Availability and Reliability Analysis of Subsea Annular Blowout Preventer

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Abstract. This paper performs availability and reliability analysis of the subsea annular blowout preventer (BOP) using stochastic Petri nets (SPN). The SPN model is developed based on the working status and failure modes of the BOP when it is located on the wellhead. Transient availability and reliability of the subsea annular BOP is obtained. It shows that availability will reach a stable value in about 2000 hours while reliability will become 0 in about 8000 hours.

Keywords: Subsea annular blowout preventer; stochastic Petri nets; availability; reliability

1 Introduction

The subsea blowout preventer (BOP) stack plays an important role in providing safety for drilling workers, rigs and natural environment. It is employed to handle the erratic pressures caused by kicks or blowouts. Kicks or blowout in the process of drilling will lead to serious consequences if the BOP fails [1].

As a kind of system tools based on graphical modeling and analysis, Petri nets are introduced by C. A. Petri. At present, Petri nets method has been widely used in system modeling and performance analysis of transportation, equipment maintenance and complex mechanical equipment. Petri net is a kind of directed network and it can reflect the states change of the system and the process of events. So, it is good at describing the transmission relation of faults [2].

This paper presents a stochastic Petri net (SPN) model of subsea annular BOP for performance analysis. Availability and reliability is obtained based on the model. The remainder of the paper is organized as follows. Section 2 establishes the SPN model. Section 3 is the analysis and results of the model. Section 4 summarizes the paper.

2 System Description and Modeling

According to the research report by Holand, failure modes for subsea annular BOP include "unable to close", "unable to open" and "internal hydraulic leakage" [3, 4] et al. Besides, failures of control system also can make the annular BOP out of control. The BOP can’t be closed or opened if there are failures of the accumulator, hydraulic circuits or valve parts. Based on the possible failure modes and its working states, the SPN model of subsea annular BOP is presented in Fig.1.

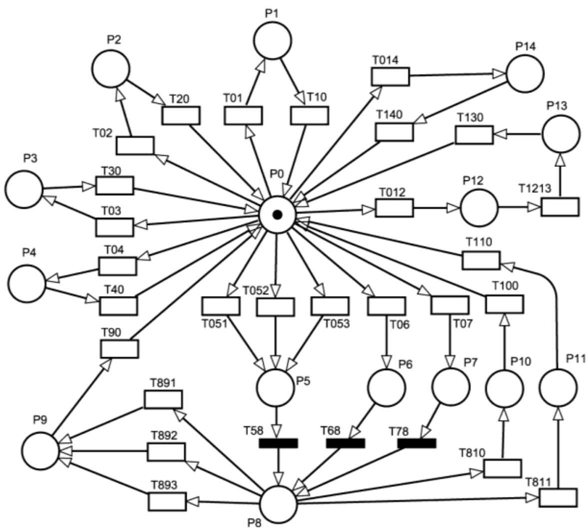

Fig.1. Stochastic Petri nets model of subsea annular blowout preventer

In the model, meanings of places are described as follows. P0: BOP is in good working condition; P1: It is in internal leaking state; P2: It is unable to close; P3: Shuttle valve or piping is in the leaked state; P4: Liquid leakage occurred for the accumulator; P5: Blue pod can't control the BOP; P6: Blue pod ring adjuster fails; P7: Blue pod is in the state of function failure; P8: Blue pod is in the failure state; P9: Yellow pod can't control the BOP; P10: Yellow pod ring adjuster is in failure state; P11: Yellow pod is in function failure state; P12: Hydraulic pipeline of blue pod is in failure state; P13: Hydraulic pipeline of yellow pod is in failure state; P14: Control system is in failure state. The firing rates values of transitions are determined according to Reference [3].

3 Analysis and Results

By solving the model, transient availability and reliability of the subsea annular BOP is plotted in Fig. 2 and Fig. 3. Fig.2 shows that availability decreases from 1 to a stable value over time. It decreases very quickly in the first 1000 hours and reaches the stable value 0.9257 in about 2000 hours. As shown in Fig. 3, reliability of the annular BOP decreases slowly and reaches 0 in about 8000 hours.

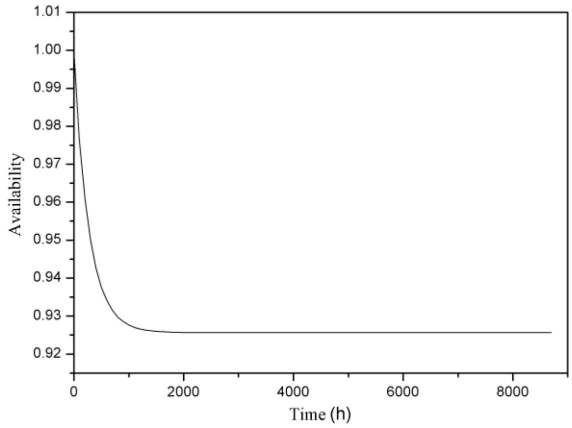

Fig. 2. Transient availability of subsea annular blowout preventer

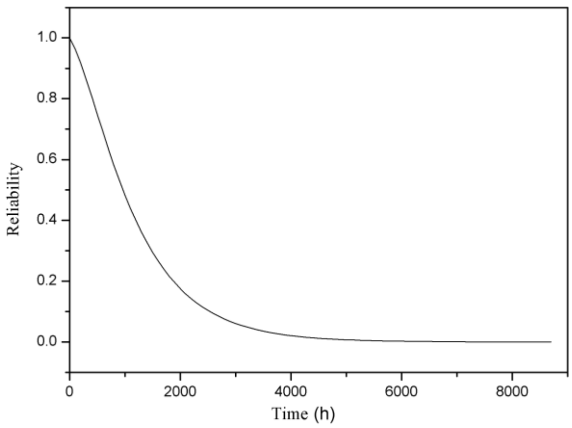

Fig. 3. Transient reliability of subsea annular blowout preventer

4 Conclusions

(1) This paper presents a SPN model of subsea annular BOP based on its failure modes and working states.

(2) Transient availability and reliability of the BOP is obtained. Availability decreases very quickly in the first 1000 hours and reaches the stable

value 0.9257 in about 2000 hours. Reliability of the annular BOP decreases slowly and reaches 0 in about 8000 hours.

Acknowledgements. The authors wish to acknowledge the financial support of the National High-Technology Research and Development Program of China (No. 2013AA09A220), Taishan Scholar project of Shandong Province (TS20110823), Program for Changjiang Scholars and Innovative Research Team in University (IRT1086), the Fundamental Research Funds for the Central Universities (14CX06052A), the Innovation Project Foundation of Graduate School of China University of Petroleum (CX2013054).

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