

Preface

The ideas of reliability, availability, and maintainability aid in the development of methods for enhancing system performance and safety. To keep pace with the increasing demand for raw materials, the mining industry is rapidly expanding with intense mechanization and automation, which urges due importance on reliability, availability, and maintainability. While maintenance analysis deals with the cost implications across the operating life of the system or product, reliability analysis helps to manage system failures. Draglines are popular capital-intensive equipment in high productive surface mines and failures of a dragline have a significant impact on mine productivity. Draglines should have higher reliability for the smooth operation of open cast mines. This research aimed at the reliability study and failure diagnosis of draglines using a Bayesian Network (BN) model and identified the critical subsystems that affect the reliability. The reliability of the critical subsystem has been studied using the Dynamic Bayesian Network (DBN) model and the critical components of the subsystem are recognised. A preventive maintenance policy has been established for the components of the critical subsystems which helps to schedule the maintenance of the components and enhanced the overall reliability and performance of the dragline. The proposed methodology has been illustrated with a case study.

Failure data for the period January 2011 to April 2015 of the dragline 'X', operating in an Indian surface coal mine, were collected for the present analysis. The dragline was decomposed into seven subsystems called bucket & accessories, dragging, rigging, hoisting, swinging, electrical auxiliary, and others. Data have been classified to calculate Time to Failures (TTF) data of each subsystem and component of the dragline. Statistical analysis of TTF data gives the parameters

of the best fit theoretical distribution. The reliability of a draglines system has been evaluated using the Bayesian network model mapped from the Fault tree. The prior probability of each component (parent) node in the BN model is calculated using the parameters of the Weibull distribution's at time $t=1$ hrs. The reliability of the dragline system has been estimated based on BN forward inference. The joint probability distribution for the developed BN model estimates reliability of the dragline system 62.03%, at $t = 1$ hour. The posterior probabilities are estimated from backward inference using the evidence on the BN model. . It can be seen that the dragging mechanism is the most critical subsystem having the lowest posterior probability (reliability) of 53.04%. While the electrical auxiliary is the second most critical subsystem, and the swing mechanism is seen to be the third most critical subsystem with a posterior probability of 68.35% and 77.08%, respectively. The accuracy of the BN model is 83.15% when it is only 71.07% in FTA. The dragging mechanism is the most critical subsystem to operate the dragline smoothly. The Dynamic Bayesian Network (DBN) model of the dragging mechanism has been mapped from the Fault tree. The overall reliability of the dragging mechanism is 84.29% at 1hr running of the case study dragline. It has been observed that the Drag motors contributes about 26% of drag mechanism failures, while the failures of power supply , drag brake and drag socket share 18.04% , 15.72% and 13.6%) respectively. The DBN model has been validated using a three-axiom-based validation approach.

Maintenance is a crucial part of ensuring the equipment operates normally. Maintenance policy has been framed for the components of the critical subsystem. An imperfect PM model for repairable components and an interval-based reliability-centred preventive replacement of non-repairable components are recommended. A cost rate optimization model has been used to estimate the optimum frequency of maintenance at a minimum cost rate, and the preventive

maintenance interval is prescribed. . Using Monte Carlo simulation, it has been estimated that within a limited use time, the optimum maintenance frequency is 2 when the cost rate reaches a minimum, of Rs. 37548 per hr for drag motors. Thus the corresponding maintenance interval is 4000hrs. A replacement policy for a non-repairable component has been established using the characteristic life and MTTF of the component. This study suggests the interval between characteristic life and mean life of a component is a favourable time for opportunistic preventive replacement and scheduled preventive replacement thereafter. The characteristic life of the drag rope and chain has been estimated using the parameters of the best fit Weibull distribution and are 751.4251hrs and 433.3874hrs respectively while the MTTF value of the drag rope and drag chain are 4508.55hrs and 2600.25hrs, respectively. This study suggests an opportunistic preventive replacement of the drag rope between 751hr – 4508 hrs. Otherwise, components replace drag ropes after 4508 hrs of use to avoid undue down time. These results are useful information for inventory management.