Journal of Petroleum Science and Engineering 139 (2016) 13–22

Contents lists available at ScienceDirect

Journal of Petroleum Science and Engineering

journal homepage: www.elsevier.com/locate/petrol

Drivers to the workover rig problem

Dayan de Castro Bissoli [a,*], Gisele de Lorena Diniz Chaves [b], Glaydston Mattos Ribeiro [c]

[a] Federal University of Espírito Santo Alto University, s/n, Alegre 29500-000 ES, Brazil
[b] Federal University of Espírito Santo, Rodovia BR 101 Norte, Km. 60, São Mateus, 29932-540 ES, Brazil
[c] Federal University of Rio de Janeiro, Avenida Horácio Macedo, 2030, Rio de Janeiro, 21941-914 RJ, Brazil

ARTICLE INFO

Article history:
Received 4 November 2014
Received in revised form
26 November 2015
Accepted 9 December 2015
Available online 10 December 2015

Keywords:
Workover rig problem
Vehicle routing problem
Dynamic
Multi-objective
Decline curves

ABSTRACT

When onshore oil wells reduce the production due to a malfunction, workover rigs are used to restore productivity. Given a set of wells needing maintenance and a set of workover rigs, the workover rig problem (WRP) consists of finding rig routes for minimizing the total production loss of the wells within a finite time horizon. The wells have different loss rates and require different services such as cleaning, reinstatement and stimulation. The rigs can be at different positions in the oil field and can have different equipment. This problem shares some of the same characteristics of the vehicle routing problems. Using a literature review, we offer some new ways to consider and approach the problem in its actual context.

1. Introduction

Throughout the productive life of onshore oil wells, workover rigs (or rigs for short) are usually designated to perform maintenances called workovers. The rigs are scarce and expensive resources however their services are important to keep a good production or possibly to improve the productivity. The workover rig is a compact mobile unit along with some other external equipment for mud preparation and power generation. The whole unit is mainly required for oil or gas wells (Accioly and Chiyoshi, 2000; Srivastava, 2010).

The rigs are moving units that travel at low speed (approximately 12 mph) (Aloise et al., 2006). Because of their high operating costs, there are relatively few rigs for the number of wells that need to be attended. For this reason, an association between wells and rigs must be established to minimize operational costs.

Since several types of maintenance have to be performed by these rigs (cleaning, stimulation, reinstatement, etc.), service levels should be considered whenever the fleet is heterogeneous (Duhamel et al., 2012). Fig. 1(a) shows a rig performing a maintenance service and Fig. 1(b) shows the truck used for transportation.

Therefore, given a set of wells needing different kinds of maintenance and a fleet of homogeneous or heterogeneous rigs spread over the oil field, the Workover rig problem (WRP) consists of defining feasible routes for the rigs such that the total production loss is minimized. A route is feasible for a rig when its duration, including service time, does not exceed the planning horizon, and each well is attended by only one rig. The route starts from the rig's initial position, i.e., where it is located, and ends at the location of the last visited well (Ribeiro et al., 2012a).

In this context, the objective and scope of this study are based on a review of the literature on approaches to the WRP and other routing problems to identify their similarities and differences to promote new approaches for solving the problem.

The remainder of the paper is organized as follows. Section 2 contains a description of the WRP and a bibliographic review is shown in Section 3. New objectives for the WRP are examined in Section 4 which is followed by Section 5 where the conclusions are presented.

2. The WRP: a description

Since its discovery, crude oil has been one of the most important industrial raw materials, with an enormous influence on the development of the global economy. Large investments in new technologies have been made to promote effective, safe and profitable extraction.

The oil is produced with high-cost equipment that operates under difficult conditions for a long period of time. The equipment and the oil wells require maintenance services over time, such as cleaning, replacement and stimulation as mentioned in Section 1, which are essential to achieving the highest possible efficiency.

Higher efficiency in oil field exploitation can be achieved

* Corresponding author.
E-mail addresses: dayan.bissoli@ufes.br (D.d.C. Bissoli), gisele.chaves@ufes.br (G.d.L.D. Chaves), glaydston@pet.coppe.ufrj.br (G.M. Ribeiro).

