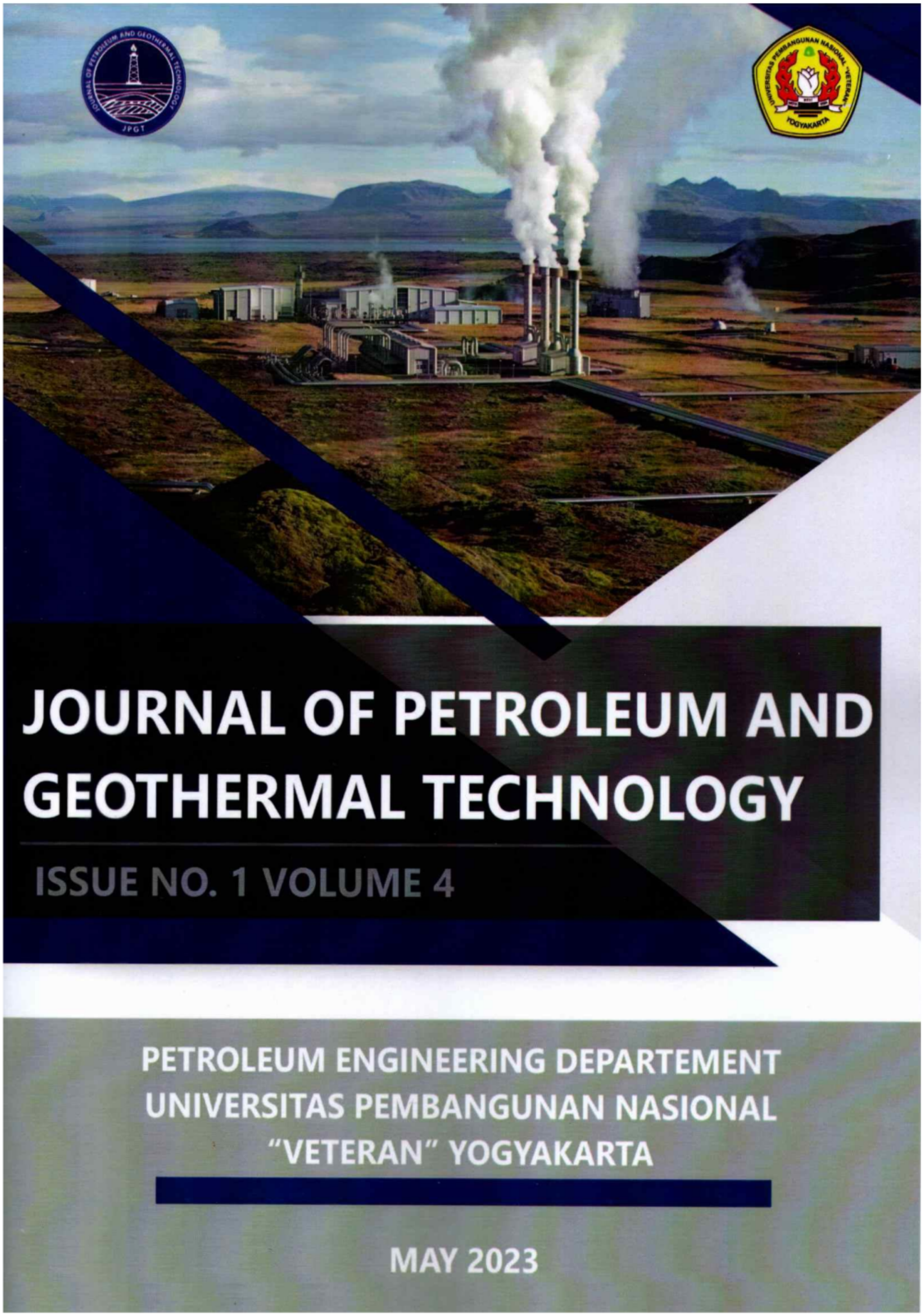
Evaluation of Drill Bit Selection on Basement Layer Exploration Drilling in AFM Block

by Dedy Kristanto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Full Issue

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Table of Contents

Articles

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JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
ISSN: 2723-0988, e-ISSN: 2723-1496
Vol.4 No. 1 2023

