Optimization of Equipment Allocation and Sound-Barriers in a Multi-noise Plant by Using Simulated Annealing Method

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ABSTRACT

Because high noise levels in industrial plants can be injurious to workers and lead not only to psychological but also to physiological ailments, noise control in factories becomes essential. In order to overcome the noise impact emitted from a multi-noise plant, a sound barrier, a popular noise control strategy, has been used in the industrial field for a long time. Yet, the traditional method in the design of a sound barrier is time-consuming. Recently, to economically improve acoustical performance, a new strategy (flexible allocation) is applied; however, the acoustical performance is still insufficient. In order to quickly, efficiently, and economically control the noise level specified by the Environmental Protection Administration, interest in shape optimization of a sound barrier in conjunction with equipment allocation around the plant’s boundary is rising.

In this paper, the novel technique of simulated annealing (SA) in conjunction with the theoretical sound propagation model and the method of minimized variation square is applied in the following numerical optimizations. Before a sound barrier is optimized, the sound propagation from one single noise is tested and compared with the experimental data for the purpose of accuracy within the mathematical model. Moreover, two kinds of sound barrier systems have been fully discussed and optimally shaped by the SA. The results reveal that the sound barrier can be properly shaped. Consequently, this paper may provide an efficient and rapid methodology in the shape-optimized work for a sound barrier installed in a multi-equipment plant.

Keywords: multi-equipment plant, simulated annealing, optimization, sound barrier

1. INTRODUCTION

As pointed out by the Occupational Safety and Health Act (OSHA) of 1970, high noise levels can be harmful to workers and can lead not only to psychological but also to physiological ailments. Consequently, noise control work on equipment becomes vital [1, 2].

Sound barrier, a popular noise control strategy, has been widely applied in the industrial field. However, the traditional design of a sound barrier by using a trial and error method is time-consuming and inefficient; Recently, Yeh et al. proposed a new strategy to economically reduce the noise level by adjusting the locations of noisy equipment [3]; nevertheless, the noise reduction was still insufficient for a multi-equipment plant which emitted tremendous noise. In order to efficiently and economically control the noise level, a numerical assessment in searching for an optimally shaped sound barrier in conjunction with an appropriate allocation of equipment is obligatory.

To this end, a multi-segment barrier system is applied; moreover, four receiving points used in noise monitoring are evenly allocated outside the plant’s fences. To numerically pursue an optimally shaped sound barrier and equipment allocation, an objective function is formed by the accumulated variation square of the SPL between the targeted value and the theoretical value. Optimal processing will be performed by minimizing the variation square of the SPL [3] in conjunction with an appropriate optimizer.

During the past three decades, there has been a growing interest in solving algorithmic problems inspired by natural systems in physics and biology. SA, a stochastic relaxation technique oriented by Metropolis et al. [4] and developed by Kirkpatrick et al. [5], imitates the physical process of annealing metal to reach the minimum energy state. One great advantage of SA optimizers is that SA has a better chance of locating the global optimum in a near optimal manner. This is achieved without complicated calculations in the first derivative of the objective function. In this paper, SA is adopted and coupled with the equations of sound attenuation and minimal variation square to optimize the shape of the sound barrier around the constrained plant area.

This paper provides a quick and effectual method to reduce the noise impact around the plant by optimally designing a shaped multi-segment sound barrier and reallocating equipment under the SA searching technique.