A Literature Review of Power Station Systems Maintenance Performance

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Abstract

Today's power station systems are commonly installed as outdoor operational systems. With the increasing complexity and operational advanced manufacturing technologies, the maintenance of these technologies is becoming very effective on the ability of the organization to compete. Motivated by the increasing significance of the different facets of maintenance in today's outdoor system manufacturing organizations (renewable power stations), the objective of this research is to systematically examine the literature dealing with the maintenance performance and their effects. Specifically, this literature review focuses on maintenance performance effect on the system design configurations (in/outdoor system). A different researches on maintenance performance effects, was utilized for the purpose of this research. As a result of this literature review, three field in maintenance performance effects are investigated. The most complexity field is the outdoor system effect on maintenance performance one. It's commonly known that the configuration of the outdoor system design (power station) and the overall system performance are affected by some environmental factors. Other literature review fields cover the research work which has investigated the effect of maintenance performance on system design out maintenance (DOM) and system preventive maintenance(PM) intervals.
This comprehensive review may help researchers to identify the future research opportunities in the field. Also it's been concluded that the findings derived from this investigation can be used to understand the different approaches of maintenance performance effects on system redesign, system preventive maintenance intervals and system design configuration as well as few researches offered an outdoor design configuration (power station) effect on maintenance performance.

Keywords: maintenance performance –outdoor system design configuration – environmental factors.

1- Introduction

Production systems can be designed in many configurations. Different configurations have profound impact on the performance of the system in terms of mean time to failure.

Many of researchers study the effect of manufacturing system configuration as series, parallel or complex system on system performance (Y. Juang[17]) but few of them study the effect of production system configuration as indoor or outdoor system on the system performance specially the maintenance performance (S. Kumar et. al[8]). Systems can be classified based on their interaction with the environment. Outdoor systems exchange information, matter, or energy with their surrounding environments, while indoor systems do not exchange such things. Indoor systems have boundaries that cannot be penetrated by environmental factors.

In the past, most of the researchers focused their efforts only on the maintenance performance on system design that efficiently moves the system from maintenance performance to design. This type of researches filed is referred to as design-out maintenance (DOM) (P. Muganyi[2]). But recently, the effect of systems design configuration has been motivated by some environmental factors as temperature, humidity and rainfall which have given birth to the concept of the effect of system design configuration on maintenance performance .

The effect of maintenance performance on outdoor system design configuration, the system design configuration concept depends on environmental variables which face the outdoor configuration, but the environmental variables changed by high variation on the temperature, humidity and rainfall. So it is more complex than indoor system configuration (J. Renyan et.al [4]).

Some other researchers concluded others work to find frameworks or models that can be used to evaluate different maintenance strategies and determine the value of these frameworks for an organization. (U. Kumar et.al [10]) classified maintenance performance both quantitative and qualitative based. Quantitative approaches include economic and, statistical and partial maintenance productivity indices. Qualitative-based approaches are adopted because of the inherent limitations of effectively measuring a complex function such as maintenance through quantitative models. Maintenance decision makers often come to the best conclusion using heuristics, backed up by qualitative assessment, supported by quantitative measures.

The evolution of performance measures and measurement, as related to the important maintenance organizational function, and its resources, activities, and practices in the current competitive business environment. (J. M. Simões, C. F. Gomes, M. M. Yasin [15]).

2- Systems Maintenance Performance Fields

In the recent years, extensive research work has investigated the systems design configuration. To select the appropriate system design configuration, some constraints should be taken into consideration. An essential system design constrain should be related to the requirements of the system maintenance performance. According to this approach, researches can be classified into three main branches as per Fig. 1.

The subject of this paper stresses the importance to examine the different researches on maintenance performance. In the next section, the literature review is classified into three different categories: a literature review related to the effect of maintenance performance on system design (design–out maintenance) configuration as outdoor system on maintenance performance, a literature review related to the effect of maintenance performance on maintenance policy and another related to the effect of maintenance performance on system design configuration as out/indoor system as shown in Fig. 1.

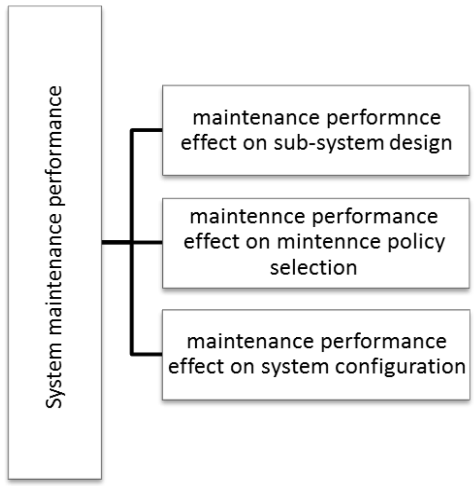

Fig.1 Summary of the related work based on maintenance performance

A- Maintenance Performance effect on subsystems design(design-out maintenance)

Researchers investigated the maintenance performance problems. The researcher's objectives from the design out maintenance are to investigate how to establish a quantitative relation between the maintenance performance problems and the design update as following:
To prevent the frequent gland packing failures that were experienced around the chest agitators machine (P. Muganyi[2]) took a design-out maintenance approach to accomplish a functional facility design modification. He analyzed the possible causes of the static packing failures to establish the causes of the failures and the general guidance was taken. After implementation of the recommended solutions He observed that the design-out maintenance strategy that was applied to solve the problem of high frequency of failure of the agitators' gland packing was effective in improving the MTBF (1 week to 8 weeks) and therefore improving reliability.

