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The Application of Well Injection Technology in the Produced Water Management Oil and Gas Industry

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Produced water is the largest liquid waste generated from the production of oil and gas. The direct discharge of produced water into the environment can be harmful to human's life and environmental. Thus, it needs to be managed, one of which is through the technology of well injection. Well injection technology is a technology where the produced water generated in the process of production of oil and gas will be returned to the earth by means of injecting it to injection wells. The purpose in this study was to identify the amount of produced water injected back into the injection wells and identify the constraints of the application of well injection technology in the company. The primary and secondary data were collected through field observations, laboratory analysis, and interviews. Descriptive analysis was conducted to know the constraints and benefits of applying this technology. The results showed that the re-injection technology was able to inject produced water of 37158 barrels per day. However, this technology led the wells to be increasingly saturated and leakage to produced water reinjection pipes.

Keywords: Produced Water, Re-injection Technology, Oil and Gas industry

1. INTRODUCTION

In the modern world the position of petroleum as a primary energy source cannot be replaced. Petroleum is the main source in the manufacture fabrication not only polymers or plastics but also a variety of chemicals used every day. Produced water is the water that comes out along with gas and oil during the extraction process; therefore, the produced water contains chemical compounds similar to hydrocarbons (crude oil) as well as all chemicals used during the process of production and management of crude oil [1]. Produced water is the largest liquid waste generated by the exploration and production of oil and gas with a composition of 80% of a liquid waste, and on an aging oil field, it reaches 95% [2, 3]; as a result, this needs to be managed by selecting the appropriate disposal or by searching for beneficial use suitable for produced water for industry. One of various types of technology that can be used to manage produced water is the re-injection technology. It is a technology where the produced water generated in the process of oil production will be returned to the oil wells. This study provides an overview of the application of technology of well injection in the management of produced water generated by oil and gas companies.

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2. METHODOLOGY

A. Data

The research was conducted for six months from January to June 2013 in the oil and gas company in Muara Badak, East Kalimantan. The primary data was collected from the unit process operations in the company including the raw materials, and environmental management that has been done, while the secondary data consists of a review of

literature, information from internet, and other related data available in the company.

B. SWOT Analysis

SWOT refers to strengths, weaknesses, opportunities and threats. Here, a SWOT analysis internal and external factors was used to identify factors that affect performance, the constraints and benefits of applying the technology of well injection (see Table I).

Table I. SWOT Analysis over Re-Injection Technology

SWOT	
Strength	1. Cost effective 2. Easily maintained 3. Easily Applied
Weakness	1. Saturated well for injection 2. Leakage in produced water pipes
Opportunity	1. Used on EOR (Enhanced Oil Recovery) 2. Used for CBM (Coal Bed Methane)
Threats	1. Saturated well for injection 2. The reservoir formations can be severely damaged during the reinjection process 3. Natural disasters

3. RESULTS AND DISCUSSION

A. The composition of produced water

Produced water has a complex composition which can be divided into two main categories: organic and inorganic compounds. In general, produced water has a composition consisting of components of dissolved and dispersed oil, minerals and addictive chemical compounds during the production process, gas, solid and liquid compounds, microorganisms and oxygen. Table 2 indicates that the composition produced water which consists of a compounds wide variety, each of which has chemical properties and different quality standards. The compounds contained in the produced water are generally compound contaminants to the environment so that if the value exceeds the quality standards that have been set, the potential for environmental pollution increases. Produced water is waste containing hydrocarbons and BTX [4]. BTX compounds particularly Benzene and Toluene compounds have been known as carcinogenic compounds [5]. The main effect which may arise from inhaling xylene vapor is depression in the central nervous system which leads to symptoms such as headache, dizziness, nausea and vomiting [6]. Phenol is an organic compound which is toxic and is persistent pollutant in the water. At a concentration of 5-25 mg / L, phenol can be carcinogenic to humans [7]. Table II shows data of produced water composition for the year 2012 measured based on eight parameters [8].

