ADVANCED FUNCTIONAL MAINTENANCE MANAGEMENT FOR MINING EXCAVATOR

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ABSTRACT

The concept of advanced maintenance management technique in the field of heavy duty mining machinery/equipment has recently been developed in India. This maintenance concept has the significance of creating a support system for mining equipment functioning. Functional maintenance is one of the most frequently used methods in maintenance management for mining industries. Management of a custom built maintenance system is the need of the day because of large capital, productivity and risk involved with the mining machinery (excavators) in a high capital intensive industrial scenario with acute sensitivity in the performance of such machines.

This paper tries to present some aspects related to the systemic approach of the functional maintenance model, starting from technical elements of the maintenance process to economical perspective of the maintenance process i.e. maintenance-related expenditure or, in other words, to develop an effective maintenance methodologies of mining machinery such that the different maintenance costs are minimized and technical constraints are efficiently monitored and maintained. Based on the above factors maintenance plans are prepared, formulated and implemented. The final part of the paper presents a systemic method of representation of the model, taking into account the two mentioned aspects.

Keywords: Functional Maintenance, Maintenance Management, Economical Aspect, Maintenance Simulation Model

1.0 INTRODUCTION

The theoretical and practical basis of the need for a mining machinery maintenance system relates to the following aspects:

- The functional maintenance of mining equipment represents a component of the mines function, but with independent tasks and responsibilities. A connection must be established between advanced technologies and equipments maintenance. The economical efficiency of maintenance and
Interventions activities must be linked to the real mines productivity and the quality of mining machinery. The functional maintenance model considers mining equipment maintenance as an integrated function of the mining processes and mining conditions. Technological analysis of the technology being used relates to two main groups – mines production and maintenance and intervention technologies for the mining equipments.

Gaps in the correlation between the two technology groups mentioned above can generate production loss, quality decrease, cost increase and overall efficiency reduction. By using this model, a strong correlation between the two groups is ensured – applying advanced technologies implies immediate modernization of the maintenance and intervention technologies.

1.1 Mining activities management, in relation to equipment maintenance and intervention:

For equipment maintenance and intervention, different methodologies are used so that the maintenance cost is minimized and technical constraints (such as engine, hydraulic and transmission system, break system, electrical and safety system, suspension and track) are efficiently monitored and maintained. These technical constraints depends upon many factors such as a) Geotechnical parameters, b) Geological parameters, c) Mine parameters, d) Production rate, e) Equipment specification and f) Dig ability assessment etc.

Based on the above factors maintenance plans are prepared for predicting equipment / component failures.

For component failure detection, which is performed continuously, we can use data similar to that monitored by protective devices to detect abnormalities in behavior.

This implies the design and implementation of methods and techniques that ensure the accomplishment of fundamental objectives of functional maintenance such as:

- Recording statistics in relation to technological equipment functioning quality;
- Using new monitoring techniques such as vibration measurement, temperature recording or oil analysis or, through various sensors.

Design and development of a specific informational system that acts as a synthesis tool that allows the monitoring of main activities and the assessment of the risk of each scenario. This subsystem has to keep up-to-date the dashboard of the maintenance responsible by:

- Grouping all relevant information in relation to programmed activities;
- Presenting in a structured manner the information required for technical and economical analyses;

1.2 by using the new maintenance model in mining, following results are expected:

- Using a preventive/predictive/expert maintenance system that would allow a better monitoring of current equipment wear, weak spots detection, usage uncertainty and defects prevention;
- Increasing the quality of maintenance and intervention activities;
- Optimal exploitation of technological equipment, according to their technical specifications.

1.3 The Expert System (optimization methods) is based on mathematical / simulation model:

The optimization methods are based on network timeline, simulations, statistical and mathematical analyses, data mining, genetic algorithm, neural network cost optimization etc:

- Using modern techniques to establish wear degree for different components of sub-components of the equipment undergoing repair (mechanical, electrical and hydraulic repair).
- Using an operative information sub-system (Expert System) that will take over all information regarding repairs but that can also provide employees with the information they require.
Expert System: This is one of the first systems planned for optimizing equipments in open cast mining in 1987. The main reasons described for using the expert system were the intense need of equipment selection process, past expertise, experiences and some of the effective parameters being qualitative hence; it tried to show the whole process of change of human experiences to an understandable language for computer in the field of mining equipments maintenance. This system is able to involve the expert knowledge in primary and secondary maintenance technique of equipment for open cast mines. In 1990, another expert system, in order to classify equipment, was planned in the open pit coal mine of Britain with the help of fuzzy logic. This expert system, for primary extraction method, employed drilling and hauling equipments and could receive geological information from software like SUPAC and DATAMINE. Data related to mine equipment is summoned from an external database. The developmental process of expert system continued in 1992, yet another system was planned for equipment needed for a project with soil conditions that includes 930 rules. This system was able to select equipments necessary for drilling, loading, hauling, placing and compacting earth and the proposed data consisted of bulldozer, scrapper, loader, trucks and excavators. For each type of equipment selected, there are unique qualities that must be considered (such as power, size, application etc.). The developed expert system can be used for earth-moving projects ranging in scope from 10,000 to 4,000,000 bank cu yd. Yet another expert system was presented in 2002 that had basic differences with previous ones such as its interference to the uncertainty related to influential factors in the matter selections. This system was much reflective and apart from calculating uncertainty ratio, it permitted user to determine the rate of important elements in selecting equipments. Some other expert systems have also been proposed for equipments maintenance, in which, proper selection system of functional maintenance are important.

