

# Design of a virtual acoustic sensor for estimating the radiated sound of cylindrical shells

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## ABSTRACT

In this paper, a virtual acoustic sensor is designed and evaluated experimentally to be used instead of microphones in active noise control of vibrating cylindrical shells. Dynamic motion equations of a cylindrical shell along with the effect of bonded piezoelectric patches are derived based on the Hamilton's principle and Rayleigh-Ritz method. The Sanders shell theory is used to relate the strains to the displacements of the cylinder. Modal structural acoustic sensing technique estimates the far-field radiated sound pressure of the cylinder. Experimental frequency response function (FRF) of the actual microphone at various locations are obtained and compared to that of the virtual one. The theoretical estimated sound pressure is in good agreement with the experimental results.

## 1. Introduction

One of the disadvantages of active noise control (ANC) is the size of control system. Because, the sensors and actuators in ANC are microphones and speakers, respectively, and they are located in the environment to attenuate the acoustic noise, thus, the physical volume of the control system is large. The situation becomes worse in case of global attenuation for complex sound sources. In many applications ANC cannot be used because of not having sufficient space to implement it. An alternative approach to overcome the drawback of the ANC is active structural acoustic control (ASAC). In ASAC, structural sensors and actuators such as accelerometers or piezoelectric patches bonded to the structure are used instead of microphones and speakers, while the controller aim is the same or let say similar as before. The control force is applied directly to the structure, therefore, the global attenuation can be achieved by reducing or changing the vibration distribution with the objective of

reducing the overall sound radiation [1].

In the literature few works are reported concerning radiation modes or structural acoustic sensing of cylindrical shells. In [2] radiation modes for noise reduction in a rectangular enclosed space and in [3] radiation modes for an irregular enclosed space are derived. Maillard and Fuller [4] studied discrete structural acoustic control (DSAS) for cylinders for broad band control. An array of equally spaced  $p \times q$  accelerometers ( $p$  and  $q$  are the numbers of sensors in axial and circumferential directions) and  $p, q$  digital FIR filters are required for estimating the pressure of one point in the free field. Loghmani et al. proposed the modal structural acoustic sensing (MSAS) in [5] and [6] using accelerometers and piezoelectric patches, respectively. The advantage of the MSAS is that with a few sensors, accurate sound pressure can be estimated. However, Loghmani et al. did not present any experimental evaluation for their proposed method.

In this study, a virtual microphone is designed to estimate the radiated sound of a cylindrical shell