Optimization Rate Of Penetration In Directional Drilling With Adjustable Bit Rotating and Hydraulic Hole Cleaning

by Herianto Phd

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Abstract

Some directional well drilling has a penetration rate that is not optimal due to several things, including RPM and poor hole cleaning. RPM settings in directional drilling for build up and tangential sections are controlled by hydraulics on the downhole mud motor by adjusting flow rate and nozzle size in the hydraulic motor. The amount of mud that enters the nozzle inside the motor will provide optimum RPM. The amount of ROP is influenced by the pump rate and the power on the motor. To control good cleaning of the hole in the bit to clean the cutting at the bottom of the drill hole the BHHP/HHP value is at least 48%. Hole cleaning is based on turbulent flow properties, cutting concentration, cutting transport ratio, and particle bed index. The hole cleaning parameters in the annulus must consider the flow pattern that occurs and the parameters of good cutting. In this research, it will be studied in an integrated manner to regulate the pump rate and pressure by providing sufficient RPM in the downhole mud motor and cleaning the cutting at the bottom of the hole to prevent from occurring bit balling and regrinding from occurring.

Kata Kunci: Directional Drilling, Drilling Optimization, Adjustable RPM, Hole Cleaning.

1. Introduction

One of the biggest challenges in high inclination/horizontal wells is the problem of hole cleaning during drilling, where a high circulation rate in horizontal wells is essential to ensure optimal hole cleaning, a model developed to ensure proper hole cleaning at critical hole corners and horizontal wells and determine the optimal flow rate and penetration rate (ROP) that will ensure the success of drilling, the result is that the penetration rate increases because the cutting concentration in the annulus is reduced thereby optimizing drilling operations (Ogunrinde et.al, 2012).

Choosing the right downhole technology requires a detailed performance analysis. Parameters such as cost, temperature limits, drilling fluid type, bit considerations, size, power, speed and torque. these parameters help achieve optimized drilling operations under economic conditions effectively and efficiently with a deterministic based approach model that has been developed to compare and rank the three selected downhole motor options (positive displacement, turbine and electric motor) available for directional drilling (Olayiwola O, 2017).

In drilling operations, it is necessary to plan for downhole mud motors, such as determining pump pressure, pump flow rate, motor inlet pressure and motor power. Downhole mud motors (DHMM) are used to complete drilling operations by converting hydraulic fluid power into mechanical mechanical rotating power to the drill bit. Analyzing cross-sectional configuration of the power (rotor and stator) that affects torque, power and angular velocity output on the mud motor as well as entering motor dimensions as variables that can also affect motor performance, where the inlet pressure affects the motor power and the pump flow rate affects the RPM (Prawira et.al, 2017).

Motorized downhole drilling operations are restricted by means of motor properties and operational parameters such that WOB and RPM cannot be selected arbitrarily as they can in ordinary drilling operations. The version used is to combine motor performance data with the ROP model in order that it could are expecting the optimal weight in bits (WOB) required to attain most ROP within the part of the hole to be drilled. A suitable motor can be selected in keeping with the predefined bits and lithological properties of the future part. The optimal WOB constant for a appropriate motor also can be determined to gain the maximum average ROP. The final choice of the motor can be stricken by the pressure loss in the transmission section of the motor as well as the most advocated differential pressure of the motor (Motahhari et.al, 2007).

Parameters affecting drilling pace can be described as offering actual-time information to hurry up knowledgeable decision making. In any rotary drilling look at it will likely be simpler to divide the elements that have an effect on ROP are WOB, RPM, FR and MW. determining ROP is one of the maximum admired parameters inside the drilling enterprise. that is because of the fact that it lets in for optimization of drilling parameters to lessen drilling expenses and increase drilling manner protection. (Erdogan Y dkk, 2018).

Hydraulics is important in the optimization of drilling operations because it saves time and costs. Rate of Penetration is optimum if the hydraulics on the motor can provide optimum RPM. In principle, the rate of penetration really depends on the optimization of hydraulic parameters both in the bit and in the annulus, and WOB, as well as RPM. (Herianto, 2018)

David A et al in their research on the optimization of bit hydraulics using impact pressure explained that bit hydraulic horse power, impact force and nozzle velocity are criteria for optimizing bit hydraulics and comparison with differential pressure produces a quantity that better describes the role of bit hydraulics in drilling operations where the method used is based on the maximum pressure generated by the bit (David A, 1979).

