APPLICATION OF NEURAL NETWORK AND GENETIC ALGORITHM TO THE OPTIMUM DESIGN OF PERFORATED TUBE MUFFLERS

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ABSTRACT

Research on new techniques of perforated silencers has been well addressed. However, the research work on shape optimization for a volume-constrained silencer within a constrained machine room is rare. Therefore, the optimum design of mufflers becomes an essential issue. In this paper, to simplify the optimum process, a simplified mathematical model of the muffler is constructed with a neural network using a series of input design data (muffle dimensions) and output data (theoretical sound transmission loss) obtained by a theoretical mathematical model (TMM). To assess the optimal mufflers, the neural network model (NNM) is used as an objective function in conjunction with a genetic algorithm (GA). Moreover, the numerical cases of sound elimination with respect to pure tones (500, 1000, 2000Hz) are exemplified and discussed.

Before the GA operation can be carried out, the accuracy of the TMM is checked by Crocker’s experimental data. In addition, both the TMM and NNM are compared. It is found that the TMM and the experimental data are in agreement. Moreover, the TMM and NNM confirm.

The results reveal that the maximum value of the sound transmission loss (STL) can be optimally obtained at the desired frequencies. Consequently, it is obvious that the optimum algorithm proposed in this study can provide an efficient way to develop optimal silencers.

Keywords: Generalized decoupling technique, Perforated muffler, Neural network model, Optimization, Genetic algorithm.

1. INTRODUCTION

Muffler research used in engine noise was started by Davis et al. [1]. Based on the plane wave theory, the studies of simple expansion mufflers without perforated holes have been well addressed [2-4]. To increase a muffler’s acoustical performance, the assessment of a new acoustical element—internal perforated non-plug/plug tubes—was discussed by Sullivan and Crocker [5]. On the basis of the coupled differential equations, a series of theoretical and numerical techniques in decoupling the acoustical problems have been proposed [6-9]. In 1981, Jayaraman and Yam [10] developed a method in finding an analytical solution; however, a presumption of the velocity equality within the inner and outer duct, which is not reasonable in the real world, is required. To overcome this drawback, Munjal et al. [11] provided a generalized de-coupling method. Regarding the flowing effect, Peat [12] publicized the numerical decoupling method by finding the eigen value in transfer matrices.

Since the constrained problem is mostly concerned with the necessity of operation and maintenance in practical engineering work, there is a growing need to optimize the acoustical performance under limited space. Yet, the need to investigate the optimal muffler design under space constraints is rarely tackled. In previous work [13-17], the shape optimizations of straight simple-expansion mufflers within a constrained space have been discussed. In order to efficiently improve the performance of the noise control device, a one-chamber perforated muffler developed by using a genetic algorithm (GA) is presented. To simplify the calculation of the OBJ function during GA optimization, a trained neural network model (NNM) is established.

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