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Mechanics, Acoustics, and Dynamics Lab



Overview of Ingard, K. Uno, and George C. Maling Jr. 's 1974 paper on Physical Principles of Noise Reduction: Energy Considerations, Noise Reducing Elements, and Sound Absorbing Materials

Janith Godakawela

Mechanical Engineering – Engineering Mechanics, Michigan Technological University, Houghton, MI, United States



NOISE-CON 2024 Classic Paper
Competition Judging



Dr. George C. Maling Jr. (1931 – 2022)

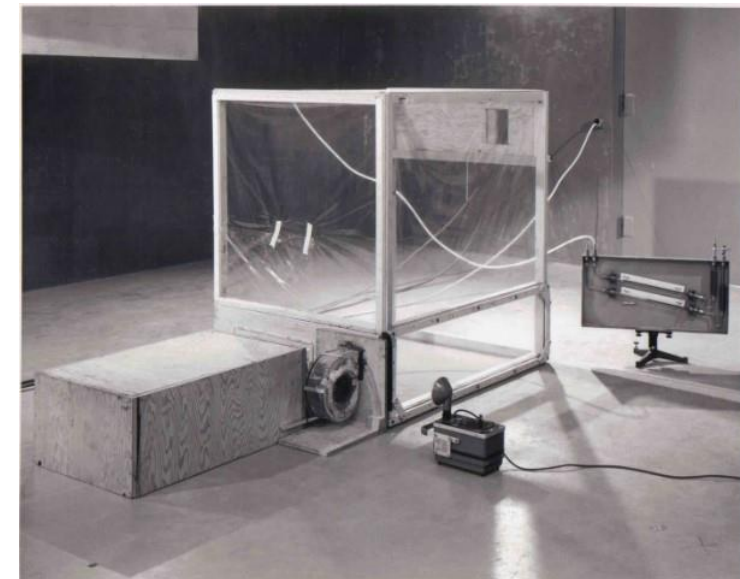


• Education

- Bowdoin College
 - BS in mathematics and physics (1954)
- MIT
 - BS in electrical engineering (1954)
 - MS in electrical engineering (1954)
 - BS in Electrical engineering (1958)
 - PhD in Physics (1963)

• Research topics

- Dissertation: *“A Study of the Propagation of Acoustic Waves and Instabilities in Inhomogeneous Media”*
- Sound power of air moving equipment.
- Reverberation room quantification.

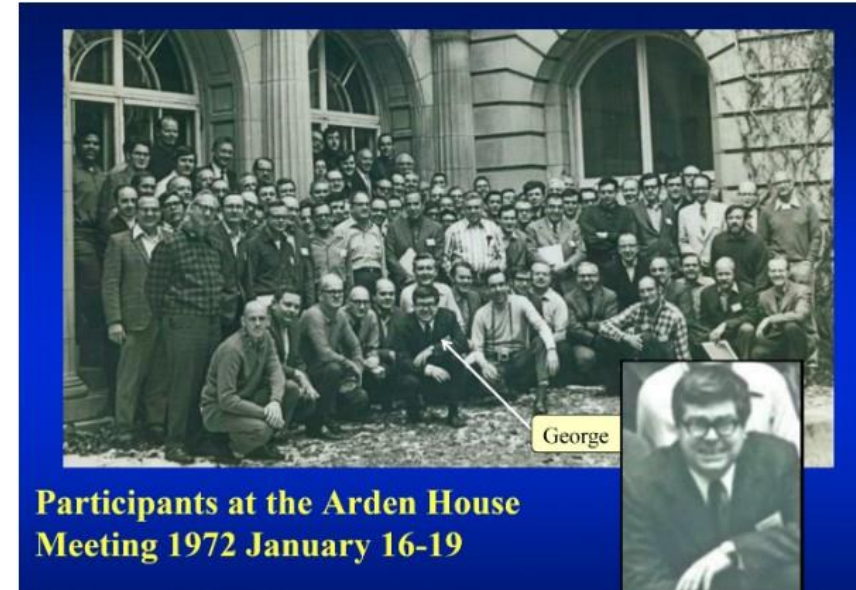


The Maling box



Service to INCE

- Founding member: INCE, 1971 & I-INCE 1974
- Member for 43 years
- President (1975)
- Vice president(1979 – 1981)
- Secretary(1972 – 1974)
- Director (1972 – 1977)
- Editor-in-Chief of NOISE/NEWS since 1972
- Awards and medals
 - ASA silver medal in noise (1992)
 - Institute of Acoustics/UK Rayleigh Medal (1999)
 - INCE/USA Distinguished Noise Control Engineer Award (2001)
 - INCE/USA Distinguished Service Medal (2009)