Evaluation of Drill Bit Selection on Basement Layer Exploration Drilling in AFM Block

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ABSTRACT

In one of the exploration drilling of the AF-01 well, there was a drilling problem on the 8 in hole when it penetrated the basement layer. ROP at the time of drilling the basement layer is far below the estimated ROP. By setting MSE as, ROP is increased so that cost savings are obtained from reducing rig time. A qualitative analysis of drillbit selection was carried out based on the type and design of the drillbit as well as the characteristics of the basement rock to be penetrated. In addition to the qualitative and quantitative assessment was carried out through the calculation of the PDC Design Index, MSE, DSE and CPF on each drill bit. ROP of Hybrid PDC-1 increased 500% when compared to PDC-1. The MSE and DSE produced by the Hybrid PDC-1 are 750% smaller than the PDC-1. Using the Hybrid PDC-1, drilling costs can be reduced up to USD 2,105,481. The low ROP at the time of drilling the basement layer in well AF-01 was due to the incompatibility of the PDC-1 bit used for the type of rock being penetrated. Hybrid PDC-1 is the most optimum bit to penetrate the basement layer in the AFM Block.

Keywords: mechanical specific energy; drilling specific energy; drill bit; rate of penetration; basement layer.

I. INTRODUCTION

The AFM block is part of the KKKS-A field of operation in Indonesia. In the AFM Block, exploration drilling is carried out to map and prove the existence of oil and gas reserves in the Block. The AF well is an exploration drilling well whose depth is targeted to penetrate the basement layer. It aims to determine the reservoir boundary and be used as a reference in the correlation between wells.

In one of the exploration drilling of the AF-01 well, there was a drilling problem on the 8 in route, namely when it penetrated the basement layer. Rate of Penetration (ROP) at the time of drilling the basement layer is very low, which is around 2-3 ft/hr. The ROP obtained is far below the ROP of the planning estimate, which is 10-15 ft/hr. The cause of this problem is thought to be due to the inappropriate type of drill bit used to penetrate the basement layer. Therefore, it is necessary to evaluate the selection of drill bits in order to obtain ROP according to the plan that will be implemented when drilling other exploration wells in the AFM Block.

II. METHODS

The method in this research is to evaluate the optimum drill bit performance in penetrating the basement layer with data collection and data analysis methods. Data collection in this study includes data on drilling parameters, rock characteristics and drill bit specifications. The analysis that will be carried out in this research is data analysis through qualitative assessment based on bit type and design as well as quantitative assessment of the calculation of ideal bit specifications, Mechanical and Drilling Specific Energy and Cost per Foot in economic considerations for each drill bit. Then each parameter will be evaluated as a consideration for the selection of the right drill bit in penetrating the basement layer of exploration drilling.

III. RESULTS AND DISCUSSION

3.1. Result

The basement rocks in the AFM block are igneous rocks containing shale at a depth of 9566 ft. The following are the characteristics of basement rocks having high compressive strength, high hardness, high abbrasiveness, medium elasticity, medium interbedded, low drillability.

The following is the result of the shear travel velocity calculation that will be used to calculate the CCV value based on rock type,

Table 1. Calculation of Shear Travel Velocity

Rock Content	Fraction	Δts/ Δtc	Δtm (sec)	Δtc (sec)	por Φ	Δtcm (sec)	ΔVs
Granite	0,2	1,7	0,00005	0,00005	0,02	0,00001	0,000017
Quartz	0,7	1,6	0,00005	0,000053	0,02	0,0000372	0,0000577
Shale	0,1	1,8	0,00005	0,000067	0,1	0,00000669	0,0000117

Compressive travel time can be calculated using **Equation 1**

$$\Delta t_c = [\Delta t_{ma}(1-\emptyset)] + [\Delta t_f x\emptyset] \qquad (1)$$

The following is a CCV calculation based on shear travel time in the previous calculation using **Equation 2**

$$CCV = \left[\frac{H_{top}}{5000ft}\right] x \left[\frac{1}{(V_{sG})+(V_{sQ})+(V_{sS})}\right] \qquad (2)$$

The CCV result is 22154 psi. The size of the cutter on the PDC and the Drillability Index of the rock can be determined based on the CCV value of the rock using table 2. So that the following results are obtained:

Table 2. Size as a Function of DBI Result (Source: Jim dan Osarumwense O.A., 2007)

CCV x	DBI	Size Cutter (mm)
20,000 - 25,000	7	16

Based on the case of drilling in the basement layer and the availability of bits in the field, several candidate bits were obtained which refer to cases similar to this research, including:

Table 3. Bit Specifications

Bit	PDC 1	PDC 2	PDC 3	Hybrid PDC 1	Hybrid PDC 2
Count of Blade	5	4	7	7	7
Count of Cutter	21	24	61	40	40
Cutter Size (MM)	16	19	16	13.44	16
Gauge	3	2	2	4.7	4.7
IADC	S333	M123	M433	-	-
TFA (in2)	0.669	0.924	0.948	1047	0.948
Recommendation RPM	45 - 300	60 - 400	60 - 400	60 - 400	60 - 400
Recommendation WOB (lbs)	4250 - 25500	3400 - 25500	3400 - 34000	3400 - 34000	3400 - 34000
Price ($)	600.0	6500.0	700.0	40200.0	40200.0
Well	AF-01	REF-01	REF-02	REF-03	REF-04

Based on the type of rock to be penetrated, the criteria for drill bits are obtained which are ideal for use in drilling through the AFM basement layer. The following are the results of a qualitative assessment of the available bits that refer to rock types:

2
JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
ISSN: 2723-0988, e-ISSN: 2723-1496
Vol.4 No. 1 2023

Table 4. Qualitative Assessment Results

Bit :	Ideal Bit	PDC 1		PDC 2		PDC 3		Hybrid PDC 1		Hybrid PDC 2	
		Spesification	**Score**	**Spesification**	**Score**	**Spesification**	**Score**	**Spesification**	**Score**	**Spesification**	**Score**
Compressive Strenght	Durable; PDC	Aggressive; PDC	2	Aggressive; PDC	2	Aggressive; PDC	2	Durable; Hybrid	2	Aggresive; Hybrid	1
Hardness	Matrix Body	Steel	0	Matrix	3	Matrix	3	Matrix	3	Matrix	3
Abbrasiveness	Durable; Roller Cone Bit	Aggressive; PDC	1	Aggressive; PDC	1	Aggressive; PDC; Exposure Cutter	0	Durable; Hybrid	3	Aggresive; Hybrid	2
Elasticity	Aggressive; Roller Cone Bit	Aggressive; PDC	1	Aggressive; PDC	1	Aggressive; PDC; Exposure Cutter	2	Durable; Hybrid	2	Aggresive; Hybrid	3
Interbedded	Hybrid	PDC	2	PDC	2	PDC	2	Hybrid	3	Hybrid	3
Drillability	As previous mention	Poor	0	Capable	1	Capable	1	Optimum	3	Ideal	2
Total Point		6		10		10		16		14	

Based on the assessment as follows the Ideal is three points, Optimum is two points, Capable is one points, Poor is zero and maximum points is eighteen.

The following are the results of calculations in determining the number of cutters, cutter sizes and the number of blades based on the rock CCV is 22154 psi and size of cutter is 16 mm

The following is the calculation in determining the number of cutters:

$$Cn= [51.967 \times \ln(CCV)-442.8] \qquad (3)$$

$$Cn= [51.967 \times \ln(22154)-442.8]= 77 \text{ pcs}$$

The following is the calculation in determining the number of blades:

$$Bn= -0.0006(Cn)^2+0.1576(Cn)-1.0245 \qquad (4)$$

$$Bn= -0.0006(77)^2+0.1576(77)-1.0245=7 \text{ pcs}$$

The following is a calculation in determining the length of the gauge:

$$GL=GLmax- [(Hsi/HTotal)x(GLmax-GLmin)] \qquad (5)$$

GL= 4.7- [0/9566 x(4.7- 2)]=4.7 in

CPF can be used as an economic reference in the selection of drill bits. Here's the equation to determine the CPF :

