SETTING A HYDRAULIC PRODUCTION PACKER: A COMPARATIVE STUDY ON EXISTING PLUGGING METHODS IN HIGHLY DEVIATED WELLS AND A PROPOSED CONCEPTUAL DESIGN

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DEDICATION

To my dearest wife, thank you very much for always believing in me.

To my beloved parents, thank you very much for all your prayers.

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I want to express my gratitude to Associate Professor Issham bin Ismail for all the guidance he gave me when I was completing this project. Associate Professor Issham bin Ismail was very patient, understanding, and flexible while guiding me throughout this project. His kind words never fail to keep me going whenever I came across setbacks. This project would never happen without the encouragement and abundance of support from him.

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ABSTRACT

One of the challenges to complete a highly deviated well is to set hydraulically set production packers. A hydraulically set production packer is set by pressuring up the tubing string to create a differential pressure between the tubing string and annulus. The tubing string's closed system can be achieved by setting a profile plug at the end of the tubing string using a ball-activated pump-out plug or the disappearing plug. The profile plug and ball-activated pump out plug are risky to be used in highly deviated wells. In contrast, the disappearing plug creates unwanted debris, and it requires additional equipment to allow well circulation if unexpected well losses happen. This study was conducted to compare the available methods for well plugging in markets and construct a concept design as an option for the current methods available in the oil and gas marketplace. The concept design was developed by refining the existing methods to offer a low-cost alternative. This devised method requires no slickline run, auto-filling tubing while running in-hole, eliminating the drop ball application, and has an option for well circulation. This study was conducted based on existing Well A data. A comparative study was done to existing methods in Well A. The concept design was built using SolidWorks software, and the concept design application in Well A was compared with the ball-activated pump out plug. From the comparative study, the ball activated-pump out plug offers the lowest overall cost. The concept design produced from this research adopted the principle of the ball-activated pump out plug with the final design offers alternative well-plugging options for oil companies with the features mentioned above. Eventually, the new conceptual design would provide oil companies with lower overall costs and lower operational risks for well plugging during well completions.

ABSTRAK

Satu daripada cabaran untuk melengkapkan telaga yang sangat melencong ialah pengesetan penyendat pengeluaran berpengesetan hidraulik. Penyendat pengeluaran berpengesetan hidraulik diset dengan mengenakan tekanan hidraulik di dalam rentetan tetiub bagi mewujudkan perbezaan tekanan di antara bahagian dalam dan bahagian luar rentetan tetiub (atau anulusnya). Sistem tertutup di dalam rentetan tetiub boleh dihasilkan menerusi pemasangan palam profil pada hujung rentetan tetiub di dalam telaga, dengan menggunakan palam pam keluar teraktif bebola, atau menggunakan palam hilang. Palam profil dan palam pam keluar teraktif bebola adalah berisiko untuk digunakan pada telaga yang sangat melencong. Sebaliknya, palam hilang menghasilkan serpihan yang tidak diingini dan memerlukan alat tambahan bagi peredaran telaga sekiranya berlaku keadaan yang tidak dijangka. Kajian ini dilaksana bagi membandingkan kaedah yang tersedia untuk pemalaman telaga, dan membina reka bentuk konsep sebagai pilihan untuk kaedah terkini yang berada di pasaran minyak dan gas. Reka bentuk konsep dikembangkan menerusi penyempurnaan kaedah sedia ada bagi menawarkan pilihan dengan kos yang lebih rendah. Kaedah yang dirancang ini tidak memerlukan talian licik, pengisian rentetan tetiub secara automatik ketika penyorongan ke dalam lubang telaga, dan pengaplikasian bola rancung. Dengan kata lain, kaedah ini menyediakan pilihan lain untuk pengedaran telaga. Penyelidikan ini melibatkan suatu kajian perbandingan yang dilakukan terhadap kaedah sedia ada menerusi penggunaan data Telaga A. Reka bentuk konsep dibina menggunakan perisian SolidWorks, dan aplikasi reka bentuk konsep pada Telaga A dibandingkan dengan palam pam keluar teraktif bebola. Berdasarkan kajian perbandingan, palam pam keluar teraktif bebola menawarkan kos keseluruhan yang terendah. Reka bentuk konsep yang dihasilkan daripada penyelidikan ini menggunakan prinsip palam pam keluar teraktif bebola dengan reka bentuk akhir menawarkan pilihan lain pelengkapan telaga kepada syarikat minyak dengan ciri-ciri yang disebutkan di atas. Akhirnya, konsep reka bentuk yang baharu menawarkan pilihan kepada syarikat minyak dengan kos keseluruhan dan risiko operasi yang lebih rendah untuk pemalaman telaga yang sangat melencong.