Dr. Maling at the Arden house meeting, 1972





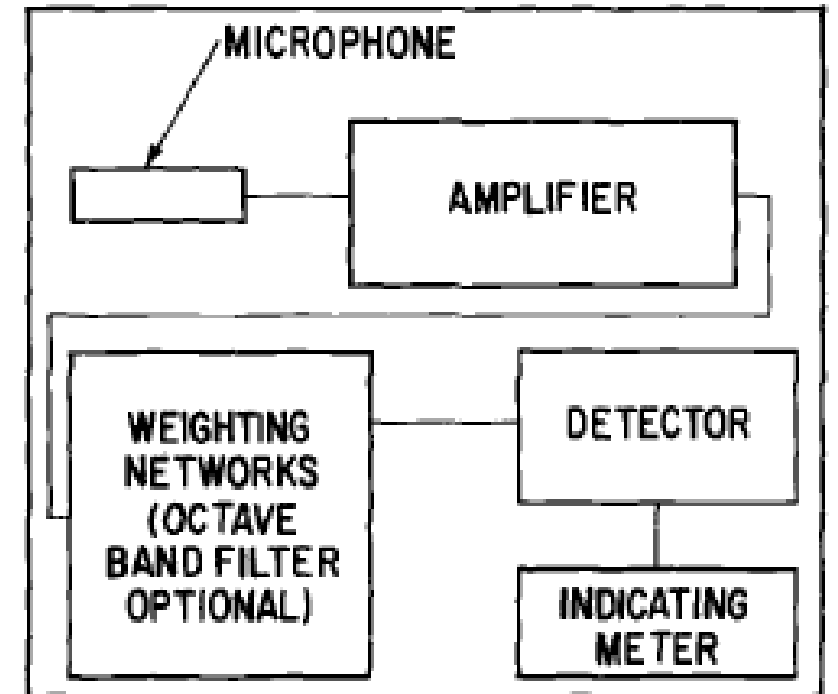
3 Volume Article Series: Physical Principles of Noise Control (1973 – 1974)

- Maling Jr, George C., and William W. Lang. "Theory into practice: A physicist's helpful view of noise phenomena." Noise Control Engineering 1.1 (1973): 46-59.
- Ingard, K. Uno, and George C. Maling Jr. "Physical principles of noise reduction: Properties of sound sources and their fields." Noise Control Engineering 2.1 (1974): 37-48.
- Ingard, K. Uno, and George C. Maling Jr. "Physical Principles of Noise Reduction: Energy Considerations, Noise Reducing Elements, and Sound Absorbing Materials." Noise Control Engineering 2.2 (1974): 81-92.

Volume 1: Theory into Practice: A Physicist's Helpful View of Noise Phenomena (1973)

Key takeaways

- Overview of the fundamental concepts.
- Physical principles of sound and noise.
- Definitions of key acoustic variables.
 - Sound pressure level
 - Intensity and power levels
 - Absorption coefficient
 - Impedances
 - Flow resistance



