Evaluation of Hydraulic Jet Pump Application in Sembakung Field

(Evaluasi Penggunaan Pompa Jet Hidrolik Di Lapangan Sembakung)

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Abstract

Sembakung Field is an "brown" remote oil and gas field located in North Kalimantan with very limited road infrastructure to and within the location. The purpose of this study is to evaluate the performance of Hydraulic Jet Pump for field development as well as to assess the opportunities for incressing oil production by applying the Hydraulic Jet Pump in the fields. Quantitative data are used and evaluated to investigate the pump design and actual pump performance by considering transient and steady state conditions. The research is performed for three wells. There was significant difference between design and actual flowrate due to the transient and steady state conditions. Steady state condition was achieved within four to seven months in this field. Based on the evaluation results it can be concluded that the application of hydraulic jet pump is proper for Sembakung Field and there is opportunity to increase oil production rate by applying the pump type in the field. The application of the hydraulic jet pump during the period can produce 78 bpd to 112 bpd of oil with liquid production rates ranging from 130 bpd to 980 bpd.

Keywords: Brown Field, Transient, Steady State, Optimizing, Hydraulic Jet Pump

Sari

Lapangan Sembakung merupakan lapangan migas "tua", terpencil yang terletak di Kalimantan Utara dengan infrastruktur jalan ke dan di dalam lokasi sangat terbatas. Tujuan penelitian ini adalah untuk mengevaluasi kinerja Hydraulic Jet Pump untuk pengembangan lapangan serta untuk menilai peluang untuk meningkatkan produksi minyak dengan penerapan Hydraulic Jet Pump dilapangan tersebut. Data kuantitatif digunakan dan dievaluasi untuk mengamati desain pompa dan kinerja pompa sebensrnya dengan mempertimbangkan kondisi sementara dan mantap. Penelitian dilakukan untuk tiga sumur. Ada perbedaan berarti antara laju alir desain dan laju alir sebenarnya akibat kondisi sementara dan mantap tersebut. Kondisi mantap dicapai dalam empat hingga tujuh bulan di lapangan tersebut. Berdasarkan pada hasil evaluasi tersebuty, dapat disimpulkan bahwa penerapan pompa jet hidrolik adalah sesuai untuk Lapangan Sembakung dan ada kemungkinan untuk meningkatkan laju produksi minyak pada lapangan tersebut. Penerapan pompa jet hidrolik selama periode tersebut dapat memproduksi 78 bpd hingga 112 bpd minyak dengan laju produksi cairan berkisar antara 130 bpd hingga 980 bpd.

Kata-kata kunci: Lapangan Tua, Sementara, Mantap, Optimasi, Pompa Jet Hidrolik

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I. INTRODUCTION

Based on the POFD (Plan of Further Development) of the Sembakung Field in 2016, it was stated that the Sembakung Field began to be produced since June 1977 and has 70 wells consisting of 44 production wells (41 oil wells and 3 gas wells), 17 suspended wells, 6 injection wells (as pressure maintenance), and 3 wells in abandoned condition. The field is located in Nunukan District, North Kalimantan, about 60 km from the city of Tarakan as shown in Figure 1, with a total area of 23.37 km2 which includes secondary swamp forest. This field consists of 3 formations, namely the Tarakan Formation, Tabul Formation and Meliat Formation [11].

Optimization studies have been carried out in the Sembakung field to increase fluid production using the available artificial lifting methods. During the years 2000-2010, various artificial lifting methods were tested such as the Electrical Submersible Pump (ESP), Progressive Cavity Pump (PCP), and the Hydraulic Pumping Unit (HPU) applied in addition to the Hydraulic Jet Pump (HJP) itself. Most of these experiments failed mainly due to the inability of the lifting method to handle sand and gas. Hydraulic Jet Pump (HJP) is considered to be the most reliable artificial lift method in Sembakung based on an evaluation of the application of the artificial lift method in Sembakung for 30 years of operation [3].

Jet pumps have several advantages, such as no moving parts or mechanical part that wear. Jet pumps can produces high fluid volume. They can be run and retrieved as a "free style" by circulation or via slickline. Jet pumps are of low maintenance are easily and quickly retrieved and replaced when maintenance is required [7, 10]. Furthermore, hydraulic jet pumps are highly reliable and can be resized quickly without a rig. Another advantage of hydraulic jet pumps is their tolerance to gas [9].

