Шестая всероссийская конференция
«Вычислительный эксперимент в аэроакустике»
19 - 24 сентября 2016 года, г. Светлогорск
CEAA

CREATING OF EXPERIMENTAL ACOUSTIC DATABASE FOR AN ISOLATED HELICOPTER`S MAIN ROTOR

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Outline

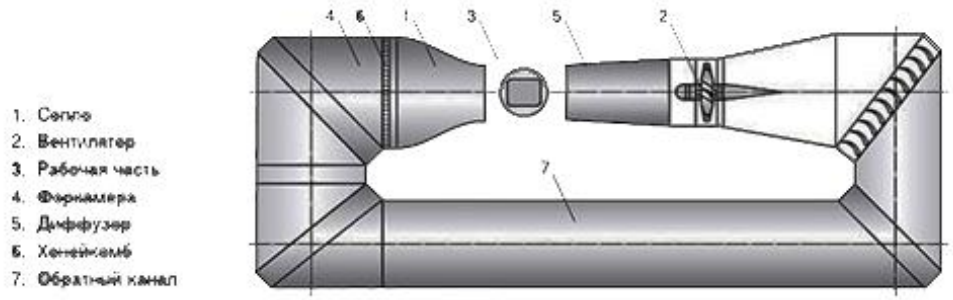
Experimental setup and data

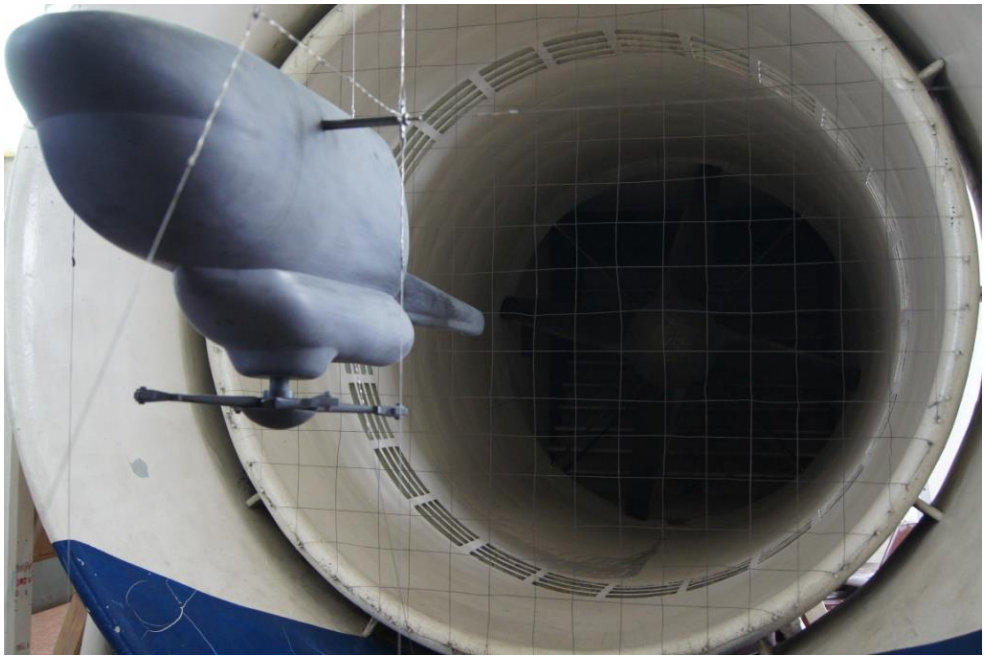
- Wind tunnel description;
- Acoustic experimental facility;
- Experimental setup;
- Test results;

CFD data and comparisons

- CFD description (brief);
- CFD results;
- CFD-to-experiment comparisons;

T-1K wind tunnel of KNRTU-KAI



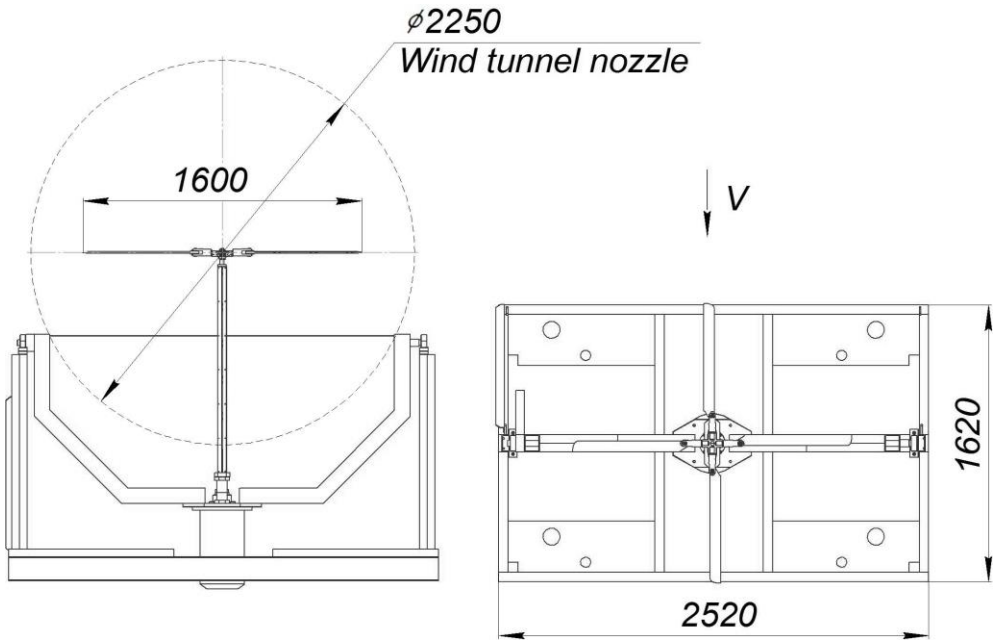


T-1K wind tunnel:

- Low-speed, closed-circuit wind tunnel with opened test section;
- Nozzle diameter: 2,25 m;
- Test section length: 3m;
- Flow speed: 0-50 m/s;
- Tu ≤ 0.5%;