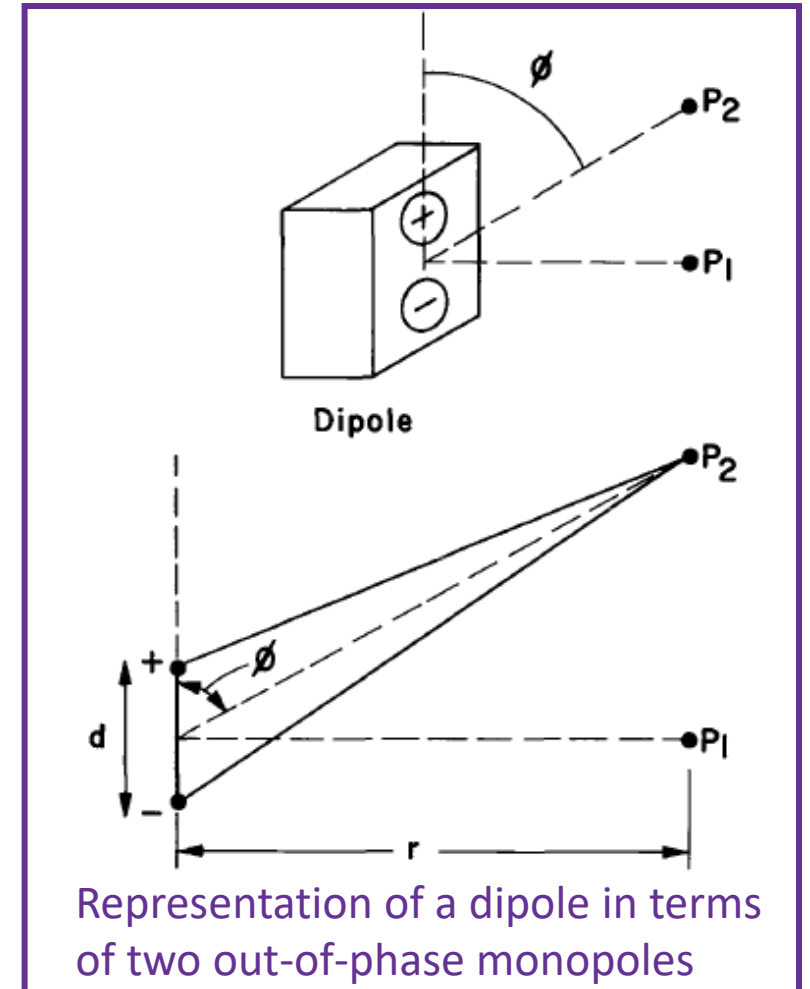
Block diagram of a sound level meter

Volume 2: Physical Principles of Noise Reduction: Properties of Sound Sources and Their Fields (1974)

Key takeaways

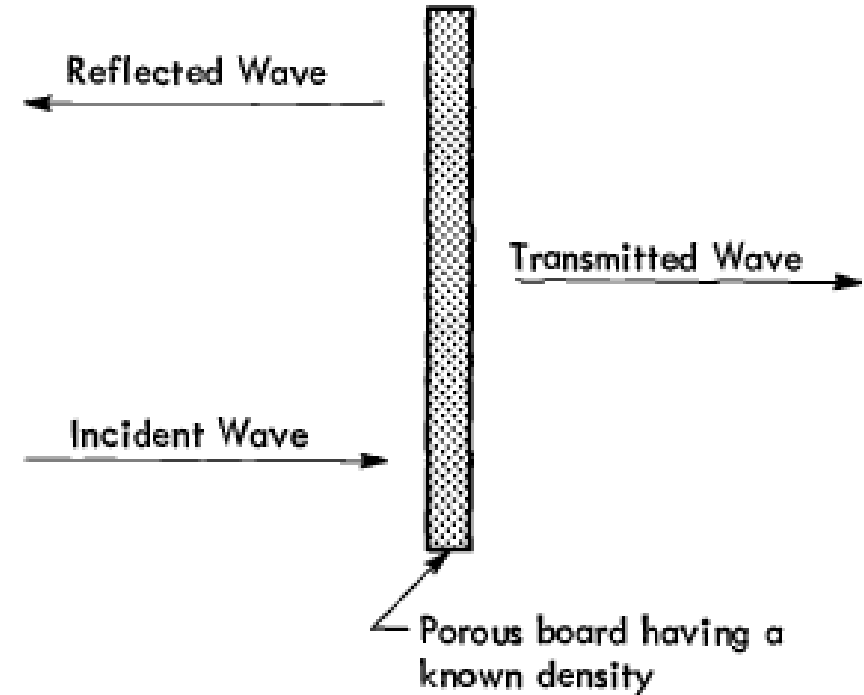
- Characteristics of sound sources.
- Types of sound Sources and their Fields.
- Impedance of sources.
- Heat and flow generated noise.

"When two loudspeakers operate out-of-phase, a *dipole* field is produced."



Volume 3: Physical Principles of Noise Reduction: Energy Considerations, Noise Reducing Elements, and Sound Absorbing Materials (1974)

- I. Energy considerations
- II. Specification of noise reduction
- III. Methods of noise reduction



I. Energy Considerations

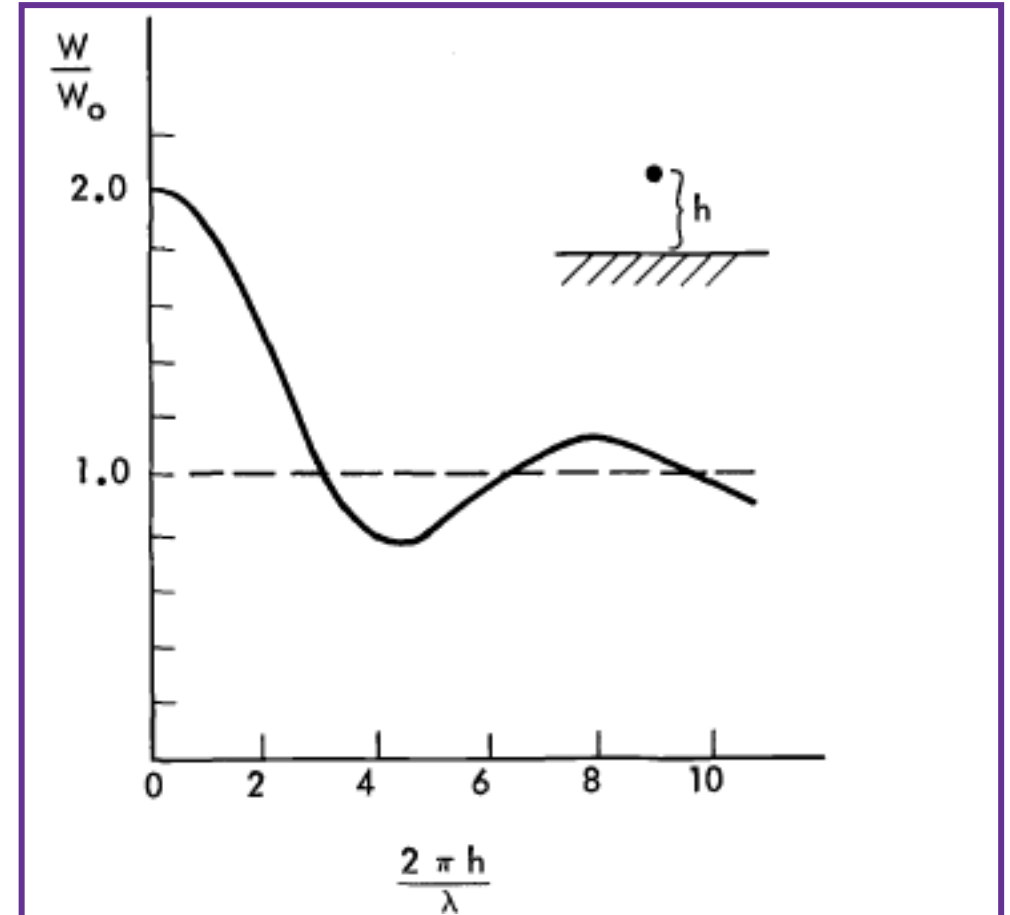
Key takeaways:

- Limitations of detailed analysis.
- Importance of acoustic power.
- Under free field conditions:

Sound pressure: $p = \rho c u$

Sound Intensity: $I = \frac{p^2}{\rho c}$

Sound Power: $W = \int I dA$



The effect of a reflecting plane on the acoustic power output of a point source

II. Specification of Noise Reduction

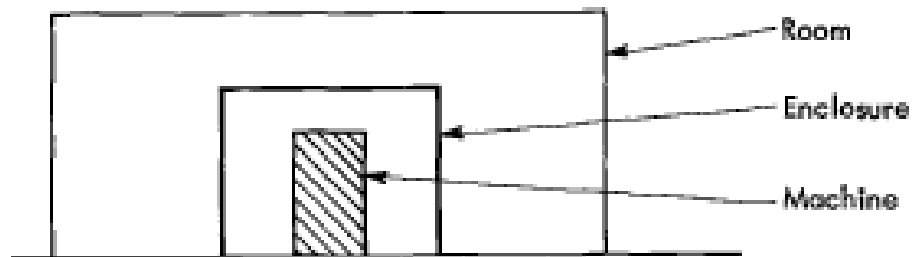
Key takeaways:

- Introduces measurements of noise reduction

Insertion loss (IL): $IL = L - L'$

Transmission coefficient (τ): $\tau = \frac{I_2}{I_1}$

Transmission loss (TL): $TL = 10 \log \left(\frac{1}{\tau} \right)$



Estimating the insertion loss of an enclosure built to reduce the sound pressure level in a room