TABLE OF CONTENTS

TITLE		PAGE
	ABSTRACT	**i**
	ABSTRAK	**ii**
	TABLE OF CONTENTS	**iv**
	LIST OF TABLES	**vi**
	LIST OF FIGURES	**vii**
	LIST OF ABBREVIATIONS	**x**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Background	1
1.2	Problem Statement	5
1.3	Objectives	6
1.4	Hypothesis	6
1.5	Research Scope	7
1.6	Significance of the Study	7
1.7	Chapter Summary	8
CHAPTER 2	**LITERATURE REVIEW**	**9**
2.1	Overview of Highly Deviated and Horizontal Well	9
2.2	Significance of Horizontal Drilling	10
2.3	Completion Technique for Highly Deviated and Horizontal Wells.	12
	2.3.1 Lower Completion Technique for Highly Deviated and Horizontal Wells.	13
	2.3.2 Upper Completion Technique for Highly Deviated and Horizontal Wells.	15
2.4	Production Packer	19
	2.4.1 Production Packer Component	21
	2.4.2 Hydrostatic Packer Operation	24
	2.4.3 Hydraulic Packer Operation	28

	2.5	Completion Well Plugging Methods	31
		2.5.1 Profile Plug	31
		2.5.2 Disappearing Plug	32
		2.5.3 Ball-Activated Pump Out Plug	33
	2.6	Proposed Method for Well Plugging	34
	2.7	Chapter Summary	35
CHAPTER 3		**METHODOLOGY**	**37**
	3.1	Research Flowchart	37
	3.2	Well Completion Design	40
	3.3	Comparative Study	41
	3.4	SolidWorks Design	45
	3.5	Hook load and Effective Tension Analysis	46
	3.6	Chapter Summary	49
CHAPTER 4		**RESULTS AND DISCUSSION**	**50**
	4.1	Introduction	50
	4.2	Well Completion Design	50
	4.3	Comparative Results	56
	4.4	Conceptual Design	57
		4.4.1 Overview of Conceptual Design	58
		4.4.2 Sequence of Operations	61
		4.4.3 Components' Details	62
	4.5	Torque and Drag Analysis	67
	4.6	Workshop Preparation Procedure	72
	4.7	Installation Procedure	74
	4.8	Comparison of Installation Procedure	75
	4.9	Chapter Summary	79
CHAPTER 5		**CONCLUSIONS AND RECOMMENDATIONS**	**81**
	5.1	Conclusions	81
	5.2	Recommendations	82
REFERENCES			**84**

LIST OF TABLES

TABLE NO.	TITLE	PAGE
Table 2.1	Comparison description and the affected area	35
Table 3.1	Comparison table for the existing method of well plugging operation	39
Table 3.2	Reservoir data	40
Table 3.3	Casing data	40
Table 3.4	Completion data	40
Table 3.5	Completion Equipment	41
Table 3.6	Estimated overall cost classification	45
Table 3.7	SolidWorks parameter	45
Table 3.8	Well A completion delineation data	48
Table 3.9	Well A profile	49
Table 4.1	Comparison table for the existing method of well plugging operation	56
Table 4.2	Workshop preparation procedure	72
Table 4.3	Installation procedure	74
Table 4.4	Installation procedure comparison between the concept design and ball-activated pump out plug	77

