International Journal of Computer (IJC)

ISSN 2307-4523 (Print & Online)



http://ijcjournal.org/

# Increasing Crude Oil Production by Intermit Operation in Mae Soon Oil Field Fang Basin, Thailand

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**Abstract**

This study conducted an experiment to increase crude oil production by applying 8 days intermit operation to FA-MS-07-08 well, located in Mae soon oil field, Fang basin. The principle of intermit operation [1] is to reduce the operating hours of the sucker rod pumping unit from 24 hours per day to 12 hours per day which is resulted in having enough time for production fluids (crude oil and water) segregation and also for oil recovering from the deeper part of the reservoir. The study methodology included (1) required data collecting, e.g. production history data, drilling data and reservoir data [11] of Mae Soon oil field, the well bore data when start and stop the sucker rod pump, (2) production fluid samples collected from tested well analyzing and testing in laboratory, and (3) economic returns evaluating. After applying intermit operation to the tested well, it had been found that the intermit operation could reduce the electricity power cost of sucker rod pumping unit about 5,680 Baht per month. This operation could increase oil production rate about 73 percent compared to the normal operation, and could also give incomes from selling crude oil about 552,320 Baht per month.

***Keywords:*** Intermit operation; Increasing crude oil production; Mae Soon oil field.

## 1. Introduction

Fang basin is a northern basin of Thailand where oil has been produced, using primary and secondary methods [12] from sandstone of the Mae Sod Formation in the Mae Soon, San Sai, Nong Yao, Sam Jang and Ban Thi structures [3,10]. Most oil fields in Fang basin were belonging to and operated by the Department of Defence (DED, and produced by natural flows which now are expelled by low differential pressures and finally resulted in the low production efficiency.

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Present day sucker rod pumping units [6] are used to improve oil recovery of these oil fields. These oil fields have a long history of operation and production in some tracts has decreased, with many wells currently exhibiting water cut increases. In order to reduce operating expenditures on electricity for sucker rod pumping unit, intermit operation is selected to study in this research. The methods of intermit test operation is to build up the pressure in a well by shut in well for 12 hours and then open hole for normal flow for 12 hours. As a result, work hours of sucker rod pump are reduced. Moreover, the useful life of sucker rod pumping unit could also be extended and this can also reduce its maintenance and spare part costs.

## 2. Materials and Methods

As previous mentioned the main objective of this study is to reduce the production cost and improve oil recovery [7] by applying intermit operation to FA-MS-07-08 well of Mae Soon oil field. In normal operation (24 hours' operation) this well produces crude oil only about 9 barrel per day. The principle assumption is to reduce operation hours of the sucker rod pumping unit whereas the obtained oil production should be comparable as without applying intermit operation. Usually in this tested well the sucker rod pump is run 24 hours per day and when the intermit operation is applied, the pump will work only 12 hours per day. In this study the sucker rod pump was turned on during 8:00 a.m. – 8:00 p.m. and after that it was turned off for 12 hours each day. The production fluids measurement was performed by Basic Sediment and Water (BS&W) measurement method in laboratory each day. Intermit operation procedures conducted in this study are listed as follows;

- Stop the sucker rod pump for 12 hours (8:00 p.m. – 8:00 a.m.), record oil level in oil storage tank,
- Start sucker rod pump for 12 hours (8:00 a.m. – 8:00 p.m.), measure the oil level in oil storage tank, calculate day rate production, measure fluid level in the tested well, and collect oil samples every 1 hour while sucker rod pump is running,
- Measure BS&W of oil samples in laboratory,
- Stop sucker rod pump for 12 hours (8:00 p.m. – 8:00 a.m.) again, and record oil level in oil storage tank,
- Calculate net oil (bbl), net water (bbl) and water cut (percent) from day rate production and BS&W measurement.

