NOISE IDENTIFICATION, MODELING AND CONTROL IN MINING INDUSTRY

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Abstract

Prolonged exposure of miners to the high levels of noise in opencast and underground mines can cause noise induced hearing loss and non-auditory health effects. To minimize noise risk, it is imperative to identify machinery noise and their impacts on miners at the work place and adopt cost effective and appropriate noise control measures at the source, path and at the receiver. In this paper, authors have summarized the noise levels generated from different machineries used in opencast and underground mines and elaborated on frequency dependent noise prediction models e.g. ISO 9613-2, ENM, CONCAWE and non-frequency based noise prediction model VDI-2714 used in mining and allied industries. The authors illustrated the applications of innovative soft computing models viz. Fuzzy Inference System [Mamdani and Takagi Sugeno Kang (T-S-K)], MLP (multi-layer perceptron, RBF (radial basis function) and adaptive network-based fuzzy inference systems (ANFIS) for predicting machinery noise in two opencast mines. The paper highlights the developments and research conducted on effective noise control measures being adopted for mining machineries and implemented in mines to minimize the noise menace so that noise levels generated in mines are within the prescribed noise standards and rules.

1. INTRODUCTION

Noise is defined as a sound without agreeable musical quality or as an unwanted sound. Increased mechanization brought in use of large and high capacity equipment. This increased the magnitude of the problem of noise in mines. Prolonged exposure of miners to high levels of noise can cause auditory and non-auditory health effects. Before initiating any administrative, engineering and medical measures against the noise hazards, noise surveys are essential. The entire article is classified in to major headings (i) Noise Measurement and Identification in Mines (ii) Prediction of Machinery and Environmental Noise and Development of Intelligence Noise Prediction Models and the Last one is (iii) Control of Noise in Mines.

1.1 Noise Measurement and Identification in Mines

Industrial machinery and processes are composed of various noise sources such as rotors, stators, gears, fans, vibrating panels, turbulent fluid flow, impact processes, electrical machines, internal combustion engines etc.

2. SOURCES OF NOISE IN MINES

Noise is generated from various fixed, mobile and impulsive sources in opencast, underground mines

3. INTRODUCTION TO ENVIRONMENTAL NOISE PREDICTION MODEL and CASE STUDY

The sound pressure level (SPL, L_p) at an observation point may be defined as the sum of sound power level (L_w) of the source; a geometric spreading factor, K, which is dependent upon the type of source and accounts for geometrical spreading as the sound propagates away from the source; a directivity index, DI_M, which accounts for directional properties of the source, including influences of reflections other than those in the ground plane; and an excess attenuation factor, A_E. The general noise prediction model is written as the following:

$$L_p = L_w - K + DI_M - A_E$$

For N sources, the sound pressure level will computed as the sum of contribution as in the following equation:

$$L_p = 10\log_{10}\sum_{i=1}^{N} 10^{L_{pi}/10}$$

Where L_{pi} is the sound pressure level due to the i^{th} source.

3.1 ISO:9613-2 NOISE PREDICTION MODEL

In this model, the equivalent continuous downwind octave-band sound pressure level at a receiver, L_{fT}, shall be calculated for each point source, and its image sources, and for the eight octave bands with octave band center frequencies varying from 63 Hz to 8 kHz.The equivalent continuous A-weighted downwind sound pressure level shall be obtained by summing the contributing time-mean-square sound pressures calculated according to equation (1). For each point source, for each of their image sources, and for each octave band, as specified by the following equation

$$L_{AT}(DW) = 10\log\left\{\sum_{i=1}^{n}\left[\sum_{j=1}^{8} 10^{0.1\left[L_{ft}(ij)+A_f(j)\right]}\right]\right\}$$

3.2 CONCAWE Noise Prediction Model

Manning and his associates developed CONCAWE noise prediction model and its industrial application.

3.3 Soft Computing Application for Frequency based Noise Prediction Models

In the empirical models, all influences are taken into account regardless of whether or not they can be separately recognized. This is the main advantage of these models. However, the accuracy of these models depends on the accuracy of the measurements, similarities between the conditions where the noise attenuation is analyzed and the conditions where the measurements are carried out, and the statistical method that is used to make the empirical model.

It has been seen that noise prediction is a non-stationary process and soft-computing techniques like Fuzzy system, Adaptive network based fuzzy inference system (ANFIS) or (Neuro-Fuzzy), Neural Network etc. have been tested for non-stationary time-series prediction for a long time.

