TRANSPORTATION SYSTEM BOTTLENECK DETECTION THROUGH AVAILABILITY IMPORTANCE MEASURE IN GOLGOHAR IRON MINE

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Abstract: Dump trucks are the main hauling pieces of equipment in the open pit mines. Management of this heavy duty equipment is crucial, therefore technical characteristic of such equipment in various operation conditions needs to be identified. The "Importance measure" approach is one of the useful methods that prioritizes the components in order of important in the system performance. Reliability, availability, and maintainability (RAM) importance measure by analyzing up and down time prioritizes components and detects the bottleneck of system. In this paper, a comprehensive approach is proposed based on the availability importance measure in order to increase the performance of equipment. After that, a dump truck data is used as a case study. In this truck, transmission and body subsystems were respectively identified as the most and the least important subsystems from an availability point of view. Also, the transmission maintainability made a major contribution toward increasing the system availability.

Keywords: Availaility, Reliaility, Maintainability, Importance Measure

INTRODUCTION

Throughput capacity (TC) of mining equipment depends on their availability, utilization and production performance. In terms of smooth production, availability is more important than the other two. Therefore, availability is known as a comprehensive metric for equipment management which is a combination of reliability and maintainability.

Since various components have their own availability, each affect the system availability differently. Therefore, identification of the critical one is a main task for weak point detection and resource allocation. Accordingly, Importance Measure (IM) approach has been introduced in 1968 in order to detection critical components from reliability perspective.

Management of mining equipment through technical characteristics have been studied since 1980. Kumar at el. were the pioneers of RAM analysis in the mining field. They have investigated reliability, availability and maintainability of Load-Haul-Dump (LHD) machines. They have stated that RAM analysis must be done in order to achieve better results in mining equipment. Less reliable items have been identified by Baraby's research in Jajarm bauxite mine . Maintenance management and identifying critical subsystem from reliability perspective of wagon drill by reliability analysis have investigated in the various studies. Dump trucks are the main haulage system in open pit mines. Reliability modelling and availability simulation in order to critical subsystem assessment and maintenance management of dump truck have been discussed in some research.

Surveying the literature clearly indicated that such studies gains useful information. In the literature, critical analysis has been carried out from reliability point of view. Availability improvement of candidate subsystem(s) in the equipment level have not been investigated. Therefore, this paper explores the weakness point of a dump truck, taking availability

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perspective, and recommends the best improvement strategy through increasing reliability or maintainability.

In this paper, RAM characteristics of a truck subsystems were estimated. After that, using the importance measure, candidate subsystem for improvement was identified and finally, the best strategy was selected through increasing reliability or maintainability.

METHODS

Flowchart of increasing uptime of an item of equipment using RAM analysis is shown in Fig.1.

Phase 1: database formation

Study level (fleet, equipment, component, etc.) and data constrant are two main factors in the boundary definition. Statistical methods represent wrong conclusion in case of small data set, for which the Bayesian method was used.

Phase 2: model selection

Reliability and maintainability modelling through renewal process (RP), homogeneous poisson process (HPP) and non-homogeneous poisson process (NHPP) must be selected using trend and autocorrelation tests.

Phase 3: Technical characteristic of system

After model selection, the reliability and maintainability of components must be estimated using selected model and corresponding parameters.

Phase 4: Priorities of components

In the literature, various equations have been proposed for bottleneck detection of systems. According to the structure of studied system, one of them can be used accordingly. Finally, the best strategy for system improvement can be selected through availability importance measure based on reliability and maintainability.

