Experimental validation of innovative liners concept, designed for hyperlift surfaces

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In landing conditions, when the flap is at its maximum deflection, a flow separation may occur on the suction side of the flap in proximity of the trailing edge that is responsible for additional wall-pressure fluctuations and thus noise. In addition to these broadband noise generation mechanisms, vortex shedding from the blunted trailing-edge of the main wing can be responsible for a tonal noise component that may arise from the broadband spectrum. The main differences between a standard flap and a lined flap are the presence of a micro-perforation on the external facing sheet and an additional honeycomb layer inside the flap. The cavities generated by the micro holes and the honeycomb behave as Helmholtz resonators resulting in a sound-absorbing effect. A computation process was implemented to define the optimal constructive parameters of the lined flap (optimal impedance):

- Acoustic near field computed with a FEM (Howe eq.)
  - Dirichlet Boundary Condition: Source Noise Model based on CFD/RANS solution
  - Impedance Boundary Condition: Analytical/Empirical Liner Impedance Model
- Optimization of the lined-flap parameters.

The main-wing “trailing edge noise” was supposed to be the main source of noise. The CFD boundary layer properties in proximity of the trailing edge were used to compute the magnitude of the wall-pressure Fourier components and imposed through a Dirichlet Boundary Condition in the FEM model.

The liner impedance, $Z$, was estimated by means of an analytical/empirical model with grazing flow effects (Motsinger and Kraft, 1991). This model correlates impedance value with frequency, flow and manufacturing parameters: $Z = Z$ (frequency, flow conditions, geometrical parameters).

Facility: Closed-loop wind tunnel with axial fan, typically used for aerodynamic tests. Most of the effort was made to reduce background noise measured within the wind tunnel test section significantly affecting aeroacoustic data.

- Sound absorbing material was applied all over the wind tunnel duct as well as downstream the test section in order to reduce the reverberation through the concrete walls of the tunnel.
Acoustic absorbers (passive panels) were installed next to the fan to reduce the acoustic tonal components as well as the boundary layer turbulence due to the blade-tip turbulence noise.

Acoustic sources like pipes, cables, light metals were removed from the test chamber.

Windows, gaps and orifices in the test chamber were closed with adhesive tape.

The profiled struts of the test rig were removed during the background noise characterization.

Preliminary tests were performed to:

- Characterize the background noise measured within the acoustic test section;
- Validate the test set-up of the beamforming antenna used to localize aeroacoustic noise sources.

The tonal fan-induced noise of about 90 dB around 100Hz (50 m/s) has been marginally reduced. The broadband noise due to the turbulence interactions has been slightly reduced of about:

- 2 dB in the range 1 kHz – 2 kHz
- 4 dB in the range 2 kHz – 6 kHz
- 1 dB in the range 6 kHz – 15 kHz

Lined Single slotted flap has shown potential in noise emission reduction

References
