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An expert knowledge based decommissioning alternative selection system for fixed oil and gas assets in the South China Sea

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ABSTRACT

The decommissioning process is constantly challenged with indeterminate risks associated with deteriorated structures and the practice of late-life decommissioning planning. The issue is further complicated by the absence of a fit-for-purpose decision framework. This work develops a knowledge based advisory expert system to address the late-life structural ambiguity of fixed jacket platforms in the selection of a best practicable decommissioning method. A review on the decommissioning industry and its growing need for data-driven management are presented. Analytic Hierarchy Process (AHP) is utilized to solve the Multi-Criteria Decision Making (MCDM) problem of choosing the best practicable decommissioning alternative. The effects and ranking of identified key structural-operation factors on the decommissioning planning process are numerically computed and discussed. The key system variables are developed with reference to established Asset Integrity Management Systems. Subject matter expert surveys are conducted on leading decommissioning and structural integrity experts in the region which are reflected in the decision matrices. A mathematical standardization technique is employed to remove inconsistencies in the intermediate decision vectors. The model is benchmarked against an actual decommissioning project in Malaysian waters which was based on conventional practices. A comprehensive framework is proposed to establish a practical working philosophy for the developed algorithm.

1. Introduction

Traditional business priorities for oil and gas operators have always been securing new hydrocarbon reserves, embarking on greenfield projects and revitalizing brownfields. It is an important consideration that at the inevitable end of their commercial lives, these projects must be decommissioned in a sustainable and socially acceptable manner to circumvent corporate backlash (World Bank Oil, Gas and Mining Policy and Operations Unit (COCPO), 2009).

Decommissioning is, by definition a complex undertaking by the operator of an offshore oil or gas facility which entails planning and implementing the method of dealing with disused facilities (Climate and Pollution Agency, 2010). Decisions in decommissioning activities are bounded by governance from various international regulatory bodies and organizations, such as International Maritime Organization (IMO) and United Nations Convention on the Law of the Sea (UNCLOS). It is understood from such regulations that “abandoned or disused offshore installations are required to be removed, except where non-removal or partial removal is consistent with the guidelines” (Lyons, 2010). Local authorities with their respective statutory requirements may differ from one country to another but general governance aims to ensure sustainable and acceptable practices (Lyons, 2010). While there are no legal guidelines specifying what would be a feasible abandonment planning strategy, the common industry practice suggests that decommissioning is in fact, a highly platform specific exercise.

The removal of offshore platforms is generally perceived to be more complicated than new built installations. Up-to-date information on the platform's in-situ structural integrity is critical for effective planning of a decommissioning campaign (World Bank Oil, Gas and Mining Policy and Operations Unit (COCPO), 2009). In dealing with aged offshore facilities, there is an inherent uncertainty with the in situ structural condition which has been subjected to various extreme loads and accidents, which may not be documented thoroughly during its operation (Connor et al., 2005; Common Data Access Limited and Schlumberger, 2011; McKinsey and Company, 2015). The challenge is in obtaining such records which are interspersed among various stakeholders and departments for platforms constructed two to three

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decades ago.

Platform end-of-life dates are considered to be very dynamic in nature which adds to the complications of planning decommissioning activities and resources (KPMG Global Energy Institute, 2015; Paik and Thayamballi, 2007). The lack of life-cycle planning and foresight are also identified as contributory factors to cost bloating of decommissioning and abandoning exercises (International Atomic Energy Agency, 2008; Kirschnick and Engelhardt, 2004; Thornton, 2014; Stokes, 2014). In a recent survey (McKinsey and Company, 2015), it was stated that under-budgeted decommissioning projects may be the result of the lack of benchmarks during preparation and submission of project plans. The focus is now on achieving balance in terms of optimization, cost cutting measures and maximization of revenues (Stokes, 2014).

Such uncertainties that drive data-centric requirements invoke the need to ensure effective data management and utilization (International Atomic Energy Agency, 2008; Byrd et al., 2014; Common Data Access Limited and Schlumberger, 2011; Computer Sciences Corporation, 2010) to aid in proactive decision making (Kirschnick and Engelhardt, 2004). An ideal decommissioning database is anticipated to function both as an inventory and a decision-making aid or optimization tool (International Atomic Energy Agency, 2008; Kirschnick and Engelhardt, 2004).