To decide the character of the drilling fluid and the most desirable drift rate to have time and flow constraints on a high and horizontal well through the use of an empirical method that relates the homes of the drilling fluid, flow rate, slicing and the time required to flow into the bottom of the borehole fluid. In his research the author explains that hole cleansing is one of the primary functions of any drilling fluid. Cuts because of bit grinding, plus the presence of caving or sloughing must be without delay lifted to the surface with the aid of the drilling mud. Failure to obtain hole cleansing which can lead to extreme issues, which includes pipe pinching, excessive torque and powerful pulling, loss ciculation, high dust costs, and gradual drilling charges (Noah, 2013).

In hydraulics optimization, mud is an important in drilling operations, especially in process of hole cleaning at the bottom of the well and lifting cuttings to the surface, where in analyzing curtting lifts we focus on several parameters and simplify existing complications. Several factors that affect the removal of cuttings in the well include: (1) fluid velocity in the annulus as a function of the area of the annulus (2); given pumping rate; (3) the capacity to hold fluids which is a function of the rheology of the drilling mud (mud density, laminar/turbulent flow, viscosity); (4) the rate of penetration carried out; (5) drilling pipe rotational speed (rpm); and (6) cutting particle size (Al-Kayiem et.al., 2010; Paiaman et.al., 2006).

In this study, development was carried out by evaluating the hydraulics on the downhole mud motor, bit and annulus on the 12 inch route (build up section) and 8 inch route (Tangent Section) in order to determine the hydraulic parameters to be optimized so as to obtain the penetration rate. and optimizes the borehole bottom cleaning effect..

2. Material and Method

2.1. Material

The data needed in the hydraulics optimization of the "DDR-07" Well includes well geometry hole data, drill string data, and mud & well pump data.

2.1.1 Hole Geometry Data & Well Profile

The hole geometry data in the "DDR-07" well is divided into 3 sections, namely the vertical section (Conductor Casing & Surface Casing), Build Up Section (Intermediate Casing), and Tangent Section (Production casing), as shown in Table 1.

Table 1. Hole Geometry and Well Profile Data

Parameter	Vertical Section		Build Up Section	Tangent Section
	Conductor Casing	Surface Casing	Intermediate Casing	Production Casing
Bit Size, in	26	17 ½	12 ¼	8 ½
Casing Size, in	20	13 3/8	9 5/8	7
Length Casing, ft	100 MD	426,3 MD	981,03 MD/ 967,35 TVD	2983,6 MD/ 2821,66 TVD
Sudut Inklinasi, °	0	0	26,13	26,13
BUR, °/100 ftt	0	0	4	0

The profile of the "DDR-07" well can be seen in Figure 1.

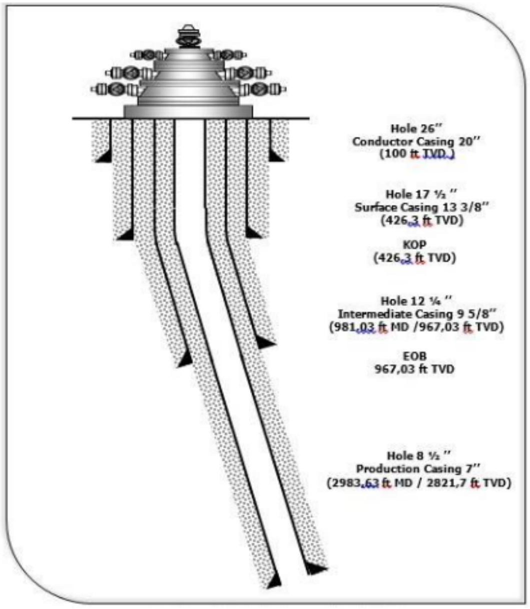

Figure 1. Well Profile "DDR-07"

2.1.2. Drill String Data

The drill hole condition data consists of hole diameter, depth, length, and drill string size data (Drill Pipe, Drill Collar, HWDP, and Downhole Mud Motor) for drilling each section used as shown in Table 2.

