JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
ISSN: 2723-0988, e-ISSN: 2723-1496
Vol. 5 No. 2 2024

EVALUATION OF THE USE OF DIPTUBE AND CYCLONE ON THE HPU PUMP DOWNHOLE TO ADDRESS THE SAND PROBLEM AND GAS INTERFERENCE IN THE ARD-22 PANGKALAN SUSU FIELD

Aris Widodo[1)], Suranto[1*)], Boni Swadesi[1)], Dyah Rini Ratnaningsih[1)], Dedy Kristanto[1)], Syahrir Ridha[2)]
[1)]Petroleum Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta
[2)]Petroleum Engineering, Universiti Teknologi Petronas
* E-mail: su_ranto@upnyk.ac.id

ABSTRACT

The problem of sand and gas interference in artificial lift pumps is a serious problem. The ARD-22 well in Pangkalan Susu often goes offline due to sand and gas interference. Solutions to overcome sand problems by reducing drag force and mechanical methods. Reducing drag force by setting the well production rate below or equal to the critical sand flow rate. The mechanical method is carried out by adjusting the flow pattern on the artificial lift and also by adding a downhole tool in the form of a Cyclone, which functions to make the fluid flow from the reservoir turbulent so as to separate solid particles from liquid. Another dominant problem with this well is the rising GOR or gas interference which causes gas lock problems, so it is necessary to redesign the diptube as a separation area between gas particles and liquid fluid. The monitoring results from this research showed that the fluid flow from the sampling point showed that there was no intermittent gas and the dynagraph readings also showed normal results. Optimum production can be recovered according to the initial potential of G/N 50/45, production lifetime increased after installation diptube cyclone to reach 7 more months and increased company revenues totaled Rp. 8.306.660,000.

Keyword: Sand Problem, Hydraulic Pumping Unit, lifetime, Cyclone

I. INTRODUCTION

Pangkalan Susu is one of the fields at Pertamina EP that is classified as mature. The production system is dominated by an artificial lift. Artificial lift is a method of removing fluids from wells by means of a production tool so that fluids can be lifted on the surface, for example, by artificial lifting gaslifts and pumping. There are many different types of pumps, including sucker rod pumps (SRP), electric submersible pumps (ESP), hydraulic pump units (HPU), and progressive cavity pumps (PCP). (Purwaka et al., 2018).

The Ardo structure uses an artificial lift hydraulic pumping unit. Hydraulic pumping unit (HPU) has the same working principle as the sucker rod pump (SRP), which distinguishes the HPU and SRP as surface parts equipment. If the SRP surface equipment uses a beam-type pumping unit bending pump, the HPU surface device uses a tower or tower driven by a hydraulic-powered machine (Nirwana Sima, 2022). Depending on the location of the installation, it can be grouped into two parts: the surface equipment and the equipment inside the well. (sub-surface equipment). Surface equipment is a prime mover and pumping unit, while sub-surface equipment is a pump intake and sucker rod string. (S. Ariyono, 2018).

Daily production Pangkalan Susu ranges from 300 – 350 BOPD, and is heavily dependent on the production of Ardo structures. 30% of Pangkalan Susu's total production is supplied by this structure. ARD-22 is the well with the largest production contribution in the Ardo Structure and also in the Pangkalan Susu Field with potential G/N 50/45 BOPD and is produced using the Hydraulic Pumping Unit (HPU) artificial lifting method. In 2021, this well often experienced low production and shut down due to sand problems and gas interference, causing a decrease in overall Pangkalan Susu's production, even production is far from the potential figure. The problem of sand measuring >325 mesh is caused by swelling from the influence of injection water and completion fluid, plus an increase in GOR. Based on this background, it is necessary to carry out an evaluation to return the production of the ARD-22 well to its potential production figures in order to significantly increase the production of the Pangkalan Susu Field.

The separation of gas in the downhole is one of the attempts to improve the efficiency of the pump (J.H. Campbell et al., 1989), Production that does not match the pump capacity can damage the pump, causing a lack of fluid to enter the pump (under load) so that the pump gets hot and damages the pump equipment (Baptista, 2010), and the sudden death of the pumps is caused by some dominant factors that often occur, like load problems inside the well (Ghareep, 2014). Designing diptubes and cyclones to overcome gas and sand interfence problems so that it is more optimal in separating gas and sand below the surface of the system as well as carrying out economic analysis. The purpose of this research is to determine the effectiveness of using diptubes and cyclones as an alternative in mitigating the sand problem in ARD-22 and it is hoped that it can increase production from the ARD-22 well in order to support production in the Pangkalan Susu field.

