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ESTIMATE RIG CAPACITY AND RENTAL COST IN DRILLING OPERATION GH-02 WELL EXPLORATION MATALOKO GEOTHERMAL FIELD

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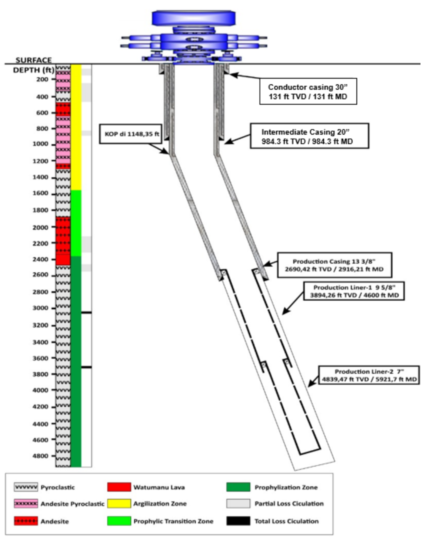
Graphical abstract



Abstract

Exploration well GH-02 will be drilled directionally at an inclination of 44º and a target of 5920 ft MD or 4840 ft TVD. So that the drilling process can be safe, the rig capacity must be determined optimally so that it is not over capacity which causes higher rig rental costs and also low capacity which causes disruption of the drilling process. The main components that influence the calculation of the horsepower required by the rig are the hoisting system, the rotary system, and the circulation system. The amount of horsepower required in the hoisting system is influenced by the lifting velocity, the hook load and the efficiency factor. While the rotary system is influenced by the amount of rpm and the target depth. Circulation system is influenced by the pump flow rate and pressure loss along the circulation system. The total horsepower required can be calculated by adding up the horsepower from the hoisting system, rotary system, circulation system, plus the safety factor of 100-250 HP for rigs with more than 1000 horsepower. The drilling time is designed optimally so that not much time is wasted which can cause the drilling costs to increase expensive. The amount of the rig rental cost is obtained from the rig rental cost per day with the planned drilling time. The results of the case study calculations show that the rig capacity is 1500 horsepower, drilling is carried out for 22 days and the cost of renting the rig is 660000 USD.

Keywords: Drilling costs, horsepower, rig capacity, drilling time, drilling operation

1.0 INTRODUCTION

Geothermal drilling campaign for 2021, PT Geodipa Energy have planning to drill 22 well, where 10 well in Dieng Field and 12 well in Patuha Field. In additional, PT PLN Gas & Geothermal also received a tender to carry out exploration drilling in the Mataloko field. It is because Indonesia government want to increase development renewable energy.

Well drilling is the highest investment in geothermal development, so it is necessary to choose a rig with high efficiency and low cost. Rig selection can be based on the target drilling depth, the diameter of the well to be drilled and the type of well to be drilled (vertical or directional) [1].

The drilling program is a major concern in determining rig capacity. The main factors influencing rig selection are the total load to be support by the tower, the size of the hook load and drawwork, the capacity and pressure of the mud pump, the size of the hole in the rotary table to handle large diameter holes, the height of the substructure to accommodate the BOP, and the size of the drill pipe. Total horse power required by the rig is influenced by three main operations, namely hoisting, turning the drill string and circulating the drilling mud. Prime movers must also have sufficient power to carry out directional drilling because the downhole mud motor requires high hydraulic power from the mud pump [2]. So that the rig capacity must be determined optimally so as not to overcapacity which causes higher costs and also low capacity which causes disruption to the drilling process.

Drilling operations run on a tight schedule. Most of the drilling workday is spent drilling wells, and activities which supports drilling, contributes to productive time (PT), while most of it time spent on drilling problems, and activities to solve this problem. Analyze data obtained from completion reports and drilling logs[10]. Drilling time is the total amount of time required to drill a well. Drilling time consists of productive and non-productive time. The drilling time is usually provided in a graph plot of the well depth against the total drilling time. Drilling time is affected by several factors, namely drilling rate, tripping time, casing and cementing time, hole problems, completion time and rig move [3].