Table 2. Drill String Data Well "DDR-07"

Parameter	Build Up Section	Tangent Section
Hole Size	12 ¼ inch	8 ½ inch
Target Depth	981,03 ft MD/ 967,35 ft TVD	2983,63 ft MD/ 2821,66 ft TVD
Total Length Drillpipe	603,07 ft	2114,2 ft
OD Drillpipe	5 ½ inch	4 ½ inch
ID Drillpipe	4.76 inch	3,64 inch

Table 3 as data on the arrangement of the BHA circuit on the 12 ¼" trajectory (Build Up Section).

Table 3. BHA Data 12 ¼" Trajectory (Build Up Section)

No	Tools	OD (in)	ID (in)	Length (ft)
1	6 ½" HWDP x 7	6,5	3	214,85
2	Crossover Sub	8	3	2,2

3	8" Drill Collar x 1	8	3	30,3
4	Jar	8	3	22,9
5	8" Drill Collar x 2	8	3	60,6
6	Float Sub w/ Non Ported Float Valve	8	3,25	2,5
7	Filter Sub	8,25	3	6,6
8	Crossover Sub	9,5	3	3
9	Stop Sub	9,5	3	3
10	9 ⅝" Downhole Mud Motor	9,612	-	26,4
11	14 ¾" Stabilizer	8,25	2,97	4,50
12	12¼" PDC Bit	-	-	1,08
Total length BHA				377,93
Total BHA Air Weight (lbs)				42.781
Total BHA Weight in Mud (below & upper jar) (lbs)				36.164
BHA Weight Below Jars (lbs) WOB				28.697

Table 4 as data on the arrangement of the BHA circuit on the 8 ½" trajectory (Tangent Section).

Table 4. BHA Data 8 ½" Trajectory (Tangent Section)

No	Tools	OD (in)	ID (in)	Length (ft)
1	5 ½" HWDP x 17	5,5	2,75	521
2	6½" Jar	6,5	2,75	19,35
3	5 ½" HWDP x 4	5	3	122,76
4	6" Drill Collar x 3	6	2,81	89,4
5	8½" DLR413	6,63	3	6,7
6	6" Drill Collar x 2	6	2,81	59,6
7	Filter Sub	6,5	3	5,67
8	Stop Sub	7	2,25	2,5
9	8⅜" Mod Stabilizer	7	2,25	4,16
10	Stop Sub	7	2,25	2,5
11	8¼" String Stabilizer x 3	6,75	2,81	12,6
12	Float Sub w/ Non Ported Float Valve	6,5	3	1,86
13	Downhole Mud Motor	6,5	-	19,6
14	8½" PDC Bit	-	-	1,08
Total length BHA				868,78
Total BHA Air Weight (lbs)				67.893
Total BHA Weight in Mud (below & upper jar) (lbs)				61.562
BHA Weight Below Jars (lbs) WOB				32.764

2.1.3. Mud & Well Pump Data

The drilling mud pump used is a triplex pump with the RS-F800 type "Rongsheng Machinery Manufacture" with an efficiency of 90%. The number of pumps provided is 3 pumps with 1 pump used for spare in case of a problem. The pump specifications used are listed in Table 5.

Table 5. Mud & Well Pump Data "DDR-07"

Parameter	Build Up Section	Tangent Section
Hole	12 ¼	8 ½
Pump Type	Triplex	Triplex
Number of units	2 (seri)	2 (seri)
Flowrate, gpm	600	325
Efficiency, %	90	90
ROP, ft/hr	17,09	18,82
Mud denisty, ppg	10,6	11
PV, cp	22	31
YP, lbf/ 100ft^2	40	34
Cutting denisty, ppg	14,6	17,3
Cutting diameter, in	0,23	0,16

2.2. Metodologi

2.2.1. Adjustable Bit Rotating

The optimization of hydraulics on the downhole mud motor aims to obtain the optimum flow rate on the motor so that the pump flow rate will be obtained, then to determine the power (HP) generated by the motor by calculating the pressure entering the motor (Pinlet) so that the optimum RPM value is obtained. will be used. Determination of the size of the motor diameter and the optimum flow rate can be determined based on the integration of the downhole mud motor size specifications used (C. Maurer et al, 1977). The specifications for the size of the downhole mud motor are shown in Table 6.

