NEAR WELLBORE REMEDIATION FOR ORGANIC IMPAIRED RESERVOIR USING A THERMO-CHEMICAL SYSTEM

JASVINDER SINGH

UNIVERSITI TEKNOLOGI MALAYSIA

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JASVINDER SINGH RAJINDAR SINGH

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ABSTRACT

The Sirikit oilfield, situated some 400 km N of Bangkok, Thailand, is a fault-bounded structure within a major half-graben basin, comprising relatively 8 km thick basin-fill succession includes alluvial fan-fluvial deposits overlain by the fluvio-deltaic Lan Krabu Formation, which contains two main oil reservoirs. Based on the production trend obtained, it can be clearly seen that there was significant decline from the wells. This may be due to organic deposits in tubing and near wellbore which causes blockage. This was proved from the SARA analysis carried out in the laboratory. SARA analysis separates the crude oil into four major fractions: saturates (including waxes), aromatics, resins and asphaltene (SARA)**.** This separation is based on the solubility and polarity of these components. This method of characterizing crude oil is done by separating it into smaller fractions, each of which has a different composition from the rest and various solubility to solvents. The tested sample was predominantly rich in macro crystalline wax (low molecular weight) along with of micro crystalline wax (high molecular weight, high melting point) and asphaltene. Agglomeration of wax along with asphaltene and naphthenate are expected around well bore and tubular. Thermo-Chemical System is a technology whereby a two pack chemical is used to dissolve and disperse organic solid depositions in production well tubing's and wellbores to enhance the oil production from wells by generating exothermic heat up to 200°C and efficient surfactant, ester. Modular pumping technology is applied to deliver the active chemical to target location, in production tubing and 2 feet near wellbore remediation.

ABSTRAK

Medan minyak Sirikit yang terletak 400 km utara Bangkok, Thailand, adalah struktur disempadani dalam lembangan separuh graben utama, yang terdiri daripada sekurangnya 8 km tebal lembangan termasuk deposit kipas fluvial aluvium ditindih oleh fluvio-delta Lan Krabu Pembentukan, yang mengandungi dua takungan minyak utama. Berdasarkan trend pengeluaran yang diperolehi, ia boleh dilihat dengan jelas bahawa terdapat penurunan yang ketara dari telaga. Ini mungkin disebabkan oleh deposit organik dalam tiub dan berhampiran lubang telaga yang menyebabkan tersumbat. Ini telah dibuktikan daripada analisis SARA yang dijalankan di makmal. Analisis SARA memisahkan minyak mentah kepada empat pecahan utama: tepu (termasuk lilin), aromatik, damar dan asphaltene (SARA). Pemisahan ini adalah berdasarkan kepada kelarutan dan kekutuban komponen ini. Kaedah mencirikan minyak mentah dilakukan dengan memisahkan ke dalam pecahan yang lebih kecil, setiap yang mempunyai komposisi yang berbeza dari yang lain dan pelbagai kelarutan pelarut. spesimen adalah terutamanya kaya dengan makro kristal wax (berat molekul yang rendah) bersama-sama dengan mikro kristal wax (berat molekul yang tinggi, takat lebur yang tinggi) dan asphaltene. Penumpuan lilin bersama-sama dengan asphaltene dan naphthenate dijangka sekitar lubang telaga dan tiub. Thermo-Chemical System ialah teknologi iaitu bahan kimia dua pek digunakan untuk membubarkan dan bersurai deposisi pepejal organik dalam telaga pengeluaran tiub dan wellbores untuk meningkatkan pengeluaran minyak dari telaga dengan menjana haba eksotermik sehingga 200 ° C dan surfactant cekap, ester. teknologi pam modular digunakan untuk menyampaikan bahan kimia aktif lokasi untuk menyasarkan, dalam tiub pengeluaran dan 2 kaki berhampiran lubang telaga pemulihan.