The cost of geothermal wells and field development is about 40% of the total investment cost for new high-temperature geothermal plants, so that the initial cost of building a geothermal power plant is more expensive than building conventional power plants. [11]. The factors that affect the cost of drilling are well design, total well depth, type of drilling rig and the method used. Other parameters may include the efficiency of drilling operations and optimization of drilling variables [4].

This paper considers the blowout preventer and ton-mile calculations in selecting the rig to be used. The calculation of the blowout preventer rate pressure is very important in order to predict whether the BOP is able to withstand the pressure when a kick happens. Ton-miles also need to be considered in order to predict the wear of the drilling line, if the drilling line breaks it can make a problem in the drilling process.

Rig Capacity

The capacity of the rig can be calculated by adding up the horsepower in the lifting system, rotary system, and circulation system

Hoisting System

The function of the hoisting system is to provide facilities for lifting, supporting, and lowering drill strings, casings and other subsurface equipment from inside the well or outside the well. Drawwork is usually determined by horsepower and depth. The horsepower required by the drawwork in the hoisting system is:

$$\mathrm{HP}_{drawwork} = \frac{W\ x\ V_h}{33.000} \times \frac{1}{\eta} \quad (1)$$

Where W is the hook load (lb), Vh is the lifting velocity of the traveling block (ft / min) and η is the efficiency factor of the drilling line (range 80 - 90%).

While the amount of horsepower input required from the prime mover can be calculated by the equation:

$$\mathrm{HP}_{prime\ mover} = \frac{HP_{drawwork}}{\eta} \quad (2)$$

Hook load

The hook load is the heaviest load between the casing load and the drill string load for each trajectory. To calculate the load on the drill string for directional drilling, can calculate with this question

W = (W1 + W2 cos α + fk sin α) x (1-0,015 ρm) (3)

Where W1 is the weight of the upright drill string (lb), W2 is the weight of the inclined drill string (lb), fk is the friction factor, α is the angle of inclination and ρm is the density of the mud (ppg). A part from the drill string load, the casing load is also considered. To calculate the casing load using the following equation

Wcsg = NW x W x(1-0,015 ρm) (4)

Where NW is the nominal weight of the casing (lb / ft) and L is the length (ft)

Load on Derrick Rig

Loads on the derrick are loads from the derrick due to hook loads, fast line loads on drilling line, deadline loads on drilling line and traveling block loads. The load that can be support by the derrick can be calculated using the following equation

BT = Whook + TF + TD + Bhb (5)

The load calculation on the drilling line can be divided into 2, namely: the load on the fast line and the load on the deadline. In a static state the load of the fast line (TF) and deadline (TD) are the same. The load on fast line and deadline can be calculated using the following equation

$$T_F = T_D = \frac{B_{hook}}{n\,(E_B)^n} (6)$$

The drill cable can only support a maximum of 50% of the total at one time. The amount of work done needs to be calculated to determine when to replace the drilling cable. Here is an equation for calculating tones of miles based on the work done on the drilling cable. The ton of miles during a round trip can be calculated using the following equation:

$$T_r = \frac{D(L_s+D)\times W_e}{10560000} + \frac{D(M+\frac{C}{2})}{2640000} \quad (7)$$

Ton miles during drilling operations, where section drilling starts from d1 to section d2 can be calculated using the following equation:

Td = 3 (T2 - T1) (8)

Tons of miles when running casing using the following equation:

$$T_s = \frac{1}{2}\left[\frac{D(L_s+D)\times W_{cs}}{10560000} + \frac{MD}{2640000}\right] \quad (9)$$

Horizontal Load

Horizontal load is the load on the derrick which is caused by the weight of the stand leaning on the derrick and due to the large influence of the wind. The weight of the stand resting on the derrick can be calculated using the following equation:

$$G_h = G\frac{1}{2h} sin\alpha \quad (10)$$

To calculate the load caused by the influence of the wind using the following equation:

$$w = 0.004\ v^2 \quad (11)$$

To calculate the maximum total horizontal load can be calculated using the following equation:

$$B = Gh + Wh \quad (12)$$

Rotary System

The rotary system functions to rotate a series of drill pipes (drill string) and provide a weight over the chisel to drill holes. An empirical equation has been developed to calculate the required horsepower using the following equation:

$$HP = FN \quad (13)$$

The torque factor (F) values are as follows 1.5 is shallow depth less than 10000 ft., 1.75 is well depth 10000 - 15000 ft and 2 is for deep depth more than 15000 ft.

