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PRELIMINARY SYSTEM-SAFETY-ANALYSIS AND COMPARISON BETWEEN TWO NEW BROADBAND NOISE ABSORBING ACOUSTIC-LINER CONCEPTS FOR CIVIL AVIATION

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ABSTRACT

This paper describes various methods of the safety assessment for aviation systems and carries out these on two concepts of future, broadband acoustic liners. The Liner concepts have a similar basic design and the same primary function. Nevertheless, with the ARP 4761 safety assessment methods, significant differences in subfunctions and possible malfunctions of the concepts can be identified. Finally, the results of the safety assessment are discussed and the concepts are evaluated in terms of function and safety.

Keywords: acoustic liner, broadband attenuation, function analysis, system safety assessment.

INTRODUCTION

The aviation industry is subject of constant development and optimization. In addition to the fundamental increase in technical and cost efficiency, particular attention is payed to the aspect of environmental compatibility. This includes the reduction of soot, NO_x and as well noise emission of the aero engine.

For many years, the reduction of airborne noise is a challenge during the development of aircrafts and aero engines. A current solution to reduce airborne noise on aero engines is to integrate noise reducing acoustic liners into the intake and bypass duct. Such acoustic liners (Standard Helmholtz Resonator Liner; SHR-Liner) are sandwich panels composed of a honeycomb core, a perforated cover layer and a bottom layer (Figure 1).

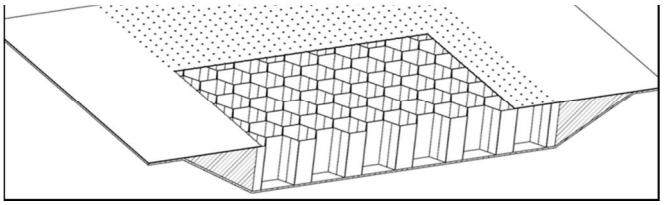

Fig. 1 - Design of a SHR-Liner

These SHR-Liners are designed as ridged structure with a fixed cell dimension, which allowing only to attenuated one frequency of the emitted noise. However, aero engines have a very broadband tonal noise character.

The first concept increase the frequency rang by integrating flexible (vibrating) structures into the honeycomb core, which dissipate the sound energy into heat (Window Helmholtz Resonator Liner; WHR-Liner; Figure 2). The second concept optimizes the transmission loss by reflection and extinction of the incoming and outgoing soundwaves by adding the flexible structure into the cover-layer (Plate Resonator Liner; PR-liner; Figure 2).

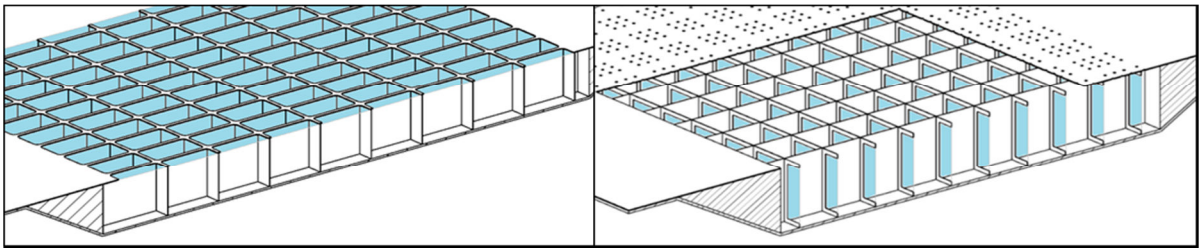

Fig. 2 - Design of a WHR-Liner (left) and an PR-Liner (right) with flexible structures

Because the flexible structures within the liners is new, there are no concrete safety regulations set up by the authorities and no aviation safety investigations has been conducted. By introducing the new geometry with flexible elements, several disadvantages and challenges for the integration and the airworthiness requirements of the new acoustic-liners could arise.

RESULTS AND CONCLUSIONS

In accordance with ARP 4754, the acoustic-liners were separated in its physical subcomponents based on their functional attributes. It is an iterative top-down development approach of the considered system and begins with the function definition of the top level system. In the case of airworthy systems, the main system is always the aircraft itself. From this point, various main functions (aircraft top-level functions), are defined and gradually refined. These are further subdivided down to the system level functions. From this system functions, the corresponding system architecture can be derived.

Subsequently the Functional Hazardous Assessment (FHA) and the Fault Tree Analysis (FTA) in accordance with ARP 4761 were performed. Through these methods, possible malfunctions and other potential failure cases, which may occur during operation can be detected and classified, based on the system functions and the system architecture. The FHA identifies possible malfunctions and the resulting low-level requirements, which are specially tailored to the liner functions. Due to the similar design of both new liner concepts, similar malfunctions can be detected.

In order to evaluate and compare the WHR- and PR-Liner concept in terms of function and safety, the SHR-Liner is used as a corresponding reference system. The SHR-Liner is currently use in service and meets compliance with all relevant requirements of the aviation authorities. In case of the functional character for broadband noise reduction, both concepts have a high potential. In terms of system safety, the flexible structures of the WHR- and PR-Liner have great structural and thermal disadvantages arise in comparison to the rigid SHR-Liner without flexible structures. Furthermore all known malfunctions and failure cases of the new broadband noise attenuating acoustic liners were identified and summarized. It can be concluded that the new liner concept has corresponding risk areas. The main tasks for further researches are to identify the probability of occurrence of the detected malfunctions and improve them by adapting the geometry and material behaviour.

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