Table 6. Dynadrill Characteristic Opertation (C. Maurer et.al, 1977)

OD (in)	Length (ft)	Flow Rate (gpm)	Pressure Drop (psi)	Avaliable Torque (ft/lbs)	Power Output (hp)	Rotary Speed (RPM)
9 5/8	26.4	600	250	1080	72	350
7 ¾	21	400	250	700	41	310
6 ½	19.6	325	250	467	36	410
5	19.7	225	250	283	25	460
3 ¾	17.6	130	170	127	10	420
2 3/8	9.7	25	595	24	4	875
1 ¾	7.9	20	425	16	2	800

Calculation of the inlet pressure on the motor can be calculated using the following equation:

$P_{inlet} = P - \Delta P$ ....(1)

The calculation of the inlet pressure at the motor starts with calculating the quantity of pressure loss alongside the circulation system (surface connection, inside pipe, downhole mud motor, bit and annulus). The total pressure loss in the circulation system is generally state in terms the equivalent length of discharge string, stand pipe, rotary house, and kelly. Table 7 and Table confirmed the sort of surface equipment used in drilling operations and regular value of pressure loss on surface.

Table 7. Surface Connection Type (Wolfgang F. Prassl, 1997)

Surface eq. Type	Stand Pipe		Rotary House		Swivel		Kelly	
	Length (ft)	ID (in)	Length (ft)	ID (in)	Length (ft)	ID (in)	Length (ft)	ID (in)
1	40	3	40	2	4	2	40	2.25
2	40	3.5	55	2.5	5	2.5	40	3.25
3	45	4	55	3	5	2.5	40	3.25
4	45	4	55	3	6	3	40	4

Table 8. Price of Constant E by Surface Connection Type (Wolfgang F. Prassl, 1997)

Surface eq. Type	Value of E	
	Imperial units	Metric units
1	2.5×10^{-4}	8.8×10^{-6}
2	9.6×10^{-5}	3.3×10^{-6}
3	5.3×10^{-5}	1.3×10^{-6}
4	4.2×10^{-5}	1.4×10^{-6}

Pressure loss at the surface connection can be calculated by equation:

$P_{SC} = C\, \rho^{0.8}\, Q^{1.8}\, \mu_p^{0.2}$ ....(2)

The calculation of pressure loss both in the pipe and in the annulus begins with calculating flow velocity and critical flow velocity both in pipe and in annulus to determine type of flow that occurs.

The average velocity of drilling mud flow in pipe with equation:

$$V = \frac{Q}{2.45\, d^2} \quad \text{..........(3)}$$

Calculation of critical velocity power law fluid can be calculated by the equation:

$$Vc = \left[\frac{5.82.(10^4)K}{\rho}\right]^{\frac{1}{2-n}} \left[\left(\frac{1.6}{d}\right)\left(\frac{3n+1}{4n}\right)\right]^{\frac{n}{2-n}} \quad \text{..........(4)}$$

Turbulent flow is a condition if If V > Vc, and laminar flow is a condition if V < Vc. For laminar flow, the magnitude of the pressure loss can be found by the equation according to [16]:

$$\Delta P_{ds} = \left[\left(\frac{1.6\,V}{D}\right)\left(\frac{3n+1}{4n}\right)\right]^{n} \frac{K\ L}{300\,d} \quad \text{.......(5)}$$

And for turbulent flow:

$$\Delta P_{ds} = \frac{2.27\left(10^{-7}\right)\rho_{m}^{\ 0.8} V^{1.8} PV^{0.2} L}{d^{1.2}} \quad \text{.......(6)}$$

The pressure loss on the downhole mud motor (ΔPmotor) can be determined based on the size specifications of the downhole mud motor used [12]. The downhole mud motor size specifications are shown in Table 9.

Table 9. Dynadrill Characteristic Opertation (C. Maurer et.al, 1977)

OD (in)	Length (ft)	Flow Rate (gpm)	Pressure Drop (psi)	Avaliable Torque (ft/lbs)	Power Output (hp)	Rotary Speed (RPM)
9 5/8	26.4	600	250	1080	72	350
7 ¾	21	400	250	700	41	310
6 ½	19.6	325	250	467	36	410
5	19.7	225	250	283	25	460
3 ¾	17.6	130	170	127	10	420
2 3/8	9.7	25	595	24	4	875
1 ¾	7.9	20	425	16	2	800

The calculation of the flow rate on the motor can be determined based on the integration of the motor specifications as shown in Table 9. To get the optimum flow rate on the motor, the flow rate on the pump is adjusted to the flow rate on the motor.

