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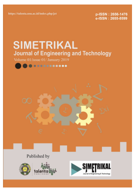

Capacity Requirements Planning in Water Injection Plant (WIP) Facilities of the Exploration Wells at Oil Company

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Abstract. The problem of production wells that have decreased production capability caused by a decrease in reservoir pressure can be overcome by means of artificial lift methods. Water injection is a method of injecting by re-injecting water that is carried along with oil during the petroleum production process using an injection pump. Based on this, capacity planning is needed in relation to the need for injection pump engines in the operating area so that the petroleum production process can run smoothly. The method used is to perform formation water forecasting needed in each exploration wells based on historical data injection water formation to obtain a plan regarding the capacity of the pump engine to be used in the coming period. Based on the results of forecasting, it is known that 32 periods have the possibility to exceed WIP capacity by 2000 bwpd. From the observations, an additional 2000 bwpd is needed to increase WTP capacity to 4000 bwpd with the proposed cost needed for the procurement of injection water per month is Rp. 22.083.333 compared to the previous required cost of Rp. 32.129.400,- per month. Thus, the costs incurred for injection water formation can be reduced if the company adds capacity from the units in the Water Injection Plant (WIP) facility.

Keyword: Formation Water, Water Injection Plant (WIP), Capacity Requirement Planning, Forecasting, ARIMA Box-Jenkins.

Abstrak. *Masalah sumur produksi yang memiliki kemampuan produksi menurun disebabkan oleh penurunan tekanan reservoir. Hal ini dapat diatasi dengan menggunakan metode pengangkatan buatan. Injeksi air adalah metode penyuntikan dengan menyuntikkan kembali air yang dibawa bersama dengan minyak selama proses produksi minyak menggunakan pompa injeksi. Berdasarkan hal ini, perencanaan kapasitas diperlukan sehubungan dengan kebutuhan akan mesin pompa injeksi di area operasi sehingga proses produksi minyak dapat berjalan dengan lancar. Metode yang digunakan adalah melakukan peramalan air formasi yang dibutuhkan di sumur eksplorasi berdasarkan data historis injeksi formasi air untuk mendapatkan rencana mengenai kapasitas mesin pompa yang akan digunakan dalam periode mendatang. Berdasarkan hasil peramalan, diketahui bahwa 32 periode memiliki kemungkinan untuk melebihi kapasitas WIP sebesar 2000 bwpd. Dari pengamatan, tambahan 2.000 bwpd diperlukan untuk meningkatkan kapasitas WTP hingga 4000 bwpd dengan biaya yang diusulkan diperlukan untuk pengadaan air injeksi per bulan adalah Rp. 22.083.333 dibandingkan dengan biaya yang diperlukan sebelumnya sebesar Rp. 32.129.400 per bulan.*

Kata Kunci: *Formasi Air, Water Injection Plant (WIP), Perencanaan Kebutuhan Kapasitas, Peramalan, ARIMA Box-Jenkins.*

