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SLAT NOISE REDUCTION BY MEANS OF ADAPTIVE LEADING EDGE DEVICES

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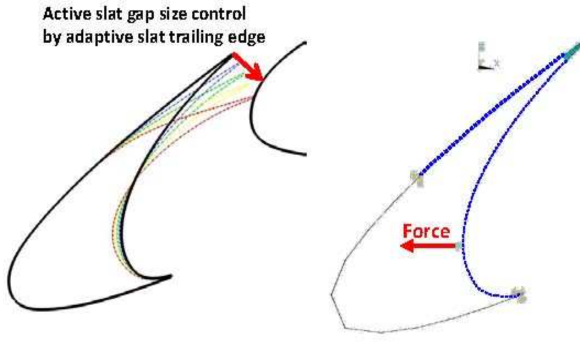
Abstract. Slat noise is regarded as the major noise source of state of the art high lift systems and contributes to the overall aircraft noise signature in particular during the approach phase [1]. Consequently any attempt to reduce high lift system generated noise should first of all target slat noise reduction. Having furthermore in mind that the slat at the same time is a very important means to achieve the necessary high lift performance any approach to reduce slat noise should address the conservation of the aerodynamic performance as well.

In the course of this work two different adaptive systems to reduce slat noise will be presented, namely an "adaptive slat" and the "smart droop nose". The concept of the adaptive slat was investigated in a joint approach between the DLR internal project SLED (Silent Leading Edge Devices) and the EU co-financed project OPENAIR. In the mainframe of the EU co-financed project SADE [2] and again within SLED studies on the smart droop nose were driven. Both approaches have in common that the conventional slat is replaced by an actuated system. The basic difference is in fact that the adaptive slat addresses a slat gap variation in order to reduce or control slat noise while on the other hand the smart droop nose concept represents a 2-element high lift system without slat aiming at the reduction of the aerodynamic penalty that occurs due to omitting the slat.

First studies on the effect of the slat setting and in particular the slat gap size on slat noise were conducted in the DLR project LeiserFlugverkehr [3]. It was demonstrated that a slat gap reduction leads to a local flow velocity decrease at the slat trailing edge and thus resukts in a remarkable slat noise reduction of up to 10 dB, the latter of course depending on the magnitude of slat gap reduction. Based on this first investigation, which was purely acoustically driven, a combined aerodynamic, acoustic and structural mechanic approach was initiated in order to design a slat with active gap size control (Figure 1, left side) that allows on the one hand to reduce slat noise during the approach phase by reducing the slat gap but which can provide on the other hand the full aerodynamic performance by opening the gap to the reference position if needed for instance in an emergency case. The final structural mechanics design concept is based on rigid slat leading and trailing edges which are connected by a somehow flexible material on both the slat suction and pressure side. The movement is invoked by an actuator which acts on the slat pressure side (Figure 1, right side). The feasibility of the design concept was assessed by means of finite element computations which were based on realistic aerodynamic loads on the slat. The acoustic assessment was performed experimentally during a wind tunnel test in the Large Low Speed Facility DNW-LLF of the German-Dutch Wind Tunnel foundation on a large scale high lift system. A rigid and none actuated adaptive slat was mounted at the inboard station of the high lift system in two setting positions. The first one was an intermediate position providing a gap reduction of about 45%. The second was the sealed slat position without any gap. The results of the acoustic assessment are provided in terms of noise source maps and 1/3-octave band sound pressure level spectra in Figure 2. On the left hand side of Figure 2 source noise maps of the reference system and the adaptive slat system are presented. As is visible noise source levels with the adaptive slat in the intermediated position are much lower as those acquired for the reference position. The same effect can be seen by comparing the sound pressure level spectra on the right hand side of Figure 2 for the reference system (red line) and the adaptive slat at intermediate position (green line). Sealing the gap leads to a cancelation of slat noise which is proven by comparing the sealed configuration result (blue line) to the respective data for a 2-element high lift system without slat.