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
Figure 1.1	Disappearing plug (Source: Larimore et al., 2000)	2
Figure 1.2	Autofill sub (Source: Larimore et al., 2000)	3
Figure 1.3	Set up of pump out plug (Source: Evolutions Oil Tools Inc, 2014).	4
Figure 2.1	Typical well orientations used in the oil and gas industry (Source: PennState College of Earth and Mineral Sciences, 2020)	10
Figure 2.2	Fluid flow profile in vertical and horizontal wells (Source: Almenhali, 2012)	12
Figure 2.3	Example of upper completion and lower completion (Source: Bergkvam, 2015)	13
Figure 2.4	Open hole lower completion (Source: Danilović *et al.*, 2006)	14
Figure 2.5	Pre-drilled or slotted liner lower completion (Source: Danilović *et al.*, 2006)	14
Figure 2.6	Pre-drilled or slotted liner with the external casing packers (Source: Danilović *et al.*, 2006)	14
Figure 2.7	Casing or liner, cemented and perforated (Source: Danilović *et al.*, 2006)	14
Figure 2.8	Open hole with the pre-drilled liner and the stand alone screen (Source: Danilović *et al.*, 2006)	15
Figure 2.9	Open hole with the stand alone screen (Source: Danilović *et al.*, 2006)	15
Figure 2.10	Open hole with the gravel pack (Source: Danilović *et al.*, 2006)	15
Figure 2.11	Components of tubing-retrievable SCSSV (Source: Halliburton, 2020)	17
Figure 2.12	Component of sliding side door (Source: Halliburton, 2020)	18
Figure 2.13	Internal component of the sliding side door (Source: Halliburton, 2020)	19

Figure 2.14	Production packer placement in a well (Source: Halliburton, 2016)	20
Figure 2.15	Component of production packer (Source: Halliburton, 2016)	21
Figure 2.16	Isometric views of barrel slips for use in a packer assembly (Source: Rood, 2015)	22
Figure 2.17	Seal material selection table (Source: Halliburton, 2017)	23
Figure 2.18	Flow chart for packer element selection (Source: Halliburton, 2017)	23
Figure 2.19	Hydrostatic packer assembly (Source: Patterson *et al.*, 2001)	26
Figure 2.20	Hydrostatic setting module in run-in position (Source: Patterson *et al.*, 2001)	27
Figure 2.21	Hydrostatic setting module in setting initiation process (Source: Patterson *et al.*, 2001)	27
Figure 2.22	Hydraulic packer's cut-to-release diagram (Source: Halliburton, 2017)	28
Figure 2.23	Hydraulic packer operation positions (Source: Halliburton, 2017)	30
Figure 2.24	Configuration of Otis® RN® No-Go Landing Nipple and Lock Mandrel (Source: Halliburton, 2020)	32
Figure 3.1	Research flowchart	38
Figure 3.2	Example of hookload analysis	47
Figure 3.3	Example of effective tension analysis	47
Figure 4.1	Vertical section of Well A	51
Figure 4.2	Inclination of Well A	52
Figure 4.3	Dogleg severity of Well A	53
Figure 4.4	Deviated well schematic	54
Figure 4.5	Well completion design	55
Figure 4.6	Bill of material	59
Figure 4.7	Conceptual design overview	60
Figure 4.8	Sequence of operations	61
Figure 4.9	Housing's dimension	62
Figure 4.10	Floating plug seat's dimension	63

Figure 4.11	Floating plug's dimension	64
Figure 4.12	Assembly dimension	65
Figure 4.13	Components dimension	66
Figure 4.14	Torque and drag schematic.	67
Figure 4.15	Effective tension analysis' result. All operating lines are within the tension limit line.	68
Figure 4.16	Hook load analysis' result. All operating lines are within the limit line.	69
Figure 4.17	Effective tension – tripping in operation	70
Figure 4.18	Effective tension – tripping out operation	70
Figure 4.19	Hook load – tripping in operation	71
Figure 4.20	Hook load – tripping out operation	71
Figure 4.19	The well schematic for Well B	76