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1 Introduction

In general, petroleum produced from a well, is initially produced through natural flow, meaning that oil comes to the surface of the earth naturally. The reservoir pressure reduction that occurs is due to the emptying of the reservoir caused by the imbalance between the volume of the reservoir fluid produced and the volume of water from the aquifer that replaces it [1]. This happens because the pressure of the reservoir that drives petroleum is still able to drain oil naturally. In line with the time of production there is a decrease in reservoir pressure and this condition causes a reduction in the economic value of the well, so it must be addressed immediately in order to produce optimally. Many researcher have investigated about water injection, it has ability to decrease combustion temperature, improved engine efficiency and also reduced emissions [2]. Water injection is often implemented in oil reservoirs with two goals. it provides an efficient of production in water-wet fields by sweepage and pressure maintenance. Pressure maintenance contributes to mitigate compaction and subsidence of highly compactable reservoirs [3]. The injection of water carried into the reservoir is expected to be able to maintain reservoir pressure to remain in a relatively stable condition. Water injection is a method of injecting by re-injecting water that is carried along with oil during the petroleum production process using an injection water pump [4]. The main function of the Water Treating Plant (WTP) is to remove produced water that comes from the main processing system that removes gas and oil. The water that has been set aside from the oil processing system will be channeled to the WTP to be refined [5]. So that, water injection can helps to keep reservoir relatively stable condition. Based on this, capacity planning is also needed in relation to the need for injection pump engines in the operating area so that the petroleum production process can run smoothly. In this study, we will discuss the application of water injection methods in exploration wells at PT. Pertamina EP Pangkalan Susu Field to find out the capacity requirements planning in the Water Injection Plant (WIP) facility in the Collection Station XII. Historical data from injection water requirements will be forecasted to determine the need for injection water in the future so that the ideal capacity of the WIP facility can be planned to support oil production activities in exploration wells. The required water discharge in each exploration well based on historical data injection water formation in each exploration well which will then be compared with the capacity of the injection pump engine and supporting units in the Water Injection Plant (WIP) available for planning regarding the capacity of the pump engine to be used in the coming period. To determine capacity requirements in the future, ARIMA Box-Jenkins forecasting techniques are used. Box-Jenkins ARIMA was used to analyze the behavior of the lake water level in Iran [6]. In 2017, ARIMA Box- Jenkins was used to predict daily influent water characteristic of Sanandaj's Water Treatment Plant, That study compare Box-Jenkins ARIMA with NNAR model, the results showed ARIMA methods stands as better alternative for forecasting task of aforementioned series [7]. The Box-Jenkins ARIMA method is one of the forecasting methods that has excellent accuracy in forecasting a data in the coming period. ARIMA uses past and present data to produce accurate short-term forecasts [8]. Forecasting uses the ARIMA periodic series method which produces stationary data and identifies the presence of seasonal factors by plotting data and residual autocorrelation values for each lag [9]. In addition, a comparison analysis of actual costs and proposals from the process of procuring injection water is carried out as an illustration to the company regarding the investment and proposals given.

2. Methods

The object of the research observed was from the performance of the Water Injection Plant (WIP) facility and formation water requirements. The data collected for use in this study are as follows [10]:

1. Primary data is data obtained by direct observation or down directly to the field to collect information / data needed. Primary data collected include the petroleum production process and historical data on formation water needs in exploration wells as well as historical data on the performance and efficiency of injection pump machines.
2. Secondary data is data obtained from literature searches. Secondary data collected are factors that influence formation water needs and performance of the Water Injection Plant (WIP) facility.

Data processing is carried out in planning injection pump machines in exploration wells, namely:

1. Collecting observational data that will be used in research.
2. Foresee the need for formation water discharge for the future.
3. Determine the capacity of the Water Injection Plant (WIP) facility.
4. Plan the need for a Water Injection Plant (WIP) facility for future exploration wells by considering the factors that have been observed.

The conceptual framework for this research contain relationship between dependent and independent variables. The independent variables are historical data of formation water, performance of water injection plant facility and factors that influence both of it. These independent variables are needed to helps designing facility for water injection plant. The conceptual framework in this study can be described as follows.

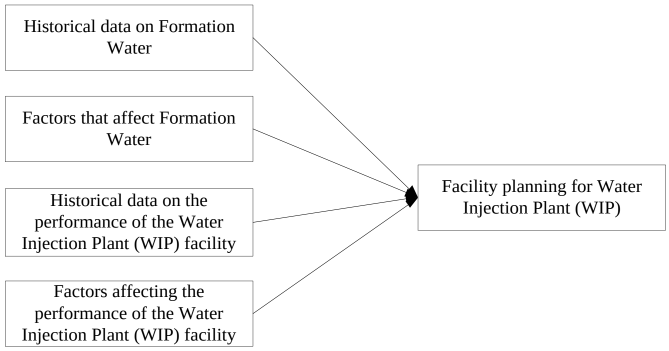

Figure 1. Conceptual Framework for Research

3 Result and Discussion

In this section, we will discuss the problem solving and analysis related to the problem also further discussion of the results obtained.

3.1. Conditions of Actual Facilities

Location of Water Treatment Facilities Produced through Water Injection Plant (WIP) with a capacity of 2000 Barrel Water Per Day (BWPD) located with a distance of 10 km to the northeast of the city and supporting facilities in the form of Water Treatment Plant (WTP). The WIP facility consists of several machines that function to purify the formation water from the result of separation from crude oil using the principle of difference in fluid density in the tank Free Water Knock Out (FWKO). Facility of Water Injection Plant (WIP). This facility consists of 6 processing units, as follows;

a. Feed pump, has a daily capacity of 3000 bwpd.
b. Sand Filter, consisting of 2 filter units with a capacity of 1000 bwpd each.
c. Cartridge Filter, consisting of 2 filter units with a capacity of 1000 bwpd each.
d. Ultra filter, consisting of 10 filter units with a total capacity of 2000 bwpd.
e. Water injection tanks function as formation water reservoirs which are ready to be injected into exploration wells.
f. The water injection pump has a pressure of 500 psi and is capable of injecting formation water with a capacity of 8000 bwpd.

