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# Possibility of Wax Control Techniques in Indonesian Oil Fields

M. Abdurrahman[a)], F.H. Ferizal, U.Z. Husna and L. Pangaribuan

*Department of Petroleum Engineering, Faculty of Engineering, Universitas Islam Riau. Jl. Kaharuddin Nasution No. 113 Km. 11, Pekanbaru, Riau – 28284, Indonesia.*

[a)]Corresponding author: muslim@eng.uir.ac.id

**Abstract.** Wax is one of the common problem which can reduce the oil production, especially for the reservoir with high paraffin content case. When the temperature of crude oil is lower than pour point, wax molecules can begin rapidly precipitated. The impacts of this problem are the clogging of production equipment, sealing off the pores in the reservoir, and decreasing production flow rate. In order to solve the wax problem, several methods have been applied in some oil fields in the world. For example, chemical methods in Jiangsu field (China) and Mumbai High field (India), hot water in Mangala field (India), magnetic method in Daqing field (China), water-dispersible in Bakken basin (US), and microbial in Jidong field (China). In general, the various crude oils present in the Indonesia contain wax content between 10%-39% and pour point of 22°C–49°C. Hot water and chemical method are commonly used to solve wax problems in Indonesian oil fields. However, the primary solution is magnetic method, and the secondary solution is water dispersible.

## INTRODUCTION

There are several problems that could affect the oil production. One of the the problems is wax deposition [1]. Wax is a hydrocarbon compound consist of long chained of alkanes and it is often precipitates rapidly as a result of the changing temperature and pressure. Figure 1 shown the effect of wax in the pipeline.

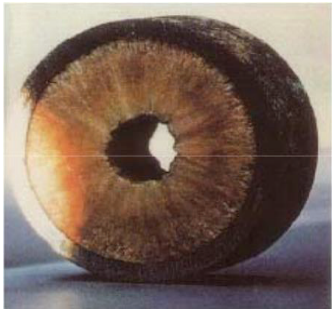

**FIGURE 1.** Wax precipitation reducing the effective diameter in a retrieved pipeline[2]

Currently, two types of wax are commonly appearing in crude oil. The first is microcrystalline wax, consist of mainly straight-chain paraffin (n-alkanes) such as $C_{20}$ to $C_{50}$. The second is microcrystalline or amorphous waxes, composed of a high portion of isoparaffin (cycloalkanes) and naphthalene like $C_{30}$ to $C_{60}$[3]. Once the temperature of crude oil is lower than pour point temperature, wax begin to appear and deposit in the wellbore[4]. Presence of wax would be detrimental for all oil process, such as production, separating, and transportation. Several effect of wax

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deposition in oil industry, such as can be reduced oil production, well shut-in, pipeline replacements, sealing off the pores in the reservoir, well abandonment, equipment failure, and additional pumping horsepower requirements[5].

Some of wax control has been successfully implemented to oil fields around the world, such as hot water[6], chemical[7], magnetic field[8], dispersible water[9], and microbial[1]. These methods give fruitful results in oil field, for instance, increased oil production, wax removed, and deposition delayed. This paper propose a number of recommendations in order to overcome the waxy crude oil problem in Indonesian oil field.

## PROBLEMS OF WAXY CRUDE OIL IN INDONESIA

Mature oil fields and primary recovery stage are the major characteristics of oil fields in Indonesia. Oil production has been declined since several years ago. Currently, oil production is around 831,000 BOPD, it is only 0.9% of the total oil production in the world[10]. The problem might be caused during the production process. One of critical problems is wax appearance in crude oil. This problem has been found in several oil fields in Indonesia, such as, in South Kalimantan has a high waxy crude oil (wax content of 31.97% and pour point of 38ºC). Tanjung field has reached peak production of 44,000 BOPD oil production. However, at present time total oil production has declined into 7,800 BOPD[11]. Another problem with wax content 24.89% and pour point 49ºC were founded in Sepanjang Island, East Java[12], and also in Bekasap Area, Riau Province (pour point around 32 ºC – 43 ºC )[13]. Similar waxy crude oil problem was found in other Indonesian oil fields, shown by following table.

**TABLE 1.** Characteristics of a Waxy Crude Oil in Indonesia

| No | Field | Wax Content, % | Pour Point, ℃ | References |
|---|---|---|---|---|
| 1. | Pinang, Riau | N.A | 39 | Tang et al, 2003[13] |
| 2. | Minas, Riau | 10.8 | 36-38 | Environment canada database, 2001[14] |
| 3. | Duri, Riau | 16 | 22 | Environment canada database, 2001[14] |
| 4. | Sepanjang, East Java | 24.9 | 49 | Kitamura et al, 2010[12] |
| 5. | Udang, Natuna | N.A | 38 | Irani et al, 1981[15] |
| 6. | Kuda Laut, Natuna | N.A | 38 | Irani et al, 1981[15] |
| 7 | Handil, East Kalimantan | 16.5 | 32 | Irani et al, 1981[15] |
| 8. | Tanjung, South Kalimantan | 31.9 | 38 | Satya et al, 2004[15] |
| 9. | Cinta, West Java | 30 | 41 | Environment canada database, 2001[14] |
| 10. | Tapian Timur, South Kalimantan | 6.7-13.5 | N.A | Hardikin et al, 2009[16] |

Table 1 clearly shows that the wax content in Indonesian crude oil. An average range of wax content is 10 % - 39 % and range of pour point of 22°C-49°C. In addition, the common method for controlling the wax problem are hot water and chemical methods[13, 16].