While the amount of horsepower input required from the prime mover can be calculated by the equation:

$$HP_{prime\ mover} = \frac{HP_{drawwork}}{\eta} \quad (14)$$

Circulation System

The circulation system has an important role in the pumping of mud which is useful for lifting the cuttings to the surface. Mud pumps are designed to provide the desired output pressure, flow rate and horsepower. Calculation of pump capacity is usually calculated using the equation

$$HP_{pump} = \frac{q \times p}{1.714} \quad (15)$$

Where the HPpump is the horsepower of the pump (HP), Q is the pumping flow rate (gal / min) and P is the pumping pressure (psi).

While the amount of horsepower input required from the prime mover can be calculated by the equation:

$$HP_{prime\ mover} = \frac{HP_{pump}}{\eta} \quad (16)$$

The calculation of the minimum pump pressure is the same as the calculation of the pressure loss in the circulation system. Total pressure loss is pressure loss in surface equipment, pressure loss in the drill string (DP, HWDP and DC), pressure loss in bit, and pressure loss in annulus drill string (DP, HWDP and DC).

Pressure Loss in Surface Equipment

In the circulation system, the first time pressure loss occurs in the surface connection equipment. This equipment includes the standpipe, rotary hose, swivel, gooseneck and kelly bushing. This pressure loss can be calculated by the following equation.

$$P_{sc} = E \times \rho^{0.8} \times Q^{1.8} \times PV^{0.2} \quad (17)$$

The combination of these tools is divided into four classes and each of them is given an equivalent to the length of the drill pipe as depicted in Table 1.

Table 1 Type of Surface Equipment

Surface Equipment Type	Value of E	
	Imperial Unit	Metric Unit
1	2.5×10^{-4}	8.8×10^{-6}
2	9.6×10^{-5}	3.3×10^{-6}
3	5.3×10^{-5}	1.8×10^{-6}
4	4.2×10^{-5}	1.4×10^{-6}

Pressure Loss in Drill String and Annulus Drill String

In calculating the pressure loss in circulating system, it is necessary to know in advance the mud flow pattern by looking at the critical flow velocity compared to the annular velocity. To calculate the annular velocity using the following equation

$$V_a = \frac{24.48 \times Q}{D_i^2} \quad (18)$$

The critical velocity can be calculated using the following equation

$$v_c = \frac{1.08\ PV + 1.8\sqrt{(PV)^2 + 12.34 d^2 YP_\rho}}{Di^2} \quad (19)$$

If Va < Vc then the flow is laminar. If Va > Vc then flow is turbulent. So to determine the pressure loss in the drill string and annulus can be calculated using the following equation. For turbulent flow using the equation

$$P_A = \frac{\rho^{0.75} Q^{1.75} PV^{0.25}}{1800 d^{1.25}} \quad (20)$$

For laminar flow using the equation

$$P_A = \frac{PV \times L \times V}{1000\ (ID - OD)^2} + \frac{YP \times L}{200\ (ID - OD)} \quad (21)$$

From the calculation of the pressure loss in each segment of the equipment above, it can be calculated the parasitic pressure loss as follows.

$$P_{parasitic} = P_{drillstring} + P_{annulus\ drillstring} + P_{surface\ equipment} \quad (22)$$

To determine the pressure loss in bits, the following equation can be used. The amount of pressure loss at the bit is usually 65% of the pressure loss total throughout the circulation system. To calculate the total pump pressure using the following equation

$$P_{total} = \frac{P_{parasitic}}{0.48} \quad (23)$$

To determine the total pressure loss in circulation system can calculated using the following equation :

$$P_{bit} = P_{total} - P_{parasitic} \quad (24)$$

Blowout Preventer (BOP)

A blowout preventer (BOP) is primarily used to seal wells to prevent uncontrolled flow, or bursts, of formation fluid. It usually consists of annular BOP, drill pipe or BOP ram casing, blind ram BOP, and accumulator system.