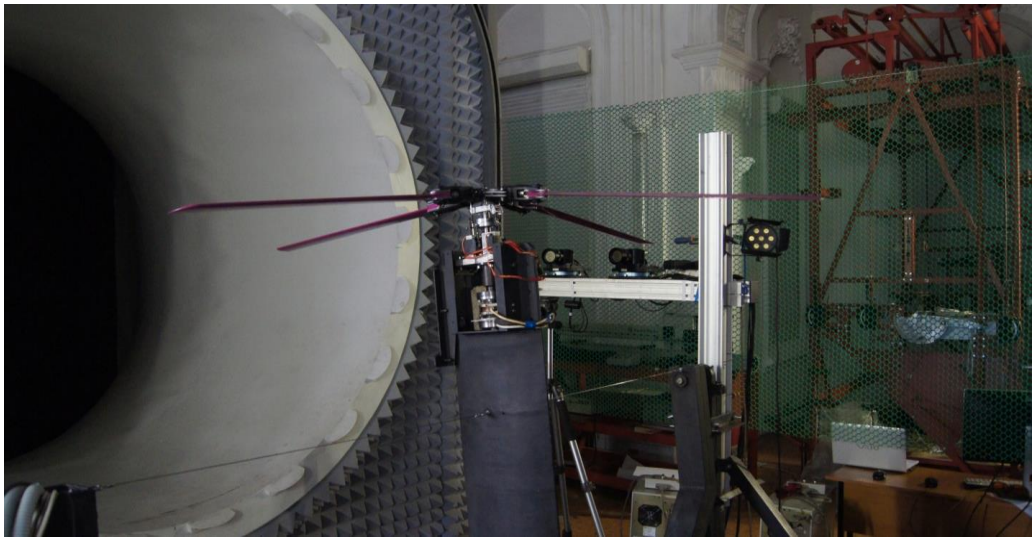
In 2014, wind tunnel has been equipped with an anechoic chamber for acoustic tests. Walls of the chamber consist of two layers: first is Heimholtz resonators for frequencies near 100 Hz (determined from preliminary tests), second is melamin-based anechoic material.

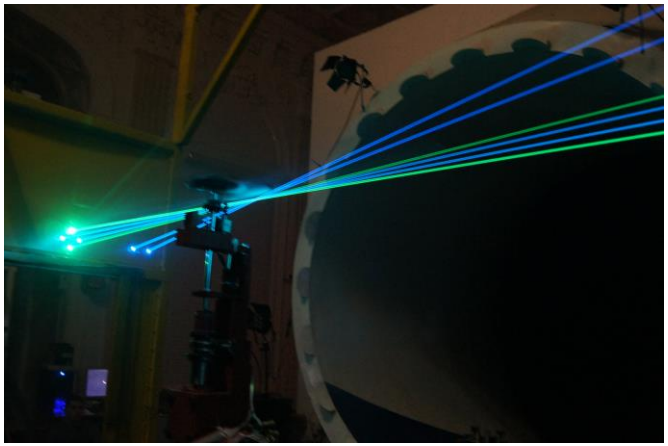
Rotor rig of the T-1K



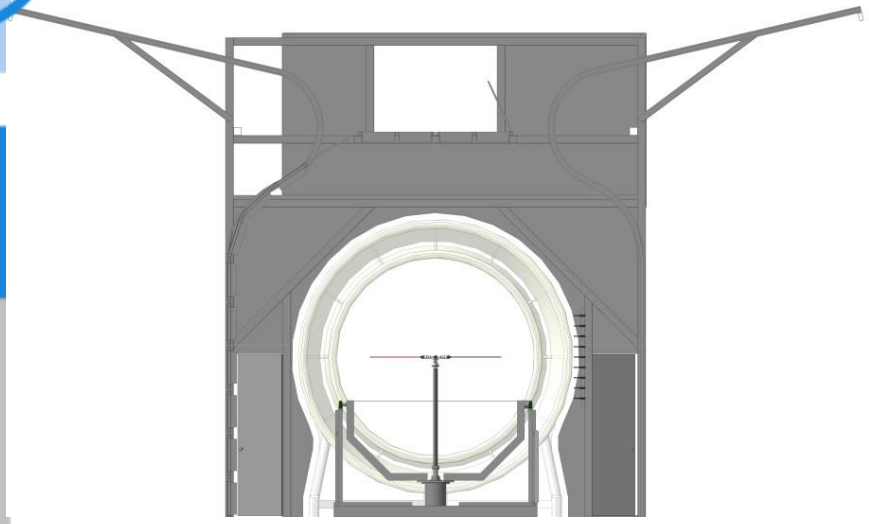
T-1K rotor rig:

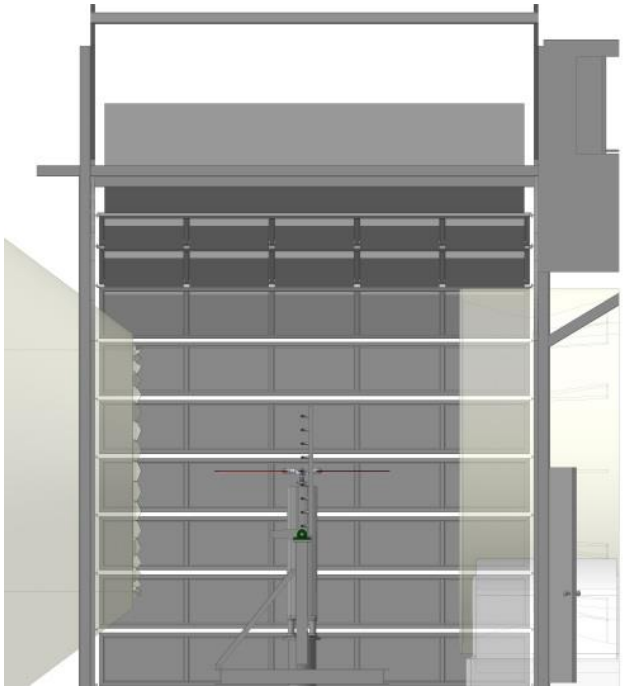
- Rpm up to1800 (2500 rpm planned);
- Rotor pitch angle -30°..30°
- Thrust/torque measurements;
- Equipped with the blade positioner;

