Trend Prediction Technology Research of Condition Maintenance for Large Water Injection Units

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Abstract: Trend prediction technology is the key technology to achieve condition based maintenance of mechanical equipment. Large-sized water injection units are key equipment in oil-field and the traditional preventive maintenance way is not economical and can not completely avoid vicious accidents. To ensure the normal operation of the units and save maintenance costs, the trend prediction technology is studied to achieve condition based maintenance for water injection units and the main methods of the technology are given and the trend prediction method based on neural network is put forward and the expert system based on knowledge is developed. The industrial site verification shows that the proposed trend prediction technology can better reflect the operating condition trend change of the water injection units and provide technical means to achieve condition-based predictive maintenance.

Key words: water injection units condition based maintenance trend prediction

1. Introduction

A lot of key equipments used in the industrial site are running with large power and heavy load while the operating condition is not stable and the condition of running is bad. The present periodic maintenance way is not economical and usually can not avoid the fault of the equipment. It's necessary to study and apply advanced condition monitoring and fault diagnosis technology and make further research and develop predictive maintenance technology.

Making large water injection units in oilfield as research target the trend prediction technology is studied to predict the equipment condition development timely and provide maintenance information. And the studied trend prediction technology experiences industrial-site verification and can ensure the normal running of the large water injection units and achieve scientific maintenance [1].

2. Large water injection units in the oil-field and the maintenance way

2.1 The operating condition and the monitoring way of large water injection units in the oil-field

Water injection units are important production sectors in the oilfield and there are usually three to six large-sized rotating injection units operating continuously and associated mechanical equipments. Large rotating injection units are key equipments to ensure the oil production, which are composed of rotating machinery called motor-centrifugal pumps running continuously with power usually above two thousand kilowatts.

The traditional maintenance way of the water injection units is compulsory periodic maintenance replacing the parts at a fixed time with high maintenance costs. Although the cumulative halting down time is long, it still can not avoid the vicious incidents.

2.2 The studied condition based maintenance way

The traditional maintenance way of the large and medium-sized water injection units is the preventive maintenance based on time, also called periodic maintenance while the predictive maintenance based on condition, also called predictive maintenance is the newly dynamic maintenance and can alter the traditional equipment maintenance way fundamentally. The advanced predictive maintenance way based on condition replacing the traditional time-based preventive way is the developing trend to achieve advanced maintenance way for the key or the large and medium-sized equipment. Trend prediction technology is the key technology to achieve condition based maintenance of machinery. The technology has great developing potentialities and broad applied field with great economic benefit and the related literature indicate that the ratio of profit to investment in applying trend prediction technology to mechanical equipment is up to 17:1. The comparison of the two maintenance ways of the large and medium-sized water injection units are show in figure 1.

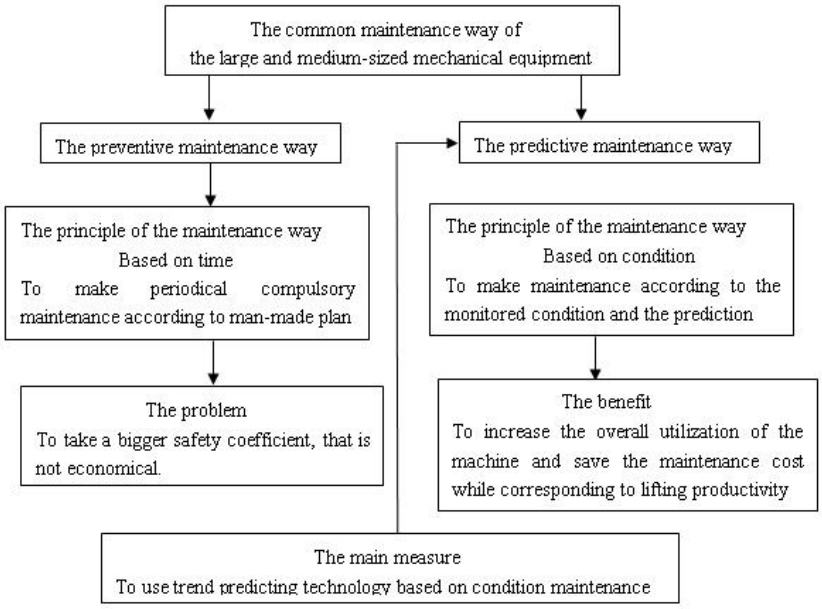

Fig1 The main maintenance ways of large and medium sized water injection mechanical equipment

3. The trend prediction technology of predictive maintenance way for large water injection units

3.1 The development of trend prediction technology and its main methods

To ensure equipment to achieve its function reliably and efficiently, the related research experiences three main stages:

The first stage is to monitor the operating condition of the equipment.

The second stage is to make fault diagnosis of the equipment, mainly when the equipment has fault.

The third stage is to predict the developing trend of the equipment operating condition, mainly before the equipment has fault, which is the target to be achieved in the future of this technology.