In order to measure crude oil and water production, some in-field measurements, including day rate production and fluid level survey in well, had been conducted in this study. Methods and equipments used in previous mentioned measurements can be summarized as follows;

### *2.1 Day rate production measurement*

The objective of this measurement is to identify and record the depth of empty oil storage tank by using a sounding tape. Sounding tape was used to measure the level of tank liquid from the bottom of the tank to the liquid surface. The recorded liquid level in the storage tank was then used to calculate the oil volume in the oil storage tank by using “the Conversion Standard Chart in Table Tank Calibration” of Fang oil field.

### *2.2 Produced crude oil samples collecting*

Crude oil samples from well FA-MS-07-08 of Mae Soon oil field were collected and kept in a plastic bag everyone hour (13 samples a day), starting from 8:00 a.m. to 8:00 p.m. each operation period. Collected crude oil samples were then conducted the Basic Sediment and Water (BS&W) measurement.

### *2.3 Basic Sediment and Water (BS&W) measurement*

Basic sediment and water (BS&W) is a technical specification of certain impurities in crude oil. When extracted from an oil reservoir, the crude oil will contain some amount of water and suspended solids from the reservoir formation. Crude oil is seldom produced alone because it generally is commingled with water. The water creates several problems and usually increases the unit cost of oil production. The produced water must be separated from the oil, treated, and disposed of properly. BS&W measurement is used to determine net oil, net water, and a water cut.  Therefore, some calculations were needed for BS&W measurement as follows.

### *2.4 BS&W calculation*

*Percent of water and oil in boiled sample calculation*

When boiled sample was clearly seen oil and water separately, oil volume (Vo) and water volume (Vw) were read record in milliliter. Then following equations were used to calculate percent of oil and water volume of the boiled sample

$$\text{Volume percent of water} = (Vw*100)/(Vw+Vo) \qquad (1)$$

$$\text{Volume percent of oil} = (Vo*100)/(Vw+Vo) \qquad (2)$$

Where Vo = volume of oil from boiler (ml)

Vw = volume of water from boiler (ml)

*Percent of water and sediment in centrifuge tube calculation*

After boiled sample had been centrifuged already, water volume in centrifuge tube (Vwc) and sediments volume in centrifuge tube (Vsc) were read and recoded. Then following equations were used to calculate percent of water and sediments in centrifuge sampl

$$\text{Water in oil} = \frac{Vo*Vwc}{100} \qquad (3)$$

$$\frac{\text{Water in oil}*100}{Vo+Vw}$$

Percent of water in = (4)

$$\text{Sediments volume in o} = \frac{Vo*Vsc}{100} \quad (5)$$

$$\text{Percent of sediment in} = \frac{Sediment\ in\ oil*100}{Vo+Vw} \quad (6)$$

Where Vwc = volume of water from centrifuge (ml)

Vsc = volume of sediment ate from centrifuge (ml)

*Percent of total water volume in oil (water cut percent) calculation*

In order to calculate percent of total water cut, following equations were used.

Percent water cut = Volume percent of water (free water) +Volume percent of water in oil

+ Sediment percent in oil (7)

*Net oil and net water calculation*

Consequently, net oil production (barrel per day) and net water production (barrel per day) could be calculated by using following equations

$$\text{Net water (bbl/d)} = \frac{Percent\ water\ cut*Total\ production\ (\frac{bbl}{d})}{100} \quad (8)$$

Net oil (bbl/d) = *Total production (bbl/d) – Net water (bbl/d*) (9)

*Electricity power cost analysis*

Theoretically it is assumed that intermit operation can reduce production costs as this operation is performed on a sucker rod pump running only 12 hours a day and turn off 12 hours instead of 24 hours operation. Therefore, in this study the electricity power cost comparison between before and after intermit operation was applied to the sucker rod pumping unit had been studied and calculated based on equation 10.

$$KW = \frac{1.73*A*V*PF}{1000} \quad (10)$$

Where KW = Kilowatt, A = Ampere, V = Volt, PF = Power factor

*Incomes from an incremental crude oil production*

Incomes from crude oil selling before and after the intermit operation was applied had been compared to each other in order to evaluate an incremental benefit from applying the intermit operation in this study. Present day crude oil price of Defence Energy Department, Thailand, is 3,281.76 Baht per barrel (include VAT 7 percent).

