far from the external side

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