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RELIABILITY AND MAINTAINABILITY STUDIES ON ELECTRICAL DRIVES WITH PARTICULAR REFERENCE TO CAPITAL INTENSIVE HEAVY COAL MINING MACHINERIES

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ABSTRACT: Collection of accurate and sufficient failure and repair data is necessary in machine reliability and performance analysis for achieving accurate results that are really helpful for mine management in decision making. Data collected from the field are assumed to be the most realistic. Field data are, however, tedious and time consuming to collect and subject to discrepancy. Again, data are required to be collected over a period of time for providing satisfactory representation of the true operational characterization of the machine. The authors have wide experience of mine environmental and closely involved with SDL operation in the past. Failure and repair data are recorded on the operation sheet and maintenance log book at each shift. The study was held at nearby underground mine owned by BCCL. The machine deployed in development heading for loading in tubs discharging the loads sideways mostly in level and rise galleries. Initial phase is by collecting the data regarding the operation schedule of SDL machine for a period of six months during the month of November-2014 to April-2015 were taken. The machine under investigation is in operation for past 17 months. Then data is sorted and classified based for each subsystem on number of failures, failure date, failure modes, type of failure, machine run hours, duration of maintenance, type of maintenance action , breakdown hours and repair hours.

KEYWORDS: Reliability, Maintainability, Drives, Machineries, Coal, Electrical.

INTRODUCTION

Reliability, maintainability and availability performance of a system have assumed great significance in recent years due to a competitive environment and overall operating and production costs. Today's technological systems, such as aircraft, nuclear power plants, military installations, advanced medical equipment, and mining equipment are characterized by a high level of complexity. The requirements for the availability and reliability of such systems are very high.

Mining history can be traced back many thousand years. The methods and equipment used was inefficient and required many workers for a small amount of goods. Today's situation is different. Mining equipment is more efficient and the turnover is in the billions. The money spent on equipment and expertise is vast and increasing. This creates a need for improvement of the already efficient process of extracting goods. The expenditure is increasing, and the demand for high quality and quantity of goods is increasing (Dhillon, 2008). The increasing need for energy and to keep expenditure low creates a need to optimize production lines. This process is more complex and challenging than before. There is an expectation that machinery, equipment and technology are supposed to be available at all times, ready for use and have a high performance. In some areas the industry is harder to improve, the cost of improvement work can seem high because the reward is not obvious at first. It may therefore be very hard to increase the reliability or availability of a system in the mining industry (Aven, 2006). The machinery is increasing in complexity and size, which adds to the list of challenges in mining industry.

Economic is important in today's industry, with the correct use one can gain high reliability which cause the maintenance cost to lower and therefore increase the profit (Barabady et al., 2008).

A method to improve this can be to imply an availability and reliability approach in order to increase the availability of the production line. The use of this method can save resources in many aspects, like logistic, unnecessary repairs, more production time etc. By using a reliability analysis the knowledge of a

system increases, with this knowledge one is more capable of making decisions when changing the system or operating circumstances (Aven, 2006).

RESEARCH PROBLEM

The mining equipment is increasing in size and complexity, and this demands a higher level of performance and reliability of such equipment (Dhillon, 2008). According to Blischke and Murthy (2003) the consequences of failure are many and varied; depending on the item and the stakeholders involved, but nearly every failure has an economic impact. A failure in equipment or facility results not only in loss of productivity, but also in loss of quality, timely services to customers, and may even lead to safety and environmental problems which destroy the company image. For example, the consequences of failures can be of such a degree that the system is not profitable and therefore not used, causing loss of potential workplaces and industrial expansion. Therefore, optimizing and improving of the performance of a mine production line is more demanding and complex than ever. In order to improve a system, it needs to be analyzed. Which analyses one uses depends on what result is needed. Improving the systems performance means achieving maximum production that the system can handle. However, there is a cost to improving system. So improvement should be done where it increase the profitability.