B. Pretreatment for Produced Water

In this company, pre-treatment process that is performed on Produced Water Pollution Control (PWPC) unit before it is injected into the injection wells is intended to separate the oil from the water to reduce the oil content in the water (see Figure. 1). Facilities PWPC in this company consists of:

a) Break Drum V-6500
   Break Drum Unit serves to separate or discharge gas carried in the water. This unit has a capacity of 25,000 bpd
b) Corrugated Plate Interceptor (CPI)
   CPI has a capacity of 25,000 bpd with outlet oil content design of 300 ppm. The results of the processing of the CPI are water and oil. The water will be treated again in GFU and the oil will go into the API Separator.
c) Gas Floatation Unit (GFU)
   Having the capacity of 25,000 bpd, GFU is a tool that serves to separate the water derived from CPI which has oil content less than 300 ppm to become less than 25 ppm. From GFU, the water is flown into the API Separator.
d) API Separator
   API separator is an oil collecting and separating pond/storage discharged from CPI and GFU. The water still containing oil will be pumped to Gun Barrel.
e) Gun Barrel
   Gun Barrel receives water from oil a plant and from an API pond/storage. At this pool there is a separation process based on density of oil and water. The oil collected at the top of the tank will go out into the recovery tank before going to the oil heater treater. Meanwhile, the water coming out of the bottom of the tank goes to the CPI and GFU before finally accommodated to the Tank one (T1) or Tank two (T2) using a pump 4385 A / B which will then be pumped into the injection wells.
f) T1 and T2, which are the last two storage tanks of produced water. There occurs settling process where oil will be on the top layer and water will be at the bottom in the bypass from T1 to T2. Oil will undergo overflow if it reaches a certain height and will be fed back to the API separator through a pipe 6 "and 8".

PWPC serves to reduce the oil content contained in the produced water, thus, the oil can be produced again and produced water injection process does not experience plugging. Figure 2 shows the oil content before and after treatment on PWPC

Table II. The Chemical Composition of Produced Water In The Oil And Gas Industry Wastewater

Month	Concentration Oil (ppm)	Salinity (ppm)	COD (ppm)	Phenol (ppm)	pH	Ammonia (ppm)	Sulfide (ppm)	TDS (ppm)
January	330,40	1945,20	1032,50	13,620	7,98	10,618	0,1260	-
February	224,75	3187,25	1157,50	12,730	8,10	13,233	1,4050	-
March	171,25	1651,00	781,13	17,023	7,61	10,260	0,0475	-
April	130,80	1598,40	830,60	16,050	7,98	7,796	0,0000	-
May	266,00	1317,25	1230,00	27,303	7,45	8,805	1,0550	-
June	309,25	1934,50	660,50	10,007	8,05	7,720	1,8755	-
July	524,20	1847,40	692,20	17,070	8,08	8,060	0,1320	-
August	759,75	2103,75	1376,88	7,745	8,11	7,663	0,1525	-
September	689,60	1558,00	1251,20	14,626	8,11	10,342	0,5400	-
October	945,75	1772,50	513,25	11,703	7,64	9,955	0,2700	3571,25
November	1024,20	1162,50	1120,25	11,310	7,67	10,710	0,3600	3675,00
December	1215,40	2186,25	1887,40	8,790	7,84	10,690	1,1900	3823,00
Average	**549,28**	1855,33	**1044,45**	**13,998**	7,89	9,654	0,5961	3689,75
Quality Standard	* 25		* 300	2	6-9	* 10	* 1	