When it comes to planning offshore projects, the uncertainties, complexities and shear data volumes inherent in such undertakings make it difficult for a group of human decision maker to arrive at the "best" solution solely based on intuitive decision making (Lev and Murphy, 2007; Evans, 2008). The complex decision-driven decommissioning environment requires improved and early planning and the advanced analytics abilities that can make sense of the complex information involved (Computer Sciences Corporation, 2010). The age of Big Data has also generated a huge volume of information making MCDM increasingly relevant and important in supporting decision making in a wide facet of industries (Xu and Yang, 2001). Such models make the interpretation and handling of large amounts of information and criteria, previously uncomprehend-able by decision makers, more manageable through structured processes and mathematical algorithms.

2. Theory and methodology

This research proposes a model for the planning and management of fixed offshore structure decommissioning activities, with joint consideration of various technicalities of decommissioning alternatives built upon expert knowledge in the region. In Malaysia alone, 65% of local platforms have exceeded their design life in 2014 and this number is set to increase to 78% in five years' time (Twomey, 2010; Ayob et al., 2014). In 2010, PETRONAS, the National Oil Company of Malaysia, has 32 platforms on the waiting list for imminent decommissioning and has stated its vision to decommission 50 wells by 2016 (Mok, 2015). It is rather alarming to note that only a handful of offshore platforms have so far been decommissioned in the country. A specific case study on one of the decommissioned platforms is provided as a benchmark in this paper.

The developed model presents a framework which is anticipated to guide business units and asset managers to plan ahead and optimize resources for a decommissioning campaign. This will result in faster and more effective decisions, taking into account the subjectivity of in-situ degraded structural conditions. The focus of the work is on ranking of feasible decommissioning alternatives based on their input structural parameters and optimal project planning. The end product of this research is integrated as a conceptual decommissioning decision aid toolbox into existing platform databases, herein named as the Asset Decommissioning Management System (ADMS).

2.1. New paradigm in decommissioning decision making

Dealing with ageing assets in mature basins requires up-to-date asset information as it is a key representation of decision making knowledge (International Atomic Energy Agency, 2008). This does not only cover the existing structural conditions of the asset, but also track records and relevant historical operating or modification repositories. Present models tend to place more emphasis on cost and environmental factors which diminishes the consideration of in-situ conditions of existing structural elements during the decommissioning planning process.

The lack of foresight into structural conditions may lead to unforeseen operational glitches or setbacks during the campaign (World Bank Oil, Gas and Mining Policy and Operations Unit (COCPO), 2009). Essential information required for decommissioning, for instance, as-built drawings, construction sequence, repairs and modifications, should be collected, maintained and revised throughout a structure's operational lifetime (International Atomic Energy Agency, 2008). These information and knowledge should be organized so that those pertinent to decommissioning are effortlessly identified and utilized. Asset information comes from various sources over the life cycle of the asset but needs niche attention to identify and manage decommissioning related risks (Thornton, 2014). The notion of structural integrity management (SIM) programs for offshore facilities is driven by the need to ensure reliability of an asset through its life cycle, to accommodate the demands of life extension projects, and prepare for successful decommissioning campaigns (Connor et al., 2005; Nabavian, 2013; Paik and Thayamballi, 2007). There is hence a need to integrate decommissioning information management models with existing asset integrity database to facilitate clear communication and exchange of operational data across the lifecycle of the asset. The preliminary framework of this concept is referred to the works of Na et al. (2012).

Keeping track on the number of offshore assets and their decommissioning priorities has always been an intense task for many asset owners. In the authors' experience, a platform can generally be earmarked for decommissioning due to unfavorable economics or old age. The in-situ structural condition of an old platform is a highly multi-variate problem incorporated into the decommissioning challenge which is impossible to be processed by a single human expert. This work develops a novel algorithm for embedding relevant structural parameter metrics into the decommissioning model via an expert knowledge based advisory system. Herein listed are the three unifying novel concepts driving the decommissioning selection toolkit in this study;

- Structural integrity as a decommissioning decision factor,
- Life-cycle based management of decommissioning knowledge, and
- Analytic Hierarchy Process as the choice analytic method.

The outcome is a localized, relative scale which provides asset managers a rational basis for decision making for decommissioning planning and management throughout the lifecycle of an offshore asset.

2.2. Decision making in decommissioning

The methods utilized in processing data to arrive at a best decommissioning solution varies considerably across the industry but can be mainly categorized into Best Practicable Environmental Option (BPEO) and other assessment methods (Environmental Agency, 2004; Environmental Resources Management Ltd (ERM), 2000; Petroleum Institute of Thailand, 2009). BPEO is defined by the European regulatory framework as "the model for accepting a decommissioning strategy based on environmental aspects" as well as providing auditable traces to support decisions (Environmental Resources Management Ltd (ERM), 2000). Commonly practiced in Malaysian waters, the BPEO