Rental RIG

Rig cost refers to the cost of renting a drilling rig and related equipment. The cost of the rig depends entirely on the rig rate per day. The estimated cost of renting rigs in the world is based on prices set by the IADC (International Association of Drilling Contractors). However, because the drilling of the Mataloko well is in Indonesia, the rental price is based on prices set by the APMI (Association of Indonesian Oil, Gas and Geothermal Drilling Companies). APMI sets rig rates based on the horsepower (HP) required and the type of work performed. The rates set by APMI are called the Operational Daily Rates (ODR). Based on the results of the convention of APMI member companies regarding the Operational Daily Rates (ODR) for onshore rig operations which were held on February 22, 2020, it was determined that the Domestic Daily Rates were as follows. Daily Rates of Onshore Operational Rig can be seen in Table 2

Table 2 Onshore Operational Daily Rates

No	Type of Operation	ODR (Cost/Day/HP)
1	2.5×10^{-4}	8.8×10^{-6}
2	9.6×10^{-5}	3.3×10^{-6}
3	5.3×10^{-5}	1.8×10^{-6}
4	4.2×10^{-5}	1.4×10^{-6}

To calculate the amount of rig rental, use the following equation below.

ODR = Cost/Day/HP x Hprig (25)

Total Rental Costs = ODR x Drilling Time (26)

2.0 METHODOLOGY

The methodology in writing research on capacity planning and drilling rig rental costs at the “GH-02” well in the Mataloko field is as follows. First, identification and processing of drilling program data includes data on casing, drillstring, hydraulics, drilling parameters and drilling activity.

Second, calculate the required rig capacity (horsepower). Calculates the horsepower in the lifting system based on the hook weight and the lifting velocity of the traveling block. To calculate the input HP divided by the efficiency of the transmission system. Calculating the horsepower in the rotary system based on the amount of RPM, the horsepower of the drawwork is obtained. To calculate the input HP divided by the efficiency of the transmission system. Calculating the horsepower of the pump in the circulation system based on the amount of pressure loss and the pumping flow rate. To calculate the input HP divided by the efficiency of the transmission system. Calculate the total horsepower by adding the horsepower of the lifting system, rotary system and circulation system and adding a safety factor of 100-250 HP.

Third, determine the drilling time based on drilling parameter data and drilling activity. Fourth, calculating the cost of renting a drilling rig based on the capacity of the rig, the drilling time for the daily ope

3.0 RESULTS AND DISCUSSION

Case Study

Well Drilling Data

Previously, the Mataloko geothermal field had drilled the 4 explorations well to a depth of 2480 ft. After the well test was carried out, it turned out that the well was not commercial for production. So that further exploration drilling was carried out by adding new wells at a target depth of up to 5905 ft MD to penetrate the waeluja fault formation. This well will change its status to development well considering the discovery of epidote minerals at a depth of 2480 ft, with estimate temperatures above 220ºC which is an indication of a potential geothermal reservoir.

GH-02 well is a directional well with a target depth of 5920 ft MD or 4840 ft TVD, the profile of the GH-02 well exploration can be seen in Figure 1. The design of GH-02 well is

