Nick V. Solokhin[1] and M. A. Sumbatyan
[1] Ultrasonic S-Lab, 100 Chilpancingo Pkwy # 2107, Pleasant Hill, CA 94523
nick.solokhin@gmail.com

Artificial Layer

Journal Research in Nondestructive Evaluation. (1994) 6:19 – 34

Abstract

The spreading of scalar waves through a structure, called the artificial layer is investigated. The artificial layer is a clearance between a piston-type radiator and acoustically hard grating. The main application of this structure is a matching layer for an ultrasonic transducer in a low acoustic impedance medium (in air). The mathematical model of this artificial layer is constructed and reduced to explicit analytical expressions that are convenient in engineering practice. The errors of these analytical expressions are estimated with the help of numerical solution of the problem in exact formulation. Two problems connected with the artificial layer are investigated numerically: a scalar wave spreading in a stepped waveguide with acoustically hard sides, and a scalar wave spreading through a grating of final thickness. The artificial matching layer is investigated experimentally at radiating of ultrasonic waves in air.

NOTES to this article.

Traditional expression for the transmission coefficient of the layer contains transmission and reflection coefficients at the boundaries of such layer. Expressions for transmission and reflection coefficients at each boundary can be written with a data for acoustic impedances of materials that form such boundary.

The artificial layer is a clearance between piston-type source of acoustic waves and some flat artificial structure that has some reflection and transmission coefficients. This flat structure (grating) provides boundary of the artificial layer. This type of matching layer was used in the middle of 1980 years to increase efficiency of flat ultrasonic transducers for operation in air (at room conditions). Author of this article was involved in analysis of this matching layer.

Noted grating was done as a flat plate with periodic circular holes (see Fig. 1 from this article). Thickness of the plate was ~ 1.5 mm, diameter of the holes – 1.5 mm. Work frequency was 35 – 40 kHz. Such artificial matching layer provides increasing of pressure in radiated waves in ~ 1.5 times. These data were published in 1994, and it is still not fully understood by many specialists in acoustics, unfortunately. Acoustic medium in the clearance between the plate and the transducer was the same like outside of this plate (the air at room conditions).

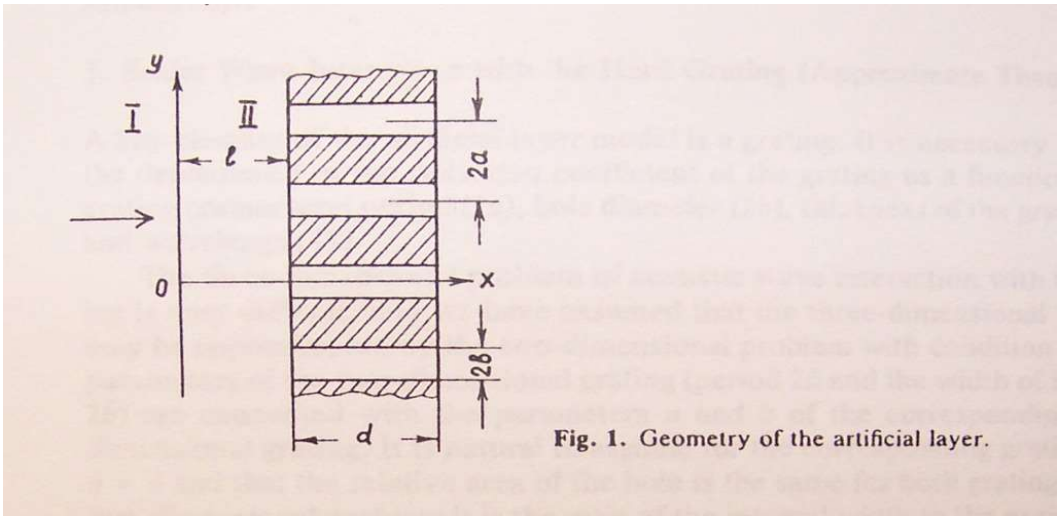

Fig. 1. Geometry of the artificial layer.

* Axis Y is on the outer surface of the piston-type transducer. Piston-type displacements (vibrations) of this surface are directed along X axis.

** Thickness of the clearance between the transducer and the grating is l (0.1 – 0.2 mm). Thickness of the plate is d, diameter of the holes is 2b, distance between neighbor axes of the holes is 2a.

The author of this article applied approximate expressions for transmission and reflection coefficients. These expressions are based on well-known approximate expressions for transmission and reflection coefficients for discontinuity “diameter step” in acoustic waveguide.

$$R_0 = \frac{S_1 - S_2}{S_1 + S_2} \qquad T_0 = \frac{2S_1}{S_1 + S_2}$$

where: S_1 and S_2 are areas of cross section for the waveguides with radii R_1 and R_2 .