International Journal of Mining Science and Technology 26 (2016) 285–293

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

Development of a multi-layer perceptron artificial neural network model to determine haul trucks energy consumption

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ARTICLE INFO

Article history:
Received 8 September 2015
Received in revised form 4 October 2015
Accepted 15 November 2015
Available online 21 January 2016

Keywords:
Fuel consumption
Haul truck
Surface mine
Artificial neural network

ABSTRACT

The mining industry annually consumes trillions of British thermal units of energy, a large part of which is saveable. Diesel fuel is a significant source of energy in surface mining operations and haul trucks are the major users of this energy source. Gross vehicle weight, truck velocity and total resistance have been recognised as the key parameters affecting the fuel consumption. In this paper, an artificial neural network model was developed to predict the fuel consumption of haul trucks in surface mines based on the gross vehicle weight, truck velocity and total resistance. The network was trained and tested using real data collected from a surface mining operation. The results indicate that the artificial neural network modelling can accurately predict haul truck fuel consumption based on the values of the haulage parameters considered in this study.

1. Introduction

The reduction of energy consumption has gradually become more important worldwide since the rise of the cost of fuel in the 1970s. The mining industry annually consumes trillions of British thermal units (BTUs) of energy in operations such as exploration, extraction, transportation and processing. A large number of research studies and industrial projects have been carried out in an attempt to reduce energy consumption in mining operations [1–4]. Current investments in the improvement of mining equipment have resulted in a significant reduction of energy consumption [5,6]. A large amount of energy can also be saved by improving mining technologies and energy management systems [7,8]. Energy saving is also associated with the reduction of millions of tonnes of gas emissions because the major energy sources used in the mining industry are petroleum products: electricity, coal and natural gas [9,10]. The type of fuel used on a mine site is greatly dependent on the type of mining method and the equipment used. Most of the equipment used for the handling of materials in mining is powered by diesel engines [11], which are highly energy-intensive, accounting for 87% of the total energy consumed in material handling.

Service trucks, front-end loaders, bulldozers, hydraulic excavators, rear-dump trucks and ancillary equipment, such as pick-up trucks and mobile maintenance equipment, are examples of the diesel equipment used in mining operations. Trucks in surface mines are used to haul ore and overburden from the pit to the stockpile, the dumpsite or to the next stage of the mining process. They are used in combination with other equipment, such as excavators, diggers and loaders, according to the production capacity and the site layout. The trucks used in the haulage operations of surface mines use a great amount of energy and this has encouraged truck manufacturers and major mining corporations to carry out a number of research projects on the energy efficiency of haul trucks [12–16].

The study conducted by Antoung and Hachibli [13] is concerned with the implementation of power-saving technology to improve the motor efficiency of mining equipment. The focus of their study is on the technical performance of motor components and how they contribute to the reduction of friction and the improvement of the motor efficiency. Beatty and Arthur [14] investigate the effect of some general parameters, such as cycle time and mine planning, on the energy used by haul trucks. They determine the optimum values of these parameters to minimise fuel consumption in hauling operations, but they do not consider the three technical key parameters of gross vehicle weight (GVW), total resistance (TR) and truck velocity (V). The research presented by Carmichael et al. [15] is concerned with the effects of haul truck fuel consumption on costs and gas emissions in surface mining operations; however, the simulation used in their research does not include the pertinent factors affecting the fuel consumption.

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http://dx.doi.org/10.1016/j.ijmst.2015.12.015
2095-2686/