RESEARCH APPROACH AND PURPOSE

The research purpose for any researcher is related to what kind of result the research work should produce. A researcher can try to explore, describe, explain, understand, predict, change, evaluate and assess impacts (Blaikie, 2010). This research should formulate and answer questions based on the research. The purpose of this research is to better understand the failures and reliability of mining equipment in the Svea coal mine. The research approach can affect the research greatly and it is important to formulate the purpose of the study. It is therefore important to know, understand and evaluate which method is the most suitable for a research study.

Table 1 – Different research approach methods (Blaikie, 2010)

	Inductive	Deductive	Reproductive	Abductive
Aim:	To establish descriptions of characteristics and patterns	To test theories, to eliminate false ones and corroborate the survivor	To discover underlying mechanisms to explain observed regularities	To describe and understand social life in term of social factors, meanings and motives
Ontology:	Cautious, dept or subtle realist	Cautious or subtle realist	Depth or subtle realist	Idealist or subtle realist
Epistemology:	Conventionalism	Falsificationism Conventionalism	Neo-realism	Constructionism
Start:	Collect data on characteristics and/or patterns. Produce description	Identify a regularity that needs to be explained Construct a theory and deduce hypotheses	Document and model a regularity and motives Describe context and possible mechanisms	Discover everyday lay concepts, meanings Produce a technical account from lay accounts
Finish:	Relate these to the research questions	Test hypotheses by matching them with data explanation in that context	Establish which mechanism(s) provide(s) the best answer	Develop a theory and elaborate it iteratively

Table 1 presents some of the different types of research methods. There are many more methods, but the most common ones are presented in the table. For this research study, a mix between the inductive, deductive and abductive method has been used. The reason for this is that already stated methods have been used.

It includes data collection and data processing. But the research study tries to provide a new view of covariate effect on equipment view.

CUTTING MACHINERY

Figure 13 presents the normal method for long wall mining. There is a pre-cut tunnel that the Shearer is moved into. The shearer then works back on forth cutting coal, moving after the coal layer. The pistons as shown in the figure let the rock collapse behind all the equipment. The coal that is cut from the Shearer is transported out of the mine using different types of conveyors.