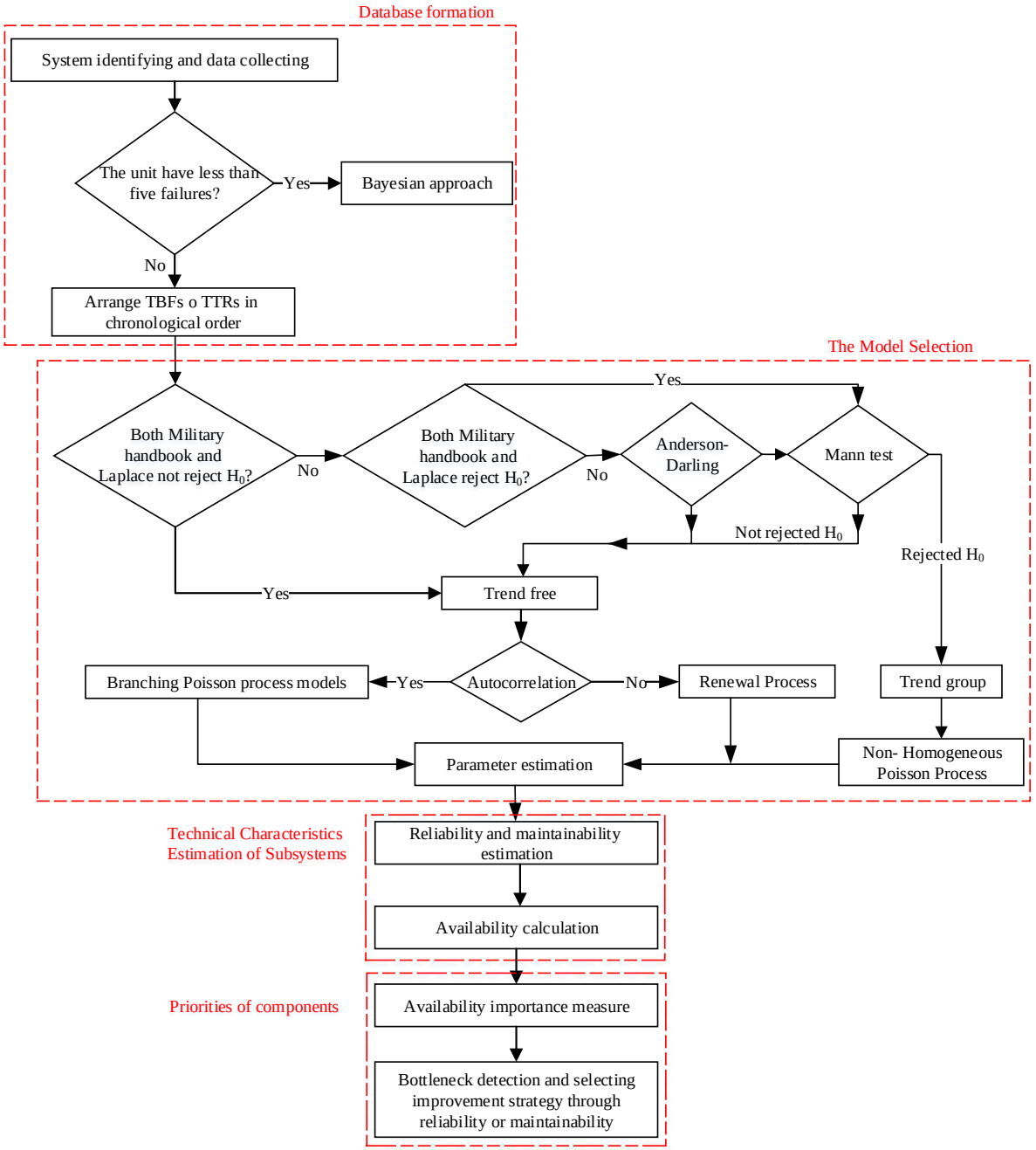

Figure 1- Flowchart of priorities subsystems in an item of equipment

FINDINGS AND ARGUMENT

Using the methodology proposed in Fig.1, a dump truck from golgohar mine has been studied. The truck has been divided into 6 subsystems, and the required data was collected, sorted, and arranged in the required format. Technical characteristics of the truck's subsystems have been analysed through the best aforementioned models, as a result, the less reliable and maintainable subsytems have been identified.

This system consists of 5 subsystem in series. So the availability of each one has been estimated using reliability and maintainability. Subsystems and system availability are presented in Table 1.

Table 1- Subsystems availability

Subsystem	MTBF	MTTR	Availability
ENG	357.84	14.37	99.6
TR	802.13	28.78	96.53
EL	572	9.55	98.36
HYD	710.56	3.5	99.51
TY	1564	33.657	97.89
BO	785.2	2.288	99.71
System availability			92.08

Detection of the bottleneck subsystem of a dump truck from an availability point of view and therefore selecting the best strategy in order to improve the availability have been explored using importance measure.

Table 2 shows availability importance (IA), reliability-based availability importance (IA,MTBF), maintainability-based availability importane (IA,MTTR) of components. As it can be seen in Table 2, TR and BO subsystems are respectively the most and the least important subsystems from an availability point of view. Therefore, resources should be allocated to TR subsystem. According to Table 2 (colmun 3 and colmun 4) in order to select the best strategy for TR availability improvement, it is preferred to increase the reliability.

Table 2- availability importance measure, availability importance measure based on reliability and maintainability

Subsystem	IA	IA,MTBF	IA,MTTR	NIA%	NIA,MTBF%	NIA,MTTR%
ENG	۰,۸۵٤۷	۰,۰۰۰۲٤	۰,۰۰۰۰۰۰۹٦	۱٦,۳۳	٤,۲٥	۱,۱۳
TR	۰,۹۰۹۹	۰,۰۰۱۰٦	۰,۰۰۰۰۳۸۰٤	۱۷,۳۸	۱۸,۹	٤٥,٦
EL	۰,۸۷٦٤	۰,۰۰۱٤۸	۰,۰۰۰۰۲٤۷٤	۱٦,۷٤	۲٦,٥۱	۲۹,۳۱
HYD	۰,۸٥٦۲	۰,۰۰۱۱۹	۰,۰۰۰۰۰٥۸۸	۱٦,۳٦	۲۱,۳٤	٦,۹٦
TY	۰,۸۸٤۸	۰,۰۰۰٥٤	۰,۰۰۰۰۱۱٦۷	۱٦,۹	۹,٦۹	۱۳,۸۲
BO	۰,۸٥۲۷	۰,۰۰۱۰۸	۰,۰۰۰۰۰۳۱٥	۱٦,۲۹	۱۹,۳۱	۳,۷۳

CONCLUSIONS

Performance of mining industry depends on its equipment performance. Therefore in this paper a guideline was proposed for improving the availability of a truck. This procedure was implemented for each piece of equipment to improve their availability. Results showed that from an availability point of view, the truck transmission subsystem was more critical. So, reliability and maintainability improvement was compared for improving the availability. According to the results, reliability improvement of the transmission subsystem was proposed and reliability centred maintenance (RCM) proved to be an effective approach.

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