http://dx.doi.org/10.1016/j.petrol.2015.12.009
0920-4105/

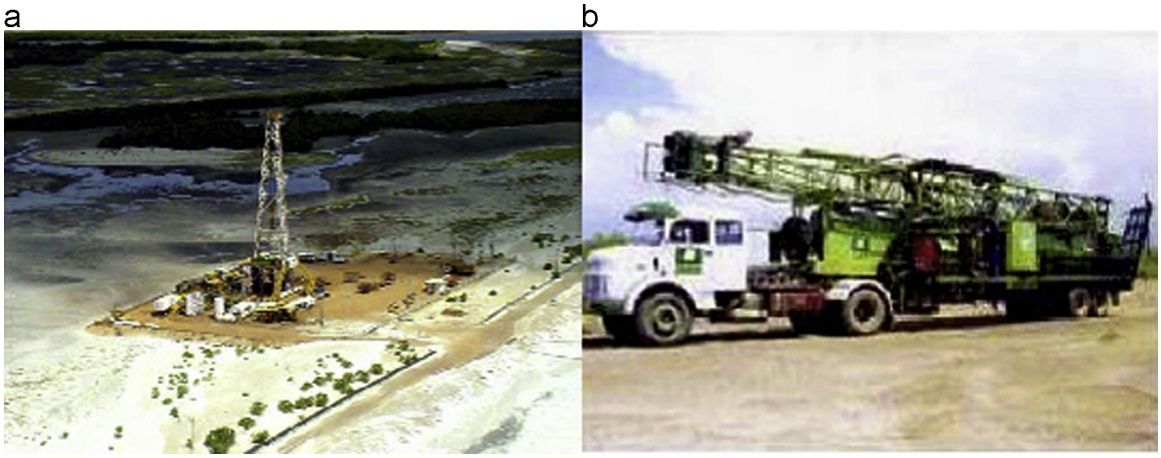

Fig. 1. (a) The workover rig performing a maintenance service and (b) the vehicle used for transportation (Aloise et al., 2006).

through a rational use of resources, especially the scarcest ones. Some of the most important and expensive activities during the oil field development and production phases are related to the use of rigs (Bassi et al., 2012).

However, the use of rigs in onshore oil wells is given mainly for drilling and workover. In the first case, a drilling rig requires an extended time to finish the work consequently the scheduling of these kind of rigs is changed slightly because it involves strategic decisions. Changes of the scheduling can be performed and the cost versus benefit must be evaluated carefully. In the second case, the workover rigs do not require a long time to perform maintenances however they must keep the wells working, performing the planned activities optimally. The wells are distributed spatially over the oil field and the distance between them can be large, consequently the time to reach a well is a function of the transportation vehicle speed and of the road conditions. In some cases, such as in Brazil, the roads are unpaved (often natural base) and the transportation vehicles are older. For example, see Fig. 1.

The onshore oil wells use normally artificial elevation methods for stimulation, as in the southeast and northeast regions of Brazil. The main purpose of stimulation is to enhance the property value by the faster delivery of the petroleum fluid and/or to increase ultimate economic recovery (Economides and Nolte, 2000). The procedures of the oil field operation are affected by some factors which lead to major production losses such as downtime of the operation process (Sonatrach and Forage, 2007). Fig. 2 shows the major components of losses present in oil fields.

Generically, workover operations are referred to such operations that are performed to resolve specific problems that are found after production has started (Ken and Stewart, 1987; Gábor, 1999). The changing of the artificial elevation method used and the permanent deactivation of a well are also workover operations (Thomas, 2001; Noronha and Aloise, 2001; Aloise et al., 2006).

The profitability of a well depends on how long it is on stream and on how much it produces, which are depends on the reservoir's initial characteristics. However, they are also dependent on keeping the wells maintained in good working order (Perrin, 1999).

Routine operations on a producing well would include a number of monitoring, safety and security programs, maintenance tasks and periodic downhole servicing using a wire line unit or a workover rig to maintain production (ONGC, 2012).

According to Cochrane (1989) and reinforced by Mansour et al. (2013), the production loss of a well can be caused by several factors. Servicing operations may be decided because of operating considerations such as an abnormal drop in production, or prematurely worn or obsolete equipment; or because of reservoir considerations such as knowing how the reservoir is evolving or

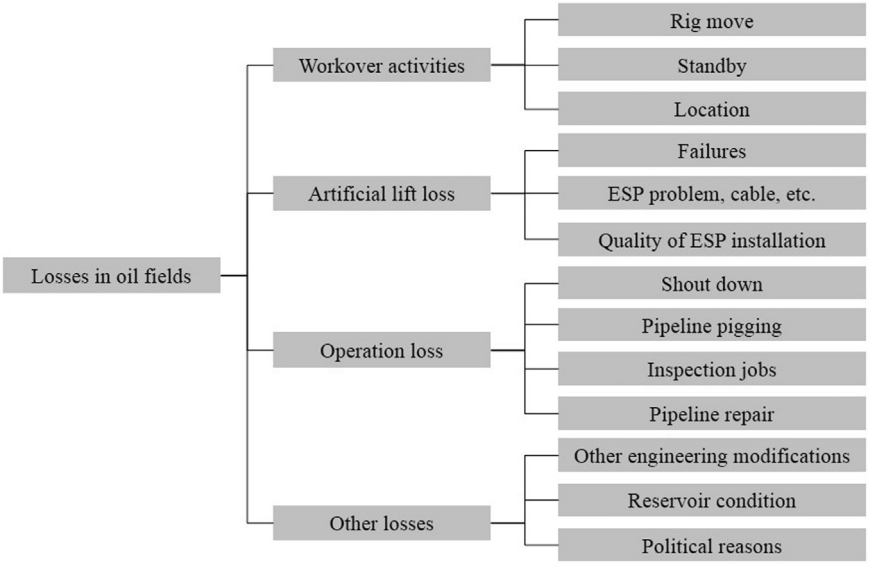

Fig. 2. Major components of losses in the oil fields (Mansour et al., 2013).