II. METHODS

JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
ISSN: 2723-0988, e-ISSN: 2723-1496
Vol. 5 No. 2 2024

To increase production in the ARD-22 well, the author conducted research by finding out the factors that cause gas interference and sand problems in the HPU in the ARD-22 well, which causes the well's lifetime to be less than 3 months. The methodology that used are:

1. Determine the optimum production flow rate target for the ARD-22 well
2. Determine the optimum equipment geometry design for the diptube and cyclone using the ANSYS simulation program.
3. Determine the effectiveness of using diptubes and cyclones as an alternative in preventing sand problems in ARD-22
4. Evaluate the results from using the diptube and cyclone
5. Economic analysis

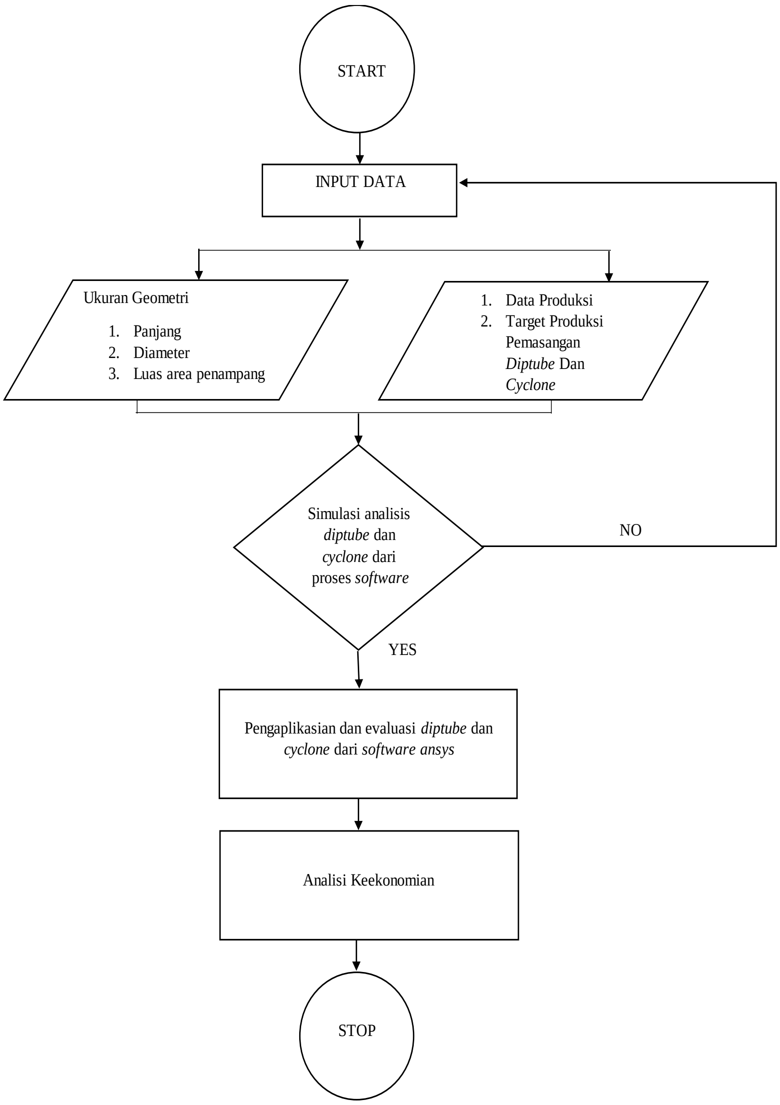

Figure 1 Flowchart Diagram Rasearch Methods

The research stage includes a survey about tools and data gathering at the Pangkalan Susu Field Workshop. The data acquired contain the size and dimensions of the diptube and cyclone, as well as subsurface and reservoir data from the well, which will be used to implement the diptube cyclone innovation. The data acquired from the survey and data collection stages will be input into ANSYS software (fluid dynamics simulator) to proceed to the next research stage, the analysis and pre-simulation stage which consists of creating a flow geometric model (well and tool geometry) for simulation. fluid dynamics, mesh analysis, and simulation set-up. Based on the acquired simulation model, simulation calculations were carried out (stage II) in the form of analysis and simulation related to the steady state flow from the reservoir that will enter the equipment through the diptube and cyclone, then absorbed by the pump.

The next step is a simulation calculation (stage III) of analysis and simulation of angle variations and the number of repeats on the diptube cyclone to see which fluid flow is the most optimal to increase production and minimize the sand that will enter the pump. From phase II and phase III simulations, it will be seen whether the fluid flow is steady state-convergent, or divergent. From these results, we will see whether the design of this diptube cyclone is capable of converging the flow of fluid according to the purpose of the tools. If the calculation iteration is not convergent, then the process will go back to stage I to make revisions and improvements to the formation of well geometry or equipment.

The results of this simulation will be used as the basis for the design of the cyclone diptube equipment, which will be tested on the ARD-22 well. The final step of this study will be to evaluate the results of the effort to address the problem of gas interference and evacuation as well as the economic outcomes of the well ARD-22, which would be indicated by the increase in the lifetime of the HPU pump on the well.