Mature Field is an oil and gas field whose production has decreased by more than 50% compared to its peak production. The HIS Cambridge Energy Research report defined if the field has generated more than 50% of the estimated proven reserves and reserves may or have been produced for more than 25 years. However, the term mature field can be interpreted as more than one approach. In fact, despite new findings, currently mature fields are still the mainstay of world industry [6].

The main challenges in the oil and gas industry are concentrated on (a) how to increase knowledge of reservoir characteristics, (b) how to track the movement of fluid in the reservoir, and (c) how to control the movement of these fluids. The problem is not our ability to drive the movement of oil, but how to detect the presence of the oil in question. This implies that the technology must be developed to increase the efficiency of oil sweeping in the reservoir [1].

The hydraulic jet pump has a high tolerance for directional wells due to its rodless configuration. Because HJP is a rodless operation and is more suitable for directional wells such as those in Sembakung [2].

The successful application of hydraulic jet pump technology has been proven in the Mangala Field, where this artificial lift method was able to adequately meet the guaranteed subsurface flow by utilizing thermal power fluids. Thereby it reduced the most significant risks associated with the waxy and viscous nature of Mangala crude oil. Hydraulic jet pump has played a very important role in maintaining field production where it has contributed for more than 50% of total field production. The lifting method with adequate surface infrastructure can then help to produce nearby fields which are located in RJ-ON 90/1 assets [4]. Another successful application of this pump was in Bakken Formation (North Dakota). Jet pumps yielded superior production and economic results to rod pump wells [5].

The choice of the Hydraulic Jet Pump in Sembakung is due to the lack of gas availability for the gas lift, the absence of a power distribution system in the field, the unavailability of pump service rigs to pull out and insert the tubing and the lack of road infrastructure because it is located in a swampy environment. The hydraulic jet pump used is a free pump type that does not require rig in the process of inserting and lifting subsurface pump equipment. These pumps have been installed in 6 of the 17 wells in the field by the end of 1983 [8]. In this research, the use of a hydraulic jet pump in three wells in the field is evaluated.

II. METHOD

The procedures and systematics of the research are as follows (Figure 2):

- 1. Conduct literature study related to mature field management, the use of artificial lift in general and the use of hydraulic jet pump (HJP) in particular.
- 2. Collect all necessary Sembakung field data related to the use of the hydraulic jet pump including production data, well diagrams and pumping pressure data as well as power fluid flow rate and well bottom pressure data.
- 3. Perform processing on the data of well maintenance, daily field production, internal and external studies by considering at the relationship between:
 - a. Suitability of field conditions and the use of a hydraulic jet pump.
 - b. The Governance System which is referred including the pump installation design process and its implementation in the field and its monitoring.
 - c. Hydraulic jet pump performance and well configuration.
 - d. Field production performance and the performance of the Hydraulic Jet Pump.
- 4. Classify pump performance and design to evaluate pump performance.
- 5. Analysis and interpretation of data processing results and formulate recommendations.

Research is only carried out on the individual wells with standalone hydraulic jet pump system. Since wells with a parallel system, where one surface pump is used for more than one production well, does not provide power fluid injection rate data or individual production data so that the calculation of the Hydraulic Jet Pump design can be correctly made. Based on the availability and validity of existing data, the wells that can be used as the object of this research are S-1, S-2 and S-3 where the objectives to be achieved from this research are how to analyze the performance of the production wells which is then can be used as a basis for increasing production and making power saving.

Studies on the performance of wells and HJP are carried out based on data obtained from two sources, namely daily data recorded by the production function in the Sembakung Field and direct measurements in the field. Figures 3 to 5 and Tabel 1 show the production profile of Wells S-1, S-2, S-3, and fluid properties.

III. RESULTS AND DISCUSSION

Evaluation of the performance of the Hydraulic Jet Pumps used in the Sembakung Field is based on the results of evaluation and calculation of pump

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design and actual field conditions for the S-1, S-2, and S-3 wells as shown in Tables 2 to 4.

The S-1 well was drilled at the end of 2017 and produced since November 2017. It was the first well based on plan of further development (POFD) 2016 [11]. Initial production rate was around 890 bfpd with a water cut of 5% (850 bopd) and within about 40 days production decreased to around 470 bfpd with a water cut of about 8% (450 bopd) in the transient production stage (Figure 3).