*Reference for Quality Standard: KEP. 42/MENLH/10/96/TERBIT

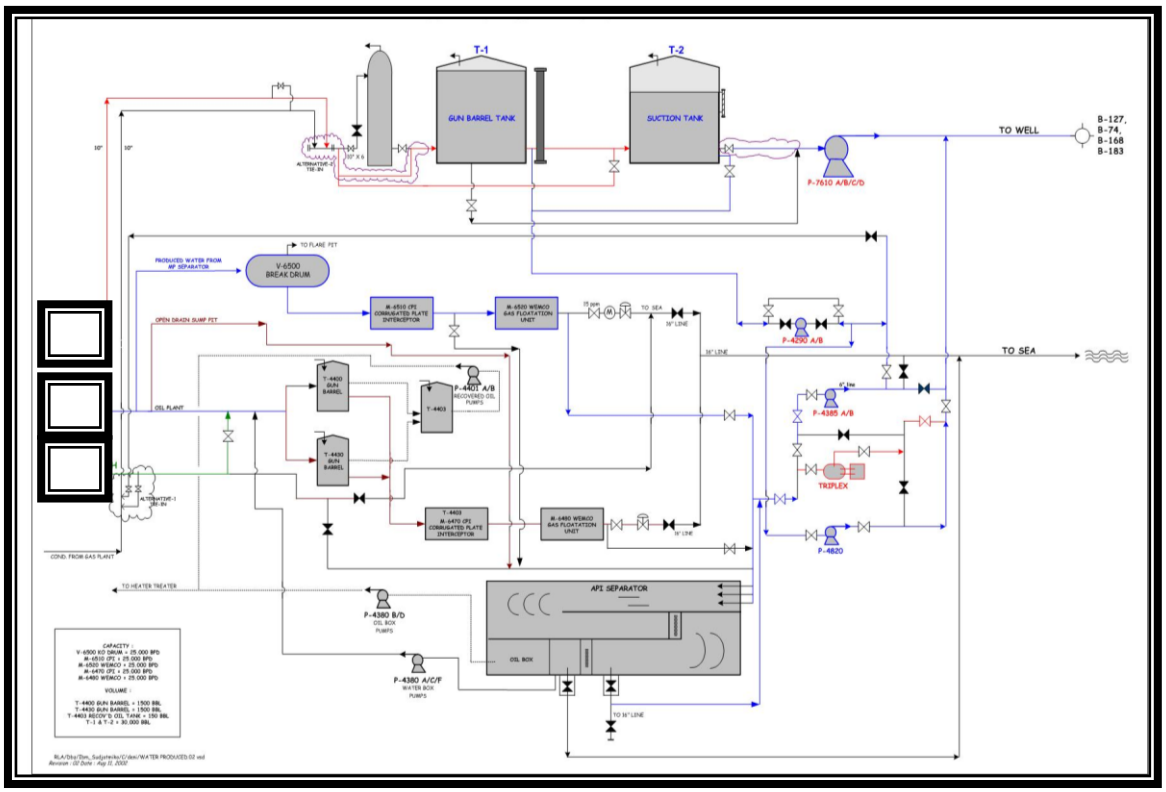

Figure 1. Produced water pollution control (PWPC) Management
(Source: Internal Oil and Gas Company)

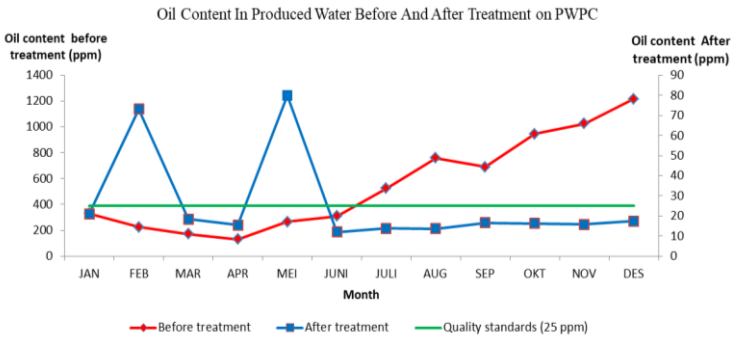

Figure 2. Pareto chart of Oil Content in Produced Water (Source: Company Laboratory)

C. Re-Injection Technology

Due to the large amount of injected produced water, the presence of the injection system is very important. The high volume of produced water is influenced by many factors, including the production age of the wells, the type of oil and gas produced the location of wells or oil field, and the geological structure [7]. Figure 3 shows the volume indicator of produced water In Injection System of 2012.

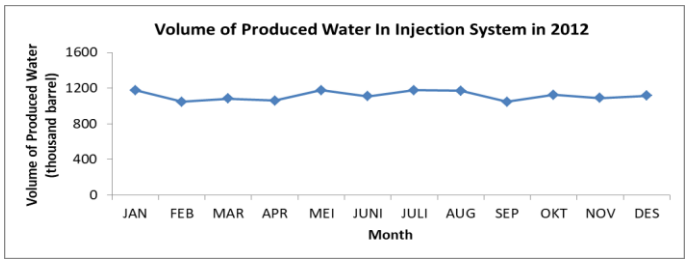

Figure 3. Volume of produced water In Injection System (Source: Internal Company)