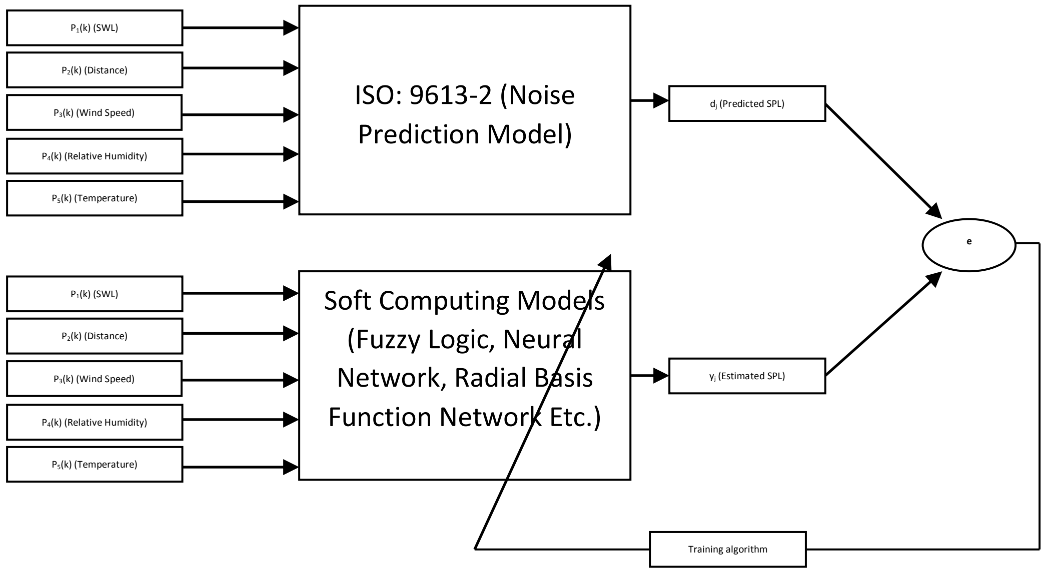

Figure 1: Soft-Computing Technique based noise prediction model.

4.1 Artificial Neural Network: An Introduction

An artificial neural network is a system, motivated by the theory of operation of biological neurons, in other words, is an emulation of biological neural system. Neural Network (NN) represents an important paradigm for classifying patterns or approximating complex non-linear process dynamics.

4.2 Artificial Neural Network based Noise Prediction Models:

The ANN base noise prediction model consist of two input constituting sound pressure level (x_k) and distance (y_k). The inputs patterns are $x_1(k), x_2(k), x_3(k) \ldots x_n(k) \in R$, $y_1(k), y_2(k), y_3(k) \ldots y_n(k)$) and the desired output patterns $d_1(k), d_2(k), d_3(k) \ldots d_n(k) \in R$. During training period the desired network output was calculated with VDI-2714 noise prediction model.

5. CONTROL OF NOISE IN OPENCAST MINES

The mining industry recognizes how important engineering noise controls are in reducing noise exposure during underground operations. But, because of the relatively small market for mining equipment, manufacturers have limited incentives to develop less noisy machinery or more innovative noise controls. Also, the specialized equipment designs imposed by the sometimes-hostile mining environment has limited the transfer of noise control technologies from other industries.

A noise control plan must be prepared and implemented within six months of completion of a noise report relating to a mine workplace. The plan is a written document listing the noise control treatments that have been decided upon and a timetable for their implementation. It should only be formulated once the initial groundwork for noise management, such as completion of a noise report, ranking of noise problems, and evaluation of available noise control treatments, is concluded.
Three methods to reduce worker noise exposure are:

1. Implementing engineering noise controls to reduce noise at the source or at the worker
2. Using administrative controls to limit the amount of time workers spend in noisy environments
3. Wearing personal protective equipment, such as hearing protectors, to reduce the sound level entering the ears.

Using engineering noise controls is the most desirable option because they address noise sources directly. Administrative controls and hearing protectors are indirect interventions and are less easily monitored and therefore more readily circumvented.

6. **CONCLUSION**

This paper highlights the measurement, prediction modelling and control of noise in opencast mines. Machinery noise is an important part of any industry, classical methods, classical and statistical models are complex and hard to use for mining engineering professionals. Hence soft computing based intelligent prediction models helps mining engineering professionals to predict machinery noise in very appropriately and these methods are very user friendly to use. This brief summery based article helps researchers to understand the problem of machinery noise, measurement of noise in octave band, development of intelligent models using artificial neural network and implementation of strategies of noise controls in mines.