$$CPF = \frac{C_B + ((T_t + T_r) x C_R)}{H} \qquad (6)$$

Table 5. Cost per Foot Result

Drill Bit	PDC 1	PDC 2	PDC 3	Hybrid PDC 1	Hybrid PDC 2
CB ($)	6000	6500	7000	40200	40200
Start Depth (ft)	10460	8914	9318	8914	11483,5
End Depth (ft)	10535	9566	9895,5	9566	12140
Hsection (ft)	75	652	577,5	652	656,5
Tripping (ft/hr)	1000	1000	1000	1000	1000
Tr (hr)	20,995	18,48	19,2135	18,48	23,6235
ROP (ft/hr)	2,5	2,5	4,17	12,5	12,5
tr (hr)	30	260,8	138,48921	52,16	52,52
CR ($/hr)	10200	10200	10200	10200	10200
C ($/ft)	7015,32	4379,0736	2797,5197	1166,7607	1244,2707

The following is the calculation of the mechanical specific energy (MSE) and drilling specific energy (DSE) of each drill bit:

Table 6. MSE & DSE Result

Drill Bit	PDC 1	PDC 2	PDC 3	Hybrid PDC 1	Hybrid PDC 2
WOB (lbs)	12500	10000	25000	10000	19750
Mud Rate (gpm)	555	500	500	500	500
Ps (psi)	3200	2493	4888	2493	6500
RPM	110	90	233	90	178
Torsi (ftlbs)	10000	10000	16000	10000	10000
ROP (ft/hr)	2,5	2,5	4,17	12,5	12,5
AB (in2)	56,8	56,8	56,8	56,8	56,8
λ	0,0175	0,0175	0,0175	0,0175	0,0175
n	1,86	1,86	1,86	1,86	1,86
Pb (psi)	2081,12	1621,32	3178,91	1621,32	4227,27

2
JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
ISSN: 2723-0988, e-ISSN: 2723-1496
Vol.4 No. 1 2023

Table 6. MSE & DSE Result (Continuation)

Drill Bit	PDC 1	PDC 2	PDC 3	Hybrid PDC 1	Hybrid PDC 2
HHPb (psi)	673,87	472,96	927,34	472,96	1233,16
MSE (psi)	2923403,6	2391871,7	5939849,4	478515,26	946396,35
DSE (psi)	2758875,6	2276396,4	5804111,3	455420,2	886180,59

MSE calculation is based on 2 components, namely thrust and rotary. Meanwhile, DSE considers drilling hydraulics. It can be seen that the equations by various researchers are as follows :

$$MSE = \frac{WOB}{A_B} + \frac{120 \times \pi \times RPM \times T}{A_B \times ROP} \quad (7)$$

$$DSE = \frac{WOB}{A_B} + \frac{120 \times \pi \times RPM \times T}{A_B \times ROP} - \frac{1980000 \times \lambda \times HHPb}{ROP \times A_B} \quad (8)$$

The following is the determination of the hydraulic factor (λ);

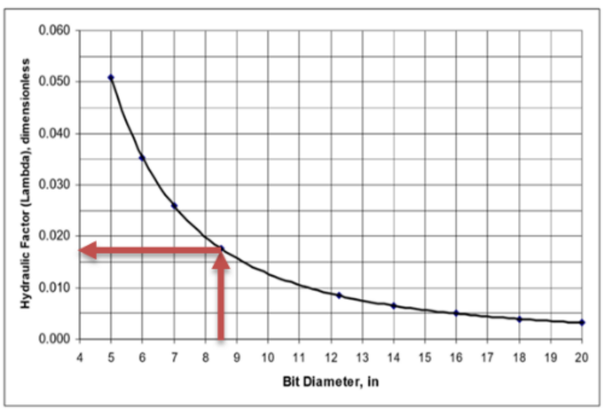

Figure 1. Determination of Hydraulic Factor
Source: Jim dan Osarumwense O.A., 2007

The following are the results of a quantitative assessment based on several calculations in determining the ideal specification:

Table 7. Quantitative Assessment Result

Bit :	Ideal Value	PDC 1		PDC 2		PDC 3		Hybrid PDC 1		Hybrid PDC 2	
		Spesification	Score	Spesification	Score	Spesification	Score	Spesification	Score	Spesification	Score

Count of Cutter (pcs)	77,00	21,00	0,27	24,00	0,31	61,00	0,79	40,00	0,52	40,00	0,52

Table 7. Quantitative Assessment Result (Continuation)