- Conductor casing with hole size 36" is drilled to between 0 ft - 131.2 ft vertically, and then running casing 30" and cemented back to the surface. Mud density used is 8.6 ppg
- The intermediate casing with hole size 26" is drilled to a depth of 131.2 ft - 984.3 ft. Then cased with 20" and cemented back to the surface, mud density used is 9.3 ppg. Based on lithological conditions, the prediction of the drilling problem is swelling clay and loss circulation problems
- 17 ½" diameter hole is drilled from depth of 984.3 ft - 2916 ft MD with kick off point for directional wells is in depth about 1148 ft. The 13 3/8” production casing is run and cemented back to the surface. The density of the mud used is 9.4 ppg, the prediction of the drilling problem that has the loss circulation
- Liner production 1 with hole sizes of 12 ¼” is drilled directional to a depth of 2916 ft - 4600 ft MD. Running casing 9 5/8" with the density of the mud used is 8.33 ppg, estimated problem is the potential for total loss circulation
- 8 ½" diameter hole is drilled between of 4600 ft - 5921.7 ft MD and running liner 7". Mud density used is 9.5 ppg. The estimated problem is the potential for total loss circulation.

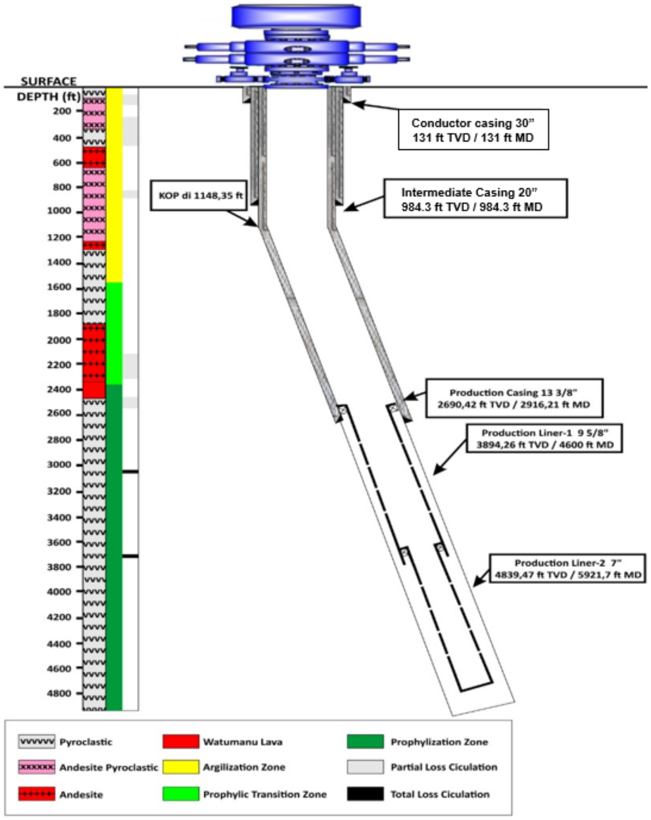


Figure 1 Profile GH-2 Well Exploration

Casing Load

The load on the casing can be calculated using equation 4. Casing 13 3/8" is the heaviest casing because the next trajectory uses a liner that is hung on this casing. The results of the casing load calculation for each trajectory can be seen in Table 3.

Table 3 Casing Load

Casing Trajectory	Type	NW (lb/ft)	Length (ft)	Weight (lb)
30"	X-56	310.00	131.24	35436.11
20"	K-55	106.50	984.30	90204.45
13 3/8"	L-80	68.00	2916.21	170341.66
9 5/8"	L-80	40.00	1775.57	62148.50
7"	L-80	26.00	1413.09	32149.63

Drill String Load

The drill string load is the load that occurs due to the drill pipe load, HWDP and BHA. To calculate the drillstring load using equation 3. 8 ½ "which is the longest trajectory, so this trajectory has heaviest drill string. The drill string weight of each trajectory can be seen in Table 4.

Table 4 Drill String load

Trajectory	WDS Vertical	WDS Directional	WDS Total	ρ	WDS
	lb	lb	lb	mw	Lb
Conductor	8691.18	0	8691.18	8.6	7570
Intermediate	60803.85	0	60803.85	9.3	52322
Production	22393.83	75792.56	155888.3	9.4	133908
Liner #1	22393.83	85964.46	173804.3	8.33	152088
Liner #2	22393.83	108648.33	213758.0	8.33	187049

After calculating the casing load, drill string load, the biggest hook load or vertical load occurs in the drill string, which is 187049 lb.