Based on the calculated design, a B4 Nozzle-Throat combination was required to produce 200 bfpd in the S-1 well regardless of cavitation because the relatively low reservoir pressure (under bubble pressure), with a Powerfluid pumping rate of 1002.6 bfpd at a discharge pump pressure of 1168 psi. The transient stage occured until the sixth month. A stable production stage was reached in the seventh month with a production rate of around 150 bfpd (100 bopd), 30% water cut (Figure 6). In January 2019 the production was stable at around 140 bfpd, with a water cut of around 33.5% (92 bopd). Hydraulic Jet Pump was installed with a nozzle and throat combination type of D7, Power fluid injection rate of 1440 bfpd, and discharge pump pressure of 2600 psi. So that there is still a space for optimizing the use of power fluid and injection pumps of approximately 30-40% (Table 2).

The S-2 well was drilled at the end of 2017 and produced since the end of December 2017. It is the second well based on POFD 2016. The initial production rate is around 770 bfpd with a water cut of about 13% (670 bopd) and within about three to four months the production drops to around 280 bfpd with a water cut of about 20% (225 bopd) in the transient production stage (Figure 4).

Based on the calculated design to be able to produce 300 bfpd in the S-2 well regardless of cavitation because the reservoir pressure is relatively low (Figure 5). It required a C11 Nozzle-Throat combination, with a Power fluid pumping rate of 1007.9 bfpd at the discharge pump pressure. 2478 psi. The transient stage occured in the four months to five months (Figure 7), where production was stable with a production rate of around 380 bfpd, water cut of 13% (335 bopd). After optimization of HJP by changing the Nozzle-Throat combination. At the beginning of January 2019, production was stable at around 130 bfpd, with a water cut of around 13.5% (112 bopd). Hydraulic Jet Pump was installed with a nozzle and throat combination type of E9, Power fluid injection rate of 1800 bfpd, and Discharge pump pressure of 2500 psi. So that there is still room for optimizing the use of Powerfluid and injection pumps of approximately 30-40% (Table 3).

The S-3 well was drilled in mid-2018 and produced since August 2018. The initial production

rate was around 1400 bfpd with a water cut of around 91% (120 bopd) and in about one month the production decreased to around 930 bfpd with a water cut of around 92% (65 bopd) is in the transient production stage. In early January 2019 production was stable at around 980 bfpd, with a water cut of around 92% (85 bopd) with a Hydraulic Jet Pump installed with a nozzle and throat combination type of E10, Power fluid injection rate of 1800 bfpd, and discharge pump pressure of 2800 psi (Table 4).

Based on the calculated design, it requires a C8 Nozzle-Throat combination was required to produce 1195 bfpd in the S-3 well by ignoring cavitation because the reservoir pressure is relatively low, with a Power fluid pumping rate of 1003.9 bfpd at a discharge pump pressure of 1804 psi. The transient stage occurs in the second to the third month where the production is stable in the fourth month with a production rate of around 1360 bfpd (177 bopd), 87% water cut. after optimizing HJP by changing the Nozzle-Throat the combination (Figure 5). In January 2019 the production was stable at around 980 bfpd (85 bopd) with a water cut of around 92%. Hydraulic Jet Pump was installed with a nozzle and throat combination type of E10, Power fluid injection rate of 1800 bfpd, and discharge pump pressure of 2800 psi. So that there is still room for optimizing the use of Powerfluid and injection pumps of approximately 70-80% (Table 4).

The production performance of the S-1 as predicted shows a sharp decline in production between the initial production of 890 bfpd and a decrease of almost 50% to 470 bfpd in 40 days. This is anticipated by replacing the nozzle-throat combination without using a maintenance rig and slight production disruption. If other pump is used, a rig is required to replace the pump for three to four working days which costs US \$ 30,000 to US \$ 40,000 with a loss of opportunity not to produce 360 to 380 barrels of oil for five days, equivalent to US \$ 20,340 to US \$ 21,470 in accordance with the January 2019 ICP of US \$ 56.5 / barrel, in addition to the possibility of skin occurring during well maintenance which resulted in reduced production performance after well maintenance.

