RESERVOIR PRODUCTIVITY RESTORATION IN DUAL-STRING COMPLETION WELL USING PERFORATION METHOD

AMMAR ZARIR BIN HARISON

A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Petroleum Engineering)

Faculty of Petroleum and Renewable Energy Engineering
Universiti Teknologi Malaysia

JUNE 2014

To my beloved parents and fellow classmates

Thank you for your continuous support.

ACKNOWLEDGEMENT

Bismillah. In the name of Allah besides whom there is no other worthy of worship, I would like to express my humble appreciation to my master project supervisor, Associate Professor Azmi Kamis for all the guidance which made me complete the project report successfully.

My sincere appreciations also to my classmate, Robby Oktobaren for his kind assistant and encouragement and also providing me valuable information that help me to finish my master project in a smooth way. Very special thanks to my beloved parents for always pray for my success and my dream to be a petroleum engineer.

Last but definitely not least to all my classmates and lectures who involved directly and indirectly during my preparation for this master project. Although the past 2 years has been a very stressful and full of tense, nevertheless it is one of the priceless moments in my life. I do cherish all the moments that we have spent together and may our path cross again in the future.

ABSTRACT

A sudden drop of production rate can happened due to formation damage, mechanical failure and others unprecedented problems. Selecting the suitable well stimulation method to treat the unproductive reservoir or to restore the reservoir productivity for a dual-string completion well which have multiple production zones becomes a challenge as there is no direct access to the problem production zone to investigate the root cause of the problem. Conventional method such as acidizing and hydraulic fracturing not an option for this situation, therefore re-perforation the production zone method have been decided to restore back the reservoir productivity. The case study have showed that a deep penetrating charge perforating system is required for this perforation method as the perforation need to penetrate the blast joint, annulus material, casing, the formation damaged zone and the formation. Further perforation analysis has been done to analyze the perforation designs which produce optimum penetration. Several parameters that expected to affect the perforation performance have been selected to simulate the perforation process using SPAN software. The result shows that the formation rock strength have a significant impact to the penetration length. Meanwhile, annulus materials slightly affect the perforation performance. A detail design of perforation gun system properties such as standoff position, shot density and shot phasing able to produce an optimum performance as each parameters have its own impact to the perforation performance. Further study on the others option of remedial sand control for the unconsolidated formation and the integrity of the blast joint after perforation is recommended to improvise this method.

ABSTRAK

Penurunan mendadak kadar pengeluaran boleh berlaku disebabkan oleh kerosakan formasi, kegagalan mekanikal dan lain-lain masalah yang tidak pernah berlaku sebelum ini. Memilih kaedah stimulasi telaga yang sesuai untuk merawat reservoir yang tidak produktif atau meningkatkan produktiviti reservoir bagi pemasangan dwi-tiub yang mempunyai zon pengeluaran berganda menjadi satu cabaran kerana tiada akses langsung kepada zon pengeluaran yang bermasalah untuk menyiasat punca masalah itu. Kaedah konvensional seperti pengasidan dan peretakan hidraulik bukan satu pilihan untuk keadaan ini, oleh itu keputusan untuk memilih kaedah penembusan semula zon pengeluaran telah diambil untuk memulihkan kembali produktiviti reservoir. Kajian kes telah menunjukkan bahawa sistem cas penebukan dalam diperlukan untuk kaedah ini kerana penembusan perlu menembusi sendi bagas, bahan dalam anulus, selongsong, zon formasi rosak dan formasi. Analisis penembusan susulan telah dilakukan untuk menganalisis reka bentuk penembusan yang menghasilkan penembusan yang optimum. Beberapa parameter yang dijangka akan memberi kesan prestasi penembusan yang telah dipilih untuk mensimulasikan proses penembusan dengan menggunakan perisian SPAN. Hasilnya menunjukkan bahawa kekuatan batu formasi memberi kesan besar kepada panjang penembusan. Sementara itu, bahan-bahan anulus sedikit menjejaskan prestasi penembusan itu. Satu reka bentuk terperinci ciri-ciri sistem senapang penebukan seperti jarak ‘standoff’, ketumpatan penebukan dan fasa penebukan mampu menghasilkan prestasi yang optimum kerana setiap parameter mempunyai kesan sendiri untuk prestasi penembusan itu. Kajian lanjut pada cadangan kawalan pasir pemulihan yang lain untuk formasi yang tidak terkokoh dan integriti sendi bagas itu selepas penembusan adalah disyorkan untuk menambah baik kaedah ini.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