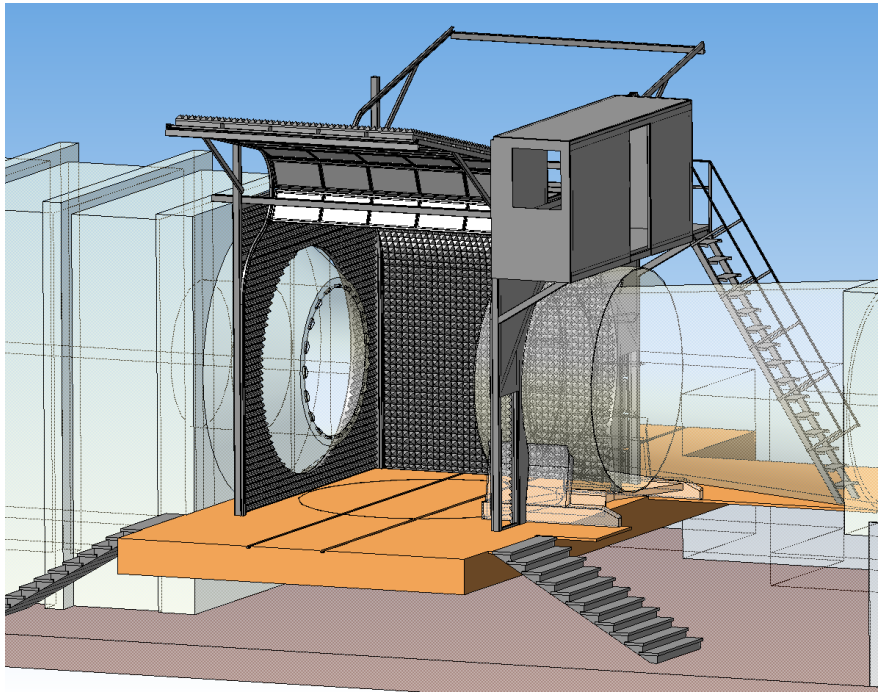




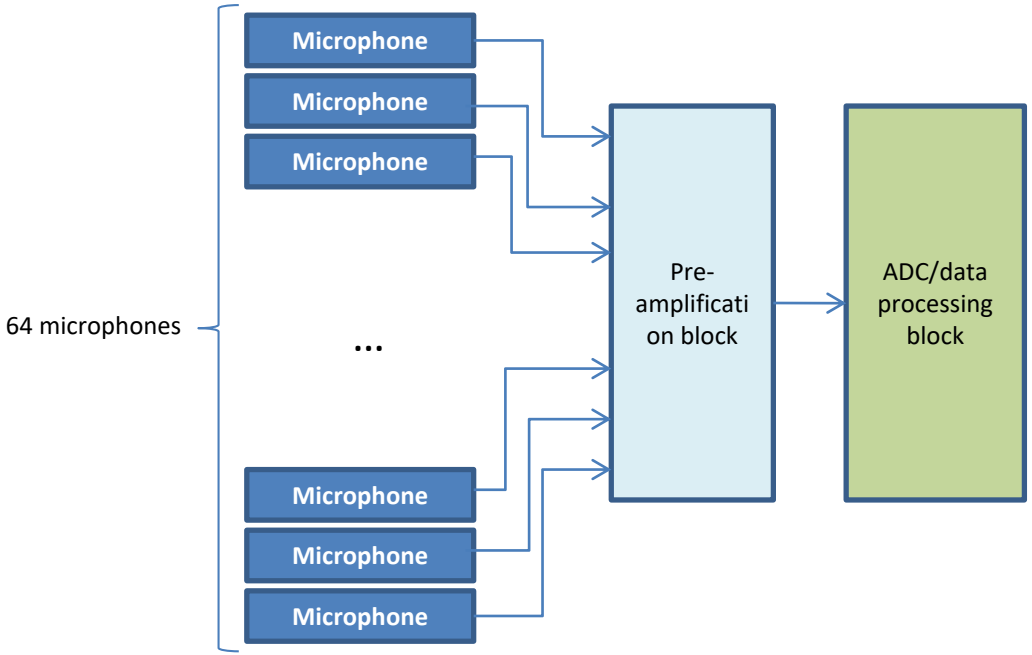
Acoustic chamber







Acoustic measurement system

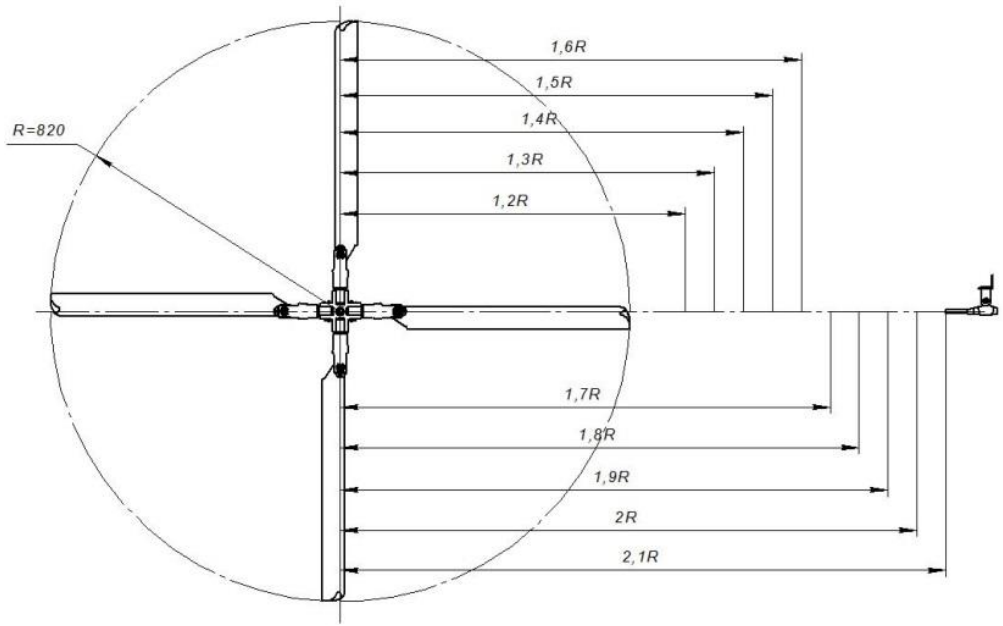


System based on NI-PXI 4496 ADC cards of National instruments specialized for acoustics and vibrations;

- Number of channels – 16;
- Input resolution: 24 bits;
- Max sampling rate: 204,8 kS/s;

Microphone	DBX RTA-M
Frequency	20..20 000 Hz
Sensitivity	-63 dB (±3)
Impedance	250 Ohm
Signal/noise	<110 dB
Excitation	9-15 V