LIST OF ABBREVIATIONS

bbl per min	-	Barrels per minute
bbls	-	Barrels
EOT	-	End of Tubing
ID	-	Internal diameter
OD	-	Outside diameter
ppf	-	Pound per foot
ppg	-	Pound per gallon
psi	-	Pound square inch
SCSSV	-	Surface Controlled Subsurface Safety Valve
STB	-	Stock Tank Barrel

CHAPTER 1

INTRODUCTION

1.1 Background

Well completion is generally defined as the design, selection, and installation of suitable flow conduit equipment in a well. Well completion brings the reservoir fluid to the surface and produces it safely, efficiently, controlled, and satisfies the company objectives for the field development (Singh & Gas, 2015). This process happens to prepare the well for hydrocarbon production or injection by providing an interface between the reservoir to the surface production system (Bellarby, 2009). An effective completion design must maintain the borehole's mechanical integrity without creating any significant restrictions in the well's flow capacity (Bybee, 2004). Well completion engineering scope includes the drilling-in reservoir, well cementing, well completing, and well production (Wan, 2011). Well completion design considers aspects such as drilling loads, production, workovers, and metallurgy compatibility with production fluid as they are critical for a well's life cycle. Failure in the completion may lead to a delay in production, well integrity issues, and impact the economic field development plan (Singh & Gas, 2015). Although the well completion is designed to overcome and address the specific field challenges, the main drive behind the well completion design process is to achieve significant cost reduction and improve the field's economics (Hilal *et al,* 2017).

One of the most crucial pieces of completion equipment is a packer, which was first introduced in the early 1900s. It can be used for injection, production, or squeeze operations. Depending on the purpose and design, it can be deployed on drill pipe, wireline, or production string and set by using setting tools or tubing pressure against a barrier device (Bisset, 2011). On the other hand, production packers can generally be classified as retrievable or permanent types of packers. It is a crucial part of the completion design as it serves to isolate and control producing fluids and pressures. It also helps isolate pressure to protect the casing and formation above and below the producing zone (Patton, 1987). A conventional completion would require a one trip plug or two trips plug to be run and set below the packer by running of wireline or coiled tubing before pressuring up the tubing to create a closed system in the completion string and set the packer (Bisset, 2011). However, this method will typically require heavy lifts offshore and weather dependant, potentially driving up the cost. Additional time to run and retrieve the plugs and the risk the plugs might not easily be retrieved may also impact the project economics. Due to these reasons, the operational cost can be reduced if this method can be eliminated (Patterson *et al*, 2001).

To come up with a cost-efficient method to set a hydraulic packer, the disappearing plug (Figure 1.1), which serves as a plugging device for setting a hydraulic-type packer, was developed. By using the disappearing plug, the tubing will be filled automatically through an auto-fill device {Figure 1.2), which will close during one of the pressure cycles. The fluid-expendable plug material disintegrates on the last pressure cycle, which allows full tubing-drift production. This disappearing plug eliminates the need for a slickline or coiled-tubing run to retrieve a plug (Larimore *et al*, 2000).

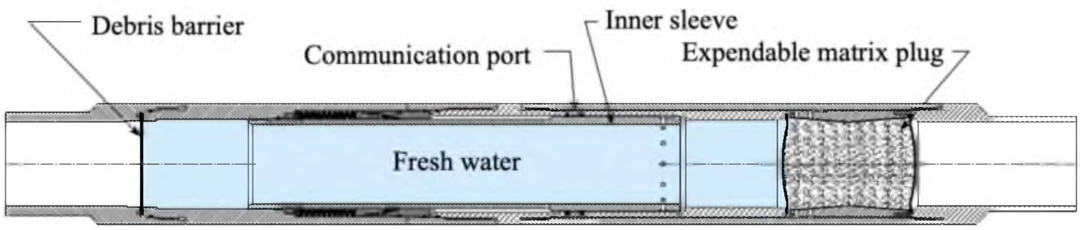

Figure 1.1 Disappearing plug (Source: Larimore et al., 2000)