For frequently failing bearings of a pump-motor set, which showed poor reliability (P. Gupta[14]) applied design out maintenance. His analysis showed that improper inspection post-manufacturing or lack of emphasis on the manufacturing drawings issued by the design department can lead to low equipment reliability and can create field problems for maintenance personnel. He concluded that the design out maintenance approach applied to the maintenance problem increased the mean time to failure of bearings from 37 days to 2066 days. And (A. K. Jain[9]) applied DOM approach on burning of pot motor and breakages of mechanical parts of pusher mechanism and he achieved a good improvements.

B- Maintenance Performance effect on maintenance policy selection

Researchers investigated the maintenance performance effect on maintenance policy selection. The researcher's objectives from the maintenance performance are to investigate how to establish a quantitative relation between the failure rate and the preventive maintenance scheduling.

For determining the optimal interval for preventive periodical maintenance and an optimal diagnostic parameter for predictive maintenance/replacement (V. Legát[21]) stated that the preventive maintenance influenced the probability of failure and the operational reliability of system elements that have undergone preventive periodical maintenance. He used analytical and simulation computing approaches. His results were in quantitative form, giving relationships between preventive maintenance intervals and reliability functions. (Y. Lian[11]) introduced the relationship between failure modes and maintenance cycle, and preventive maintenance cycle optimization model for the metro vehicle. He analyzed the statistically fault data and determined the fault distribution type of the system. He used the genetic algorithm method to obtain the optimal maintenance cycle.

To reduce the maintenance cost on auto rooting machine in toy manufacturer by developing a scheduled preventive maintenance. (A. L. Maukar [5])proposed a minimum cost model. The result showed that by implementing proposed maintenance schedule the machine reliability has 45% increase and maintenance cost decreases by 48%.

C- Maintenance Performance effect on system configuration(in/outdoor sub-system)

Researchers investigated the outdoor system factors. The researcher's objectives from the outdoor system (renewable power stations) factors are to investigate how to establish a quantitative relation between the failure rate and the main climate variables then how the maintenance workload forecasting and preventive maintenance planning. For the effect of operational environment (as outdoor system design) on the reliability performance, (E. S. Kumar and B. Sarkar[12]) identified the factors which had the most significant influence on the reliability performance of photovoltaic modules and systems and how large is the effect. They used PHM (Proportional Hazards Model) for predicting the effect of environment on the system reliability. They modified the time equation of reliability with incorporating environmental impacts like temperature, wind and snow. (E. S. Kumar and B. Sarkar [8]) studied reliability characteristics of PV modules. They modified the time equation of reliability with incorporating environmental impacts like temperature, wind and snow and remodel the equation with various statistical distributions. (R. Jiang, Y. Liao, and C. Fei[13]) measured the reliability by monthly average MTBF; They described the climate conditions by monthly average temperature, monthly average relative humidity, and monthly average rainfall. The influence of these variables on the reliability of the vehicles was quantitatively analysed. They concluded that the climate conditions have a significant influence on the reliability of the vehicles and the influence could be different in different sites. (J. Renyan, H. Ruizhi and H. Chaoqun[4]) studied the climate condition of a wind farm which has a significant influence on the reliability of wind turbines. The climate condition varies with season in a year and hence the reliability changes in a complex way. They measured the reliability by monthly-averaged mean time between failures (MTBF), they described the climate conditions by variables of monthly-averaged temperature, relative humidity, rainfall and wind speed. They developed a quantitative relation between the MTBF and the climate variables by physics of failure models in accelerated life testing (ALT). They estimated model parameters data by regression, and the insignificant variables are gradually deleted based on the P-value of the regression coefficients.

The principal causes of unreliability are design deficiency, unknown environmental conditions, lack of capacity of parts and equipment also with increase in complexity of the present systems. The effect of various failures such as major failures, catastrophic failure, minor failure, critical human failure and Environmental failure cannot be neglect. The environmental failure mainly occurs due to the operation of the system in unusual conditions which were not considered at the designing stage of system so (S. Kumar[16]) developed a mathematical model for exponential failure and general repairs. He dealt with a 3-state repairable complex system with three types of failure. in order to develop a test method to induce similar failures as observed in service conditions, the effects of differing environmental stresses both separately and concurrently has been studied (J. Kiilunen[7]) studied different methods for test time acceleration for products in different environmental conditions with high reliability requirements and long service lives.

