SHAPE OPTIMIZATION OF MULTI-CHAMBER MUFFLERS WITH PLUG-INLET TUBE ON A VENTING PROCESS BY GENETIC ALGORITHMS

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ABSTRACT
Research on new techniques of single-chamber plug-inlet mufflers has been addressed. However, research work on shape optimization of multi-chamber plug-inlet mufflers along with work on the maximal back pressure has been neglected. Therefore, a numerical case for eliminating a broadband steam blow-off noise using multi-chamber plug-inlet mufflers in conjunction with genetic algorithm (GA) as well as numerical decoupling technique under space-constrained pressure drop is introduced in this paper. To verify the liability of GA optimization, optimal noise abatements for various pure tones on a one-chamber plug-inlet muffler are exemplified. Also, the accuracy of the mathematical model has to be checked by experimental data. Results indicate that the maximal sound transmission losses are precisely located at the desired target tones. Consequently, both the pressure drop and the acoustical performance will be increased when the diameters (at inlet tubes and perforated holes), the perforated ratio, and the length of perforated tube decrease.

1 INTRODUCTION
In dealing with industrial exhaust noise which is emitted from a venting system, a reactive muffler is customarily used [1]. Moreover, because the constrained problem is mostly concerned with the necessity of operation and maintenance in practical engineering work, there is a growing need to optimize acoustical performance within a confined space. In addition, in order to keep the volume-flow-rate steady in a venting system, the back pressure of mufflers within an allowable range is compulsory. In the past decade, to increase acoustical performance, the assessment of a new acoustical element — an internal perforated tube, an essential acoustical element used to depress the low frequency sound energy — was introduced and discussed by Sullivan and Crocker in 1978 [2]. Based on the coupled equations derived by Sullivan and Crocker, a series of theories and numerical techniques in decoupling the acoustical problems have been proposed [3, 4, 5, and 6]. Concerning the flowing effect, Munjal [7] and Peat [8] published the generalized decoupling and numerical decoupling methods. Munjal et al. [9] investigated the acoustical effect and the system’s back pressure with respect to several design parameters for perforated plug and cross-flow perforated mufflers. However, the assessment of the muffler’s optimal shape design within a constrained space has rarely been tackled. In previous work [10], the shape optimization of a one-chamber perforated muffler has been discussed. However, the effect of the system’s back pressure, which may cause the decrement of the flow rate in the system, has not been considered.

The application of a single-chamber plug-inlet muffler in depressing a venting noise emitted from gas blow-off processing has prevailed in modern industries. However, on the basis of experimental trials, the muffler design has proved to be time-consuming and the acoustical performance insufficient. In order to improve the performance of the noise control device, two kinds of space-constrained multi-chamber plug-inlet mufflers — a one-chamber and a two-chamber muffler conjugated with perforated and plug-inlet tubes — are proposed and investigated. Moreover, to overcome the drawback of a possible overload pressure drop in the mufflers, the specified allowable pressure drop in a muffler has been considered in conjunction with the process of GA optimization. By using a genetic algorithm (GA), the muffler’s performance is improved. Additionally, to investigate the acoustical effect with respect to chambers and \( \Delta p_{\text{max}} \), the shape optimization of a multi-chamber plug-inlet muffler at various chambers (one chamber and two chambers) and \( \Delta p_{\text{max}} \) (100 Pa, 200 Pa, 300 Pa, 400 Pa, 500 Pa, and infinite Pa) has also been discussed.

In this paper, the numerical decoupling methods used in forming a four-pole system matrix are in tune with the above GA method. These, in turn, are responsible for developing a new muffler shape by adjusting the perforated plug-inlet