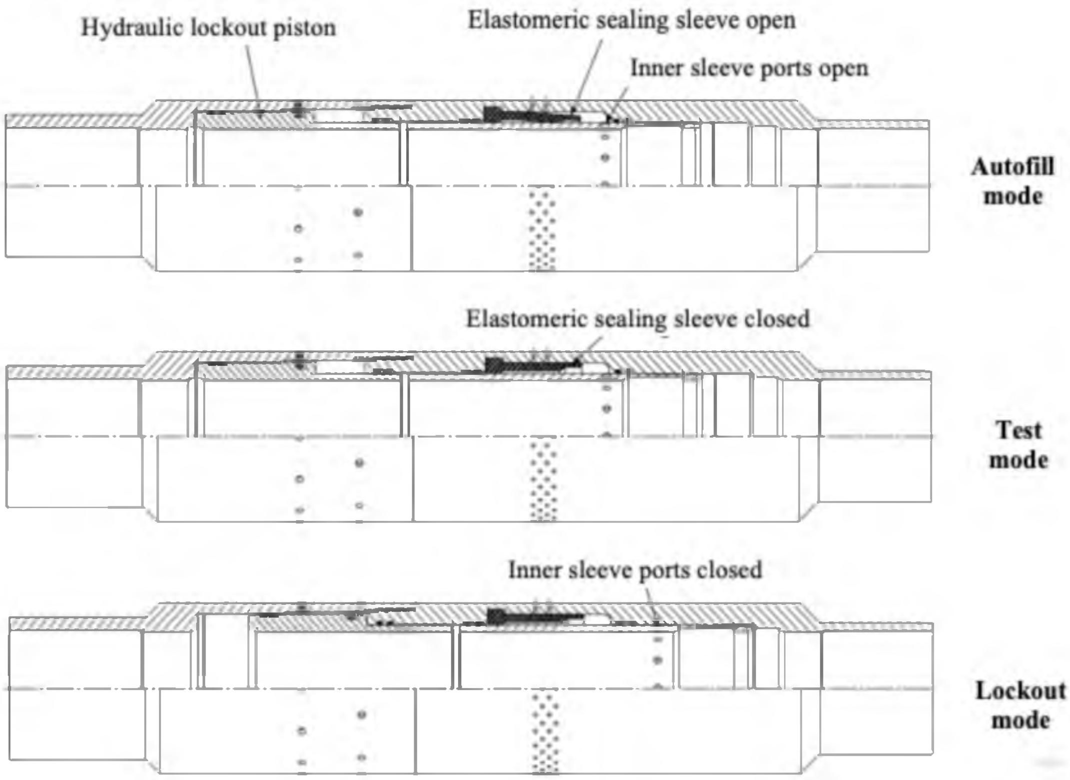

Figure 1.2 Autofill sub (Source: Larimore et al., 2000)

A ball-activated pump-out plug (Figure 1.3) is another piece of equipment used to replace the profile plug to set the hydraulic packer. The pump-out plug consists of a ball seat and a ball. The ball seat will be run as part of the tubing string, located at its end. The ball seat is open-ended, providing a self-filling for the tubing string during running in-hole and well circulation capability when required. When it is decided to set the hydraulic packer, the ball will be dropped from the surface. This type of plug allows the tubing to be pressured to set a device such as a packer. After the required pressure is reached, the brass screws shear, expelling the core downward out of the tubing (Evolutions Oil Tools Inc, 2014). However, there is a risk that the ball will not be placed on the seat in a horizontal or high angle hole, especially when there might be debris in the well (Wong & King, 2008).