Based on the description of the facilities of the WIP above, it can be described the actual capacity of each unit is as follows.

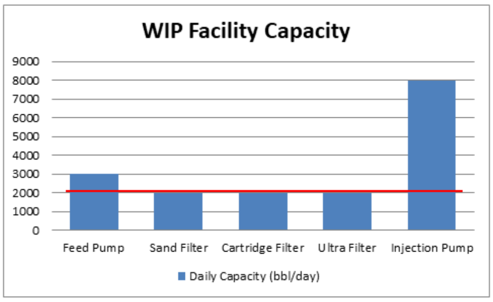

Figure 2. Capacity of Water Injection Plant (WIP) Facilities

Based on observations of the actual capacity, preventive measures from the company need to be carried out on the capacity of the water injection plant facilities and its supporting units so that the need for formation water injection can be met at the WIP facility.[11]

The need for injection water that will be pumped into exploration wells so far uses WIP facilities of 2000 bwpd. If there is a shortage of injection water needs, the production department carries injection water from the Water Treatment Plant (WTP) facility which is 10 km away from the WIP facility using a road tank with a capacity of 18,000 liters or 113,217 barrels to meet injection water needs.

3.2. Water Injection Needs Forecasting

The data to be processed is secondary data which is the data of formation water injection needs in exploration area for the period of August 2015 to July 2018. Data processing is carried out using the Minitab 16 English software program to provide more accurate results and minimize the possibility of calculation errors .

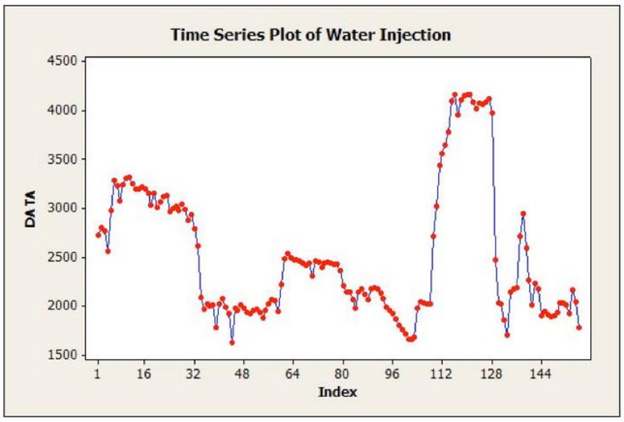

Figure 3. Formation of Water Injection Needs Data Plots

From the graph above it can be seen that the data is quite stationary in terms of variance, but the data is not stationary in the mean because the data has an increasing trend in certain periods.

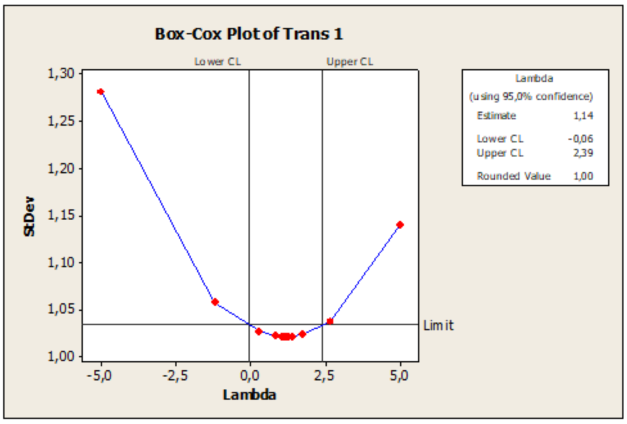

Figure 4. Box-Cox Plot for Transformation of Formation Water Injection Needs Data

Box-Cox examination results indicate that the data has been stationary in variance, it can be seen in the lambda value or Rounded Value has produced a number 1. To see whether the data is stationary in the mean, it must be seen from the graphical form [12] [13]. Graphs of ACF and PACF for data on formation water injection needs can be seen in Figures 5. and 6.