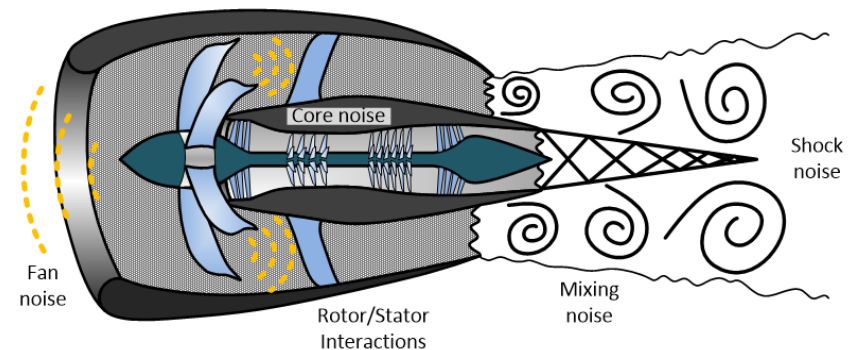
III. Methods of Noise Reduction

Reduction of strength of the source

Machine
Noise Reduction



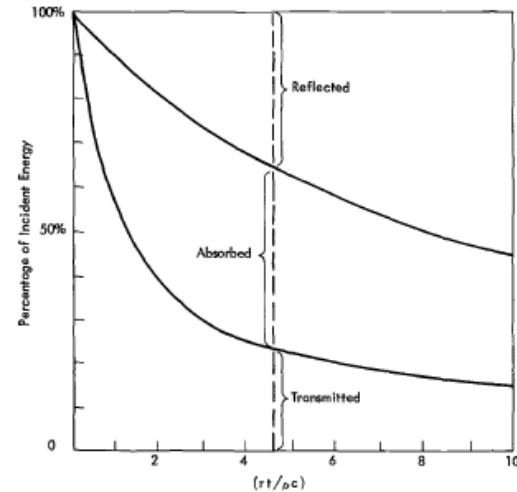
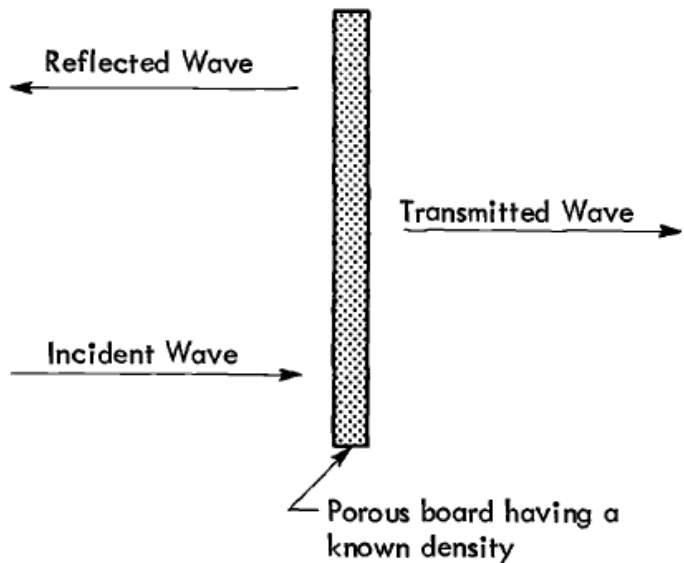
Aerodynamic
Noise Reduction



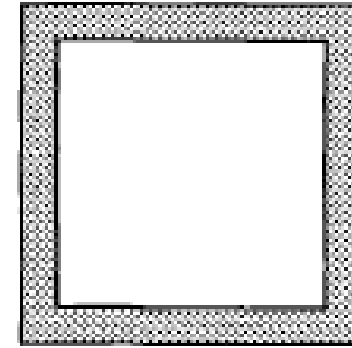
III. Methods of Noise Reduction

Noise reducing elements

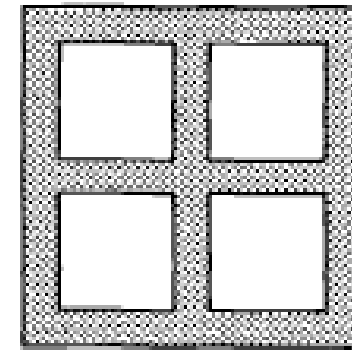
- Partition walls and enclosures (Reflection)
- Sound absorbing materials (Absorption)
- Sound-attenuating Ducts and mufflers