## 3. Results and Discussion

Results from this study, including day rate production measurement, BS&W measurement, and economic evaluation, were addressed as follows;

### *3.1 Day rate production and income from an incremental crude oil*

Result from tank oil level survey in the crude oil storage tank which were then converted to be day rate production (bbl/day) by using the Tank Calibration Table of Fang oil field during applying intermit operation are summarized in Table 1. It was found that the total day rate production was range between 74.30 and 87.66 barrel per day with an average production rate of 79.05 barrel per day.

**Table 1:** Summary of the day rate production (total production) of the tested well FA-MS-07-08

| Date | Height of oil level in storage tank | Day rate production(BBL/D) |
|---|---|---|
| 13/10/2011 | 2'3.5" | 76.97 |
| 14/10/2011 | 2'2.8" | 74.3 |
| 15/10/2011 | 2'4" | 77.28 |
| 16/10/2011 | 2'7.6" | 87.66 |
| 17/10/2011 | 2'4" | 77.28 |
| 18/10/2011 | 2'6" | 82.56 |
| 19/10/2011 | 2'4" | 77.28 |

### *3.2 BS&W calculations*

Results of BS&W content measurement during applying intermit operation period are summarized in Table 2. It revealed that produced crude oil was range between 11.06 and 18.88 barrel per day with an average rate of 15.18 barrel per day. Whereas produced water was range between 59.45 and 68.78 barrel per day. The production history of this tested well revealed that it has an average net oil production 8.78 bbl/day. Therefore, it was clearly seen that after applying intermit operation the produced crude oil had been increased about 72.89 percent compared to the normal operation.

### *3.3 Economic considerations*

In order to evaluate economic return of using intermit operation, some calculations on electricity power cost and incomes from selling crude oil had been conducted.

It was observed at well FA-MS-07-08 that within 1-hour operation the pumping unit consumed electricity of 10 Amp, 380 Volt, and if the power factor is 0.8, therefore,

$$KW = \frac{1.73*10*380*0.8}{1000} = 5.258 \text{ kw/ hour}$$

Then for 1-day operation pumping unit consumes electricity power equal to

$$KW = 5.258 * 24 = 126.22 \text{ kw /day,}$$

**Table 2:** Summary of BS&W measurement of the tested well FA-MS-07-08

| **Date** | **Time** | **Total (bbl/d)** | **Crude (bbl/d)** | **Water (bbl/d)** | **Water cut (%)** |
|---|---|---|---|---|---|
| 12/10/2554 | 08.00-20.00 | - | - | - | - |
| 13/10/2554 | 08.00-20.00 | 76.97 | 11.06 | 65.91 | 85.63 |
| 14/10/2554 | 08.00-20.00 | 74.3 | 14.84 | 59.45 | 80.02 |
| 15/10/2554 | 08.00-20.00 | 77.28 | 11.38 | 65.9 | 85.27 |
| 16/10/2554 | 08.00-20.00 | 87.66 | 18.88 | 68.78 | 78.46 |
| 17/10/2554 | 08.00-20.00 | 77.28 | 15.28 | 62 | 80.23 |
| 18/10/2555 | 08.00-20.01 | 82.56 | 17.11 | 65.45 | 79.28 |
| 19/10/2556 | 08.00-20.02 | 77.28 | 17.72 | 59.56 | 77.07 |

The electricity power cost that charged to DED is 3 Baht per 1KW, therefore, within one day the electricity power cost for the 24 hours' operation of sucker rod pumping unit could be calculated as

1 day pumping unit operating cost = 126.22 (kw) * 3(Baht/kw) = 378.648 Baht/day

In this study intermit operation had been conducted 8 days (12 to 19 October, 2011). Then the electricity power cost during this operation was equal to

Electricity power cost = 378.648 (Baht/day) * (8*(1/2) (day) = 1,514.59 Baht

Then the electricity power cost comparing between normal operation (24 hours' operation) and intermit operation (12 hours' operation) could be further predicted as showed in Table 3. Results from calculation revealed that the electricity power cost of the intermit operation was only a half of the normal operation.