m	-	meter
ft	-	feet
g	-	gram
psia	-	pounds per square inch absolute
spf	-	shot per foot
bbl/d	-	barrel per day
SSD	-	Side Sliding Door
PBU	-	Pressure Build Up
HSD	-	High Shot Density
SPAN	-	Schlumberger Perforation Analysis
UCS	-	Unconfined Compressive Strength
PJO	-	PowerJet Omega
PF	-	PowerFlow
MDDF	-	Measured Depth Drill Floor

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The upstream of the petroleum industry involves itself in the business of exploration and production activities. The objectives of the exploration activities are to find the hydrocarbon reservoirs, while the production activities are to deliver the hydrocarbon to the downstream of the industry. The delivery process including the reservoirs to the above ground facilities via tubing string and others completions devices.

The world's oil companies continue to enhance their production to meet the high demand of hydrocarbon energy. This situation has driven the company to explore the reservoir in all productive formations. Dual completions are most common in stacked reservoir sequences in low to moderate rate, shallow water wells. Figure 1.1 shows the typical well schematic of dual-string completion.

The dual-zone completion using parallel tubing strings method generally is used in applications in which it is desirable to produce two zones simultaneously while keeping them isolated from each other. Despite their obvious complexity, there are a surprisingly large number of dual (and triple) completions around the world and they are not a modern invention.

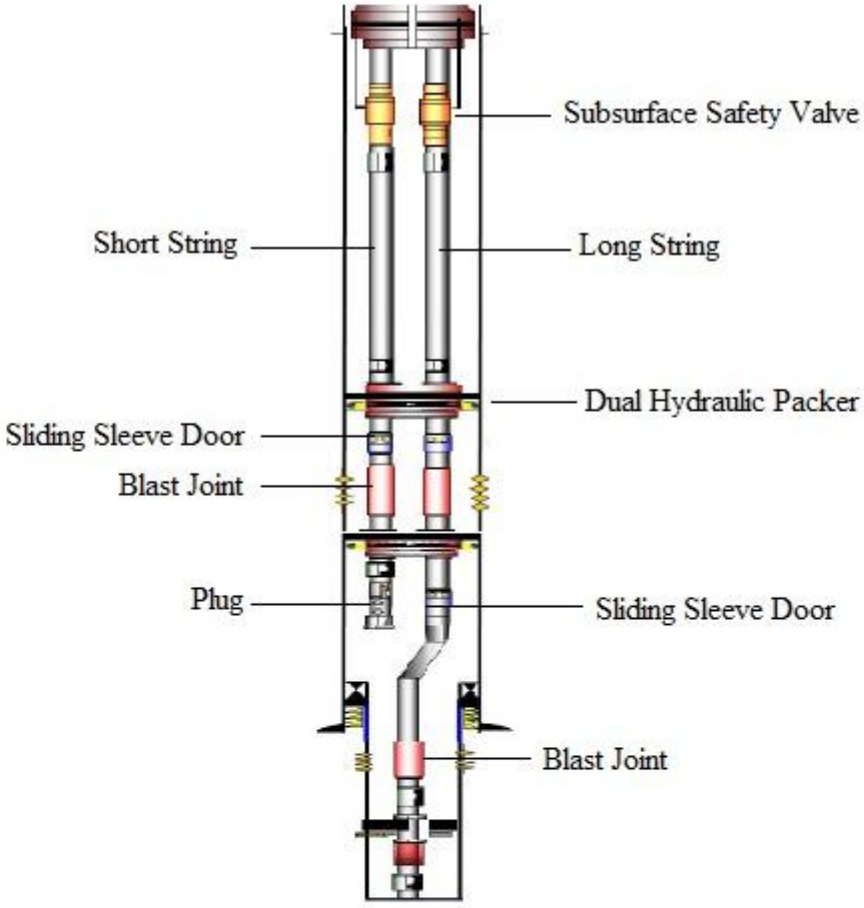

Figure 1.1 Typical parallel-string dual-zone completion well schematic

In this completion, two strings of tubing are run from the surface to the dual packer. One string terminates at the dual packer, and the other string of tubing extends from the dual packer to the lower single string packer. The tubing string that produces the upper zone is referred to as the “short string” (or upper tubing), and the tubing string that produces the lower zone is called the “long string” (or lower tubing).

