COILED TUBING DRILLING FOR OFFSHORE WELLS

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"My wife, family members and friends"

Thank you for your support. This is for all of you

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ABSTRACT

Coiled Tubing Drilling (CTD) is becoming more popular in the oil and gas industry as an alternative drilling technique to rejuvenate depleting fields. Its cheaper drilling cost makes CTD viable to be applied for idle wells and brownfields. The in-depth investigation is carried out to identify the process and workflow of selection criteria for suitable wells to be drilled using CTD application. CTD is one of the enabling technologies in well intervention technique which can offer industry another option especially in the re-development of brownfields. It has unique capabilities in underbalanced drilling which can prevent formation damage and reduce drilling risks. This technique can be used to replace the traditional sidetracking techniques, i.e., rotary rigs to sidetrack wells as it reduces the time taken to make-up and break-out the joint pipe and also requires a smaller footprint for coil tubing unit which provides an additional advantage to work on smaller structures. A case study has been detailed out in this research work to show the importance and applicability of CTD. Overall, this technology costs lower than the conventional drilling or hydraulic workover unit which makes it more attractive to access bypassed oil or untapped reservoirs hence prolong a field's economic life.

ABSTRAK

Penggerudian tetiub gegelung (CTD) menjadi semakin popular dalam industri minyak dan gas sebagai satu pilihan teknik penggerudian untuk memberikan nafas baharu kepada medan susut. Penggerudian jenis ini adalah murah lalu menjadikannya sebagai suatu teknik boleh jaya yang sesuai untuk digunakan terhadap telaga terbiar dan medan matang. Projek ini adalah untuk mengenal pasti proses dan aliran kerja untuk memilih calon telaga yang sesuai untuk digerudi menggunakan CTD. Penggerudian tetiub gegelung memberi pilihan kepada industri untuk membangunkan semula medan matang. Penggerudian jenis ini mempunyai kemampuan yang unik dalam penggerudian bawah imbang yang boleh mencegah kerosakan formasi dan mengurangkan risiko penggerudian. Teknik ini boleh diguna untuk menggantikan teknik pelencong telaga lazim, misalnya rig berputar yang diguna bagi menggerudi telaga secara melencong, kerana teknik terbabit mampu mengurangkan masa mengikat dan menanggalkan sambungan paip. Selain itu, CTD juga memerlukan kawasan kerja yang lebih kecil untuk ditempatkan unit tetiub gegelung dengan keadaan itu memberikan kepadanya kelebihan untuk beroperasi pada rig atau pelantar yang kecil. Suatu kajian kes telah diketengah bagi menunjukkan tentang kepentingan dan pengaplikasian CTD. Secara keseluruhan, teknik ini melibatkan kos yang rendah berbanding penggerudian lazim atau unit kerja semula hidraulik, lalu menjadikannya lebih menarik untuk menggerudi laluan ke dalam reservoir yang terlepas pandang sebelum ini atau reservoir baharu bagi memanjangkan hayat ekonomik medan.

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UTM	-	Universiti Teknologi Malaysia
BBL	-	Barrel
BHP	-	Bottom Hole Pressure
BPD	-	Barrel Per Day
CTD	-	Coiled Tubing Drilling
DLS	-	Dog Leg Severity
GLM	-	Gas Lift Mandrel
OH	-	Open Hole
OBD	-	Overbalanced Drilling
m-MD	-	Meter-Measured Depth
NPT	-	Non Productive Time
SSD	-	Sliding Sleeve Door
SSSV	-	SubSurface Safety Valve
UBD	-	Under Balanced Drilling
WOB	-	Weight On Bit

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CHAPTER 1

INTRODUCTION

1.1 Background

Drilling operation is an important phase in the upstream of oil and gas industry. It involves in drilling a conductor, surface, intermediate, and production holes; which should penetrate the reservoir until its total depth is about 75 ft below the bottom of the reservoir. All the casing strings should be cemented prior to drilling the next hole (Dupius, 2007; Brunherotto et al., 2017; Holden et al., 2017).

Due to lower current global oil prices, oil companies are looking at many aspects to lower their capital and operating expenditures especially in drilling operations. Apart from reducing the non-productive time in drilling operations, another possibility that they can look into is the usage of coil tubing drilling (Ahmed et al., 2012; Kruger et al., 2013; Leising and Newman, 1993).

Coiled Tubing Drilling (CTD) is very important in drilling operations as it can drill a hole with cheaper cost compared to conventional way without compromising the quality of the well and safety (Kumar et al., 2011). The technology has been applied and proven for more than 30 years. It should be re-visited because it can give an alternative method of drilling to oil operators to reconsider the by-passed oil in mature fields. As highlighted earlier, the current downturn in oil price has forced the industry to find a cheaper alternative compared to conventional way of using drill pipe. CTD can drill faster and save drilling time by almost 60% than conventional drilling

(Littleton et al., 2010), thus provides a significant impact in getting the revenue and improve the economic (*Liu et al., 2017; Lheure et a.l, 2000; McCarty et al., 2001*; Mc Carty et al., 2002).