Trend prediction technology is developing on basis of condition monitoring and fault diagnosis and the mechanical equipment condition is got by online real time detection and artificial intelligent analysis to reveal the current operating condition effectively and then to predict how long the future condition of the equipment will reach an unacceptable level and should be down for maintenance, thereby from the traditional preventive maintenance up to the advanced condition based maintenance. The current main trend prediction analysis methods are shown in figure 2.

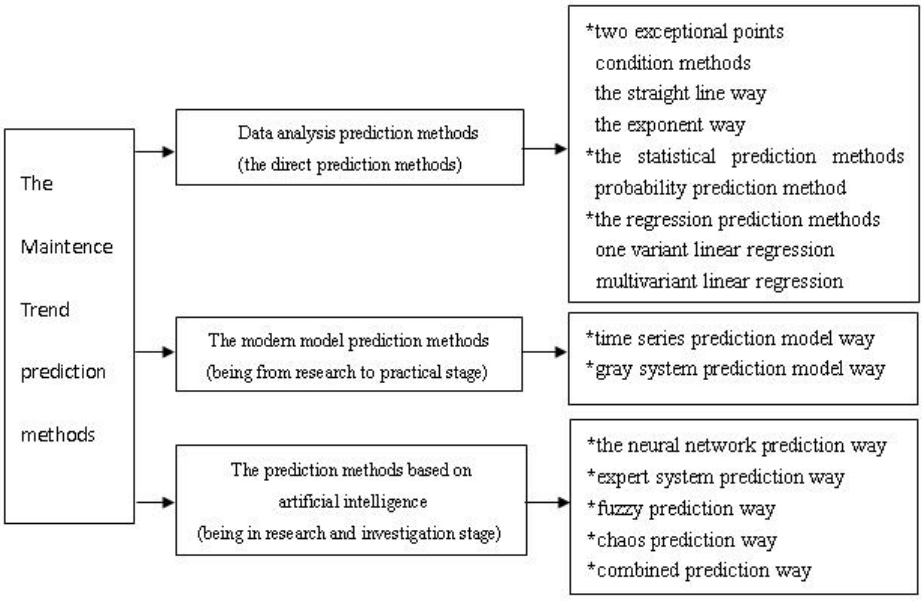

Fig 2 the main trend prediction methods

3.2 The sensitive characters in the trend prediction of the large water injection units

The mechanical dynamic characteristics of the injection water units mainly refers to vibration characteristics, which can reflect the running condition of the mechanical systems more directly, rapidly and accurately than the other condition parameter. The mechanical dynamic parameters are got through the real-time detecting by vibration sensors and analysis of the dynamic characteristics is made to identify the class values-time trend and then achieve the trend prediction of the water injection units.

The intensity of vibration mainly reflects the overall vibration of the units so as to reflect the overall operating conditions. The intensity of vibration relates to energy contained in the signals closely, which is impacted less by the changes in the frequency. And RMS value is sensitive to fault of the non- surface damage which takes place frequently. The intensity of vibration is chosen as the sensitive factor and its value is made as basis for the overall condition fault prediction, providing predictive maintenance information.

3.3 The prediction method of neural network for large water injection units

As the neural network has the parallel processing and powerful nonlinear mapping capability, it can be used to learn and then predict and control the unknown power system. The large water injection units under the normal operational condition are chosen as the research target to make prediction analysis. The neural network prediction system adopts three layers BP neural network which consists of one input layer (the input layer has 7 neurons) and one hidden layer (the hidden layer has 35 neurons) and one output layer (the output layer has 5 neurons) and the input is the vibration intensity value [2,3].

All the monitored parameters of the three water injection units in the water station are collected on-line automatically by the condition monitoring and predicting system in industrial field and the collected data are stored in file. Then the 18 months data will be acquired continuously to make tracking and analysis of the monitored points which has the sign of fault.

The vibration intensity time series data of large centrifugal pump of the water injection units will be put into the neural network forecasting model to predict. The coordinate stands for the average intensity of vibration (inches/sec) while the abscissa stands for time (days). Comparison will be made between the predicted value and the actual value, making the data from the first 130 days to 150 days as training samples and then the neural network is trained. When the predicting accuracy achieves the requirements, the data from the first 151 days to the first 200 days will be predicted.

3.3.1 The neural network static prediction method

In the static prediction process the weight values of the neural network remain unchanged with actual value as the

input to the next step prediction and the prediction result is shown in dotted line in figure 3. As this method does not have to undergo frequent network training, the real time performance is better.