III. RESULTS AND DISCUSSION

One option for solving the problem in the background of this study is the use of gas and solid separation equipment produced under the surface so that the gas and solids produced do not enter the pump intake unit and make the pump's lifetime more optimal. The effect of optimizing the life of this pump will lower the low and off value of the well and lower the production cost of reducing the well maintenance activities. In planning the equipment for the separation of gaseous and solid subsurfaces, this requires an optimal calculation design to produce an optimal separation result.

3.1 Reservoir Flow Capacity Calculation and Production Target

In performing artificial elevator optimization, it is essential to know the capacity of the formation to produce. By knowing the production performance of a formation described through IPR, a realistic production target can be determined. In this study, for the calculation of IPR, well ARD-22 type IPR is used, which is IPR 2 phase developed by Vogel. The IPR calculation of the ARD-22 well uses the Pipesim program to speed up the calculation process. Figure 2 shows the results of IPR curve calculations from the ARD-22 well. Table 1 is a recapitulation of the input used for IPR calculations in the Pipesim program. Based on the IPR computed from the pipesim model, ARD-22 has an AOF of 79 BFPD.

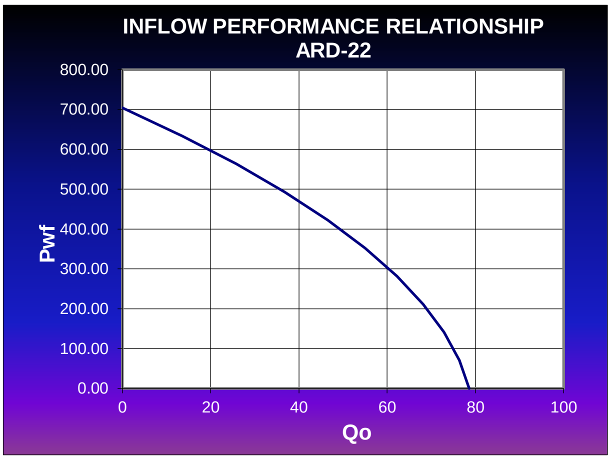

Figure 2 IPR Well of ARD-22

Table 1 IPR Calculation Input Data

Qf	20.00	BFPD
WC	5.00	%
Ps	704.00	psi
Pwf	597.75	psi
Mid Perfo	1038.00	m
DFL	504.00	m
SGoil	0.78	-
Sgwater	1.01	-
Sgmix	0.79	-

3.2 Subsurface Pump Design and Diptube Cyclone

JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
ISSN: 2723-0988, e-ISSN: 2723-1496
Vol. 5 No. 2 2024

3.2.1 Subsurface Pump Design

The calculation of the subsurface pump design of the ARD-22 well is based on the IPR input data in Table 1. In this simulation, the availability of the number and type of available rods are taken into consideration, and the percentage division of the string combination of rods is referred to in Tables 2 and 3. A combination of the size of the tried rod is chosen that is light, which means that it meets the economic criteria, but on the condition that it does not disregard the stress allowed on the allowable stress of the rod. The sucker rod selected from the surface to the pump unit at the bottom of the well is not always the same diameter; it can be a combination of several types of rod sizes, as shown in Table 3. The design of the ARD-22 well pump also pays attention to the statistical data of pump intake and flow rate, which can produce constant absorption. So at the beginning of operation, the pump is done with a low SPM and Stroke Length.

Table 2 Percentages for Tapered Rod Strings

PLUNGER DIAMETER	THREE COMBINATIONS				TWO COMBINATIONS		
	1" - 7/8" - 3/4"		7/8" - 3/4" - 5/8"		1" - 7/8"	7/8" - 3/4"	3/4" - 5/8"
	% 3/4	% 7/8	% 5/8	% 3/4	% 7/8	% 3/4	% 5/8
1,25	55,8	23,5	46,6	28,6	76,5	72,2	65,6
1,75	45,4	29,0	30,2	37,4	72,1	65,7	55,0
2,25	31,4	36,5	8,3	49,2	66,3	56,9	41,0
2,75	14,1	45,6	-	-	59,0	45,9	23,4

Table 3 Rod Combination

No.	DP	SR
1	1-1/4"	1" - 7/8" - 3/4"
2	1-3/4"	1" - 7/8" - 3/4"
3	2-1/4"	1" - 7/8" - 3/4"
4	2-3/4"	1" - 7/8" - 3/4"
5	1-1/4"	7/8" - 3/4" - 5/8"
6	1-3/4"	7/8" - 3/4" - 5/8"
7	2-1/4"	7/8" - 3/4" - 5/8"
8	1-1/4"	1" - 7/8"
9	1-3/4"	1" - 7/8"
10	2-1/4"	1" - 7/8"
11	2-3/4"	1" - 7/8"
12	1-1/4"	7/8" - 3/4"
13	1-3/4"	7/8" - 3/4"
14	2-1/4"	7/8" - 3/4"
15	2-3/4"	7/8" - 3/4"
16	1-1/4"	3/4" - 5/8"
17	1-3/4"	3/4" - 5/8"
18	2-1/4"	3/4" - 5/8"
19	2-3/4"	3/4" - 5/8"

