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The Study of Welding and U-Press Machine Maintenance and Repairing Policies with Markov Approach: A Case Study in APM

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Abstract

This research aimed to clarify maintenance and repairing policies with Markov approach in the case study of Welding and U-press machines in Ahwaz pipe Mills. Documents and the reports of maintenance and accounting unit of the factory are the tools for collecting data. Sampling is the method of data collection in this study prepared by Welding and U-press machines produced in the production line No. 4 of the factory. The data used in this study were related to the year 2010 when the factory was working at full capacity. The five research questions were used to describe the subject dimensions relating to the replacement policies: Fixed time, fixed course, group replacement, repairing or replacing. The production line No. 4 of Ahwaz pipe Mills factory is the statistical population of the study. Research approach is Markov chain utilized in pipe mills factory according to the description of maintenance and repairing policies. By using probability matrix of previous data, the future behavior was predicted and the production data was used in data mining to investigate further. The results of this study confirmed that choosing correct maintenance and repairing policies according to the study of system behavior and considering the information facilitate the repair costs and indicated a possible solution is not possible for all situations. And proper policy for the U-Press machines is to replace at the fixed time.

Keywords: preventive maintenance, data mining, productive maintenance, predictive maintenance, Markov chains

Introduction

Organizations are utilizing the modern and necessary equipment to survive and introduce their products. In the world, some incomes of the organizations are annually spent to meet their cost of the production equipment to promote more cost savings on the maintenance. Organizations use various techniques to manage and reduce the costs of maintenance and repairing the equipment. Finding the optimal point and deciding to replace worn out and non- economic equipment is one of the ways to reduce the cost of repairs. If this ideal condition was identified in a specific way, it would lead to lower maintenance costs and increase the profitability of the organization. Simulation is one of the modeling techniques for understanding the evaluation status in order to provide acceptable solutions. Ahwaz Pipe Mills is one of the poles in producing a fluid transfer tube with a good number of capital equipment in the Middle East that their maintenance is part of the organization policies. However, due to its high costs and lack of high monetary value, reducing the production pauses plays a significant role in increasing the profitability of the organization. There are different policies for maintenance and repairs including prevention with replacing on the fixed date, prevention with replacing at fixed time, group replacement at fixed time, maintaining or replacing the vehicle and inspection for production process (French et al, 1997). The components after a fixed period of time - if they are not damaged will be replaced according to the first policy. According to the second policy, the time of preventative replacement is always clear and definite. The third policy determines the time of group replacement of all components not applied in these

machines. The length of maintenance and replacement can be determined by the fourth policy. Lack of information about Ahwaz Pipe Mills policies for economic economies and determining the model of repairing and replacing the equipment is the main problem in this study. For this purpose, the information and cost of repairs and stops of the machines were studied in order to select the appropriate policies consistent with scientific patterns among the results. Policies are kind of guidelines in decisions making and determine the scope and method of inspection and the way to handle the organization and expectations and also approach of maintenance unit planning. The policy of repairing is the general approach based on repairing the equipment and necessary actions will be taken to solve the problem when it is in service or in the case of a problem. In the replacement policy at the fixed course and based on an anticipated program and after unknown functions, defective parts or equipment will be replaced. And, policy of this approach is based on preventing unexpected defects. It should be noted that, according to previous studies, the more scheduled time to perform repairs and maintenance the less time for emergency repairs which means reducing unexpected stops. Applying proper maintenance and repairing policy in addition to reducing the costs will increase the equipment of organization and ultimately its productivity and profitability go up. The research will help clarify the repairs and maintenance policies in the organizations. Costs are generally divided into two categories: seen costs and unseen costs. Unseen costs are not estimated and are not included in the calculation. According to theory of the iceberg, the unseen costs comprise main bulk of the costs, so choosing the right approach and proper maintenance and repair policies can reduce potential accidents and unforeseen costs or omit them. On the other hand, in the current competitive atmosphere between different industries the better service and production factors the more competitive capabilities of the organization and leads to more profitability and productivity.

Research Questions

Is replacement policy in Pipe Mills factory based on replacement policy at fixed time?
Is replacement policy in Pipe Mills factory based on replacement policy at fixed course?
Is maintenance policy in Pipe Mills factory based on repairing the equipment?
Is maintenance policy in Pipe Mills factory based on replacing the equipment?
Is maintenance policy in Pipe Mills factory based on inspecting the process?