Drilling Line Load

The calculation of the drilling line load is divided into two, namely fast line load and deadline load. To calculate the amount of the drilling line load with a hook load of 187049, with assumption of the number of cables 10 and the efficiency of 98% can use equation 6. The result of fast line load is 22892 lb. Because in static condition deadline load value will be the same as the fast line. So that the amount of load deadline is 22892 lb

Ton Miles Calculation

To calculate the amount of tripping ton-miles can be calculate with equation 7, drilling ton-miles can calculate by equation 8 and the running casing ton-miles can calculate by equation 9. Result of ton-miles calculation is done by adding up the tripping, drilling and running casing ton miles. The calculation results can be seen in the following Table 5.

Table 5 Ton Miles

Trajectory	Tripping	Drilling	Running Casing	Total
	Ton-miles	Ton-miles	Ton-miles	Ton-miles
Conductor	1.11	2.22	131.24	4
Intermediate	18.22	31.94	984.30	59
Production	47.32	68.72	2916.21	150
Liner #1	84.59	77.75	1775.57	174
Liner #2	118.36	72.43	7.29	198

Horizontal Load

The horizontal load is affected by the weight of the stand that is leaning on the derrick and the influence of the wind. The weight due to the stand back on the derrick can be calculated by the following equation 10. Where the assumption is that the weight of all stands is 40.7 tons, the cross-sectional area of the stands is 500 ft2, the racing platform height is 8.82 m and the average length of the stands is 18.82 m with a 2.50 angle of recline. Result of the load due to the back of the stand is 4056 lb.

The load due to the effects of wind can be calculated by equation 11. Where assumption for the wind load area on the 1500 HP rig is 510 ft2 and wind velocity in field is 10 mph, so that, the total wind load is 816 lb. The maximum horizontal load can be calculated by adding the weight of the leaning stand and the wind-induced load, the result of horizontal load is 4872 lb.

Derrick Load

Derrick load can be calculated by adding up the heaviest loads on the hook, fast line load, deadline, and traveling block load. The result of the load can be supported by derrick is 238656 lb.

Hoisting System Horsepower Calculation

Horsepower in the hoisting system is calculated based on the hook load of 187049 lb, assuming a lifting velocity of 30 ft/min and a drilling line efficiency of 0.811. To calculate the horsepower required by the draw work, can be calculated by equation 1. The result of horsepower draw work is 209 horsepower. The power transmitted from the prime mover to the draw work is lost, so to calculate the amount of horsepower that must be provided by the prime mover using equation 2 with assuming an efficiency of 85%. The result of the horsepower required by prime mover is 246 horsepower.

Rotary System Horsepower Calculation

The rotary horsepower system is affected by the amount of RPM and torque of the drill string. Horsepower in the rotary system can be calculated by the equation 13. The result of horsepower draw work is 225 horsepower. The power transmitted from the prime mover to the draw work is lost, so to calculate the amount of horsepower that must be provided by the prime mover using equation 14 with assuming an efficiency of 85%. The result of the horsepower required by prime mover is 264 horsepower.

Mud Circulation System

Mud circulation is a system that requires a large horsepower, because it is used to lift and clean the holes from cutting. In the horsepower plan of this circulation system, the 17 ½ "trajectory is an example of calculation. Because the trajectory below are 12 ¼ "and 8 ½" trajectory using the blind drilling method. Where blind drilling method is assumed do not lifting the cutting from hole to surface.

Pressure Loss in Surface Equipment

The calculation of the pressure loss on surface equipment uses equation 17, and assumes the type of surface equipment is the fourth type with an imperial unit value of 4.2 x 10. So that the result of the calculation of pressure loss in surface equipment is 239 psi

Pressure Loss in Drill String and Annulus Drill String

The calculation of pressure loss on the drill string or the annulus of the drill string needs to consider the flow patterns both laminar and turbulent. To calculate the annular velocity using equation 18 and the critical velocity calculated using equation 19. The result of the calculation of the annular velocity in the drill string is 1556 fpm while the result of the calculation of the critical velocity in the drill string is 337 fpm. The flow pattern that occurs in the drill string is turbulent. The result of the calculation of the annular velocity in the annulus drill string is 28.5 fpm while the result of the calculation of the critical velocity in the annulus drill string is 279.9 fpm and then the flow pattern that occurs in the drill string is laminar.