The current technology enables oil operators to drill slim holes (Ibrahim et al., 2013) and extended reach horizontal holes (Alimuddin et al., 2012; Burke et al., 2014; Li et al., 2017) in an underbalanced condition (Tinkham et al., 2000; Khamess et al., 2013a, Khamess et al., 2013b) using coiled tubing successfully. Advancement in CTD operation was realized with the successful drilling and completion of world's first multilateral well (Ooi et al., 2016) in Malaysia. But to achieve a high successful rate in CTD operations, a proper planning on candidate selection criteria is very crucial (Gary et al., 1995; Ross et al., 2015; Vonthetoff et al., 2009). In fact, CTD has a bright future especially in lower global oil price environment (Crabtree, 2017).

In field development plan (FDP) and development phases, due to deadline to achieve the first oil and economic factors, oil operators may optimize the development plan via bypassing some of pay zones (Rahman et al., 2012). Once the field matured, accessing the by-passed oil behind the casing which is normally in a thin reservoir with low permeability can be economically attractive but is very challenging especially if it is located offshore compared to onshore environments (Ooi et al., 2016).

As a background drilling using coiled tubing concept started in late 1940's an operation used a continuous string and downhole motor for drilling. In 1960's the prototypes were developed and commercially introduced in mid-1970s. However, the modern CTD era started in 1991 with a horizontal sidetrack re-entry drilled by Oryx Energy in the Austin Chalk of Texas (Leising and Rike, 1994). Coiled Tubing Drilling application has been successfully implemented in Canada (Madarapu *et al.*, 2007), United States of America, Russia, North Africa, Middle East (Surewaard *et al.*, 1997; Khamess *et al.*, 2013a; Khamess *et al.*, 2013b), and South-East Asia (Rahman *et al.*, 2012; Al-Humood and Al-Khamees, 2017). The overwhelming application of CTD in North America which focused on 'shale play' has spurred many innovative developments in well design and completion techniques (Misselbrook, 2011; Ortega *et al.*, 2010). CTD can be described as drilling using seamless tube coil on a reel. The use of coiled tubing keeps increasing as shown in Figure 1.1 (ICoTA, 2017).

Various geological formations have been successfully drilled with CTD systems (Peng et al., 2017). Active area drilling and re-enter the wells with technology are Canada and United States of America. Malaysia via Petronas initiated the CTD study back in 2005 with the pilot projects were carried out in 2011. List of some CTD operations are outlined in Chapter 2. The evolution (Kazlov et al., 2010) of CTD technology is one of exciting sections in drilling and has become a competitive advanced drilling method in oil industry (Crouse et al., 2000; Liu et al., 2017). This new technology has the potential to be applied widely in Malaysia as it is experiencing an increase in number of matured fields and idle wells (Hamzah, 2012; McCarty et al., 2002; Bumbaugh, 2011).

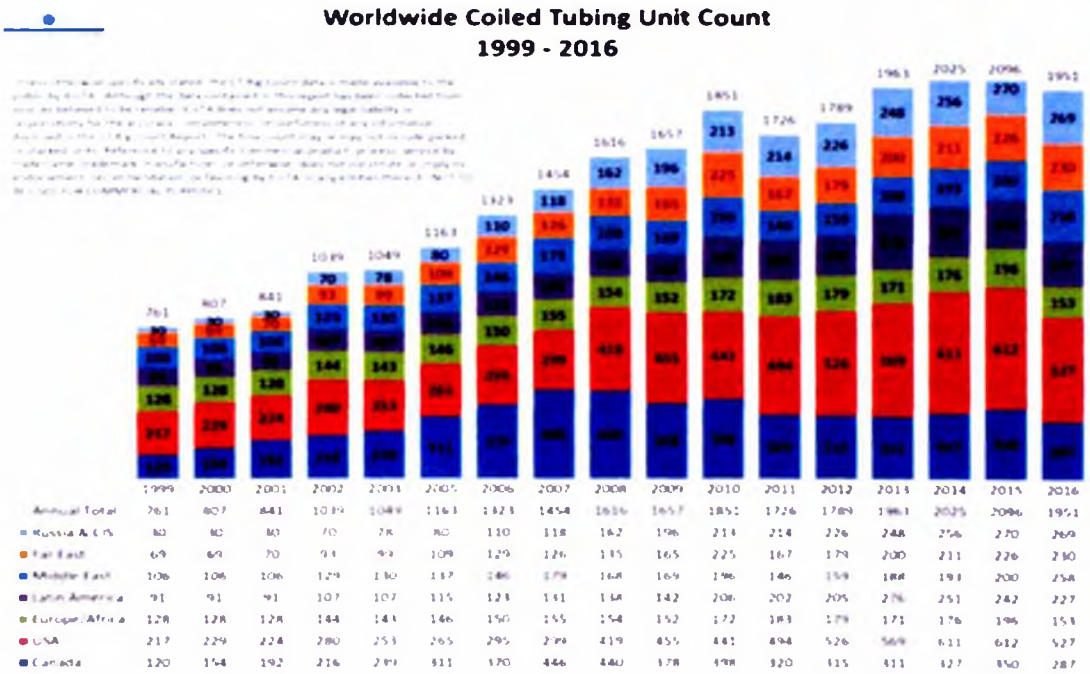

Figure 1.1 Worldwide coiled tubing unit count from 1999-2018 (ICoTA, 2017)

Coiled tubing drilling can be described as drilling using seamless tube coil on a reel. The use of coiled tubing keeps increasing as shown in **Figure 1.1** Worldwide coiled tubing unit count from 1999-2018 (ICoTA, 2017).