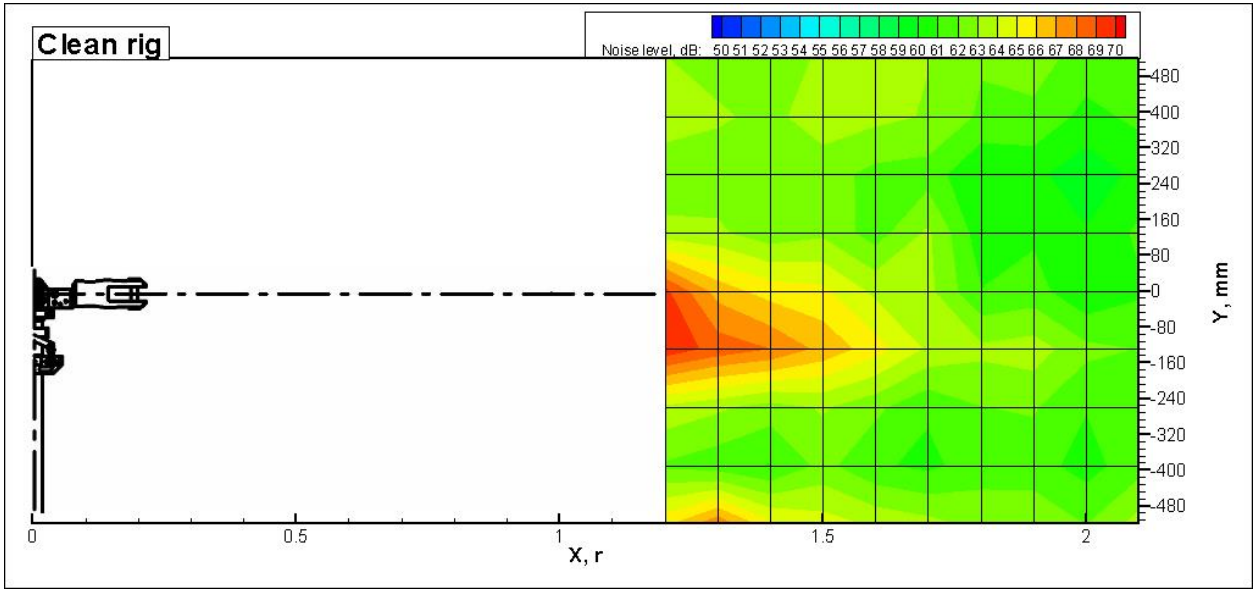
Test setup for acoustic measurements



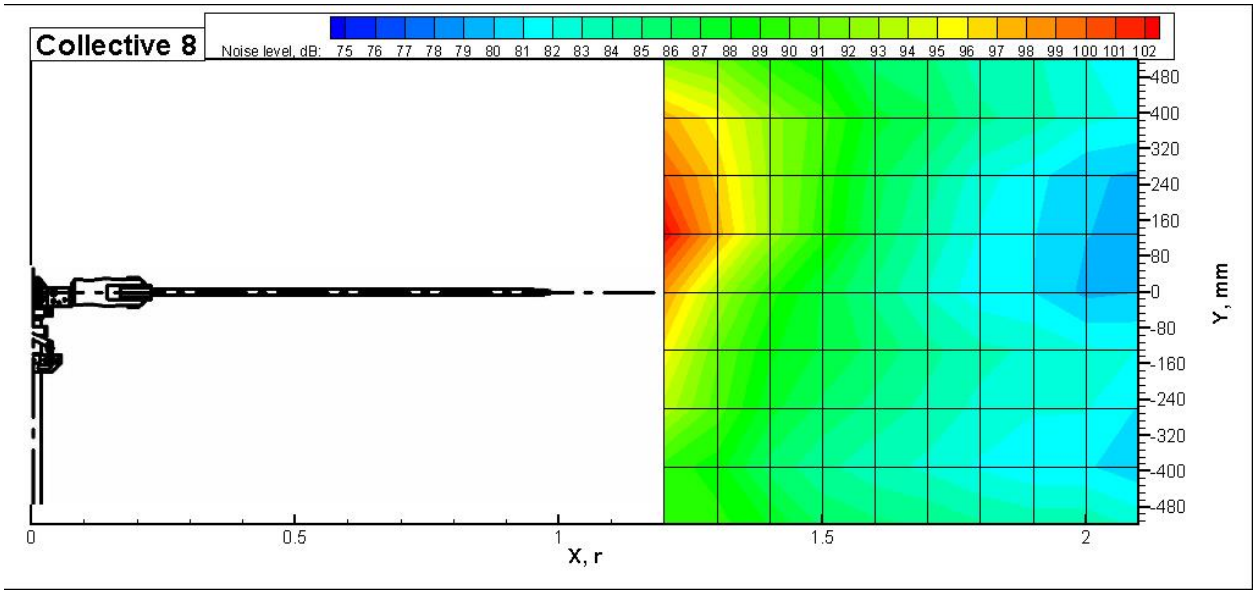
Experimental conditions:

- 900 rpm;
- Hover mode;
- Tests performed for all possible wall open/close configurations;
- Test case with blades unmounted has been performed;

Test results

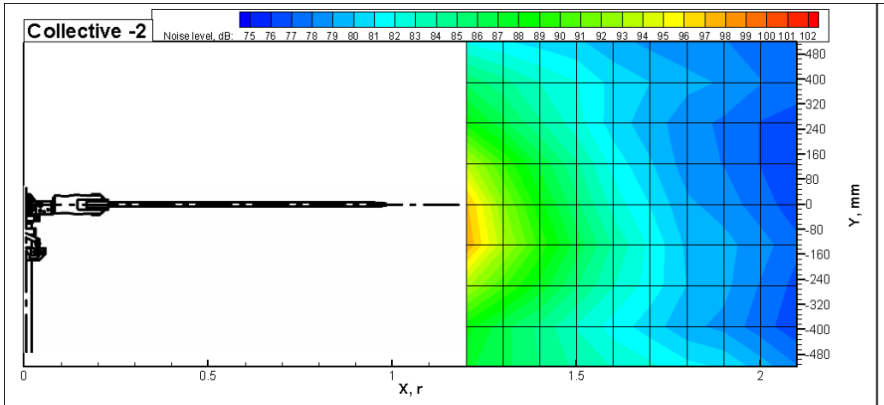


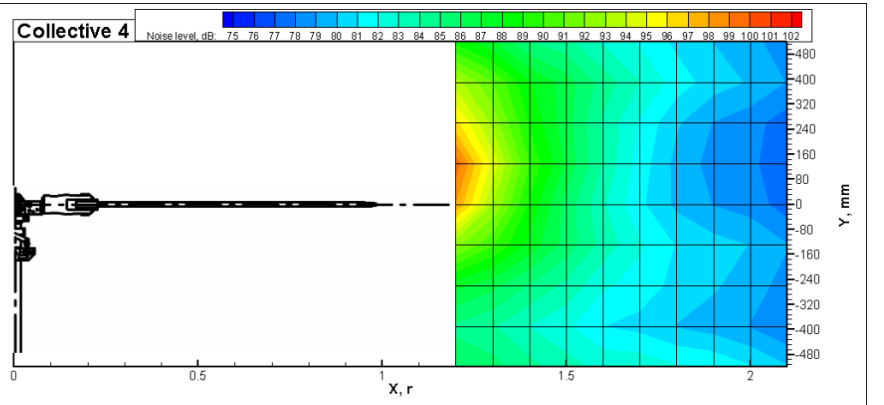
Test results shows a peak just in a traverse of the blade for the clean rig; An engine`s peak is also observed;