Predicted incomes as showed in Table 4 also indicated that predicted incomes from the intermit operation was about 60 percent more than the normal operation.

### *3.4 Water coning technical considerations*

In term of technical consideration, the intermit operation that allow turning off the sucker rod pump for 12 hours can cause the segregation of oil and water and lowering the water coning within the surrounding rock formations. These two situations result in giving a good condition to oil flow, especially in the perforated interval, and also result in having more oil production when the sucker rod pump is turned on again.When fluid is producing from production well, there are some parameters and conditions that control flow behavior [2] of produced fluid e.g. mobility ratio, gas-oil ratio, differential pressure between bottom hole and well head, water coning, etc. This section discusses only on water coning and mobility ratio because they are believed to be the main parameter that concerning to oil and water flow correlation during the intermit operation is applying and lacking of other data. In this study water coning was considered both in dynamic (fluid flow) condition and in static (fluid does not flow but segregate) condition

**Table 3:** Predicted electricity power cost on normal (24 hours) operation and intermit (12 hours)

| **Time** | **Electricity power cost on 24 hours operation (Baht)** | **Electricity power cost by Intermit operation on12 hours operation (Baht)** |
|---|---|---|
| 1 day | 378.65 | 189.32 |
| 8 days | 3029.2 | 1,514.56 |
| 1 month | 11,359.50 | 5,679.60 |
| 1 year | 138,207.00 | 69,101.80 |
| 5 years | 691,036.00 | 345,509.00 |

**Table 4:** Summary predicted incomes on normal (24 hours) operation and intermit (12 hours)

| **Time** | **Predicted income on Normal (24 hours) operation (Baht)** | **Predicted income on Intermit (12 hours) operation** |
|---|---|---|
| 1 day | 28,813.90 | 47,224.53 |
| 8 days | 230,511 | 377,796.24 |
| 1 month | 864,416 | 1,416,735.90 |
| 1 year | 10,517,073 | 17,236,953.50 |
| 5 years | 52,585,367 | 86,184,767.30 |

*Dynamic condition*

Dynamic condition in this study means situation that well fluids are producing during sucker rod pump is turned on [5]. In general water can flow to the well more easily than oil, therefore in dynamic condition water coning tend to occur as depicted in Figure 1.

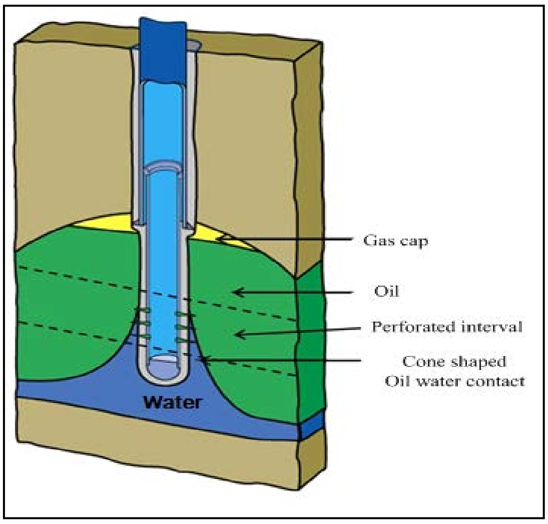


**Figure 1:** Water coning in "Dynamic Condition"

*Static condition*

Static condition in this study means the situation that occurred when the sucker rod pump is turned off and there is no fluid flow in well surroundings. In this condition fluid both in well and in surrounding formation do not flow but segregate instead. During this period water and oil is segregated from each other. As a result, oil saturation around perforated interval tends to increase and resulting in increasing in relative oil permeability (kro). Therefore, when the sucker rod pump is turned on again, oil will flow more than water in this interval, and resulting in having high oil production rate again as depicted in Figure 2 until the water coning is built up again.