## WAX CONTROL TECHNIQUES

### Chemical Method

For this method, various chemical substances are used to control waxy oil, such as diesel fuel, xylene, toluene, and naphthalene. These substances are used as solvent to dissolve wax deposit in reservoir and increase the well productivity and reservoir condition[7]. There are two ways to inject solvent, continuous injection and soaking injection. Continuous injection is a method using a special injection pump, which set up on the wellhead. The chemical is injected into the wellbore through the annulus. For the soaking method, a technique utilizing a small pump truck dropped the chemical into the wellbore through the annulus at a particular time[7].

A chemical method can be applied in the field under following criteria; wax content more than 30%, pour point higher than 35ºC. This method has been proved in several oil fields, such as in Jiangsu (China) and Mumbai High (India). The wax loosen in the reservoir and the result is oil production was increased. The data clearly shown that the production increased from minimum 8 BOPD to 453 BOPD in Mumbai High (India) for one job[17]. As well as, oil production increased from 202 BOPD to 231 BOPD from Jiangsu oil field (China)[7].

## Hot Water Method

Hot water is one of method used for maintaining the reservoir temperature. Furthermore, hot water which injected into the wellbore slow down the deposition wax process. It can be applied during completion and production. During completion, hot water is circulated into the annulus using coiled tubing. Then, tubing string is heated to maintain the temperature above the pour point. In terms of production, hot water is being used along with water injection to maintain the pressure and temperature. The hot water collected at the manifold for certain purposes. This technique can also be combined with chemical method in order to prevent the appearance of wax in the wellbore[6].

Hot water method has been successfully implemented to control the wax in Mangala field (India)[6]. The wax content in this field is up to 26% and pour point is about 40ºC-45ºC. In another field, such as Huabei (China) has 21.2% of wax content and pour point around 33 ºC. This method was applied extensively and it is successfully remove the wax content in the wellbore. The result of hot water method is the oil production was increased up to 102 barrels/day[7].

## Magnetic Field Method

Tung, et al [12] said that magnetic fields method, the viscosity of crude oil samples would be significantly decrease. This method is called as Magnetic Fluid Conditioners (MFC). This method can prevent wax appearance in the crude oil without affecting the crude characteristics. However, the effects of magnetic treatment is strongly depended on temperature, magnetic intensity, and time of exposition. The amount of depositions of heavy organic compound in petroleum crude are depending on the hydrocarbons present in oil [12].

The magnetic method was implemented into the field which has the wax problem. For example, in Daqing (China) with pour point 30 ºC and wax content 26.2%. This method produce excellent results by increasing the oil production up to 2 MMbbl per year[7]. This method was also tested into offshore area by a screening study at the White Tiger field in Vietnam. Through the magnetic treatment, the result showed that the reduction of wax deposition was about 20-25%[12].

## Water Dispersible Wax Inhibitor Method

This method inspired by the result during hydraulic fracturing, which is the fluid temperature that has been used is often less than the reservoir temperature, and if the formation temperature lower than pour point, paraffin may precipitates, form the wax deposition in the formation pores. For paraffin-rich reservoirs, such as shale oil, formation damage could be caused by wax deposition in the fracture. Thus, skin can decreased the production rate, hard to clean up wellbores, or failure to achieve predicted maximum recovery. On water-dispersible system, particularly in colloidal micro dispersion, since they are the most prevalent type of dispassion found to be viable for hydraulic fracturing application. The methods using water-dispersible inhibitors that prevent paraffin deposition from waxy crudes during the fracturing job, which is providing the protection during fracturing job before proppant is placed and also function as early prevention for wax deposition. However, water dispersible additives cannot clean the wax directly. They needed for a long term paraffin control, which can be provided by slow release of solids or infused porous proppants, but can be complementary done and perhaps avoid the use of heated fracturing fluids in completing waxy crude wells[9].