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bbl	-	barrel
cP	-	Centipoise
bpm	-	Barrel per minute
ppm	-	Pound per million
psi	-	Pound per square inch
psig	-	Pound per square inch gauge
psi/ft	-	Pound per square inch per feet
°C	-	Degree Celsius
°F	-	Degree Fahrenheit
STB/D	-	Stock tank barrel per day
mgKOH/g	-	Milligram potassium hydroxide per gram

NOMENCLATURE

bbl	-	barrel
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STB/D	-	Stock tank barrel per day
mgKOH/g	-	Milligram potassium hydroxide per gram
WAT	-	Wax Appearance Temperature
XRD	-	X-Ray Defraction
LOI	-	Loss of Ignition
FTHP	-	Flowing Tubing Head Pressure
API	-	Density of Crude
BHT	-	Bottom Hole Temperature
BHP	-	Bottom Hole Pressure
BOPD	-	Barrel Oil Per Day
HTHP	-	High Temperature High Pressure
ppd	-	Pour Point Depressant
IPR	-	Inflow Performance Relationship
PI	-	Productivity Index
VLP	-	Vertical Lift Performance
CII	-	Colloidal Instability Index
SARA	-	Saturates, Aromatic, Resin, Asphaltenes
TAN	-	Total Acid Number
CO_2	-	Carbon Dioxide
H_2S	-	Hydrogen Sulphate
MASTP	-	Maximum

CHAPTER I

INTRODUCTION

1.1 Background of Study

Wells that have been producing over a period of 20 to 30 years are bound to have a decline in production due to many factors such as high water cut, reduce reservoir pressure, depleted reserve and many more. However, some wells that are considered “virgin” in the production era are also undergoing drastic production decline. Many reasons has been stated over the fall in production of these newly drilled wells. Some of the reasons are mainly due to fault in drilling fluid used during drilling, or inaccurate perforation zone that may lead to an un-optimised production. Nevertheless, there is another major issue that relates to the suffering of production in producing wells, it is named wax deposition.

Wax deposition usually occur in newly drilled field or brownfields. It is the most common problem besides scale precipitation in the oil and gas industry due to the nature of the crude oil that is being produced over the years. Some studies also relate wax deposition to the stability of the crude oil during production. This stability is in terms of the precipitation of asphaltenes that creates a nucleus or "home" for the wax to start breathing into higher and more complex chain molecules.

One of the major questions that has always been raised by Production Technologist all over the world is "when" will the precipitation begin and how much will it be clogging the flow conduits/paths of the production. The simplest answer to these questions are usually the type and amount of deposit may vary from various complex fluid mixtures depending on the composition of the crude oil being produced. Many mitigation methods have been developed to extend the time of deposition in a wax deposit prone system.

Several key parameters play a role in wax precipitation. The main mechanisms that strongly aids the precipitation of wax is the temperature. As wax has its own appearance temperature, analysis can purely predict the potential of its precipitation by analysing the bottom-hole temperature and flowing wellhead temperature. Wax appearance temperature (WAT) is the temperature at which the first wax crystals starts to form while cooling of the paraffinic system. Similarly, in crude oil production, the paraffin deposition occur by forming sharp-like crystals by means of agglomeration with the formation fluid or crude oil ultimately leading to the blockage and reducing effective flow area in the pores or flow path of the crude oil.

Organic deposition that is mostly located at the near wellbore and in production tubing create a severe oilfield problem related to flow restrictions, near wellbore damage and reduced in crude oil processes efficiency.

The deposition of this solid organic contribute to the overall decline in productivity of affected wells over a period of time. Particularly in Malaysia and Thailand, the crude is very waxy which can lead to higher rates of organic deposits as changes in reservoir characteristics such as temperature, pressure and composition of the crude oil occurs during the life-time production of the wells.

The economics concerns of these organic deposits problem are overwhelming. Heavy organic molecules such as asphaltenes, paraffin/wax, aromatics and resins exists in the crude oil in various quantities, forms and accumulation of these molecules subsidise to the deposition of organic deposits.