3.2.2 Anchor Gas Modification Adjustments or Plans

After determining the optimal SL and SPM for the ARD-22 well, the next step is to determine the optimal dimensions of the anchor gas for conducting gas separation under the surface. This is important because there is an indication of gas interference occurring, as indicated by the results of the dynagraph. The parameter that will be optimized for this study is the length of the dip tube, which can be calculated with the equation below. The area of the mud anchor available in the field has an OD of 1.99 inches.

$$LDT = (2xSLx\,(Dx2)\,x0.785/AMA$$
$$LDT = (2x100x(1.75x2)\,x0.785/(0.25x3.14x1.99^2)$$
$$LDT = 176.76 \text{ inch}$$
$$= 6.92 \text{ m}$$

Based on the calculations carried out, the optimal diptube in an effort to solve the problem of gas interference on ARD-22 is to use a length of 7.56 m. The conclusion of the results of the optimization of the anchor gas performed in this study is illustrated in Table 4. Based upon the result of the HPU optimization analysis in the well ARD-22, the length required of the dip tube is longer than the standard dip tube length commonly used in the ARD field, so it requires modification of the standard dip tube. This innovation has the name Special Dip Tube (SDT).

Table 4 Parameter *Special Diptube Gas Anchor*

Parameter	Eksisting	Optimasi
Stroke length (SL), in	100”	100”
Stroke Per Minutes	6.5	6.5
Pump Setting Depth, m	1,007	1,010
Diameter plunger (D), in	1.75”	1.75”
OD mud anchor, in	1.99”	1.99”
OD diptube, in	-	1”
Length of diptube (LDT), in	-	176,76”
Length of diptube (LDT), m	-	6.92
Length of perforated tube, m	-	0.4
Total diptube, m	0	7.0

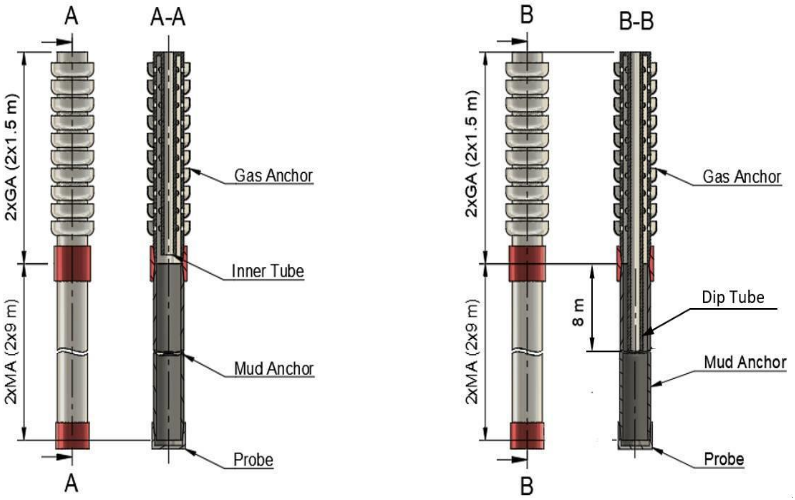

Figure 2 Gas Anchor Inner Tube and Special Diptube Fountain ARD-22

3.2.3 Adjustment or Cyclone Planning

The cyclone diptube equipment modeling simulation Figure 3 is a step taken to determine the geometry design of the optimal equipment that provides the best gas and sand separation efficiency. The simulation is based on acquired well data and initial assumptions about the geometry of the equipment to be made. The output obtained from this simulation is the optimum geometry of the cyclone flares, consisting of the number of flares and the degrees of folding of the cyclones (Table 5).