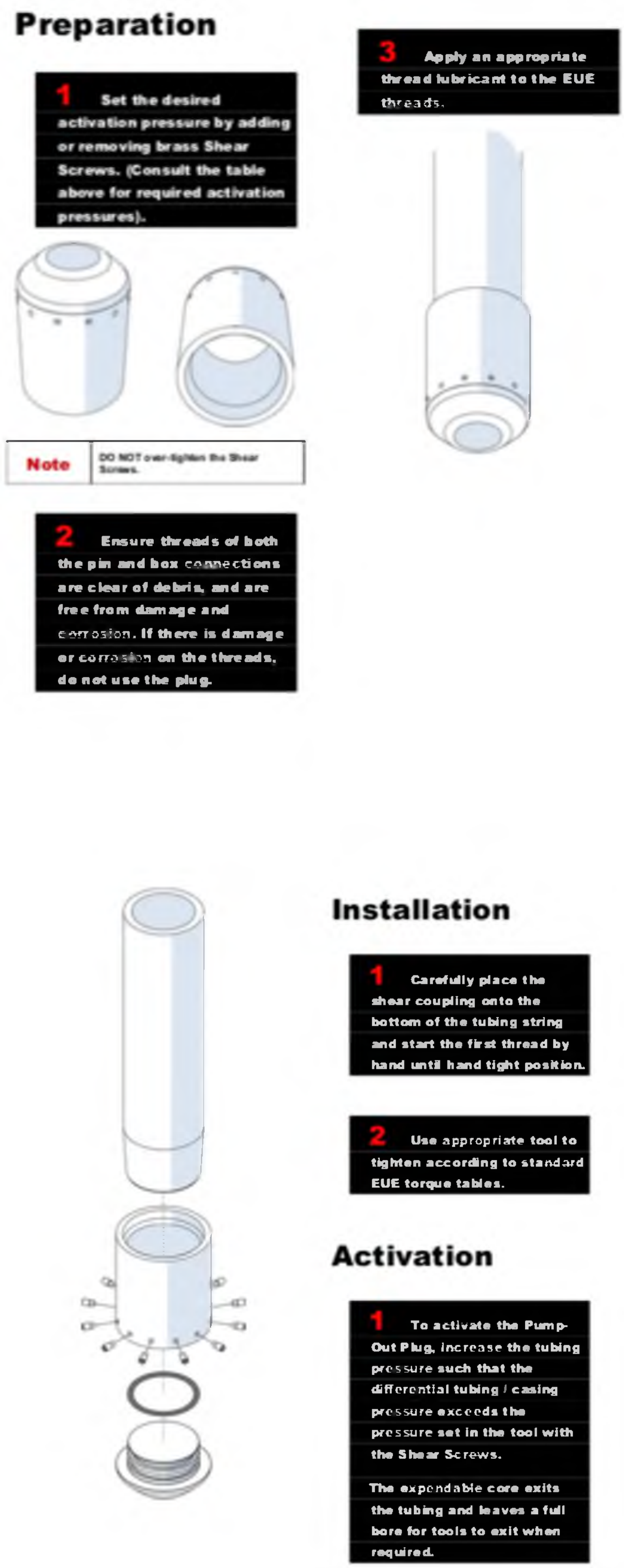

Figure 1.3 Set up of pump out plug (Source: Evolutions Oil Tools Inc, 2014).

1.2 Problem Statement

A hydraulic set packer is a packer that establishes a pressure differential across the packer's setting piston, which usually requires the setting of a tubing plug below the packer (Patterson et al., 2001). Traditionally, when the packer reaches its setting depth, a wellhead hanger will be landed, and the plugging device will be installed below the packer before pressuring up the tubing (Triolo et al., 2002). After it is set, the packer's function is to grip and seal against the casing ID. A properly functioning packer must remain anchored stationary within the casing to maintain pressure sealing integrity with differential pressures from below and above the packer (Fothergill, 2013). The available method to achieve this condition in the well is by using the profile plug, disappearing plug, and ball-activated pump out plug. Although there is an option to use a hydrostatic set packer, the absolute well activation pressure requires the well to be cased hole, unperforated, or to have lower completion completely isolated before setting the packer (King & Arrazola, 2004). These conditions are usually difficult to meet.