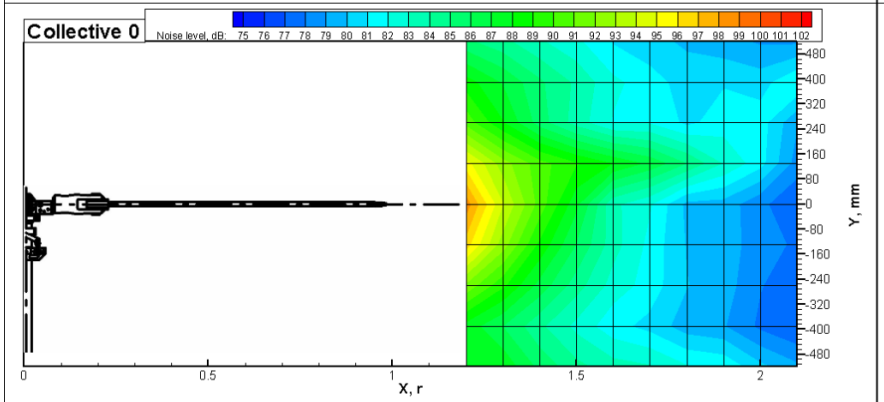


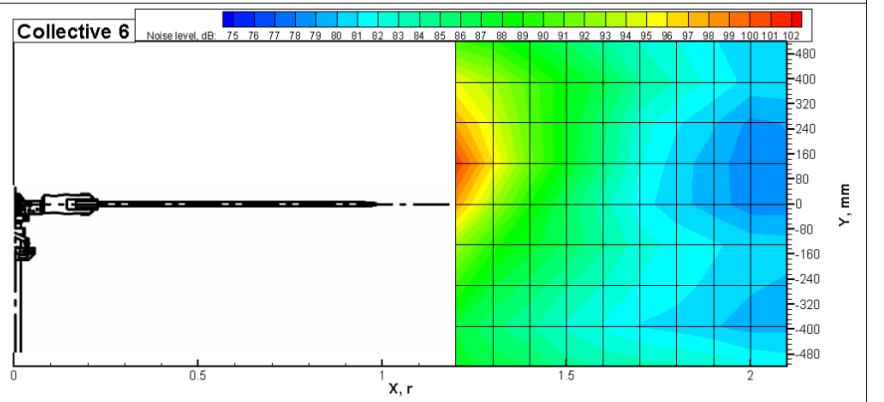
For 8 degrees of collective pitch, the read pick is located a little bit higher than the blade`s tip. It is due to a cone angle;