Pressure loss that occurs in the drill string and drill string annulus can be calculated using equation 20 for turbulent flow patterns, while the calculation of pressure loss for laminar flow uses equation 21. The results obtained from the calculation of pressure loss in the drill string hole 17 ½", especially in the drill collar is 31 psi. while the pressure loss that occurred in the annulus, especially the drill collar annulus in hole 17 ½" is 0.001 psi.

Pressure Loss Parasitic

After calculating the pressure in each of the segments, then each segment is added to the parasitic pressure. To calculate parasitic pressure, equation 22 can be used. The results obtained from the calculation of parasitic pressure loss are 751 psi.

Total Pressure Loss

The total pressure loss can be calculated using equation 23. For wells, the directional pressure loss at the bit is 52%. so that the total pressure along with the circulation system, especially in the hole is 1474 psi. The results of the pressure loss calculation for each trajectory can be seen in Table 6 below.

Table 6 Result of Pressure Loss

Section	Pressure Loss psi					
	36"	26"	17 ½"	12 ¼"	8 ½"	
DP	16.06	52.16	177.59	291.71	380.74	4
HWDP	0.00	0.00	328.82	62.04	35.33	59
DC	199.51	516.94	167.33	84.05	45.50	150
DC-Hole	0.03	4.03	4.30	0.00	0.00	174
HWDP-Hole	0.00	0.00	8.98	0.00	0.00	198
DP-Hole	0.21	0.56	11.62	0.00	0.00	
DP-Casing	0.00	1.8	10.58	0.00	0.00	
Surface	160.06	61.18	57.29	16.75	17.52	
P bit	201.13	342.3	707.47	419.58	442.23	
P loss total	577	979	1474	874.13	921.32	

Horsepower in The Circulation System

The largest total pressure loss is found in the trajectory production casing so that the trajectory requires the greatest horsepower. The calculation of horsepower in the circulation system can use equation 15. The results obtained from the calculation of horsepower in the production trajectory with a pressure loss of 1474 psi and a pumping flow rate of 700 GPM is 610 horsepower. because the horsepower from the engine does not reach the slurry pump 100%. Therefore, it is necessary to calculate the efficiency at the horsepower input on the engine assuming an efficiency of 0.85. Horsepower circulation system needed is 708 horsepower.

Total Horsepower

Total horsepower is obtained by adding up the horsepower in the hoisting system, rotary system, circulation system and adding the safety factor of 250 horsepower for rigs with more than 1000 horsepower. The total horsepower required by the rig is 1451 horsepower. Because there is no rig with a capacity of 1451 on the market, the rig capacity will be determined to be 1500 HP.

Drilling Time and Rental Cost

Drilling Time

Design of drilling time is based on the amount of rate of penetration (ROP), connection time, tripping time and casing running time from offset well. In 36” hole ROP is estimated 50.14 ft/hr, in 26" hole ROP is estimated 31.55 ft/hr, in 17.5" hole ROP is estimated 37.04 ft/hr, On the 12.25” hole ROP is estimated 64.71 ft/hr, and in 8.5” hole ROP is 53.07 ft/hr. For all trajectory, casing running time is 9.84 min/ft. the tripping speed – drill pipe is 10 min/stand while the tripping speed – drill collar is 15 min/stand. The comparation between Drilling Time and Drilling Depth can be seen in Figure 2 below.

