Aeronautical Engineering PhD Research Student

Turning Jet Engine Noise Down to 2020

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1.Motivation

This project investigates non-traditional acoustic liners for civil jet engine fan inlets.

Industrial:

- The engine is the largest contributor to aircraft noise; at approach it accounts for ~68% and at take-off ~98% [1].
- The Advisory Council for Aircraft Research and Innovation targeted a 50% reduction in perceived noise for new civil aircraft entering into service in 2020, but as of 2017 only a 32% reduction was secured and 37.5% reduction foreseen [2].

Social:

- Residential areas around airports experience unacceptable noise levels as part of daily life and research demonstrates that prolonged exposure to ≥55 dB day-evening-night level is linked to conditions including tinnitus, hypertension, coronary heart disease and myocardial infarctions [3].

2.Project Aims

Industrial Aims:

- Propose a proto-type acoustic metamaterial panel for a jet engine inlet.
- Model and predict noise attenuating capabilities in the presence of high-speed grazing flow.
- Undertake experimental and computational testing of metamaterial panels.

Academic Aims:

- Understand and apply metamaterial theory to aeroacoustics.
- Competent use of the CFD software OpenFOAM for computational modelling.

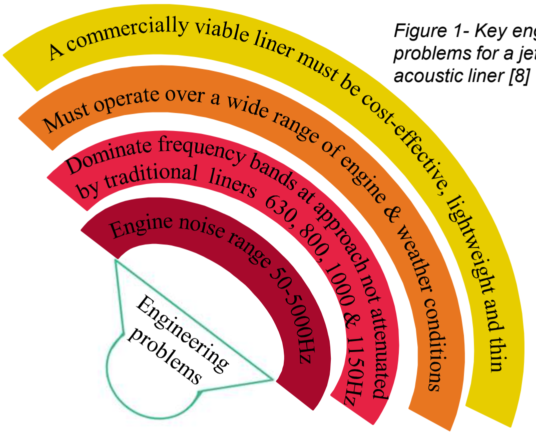


Figure 1- Key engineering problems for a jet engine inlet acoustic liner [8]

Table 1- Summary of Traditional and metamaterial liner comparison

	Traditional liners [4]	Metamaterial liners [5]
Theory	Helmholtz Resonators comprises of a rigid cavity and neck which connects the resonator to the wider system. The action of the volume of air in the cavity is comparable to a mass spring system.	Metamaterials introduce a new structure into the basic material usually an array of structures smaller than the wavelength of interest providing acoustic attenuation properties.
Advantages	• Simplicity of construction. • Widely used e.g honeycomb.	• Lightweight, thin liners. • Increased attenuation for low frequency. • Can be combined with existing liners technology.
Drawbacks	• Poor at low frequency. • Causes detrimental back pressure upstream of the system from the attenuated sound.	• Emerging technology without a certification precedent. • Currently more expensive.
Absorption coefficient	• Typical Honeycomb 0.3 for 10-2000Hz [6]	• Thin-film elastic acoustic metamaterial 0.4 for 10-1000Hz [7] • Metamaterial perforated honeycomb-corrugation hybrid 0.5 for 10-2000Hz [6]

3.Process

Understanding the problem and identify opportunities:

- Identify the key engineering problems (Fig 1).
- Research and compare current liners (Table 1).
- Classify the opportunities of metamaterials.

Computer modelling:- Current stage

- Generate a suitable model in OpenFoam CFD software. (Fig 2)
- Determine acoustic solver and meshing method for liner prototyping.

Experimental testing:

- Validate the OpenFoam model.
- Use 4 microphone impedance tube method (Fig 3).
- Measure the pressure and particle velocity and determine the sound transmission loss.

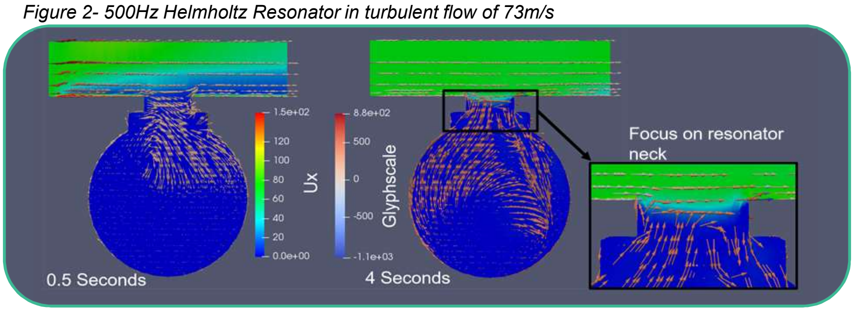
Liner prototyping

- Design metamaterials acoustic liner prototypes.
- Determine attenuation properties including transmission loss and frequency range using OpenFoam Model.

Final selection and validation:

- Evaluate the preferred liner designs.
- Validate the final design for operating, commercial and manufacturing criteria.

Figure 2- 500Hz Helmholtz Resonator in turbulent flow of 73m/s



4. Research Direction

- Metamaterial panels alone will not meet reduction targets of 10EPNdB per operation (effective perceived noise). Currently the Clean Sky 2's acoustic liner only gave a 0.5dB overall engine noise reduction.[2]
- The direction is to prototype metamaterial absorbers within the traditional Honeycomb acoustic liner. (Fig 4)

Figure 3- Four microphone impedance tube

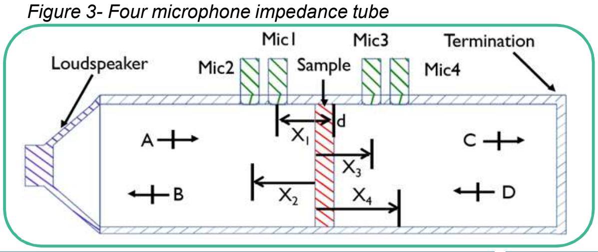
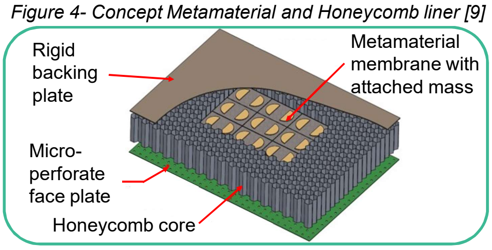


Figure 4- Concept Metamaterial and Honeycomb liner [9]



5. Future Work

- In situ engine testing.
- Investigate applications in other modules of jet engines.
- Investigate other industrial applications such as factory environment noise cancellation.

REFERENCES

Available on request.

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