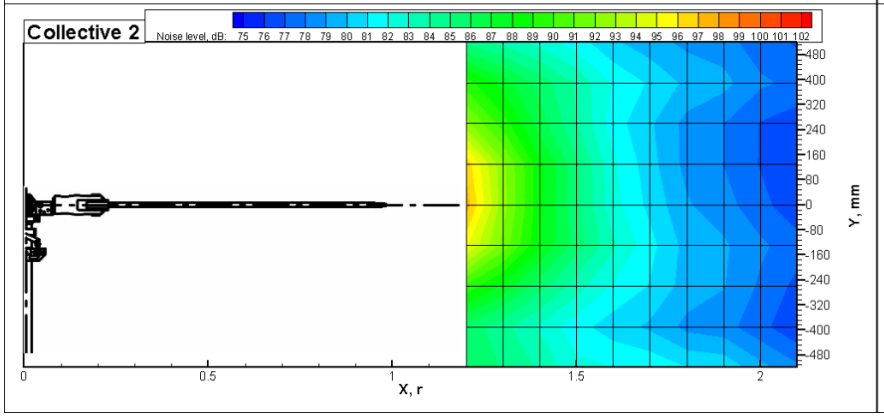
Test results

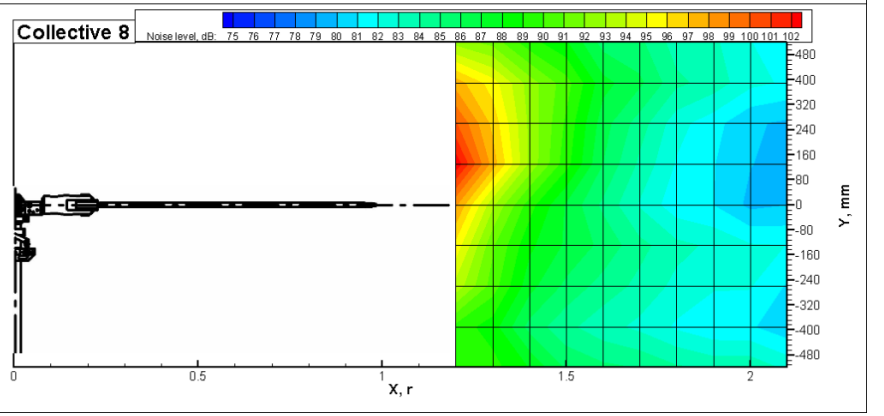




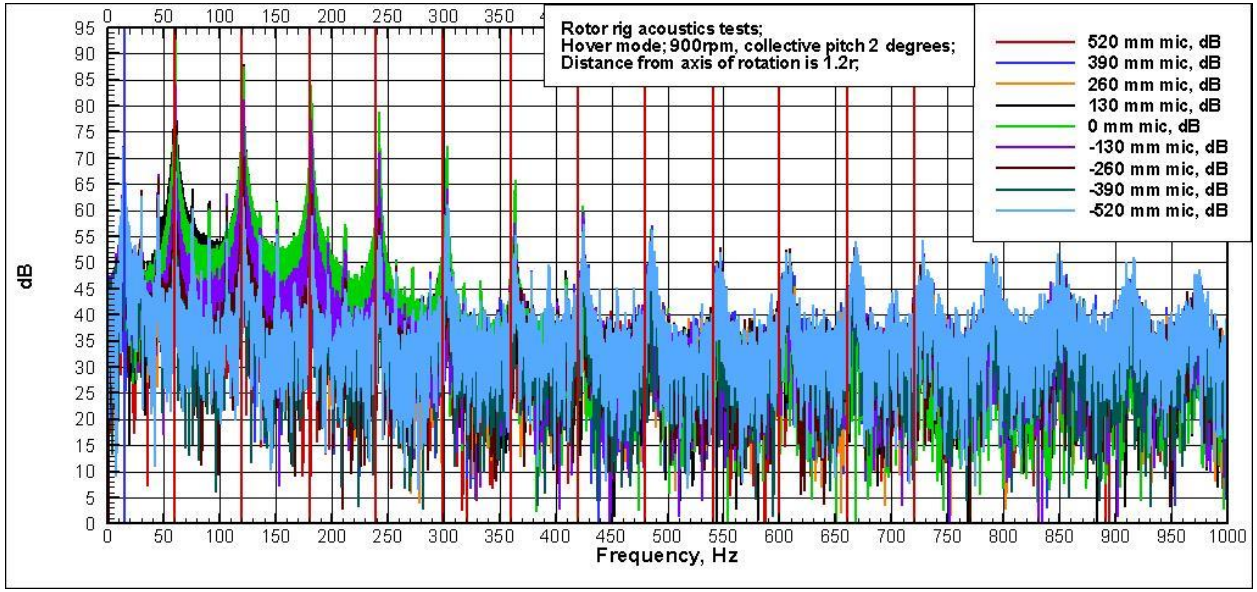




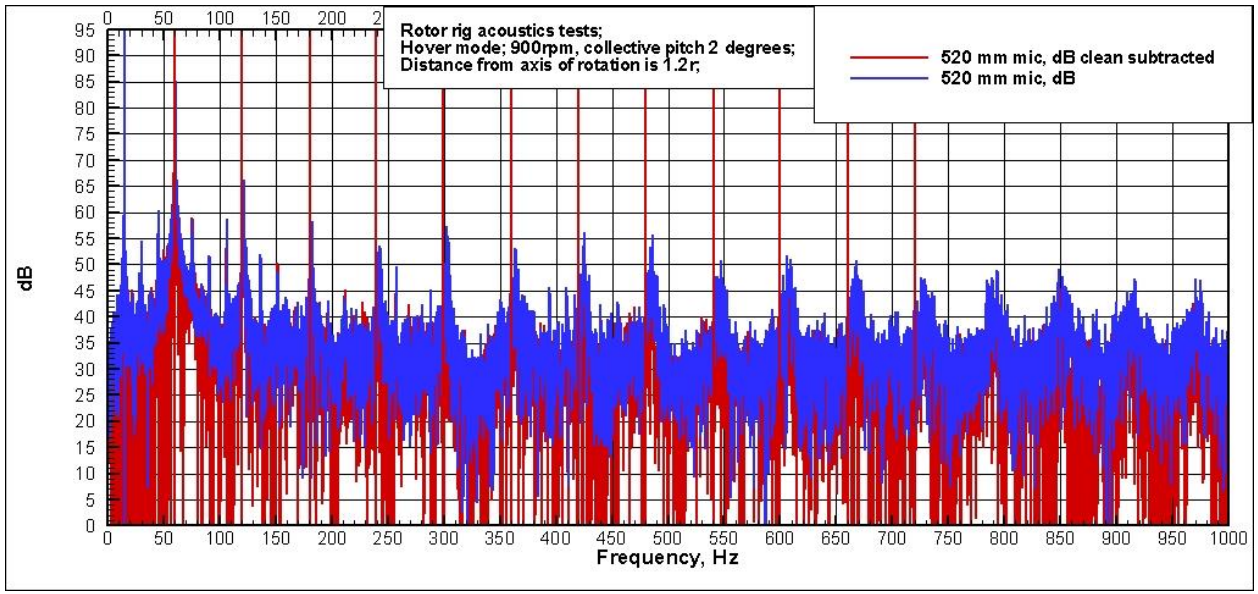




Test results

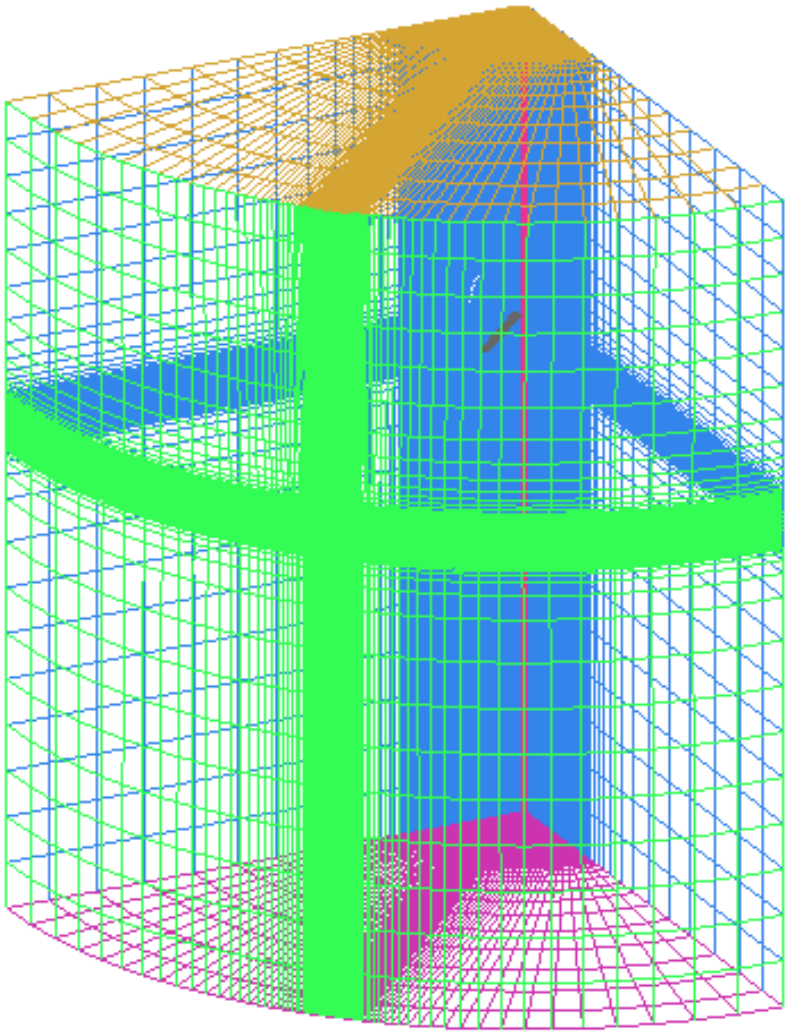


For 2 degrees of collective, the black curve is slightly bigger than 0 mm mic. This can be caused by cone angle;



Some analysis has been performed for the clean-subtracted signal. It shows that the first harmonic is least influed;

CFD details



- Numerical simulation of the flow around the rotor model for hover mode is based on RANS simulation with the k-ω turbulence model and was carried out in HMB CFD-code;
- The flow around isolated rotor in hover mode has periodical structure. On this reason computational domain was constructed only for one blade.
- The multiblock hexa-grid grid was created in ICEM CFD tool and contains about 4.4 mln of cells.

