IMPROVEMENT OF 4 ½ INCHES CEMENTED MONOBORE DESIGN TO REDUCE WELL COST

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ABSTRACT

This study focuses on the improvement of 4½ inches cemented monobore completion conceptual design through a detailed engineering analysis where it is one of the efforts to reduce well cost without jeopardizing safety and well integrity. A thorough planning on well completion design is imperative to ensure successful delivery of the well. In this research work, the initial plan was to develop overpressured K reservoir with 4½ inches tieback monobore completion. It is a proven concept which can deliver the well safely and without any well integrity issues. During the conceptual design planning in 2013, the oil price was high at USD110/bbl and the tieback monobore well completion design was optimized to 4½ inches cemented monobore with lower cost to improve the project economics. When the detail design planning in 2016, the global oil price crash to USD30/bbl and high MYR *vs.* USD exchange rate was observed. There was a need to redesign the cemented monobore well to further reduce the overall well cost and improve the project economic of the well. The study also focused on collaborative well planning with multi-disciplinaries teams, selection of critical well completion equipment, and tubing stress analysis using WELLCAT™ simulation program to improve the cemented monobore well design to lower the cost without jeopardizing safety and well integrity. The improved cemented monobore design has reduced the well casing schemes; from five casing schemes to four casing schemes through the collaborative well planning initiative. The selection of Weatherford multi-latch in plug, Welltec well annular barrier, and Halliburton SP cement-thru TRSV as critical well completion equipment for cement plug and accessories, and cement-thru packer have preserved the well safety and integrity. The 4½ inches, 12.6 ppf, 13Cr-L80, JFE BEAR tubing string and 9⅝ inches, 47 ppf, L80, JFE BEAR casing string satisfy the tubing load and the annular fluid expansion requirement from WELLCAT™ simulation.

ABSTRAK

Kajian ini tertumpu kepada kerja untuk menambah baik reka bentuk konsep pelengkapan monolubang tersimen bersaiz 4½ inci menerusi analisis terperinci kejuruteraan sebagai satu daripada usaha bagi mengurangkan kos telaga tanpa mengabaikan aspek keselamatan dan integritinya. Perancangan yang teliti tentang reka bentuk telaga adalah penting demi kebolehpengeluaran telaga terbabit. Dalam kajian ini, perancangan awal adalah untuk membangunkan reservoir K yang bertekanan tinggi menerusi pelengkapan monolubang rentetan ikat bersaiz 4½ inci. Konsep telaga itu jelas terbukti selamat dan bebas daripada permasalahan integriti. Ketika perancangan reka bentuk konsep itu pada tahun 2013, harga minyak mentah dunia adalah tinggi, iaitu USD110 setong, tetapi reka bentuk itu kemudiannya terpaksa dirombak kepada pelengkapan monolubang tersimen bagi mengurangkan kos demi kelestarian ekonomi projek. Ketika perancangan reka bentuk terperinci pada tahun 2016, berlaku kejatuhan teruk harga minyak dunia hingga ke paras USD30 setong serta kadar pertukaran wang asing MYR *vs.* USD yang tinggi. Berikutan itu, timbul keperluan untuk menilai semula konsep telaga monolubang tersimen bagi mengurangkan lagi kos keseluruhan telaga demi kelestarian ekonomi projek. Kajian ini turut memberikan tumpuan terhadap permuafakatan dengan pasukan berlatar belakang pelbagai disiplin, pemilihan peralatan kritikal pelengkapan telaga, dan analisis tegasan rentetan tetiub menerusi penyelaku WELLCAT™ bagi meningkatkan kualiti reka bentuk telaga monolubang tersimen serta mengurangkan lagi kos tanpa menjejaskan keselamatan dan integriti telaga. Reka bentuk monolubang tersimen yang diperbaik berjaya mengurangkan bilangan rentetan selongsong; daripada lima rentetan selongsong kepada empat rentetan selongsong berikutan usaha permuafakatan terbabit. Pemilihan palam pelbagai selak Weatherford, sawar anulus telaga Welltec, dan TRSV simen lalu SP Halliburton sebagai peralatan kritikal pelengkapan telaga masing-masing untuk palam simen dan aksesori simen, dan penyendat simen lalu telah menjamin keselamatan dan integriti telaga. Hasil penyelakuan daripada WELLCAT™ menunjukkan bahawa rentetan tetiub 4½ inci, 12.6 ppf, 13Cr-L80, JFE BEAR dan rentetan selongsong 9⅝ inci, 47 ppf, L80, JFE BEAR masing-masing telah memenuhi keperluan beban tetiub dan keperluan pengembangan cecair anulus.