A sliding sleeve is positioned between the packers for aid in circulating kill-weight fluid in the hole or circulating lighter fluid or gas in the tubing strings to bring the well on production. A blast joint should be positioned across the perforations of the zone between the packers to reduce the risk of erosion damage to the long string from well fluids and produced sand. Profile seating nipples should be run above the dual packer on both strings for well control or testing tubing for well-diagnostic purpose.

These completions are used where independent production or injection is required. This can be for a number of reasons such as incompatible fluids (e.g. scales), different pressure regimes (severe cross-flow if the fluid is commingled), reserve assurance (one interval can "kill" production from another when it waters out) and multipurpose wells (injection into one interval combined with production from another.

The complexity of dual completions is their main drawback. It is difficult to integrate with sand control reservoir completion in this type of well completions. It is also difficult to perforate the upper interval. Options include oriented guns run through the short string, perforating prior to running the completion and side-string perforating.

One of the disadvantages of the dual completion is limited access to the upper interval. The only access to the upper interval is through the sliding sleeve door. However this access is above the perforation zone. Therefore, there is no direct access to the reservoir producing zone if the interval encountered with production related problem.

It is always difficult to ascertain just what is going on inside a reservoir. Sand problems are most common in the production of hydrocarbon. Sand production is solid productions which produce together with the production fluid from the productive formation. The sand will be reproduced if it does not meet the geometry of a stable arch (Suman et al., 1992). Figure 1.2 shows the geometry of a stable arch around perforations tunnel.

The sand production will accumulate in the surface equipment from time to time. The flow rate production will lift up the sand through tubing to the surface and trapped inside the separator or production pipe. Fluid production rate will decrease along with the accumulation of sand that clogs in the well.

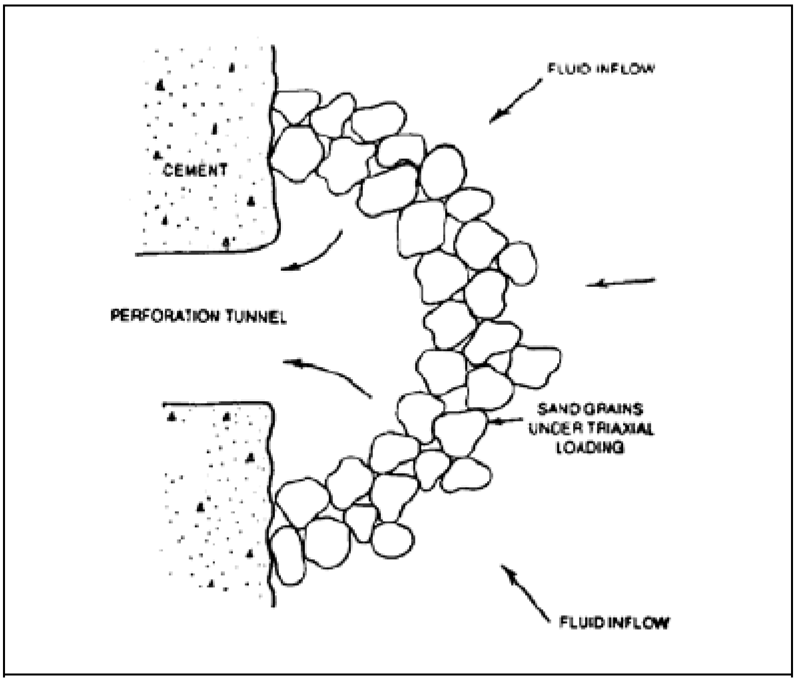

Figure 1.2 Geometry of a stable arch around perforations (Source: Suman, 1992)

Besides sand problem, the oil industry has long been aware of minerals deposition problems (scale, asphaltene, wax etc) in production tubing, flowlines, bottomhole pumps and surface equipment. This phenomenon can also occur inside the reservoir itself, where the temperature and pressure variations may also give rise to minerals deposits that block pores and seriously impair well productivity. When minerals precipitation problems affect production tubing, surface equipment or flowlines, they are easily detected, but when they occur inside porous media, the investigation becomes more difficult.

