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EXPERIENCE OF THE NATIONAL AVIATION UNIVERSITY IN THE APPLICATION OF ACTIVE NOISE CONTROL IN AN AIRCRAFT CABIN

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Abstract. This presentation is focused on the problem of noise reduction in the aircraft cabins including cockpits. The noise has an adverse effect on the crew first of all, since it is disturbing, tiring, and interferes with transfer and recognition of information. Together with other adverse factors it can result in human errors and hence influence on flight safety. Aircraft cabin noise can be generated by a variety of sound sources. The main of them in aircraft cabins include: the power unit (engines), the turbulent boundary layer on aircraft surfaces, the avionics, and the air conditioning system (ACS). The noise from power unit, turbulent boundary layer is transmitted through the fuselage. The structural-born noise is also one of essential sources of noise in aircraft cabin. Spectrum of the noise in the cabin is broadband with tonal components. There are two major techniques for reducing noise: passive and active. Passive noise control is based on the absorption and/or reflection properties of materials, and is effective for high-frequency noises. However, these passive techniques are not effective at low frequencies. The most effective way to reduce of cabin noise in low frequency range is to use active noise control (ANC) system.

ANC is based on the principle of superposition, where the secondary loudspeaker generates an anti-noise with the same amplitude but an opposite phase in order to cancel the primary noise produced by the noise source. Feedforward and feedback control are the two main methods that have been used for ANC system. A feedforward controller requires a measure of the incoming disturbance to generate the required control signal for the control source. A feedback controller requires no knowledge of the incoming disturbance and acts to change the system response by changing the system resonance frequencies and damping.

There are specific features of the application of ANC system in an aircraft cockpits.
1. Small cockpit volume.
2. Small time of reverberation and noise transmission loss of the fuselage inside the low frequency bands.
3. Aircraft cabin noise from external sources (propellers, engines) is determined by near acoustical field.
4. Low frequency noise less than Schroder frequency (f_{Shr} < 300 Hz):

$$f_{Shr} = 2000\sqrt{\frac{T_{60}}{V}}.$$

5. The non-stationary acoustic field inside the cockpits include: the noise from aircraft engines, airframe noise, the noise from ACS, and the structure–born noise.

Active reduction of interior noise in the cabin of aircraft Antonov 24 was carried out at three points at the head of the copilot. The table shows the results of studies on the compensation of the fundamental blade pass frequency and second harmonics of the propeller in the three control points.

	Synphasing			Implementation feedback control and synphasing		
Decreasing of sound pressure level, dB	1	2	3	1	2	3
	2	4.7	5.6	3.5	5	10.4

To reduce airborne noise in ducts of air conditioning systems ANC of noise in open ducts are investigated. One method of noise reduction in the cabin from the air conditioning system is the use of compensating loudspeakers near air distribution jet nozzles. The analytical algorithm for compensation of acoustic radiation from the open duct in the presence of air flow was proposed. If you want to provide a more effective compensation of sound in the open duct, you must consider the dependence of the amplitudes of compensating signals from sound reflection coefficient R from the open duct. The analysis showed that the amount of compensating the loudspeaker N should be more than 2(k+1), where k is order of the expansion in the number of the oscillation amplitude of the control voltage as a function of the coefficient of reflection of sound from the open end of the duct $|R^k|$.

In the National Aviation University theoretical and experimental has been studied the sound transmission through isotropic and composite cylindrical shells panels. Studies have shown that sound insulation composite panels in the low and mid audio frequencies less than the sound insulation existing aircraft panels. Therefore it is necessary to use new methods to increase the transmission loss of composite panels.

The optimization task is to design such distributed point masses (control parameters), which minimize the objective criteria:

$$\min \quad F_{obj} = 10\lg \frac{1}{f_{max} - f_{min}} \int_{f_{min}}^{f_{max}} \tau_d df,$$

where τ_d is transmission coefficient. The logarithmic form of transmission coefficient is the transmission loss: TL = -10lg τ_d. Thus minimizing the objective criteria, we obtain the maximum value of the transmission loss of the panel. The genetic algorithm with penalty functions for the constraints has been used to solve this task. Theoretical and experimental investigation showed increase soundproofing of the panel of the aircraft Antonov 72 at a frequency of 374 Hz to 6.9 dB. The panel is made of duraluminium with dimensions 2.22 m x1.6 m, thickness is 1.2 mm, mass is 23.6 kg. The effect of number of distributed mass to increase the transmission loss at the optimum location mass on the panel (total weight of distributed point masses is 13.3% of the panel mass).

Keywords: noise**,** aircraft cabins, cockpits, air conditioning system, transmission loss, active noise control.