The more radical approach to reduce slat noise is to omit the slat. In this case, of course, an aerodynamic penalty occurs which has to be recovered as much as possible without introducing a new noise source. The selected approach was first to optimize the flap setting for the 2-element high lift system and second to design a droop nose in order to gain as much aerodynamic as possible (Figure 3). The final droop nose design was investigated experimentally in the cryogenic wind tunnel DNW-KKK in order to check on the aerodynamic performance and in the acoustic low speed wind tunnel DNW-NWB to identify the achieved noise reduction. The acoustic result is presented in Figure 4 in terms of narrow band sound pressure level spectra. As can be seen the noise levels obtained for the droop nose compare very well to those acquired for the 2-element reference system and thus provide a broadband noise reduction of at least 5 dB with respect to the 3-element reference system. From the aerodynamic point of view the smart droop nose was capable to recover about 40% of the inevitable aerodynamic loss.

The presented work demonstrated that adaptive systems can be of beneficial use to reduce airframe noise.



1: Principle of slat noise reduction by means of slat gap size control

Fig. 1. Principle of slat noise reduction by means of slat gap size control (left) and structural design and actuation concept (right)

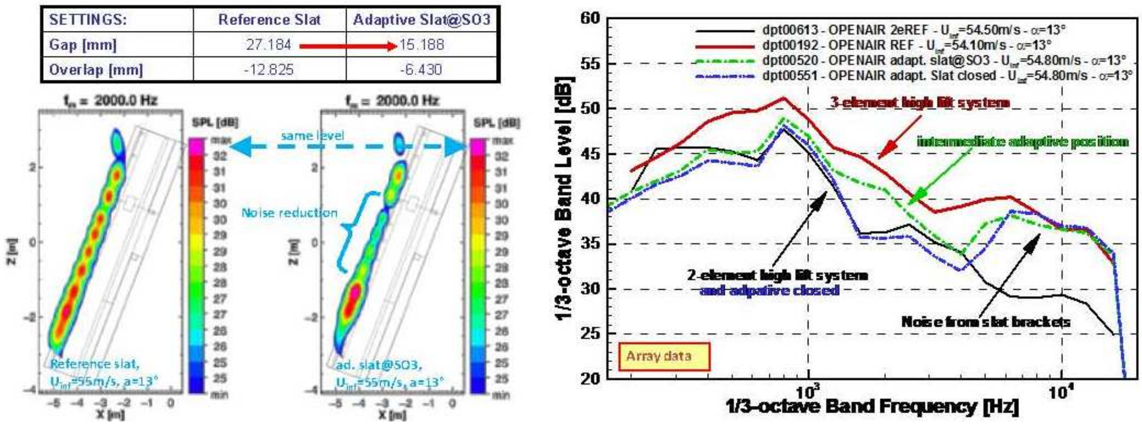


Fig. 2. Noise reduction as achieved with an adpative slat at sealed position and with intermediate gap size

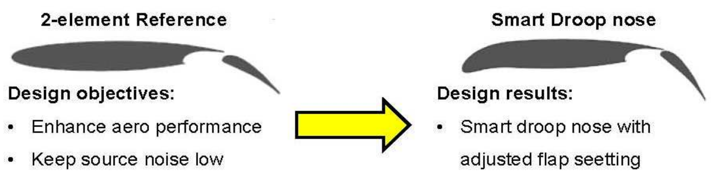


Fig. 3. Concept of a smart droop nose to reduce slat noise and to recover aerodynamic performance

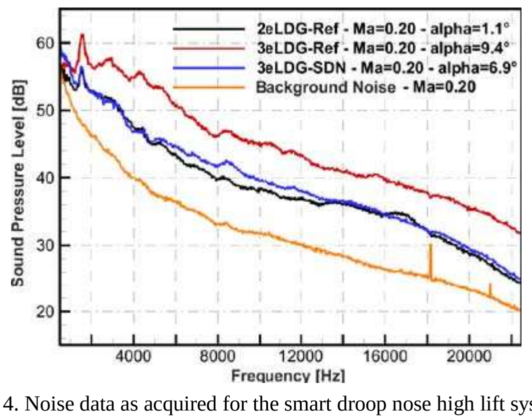


Fig. 4. Noise data as acquired for the smart droop nose high lift system in comparison to both the 3-element and the 2-element reference systems

Keywords: slat noise, airframe noise reduction, adaptive slat.

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