Mineral scales are inorganic solids precipitated from water and subsequently deposited. Waxes are long-chain alkaline hydrocarbons that are solid at low to moderate temperature. Like waxes, asphaltene are organic solids that precipitate from crude oil system.

The sand problem and minerals precipitation can cause plugging of the formation, hence reducing the well productivity due to the declination of reservoir pressure. If the formation not be treated properly, the problem can cause to the extent of formation damage and collapsing the formation.

Generally, well stimulation will be performed on a well to increase or restore production. Stimulation also used to further encourage permeability and flow from an already existing well that has become under-productive. The common well stimulation techniques are acidizing and hydraulic fracturing. Operators facing a major challenge when trying to determine the best stimulation method to choose, which provide the best economics over the life of the field. When selecting a control measure, it is necessary to understand the formation mechanism prior selecting the most suitable method. However, it is difficult to determine the best method for dual-string completion well as there is no direct access to the reservoir zone for investigation. Therefore a mitigation method has to be planned for this kind of situation.

1.2 Problem Statement

Every reservoir will face declination of productivity due to the reduction of reservoir pressure after few years of production. Generally, this declination phase expected to occur after the production reaches its plateau and can be estimated early during the field development study of the reservoir. However, a sudden drop of production rate can happened due to formation damage, mechanical failure and others unprecedented problems. Formation damage cause by the sand production or due to mineral deposition inside the reservoir which can possibly plug the formation is required to be treated appropriately to prevent further damage to the reservoir.

At this stage, well stimulation exercise will be done to treat the reservoir and restore or enhance the reservoir productivity. It is important to identify the reason that caused the production problem prior selecting the suitable stimulation method. It is difficult to detect the root cause of the problem for a dual-string completion well which have multiple production zones as there is no direct access to the problem production zone. Hence, re-perforation method has been selected to treat and restore back the reservoir productivity as conventional stimulation method is not preferable for this situation.

1.3 Objective of Study

The objectives of the study were:

1. To study the relevance of perforation method to restore the reservoir productivity in dual-string completion well.

2. To analyze factors that affects the perforation performance by conducting perforation analysis using Schlumberger Perforation Analysis (SPAN) software.

3. To identify the best method and challenges to optimum the perforation performance efficiency.

REFERENCES

Regis Kruel Romeu, Carlos Nagib Khalil and Andre Rabinotiv (1990) SPE 21108 *Paraffin Precipitation in the Formation in Dom Joao, Brazil.*

Irwin P. Thomas, Carl E. Johnson, Jr., (1978) *Perforating Resin-Consolidated Zones for Capacity Improvement.*

Terri M. Sherlock-Willis, R.H. Morales, P.Price (1998) SPE 50652 *A Global Perspective on Sand Control Treatments.*

B.J Todd and D.J. Bradley (1986) SPE 15029 *Perforation Geometry and Skin Effects on Well Productivity*.

Zhengchao Zhao, Houli Sun, Ping Zhao, Xiangming Liu, Jianjun Zhang, Yanhong Qin (2002) SPE 77843 *Combined Perforation and Sand-Control Technique*.

Jonathan Bellarby (2009) *Well Completion Design Volume Fifty Six.*

N.Morita and P.A. Boyd (1991) SPE 22739 *Typical Sand Production Problems: Case Studies and Strategies for Sand Control.*

American Petroleum Institue, Recommended Practice 19B, 2000. *Recommended Practices for Evaluation of Well Perforators*.

Walton, I. C., Atwood, D. C., Halleck, P. M., et al.,2001 SPE 71458 *Perforating Unconsolidated Sands: An Experimental and Theoretical Investigation*

Wulan, R. S., Susilo, R. Y., Hendra, Y. S., et al 2007 SPE 104532 *Development Strategy o Soft Friable Carbonate Gas Reservoir Through Horizontal Open Hole Gravel Packed Completion: APN Field Offshore West Java*

Onaisi, A. and Richard, D., 1996 *Solids Production in a Highly Heterogeneous Carbonate Formation. Int J. Rock Mech. Mining Sci. Geomech. Abstracts, 35(4,7): 527*

McPhee, C. A., Lemanczyk, Z. R., Helderle, P., et al., 2000 SPE 64467 *Sand Management in Bongkot Field, Gulf of Thailand: An Integrated Approach*

Van Den Hoek, P. J. and Geilikman M. B., 2005 SPE 96715 *Prediction of Sand Production Rate in Oil and Gas Reservoirs: Field Validation and Practical Use*