Acoustical characteristics of a porous wall



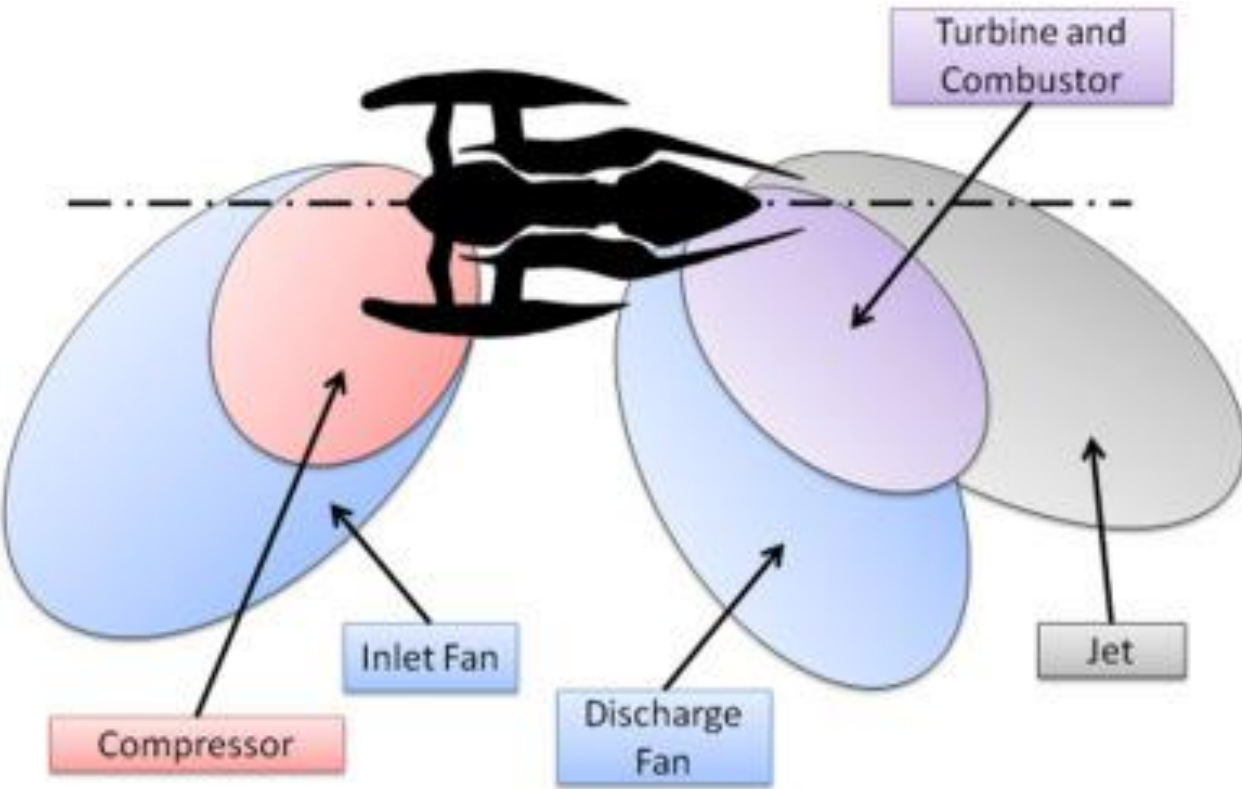
Before



After

Design of an attenuating duct with a porous lining

Noise: An Ever-Evolving Problem



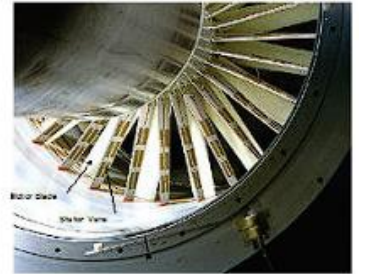