Calculation of power (HP) on the motor can be calculated using the equation:

$$HP = \frac{\Delta P \times Q}{1714} \quad \text{.......(7)}$$

Calculation of the optimum RPM operation on the motor can be calculated using the equation:

$$RPM = \frac{60 \times f_{e}}{n_{r}} \quad \text{.......(8)}$$

The configuration of BHA (rotor and stator) will affect the torque, power and output speed and angle of the motor. Then, the dimensions of the lobe size on the motor as a variable that can also affect the performance of downhole mud motor. The configuration of lobe sizes on the stator and rotor can be seen in Table 10 and Table 11.

Table 10. Torque Data For Power Section Configuration on Motor 6 ½ inch (Prawira et.al, 2017)

Power Section	Torque (N.m)
2:3 lobes Configuration	4203.03
5:6 lobes Configuration	8812.81
6:7 lobes Configuration	14913.99
7:8 lobes Configuration	16373.54

Table 11. Torque Data For Power Section Configuration on Motor 9 5/8 inch (Prawira et.al, 2017)

Power Section	Torque (N.m)
2:3 lobes Configuration	9761.88
5:6 lobes Configuration	11660.03
6:7 lobes Configuration	14981.78
7:8 lobes Configuration	17625.63

Calculation of the nozzle size area using the equation (Bourgoyne, 1986):

$$TFA=\sqrt{\frac{Q^2 \times MW}{P \times 10858}} \quad (9)$$

In downhole directional drilling, the mud motor is used to drill wells that have an inclination angle. One part of the downhole mud motor is the bent housing which serves to determine the direction of the bend during drilling or is called the Adjustable Kick Off (AKO). The value of the Adjustable Kick Off (AKO) can be determined based on the drill hole size, which can be seen in Table 7.

Table 12. Navi-Drill Motor Spesifications (Bakher Hughes, 2020)

Hole Size	Slick			Partial			Full		
in	AKO	BUR	RPM	AKO	BUR	RPM	AKO	BUR	RPM
12 ¼	-	-	-	2,5	12,6	-	2,5	10,4	-
8 ½	2,75	19,7	-	2,75	19,1	-	2,6	15,3	-

2.2.2. Adjustable Hole Cleaning in Bit

The hydraulics optimization of the bit aims to provide an optimal borehole cleaning effect to avoid drilling problems such as regrinding and bit balling. The calculation step for the optimization of hydraulics on the bit is done by calculating the amount of pressure entering the bit and then calculating the percentage ratio of the power on bit to pump power on surface where the BHI method is said to be optimum if the BHI/HPs value is ± 48%, then calculates bit impact force

(BIF) to evaluate the results of optimization carried out and calculate the flow velocity at the nozzle. The following are the calculation steps used in the bit hydraulics optimization.

Calculation of the inlet pressure on the bit can be calculated using the following equation:

$$P_{inlet} = P - \Delta p \quad \text{.....(10)}$$

Calculation the pressure loss on bit (Pb) can be calculated using equation:

$$\Delta P_b = \frac{Q^2 \rho_m}{10858 A_n^2} \quad \text{..... (11)}$$

Calculation of the hydraulic impact bit (BHI) can be calculated using equation:

$$BHI = \frac{Pinlet \times Q}{1714} \quad \text{..... (12)}$$

Calculation of horse power surface (HPs) can be calculated using equation:

$$HPs = \frac{P \times Q}{1714} \quad \text{..... (13)}$$

The amount of power in the bit used to clean wellbore during drilling can be calculated by comparing BHI value and pump power on the surface (HPs), using the equation:

$$BHI / HPs = \frac{BHI}{HPS} \times 100\% \quad \text{.....(14)}$$

Calculation of the price of Bit Impact Force (BIF) can be calculated using the equation:

$$BIF = 1.73 \times 10^{-2} \times Q(\rho m \times Pb)^{0.5} \quad \text{..... (15)}$$