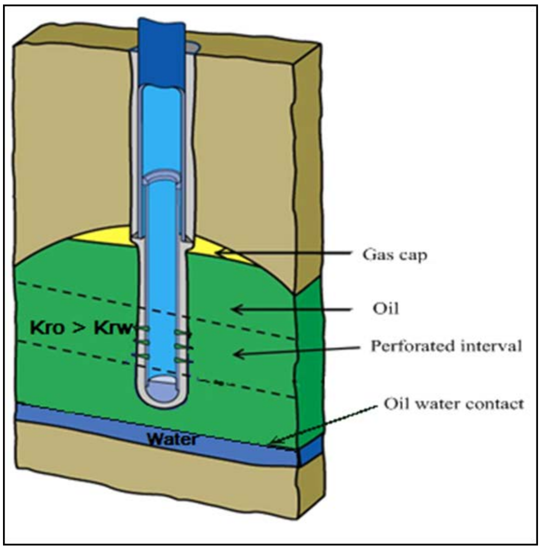


**Figure 2:** Oil and water segregation in "Static Condition

### *3.5 Mobility ratio technical considerations*

The mobility ratio, M, is defined as the ratio of mobility of the displacing fluid to that of the displaced fluid

$$M = \frac{(k/\mu)_{displacing}}{(k/\mu)_{displaced}} \tag{11}$$

If water is a displacing fluid and oil is a displaced fluid, therefore

$$M = \frac{(k_{rw}/\mu_w)}{(k_{ro}/\mu_o)} \tag{12}$$

Where $k_{rw}$ = relative permeability to water (dimensionless)

$k_{ro}$ = relative permeability to oil (dimensionless)

$\mu_w$ = water viscosity (centipoise)

$\mu_o$ = oil viscosity (centipoise)

During intermit operation [4], when the sucker rod pump is turned off, oil and water both in well and in reservoir is segregated from each other by its different in density. After segregation process had been accomplished oil tended to be accumulated at this perforated interval and resulted in increasing relative oil permeability (kro). If assume water and oil viscosity are constant and do not change in the system, therefore, when the relative permeability to oil increase, the mobility ratio decrease. This is resulted in giving this ratio less than 1.0, which is called "favorable mobility ratio". Therefore, with this condition, oil flow easier than water within the perforated interval around the well and it causes an increasing in oil production rate as a result when well starts its operation again.

## 4. Conclusion

After the study had been accomplished, some advantages of using intermit operation on the tested well FA-MS-07-08 can be summarized as follows;

- There was an incremental oil production about 73 percent during the intermit operation had been applied comparing to the normal operation.

- During the intermit operation had been applied, the electricity power cost for the sucker rod pumping unit of the tested well had been reduced up to 50 percent.

- In term of incomes from selling crude oil, it could be clearly seen that predicted incomes on selling crude oil produced by intermit operation was about twice time compared to those of normal operation.

**Table 5:** summaries the forecast profit from reducing electricity power cost and incremental incomes of the tested well FA-MS-07-08 when applying the intermit operation through period of times

| Time | Profit from electricity power cost reducing (Baht) | Profit from crude oil selling (Baht) | The total Profit (Baht) |
|---|---|---|---|
| 1 day | 189.33 | 18,410.68 | 18,600.01 |
| 8 days | 1,514.64 | 147,285.44 | 148,800.10 |
| 1 month | 5,679.90 | 552,320.40 | 558,000.30 |
| 1 year | 69,105.45 | 6,719,880.50 | 6,788,986 |
| 5 years | 345,527.00 | 33,599,400 | 33,944,927 |

## 5. Recommendations for future study

This intermit operation had been conducted in a short time period (only 8 days), therefore, this gave a few production data and might give some errors in calculations and interpretations. The future study should conduct this kind of operation in a longer period of time, e.g. weeks or months, for getting more production data.

Further study should try to change duration of turning on and turning off the sucker rod pumping time to test the relationship between oil/water flow behaviors and pump shut-down time. Then, the optimized turning off and turning on period of time that gives the optimized production rate might be reached.

## Acknowledgments

The research presented in this paper was fund and supported by the Suranaree University of Technology. The permission of the Defence Energy Department, Thailand, to use required data for this research is also appreciated.

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