While the production performance of the S-2 as in the S-3 shows a sharp decline in production between the initial production of 770 bfpd and a drop of almost 65% to 280 bfpd in 120 days, this is also anticipated by replacing the nozzle-throat combination. The S-3 production performance shows a decrease of around 33% from 1400 bfpd to 930 bfpd during the transient period of around 30 days. After that, the production was relatively stable. However, the water cut tends to increase.

There was significant difference between design and actual flowrate ranging from 43.3% to

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82% (Tables 2 to 4). It was due to transient and steady state conditions. Steady state condition was achieved within four to seven months in this field. Therefore the behavior of the reservoir should be considered in hydraulic jet pump design.

IV. CONCLUSIONS

Jet pumps are an effective way to produce the three oil wells in Sembakung Field. They are easily and quickly retrieved and replaced without a rig. In addition, the pumps are flexible to adjust their lift capacity due to the change of reservoir performance.

The design of Hydarulic Jet Pump should take into account the behavior of the reservoir, namely transient and steady state production conditions. The steady state condition was achieved within four to seven months in Sembakung Field after the well produced.

The application of the hydraulic jet pump in this field can produce78 bpd to 112 bpd of oil with liquid production rates ranging from 130 bpd to 980 bpd.

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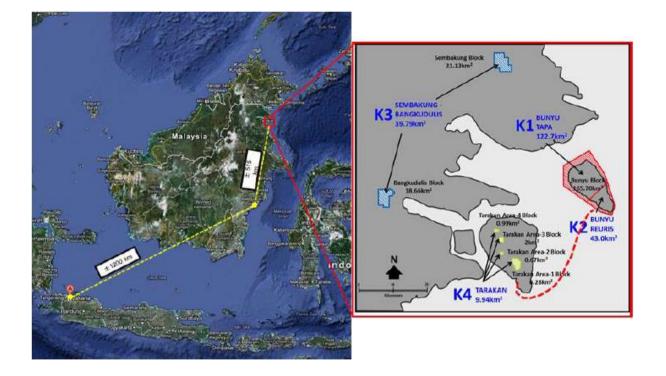


Figure 1. The Location of Sembakung Field

Table 1. The Properties of Sembakung Field

Parameter	Value	Unit
SG water, γ_w	1	
SG oil, γ_o	0.84	
SG gas, $\gamma_{\rm g}$	0.73	
Oil viscosity, μ_0	1	ср
Wellhead Temperature, T _{wh}	80	°F
Bottomhole Temperature, T _{wh}	164.2	°F
Pump Capacity	3000	bfpd

Table 2.	Pump	Design	vs	Installed	on	the S	-1	l
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Parameter	Unit	Design	Actual	%	
Liquid flowrate, q ₁	bfpd	200	140	70	
Oil flowrate, q _o	bopd		93.1		
Water cut, WC	%		33.5		
Nozzle-throat combination		B4	D7		
Nozzle to throat area ratio, b		0.3025	0.3333	110.2	
Pump flowrate, q _p	bpd	1002.6	1440	143.6	
Pump discharge pressure	psi	1168	2600	222.6	

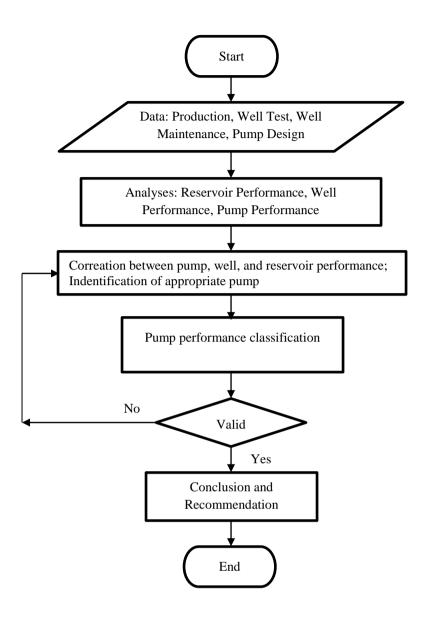


Figure 2. Research Procedure

Devenuetor	Unit	S-2				
Parameter	Unit	Design	Actual	%		
Liquid flowrate, q ₁	bfpd	300	130	43.3		
Oil flowrate, q _o	bopd		112.45			
Water cut, WC	%		13.5			
Nozzle-throat combination		C11	E9			
Nozzle to throat area ratio, b		0.1029	0.2998	291.2		
Pump flowrate, q _p	bpd	1007.9	1440	142.9		
Pump discharge pressure	psi	2478	2500	100.9		