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INTRODUCTION

1.1 Background

Monobore completion design is a standard completion design for gas well in PETRONAS operations in Malaysia. Majority of the gas fields have been completed with 7 inches, 5½ inches and 4½ inches monobore completions. Monobore completion comprises a completion tubing which has a uniform internal diameter throughout its entire length (Simonds and Swan, 2000). A monobore completion design involves the installation of lower completion in the open-hole section and tie back the upper completion with the same tubing size as per the lower completion. It is also known as tieback monobore completion.

Monobore completion can reduce well completion days and improve well economics compared to conventional completion (Mohammad and Maung, 2000). The monobore completion technology improves the project economics by reducing drilling and completion cost in relation to conventional completion (Mieres *et al*., 2015). Conventional completion is a cased hole completion design namely single completion, single selective completion, dual completion, and dual completion with selectivity. These types of completion are completed with 9⅝ inches casing or 7 inches casing with either 2⅜ inches, 2⅞ inches, or 3½ inches production tubing string with accessories such as sliding side door (SSD), landing nipple, production packer and subsurface safety valve (Mieres *et al*., 2015).

A marginal gas field located in offshore Peninsular Malaysia. The development plan was to complete the K reservoir with 4½ inches monobore completion — Besar well completion. K reservoir has high unconfined compressive strength (UCS) with no potential sand production issue. Lower completion proposed design was cemented

liner. Besar's well completion design had been challenged to improve the economics of the well in the high oil price environment. Since the well has no sand production issue, cemented monobore design concept was proposed to further optimize the well completion design.

In a cemented monobore completion design, the completion string is run and cemented straight into the reservoir open hole after the well has been drilled to cover the producing zone. It is a proven design that provides opportunity to reduce completion cost and improve well completion operation days without impacting safety and well integrity (Salahaldeen *et al*., 2015).

This study focuses on detail engineering design of the first 4½ inches cemented monobore completion. The objective is to further improve the conceptual design at a lower cost without jeopardizing safety and well integrity. The areas of improvement comprise the well construction improvement, selection of the completion equipment, and tubing stress analysis to ensure the final design meets the design criteria.

1.2 Problem Statement

The initial plan was to develop overpressured K reservoir with 4½ inches tieback monobore completion. An offset well was completed with tieback monobore completion concept that had production hole cased with 9⅝ inches × 7 inches liner hanger tapered to 4½ inches liner and cemented for lower completion. The 4½ inches upper completion with 9⅝ inches production packer rated to ISO 14310 V0 was tied back to the lower completion as per Figure 1.1. The 9⅝ inches production packer rated to ISO 14310 V0 which was a gas tight packer acts as a double barrier against cemented liner hanger to prevent well integrity issues such as sustained casing pressure (SCP). The design had been successfully run and become a standard design in completing gas well. It is a proven concept such that it can deliver the well safely and without any well integrity issues.