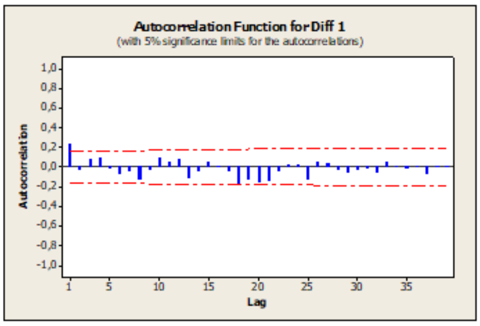

Figure 5. ACF Chart for Formation Water Injection Needs Data

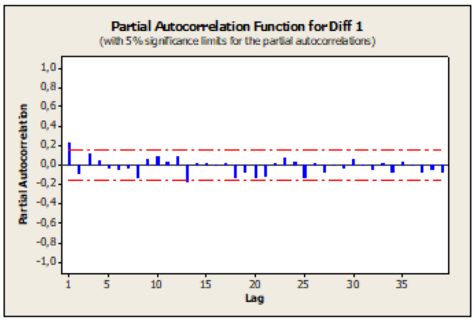

Figure 6. PACF chart for Formation Water Injection Needs Data

Model identification is done if the data has been stationary in variance or mean. The model formed depends on the ACF and PACF charts that have been previously plotted, where the ACF graph is dies down on first lag and the PACF graph is dies down. For more details, see Table 1.

Table 1. Identification of Formation Water Injection Needs Data Model

Model	ACF	PACF
AR (p)	*Dies down*	*Cuts off after lag* p
MA (q)	*Cuts off after lag* q	*Dies down*
ARMA (p, q)	*Dies down after lag* q-p	*Dies down after lag* p-q

Based on Table 1. the models formed are AR (q) and MA (q). However, the data experienced differencing once. Therefore, the ARIMA model that is formed is ARIMA (1,1,1). Model testing is done to see whether the model that has been formed above is correct or not. Model testing is done by testing residual independence. Residual independence test is used to detect the presence or absence of residual correlation between lags. The Ljung Box value at 12th, 24th, 36th and 48th lags does not exceed the value of α2 (α, K-p-q), it can be concluded that there is no residual correlation between t-lags so that it meets the assumption of residual independence[14].

The forecasting model for the data of formation water injection needs has been through residual independence testing. This means that the ARIMA model (1,1,1) is suitable to be used as a forecasting model for estimating the need for formation water injection needs in the future[15][16].

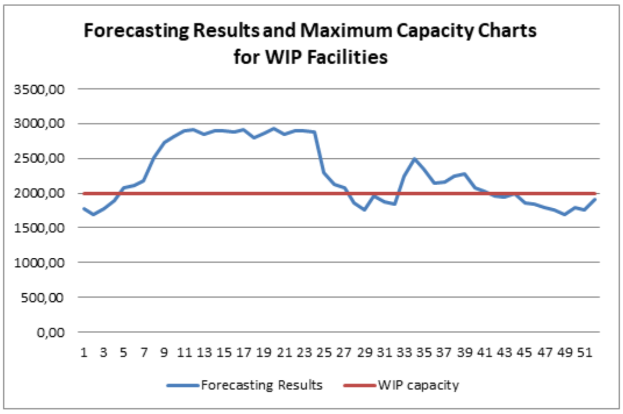

Figure 7. Forecasting and WIP Capacity Graph

3.3. Cost of Investment Factors

In this section, will be discussed about the comparison of the costs of the actual conditions of the formation of formation water with the costs of the conditions of the proposed proposal.

3.3.1. Investment with Road Tank Use

The process of procuring actual injection water to meet injection needs was imported from the Water Tratment Plant (WTP) facility, which is 8.3 km away from the Water Injection Plant (WIP) facility in exploration area. Meanwhile, the details of the costs required in procuring injection water are as follows.

Table 2. Details of the Need for Actual Injection Water Procurement Costs

No.	Needs	Unit / Month	Unit Cost	Total Cost Required / Month
1	*Road Tank* Rent	1	Rp. 15.000.000	Rp. 15.000.000
2	Driver Wages	1	Rp. 3.000.000	Rp. 3.000.000
3	Operator Wages	1	Rp. 4.000.000	Rp. 4.000.000
4	Biosolar Fuel	Price of Biosolar Rp. 5,150 to 2.5 km / liter	83 km / day for 5 times PP trip	Rp. 5.129.400
5	*Road Tank* Maintenance	2	Rp. 2.500.000	Rp. 5.000.000
		Total Cost / Month		**Rp. 32.129.400**
		Total Cost / Year		**Rp. 385.552.800**

3.3.2. Investment with Units Procurement

The capacity available in the Water Injection Plant (WIP) is 2000 bwpd. The addition of WIP capacity with the procurement of new units can increase the capacity of the formation water injection facility. So that the need for injection in exploration wells can be met. It is known that 32 periods have the possibility to exceed WIP capacity by 2000 bwpd. From the observations, an additional 2000 bwpd is needed to increase the WTP capacity to 4000 bwpd. The following are the details of the procurement of supporting units in the Water Injection Plant (WTP) facility.