Turbofan engine noise directivity



(a) Ultra-High Bypass Ratio



(b) Scarf Inlets



(c) Active Noise Control



(d) Forward-Swept Fans



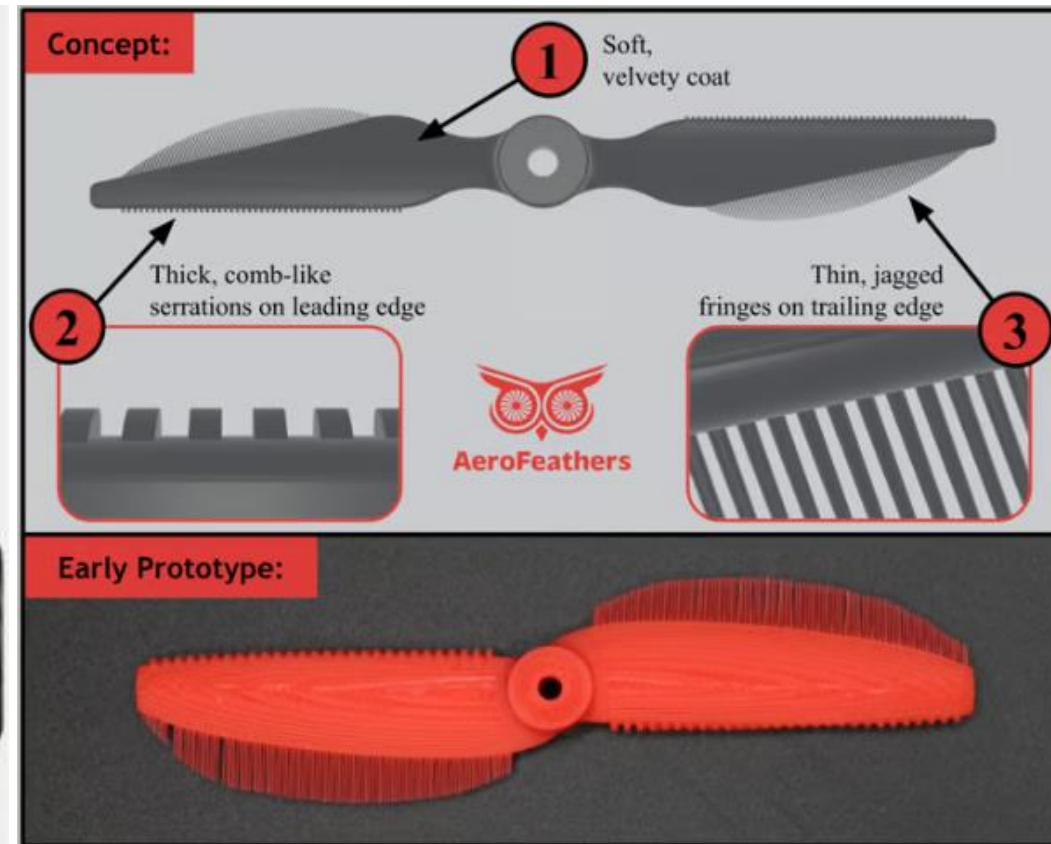
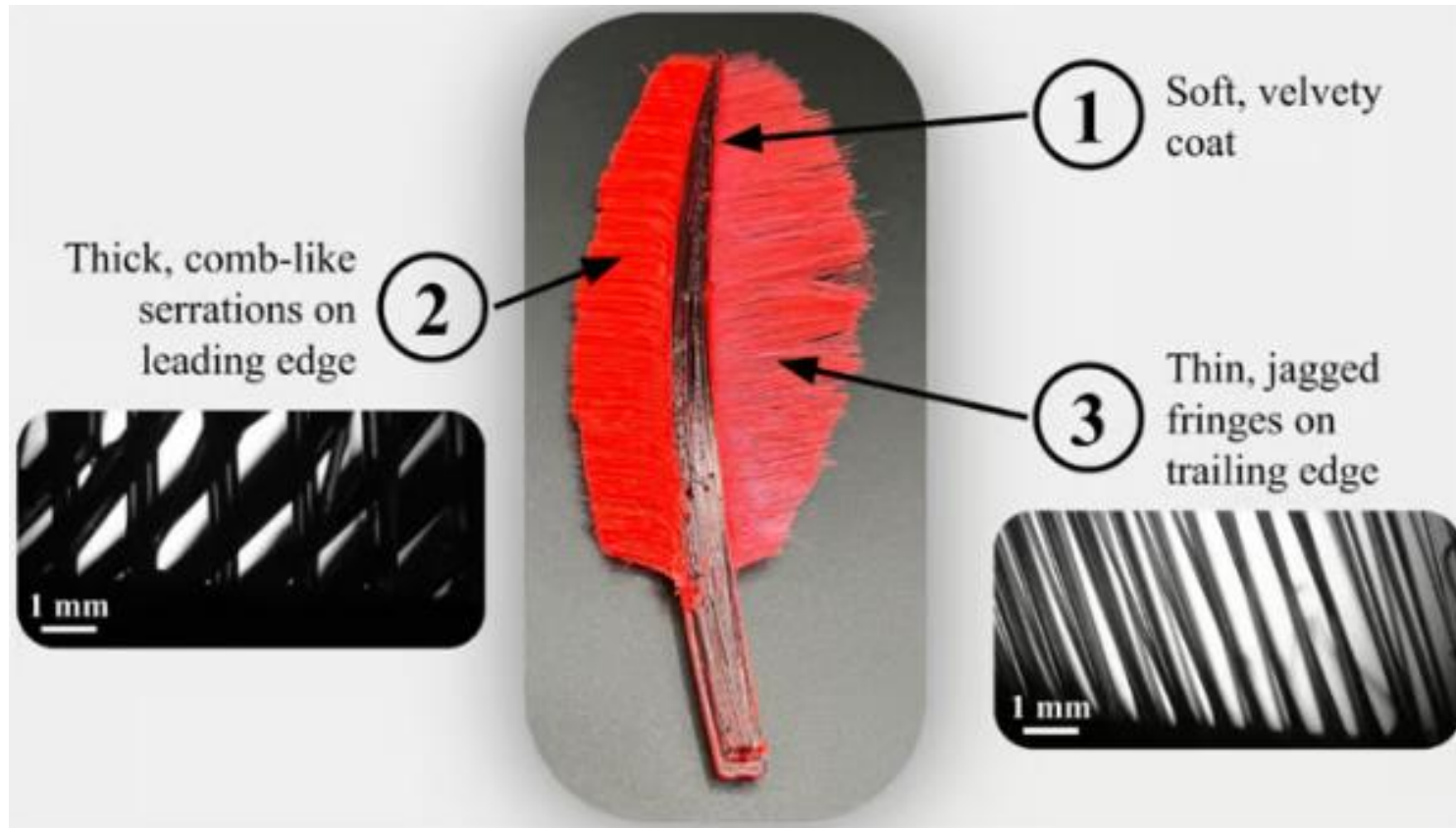
(e) Swept/Leaned Stators



