Acoustic Absorbers and Diffusers: Theory, Design and Application 2nd Edition

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Taylor & Francis Group London New York, (2009). 478 pp, 90 USD, ISBN 10: 0-415-47174-5; ISBN 13: 978-0-415-47174-9

The concept of acoustical diffusion appears within the Hollywood movie Spider-Man 3 (2007). Peter Parker, the principal character when not slinging webs as Spider-Man, meets with his girlfriend in waiting, Mary Jane Watson, after an evening at the theatre. The fictional Parker at an earlier time within the movie was in the audience, and Watson, was acting on the stage. The drama of the fictional stage play was earlier conveyed to the audience, including Peter Parker, through the unamplified speech of the stage actors.

Watson: Tell me again. Was I really good? I was so nervous, my knees were shaking.

Parker: Your knees were fine.

Watson: The applause wasn't very loud.

Parker: Yes, it was. Well, it's the acoustics. It's all about diffusion. It keeps the sound waves from grouping. You see when the sound waves, they propagate, then it…

Watson: You are such a nerd.

Has Peter Parker, the fictional student scientist, managed to offer an explanation that agrees with the science and engineering of acoustics? Does the perception of diminished loudness, for an impulsive array of clapping hands, correspond to the inverse problem of speech intelligibility from stage to audience? So we have "Acoustic Absorbers and Diffusers…"

After the Introduction, there are thirteen chapters, the first two treat absorption and diffusion as separate subjects, followed by four on topics related to absorption, interleaved with four with distinct content related to diffusion. Three concluding chapters outline practical and abstract applications.

Chapter 1 Applications and Basic Principles of Absorbers, establishes preferred statistical methods for calculating reverberation times. The second chapter deals with diffusers and establishes the problem of distinct echoes. The solution is diffusion that gives less "grouping" of waves, lower amplitudes, and softer sounds. To illustrate, the measured reverberation time within a room shows how increased diffuse reflection corresponds to decreased reverberation time, which mimics increased absorption. As a practical effect, increased diffusion can enhance the intelligibility of speech.

Chapter 3 Measurement of Absorber Properties, discusses isotropic and non-isotropic materials, finite and semi-infinite dimensions, plane and non-plane surfaces, laboratory versus in situ testing, and non-acoustical parameters. Chapter 4 deals with the measurement and characterization of diffusion and defines diffusion and scattering coefficients and how these work together. A polar plot for the engineered Skyline™ diffuser product provides a discussion piece for the techniques shown for measurement and presentation. A set of energy decay curves compares how sound levels decay differently over time within a room for flat and semi-cylindrical test articles.

Chapter 5 on porous absorbers, details the non-acoustical parameters including porosity, flow resistivity, pore shape factor, tortuosity, solid-fluid boundaries, layering of materials, local versus extended reaction, elastic properties of solid components, and angle of incidence. Chapter 6 Resonant Absorbers, continues similarly with membrane, Helmholtz, and micro-perforated absorbers. It concludes with a section on the practical issue of layered geometries of varying materials. Chapter 7 reviews the seating areas of audiences, sonic crystals, and foliage. A section on [Manfred] Schroeder diffusers provides the most comprehensive content of this chapter.

Chapter 8 on Prediction and Scattering, classifies a number of time- and frequency- domain methods for estimating the reflective scattering of sound. The categories include various integrals with complex numbers that define the limits of integration and numerical techniques. This organized scattering knowledge is subsequently applied to the controlled chaos of diffuser design.

Chapter 9 Schroeder Diffusers, acknowledges the historical development of the quadratic residue diffuser (QRD) and the engineering steps for design of a QRD. The pictured geometries for 1-D strips, and 2-D squares show the results of the required periodicity and modulation of depths for 1-D strips and 2-D squares. Alternatives to the quadratic residue are developed that further optimize scattering and diffusion, including the primitive root diffuser (PRD), Feldman modified PRD, and Cox-D'Antonio modified PRD.

Chapter 10 Geometric Reflectors and Diffusers, makes further use of the well-defined surfaces of pyramids, and the curved surfaces of cylinders and arcs towards the analysis and design of diffusers. The divergence of sound waves upon reflection is analyzed as a contributor to the apparent absorption of reflective surfaces. The equations needed to study scattering from these surfaces are developed and the optimization objectives given as the uniformity of sound scattered in all possible directions. In place of quadratic and primitive root residues, the mathematics of fractals are contemplated the path forward to the optimal chaos of diffusion. A glimpse of optimal diffusion is given last glimpse through the prism of 3-D volumetric diffusers.

Chapter 11 Hybrid Surfaces, examines how changes of material across plane and curved surfaces themselves cause absorption and diffusion. Theories for optimizing the acoustical design are discussed with the binary amplitude diffuser BAD™ panel used as the engineered product success story. Chapter 12 Absorbers and Diffusers in Rooms and Geometrics Models, covers high-frequency, ray-tracing approximations for calculating the acoustical characteristics of rooms. It highlights the importance of converting absorption coefficients of angle-dependent data to and from random-incidence data.

Chapter 13 Active Absorbers and Diffusers, outlines future applications where active control of surfaces could extend performance to lower frequencies.

The appendices tabulate absorption coefficients for many types of surfaces and materials, with separate diffusion coefficients shown for select surface geometries and engineered diffuser products. Acoustical designers could make use of even more data than presented that shows side-by-side absorption and diffusion coefficients for both conventional materials and engineered products.

The book succeeds by confirming that absorption and diffusion are common to all surfaces and all materials. Highly recommended.

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