Table 3. Details of WIP Unit Procurement Costs Needs

No.	Needs	Unit	Additional Capacity (bwpd)	Unit Price	Total Cost Needed for 1 Year Life	Total Cost Needed Monthly
1	*Feed Pump*	1	3000	Rp. 15.000.000	Rp. 15. 000.000	Rp. 1.250.000
2	*Sand Filter*	2	2000	Rp. 25.000.000	Rp. 50.000.000	Rp. 4.166.666,7
3	*Cartridge Filter*	2	2000	Rp. 15.000.000	Rp. 30.000.000	Rp. 1.250.000
4	*Ultra Filter*	10	2000	Rp. 5.000.000	Rp. 50.000.000	Rp. 4.166.667
5	Maintenance costs	-	-			Rp. 10.000.000
		Total Cost			**Rp. 145.000.000**	**Rp. 22.083.333**

Thus, the capacity of the Water Injection Plant (WIP) after installation of additional capacity is as follows.

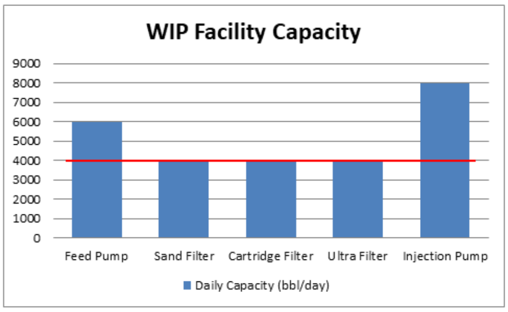

Figure 8. Proposed Water Injection Plant (WIP) capacity

3.4. Discussion

Based on observations of the actual capacity, preventive measures from the company need to be carried out on the capacity of the water injection plant facilities and its supporting units so that the need for formation water injection can be met at the WIP facility. There is a need for preventive action from the company towards the capacity of the water injection plant facility and its supporting units. So that the need for formation water injection can be met at the WIP facility considering the capacity available at the facility is no longer it is possible to meet the needs of formation water injection in production wells. It is known that 32 periods have the possibility to exceed WIP capacity by 2000 bwpd. Thus, the production department must bring in an external injection water source from the Water Treatment Plant (WTP) using a road tank. The consideration that you want to know is by increasing the capacity of the WIP or still bringing in external injection water sources. The process of procuring actual injection water to meet injection needs was imported from the Water Tratment Plant (WTP) facility, which is 8.3 km away from the Water Injection Plant (WIP) facility. The cost required in procuring injection water per month using a road tank (tank car) is Rp. 32,129,400. If the company adds capacity from the WIP facility, the cost required is Rp. 22,083,333. Thus, the costs incurred for injection water formation can be reduced if the company adds capacity from the units in the Water Injection Plant (WIP) facility.

4 Conclusion

From the results of the discussions that have been conducted, the following conclusions are drawn:

1. Based on the observation of the actual capacity, preventive measures from the company need to be carried out on the capacity of the Water Injection Plant (WIP) facilities and its supporting units so that the need for formation water injection can be met at the WIP facility.

2. Based on the forecasting results, it is known that 32 periods have the possibility to exceed WIP capacity of 2000 bwpd. Thus, the production department provides deficiencies of injection water requirements. The consideration is to increase the capacity of the WIP or keep bringing in external injection water sources.
3. The cost required in procuring injection water per month using a road tank (tank car) is Rp. 32,129,400. - If the company adds capacity from the WIP facility, the required cost is Rp. 22,083,333. Thus, the costs incurred for injection of formation water can be reduced if the company adds capacity from the units in the Water Injection Plant (WIP) facility.

This study only used one forecasting method, future research may use several methods to make a comparison. It helps to make some options and suggestions. This study can be applied to other cases but need some adjustment.

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