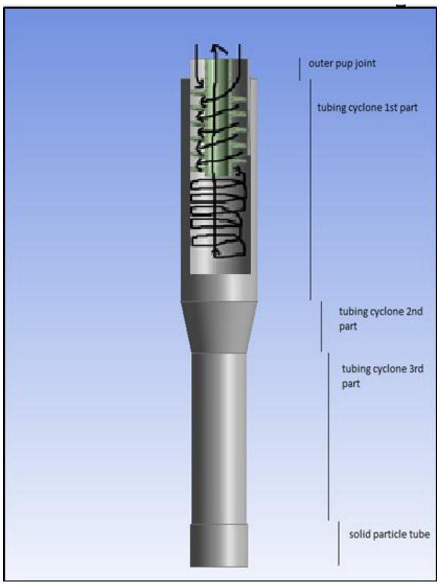

Figure 3 Geometry of the Diptube Cyclone

Table 5 Input Geometry Tubing Diptube Cyclone

Geometry	Size	Unit
OD dip tube	0.033	m
ID dip tube	0.025	m
Spindle Thickness	0.004	m
Distance from the bottom part of the diptube to the bottom reel	0.007	m
The distance from the top part of the diptube to the top reel	0.051	m
Solid particle tube OD	3	in
Solid particle tube ID	2.5	in
Height of the outer solid particle tube	0.05	m
The height of the tube of the particle is inward.	0.045	m
OD tubing cyclone 3rd part	2.875	in
ID tubing cyclone 3rd part	2.441	in
High outer tubing cyclone 3rd part	0.2	m
High inner tubing cyclone 3rd part	0.25	m
High tubing cyclone 2nd part	0.06	m
OD tubing cyclone 1st part	4	in
ID tubing cyclone 1st part	3.476	in
High tubing cyclone 1st part	0.16	m

The next step after gathering data and determining the tubing size and geometry of the diptube cyclone is to perform sensitivity analysis by assuming several values of the number of cylinders and the degree of the cylinder. Table 6 shows the assumptions made and the length of the repeat result.

Table 6 Assumes Several Degrees of Inclination and The Number of Scales

Degreesb of Inclination	Number of Inclination	Total Cyclone Length (m)
30	5	0.59
45	5	0.67
50	5	0.70
60	5	0.79
30	7	0.63
45	7	0.73
50	7	0.78
60	7	0.91
30	9	0.67
45	9	0.80
50	9	0.86

The modeling process continues with the determination of variables for pre-processing. The determination of this variable is based on production rate data, production fluid characteristics, and reservoir conditions. Table 7 shows the value of the variable specified for the simulation pre-processing stage. The output of this pre-processing phase is to determine the mesh of the model to be analyzed based on each scenario of the previously specified number and degree of recurrence. Table 8 shows the pre-processing results of the diptube cyclone model based on every assumption of the number and degrees of recursion inclination.

Table 7 Pre-Processing Variable Value Determination

Variable	Value	Unit
Mass Flow Rate	0.092	kg/s
Inlet Preassure	405	Psi
Flow Density	806.14	kg/m3
Viscosity	45	CentiPoise
Temperature	29	degree Celsius
Inlet Speed	0.034	m/s

Table 8 Stage Results Pre-Processing

Number of threads_ degree of angle	5_30	5_45	5_50	5_60	7_30	7_45	7_50	7_60	9_30	9_45	9_50	9_60
Number of elements	2500520	3036036	3270551	3943696	2829024	4148372	4214666	5665970	6876129	8369513	9036969	15602485
Orthogonal Quality	0.79082	0.79353	0.79407	0.79739	0.78636	0.7953	0.79492	0.79941	0.79757	0.80011	0.80123	0.80346
Orthogonal Quality category	Very Good *(ANSYS, Inc., 2017)*											
Skewness	0.20469	0.20227	0.20162	0.19888	0.20819	0.20049	0.20084	0.19702	0.19899	0.19677	0.19575	0.19428
Skewness category	Excellent *(ANSYS, Inc., 2017)*											

Once the data collection is done and the simulation model is ready to run, the next step is the execution of the model simulation. Calculations at the model execution stage are performed to obtain outputs such as (a) velocity magnitude, (b) speed count map vertical section, and (c) speed vector under the equipment. Table 9 shows the results of the calculation of velocity magnude.

Based on the results of the simulation calculations, the best turbulence pattern is obtained in a simulation with a threaded 5 with an angle of 30 degrees, so the manufacture of the equipment diptube cyclone will use the specifications of this simulation. A good turbulent pattern implies the efficiency of the separation of cyclonic components; the higher the separation efficiency value, the less solidity will enter the pump intake. Figure 4 shows a summary of the simulation results for the specification of a cyclone with a 30-degree inclination and a 5-degree number of inclinations

Table 9 Calculation Results *Velocity Magnitude*

Number	Degreesb of Inclination	*Velocity Magnitude (m/s)*
5	30	0.159
5	45	0.119
5	50	0.043
5	60	0.041
7	30	0.047
7	45	0.045
7	50	0.043
7	60	0.041
9	30	0.533
9	45	0.077
9	50	0.047
9	60	0.043

JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
ISSN: 2723-0988, e-ISSN: 2723-1496
Vol. 5 No. 2 2024

