Numerical Assessment of Plant’s Noise Identification by Using Simulated Annealing Method

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NSC Project No.: NSC 96-2221-E-235-006

Abstract

Noise control is important and essential in factory, where the noise level is restricted by the occupational safety and health act. An improper machine allocation will not only result in the tremendous cost on noise control work, but also will cause the harmful environment for residence nearby the plant; therefore, the approach of optimal and economic allocation of noise sources within a constrained plant area becomes crucial and obligatory. In this paper, the novel technique of simulated annealing (SA) in conjunction with the method of minimized variation square is applied in the following numerical optimization. In addition, two kinds of sound monitoring systems in detecting the noise condition within the plant area are also introduced. Before noises identification, one single noise is tested and compared with the simulated data of SoundPlan (professional simulation package in sound field) for the accuracy purpose in mathematical model. The results reveal that the locations and sound power levels (SWLs) of noises can be precisely distinguished. Consequently, this paper may provide an efficient and rapid methodology in the noise identification work for a multi-equipment plant.

Keywords: simulated annealing method, the method of minimized variation square, noise identification

1. Introduction

As investigated by the Occupational Safety and Health Act (OSHA) of 1970, high noise levels can be injurious to workers and can lead not only to psychological but also to physiological ailments. As a result, the noise control work on equipment becomes vital (Cheremisinoff et al., 1977; Alley et al., 1989). Several research studies on various designs of noise-proofing devices have already been addressed prosperously (Munjal, 1987; Lord et al., 1985). To achieve the appropriate and sufficient treatment on noisy source, the noise investigation on plant site shall be primarily performed in advance; however, as the accumulation effect of multi-equipment sound field is remarkable, the sound identification by human ear becomes vogue and unreliable. Czyzewski (2003) introduced the computer learning system of neural network to distinguish the propagating direction and locations of primary sound source; however, the values of sound level with respect to individual sound source are not available. Crocker et al. (2004) recommended a method of sound intensity measurement to differentiate air conditioner by the octave band sound level; regrettably, they cannot discriminate the exact location of the prime noise.

During the past three decades, there has been a growing interest in solving algorithm problems inspired by natural systems in physics and biology. SA, a stochastic relaxation technique oriented by Metropolis et al. (1953) and developed by Kirkpatrick et al. (1983) imitates the physical process of annealing metal to reach the minimum energy state. One great advantage of SA optimizers is that it has a better chance of locating the global optimum in a near optimal manner. Such location is achieved without the complicated calculations in the first derivative of the objective function (Chang et al., 2005). In this paper, the novel technique of simulated annealing (SA) is used in conjunction with the method of minimized variation square (Yeh et al., 2004) to minimize the variation of sound pressure level (SPL) between trial noises and the actual noises.

2. Theoretical Background

In this paper, an allocation plan of m-noise plant is proposed and shown in Figure 1; wherein, the actual coordinates and SWL of j-th noise is given as \{x_{j[act]}, y_{j[act]}, z_{j[act]}, SWL_{j[act]}\}. To accurately identify the n’s noises by using internal noise data inside the plant, two kinds of n-point monitoring systems with n=18 and 36 are then built. The related locations and coordinates are illustrated and listed in Figures 2, 3 respectively. With the monitoring system, n-sets of sound pressure levels –SPL_{j[act]} at the j-th receiving point can thus be detected. To recognize the locations and sound energies of noises, an trial parameters set with \{x_{j[trial]}, y_{j[trial]}, z_{j[trial]}, SWL_{j[trial]}\} at j-th noise is then preset. For a sound wave propagating in a free sound field, the effects of distance decay and air absorption (Bies et al., 1988; Magrab, 1975; Beranek, 1971) have been considered. For a specified receiving point i, the total sound pressure level - SPL_{i} radiated and accumulated from