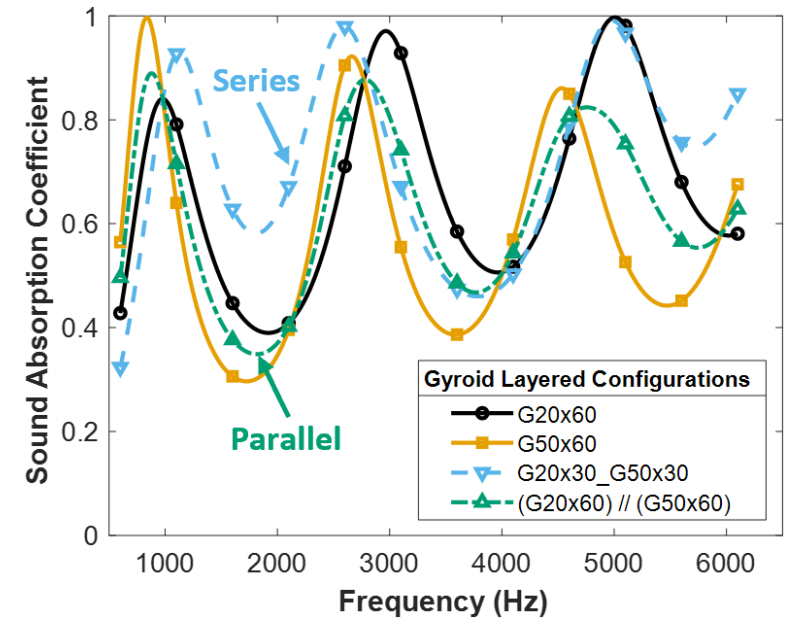
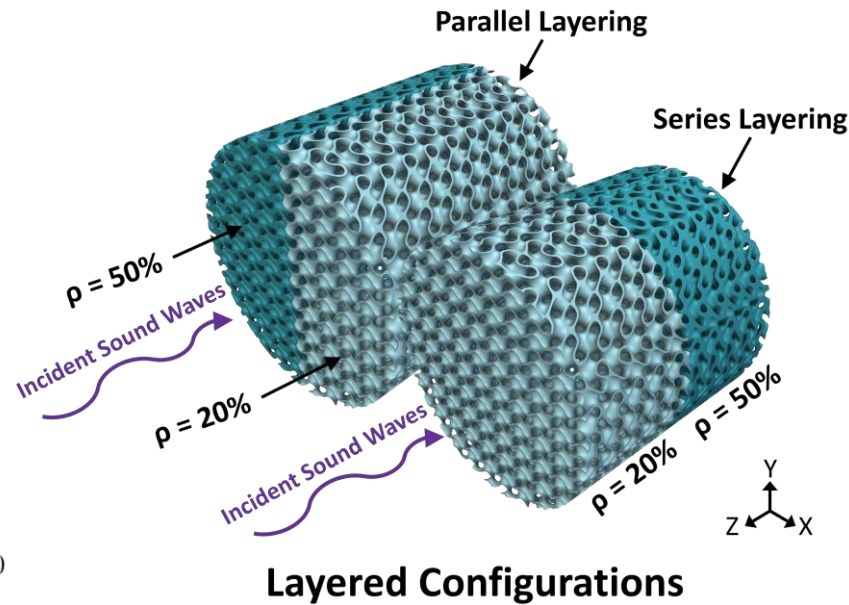
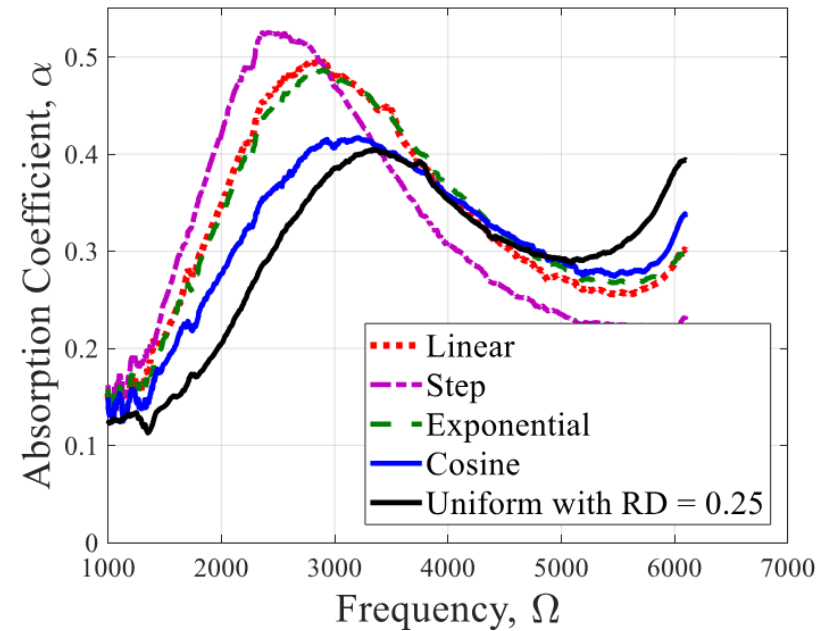
(f) Chevron Nozzles

Current turbfan engine noise reduction methods

Source Reduction: AeroFeathers: Owl Inspired Feathered Propeller Blades to Minimize Aeroacoustic Noise



Noise Reducing Elements: Improving Absorption of Porous Absorbers Through Impedance Mismatch





References

- Maling Jr, George C., and William W. Lang. "Theory into practice: A physicist's helpful view of noise phenomena." *Noise Control Engineering* 1.1 (1973): 46-59.
- Ingard, K. Uno, and George C. Maling Jr. "Physical principles of noise reduction: Properties of sound sources and their fields." *Noise Control Engineering* 2.1 (1974): 37-48.
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Thank you!

Janith Godakawela, pgodakaw@mtu.edu
Bhisham Sharma, bnsharma@mtu.edu