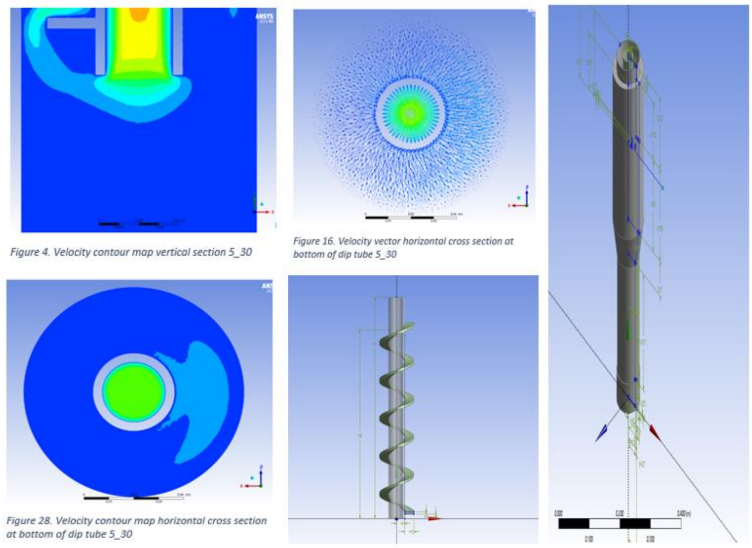

Figure 4 Summary of Simulation Results for Scenarios

3.2.4 Manufacture and Modification of Tools

Once the best specifications of the diptube cyclone have been obtained, the next step is to manufacture the equipment based on the input geometry dimensions in Table 10 and the cyclones with threaded 5 and 30 degree reels. The manufacturing process is shown in the documentation contained in this sub-chapter.

Figure 5 Manufacture Diptube Cyclone

Table 10 Used Fabrication Standards

Design Information	Reference Standard	Explanation
Selection Of Material Type	chemical engineering design by coulson & richardson's	material selection according to chemical engineering design references using iron plates
Type Of Material	iron plate material certificate	selection of iron plates that are resistant to pressure and temperature in the well
Fabrication Process	applied machining technology heinz tschatsch	fabrication method for making threads on existing special diptubes
Welding	ASTM A276 standard specification for bars and shapes AWS D11.2 welding cast iron	the method of welding or joining light steel plate material to special diptubes in accordance with standards ASTM A276 and AWS D11.2
Tubing Selection	API 5CT casing and tubing spesification	appropriate tubing selection method for cyclone tubing

3.3 Diptube Cyclone App Evaluation

The final step of this research is to evaluate the application of cyclone diptube equipment based on an acquired, manufactured design. Figure 6 show a comparison of the production performance of the ARD-22 wells before and after installation. Based on the comparison of the production performance of ARD-22, it is known that the lifetime has increased from under 3 months to over 6 months, and the gross production has increased from 50 BFPD to 70 BPFD (peak).

Before **After**

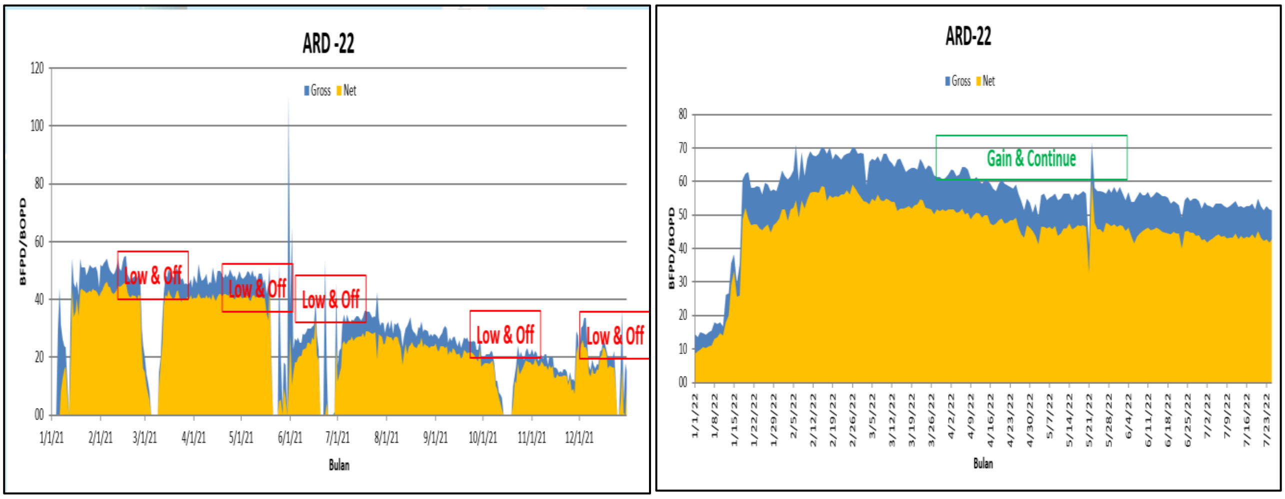

Figure 6 ARD-22 Production Performance Before and After Cyclone Diptube Application

Based on the IPR design of the ARD-22 well, a reduction in pressure drawdown was achieved from 141 psia to 422 psia according to Figure 7. The increase in production from the installation of equipment is obtained from the increased efficiency of the pump due to the installation of diptube cyclone equipment, which has good liquid, gas, and solidity separation efficiency, so that the amount of fluid that enters the pump is higher when compared with without the equipment of the diptub cyclon. Another effect of the installation on the ARD-22 well is the increase in the lifetime of the well, which is also caused by the good under-surface separation effectiveness so that sand and mud do not enter the pump intake and cause damage to the pump.