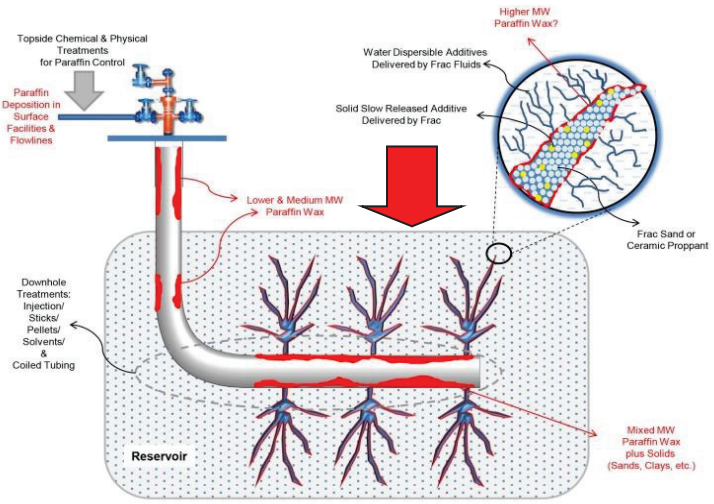


**FIGURE 2.** Schematic representation of paraffin wax deposition and treatment remedies in downhole[9]

Dispersions or suspensions may be defined as a preparation containing finely divided solid particles distributed uniformly throughout a fluid or semisolid material. These particles are enough to lead precipitate occur under the effect of gravity. The suspension should settle slowly, however may be readily re-dispersed upon gentle shaking. They pour readily and maintain the particles of the ingredients throughout long periods of storage.

Water dispercible is a new method which was tested in experimental studies from crude oil from Baken, Permian, and Eagle Ford basins in the USA. The characteristics of this crude oil are pour point less than $21^0$C and wax content is 30%-50%. By using this method, it can prevent wax deposition during the fracturing operation or early post-stimulation flowback and may bring another option to increase production rates and also to increase profits[9].

## Microbial Method

The subject of this method is to decrease the cloud point or appearance of wax as apparent molecular weight of crude oil. This method used the microorganisms that alter the composition of crude oil through bio-degradation. Crude oil in contact with the microorganism (such as Pseudomonas aeruginosa, Bacillus subtillis, and Bacillus licheniformis) may be degraded directly or break the long chain into short chain[1].

Most of the tested wells obtained excellent result. But, the microbe vaccine mainly depends on the imports of microbial and the price is highly expensive. Other factor is the implementation in the field could be problematic as the well must be clean-out before injecting the microorganism into the wellbore. This method only used for small-scale test. For example, Jidong Field (China) has wax content between 15%-25% and pour point between 25ºC-35ºC has applied in this method and oil production in several wells increased from 72 barrels/day to 103 barrels/day[7].

Based on the wax control techniques that implemented in the field and study above, it can be concluded in the following screening criteria.

**TABLE 2.** Screening Criteria of Wax Control Techniques

| No | Wax Control Techniques | Characteristics | |
|---|---|---|---|
| | | Wax Content, % | Pour Point, ℃ |
| 1. | Chemical | >30 | >35 |
| 2. | Hot Water | 20-30 | 35-45 |
| 3. | Magnetic Field | 20-25 | 30-40 |
| 4. | Water Dispersible Wax Inhibitor | >30 | <21 |
| 5. | Microbial | 15-25 | 25-35 |

## POSSIBILITY OF IMPLEMENTATION TO INDONESIA WAXY CRUDE OIL

According to several wax control techniques explained in the previous chapter, we can conclude that the method most likely used in Indonesia are hot water and chemical method. Based on the characteristics of Indonesia waxy crude oil field, others techniques are applicable too. The pour point and wax content which are ranged between 35ºC-40ºC and 20%-25%, shows that Indonesia waxy crude oil potential with the use of the magnetic field method. On the other hand, the cost in the installation of the Magnetic Fluid Conditioners (MFC) are not high due to it only required one times payment for the installation and there are no other substances needed during the treatment. Biao and Lijian[7] mentioned that the benefit obtained is very prominent. The method does not need to apply any chemicals or other substances, even a little higher investment at the first time. Then, the total expenses for the magnetic field method is relatively lower. Moreover, this method were implemented in several fields, resulting significant increase in oil production, such as in China and Vietnam which mentioned in the previous chapter. In other cases, the hydraulic fracturing activity, the use of water dispersible wax inhibitor is also possible to be done in the Indonesian waxy reservoir. This method is more beneficial than others are, because it was able to provide protection during the fracturing job before proppant is placed and as early prevention for wax deposition.

## CONCLUSION

This work shows the best method to be applied in the waxy crude oil problem, particularly in Indonesia. As there many kinds of techniques have been developed to overcome this case and they were successfully done in many countries all around the world. Proper consideration is highly required to determine the best methods that will be applied, such as main objective, field characteristics, and appeared results. For Indonesian cases, the magnetic field method is chosen as the way to overcome the waxy crude oil problem. In other hand, water dispersible wax inhibitor are also good to be implemented for hydraulic fracturing operation.

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