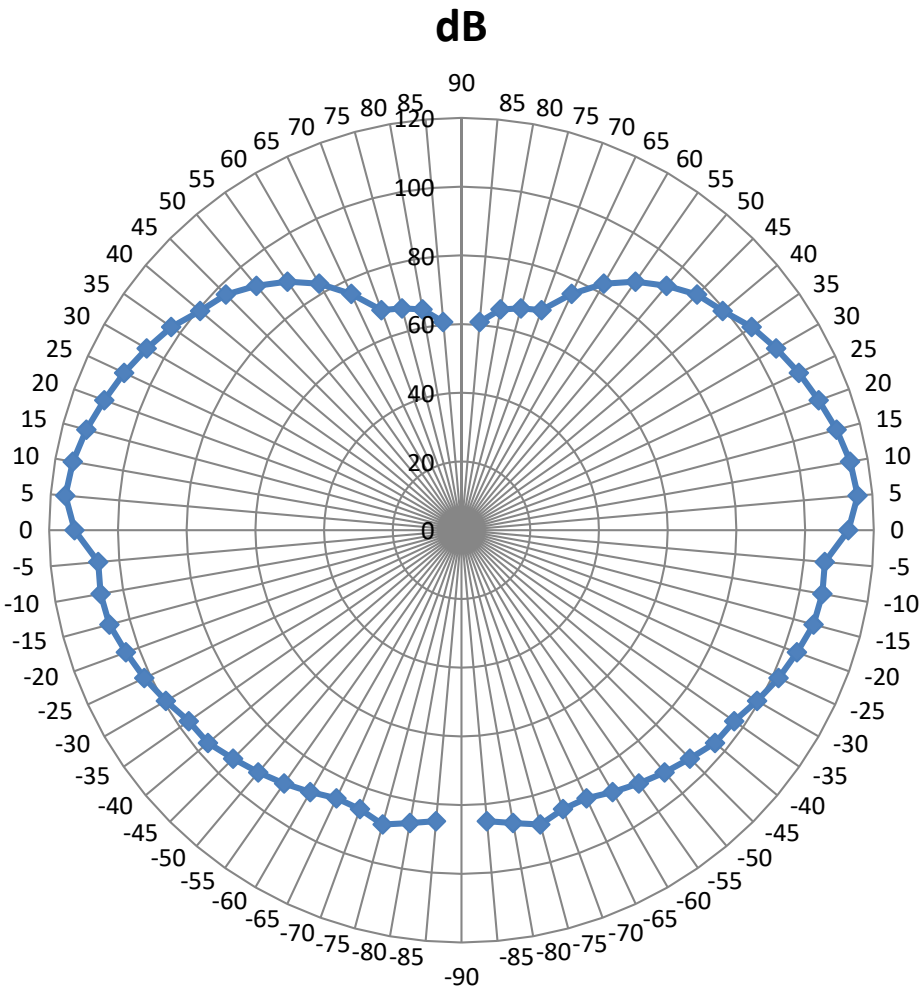
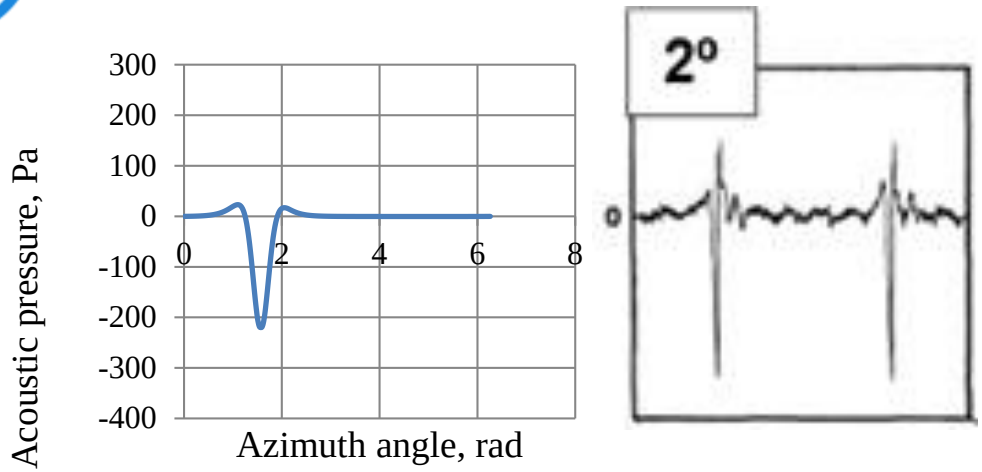
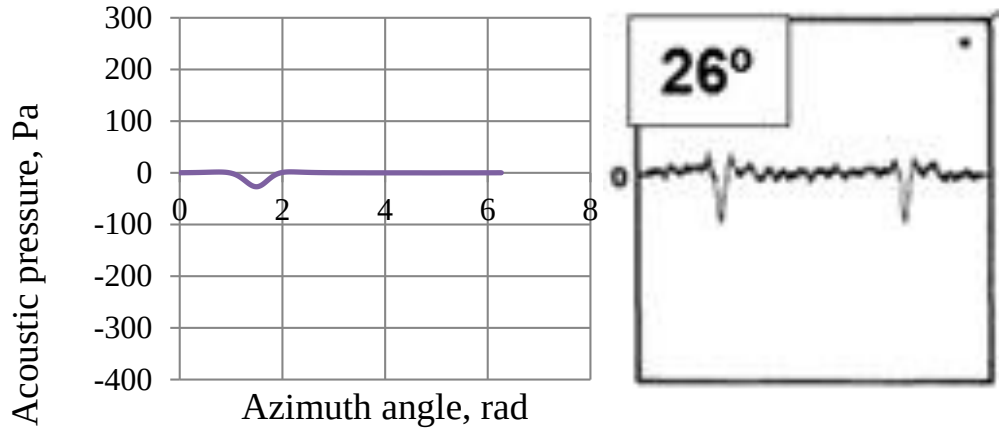


Diagram of direction (SPL, dB) for near-field (d=1.2R)

CFD results





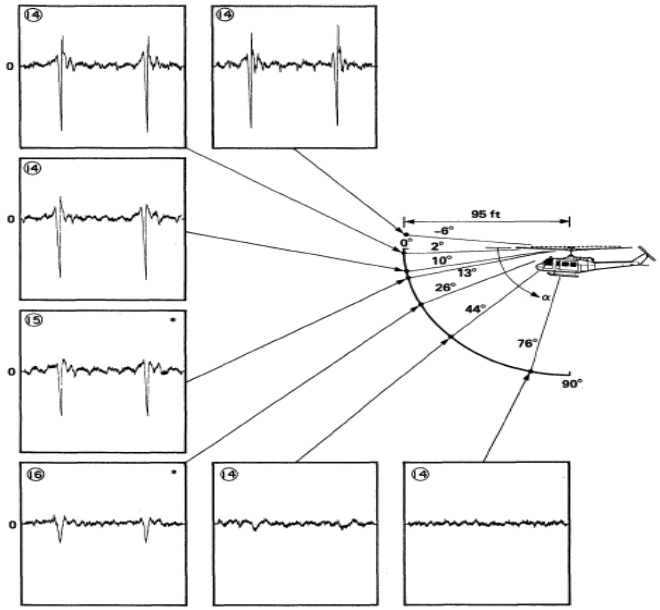
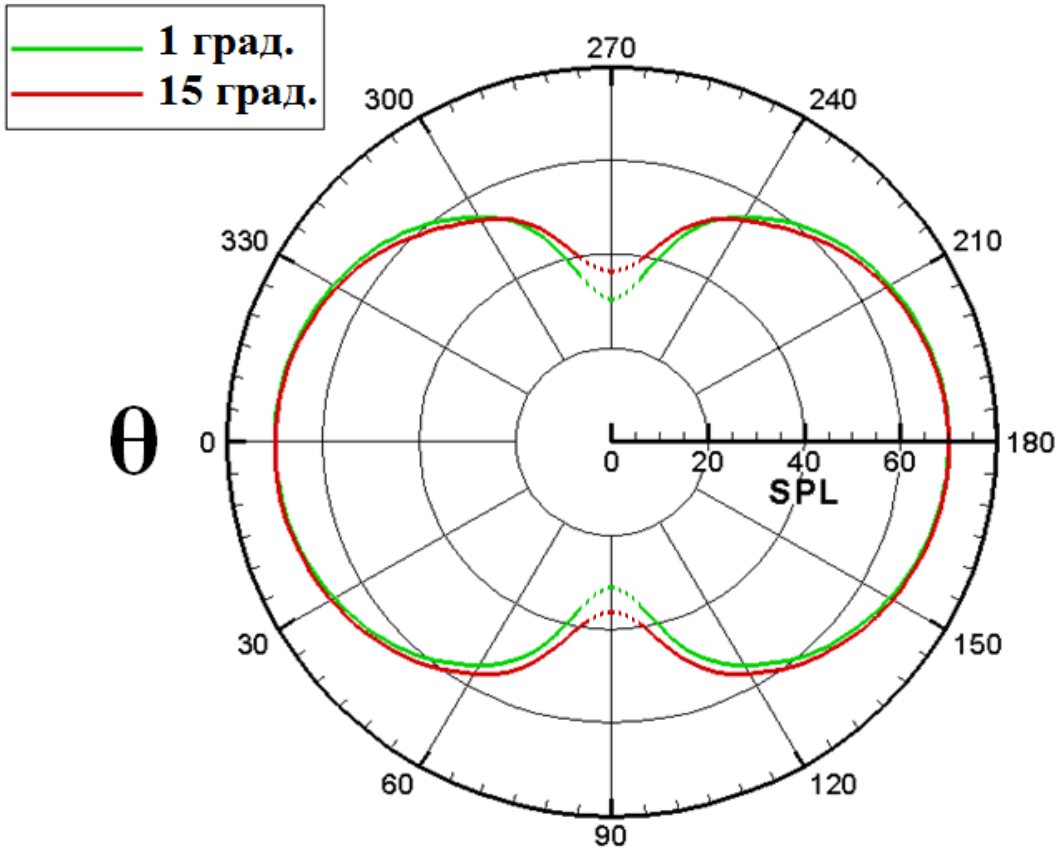