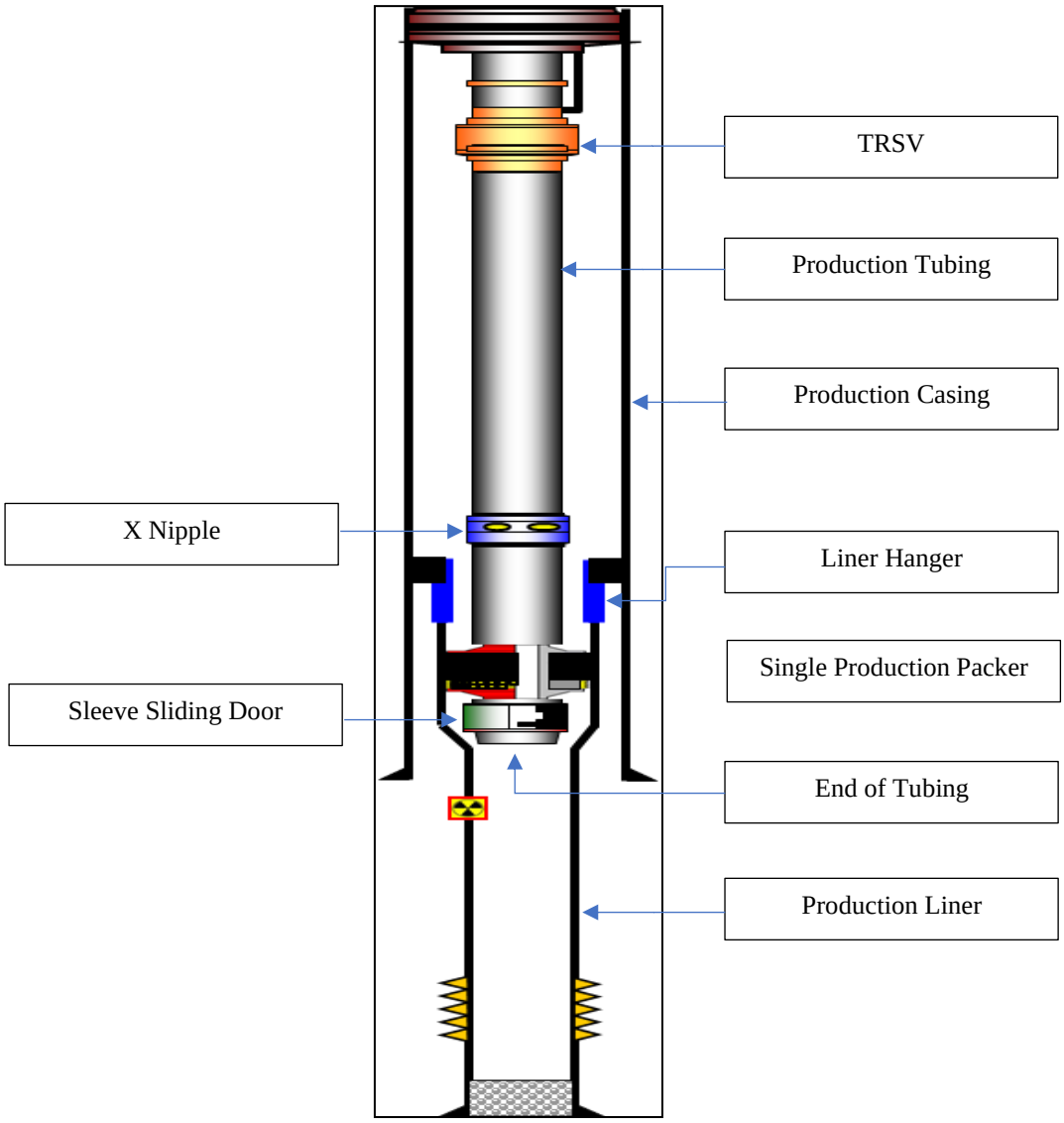

Figure 1. 1 4½ inches tieback monobore (PETRONAS, 2012)

The tieback monobore completion operation required the 4½ inches liner to be run into the open hole with a 9⅝ inches × 7 inches liner hanger and cemented as the lower completion. A dedicated wellbore clean out (WBCO) was needed to be run in hole (RIH) to clean the casing from the drilling mud and changed over to completion fluid. The 4½ inches upper completion would be run with 9⅝ inches production packer to complete the well (Taoutaou *et al*., 2007).

In 2013, the oil price was high at USD110/bbl (Brent crude oil price). Contracted rig service rate, well completion equipment and completion related

services were on the high side at the time of the design cost estimate. The high daily rig spread rate had a big impact on the number of well completion operation days to complete the well. Tieback monobore well completion design was challenged to be optimized and delivered with lower cost to improve the project economics. The optimized well design should not compromise safety and integrity of the well during the well construction and production life of the well.

Cemented monobore has an advantage of optimizing the well completion design and operation days. The cemented monobore design concept was proposed for the well completion strategy as per Figure 1.2. The well construction design was with five casing schemes with 6 inches production hole. The 4½ inches tubing string would be run and cemented in place after drilling the production zone. Besar's economic evaluation passed the threshold value for all scenarios except for the low price scenario.

The global oil price crashed to USD30/bbl (Brent crude oil price) and high MYR vs USD exchange rate ware seen in 2016. Figure 1.3 shows five years oil price trend from 2013 to 2018. A study conducted by Havard Business School shows that USD50/bbl oil price puts some producing countries under considerable stress as they struggle with less oil revenue in their national budgets (Hartmaan & Sam, 2016). There was a need to redesign the cemented monobore well to further reduce the overall well cost and improve the project economic of the well.