Bit :	**Ideal Value**	**PDC 1**		**PDC 2**		**PDC 3**		**Hybrid PDC 1**		**Hybrid PDC 2**	
		Specification	**Score**	**Specification**	**Score**	**Spesification**	**Score**	**Spesification**	**Score**	**Specification**	**Score**
Count of Blade (pcs)	7,00	5,00	0,71	4,00	0,57	7,00	1,00	7,00	1,00	7,00	1,00
Gauge Length (in)	4,70	3,00	0,64	2,00	0,43	2,00	0,43	4,70	1,00	4,70	1,00
Total Flow Area (in2)	1,05	0,67	0,64	0,92	0,88	0,95	0,91	1,05	1,00	0,95	0,91
Cutter Size (mm)	16,00	16,00	1,00	19,00	0,81	16,00	1,00	13,44	0,84	16,00	1,00
Cost Per Foot ($/ft)	1167	7015	0	4379	0	2798	1	1167	1	1244	1
MSE (psi)	478515	2923404	1	2391872	1	5939849	0	478515	1	946396	1
DSE (psi)	455420	2758876	1	2276396	1	5804111	0	455420	1	886181	1
Total Point		4,39		4,76		4,84		7,36		7,25	

The selection of drill bits to be used in the AFM basement layer drilling is determined based on the results of the qualitative assessment and the highest quantitative assessment. Here are the results of the assessment for each bit:

Table 8. Quantitative & Qualitative Result

Bit :	**PDC 1**	**PDC 2**	**PDC 3**	**Hybrid PDC 1**	**Hybrid PDC 2**
Penilaian Kualitatif	33	56	56	89	78
Penilaian Kuantitatif	55	60	61	92	91

JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
ISSN: 2723-0988, e-ISSN: 2723-1496
Vol.4 No. 1 2023

Total Point	44	58	58	90	84

After drilling the basement layer using Hybrid PDC-1 in well AF-02, an evaluation of the mechanical specific energy, drilling specific energy and drilling costs was carried out. The performance of the Hybrid PDC-1 is compared to the PDC-1 which was previously used in the basement drilling of well AF-01. The following are the results of evaluating the performance of the Hybrid PDC-1 compared to the PDC-1:

Table 9. PDC-1 Hybrid Performance Evaluation Results

Drill Bit	PDC 1		Hybrid PDC 1	
8,5	**Min**	**Max**	**Min**	**Max**
WOB (lbs)	5000	40000	5000	40000
Mud Rate (gpm)	550	560	450	660
Ps (psi)	3150	3250	1650	1815
RPM	100	120	90	120
Torsi (ftlbs)	8000	12000	3000	8000
ROP (ft/hr)	2	3	10	15
AB (in2)	57	57	57	57
λ	0	0	0	0
n	2	2	2	2
Pb (psi)	2049	2114	1073	1180
HHPb (psi)	657	691	282	455
CPF ($/ft)	7015		1167	
Drilling Cost ($)	2525515		420034	
MSE (psi)	2657528	3189632	179465	425895
DSE (psi)	2456905	3049129	162269	407399

Based on the results of the Hybrid PDC-1 performance above, it can be seen that there are significant improvements compared to the PDC-1, including:

Table 10. PDC-1 Hybrid Performance Evaluation Results

Parameter	Improvement
ROP Increasess	500%
MSE Decreasess	749%
DSE Decreasess	748%
Cost Saving	$ 2.105.481

3.2. Discussion

Well AF-02 is an exploration well in the AFM block. Well AF-02 is planned to be drilled through the basement layer to a depth of 360 ft. Previously, well AF-01 had penetrated the basement layer during the first exploration, but did not reach the final depth target. This is due to inefficient drilling due to low ROP so that drilling is stopped.

The low drilling rate in well AF-01 was caused by the inaccurate drill bit used to penetrate the basement layer. Therefore, it is necessary to evaluate the selection of the right bit for drilling the basement layer in well AF-02 in order to increase ROP and reduce drilling costs.

The basement layer blocked by AFM that will be penetrated is igneous rock with shale insertion. The rocks contained are granite, quartz and shale. Like the basement layer in general, the compressive strength of this rock is high. CCV in AFM block basement rocks is 22154 psia.