Nozzle Velocity calculation can be calculated using equation according to (Bourgoyne,1986):

$$V_b = 0.321 \frac{Q_{opt}}{A_n} \quad \text{.....(16)}$$

2.2.3. Adjustable Hole Cleaning in Annulus

The optimization of hydraulics in the annulus aims to provide an optimal cutting effect to avoid drilling problems such as pipe sticking. There are three methods of cutting removal analysis with reference to different parameters, but all three determine the success of a good cutting removal, so the analysis of the three methods must be optimized. The three methods are;), Cutting Transport Ratio (Ft), Cutting Concentration (Ca), and Partical Bed Index (PBI)

Cutting Transport Ratio (Ft)

Due to the slip velocity, the cutting speed is slower than mud velocity in annulus (Bourgoyne, 1986). Cutting flow velocity in annulus can be calculated by the equation:

$$V_p = V_a - V_s \quad \text{.....(17)}$$

The mud velocity in annulus can be calculated using equation:

$$V_a = \frac{Q}{2.448\left(ID_{Hole}^{\ 2} - OD_{DP}^{\ 2}\right)} \quad \text{.....(18)}$$

The slip cutting speed can be calculated using equation:

$$V_s = \frac{82{,}87 \times Dc^2 \times (\rho_c - \rho_m)}{\mu_a} \quad \text{.......(19)}$$

By knowing the magnitude of the cutting flow velocity in the annulus, transport ratio of cutting (Ft) can be calculated using the equation:

$$F_t = \frac{V_p}{V_a} \quad \text{.......(20)}$$

When substituted with the previous equation, it becomes:

$$F_t = \frac{V_a - V_s}{V_a} \times 100\,\% \quad \text{.......(21)}$$

Cutting Concentration (Ca)

To calculate the cutting concentration (Ca) in he annulus, the following equation is used:

$$C_a = \frac{(ROP)D^2}{14.7\,F_t Q} \times 100\% \quad \text{....... (22)}$$

Particle Bed index (PBI)

In directional well drilling operations, cutting removal analysis must consider the inclination of the hole trajectory to the direction of Earth's gravity which causes the cutting velocity vector to appear towards the borehole wall, so that the cuttings will settle to form cutting deposits.

- For laminar flow:

$$\text{PBI} = \frac{(D_h - D_p)(\text{V}_\text{a} - \text{V}_\text{sa})}{L_c V_{sr}} \quad \text{....... (23)}$$

For the angle of inclination $0^o < \theta < 90^o$ dan $\theta = 90^o$, the equation will be:

- $0^o < \theta < 90^o$

$$\text{PBI} = \frac{(D - D_O)(\text{V}_\text{a} - \text{V}_\text{s} \cos\theta)}{12\,L_c\,V_S \sin\theta} \quad \text{....... (24)}$$

- $\theta = 90^o$

$$\text{PBI} = \frac{(D - D_O)(\text{V}_\text{a} - \text{V}_\text{s})}{12\,L_c\,V_S} \quad \text{.......(25)}$$

- Turbulent flow:

$$PBI = \frac{V_a}{17 \times V_s} \,. \quad \text{....... (26)}$$

3. Result

The well used to conduct the research in this paper is a DDR-07 directional well located in the MAR Field, Aceh Tamiang District, North Sumatra. In the 8½" (Tangent Section) drilling, the route is evaluated, this route has a depth interval of 981.03 ft MD/967.35 ft TVD to 2983.6 ft MD/ 2821.66 ft TVD. With the formation target being the Seurula formation. Drilling data required for evaluation and optimization includes hole geometry & well profile data, drill string data, and mud & well pump data. Optimization is done by adjusting the bit rotation, hole cleaning in bit and annulus.

3.1. Adjustable Bit Rotating

Optimization of downhole mud motor hydraulics is done by adjusting the amount of RPM and WOB to be used so that the optimization value will be achieved. Determination of the optimum flow rate on the motor is determined based on the integration based on the specifications of the downhole mud motor so that it can determine the RPM to be used and obtain the optimum penetration rate. The results of the hydraulic optimization calculation for the downhole mud motor on the 12 ¼"(build up section) and 8 ½" (tangent section) well "DDR-07" can be seen in Table 13.