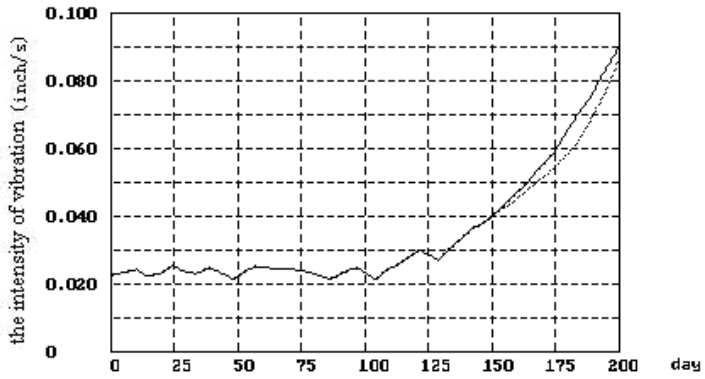

Fig3 neural network static prediction curve of the large water injection units

3.3.2 The neural network dynamic prediction method

In the dynamic prediction process each predicted data is compared with the actual data and then the new data is used to train the neural network and further prediction is made after the accuracy achieving the requirement. The prediction result is shown in dotted line in figure 4. As each predicting step of the method undergoes learning how to operate itself, the prediction accuracy is high.

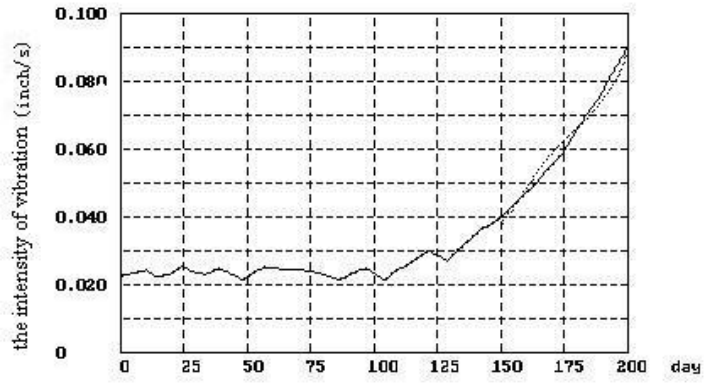

Fig 4 neural network dynamic prediction curve of p the large water injection units

The data collected from the industrial site is used to test the neural network prediction method and the research result shows that the predicted value is close to the actual and the method is fit for prediction.

4. Expert system based on knowledge of water injection units

After acquiring the related parameters and making characteristics comparisons, professional staffs have to make decision based on the related standard and criterion with the reference of the data and characteristics of the filing dynamic characteristics. And the working amount is large and hard to achieve the online real time automatic judge and pre-alarm or alarm. To solve the problem this paper studies and constructs maintenance expert system based on knowledge for water injection units. The expert system is used to achieve the judge and decision automation of the mechanical equipment predictive maintenance [4].

The predictive maintenance structure of expert system for the water injection units is shown in figure 5 and the flow chart of the intelligent predictive expert system knowledge processing (KPS) is shown in figure 6.

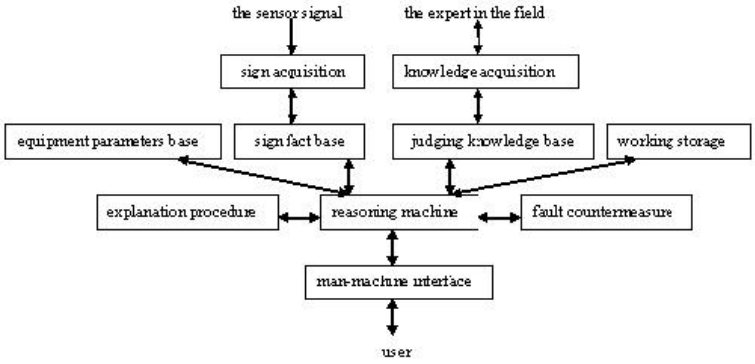

Fig5 the intelligent predictive maintenance structure of expert system for the water injection units

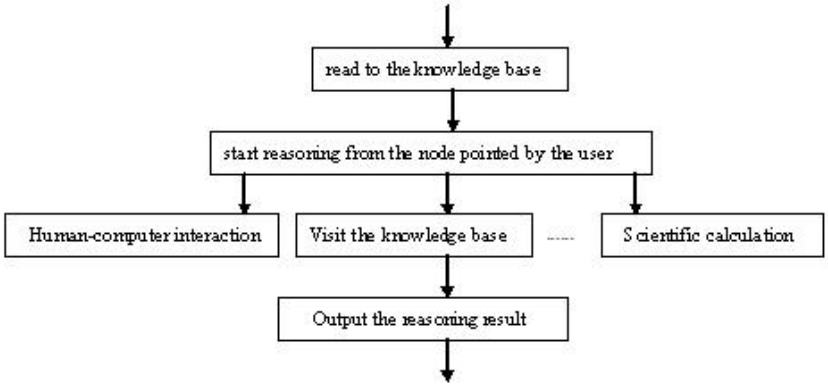

Fig6 the flow chart of KPS of the water injection units

5. Conclusion

Making large water injection units in oil-field as research object the trend prediction method based on neural network is studied and the expert system based on knowledge is developed to achieve condition based maintenance of the equipment. And the result of the research and the industrial test indicates that the proposed prediction method can better reflect the developing trend of the running condition of the units and achieve better prediction effects and the developed expert system based on knowledge can provide technical means to achieve condition based predictive maintenance.

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