Chapter 16
Prognostics and Health Management of Choke Valves Subject to Erosion: A Diagnostic–Prognostic Frame for Optimal Maintenance Scheduling

Giulio Gola
Institute for Energy Technology, & IO-center for Integrated Operations, Norway

Bent H. Nystad
Institute for Energy Technology

ABSTRACT

Oil and gas industries are constantly aiming at improving the efficiency of their operations. In this respect, focus is on the development of technology, methods, and work processes related to equipment condition and performance monitoring in order to achieve the highest standards in terms of safety and productivity. To this aim, a key issue is represented by maintenance optimization of critical structures, systems, and components. A way towards this goal is offered by Condition-Based Maintenance (CBM) strategies. CBM aims at regulating maintenance scheduling based on data analyses and system condition monitoring and bears the potential advantage of obtaining relevant cost savings and improved operational safety and availability. A critical aspect of CBM is its integration with condition monitoring technologies for handling a wide range of information sources and eventually making optimal decisions on when and what to repair. In this chapter, a CBM case study concerning choke valves utilized in Norwegian offshore oil and gas platforms is proposed and investigated. The objective is to define a procedure for optimizing maintenance of choke valves by on-line monitoring their condition and determining their Remaining Useful Life (RUL). Choke valves undergo erosion caused by sand grains transported by the oil-water-gas mixture extracted from the well. Erosion is a critical problem which can affect the correct valve functioning, resulting in revenue losses and cause environmental hazards.

DOI: 10.4018/978-1-4666-2095-7.ch016
1 INTRODUCTION

A diagnostic-prognostic scheme for assessing the actual choke valve health state and eventually estimating its RUL is here proposed. In particular, focus has been on the identification of those parameters which contribute to the actual erosion of the choke valve, the development of a model-based approach for calculating a reliable indicator of the choke valve health state, the actual estimation of the choke RUL based on that indicator and, finally, the investigation of methods to reduce the uncertainty of the RUL estimation.

On July 6, 1988 an explosion and a resulting fire on the North Sea oil production platform Piper Alpha caused nearly two hundreds fatalities and a £1.7 billion estimated loss. According to the Cullen Inquiry (Ross, 2008), the disaster was caused by an initial condensate leak as a result of maintenance work carried out simultaneously on a pump and the related safety valve. The safety valve was taken out of a production line for repair and replaced with end flanges. Pressure was put back in the system, which later resulted in a gas leakage and combustion. Piper Alpha’s operator was found guilty of having inadequate maintenance and safety procedures.

More recently, on April 20, 2010 an explosion on the Deepwater Horizon platform in the Gulf of Mexico caused many fatalities and a 4.9-million-barrel crude oil spill into the water which resulted in extensive damages to marine and wildlife habitats and to the Gulf’s fishing and tourism industries. A critical factor in the causal chain of events that contributed to this accident was the failure of a blow-out preventer to seal the leaking reservoir (Nomack, 2011). The British Petroleum team conducted an audit on the disaster including the maintenance management system for the blow-out preventer. The findings made it clear that control-related equipment maintenance were manually documented on separate spread sheets and in the daily logbook, but had not been recorded in the Transocean maintenance management system (RMS-II). This made it difficult to track blow-out preventer maintenance actions. The fact that maintenance records were not accurately reported in the maintenance management system was identified as a potential cause of the failure of the blow-out preventer system.

Although these disasters resulted from a complex mix of mechanical failures, human judgement, engineering design, operational implementation and team interfaces, they illustrate the importance of valves as safety barriers in a process system (Meland, 2011; Andrews et al., 2005; Haugen et al., 1995; Ngkleberg & Sontvedt, 1995; Hovda & Lejon, 2010).

Failure to close on command and leakages through the valve when in closed position are so-called dangerous undetected failure modes and represent serious hazards for the safe operation of the system.

To reveal and repair dangerous undetected failure modes, valves must be periodically tested. In the offshore oil and gas industry, tests are normally performed during annual revisions and involve stopping the hydrocarbons flow and consequently a process shut-down. On average, operation tests for a single valve last between three and four hours (Meland, 2011; Haugen et al., 1995). Production downtime can be reduced either by increasing the length of the test interval or by performing the test during unplanned system shutdowns. Another approach would be removing tests without compromising safety by resorting to methods for monitoring the valve condition with an accuracy that would allow avoiding testing (Haugen et al., 1995). In this view, it is critical to devise systems which can early detect, identify, quantify and accurately predict the degradation processes directly related to the dangerous undetected failure modes.

A viable way to achieve this is offered by Condition-Based Maintenance (CBM) strategies (Baraldi et al., 2011a; Baraldi et al., 2011b; Grall et al., 2002; Tsang, 1995; Williams et al., 1994). Components’ CBM relies on an adequate
Related Content

A Comparative Performance Study of Ad Hoc Routing Protocols to Improve the Route Discovery Process of AODV

An Efficient Evolutionary Algorithm for Strict Strong Graph Coloring Problem
[www.igi-global.com/article/an-efficient-evolutionary-algorithm-for-strict-strong-graph-coloring-problem/114215?camid=4v1a](www.igi-global.com/article/an-efficient-evolutionary-algorithm-for-strict-strong-graph-coloring-problem/114215?camid=4v1a)

Innovation Diffusion Among Heterogeneous Agents: Exploring Complexity with Agent-Based Modelling (ABM)
[www.igi-global.com/chapter/innovation-diffusion-among-heterogeneous-agents/5136?camid=4v1a](www.igi-global.com/chapter/innovation-diffusion-among-heterogeneous-agents/5136?camid=4v1a)

Particle Swarm Optimization For Hidden Markov Model
[www.igi-global.com/article/particle-swarm-optimization-for-hidden-markov-model/129081?camid=4v1a](www.igi-global.com/article/particle-swarm-optimization-for-hidden-markov-model/129081?camid=4v1a)