The growth of coil tubing from 2014 to 2025 as explained in Section 2.7 also shows the increases usage particularly in well intervention and CTD. Major factors

contributing to the demand are increasing operating cost for extracting oil from existing wells and regeneration of matured oil wells. In addition, the rise in shale gas projects and development in other unconventional resources are also anticipated to drive the market growth. Current experiences in CTD show there are many advantages of CTD especially in saving drilling time, ability to re-enter an integrated coiled tubing gyro measurement-while-drilling (MWD) instrument (Madarapu et al., 2007; Mix et al., 1996) and drill thru-tubing that save the cost for upper completion and the drilling equipment is light and moveable (Cassee et al., 2006). Lesson learnt from other projects also outlined the disadvantages of CTD particularly on the depth limitation to reach extended reach objectives, people competency and high total day rate cost. These disadvantages make the drilling team thought that the CTD application is more expensive and riskier than the conventional drilling. Throughout the experiences with a lot of success stories including multi drilling and completion, extended reach, slim hole drilling and lesson learnt from other projects has made CTD application becoming more attractive to the oil and gas industry.

Active area drilling and re-enter the wells with CTD technology are mainly found in Canada and US. Malaysia operation started the CTD study in 2005 and the pilot projects carried out in 2011. German, Oman, and United Arab Emirates are also successful in applying CTD in their operations. A list of some CTD operations is given in Chapter 2.

1.2 Problem Statement

CTD development started in 1991 with a horizontal sidetrack re-entry drilled by Oryx Energy in the Austin Chalk of Texas. It can be described as drilling using seamless coil on a reel. This new technology has the potential to grow further in Malaysia's upstream operations as there are many matured fields and depleted wells with difficult or challenging next drilling targets to be accessed from existing wells or platforms. The implementation of CTD should be considered because to sidetrack existing depleted wells is expensive; CTD application is an alternative to reduce the project cost for fields to remain economic. However not all wells are suitable for CTD,

thus selection criteria is required for re-entry the well. It is imperative to have a proper planning especially on the candidate selection criteria to allow oil operators achieving a high successful rate in CTD operations.

1.3 Objectives

The objectives of this project are:

1) To develop CTD selection criteria for re-entry well.

2) To compare the cost between CTD and conventional drilling

1.4 Hypotheses

The hypotheses for this research work are as follow:

1) Technical feasibility study and candidate screening can reduce risk in re-entry well drilling operation.

2) A good feasibility study and planning can increase the chances of achieving 100% success rate.

3) A reliable technical feasibility study and candidate screening can improve project economics.

4) Coiled tubing drilling enables oil operator to drill sidetrack wells in challenging depleted existing wells at lower cost.

1.5 Scope

The scope of this research works are as follow:

1) To identify the criteria and elements which help to increase success rate of CTD application.

2) To develop the selection criteria for CTD by analyzing the current situation of the well, i.e., completion type, angle, technical capabilities, impact of time, platform capacity (such as deck space and people onboard capacity), and history of the well for re-enter to develop the by-passed hydrocarbon zone(s) (Lheure *et al.*, 2000).

3) To study the cost elements between CTD and conventional drilling in order to outline the cost reduction initiatives for sidetracking holes using CTD in underbalance drilling environment (Venrooy *et al.*, 1999).

1.6 Significance of Study

This study provides a guideline and candidate selection procedures in helping the engineers and oil operators to re-enter an idle well in a very competitive cost with high success rate. Thus, it will increase commercial value of a mature/depleted field and prolong the field's life. The findings from the project can provide invaluable information on the process of selecting the right matured/depleted well to be rejuvenated using CTD which will subsequently improve the success rate in the CTD project executione.

1.7 Chapter Summary

This chapter discusses the importance of CTD in drilling operation especially in re-visiting brown fields. The application of CTD requires simple unit components, less manpower, less time usage, and is lighter which makes it mobile and perfectly suited for drilling matured fields using underbalance drilling method. In fact, CTD is another method of drilling which allows oil operators to drill cheaper to reach untapped hydrocarbon. Based on recent technology development and experiences worldwide, it is proven that CTD drilling's objectives are achievable with proper selection criteria and planning. For this research project execution, three scopes have been identified to satisfy the objectives of developing CTD selection criteria for re-entry well and outline its cost reduction initiatives.

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