The shale content in the basement layer increases the elasticity of the rock. This makes the rock more difficult to drill. In addition, the nature of this rock is very abrasive. There are many scratches and drill bit erosion on the body and cutter when drilling the AF-01 well.

Basically, drill bits have two contradictory properties, namely aggressive drill bits and durable drill bits. Aggressive drill bits generally result in high drilling rates. This is because aggressive drill bits have fewer cutters and blades, but are large in size. In addition, the aggressive drill bit has a large rake cutter and is equipped with an exposure cutter so that the rock is more easily crushed and eroded. However, aggressive bits have a low life time and their performance will decrease if there is damage so that drilling is not efficient.

Bits with high durability have a longer life time. Generally these bits have a large number of blades and cutters and do not have rake cutters and exposure cutters. Drilling will be more stable but the drilling rate is smaller when compared to aggressive bits.

Based on high compressive strength and hardness, the optimum bit to overcome these rock properties is PDC type bit with high durability. The grinding properties of the PDC cutter are effective in drilling hard layers. However, it takes a number of cutters, a large number of blades and a matrix body material to maintain the durability of the bit, so that the drillbit does not quickly wear out and be damaged.

Based on the abrasiveness of the rock, the optimum bit to overcome these rock properties is the roller cone bit. The nature of the roller cone bit that destroys rock can minimize the presence of scratches / friction that can erode the bit, especially the body and cutter. In addition to using roller cones, the use of high-durability bits can reduce bit damage.

Based on the elastic properties of shale rock, the optimum drill bit to overcome these rock properties is the roller cone bit. Elastic rock is easier to crush by impact than by grinding. This is due to the elastic nature of the rock which prevents the rock from being eroded or eroded.

Based on the various properties of basement rocks, drill bits are needed that can overcome each of these properties in order to obtain an optimum drilling rate. In this study, a qualitative assessment was carried out to determine the type of bit with the right specifications to be used. Qualitative assessment is categorized into 4, namely optimum, ideal, capable and poor. This category is determined based on the suitability of drill bits in handling rock properties with a maximum rating of 18 points.

One of the bits available in the field is PDC-1. This PDC bit has quite aggressive properties with steel body material. PDC-1 is optimum enough to overcome the compressive strength of rock. However, PDC-1 has poor performance to handle rock hardness due to using steel body material which can result in body material thirst. Although this bit is able to handle abrasive and rock elasticity problems from its aggressive nature, it is not yet ideal because it is not a roller cone bit. In general, PDC-1 is not suitable for penetrating basement layers in AFM blocks. This is evidenced by the results of a qualitative assessment of 6 out of 18.

PDC-2 has similar properties to PDC-1, except that PDC-2 has a matrix body material. This will be ideal in penetrating layers with high hardness because the body will be more resistant and have better durability. However, similar to PDC-1, PDC-2 is less than optimum in penetrating abrasive layers due to the aggressive nature of this bit. Although better than PDC-1, PDC-2 is generally considered less suitable for penetrating basement layers blocked by AFM. This is evidenced by the results of a qualitative assessment of 10 out of 18.

PDC-3 is the most aggressive PDC when compared to PDC-1 and PDC-2. This bit is equipped with a conical cutter which is exposed outward. This makes PDC-3 ideal in dealing with the elastic and interbedded properties of basement rocks. However, the use of PDC-3 is not very good for drilling abrasive rocks. The exported cutter will be quickly eroded by rocks so that the performance will decrease. PDC-3 has the same qualitative assessment result as PDC-2, which is 10 out of 18.

The Hybrid PDC-1 is a combination of roller cone and PDC. Hybrid PDC 1 is ideal for treating hardness, abrasiveness and interbedded basement rock. This is because the Hybrid PDC-1 has high durability and has 2 crushing properties, namely the roller cone and the PDC cutter. This bit is quite optimal in overcoming compressive strength properties due to its PDC cutter and optimal in overcoming elasticity due to its roller cone. Hybrid PDC-1 is the most ideal bit for use through basement layers. This is reinforced by the results of a qualitative assessment of 16 out of 18.