Table 3. Pump Design vs Installed on the S-2

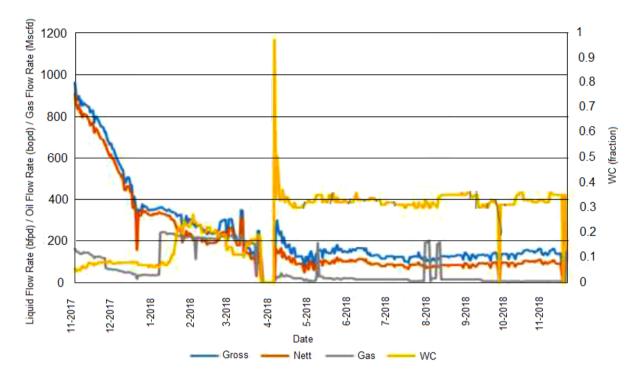


Figure 3. Production Profile of S # 1



Figure 4. Production Profile of S # 2

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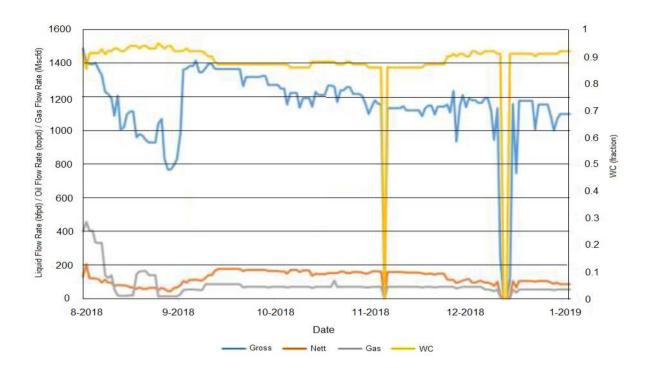


Figure 5. Production Profile of S-3

Davamatan	T	S-3			
Parameter	Unit	Design	Actual	%	
Liquid flowrate, q ₁	bfpd	1195	980	82.0	
Oil flowrate, q _o	bopd		78.4		
Water cut, WC	%		92		
Nozzle-throat combination		C8	E10		
Nozzle to throat area ratio, b		0.1861	0.2017	108.4	
Pump flowrate, q_p	bpd	1003.9	1800	179.3	
Pump discharge pressure	psi	1804	2800	155.2	

Table 4. Pump Design vs Installed on the S-3 Well

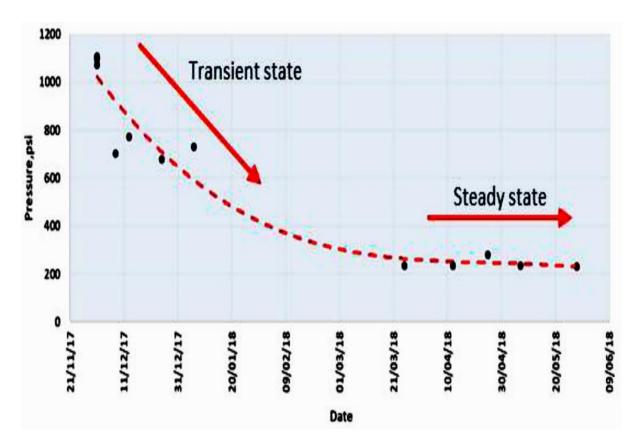


Figure 6. Pressure Monitoring in S-1 Well

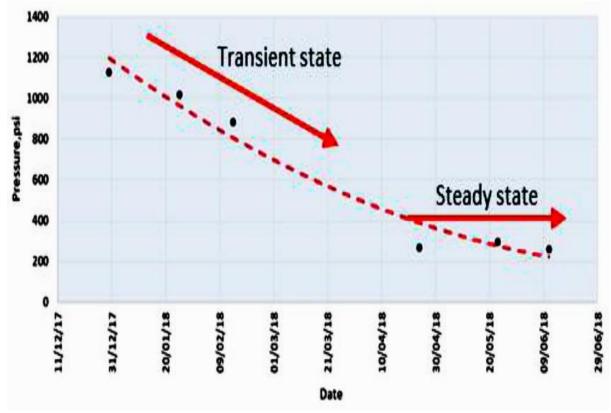


Figure 7. Pressure Monitoring in S-2 Well