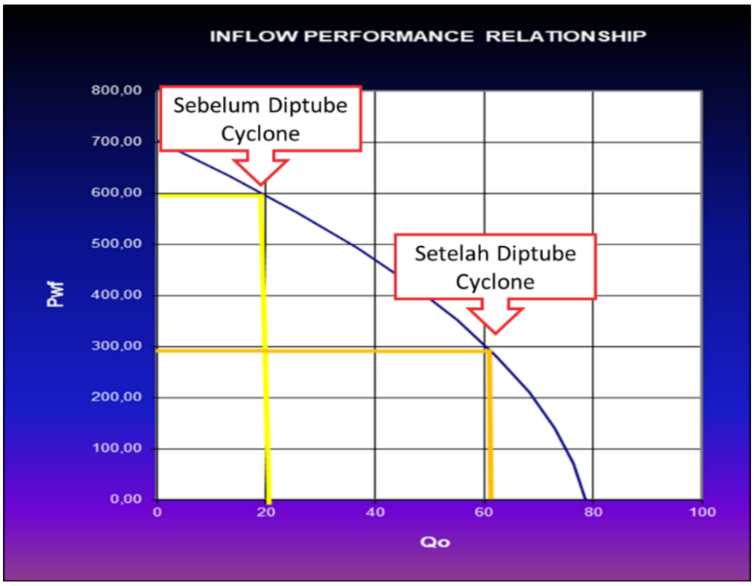

Figure 7 ARD-22 IPR performance before and after application Diptube Cyclone

3.4 Economic Evaluation

The Diptube Cyclone innovation was applied to the ARD-22 well, resulting in additional revenue and cost savings from Rig operations totalling Rp. 8.306.660.000.

Table 11 Calculation of Economic Evaluation

No	Before Diptube Cyclone Description	Cost	No	After Diptube Cyclone Description	Cost
1	Low and off 18 BOPD ARD-22 Jan-Dec 2021 (rig work and low waiting for rig schedule = 8 days/ 2 months) Total 48 days	Rp 894.240.000	1 2	Cost rig well service cost of making a diptube cyclone	Rp 110.500.000 Rp 500.000
					Revenue
2	rig well service costs	Rp 663.000.000	1	Production existing Jan-Jul 2022 (18 BOPD)	Rp 3.949.560.000
3	Rental cost HPU during off	Rp 120.000.000			
4	other risks: a. Swealling of production layers b. Sand massive		2 3	Gain Production Jan- Jul 2022 (27 BOPD) savings on rig service costs Feb- Jul 2022	Rp 5.924.340.000 Rp 221.000.000
Total		Rp 1.667.240.000	Total		Rp 9.983.900.000

1. Revenue earned Jan – Jul 22 after the installation of a large cyclone diptube is Rp. 9.983.900.000.
2. Total Revenue Jan 21 – Jul 22 as income earned is Rp. 8.306.660.000

Based on the results of the simulation calculations, the best turbulence pattern is obtained in a simulation of threaded 5 with an angle of 30 degrees, so the manufacturer of diptube cyclone equipment will use the specifications of this simulation. A good turbulent pattern implies the efficiency of separation from the cyclon component, where the higher the separation efficiency value, less solidity will flow into the pump intake. Based on the simulation calculation, the next steps of this research are the fabrication and installation of equipment on the well.

Based on the comparison of the performance of the ARD-22 wells, it is known that the lifetime of the well increased from under 3 months to more than 6 months, and the gross production increased from 50 BFPD to 70 BPFD (peak). The increased production from installed equipment is obtained from the pump efficiency due to the installation of the cyclone diptube equipment, which has a higher liquid separation efficiency value, gas, and solidity; as a result, the amount of fluid flow into the pump is greater when compared with the absence of diptube cyclones. Another effect of the installation of this cyclone diptube equipment on the ARD-22 well is the increased lifetime of the well, which is also caused by good surface separation efficiency; as a result, sand or mud does not flow into the pump intake and cause damage to the pump. With the increasing lifetime of ARD-22 wells, the production cost caused by rig work frequency is reduced significantly, resulting in a financial gain of Rp. 8.306.660.000 (Table 11).