References

1. D.P. Tripathy(1999). Noise Pollution. APH Publishing Corporation, New Delhi.
2. T. South, *Managing Noise and Vibration at Work a Practical Guide to Assessment, Measurement and Control*. Elsevier, UK., 2004.
3. *Hand book of Noise and Vibration Control*, 4th ed. Trade & Technical Press Ltd, UK.
4. L. L. Beranek and I. L. Ver, Eds., *Noise and Vibration Control Engineering (Principles and Applications)*. John Wiley & Sons, New York, 2006.
5. S.P.Singal, *Noise Pollution and Control Strategy*. Narosa Publishing House, New Delhi, India, 2005.
6. N. P. Cheremisinoff, *Noise Control in Industry A Practical Guide*. Noyes Publications, USA, 1996.
7. M. J. Crocker, Ed., *Handbook of Noise and Vibration Control*. John Wiley & Sons, New Jersey, 2007.
8. Bies, David A. and Hansen, H., Engineering Noise Control Theory and Practice, Spon Press, New York, 2003.
9. R. Tonin, "Environmental noise modelling," in *Computer Methods and Software for Simulating Environmental Pollution and Its Adverse Effects*, P.Zannetti, Ed., vol. 1. London:Computational Mechanics Publication, Elsevier Applied Science, 1993.

10. Acoustics- "Attenuation of sound during propagation outdoors-Part 2: General method of calculation", ISO 9613-2, International Organisation for Standardisation, Geneva, Switzerland, 1996.
11. Acoustics- "Attenuation of sound during propagation outdoors-Part 1: calculation of the absorption of sound by the atmosphere", ISO 9613-1, International Organisation for Standardisation, Geneva, Switzerland, 1993.
12. Manning, C.J., "The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighboring Communities", CONCAWE report 4/81, CONCAWE, 1981.
13. Marsh, K. J., "The CONCAWE Model for Calculating the Propagation of Noise from Open-Air Industrial Plants," Applied Acoustics, 1982, 15 (6), 411–428.
14. A.K. Pal, Y. Mishra, , S. Mitra, and N.C. Saxena, "Noise model for mining complex- a case discussion", Second World mining environment congress, (Katwice, Poland, 1997), pp 1-10
15. R. Tonin, "Estimating noise level from petrochemical plants, mines and industrial complexes", *Acoustics Australia* **13** (2), 59-67 (1985).
16. R.E. Rabeiy, M. Mohamed, A-K., and W. Gomma. "Study on the noise prediction in mining and industrial plants", *Ass.Uni.Bull.Environ. Res* **7** (2), 77-89 (2004).
17. K. Pathak , S. Durucan, and A. Korre, "Development of an air attenuation model for noise prediction in surface mines and qurries", *International Journal of Surface Mining, Reclamation and Environment* **14** (3), 223-230 (2000).
18. K.S. Narendra and K. Parthasarathy, "Identification and control of dynamical systems using neural networks". *IEEE Transactions on Neural Networks*, **1**, 4–27 (1990).
19. S. Haykin, *Neural Networks: A Comprehensive Foundation*, (Prentice-Hall, Reading, MA, 1994).
20. S.K. Nanda, D.P.Tripathy, and S.K. Patra (2008). "A sugeno fuzzy model for noise induced hearing loss in the mining industry", *Noise and Vibration Worldwide*, **39** (10), 25-36 (2008).
21. M.R. Cowper, B. Mulgrew, and C.P. Unsworth, "Nonlinear prediction of chaotic signals using a normalized radial basis function network", *Signal Processing*, **82** , 775 – 789 (2002).
22. Noise Control Resources Guide-Surface Mining (1999). available at, http:/www.msha.gov/1999noise/Guides/SurftotalFinal.pdf
23. www.navcon.com/DRAGLINE.pdf
24. http://www.hfpacoustical.com/HFP_site/Downloads/horizontal_drilling_00.pdf
25. www.calm-network.com/calm-noisetech-1103.pdf
26. Noise Control Resources Guide-Mill and Preparation Plant (1999). available at, http:/www.msha.gov/1999noise/Guides/MillPretotalFinal.pdf
27. Murthy, Ch. S.N. Vardhan, Harsha & Aruna, M., (1999). Control techniques for machinery noise reduction, Proceedings of National Seminar on Mining Machinery: Present Status and Future Development, ed. Prof. D.K. Misra, Department of E.M.M., ISM, Dhanbad, Nov. 26-27, Mintech Publisher, Bhubaneswar, 146-149.