Table 13. Downhole Mud Motor Hydraulic Evaluation Calculation Results

Parameter	Build Up Section	Tangent Section
OD, inch	9 5/8	6 ½
Q, gpm	420	245
Pinlet, psi	666,78	731,03
ΔP, psi	250	250
HP	60	50
TFA, in^2	1,2	0,64
RPM	210	150

3.2. Adjustable Hole Cleaning in Bit

The BHI concept in principle assumes that the greater the impact (immediate impact) received by the formation rock from the mud emitted from the bit, the greater the cleaning effect. BHI is said to be successful if the pressure loss at the bit is 48% of the maximum pump pressure available at the surface. The results of the bit hydraulics analysis using the BHI method on the 12 ¼"(build up section) and 8 ½" (tangent section) showed in the Table 15.

Table 15. Bit Hydraulic Evaluation Calculation Results

Parameter	Build Up Section	Tangent Section
Pinlet	416,78	481,03
ΔP	244,06	261,25
BHI/HPs	48,46	48,59
BIF	527,96	301,41
Vn	161,23	163,74

3.3. Adjustable Hole Cleaning in Annulus

There are three methods of cutting removal analysis with reference to different parameters, but all three determine the success of a good cutting removal, so the analysis of the three methods must be optimized. The three methods are; Cutting Transport Ratio (Ft), Cutting Concentration (Ca), and Partical Bed Index (PBI). Results of the hydraulics calculations in the annulus showed in the Table 17.

Table 17. Hydraulic Cutting Lift Calculation Results

Parameter	Ft %	Ca %	PBI
Drill Pipe	93,4	0,30	1
HWDP	94,5	0,30	1
Drill Collar	93,8	0,30	1

4. Discussion

The optimization of hydraulics on the downhole mud motor aims to get the optimum RPM so that it can increase the penetration rate. Based on the results of calculations on the 12 " (build up section) route, the size of the downhole mud motor used is 9 5/8", so that the optimum flow rate (Q) at pump is 600 gpm, motor inlet pressure is 666.78 psi, the pressure loss on motor is 250 psi, the power (HP) on motor is 233.41 hp, the nozzle area is 1.2 in^2, the rotation rate is 210 RPM where on this route has the characteristics of soft rock hardness so that the RPM is set at the same rate. large in order to cut the cutting and reduce the value of the WOB because a WOB that is too large will cause the bit to sink so that when the circuit is pulled it will cause the pipe to be squeezed and not form a perfect hole. Based on the evaluation results on the 8 " (Tangent Section) downhole mud motor, the size of the downhole mud motor used is 6 inch, so that the optimum flow rate (Q) at the pump is 350 gpm, the motor inlet pressure is 731.03 psi, the pressure loss at the pump is 731.03 psi. the motor is 250 psi, the power (HP) on the motor is 138.61 hp, the nozzle area is 0.64 in^2, the rotation rate is 150 RPM where on this route has the characteristics of medium rock hardness so that the RPM is set with a small rate and maximizes the value of of WOB in order to get the optimum penetration rate.

The hydraulics optimization of the bit aims to provide an optimal borehole cleaning effect to avoid drilling problems such as regrinding and bit balling. Based on the results of calculations using the BHI method, it shows that the bit hydraulics in the DDR-07 well on the 12 " (Build Up Section) route, the percentage value (BHI/HPs) is 48.46 % (≥48 %), this condition can be said to have been optimum where the optimum method Bit Hydraulic Impact 48%. Bit Impact Force (BIF) of 527.96 lbf. with a nozzle speed of 255.6 ft/s. Based on the results of the optimization bit hydraulics using the BHI method, the bit hydraulics on the DDR-07 well on the 8 " route (Tangent Section) obtained the Bit Hydraulic Impact (BHI) value of 105.12 hp, Horse Power Surface (HPs) 217.16 hp and the percentage (BHI/HPs) of 48.59% (≥48 %), this condition can be said to have been optimum where the optimum condition of the Bit Hydraulic Impact method is 48%. Bit

Impact Force (BIF) is 301.41 lbf where on the tangential route the bit impact force value must be high to be able to maintain the angle. with a nozzle speed of 255.6 ft/s.