In reality, over the past of many decades, major operators have faced complex deposition problem of organic deposition. To cater to this problem, deposit samples are usually collected using wireline intervention, if these deposits are located in the tubing for analysis purpose. Analysis such as SARA analysis, X-Ray De-fraction (XRD), WAT and Loss of Ignition (LOI) are able to provide high accuracy results to detect the presence of organic species such as paraffin in the crude or deposit sample. Co-precipitation of asphaltene and resins along with paraffin creates a very complex organic deposit.

Wax deposition that affect the well productivity in terms of increasing the near wellbore skin and plugging of upstream production units usually require conventionally cleaning methods such as mechanical cleaning (wireline or pigging), steam injection or hot oil circulation. No doubt these techniques have recorded high success rate, however, with the evolving technology practice, a unique thermo-chemical system has been developed to further improve the efficiencies of the current treatment practices. The unique system combines the effect of in-situ heat generation, increase solvency of the crude oil and by-product reaction (ester) to dissolve and disperse complex organic deposits that accumulate down-hole and in upstream processing equipment.

This thermo-chemical solution has been applied in Sirikit Field in Thailand and to be proven to be a huge success in terms of removing the deposits in the tubing as well as increasing the production of the wells by reducing the skin near wellbore.

The first oilfield that was discovered in late 1981 by the Thai Shell EP Co. Ltd. was the Sirikit oilfield. After reaching to a mutual decision to develop the field, the installation of the production stations and organization of the local transportation facilities such as road tanker and railway only took one year to design. The first oil was produced in 1983. Over the years, to cope with the build up of production to plateau phase of approximately 21,000 bbl/d, the facility was being upgraded from time to time. Sirikit field possess a waxy crude production (pour point estimated around 35°C) but it is light (around 40°API). Gas produced from the field was sold to nearby electricity generating stations.

However, in 1985, gas compression system was commissioned to increase the utilization of gas which was previously flared or sold. Thai Shell Company practiced two interest subjects throughout the field development, they were safety and security. The field is in a geologically complex, extensively faulted lacustrine environment, and the reservoir quality is extremely stratified and heterogeneous. One of two major reservoirs has a gas cap. After some early surprises in delineating the field, a 3-D seismic survey was carried out which better defined the structure and reserves. Nevertheless, parallel appraisal and development continues on a careful step-by-step approach, using the latest production and pressure data to refine the reservoir-geological model. In November 1985 the Petroleum Authority of Thailand became a minority partner, with Shell remaining as operator.

1.2 Problem Statement

The current oil price crisis has peaked and deemed to be the one of the worst oil price breakdown in the history of mankind. The fall of oil price from USD27 to

USD 10 in 1986 is still the nastiest fall in the oil price. However, these days, the problem of oil price is part of the oil and gas history where National Oil Companies (NOCs) and Production Sharing Contract (PSCs) companies juggle around their respective capital cost (CAPEX) and operational cost (OPEX) in effort to make the most of the current situation.

In theory, the rate of crude oil production in a well varies directly with reservoir pressure and inversely with the resistance experienced to its flow from reservoir to surface equipment. During the production process, the change in oil properties such as composition, viscosity, equilibrium and others due to the decrease in temperature and pressure leads to separation, precipitation and deposition of heavy organics components of the crude oil and inorganic scales from the formation water.

In order to perform near wellbore remediation wells, it is important to understand the change in temperature and pressure of around the wellbore as maximum deposits of the heaviest solids are expected to deposit around this area. The deposition of this deposits lead to the plugging and blocking of the formation in-and-around the wellbore mainly effecting its effective permeability, increasing the skin around wellbore and reduction in pore sizes. This blockage can also be present in the production tubing and flow lines which can lead to total deterioration of the crude production.

