JASA REFLECTIONS

The *Reflections* series takes a look back on historical articles from *The Journal of the Acoustical Society of America* that have had a significant impact on the science and practice of acoustics.

The launch of statistical energy analysis simulation of double panels

Article: Sound Transmission through Double Panels Using Statistical Energy Analysis
Authors: A. J. Price and M. J. Crocker
Publication Date: March 1970 (JASA **47**, 683); https://doi.org/10.1121/1.1911951

ARTICLE OVERVIEW

More than 50 years ago, Price and Crocker published their second successful paper[1] applying the statistical energy analysis (SEA) method to double panels. After their initial paper[2] that established the concept of resonant and non-resonant paths in the room-plate-room setup, the authors proposed the sophisticated network of two rooms connected by a double panel setup.

The five-system SEA model (see Fig. 1) of both large cavities (1 and 5), two panels (2 and 4), and the inner cavity (3) is presented as individual equations not using the matrix form of later textbooks from Lyon and DeJong.[3]

Whereas all non-resonant coupling loss factors (CLF) are derived based on the mass law, great care is taken of the resonant transmission using a corrected version of Maidanik's[4] radiation theory. Remarkable is the modification that is made to correct the panel radiation resistance to the thin double wall cavity (DW-cavity) below the coincidence frequency of the panels by doubling the radiation efficiency into the DW-cavity.

Two aspects of the paper are noteworthy from today's SEA perspective:

First, the radiation resistance of the panels is determined from tests by solving the SEA equations with power input into one plate and measuring the energy in all subsystems. This leads to unrealistically high radiation resistance that may be caused by structure-borne coupling in the experimental setup. This calibrates the model to the test results and leads to a surprisingly good agreement between both.

Second, the double wall resonance and related strong coupling are not considered at all, even though the frequency would be at 100 Hz in Fig. 5 in their paper.

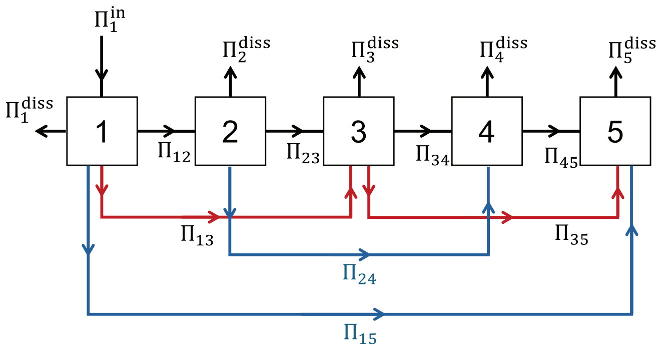

FIG. 1. Price's block diagram representing the power flow between the room-panel-cavity-panel-room SEA systems connected via several resonant and non-resonant junctions. Later authors considered additional connections that account for the double wall resonance (1–5) or the coupling of the plates via the cavity (2–4). Image redrawn with permission from J. Price and M. J. Crocker, J. Acoust. Soc. Am. 47, 683–693 (1970). Copyright 1970 Acoustical Society of America.

The paper concludes with several simulation results. The calibrated radiation efficiency leads to good agreement with the test result but leads to a non-plausible broadband shift of the transmission loss (TL) for higher plate damping loss (see Fig. 8 in their paper). However, once the golden rules of SEA are fulfilled at and above coincidence, all results are in line with modern SEA theory.

IMPACT OF THE ARTICLE

The double panel problem is a challenging and critical case for SEA. Thus, this first paper triggered still ongoing research and discussion about what is the correct choice of SEA subsystem configuration and which paths have to be considered in each specific frequency range. Thirty years later, Craik[5] gave up the separation into non-resonant and resonant transmission and investigated specific expressions for the coupling of the cavity to the rooms. Commercial software packages such as VAONE™ introduce the double wall connector using transfer matrix modelling of heavy layer lay-ups that added the room-room coupling, considering the (limp) two plates and the cavity as one subsystem. Campolina[8] and Barbagallo[9] dealt with this multiple path approach in detail.

SOLUTIONS TO THE DOUBLE WALL DILEMMA OF SEA

The confusion about the correct subsystem and junction configuration was solved by the introduction of the hybrid finite-element method/statistical energy analysis (FEM/SEA) theory of Shorter and Langley[6] and applied to the double wall problem by Langley and Cordioli.[7] The hybrid theory allows coupling deterministic (FEM) and random (SEA) subsystems. With this approach, the

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decision about the best subsystem configuration depends solely on the statistical properties of each component in each specific frequency range. In addition, the issues of panel radiation are solved by numerical methods.

The results of a sequence of FEM, hybrid FEM/SEA, and pure SEA models of a trimmed aircraft panel are shown by Peiffer,[10] revealing that a correct double panel model requires several different model setups over the full frequency range. Fifty years after Price's paper, it was shown that the strongly coupled double panel setup is a delicate case for SEA.

For further reading, the original models of Price's paper are implemented in the open source software PYVA.[11]

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