The optimization of hydraulics in the annulus aims to provide an optimal cutting effect to avoid drilling problems such as pipe sticking. Based on the results of calculations on the DDR-07 well for the 8½" (Tangent Section) route, the cutting transport (Ft) value of annulus DP is 95.61 %, annulus DC is 95.20%, and annulus HWDP is 95.53%. The optimization value for the annulus DP cutting concentration (Ca) is 0.30%, the annulus DP is 0.31%, and the annulus HWDP is 0.30%, and particle bed index (PBI) is 1. actual calculation, the result of cutting transport (Ft) 90%, concentration (Ca) < 5%, and particle bed index (PBI) = 1, which indicates that there is no deposition of drill cuttings. Based on the results hydraulic optimization cutting lifting on the DDR-07 well on the 8½" (Tangent Section) route, transport ratio of cutting (Ft) value of annulus DP is 95.18%, annulus DC is 96.04%, and annulus HWDP is 95.48%. The optimization value for the annulus DP cutting concentration (Ca) is 0.30%, the annulus DP is 0.30%, and the HWDP annulus is 0.3%, and particle bed index (PBI) is 1. actual calculation, the results of transport ratio of cutting (Ft) 90%, concentration (Ca) < 5%, and particle bed index (PBI) = 1, indicates that there is no deposition drill of cuttings.

5. Conclusion

Based on the results of the research and discussion that have been presented, the following conclusions can be drawn:

1. The results of the optimization of the hydraulics of the downhole mud motor on the 12 1/4 " (Build Up Section) route. The type of downhole mud motor used is a dyna drill with an OD size of 9 5/8 inch, so that a flow rate (Q) of 600 gpm is obtained, the pressure loss at the motor is 250 psi, the inlet pressure is 682.29 psi, the HP motor is 238.84 psi, the nozzle area is 0.64 in2 and the RPM is 130. On the 8 ½" (Tangent Section) route, the type of downhole mud motor used is a dyna drill with OD size 6 ", so that the flow rate (Q) is 325 gpm, the pressure loss on the motor is 250 psi, the inlet pressure is 682.29 psi, the HP motor is 238.84 psi, the nozzle area is 0.64 in2 and the RPM is 150.
2. The results of the optimization of bit hydraulics using the BHI method on the 12 ¼" (Build Up Section) route with a pump of 1000 psi, the pressure loss value on the bit is 207.96 psi, the bit inlet pressure is 432.29 Bit Hydraulic Impact (BHI) of 151.33 hp, Horse Power Surface (HPs) 315.05 hp, percentage (BHI/HPs) 48.03% (± 48%) Bit Impact Force (BIF) 487.34 lbf and nozzle speed 148.82 ft/s. On the 8 ½" (Tangent Section) route with a pump pressure of 1200 psi, the value of the pressure loss on the bit is 261.25 psi, the bit inlet pressure is 476.93 Bit Hydraulic Impact (BHI) is 90.433 hp, Horse Power Surface (HPs) is 185 .82 hp, percentage (BHI/HPs) of 48.67 % (± 48 %) Bit Impact Force (BIF) of 301.41 lbf and nozzle speed of 163.74 ft/s.
3. The results of the hydraulic optimization of cutting lifting on the 12¼" (Build Up Section) route obtained the Cutting Transport Ratio (Ft) annulus DP value of 92.39%, annulus DC of 92.44%, and annulus HWDP of 92.21%. The optimization value for the Cutting Concentration (Ca) annulus DP is 0.31%, annulus DP is 0.31%, and annulus HWDP is

0.32%, and the Particle Bed Index (PBI) is 1. From the calculation results, the results of the Cutting Transport Ratio (Ft) 90 %, Cutting Concentration (Ca) < 5%, and Particle Bed Index (PBI) = 1, which indicates that there is no deposition of drill cuttings. On the 8½" (Tangent Section) route, the Cutting Transport Ratio (Ft) value of the annulus DP is 95.28%, the annulus DC is 92.44 %, and the annulus HWDP is 95.39%. The optimization value on the Cutting Concentration (Ca) annulus DP is 0.29%, annulus DP is 0.29%, and annulus HWDP is 0.29%, and the Particle Bed Index (PBI) is 1. From the calculation results, the results of Cutting Transport are obtained. Ratio (Ft) 90%, Cutting Concentration (Ca) < 5%, and Particle Bed Index (PBI) = 1, which indicates that there is no deposition of drill cuttings.

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