Conventionally, paraffin that is accumulated either near wellbore, in the production tubing or in surface flowline are removed by the following methods:

i. Mechanical removal of deposits
ii. Using of solvents to dissolve the deposits
iii. Using of heat or steam of melt and remove the wax

Mechanical methods are deemed relatively inexpensive however they are always limited to the area of penetration. Using wireline or electric line intervention, the maximum depth a scrapper or wax cutter can reach is the end of tubing (EOT). Chemical solvent is one of the most common method used to remove paraffin from tubing and near wellbore. These solvents are made of organic and inorganic solvents that play a role to tackle the paraffin and scale issues. However, this method is reasoned to be expensive if compared to mechanical of hot oil circulation. Some of the other alternatives is the circulation of heat or steam to melt and remove the paraffinic deposits. The circulation temperature may reach to a range of 200°F to 300°F. The heated oil is usually heated through an injection port located in the tubing or annulus. The high temperature induces mixing and reduces the viscosity of the crude oil, thus not allowing any deposit to precipitate around the tubing or wellbore. It is considered a cheap method to restore the productivity of the well, but the question would be the how long can it sustain.

In this project, the field that will be studied is a field that has been suffering from organic deposition that has impaired the performance of the surrounding producer wells. The Sirikit oilfield, situated some 400 km N of Bangkok, Thailand, is a fault-bounded structure within a major half-graben basin, comprising a relatively unreformed eastern sector and a western area characterized by a complex pattern of isolated fault blocks. The 8 km thick basin-fill succession includes alluvial fan-fluvial deposits overlain by the fluvio-deltaic Lan Krabue Formation, which contains two main oil reservoirs. Deposition samples were collected from this field and laboratory analysis was performed to identify and characterise the nature of deposition of the field. Through compatibility reports, Thermo-Chemical prevail to be the best chemical to remove organic solid deposition exhibit the wellbore area and congeal on production tubing.

Thermo-Chemical Two Pack System have superior advantage over the market on top the only unique way to address the organic solid deposit using combination of

chemical and thermal method in single stage. In short the following are salient points on the technology:-

- Removes tough organic deposits
- Create high temperature, range up to 200°C
- Modular technology, hence very mobile
- Long term productivity improvement and restores rock wettability
- The chemical product does not induce any corrosion rather behave with excellent corrosion inhibition
- The solution is also totally compatible with formation hydrocarbon, well completion system and refinery products. Therefore, does not require any post-treatment procedures like controlled discharged and etc.
- The solution also behaves as excellent demulsifier with prescribed dosage.
- The technique is very cost effective.

Thermo-Chemical system is a unique Two-Pack' designed formulations which will produce heat upon mixing. This two-pack cocktail is injected into targeted location (i.e. pipeline, wellbore area, tubing, etc.) the product of mixing is in-situ heat, surfactant and ester. The main purpose for this treatment was to ensure that the productivity of the field increases and sustains. Dissolution test illustrated that the samples were fully dissolved and dispersed; most importantly fully flow able. Critical operational set up was planned by injecting the active chemical via pumping a pill of pre-flush and two-pack system simultaneously will melt, dissolve/disperse waxy deposits in the tubing, followed by pill of post-flush chemicals which acted as inhibitor and injection 2 feet behind the casing. This to ensure that melted/dissolved/dislodged deposit remains in disperse phase and do not re-precipitate in tubing, it is imperative to push them in to the sump and allow it to soak for a period of 12 hours. The temperature that was generate is 125˚C which would generally dissolve and disperse any wax or heavy organic congealed onto the production tubing as well as near wellbore.

1.3 Objective of Study

The objectives of this study were to:

i) To evaluate the problem that is causing the reduction of crude production in the field

ii) To determine the nature of the organic deposition in the wells by laboratory analysis and to develop a suitable formulation

iii) To recommend an effective treatment methodology and operational set up to restore the productivity of the wells

1.4 Scope of Study

i. Analysing the problem and location of deposits that causes the decline in production of crude oils in the wells

ii. Studying the theory of how deposition near wellbore relate to the formation damage and skin build up

iii. Performing laboratory analysis to conclude the type of deposits choking the formation hindering the crude oil production

iv. Establishing an effective thermo-chemical formulation to dissolve and disperse the deposits hindering its re-crystallization near wellbore

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