The profile plug and the ball-activated pump-out plug is the conventional method to introduce the closed system in the tubing string. However, the profile plug is not recommended in horizontal or high angle well due to slickline run has its limitation to run in well with an angle more than 60°. The ball-activated pump-out plug's operation also risky in horizontal and high deviated well as the ball might not reach the ball seat to contain the tubing pressure. As for the disappearing plug, although the application eliminates the need for slickline run and ball drop operation, this application will not provide the pump down capability option in the event of a well control issue. This study was conducted to analyse the advantages and limitations of the existing methods for well plugging to set a hydraulic packer, and propose a concept design that eliminates the slickline run and drop ball application, provides tubing self-filling while running in-hole, and capable of well circulation.

1.3 Objectives

The objectives of this study are as follow:

(1) To compare the existing methods to set a hydraulic packer. The current methods are the profile plug, which requires slickline run, ball-activated pump out plug that requires drop ball operation, and disappearing plug.

(2) Based on the comparative study's result, to produce a concept design to set a hydraulic packer, which eliminates the slickline run and drop ball application, provides tubing self-filling during run in-hole and the capability to pump through the completion string.

(3) To compare the workflow and operational procedure between the concept design and the existing methods; profile plug, ball-activated pump out plug, and disappearing plug.

1.4 Hypothesis

(1) By eliminating the slickline run and the drop ball application, the non-productive time resulting from these operations' risk in highly deviated wells and horizontal wells will be reduced.

(2) The overall operational cost will be reduced by eliminating the need for a slickline run since no slickline package, and slickline personnel is required.

(3) The operational time will be reduced and subsequently reduce the rig cost. The tubing self-filling feature will eliminate the need to manually filling the completion string during run in-hole. The concept design also will remove the time allocate for slickline rig up and run in-hole.

1.5 Research Scope

This study was conducted as follows to achieve the objectives:

(1) Compared existing plugging methods in the marketplace by focusing on the advantages and limitations of each method.

(2) Constructed a drawing of the concept design to set a hydraulic packer by using SolidWorks software. The concept design was produced by adopting the principle of all-activated pump out plug based on the comparative study. The concept design provides a self-filling feature, well circulation capability, no slickline, and ball drop requirement.

(3) Produced a well completion schematic for the concept design. Based on the gathered well data, a completion design that consists of upper completion equipment was produced by using WellPlan software.

(4) Performed the hook load and effective tension analysis of the well completion schematic with the concept design by using WellPlan software.

(5) Produced a workshop preparation workflow, running in-hole, and setting the hydraulic packer for the proposed concept design. The installation procedure of the proposed concept design with the adopted existing method was compared.

1.6 Significance of the Study

This study provides oil operators with a low-cost and low-risk option for completion strategies generally. The method of setting the hydraulic production packer in horizontal or high deviated wells, specifically. Eliminating the slickline run alone reduced operational cost while eliminating the ball drop requirement reduced the risk of unable to pressure the tubing string to set the hydraulic packer. With an in-built self-filling feature and pump down capability, the operation ready for any well control contingency when needed. The concept design was a low-cost application with lower operational risks based on the comparison study performed.

1.7 Chapter Summary

The purpose of this study is to propose a concept design of plugging method to set a hydraulic packer that offers no slickline run, none ball-activated system, tubing self-filling feature, and a pump down through the tubing capability. We can see that none of the discussed methods can offer the features in one system through the discussion in this chapter. Understand that each of the existing methods has its advantages and disadvantages. This study aims to optimize the strengths and minimize, if not eliminates, the limitations.

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