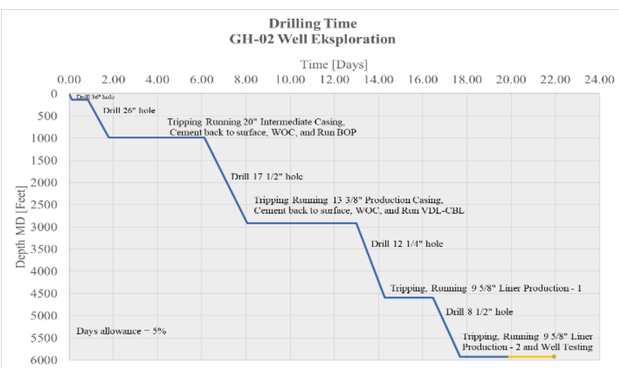


Figure 2 Drilling Time vs Drilling Depth

Description of the drilling operation in GH-02 Well Exploration. In conductor casing, the time required to drill from the depth between 0 – 131 ft is 2.90 hours, tripping time is 6.97 hours, casing running time is 2 hours, time for cementing is 1.47 hours and the waiting on cement is 6 hours. In intermediate casing, the time required to drill from the depth between 131 – 984 ft is 21.53 hours, tripping time is 45.34 hours, casing running time is 15 hours, time for cementing is 2.51 hours, the waiting on cement is 12 hours, and Blowout Preventer installation required time is 24 hours. In production casing, the time required to drill from the depth between 984 – 2916 ft is 44.24 hours, tripping time is 47.16 hours, casing running time is 44.44 hours, time for cementing is 4 hours, the waiting on cement is 12 hours, and time for a pressure test, CBL-VDL is 6 hours. Liner production – 1, the time required to drill from the depth between 2916 – 4600 ft is 29.61 hours, tripping time is 32.03 hours, liner running time is 18.04 hours. Liner production – 2, the time required to drill from the depth between 4600 – 5921 ft is 27.83 hours, tripping time is 34.50 hours, liner running time is 14.36 hours and time required for well testing is 48 hours. So that the total drilling time with a tolerance of 5% planned for the well drilling operation "GH-2" is 22 days.

Rental Cost

During this pandemic, drilling of oil and gas or geothermal wells have stalled. Therefore, companies that provide rig rental services will choose the lowest price set by APMI. In addition, the rental cost also influenced by rig capacity and drilling time. To calculated rental cost can use the 25 and 26 equations. To calculate the rig rental cost where APMI decree states that the cost of renting a rig/day/HP for drilling is 20 USD and the result of calculation rig capacity of 1500 horsepower and planning of drilling time is 22 days. So, the result of the rental cost is 660000 USD.

4.0 CONCLUSION

GH-02 well is a exploration well with big hole type and drilled directly. In the hoisting system, which calculates the vertical load which includes drill string weight, casing weight. In addition, it also takes into account the horizontal load due to the pipe stand leaning on the rig and the wind load. For the smooth running of the drilling operation, also calculate the ton-mile size of the drilling line and the load that must be support by the derrick so that it does not collapse. From the case study calculations, it was found that the hook load is 187049 lb. Then the heaviest load that must be support by the derrick during drilling is 238656 lb. The horizontal load that must be support by the rig is 4872 lb. The amount of ton-miles on intermediate trajectory is 59 ton-miles, production trajectory is 150 ton miles, liner trajectory # 1 is 174 ton miles, and on liner trajectory # 2 is 198 ton miles. Horsepower rig on the hoisting system is 246 horsepower.
The rotary system connects the drawwork and drill string circuit. In calculating the amount of horsepower of the rotary system is affected by RPM and depth. However, there is an empirical equation that can be used to calculate the horsepower based on the target well depth. Based on this equation there is a coefficient of 1.5 for shallow holes less than 10,000 ft, 1.75 for medium conditions 10,000-15,000 ft and 2 for depths more than 15,000 ft. From the calculation of the rotary system, while the highest of RPM when drilling is 140 RPM. The horsepower requirement in the rotary system is equal to 264 horsepower. From the calculation of the amount of pressure loss of 1474 psi with a mud flow rate of 700 GPM so that the amount of horsepower in the circulation system is 708 horsepower. The total rig capacity required for GH-02 well drilling operations is 1500 horsepower. Drilling time is required to drilling is 22 days, so rig rental cost for the drilling operation is USD 660000.

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