IV. CONCLUSION

Based on the research carried out on this thesis, some conclusions can be drawn, namely:

1. The use of diptube cyclone has been proven to overcome the problems of sand, gas interference, and increase the lifetime of the ARD-22 wells.
2. According to the geometry design simulation calculations, the optimal diptub cyclones have a threaded number of 5 and an inclination of 30 degrees, and the average well production increases from 20 BFPD/18 BOPD to 50 BFPD/45 BOPD, which is the initial potential.
3. Cyclone designs are chosen based on Skewness - Orthoigonal Quality, Velocity magnitude largest, Velocity countour map vertical - horizontal and Velocities countoor map horizontal cross section of the bottom of the diptube.
4. The Diptube Cyclone innovation on the ARD-22 wells achieved the lifetime of the well to > 6 months and the revenue obtained Jan – Jul 22 after the installation of the diptube cyclone amounting to Rp. 9.983.900.000. Total Revenue Jan 21 – Jul 22 as revenues obtained amounting to Rp. 8.306.660.000

REFERENCES

Beggs, H.D., 2003, "Production Optimization Using Nodal System Analysis",chapter 5page 155, Oil and Gas Consultans International, Inc., Tulsa.

Pertamina EP, "Plant of Future Development (POFD) Full Scale Water Flooding Lapisan 1000A1 dan 1000A2 Lapangan Pangkalan Susu", Bab II Geological Finding and Review Reservoir.

A T. Adeniyi, 2018, "Economic Evaluation of Selected Artificial Lift Methods In A Marginal Oil Lapangan In The Niger Delta", International Journal of Petroleum and Gas Engineering Research, Vol.2, No.1, pp.8-22, July 2018, UK.

Allison, A. P, C.F. Leal, 2018, "Solving Gas Interference Issues with Sucker Rod Pumpsin the Permian Basin", Texas, USA : SPE.

ANSYS, Inc., 2013. ANSYS Fluent User's Guide. Canonsburg: SAS IP, Inc.

ANSYS, Inc., 2017. ANSYS Meshing Advance Technique. s.l.:Series, PADT Lunch & Learn.

Brown, Kermit. E., 1977, "The Technology of Artificial Lift Method", Vol.2a chapter 2 page 52, Pennwell Publishing Company, Tulsa, Oklahoma.

Brown, Kermit. E., 1980, "The Technology of Artificial Lift Method", Vol.2b chapter 9 page 567, Pennwell Publishing Company, Tulsa, Oklahoma.

Brown, Kermit. E., 1982, "Overview of Artificial Lift System", Vol.34 Number 10, Journal of Petroleum Technology.

Campbell, J.H., R.M. Brimhall., 1989, "An Engineering Approach to Gas Anchor Design", Oklahoma : SPE.

Ghareep, (2014) SPE International Production and Operations Conference & Exhibition, Doha, Qatar.

Jameson, A. et al., 1981. Numerical Solutions of the Euler Equations by Finite Volume Methods Using Runge-Kutta Time-Stepping Schemes.

Li, Guixi, 2007, "Design and Analysis of Hydraulic Pumping Units ", ASME International Mechanical Engineering Congress and Exposition, Washington.

Lidwin S. E., et. al., 2013, "Novel Approach in Sand Production Management" SPE Technical Conference, Beijing, China

Santana, U.P., L.C.L Santos., G.Simonelli, 2017, "Analysis of Downhole Gas Separators in Sucker Rod Pumping", Brazil : American Journal of Engineering Research(AJER).

Ekker et al, 2005, "Vertical Cyclone Separator", Paper US006979358B2, United States Patent.

S. Ariyono. (2018). Kajian Teknis Pompa SRP Untuk Optimalisasi Produksi Komering) Ltd , Air Serdang Lapangan Technical Study of SRP Pump for Optimazation of Well- Form Production AS-100 in Job Pertamina-Jadestone Energy (Ogan Komering) Ltd , Air Serdang Lapangan. *Kajian Teknis Pompa Srp Untuk Optimalisasi Produksi Sumur As-100 Di Job Pertamina-Jadestone Energy (Ogan Komering) Ltd, Air Serdang Lapangan*, *2*(3), 11–18.

Saputra, M. N. W., Ciptaningsih, R., & Febryana, N. E. (2021). Unlocking ESP potential in high gas/liquid ratio wells using gas lock prevention control in West Java lapangan, Indonesia. *Society of Petroleum Engineers - SPE/IATMI Asia Pacific Oil and Gas Conference and Exhibition 2021, APOG 2021*, *August 2020*. https://doi.org/10.2118/205643-MS

Surreau, J.J., 1994, "A Three-Phase Separator for the Removal of Oil and Solids from Produced Water", SPE Technical Conference, Texas, USA

Tu, J., Yeoh, G. H. & liu, C., 2008. Computational Fluid Dynamics, A Practical Approach. Burlington: Butterworth-Heineman.