Prediction of spontaneous heating susceptibility of Indian coals using soft computing techniques

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ABSTRACT

Coal mine fires due to spontaneous heating have been a great concern both for the industry and researchers worldwide. They not only endanger the lives of men in mines, but also cause considerable economic losses to the organization. Most of these fires could be averted if suitable preventive measures are taken. Since all coals are not susceptible to spontaneous heating to the same extent, its accurate prediction is essential to plan efficient preventive measures and improve production and storage capabilities of a mine. The present paper presents a comparison of two soft computing approaches viz. fuzzy expert system and the commonly used artificial neural networks (ANN) for predicting the self heating of coals. To apply these techniques, a number of coal samples of varying ranks were collected from all the major coalfields of the country. The intrinsic properties of the coal seams were determined by proximate, ultimate and petrographic analyses. The spontaneous heating proneness of the samples was studied using crossing point temperature (CPT), which is used as a measure for fire susceptibility of coal seams in Indian mines. Correlation studies between the intrinsic properties and CPT was carried out to identify the parameters for prediction purpose. Using the constituents of proximate analysis as input parameters, CPT is predicted using fuzzy logic based on Takagi-Sugeno-Kang (TSK) model and ANN based on back propagation algorithm. The results show both the models predict CPT with reasonable accuracy.

Keywords: Mine fire, Spontaneous heating; Coal; Crossing point temperature; Fuzzy expert system; Artificial neural network

INTRODUCTION

Coal mine fires have been a great concern both for the industry and researchers worldwide. Studies carried out by different researchers reveal that in most of the cases, they are caused by spontaneous heating of coal (Feng et al., 1973; Saghafi and Carras, 1997; Sensogut and Cinar, 2000). It is known that all coals, when exposed to air, undergo natural oxidation even at ambient temperatures. Oxygen is adsorbed by a purely physical process, which rapidly converts into a chemical chain reaction resulting in the oxidation of certain constituents of coal with the evolution of small quantity of heat. If this heat is not dissipated either by conduction or convection or radiation or by all three processes, then there occurs further rise in temperature, which accelerates the rate of oxygen sorption and production of heat, culminating in fire.

Spontaneous combustion of coal can lead to loss of desirable coal properties and products, creates environmental pollution, agricultural land degradation, and raise concerns about safety and economic aspects of mining especially in coal stockpiles, transportation over long distances, and in underground mining etc. It is well known that spontaneous heating of coal depends mainly on two types of factors, such as intrinsic and extrinsic. The intrinsic parameters are mainly associated with the nature of the coal, i.e. its physico-chemical characteristics, petrographic distribution and mineral make up. On the other hand, the extrinsic parameters are related to atmospheric, geological and mining conditions prevailing during extraction of coal seams and these are mainly site specific.

Most mine fires start very small and gradually expand in size. Most of these fires could be averted if suitable preventive measures are taken. Accurate prediction of self heating