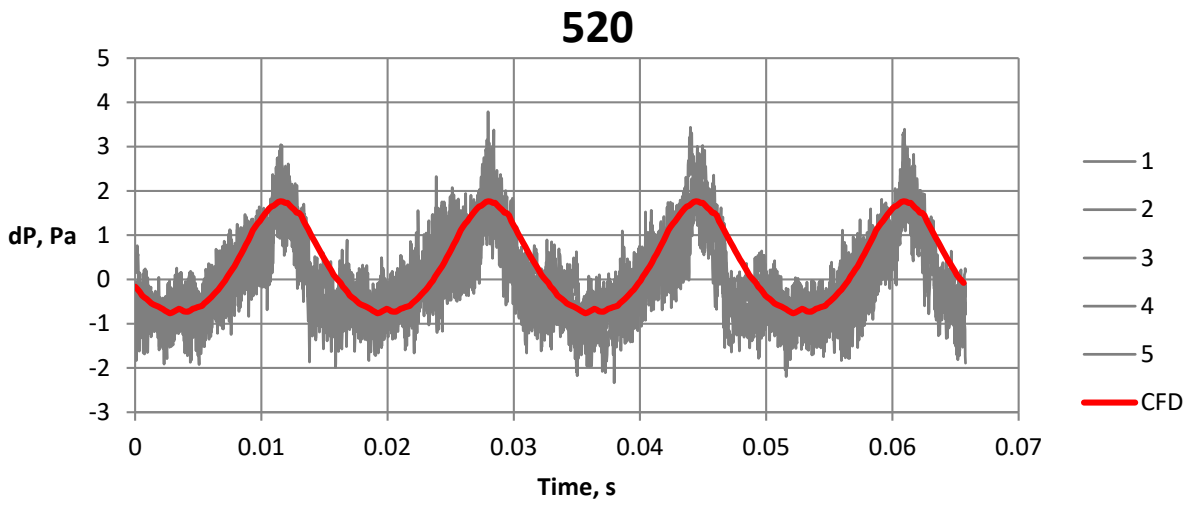
Figure 20.- UH-1H longitudinal acoustic directivity, level flight, 115 knots IAS (β = 0°).

CFD-to-experiment comparisons for the FF mode

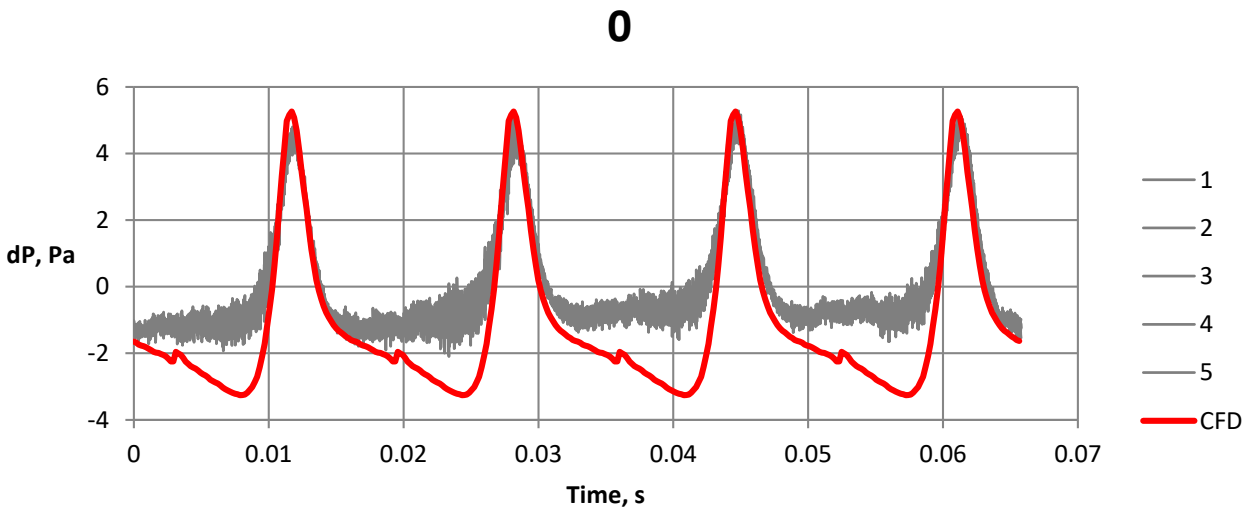


Directivity diagram for the model of helicopter`s isolated main rotor(SPL, dB) for various collective pitch angles(1˚ and 15˚). $d = 3R$, $M_{tip} = 0.2273$. Plane of rotation is θ=0° (θ=180˚)

CFD comparisons



Best comparisons for distance -520;



Worst comparisons for plane-of-rotation microphone;

Conclusions and future work

- A number of tests for the rotor rig has been performed for various collective pitch angles for hover mode;
- Test results looks acceptable;
- Acoustic chamber can be preliminary characterized as suitable, but needs additional testing;
- Reached first agreement between CFD and experiment;
- Works for microphone array are in process;

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Thank You For Attention!