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Original article

Ocean Economy and Fault Diagnosis of Electric Submersible Pump applied in Floating platform☆

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Abstract

Ocean economy plays a crucial role in the strengthening maritime safety industry and in the welfare of human beings. Electric Submersible Pumps (ESP) have been widely used in floating platforms on the sea to provide oil for machines. However, the ESP fault may lead to ocean environment pollution, on the other hand, a timely fault diagnosis of ESP can improve the ocean economy. In order to meet the strict regulations of the ocean economy and environmental protection, the fault diagnosis of ESP system has become more and more popular in many countries. The vibration mechanical models of typical faults have been able to successfully diagnose the faults of ESP. And different types of sensors are used to monitor the vibration signal for the signal analysis and fault diagnosis in the ESP system. Meanwhile, physical sensors would increase the fault diagnosis challenge. Nowadays, the method of neural network for the fault diagnosis of ESP has been applied widely, which can diagnose the fault of an electric pump accurately based on the large database. To reduce the number of sensors and to avoid the large database, in this paper, algorithms are designed based on feature extraction to diagnose the fault of the ESP system. Simulation results show that the algorithms can achieve the prospective objectives superbly.

Keywords: Ocean economy; Fault diagnosis; Electric Submersible Pump (ESP); Floating platform; Feature extraction; Current card

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1. Introduction

During past decades, concerns over energy shortages and environmental pollution problems have been growing. A current phenomenon occurring is that more and more researchers pay attention to ESP due to its oil production performance advantages such as high discharge head, convenient management, and Yang (2004) has researched both the features and applications of ESP. Since the fact that the structures of the ESP are more complicated and the working conditions under the shaft are also comparatively odious, the fault rate of ESP is unpredictable during the period of oil production. Many efforts have been paid to deal with the fault problems of ESP. Meanwhile, Liu et al. (2011) proposed the fault diagnosis methods about ESP based on wavelet analysis and Xi (2008) put forward another method based on vibration detection, which has investigated the fault diagnostics of the centrifuge pump by using both data analysis in the spectrometric and discrete wavelet transform method.

It is a basic method based on current cards to diagnose the faults of ESP but it has low efficiency and inevitable human errors will also occur. According to Harihara and Parlos (2012), the pumps fault can be diagnosed by the motor electric signals. Therefore, a mathematical model is established to improve the oilfield development effectiveness after the relationship between ESP wells pressure-out value and time is known through the study of Zheng et al. (2012). The holding pressure diagnosis techniques in the management of submersible electric pump well have been applied in Bohai Q Oil field by Dong (2004). However, if the pressure-out time is too long, the production status and efficiency will be affected, which will aggravate the more serious fault degree of ESP. On the other hand, the macro-control diagram of ESP is helpful to improve the production efficiency of ESP well, and Li et al. (2008, p.121) analyzed the production situation of the wells in each region and discusses the relevant technical measures that should be adopted.

According to Zhao et al. (2006) and Zhang (2008), not only can the fault tree of the ESP can be drawn, but also the minimum cut sets, minimum path sets and structure function were solved after the qualitative and quantitative analysis of ESP faults, which based on the FTA method. Before that, Gan et al. (2002) researched the fault diagnosis and fault prognosis by taking advantage of the FMECA and FTA's information. Besides this, mode analysis and feature extraction from the vibration signals of good and fault conditions were also reported by Sakthive et al. (2010). In addition, Farokhzad (2013) used the technique of Fast Fourier Transform and Adaptive Neuro-Fuzzy Inference System to detect the fault of pumps, and Li et al. (2010) adopt the method of Fuzzy Petri Nets to diagnose the ESP. The theory of fuzzy mathematics and expert data have been used to establish the pattern recognition model of ESP faults, of which drawback is the establishment of the fuzzy relationship matrix has some limitations and uncertainties. In recent years, the method of neural network fault diagnosis has been widely used in ESP to improve the accuracy and quickness of diagnosis, such as Peng (2016) and Wang et al. (2007) diagnosed pumps fault using the neural network. Besides, Wang (2013) and Rajakarunakaran et al. (2008) have detected and diagnosed the faults of pumps systems. According to many researchers, such as both Li (2010) and Zhao (2011) diagnosed the faults based on analyzing the vibration signals. Before that, Leon et al. (2000) researched the parameters of motor. So the approach that vibration signal analysis and feature extraction of electric pump unit and the establishment of the typical fault vibration mechanics model can implement an effective diagnosis of ESP. Besides, Behzad et al. (2004) presented the technique that both vibration analysis and motor current signature analysis (MCSA) can be used for detection of faults and abnormalities in machine systems. In addition to the above methods of faults diagnosis, there are some other comprehensive diagnosis techniques. such as those discussed by Mckee (2015) who detailed the relationship between vibration cavitations sensitivity parameter and centrifugal pumps condition, Zhao (2010) and Feng (2007) researched the state monitoring and fault diagnosis technology and synthetic diagnosis model of ESP respectively.

In this paper, we propose a technique by extracting the features of current cards in different fault modes of ESP to recognize the faults of ESP. We aim to reduce environment pollution, increase the ocean economy and improve the fault diagnosis level. After collecting the common fault's current cards, the features, such as expectation and variance, need to be extracted respectively from different current cards. Besides, a