ABSTRACT

Coal mill is an essential component of coal fired power plant, which grinds the coal into fine powder and provides pulverized coal for efficient combustion. They can be a bottleneck in plant operation as the performance of the overall plant is greatly influenced by the mill downtime. Frequent changes in coal properties such as moisture, poor controls and several faults occurring in the mills are the major concerns affecting the efficiency of the milling system. It is required to closely monitor the operation of the milling system and isolate any abnormality in time. Currently, the operational issues in various equipments are identified by the judgement of experienced plant operators. As the information received at the control centre is huge, it is hard for the technical staff to analyze the data properly and take corrective measures in time to improve the availability and operation of the plant.

The main objective of the work is design and development of a novel method for intelligent decision support system for detection and diagnosis of common faults in the mills namely choking, coal shortage, and mill fire. Realizing the impact of high coal moisture on the combustion and availability of mills, a soft sensor for online estimation of moisture is also designed. It is realized that an automated early detection and diagnosis of mill faults can lead to significant savings due to reduction in maintenance costs and production losses. It ensures increased reliability and reduces the challenges involved in operation of the mills. A deeper review of the earlier works reveals that the works on fault detection and diagnosis (FDD) and soft sensing for mills are constrained by simplified models of coal mill employed for simulating the behaviour of mills under normal conditions. Further, the previous works focussed only on one fault and failed to provide any information regarding the severity and cause of the fault. It is also noticed that abundant literature is available in the area of FDD but their applicability and adaptation in the actual plants is limited.

In this work, firstly, an improved gray box dynamic model of coal milling system is derived to replicate the behaviour of coal mills under different operating conditions. The model is formulated using first principle conservation laws of mass and heat balance and plant data is utilized for estimating the unknown model parameters. The effectiveness of the model under start up, steady state, shutdown, and transient load change conditions is evaluated using data obtained from two actual power plants in India. The developed model is utilized for designing a cost effective soft sensor for online prediction of moisture content in
coal, which is presently determined only once per day using time consuming laboratory tests. Extended Kalman filter (EKF) based state estimation is selected and the results show that the online predictions by the soft sensor are in close agreement with the directional trend of per day moisture value.

A novel model based residual evaluation approach involving intelligent decision support system is considered for the purpose of early fault detection and diagnosis in mills. The work presents an intuitive application of fuzzy logic and probability theory where they are used in conjunction to solve the overall problem. The major symptoms, and causes for various faults in the mill are identified based on available literature and discussion with experienced plant operators. Knowledge base for these faults is built and fuzzy rule based system is designed for identifying the type, and severity of the faults. As the corrective action to be taken depends on the root cause of the problem, support for troubleshooting the root cause is also provided using Bayesian networks. Several steps are included to make the proposed mill FDD system fit for the real time plant deployment. The need of data preprocessing for improving data quality and adaptive learning of the model to evolve with slowly drifting measurements is discussed. Appropriate methods are chosen for these steps based on the nature of coal mill system. Simple methods are found to be suitable for missing values and obvious outlier treatment, while an elaborate method based on wavelet transform is selected for reducing the noise in the data. CUSUM based control charts are suggested for monitoring the slow evolving drift due to wear in the mill. Model parameters are retrained once change detection method issues an alert.

In order to develop a field worthy system that is relevant for real time applications, actual data from two different coal fired power plants in India is collected and used for validating the work. The performance of the proposed mill FDD system is computed using normal and faulty data obtained from mills of these plants. Total 47 fault cases and 150 randomly selected one day normal data are selected for quantifying the performance of the proposed algorithm. Ten case studies are detailed to demonstrate the capability of the proposed method. The validation results using actual plant data are found to be promising, which confirms that the proposed algorithm is effective for real time online FDD in power plant coal mills.