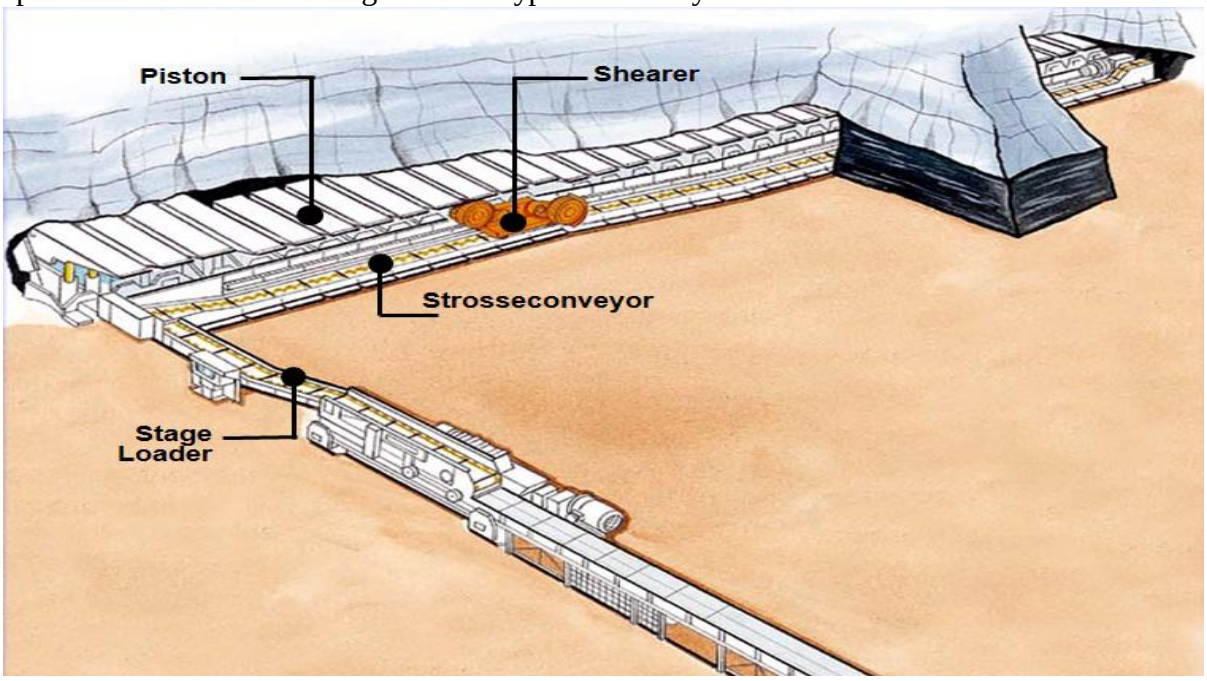

Figure 1 – Long wall mining components

Then the Bolters secure the roof and walls by bolting it in order to not have a fracture in the walls. Then this process is repeated. The main function of the Mine Bolter is to prepare travelling ways or a new face for the shearer. The continuous miner (CM) has the same purpose and function as the Mine Bolter, the difference is that this is one machine, doing the bolting and mining at the same time.

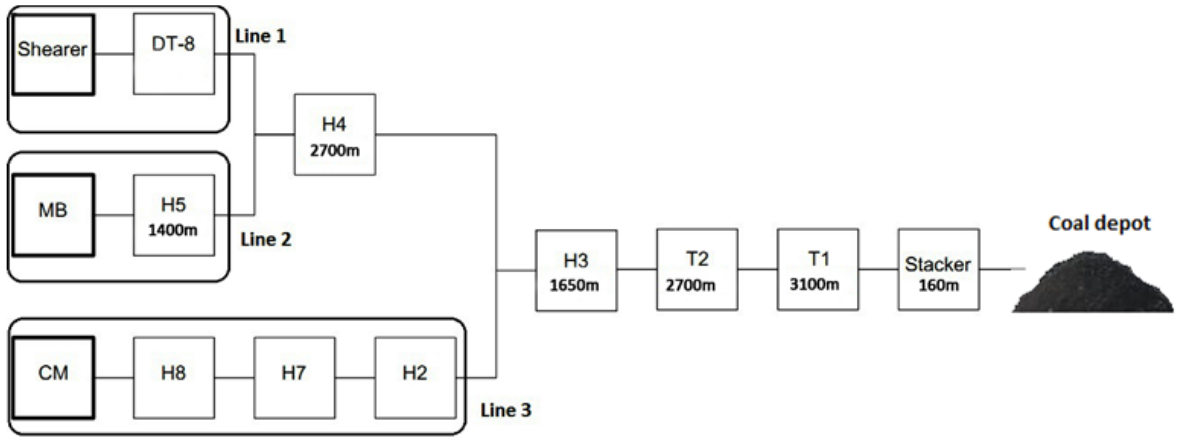

Figure 2

CONVEYORS

As in many other long wall mines there are several conveyors that are changed, moved and serve different purposes. The objective of the conveyor is to transport the coal from cutting machinery, Shearer, MB and CM. SNSK claim to have enough spare parts at any given time to build a new conveyor system, therefore spare parts are assumed to be available and in storage at all times. The maintenance at Svea is a two part phase that will be discussed more. During down time of the system, maintenance crews take oil samples and do vibration tests and use infrared cameras. This is to make decisions about whether or not they should do maintenance one specific equipment. By these means, one can say that both the maintainability and supportability seems to be in a good nature.

Figure – 3

Table-1: Relationship between reliability, maintainability and availability

Reliability	Maintainability	Availability
Constant	Decreases	Decreases
Constant	Increases	Increases
Increases	Constant	Increases
Decreases	Constant	Decreases

TREND TEST AND SERIAL CORRELATION TEST

Trend test can be done using graphical method as shown in figure-18. Trend test involves the cumulative frequencies over cumulative time.

If the curve shows a concave upwards, the data indicates an improving system. If the data shows a concave downward, the data indicates a deteriorating system. If the curve shows approximately a straight line, then the data is identically distributed or free from trends. Serial correlation test also can be performed graphically by plotting TBF or TTR i th with TBF or TTR (i-1)th with i=1, 2, 3,…. n. If the points are normally scattered without any clear pattern, it may be concluded that the data are free from serial correlation or independent.