Definition of key terms

Reactive maintenance: in this method, after the failure to repair the machines returning to the initial state is presented.

Preventive maintenance is a systematic and scheduled method to do needed and planned maintenance to prevent unusual erosion of machines components and reducing machinery emergency stops (Zandin, 2001).

Predictive maintenance refers to the set of tasks which are identified to evaluate the technical condition of machine components (measuring the erosion rate of the components) done during operation and on the basis of its results, the timing and type of required maintenance activity is determined (Zandin, 2001).

Effective maintenance refers to the set of activities that aim to improve the machines performance, reducing maintenance and eliminating all causes of failures.

Productive and inclusive repairs and maintenance: The sensitive and key innovation of the system is that the operators themselves primarily do the maintenance of their machines (Hajshimohamadi, 2003).

In general, data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into practical information which can be used to increase the income, reduce the costs, and both of them (Shahrabi, 2011). The theory of Markov chains was presented by Markov A.A., Russian theorist in the field of probability (Hamidizadeh, 2012). Markov chains are a special case of probability established based on stochastic processes unexpected processes. In these models, the current state of a system depends on all previous modes. Unexpected process is the process which the current state of the system depends on the previous state of the system. In fact, the process movement from one state to another is a Markov process which has unexpected outcomes and the consequences possibility depends on the current state. Markov analysis can be used to change the commodities brand, consumer receivables accounts behaviors, and machines repair and maintenance, storage issues and lines, inspection and replacement analysis and analysis of water sources and etc. In the processes of a system with Markov model the states of the system and the possibility of movements between states, called "transition probability" is called play roles. State of a system is a situation at a time like a machine works properly or not, payment was paid or not, how many customers use the products with specific brand or not, etc. Transition probability, presents the possibility of the system movement from one state to another state during a specified period.

Literature review

Syadmanesh (2012) studied the selection of appropriate maintenance approach based on maintenance capability in Saipa Diesel Company. Khazaei (2009) investigated the maintenance and repairing water pumping station and presenting a model to determine optimal distances of the preventative parts replacement by applying simulation. Firstly, the maintenance of water pumping stations, one of the main objects of each water system was evaluated and after identifying the problems, in order to reduce the costs and increasing reliability, a model is presented that determines the best preventive replacement interval. Alborzi (2011) researched choosing the most appropriate maintenance strategy using analytic hierarchy and fuzzy process in the case study of the transfer motors of Isfahan Mobarakeh Steel Company with the aim of selecting the most appropriate maintenance strategy by using analytic hierarchy and fuzzy process in the transfer motors of Isfahan Mobarakeh Steel Company. Shahin, Bolandi, and Baluei (2011) indicated that, in order to determine the maintenance policy by using analytic hierarchy and fuzzy process they found the fact that preventive maintenance policy in selecting maintenance systems and repairs is more important than other options. Eslami, Sajadi, and Hoseizadeh (2011) compared the output of all three techniques using the method of Top in presenting a multiple criteria decision making model, preventive maintenance scheduling using Arena simulation models in multi –machinery systems and founded that the most appropriate preventive maintenance techniques were chosen for this particular case. According to Far, Emadi, and Nurifar(2008), in determining maintenance strategies using the analysis phase of development in the case study of the power plant of Shahid Salimi Neka it was founded that maintenance strategies and preventive maintenance are more appropriate for boilers. Since the replacement or repair of parts and equipment determine the needed policies, performing each of them leads to consider maintenance policies. In other words, the independent variables are different types of maintenance policies and selected policy of dependent variables.

Methodology

The main purpose of this study is to identify the policies of Ahwaz Pipe mills to determine repairing and replacing the equipment based on Markov chains approach. Regarding the secondary goals, the following can be mentioned:

Explaining replacement policy in Ahwaz Pipe Mills Company based on the replacement policy at fixed time and also fixed courses.

Explaining maintenance policy in Ahwaz Pipe Mills based on repairing and replacing the equipment and inspecting the process.

Introducing a solution based on approved policies and the current status of the maintenance organization.