Bale, A., Owren, K. and Smith M. B., 1994 SPE 24992 *Propped Fracturing as a Tool for Sand Control and Reservoir Management*

Vaziri, H., Barree, B., Xiao, Y., et al., 2002a SPE 77683 *What is the Magic of Water in Producing Sand?*

King, G. E., Wildt, P. J. and O'Connell. E., 2003 SPE 84262 *Sand Control Completion Reliability and Failure Rate Comparison with a Multi-Thousand Well Database*

R. S. Lestz, J.N. Clarke, D. Plattner, A. C. Byrd 2002 *Perforating for Stimulation: An Engineered Solution.*

Suman, G.O Jr., Ellis, R.C., and Snyder, R.E., *Sand Control Handbook*, Second Edition, Gulf Publishing Company, Houston, Texas, 1992.

Vassenden, F., Gustavsen, O., Nielsen, F.M., et al., 2005 SPE 94578 *Why Didn't All the Wells at Smorbukk Scale in?*

Voloshin, A. I., Ragulin, V. V., Tyabayeva, N.E., et al., 2003 SPE 80407 *Scaling Problems in Western Siberia.*

Turekian, K. K., 1976 *Oceans*. Prentice-Hall, Englewood Cliffs, NJ.

Vetter, O.J., Kandarpa, V. and Harouaka, A., 1982 SPE 7794 *Prediction or Scale Problems Due to Injection of Incompatible Waters*.

Vetter, O. J. G., Vandenbroek, I. and Nayberg, J., 1983 SPE 11803 *$SrSO_4$: The Basic Solubility Data.*

Vetter, O. J. G. and Phillips, R. C., 1970 SPE 2620 *Prediction of Depostion of Calcium Sulfate Scale Under Down-Hole Conditions.*

Brown, A. D. F., Merret, S. J. and Putnam, J. S., 1991 SPE 23106 *Coil Tubing Milling/Underreaming of Barium Sulphate Scale and Scale Control in the Forties Field.*

Gholinezhad, J.,2006 SPE 99683 *Evaluation of Latest Technique for Remedial Treatment of Scale Deposition in Petroleum Wells*.

Nasr-El-Din, H. A., Al-Mutairi, S. H., Al-Hajji, H. H., et al., 2004 SPE 86501 *Evaluation of a New Barite Dissolver: Lab Studies.*

Frenier, W. W., 2001 SPE 65027 *Novel Scale Removers are Developed for Dissolving Alkaline Earth Deposits.*

Boreng, R., Chen, P., Hagen, T., et al., 2004 SPE 87438 *Creating Value with Green Barium Sulphate Scale Dissolvers – Development and Field Deployment on Statford Unit.*

Becker H. L., Jr., 2000 SPE 57703 *Asphaltene: To Treat or Not.*

Mullins, O. C., 2005 SPE 95801 *Molecular Structure and Aggregation of Asphaltenes and Petroleomics.*

Ellison, B. T., Gallagher, C. T., Frostman, L. M., et al 2000 OTC 11963 *The Physical Chemistry of Wax, Hydrates and Asphaltene.*

Branco, V. A. M., Mansoori, G. A., Xavier, L. C. D. A., et al., 2001 *Asphaltene flocculation and collapse from petroleum fluids. J. Pet. Eng., 32: 217-230.*

Dashiti, Q., Kabir, M., Vagesna, R., et al 2007 IPTC 11347 *An Intergrated Evaluation of Successful Acid Fracturing Treatment in a Deep Carbonate Reservoir Having High Asphaltene Content in Burgan Field, Kuwait.*

Alkafeef, S. F., Al-Medhadi, F. andAl-Shammari, A. D., 2003 SPE 84609 *A Simplified Method to Predict and Prevent Aphaltene Deposition in Oil Well Tubings: Field Case.*

Sanda , A. and Miyagawa. Y., 2006 SPE 101102 *A Case Study of a Successful Chemical Treatment to Mitigate Asphaltene Precipitation and Deposition in Light Crude Oil Field.*

Lightford, S., Pitoni, E., Armesi, F., et al 2006 SPE 101022 *Development Field Use of a Novel Solvent-Water Emulsion for the Removal of Asphaltene Deposits in Fractured Carbonate Formations.*