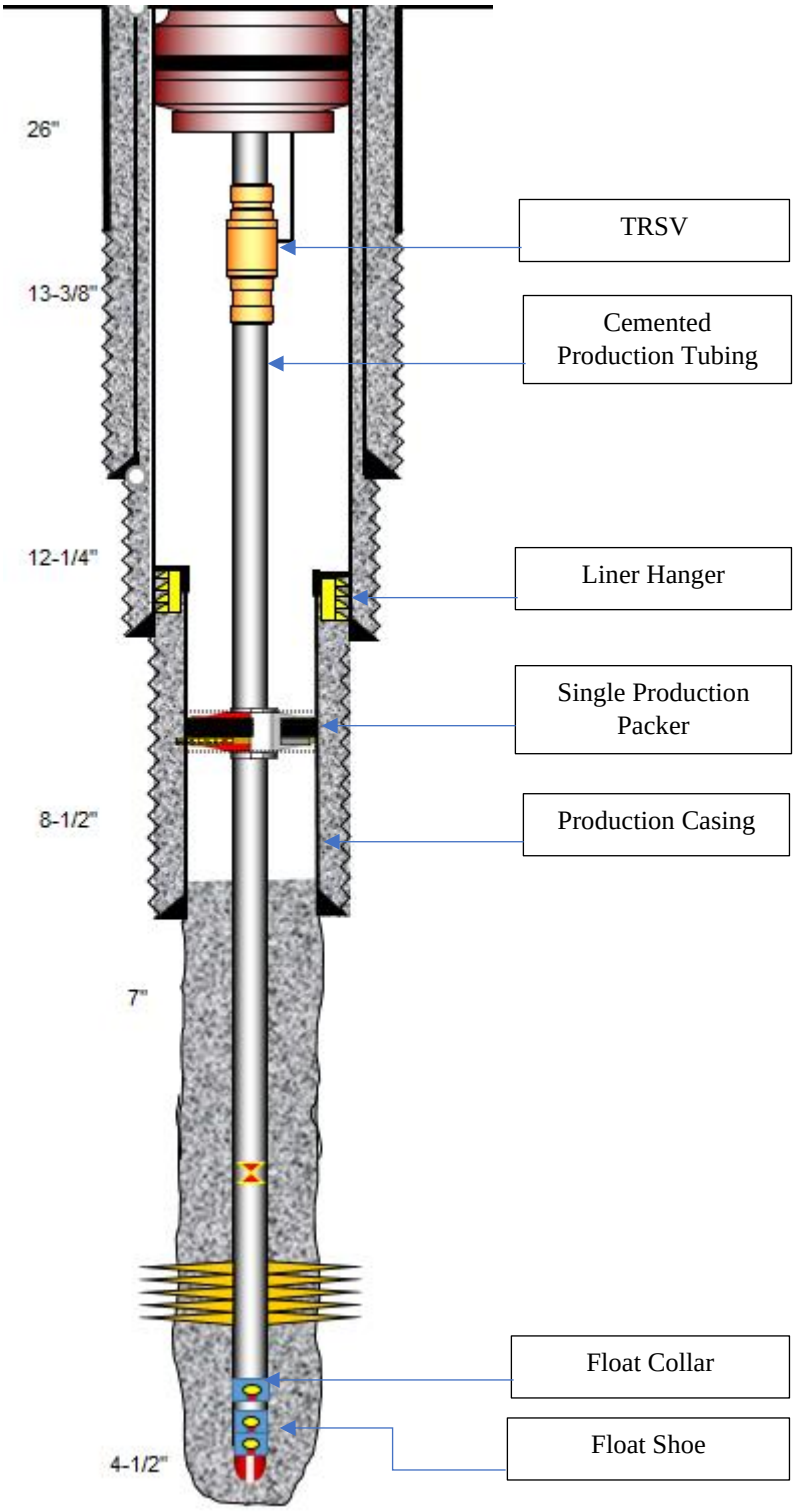

Figure 1. 2 Planned 4½ inches cemented monobore (PETRONAS, 2013)

Figure 1. 3 Five years global oil price trend (Infomine, 2018)

1.3 Objectives

The objective of this study is to conduct a detail engineering design of 4½ inches cemented monobore completion from conceptual design at a lower cost without sacrificing well safety and integrity.

1.4 Hypotheses

The hypotheses of this study are as follow:

(1) An improved cemented monobore design may produce hydrocarbon without sacrificing well integrity.
(2) The improved design may further reduce the overall well construction cost of cemented monobore design.
(3) The cemented monobore design may improve project economics especially for marginal fields.

1.5 Research Scope

The scope of this research work are as follow:

(1) Perform collaborative well planning to design the well cemented monobore well. Multidiscipline input from geology, subsurface, production technology and wells team.
(2) Selection of well completion equipment for cemented monobore completion.
(3) Tubing stress analysis using Landmark WELLCAT^{TM} design with multiple scenario during the life of the well.

1.6 Significance of study

The success of the detailed design planning of the well would results in the success of the first cemented monobore well in PETRONAS.

1.7 Chapter Summary

Cemented monobore has an advantage over tieback monobore in terms of number of well completion days. Oil price crash from USD110/day in 2013 to USD30/day in 2016 required cemented monobore to be redesigned to reduce the well cost. The objective of the study is to improve the conceptual design of cemented monobore established in 2013 in terms of detail engineering design of the 4½ inches cemented monobore completion. The aim is to deliver an improved cemented monobore well which meets the design standard as per PETRONAS standard at a lower cost without jeopardizing safety and well integrity. The research scope involve collaborative well planning, selection of well completion equipment, and tubing stress analysis. This study has the significant impact on the success of the first cemented monobore well in PETRONAS.

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