The sampling method to gather data in a research is targeted method in which based on the goals of the research which is to determine maintenance multi policies the machineries of the production line No. 4 of the factory were studied and the samples were chosen. Data collection tools are statistical records of the all welding machines and U-press collected on the system and line on time every day by the company. The data from 2009 to 2011 available in the weekly records was the sample and the data on the number of stops of the machines in 2010 was used, too. The accounting data of the costs of repairing the equipment and monthly and yearly reports of maintenance office of the factory was also used. Reliability of the measurement tool was done based on the method of verification or retesting and the reliability of the measurement was done by criterion content. However, due to the results consistent with the facts of the industry and previous researches, the correctness of the calculations can be cited. The calculations of the model for welding machines and U-press were done in a period of three years. In this three-year period, simulation and anticipating the future scenarios were done based on Markov chains. And, due to the fact that the results are consistent with the Bathtub Curve graph, the cost of production and repairs, and the facts of the industry and valid published references, indicate the accuracy of measuring tools and measurement. After data collection, the data were classified. This category was based on the selected devices including stops data, slow production, data related to the maintenance costs, and production statistics. For classification and data extraction and in order to facilitate to use Excel software and output reports analysis, Database software is used. Secondly, data from the transition states and relating probabilities for each machine like U-press was calculated and this calculation was introduced as the calculation at the beginning of the first states. This stage was separately done for welding machine. The third step was about anticipating the future condition and related calculation according to the calculated probabilities in the previous stage and forming 3 × 3 square matrix of Markov chains anticipated the future condition and future states of the machines. This circle happened three periods of one year (three years) for each machine. To control the production rate fluctuations and its possible changes limited period of time was used but it is possible to continue it to more courses. The fourth step was about providing matrix tables of the transitions states and the corresponding probabilities using the data collected.

Data analysis

As indicated in Table 1, data of the year 2010 has been investigated for the U-press. 52 weeks of the year as the week of production, slow production occur for 30 cases (this state happens for the machines working in parallel and production could not stop). Production stop happened for 9 cases. This table was provided for welding machines, too. Table 2 contains the columns and rows indicate stop and slow production in the form of a cross. For example, the written number in the column and row of production mean possible production in the current and following weeks or in other words, new production depends on the previous production if the output produced in the previous week. The number in the column of slow production and in the row of production stop means the possible production stop in the next week due to the production in the previous week. As indicated in Table 3, it contains three tables of 3 × 3 cross square matrix. Each square represents the results anticipated by year and in total, it was anticipated for three years for U-press.

For example, first-year production forecast if the production happened is 0.47 and the anticipation second year of slow production if the production stops is 0.44. According the point that the production rate was decreased and complete production is the base of calculation, the machine works differently and to cover this issue attention and accuracy is required for the measurement and calculation and it is necessary to update the calculation at the end of the courses.

Table 1: The rate and kind of stops

Year	Machine	Weekly production stop	Weekly slow production	Weekly production
2010	U-press	9	30	52
2010	welding OD3	9	27	52

Table 2: **The anticipation of future states of U-press**

Slow production	Slow production	production	U-press
0.36	0.17	0.47	production
0.37	0	0.83	Production stop
0.1	0.02	0.88	Slow production

Table 3: Matrix of transition states and possibilities

.399	.235	.4	0.207	.070	.723	.36	.17	3.47
.055	.024	.134	.144	0	.044	.17	0	.83
.132	.037	.85	.127	.044	.837	.1	.02	.88

Table 4: Results of the policy in different courses

Machine	Process inspection	Repairing the equipment estimated with Rial currency	Replacing the equipment estimated with Rial currency	Changing the fixed course estimated with Rial currency	Changing the fixed time
U-press	Not practical	decrease	increase	increase	0
U-press	Not practical	decrease	increase	increase	Course 2
U-press	Not practical	decrease	increase	increase	Course 3

Conclusion

In the present study, the costs of preventive maintenance for three years are acceptable. And, the policy of repairs and maintenance is more appropriate in the fixed courses. In order to better describe and conclusion, it is recommended to consider the data about the costs of the machines that stopped working, and added value per machine in their structure costs. Those interested can complete the model according to the type and nature of the equipment or the equipment used to evaluate the efficiency of the equipment.

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