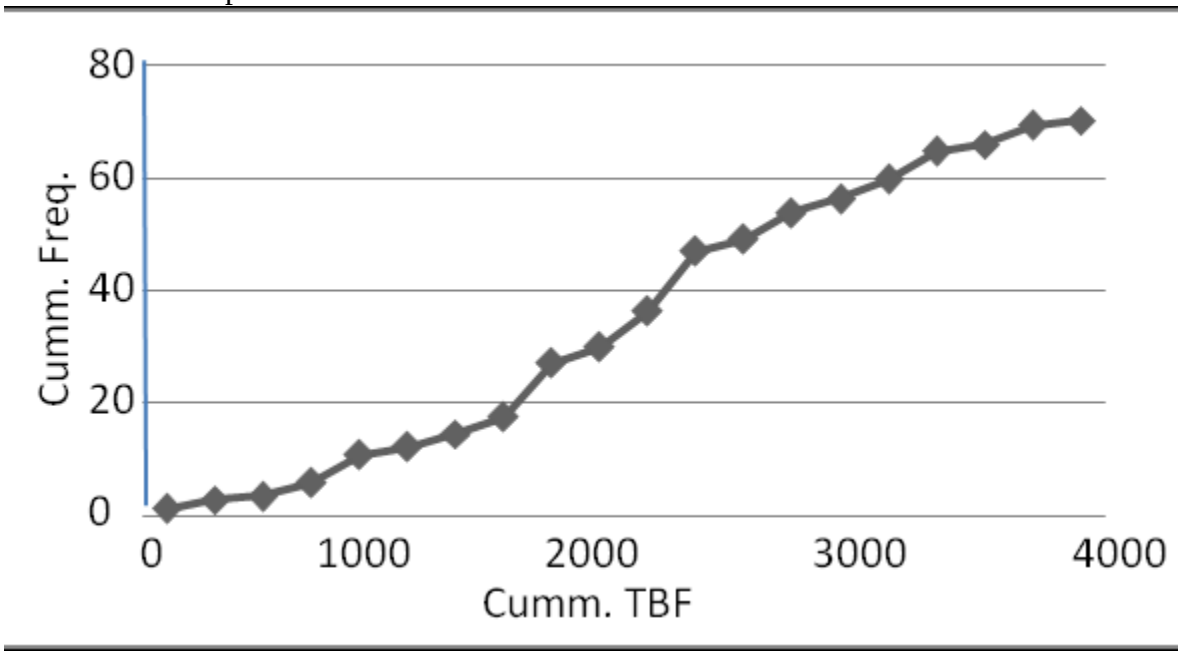

Figure -4

CONCLUSIONS

Based on the previously discussed chapters, it can be concluded that the research produced the following results. Improvement of the data collection should be done It may seem like the bulk of maintenance is done as correctively, as known, this maintenance is unscheduled and unplanned. It may therefore be a high cost related to the high frequency of failure. Maintenance costs may by lowered by increasing the preventive work for the conveyors. With these conclusions it could make an argument that a considerable amount of money can be saved by improving the reliability more as there is many repair operations. From the discussion that by improving the Stacker to the same level as the other conveyors, a considerable amount of money can be saved. The effects of operational conditions were found to be

significant for the Stacker. This should be improved. Generally there are two options for improving the Stacker, increase the maintenance of the work during winter season or winterize the Stacker. A mix of these can also be used. However, the cost of improvement should be considered for the decision. Data collection in Svea should improve in order to make a more accurate analysis. The available data is good enough to do an analysis, but the accuracy of the analysis may be inaccurate. An argument for this statement is the fact that the unknown cause of failure ranks high both in components and in system reports. Also, the fact that sometimes the time of failure is not recorded should be included in the reports. An interesting subject to research and for the company should be to collect covariate data for the Stacker and other equipment in the mine. In order to study the operational conditions effect on the performance of equipment, the result of such an analysis can contribute to make better decision making with respect to operations and maintenance planning and optimization of the equipment.

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