For inducing accelerated moisture degradation within adhesively bonded joints, (W. R. Broughton[23]) evaluated environmental conditioning methods. He estimated the significance and limitation of the durability data generated by single-lap joint and thick adherend tensile tests and evaluates the two methods in terms of fitness for purpose in assessing environmental performance.
For the degree of reliability degradation when the equipment is operated, outside the recommended temperature-humidity range, (K. Pujara[6]) studied the effect of temperature and humidity on corrosion-related hardware failures by studying copper and silver corrosion rates as a function of temperature and humidity. (G. Caswell[18]) assessed the temperature and humidity acceleration factors. He provided technical explanations of the different failure modes and failure mechanisms, specifically with regards to temperature and humidity exposure.
The influence of each of the environmental factors in the process of deterioration of materials induced, of biological processes and frequently of complicated chemical processes resulting from the impact of pollutants and natural constituents from the surrounding environment, (A. Moncmanová[19]) concluded that the principal natural environmental factors affecting the deterioration of materials include, but were not limited to, moisture, temperature, solar radiation, air movement and pressure,

precipitation, chemical and biochemical attack. To estimate reliability metrics for degradation data arising from exposure to outdoor environments (V. Chan[22]) developed two simulation-based methods. He estimated the probability distribution of cumulative degradation in *x* years and the probability distribution of failure time for products that degrade due to weathering. He concluded that the degradation data of this type arise from numerous applications such as crack growth of a mechanical part in automobiles due to variation in driving conditions, and gloss loss in paints exposed to the outdoor weather.

The effect of design parameters (series- parallel system design) on maintenance performance (availability and reliability) has been studied by (Y. Juang[17]). He proposed a genetic algorithm based optimization model to improve the design efficiency. His objective was to determine the most economical policy of components' mean-time-between-failure (MTBF) and mean time-to-repair (MTTR) because of the system availability. He concluded that while improving the system's reliability, the cost is also on the upswing. For the optimal selection of redundancy bearing reliability concerns based on fixed probability of environmental failure for single potential units. (Y. Ye,[1]) proposed a general mixed-integer framework. The researches summary present in Table 1.

4. Conclusions

This literature review examined issues relevant to the different effect of maintenance performance in manufacturing organizations. Based on this literature review, which examined relevant articles published from 1998 to 2018, a trend toward moving from the effect of maintenance performance on redesign concept (DOM) and the effect of maintenance performance on the preventive maintenance(PM) interval, to the effect of maintenance performance on the system design configuration (outdoor system).

This paper gives a literature review on extensive research work which has investigated the effect of maintenance performance on system design configuration (for outdoor and indoor systems). It's commonly known that the configuration of the power station systems design and the overall system performance are affected by some environmental factors. During the process of reviewing researches covered that topic it's been concluded that there are a few researches offered an environmental outdoor design parameters effect on maintenance performance. So there is a big gap in the field of studying outdoor design parameters effect on maintenance performance. In this paper, the influence of outdoor power system design configurations with environmental factors on the failure rate and maintenance performance is examined. This literature review determined the effectiveness of outdoor system design parameters such as temperature, rainfall, humidity and other environmental factors on the mean time between failures (MTBF), which used as indices for maintenance performance. A literature review is introduced to describe the relationship between failure modes for environmental factors in the outdoor system configuration on the maintenance performance.This literature review is useful for provide decision-making guidance and theoretical support for the outdoor system design configuration, the maintenance departments and preventive maintenance planning.

Table 1. Summary of the effect of maintenance performance

Maintenance performance effect	Research	Maintenance performance measure	Design factor	Proposed model	Solution algorithm	Case study
Effect on subsystem design	P. Muganyi 2018	MTBF	PM	Imperative systematic approach	Evaluation technique,	Chest agitators machine
	P. Gupta 2013	MTBF	PM	Analytical analysis, step wise analysis	Evaluation technique	Bearings pump-motor
	A. K. Jain(2013)	Maintenance cost	PM	Optimization-cost model	Redesign concept	Burning of pot motor
Effect on maintenance policy	V. Legát (2017)	PM interval	PM	Optimization-cost model	Analytical and simulation computing approaches	Cylindrical feeder beater
	Y. Xiulian (2013).	PM interval	PM	Optimization-cost model	Genetic algorithm	Metro vehicle
	A.L. Maukar (2016)	PM interval	PM	Optimization-cost model	Evaluation technique	Locomotive truck
Effect on system configuration	Y. Juang (2008).	Availability, Reliability, MTBF	Parallel –series	Optimization-cost model	Genetic algorithm	Solar power station
	E. S. Kumar et.al (2012).	Reliability	Environmental conditions	Proportional Hazards Model	Regression analysis	Solar power station
	R. Jiang et.al (2016).	Reliability, MTBF	Environmental conditions	Accelerated life testing (ALT) model.	Regression analysis	Wind turbines

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