A Comparison of Impedance Eduction Test Rigs with Different Flow Profiles

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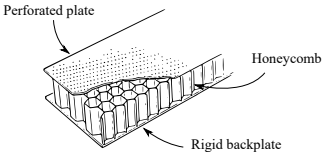
Introduction

- Acoustic liners are the main noise control treatment applied to aircraft turbofan engines and are generally characterized by their acoustic impedance;
- The acoustic impedance is a function of the liner geometry, SPL, grazing flow Mach number, frequency, etc., requiring an experimental characterization;

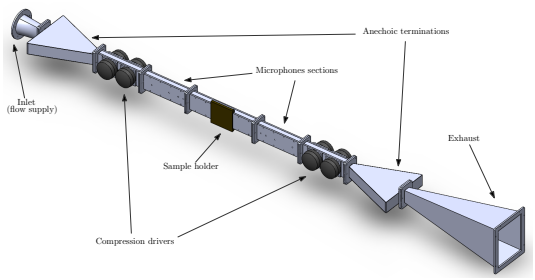


$$Z(\omega) = \theta(\omega) + \mathrm{i}\chi(\omega)$$

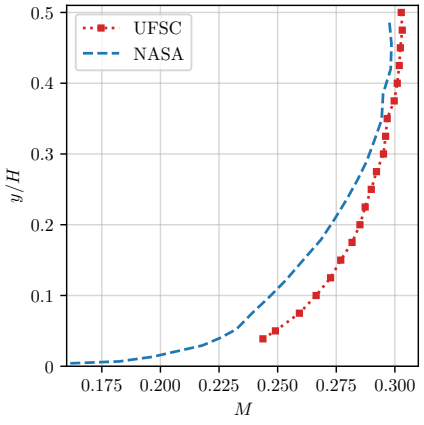
- Eduction Methods are the main experimental techniques used to determine a liner acoustic impedance;
- Recently comparisons between impedance results obtained by different test rigs using different Eduction Methods have identify some discrepancies and raised questions about the possible sources of these discrepancies;
- There is especial interest in evaluating the impact of the flow profile characteristics within the test rig over the educed impedance

Objectives

- Comparison between impedance results for the same liner evaluated at UFSC and the NASA test rigs under similar conditions;
- Eduction methods based on Prony-like algorithms were applied by both UFSC and NASA;
- A pair of identical liner samples was 3D printed by the same vendor using the same equipment;
- The Goodrich semiempirical model was used to evaluate the influence of flow profile parameters in the educed impedance;
- Raw acoustic data were shared between the teams to cross-check eduction methods.

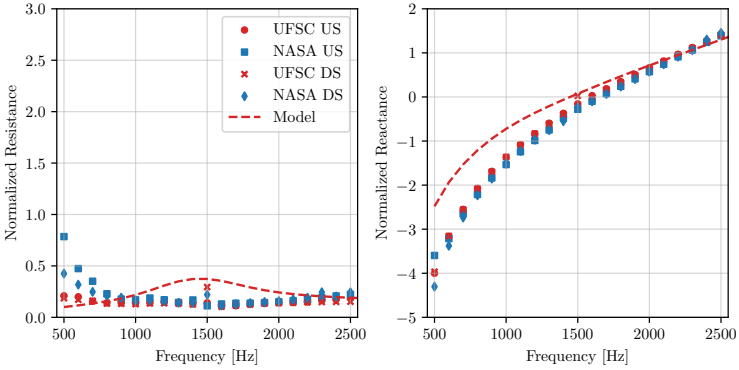


Results - Flow Profile



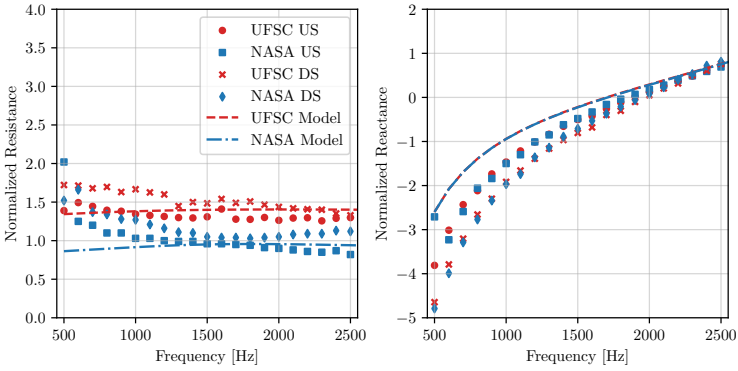
- Different flow profiles were observed in each test rig, the boundary layer displacement thickness was evaluated as $\delta^*_{\text{UFSC}} = 1.02\,\text{mm}$ and $\delta^*_{\text{GFIT}} = 2.60\,\text{mm}$.

Results - No Flow - 130 dB



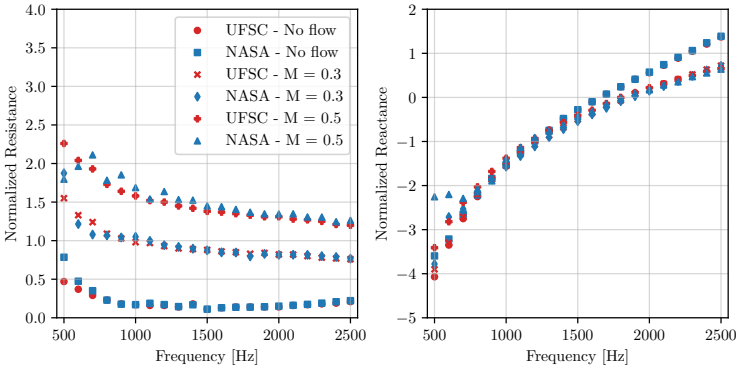
- Good agreement was observed in most frequencies;
- These results show the similarity between samples and the manufacturing process.

Results - M = 0.3 - 130 dB



- Very good agreement was observed for the educed reactance with flow;
- Educed resistance with flow is consistently higher for the UFSC facility;
- The semiempirical model captures the difference well in the resistance when accounting for each rig flow profile parameters.

Results - Cross-check - NASA Data Set - Upstream Source



- Impedance results using each institution implementation of the Eduction Method but the same dataset match well;
- Results provide high confidence in the implementation of the Eduction Methods by each institution and point to the flow profile differences as the main source of discrepancies

Concluding Remarks

- Impedance results obtained by each institution for no flow case were very similar, indicating identical samples;
- Higher values for the resistance were obtained at UFSC test rig, when matching the same bulk Mach number or the same centreline Mach number.
- Analysis made with the semiempirical model indicates that the differences are caused by the different flow profiles, represented in the model by the boundary layer displacement thickness.
- Impedance educed using each institution implementation of the Eduction Method showed great similarity, indicating that the differences previously observed are not caused by the eduction methods.

Acknowledgments

Thanks for your attention!