2.0 SYSTEMIC APPROACH ON FUNCTIONAL MAINTENANCE MANAGEMENT:

The functioning of technological equipment in specific safety conditions implies: a technological preparation of interventions based on real and complete knowledge of the equipment wear, planned monitoring of safety status by periodical technical inspections, professional training of the personnel etc.

The fundamental components of the functional maintenance model include:

- Management of maintenance and intervention activities;
- The actual technological process of maintenance and intervention activities
- The existence of an information sub-system with a database of processed data that ensures the connection between the managing system and the managed system.
- Economical analysis of maintenance expenditures and analysis of methods to recover such expenditures in the course of the production section.

2.1 Evolution based on controlled action:

The evolution of the system in a specific direction under the influence of certain positive constraints can be adjusted based on control actions such as:

- Planned periodic technical inspection that must aim to detect weak spots of the equipment undergoing monitoring;
- Operative monitoring of repairs for which there has been a network-graph developed based on critical path;
- Operative monitoring of capacity loading for the manufacturing of spare parts for the existent equipments;
- Monitoring the evolution of spare parts consumption;
- Economical analysis of maintenance and intervention costs for each equipment.
Functional Maintenance

Maintenance System

Preventive and corrective maintenance subsystem

Spare parts subsystem

Predictive

Condition based monitoring system

Defect monitoring system based on expert system

Planning, preparing, programming, launching and monitoring

Technical inspection based on electrical, Mechanical and hydraulic

Revisions and repairing

Spare parts manufacturing and it management

Weak spots discovery

Exploitation uncertainties solving

Redundant equipment

Ensuring optimum spare parts stock based on critical items check list

Technical Analysis based on Technical

Dig ability condition, mines safety and mining machinery design

Fig-1: Functional Maintenance and repair system design
The maintenance and intervention system (figure 1): that includes: preventive and corrective maintenance components, spare parts and defects; programming, preparation and monitoring of activities; execution of specific interventions; objective controlling; technical analysis of activity execution.

Fig-2: Economical activities system related to the functional maintenance and repair system design
The economical system (figure 2): that includes: monitoring maintenance expenditures and including them in the approved budget, identifying intervention with high costs and costs of defects. The two types of analyses – technical and economical – will lead to the development of an optimum solution in relation to the decision regarding each equipment maintenance and repair.

Fig-3: Functional Maintenance Simulation Model
The economical concept of functional maintenance implies that decisions related to interventions are based on the following criteria:

- Safety of operation, criteria that has no constraints and does not take into account the duration or cost of intervention;
- Preset budget for maintenance expenditures as well as the cost for interventions has to be included in the general budget approved by the section management;
- The duration of interventions is variable; thus some interventions can be requested as an emergency in this case the budget being not set. Optimization requirements are subordinated to the criteria related to the duration of the respective intervention.

The Model implies in most cases a decision-making process related to maintenance and repair interventions based on the correlation of the three fore-mentioned criteria.

From an economical point of view, maintenance costs (Cm) depend on a functional level on:

- The duration of the mining equipment in a safety state (Ts);
- The moment of replacing the worn equipment (M);
- The evaluation of the necessary budget for equipment maintenance for its entire exploitation period (Fe).

The functional relation of expenditure with system maintenance is thus: Cm= f (Ts; M; Fe). A structuring model for the functional maintenance and intervention model is presented in figures 1 and 2.

**Functional Model Simulation model (Figure 3):** For optimal solution in relation to the decision regarding mining equipment maintenance, simulation model must be prepared for final maintenance analysis.

**CONCLUSIONS**

In the actual economic context, using modern maintenance models that are supported by an adequate computerized maintenance management system such as data mining and expert system that can ensure an increased efficiency of mining equipment. To accomplish this, a significant level of attention must be given to such maintenance models by the management of the organization.

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