Injection system is the most appropriate disposal method of produced water according to the company due to the economic costs such as inexpensive, easily maintained, as well as easily applied technology. Disposal of produced water into the unused wells in oil and gas fields on land does not require complex treatment process, it can be directly injected into the well [8, 9]. Management cost of produced water will increase along with the increasing number of treatment processes of the company [10]. This is supported by the facts that there is a lot of available oil wells that are no longer in production and this condition is technically suitable to be used as injection wells. Injection of produced water into the wells has an advantage to environmental. In addition, it is more efficient for the company than other technologies of produced water disposal and economically the most inexpensive technology [11]. Produced water injection requires a system that starts from the pre-treatment process to the injection of produced water into injection wells using pumps [12]. In this company, Produced water injection is centralized in one oil field which is the biggest this is because the injection wells are located in there, hence, the produced water generated in the others oil field will be streamed to there, then collected for pre-treatment process prior to injection (PWPC). The average monthly volume of produced water which will be injected is 37158 barrels every day. Due to the large amount of injected produced water, the presence of the injection system is very important. The high volume of produced water is influenced by many factors, including the production age of the wells, the type of oil and gas produced the location of wells or oil field, and the geological structure [13]. The pumps used for the injection process are four pumps arranged in series and one separate pump (Figure 4), A pump is a motor driven in which the speed can be set variously, it also has a mechanical pump silt which serves to prevent the escape of water from the pump. The total produced water debit injected in Field is an average of 38,500 barrels / day with an average injection pressure of 678-1052 psi.

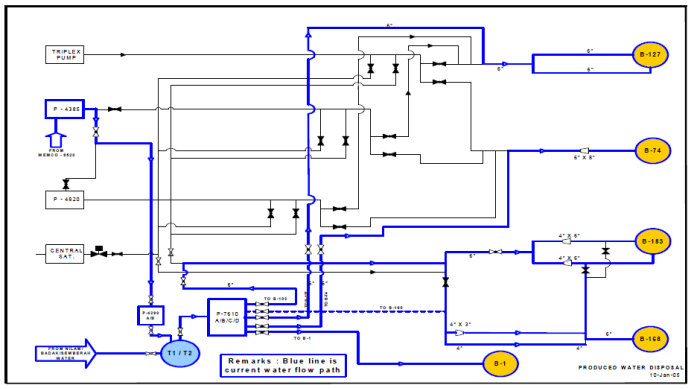

Figure 4. Flow of Re-Injection of Produced Water (Source: Internal Oil and Gas Company)

D. Injection wells monitoring and construction

In this oil and gas company, to operate the injection system, it must carry out monitoring actions to maintain the stability of the injection system. This aims to know injection condition of produced water into injection wells. The following are monitoring conducted by the Company:

a) Monitoring the injection pressure of the well once a day.
b) Testing the casing pressure of all wells twice a year.
c) Monitoring cumulative volume and injection debit once a day.
d) Checking the Caliper once a year.
e) Monitoring of chemical-physical characteristics of the waste regularly, every three months.

A properly functioning well must have a standard construction (see Figure 5). Company's injection wells have the following construction:

a) The casing pipe: A steel pipe mounted on the wall of the well and then fortified with cement.
b) Tubing pipe: A pipe protecting the production pipelines which can also serve as a production pipelines.

c) Insulation (packer): Serving as a boundary between zones as well as the stopper.
d) The annulus: The space between the casing and tubing.
e) Well head: Equipment for controlling wells.

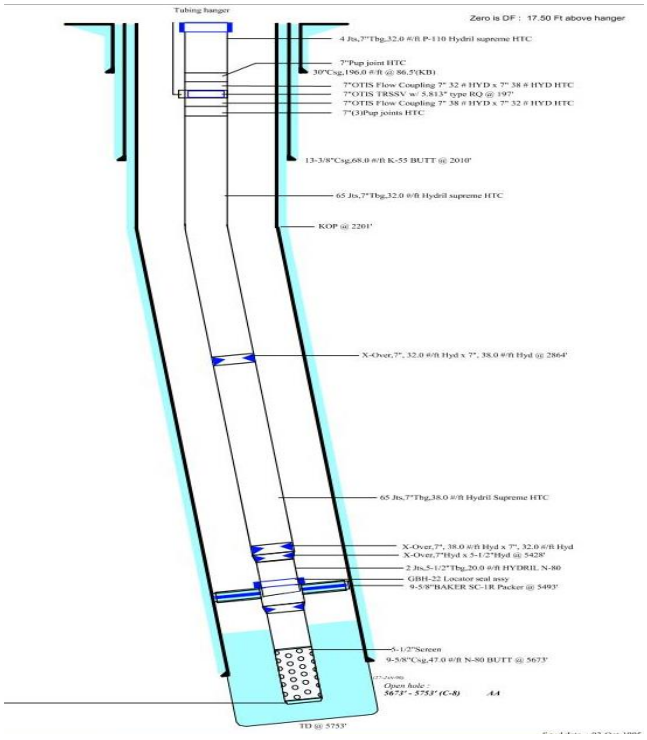

Figure 5. Example of Sectional Injection wells on construction Oil and Gas Company
(Source: Internal Oil and Gas Company)

Constraints in the management of produced water by the company's injection system are:

a) Increasingly saturated wells.
The more the produced water injected into the injection well, the more saturated the well will be. The pressure that comes from the bottom of the well will be even greater, making it increasingly difficult to inject produced water.
b) Leakage in produced water pipes.
A produced water pipe is one of the important components in the injection system. The water pipe is a means of transportation of produced water from one location to another and from the oil field to the injection wells.

There is a 2 (two) types of leakage incident: leakage and spill. This distinction of the two is based on total volume of produced water that comes out of the water pipe. An incident is said to leak if the volume of produced water that comes out of the pipes is less than 1 barrel, while an incident is called spill if the produced water coming out of the pipes is over 1 barrel. The most common leakage incident happened in 2012. There were 11 incidents: 4 incidents of leakage and 7 times of spill incidents. Incident of leakage is a serious problem due to the large impact on the environment. However for the constraints of increasingly saturated wells, the company had an alternative solution which is to replace with another well and use it alternately until the pressure at the initial well drops.

E. The latest developments Re-Injection Technology on produced water management

Injection system is the most appropriate disposal method of produced water from the perspective of cost effectiveness. Figure 4 shows In the United States, produced water management is generally categorized into disposal and injection operations. Most of the onshore hat produced water is injected while most of the offshore produced water is discharged, regulated by different federal and state laws.

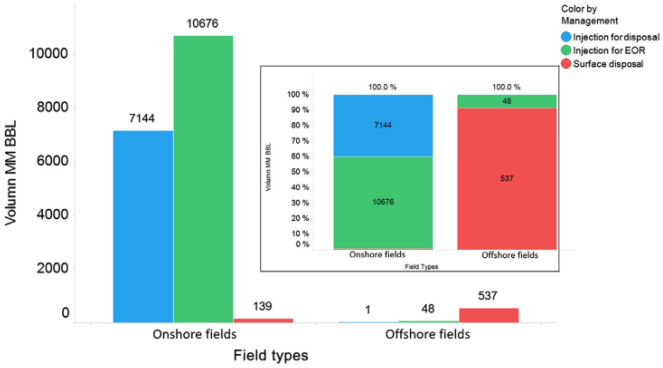

Figure 4. US produced water volume by management practice [14]

In Indonesia, PERTAMINA branch EP Asset 4 Field Sukowati on 2019 was start to Spud in, the goal is to get one injection drilling well to treat the produced water from the oil mixture in oil field so that it can increase the amount of production or EOR [15]. Shallow reinjection provides good pressure support, and allows a higher rate of steam production than the deep reinjection case. For the high reinjection rate case, although injecting into the deeper level gives a significantly smaller steam production rate than shallow reinjection initially, after 25 years of production, the deep reinjection starts to show better support of steam production than the shallow reinjection [16]. Re-injection Technology is an important method for handling and utilizing produced water, but the reservoir formations can be severely damaged during the reinjection process if the process is not fully understood and adequately managed [14].

4. CONCLUSION

Technology of well injection is the most appropriate disposal method of produced water for the company because it is more environmentally friendly, efficient and

effective than other technologies of produced water disposal. Constraints in the management of produced water using well injection system are that the well will be increasingly saturated and the pipes will have leakage. However the reservoir formations can be severely damaged during the reinjection process if the process is not fully understood and adequately managed.

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