Hybrid PDC-2 is a bit similar to Hybrid PDC-1, which is a bit equipped with a roller cone and PDC cutter. However, this bit is more aggressive than the Hybrid PDC-1 because the Hybrid PDC-2 has a larger cutter size. Therefore Hybrid PDC-2 is optimal enough to be used to penetrate the basement layer even though it is not as ideal as Hybrid PDC-1. This is evidenced by the results of the qualitative assessment of Hybrid PDC-2 14 out of 18.

JOURNAL OF PETROLEUM AND GEOTHERMAL TECHNOLOGY
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Vol.4 No. 1 2023

Based on the determination of several parameters such as number of cutters, cutter size, number of blades, gaugle length, total flow area, cost per foot, MSE and DSE, a quantitative assessment is carried out which refers to the approximate value of the calculation results. Each parameter is rated 1 (one) for the maximum approach rating.

The ideal number of cutters for drilling the basement layer of AFM blocks based on calculations is 77 pcs. The number of cutters is directly proportional to the hardness of the rock. The harder the rock, the more cutters are needed. Because the rock to be penetrated is relatively hard, it is ideally needed a large number of cutters. PDC-3 is the bit that has the number of bits that is closest to the ideal number, which is 61 pcs, followed by Hybrid PDC-1 and Hybrid PDC-2 with 40 cutters.

The number of blades based on the calculation is 7 blades. The number of blades is also directly proportional to the hardness of the rock. The harder the rock, the more blades needed. Because the rock to be penetrated is relatively hard, it is ideally needed a large number of cutters. Hybrid PDC-1, Hybrid PDC-2 and PDC-3 are the most ideal bits with the number of blades 7. This number of blades corresponds to the number of blades that have been calculated

Cutter size based on confined compressional velocity correlation table with drillability index obtained 16 mm. This indicates that the most ideal bit is a bit that uses a 16 mm cutter size. The bits that have the appropriate cutter sizes are PDC-1, PDC-2 and Hybrid PDC-2 with a size of 16 mm. Then followed by the Hybrid PDC-1 with a size of 13.4 mm. The larger the size of the cutter, the faster the drilling and the easier the rock will be crushed. However, this only applies when the bit is sharp. Performance will decrease if the cutter is thirsty. Therefore, the durability factor needs to be considered in order to obtain the ideal bit with balanced performance and durability.

In the calculation of gauge length, the ideal length is 4.7". The gaugle determination is influenced by the length of the directional drilling path. The longer the directional drilling path, the shorter the gauge on the bit. This is because bits with long gauges tend to be stable and difficult to angle. Because the well is planned to be drilled vertically, the bit with the most optimum gauge length is Hybrid PDC-1 and Hybrid PDC-2, which is 4.7".

The total flow area is determined based on the largest TFA. This is so that the drill bit can support maximum hydraulics when needed when drilling the AF-02 well. In the candidate bits available in the field, Hybrid PDC-1 is the bit that has the largest TFA, which is 1.04".

Based on the price of the bits, Hybrid PDC-1 and Hybrid PDC-2 are the most expensive bits with a price of 40,200 USD. This price is much more expensive when compared to the PDC-1 used in the AF-01 well at a price of 6,000 USD. However, in the calculation of cost per foot the most economical Hybrid PDC-1 is 1.168 USD/ft while PDC-1 is the bit with the highest cost per foot which is 7.015 USD/ft. This is due to the significant difference in ROP and the very high spread of submersible rig rate of 10,200 USD/hr which increases the cost of drilling.

MSE and DSE are the energy required to crush rock. The smaller the MSE and DSE values, the more efficient the drilling takes place. In this calculation Hybrid PDC-1 is the most efficient bit because it has the smallest MSE and DSE. The DSE value will be smaller than the MSE because the DSE takes into account the energy generated by hydraulics. Based on the results of MSE and DSE calculations, the bit that requires the least energy to crush rock is Hybrid PDC-1 with MSE value of 478,515 psi and DSE of 455,420 psi. This value is much smaller than the PDC-1 which has an MSE and DSE of about 2.7 to 2.9 x 10^6 psi.

Based on the results of a quantitative assessment of several parameters, the most optimum drill bit to be used for drilling the basement layer in the AFM block is Hybrid PDC-1 with a total rating of 7.36 out of 8.00. When compared with PDC-1 which was used in the AF-01 well drilling, the quantitative assessment result was the smallest at 4.39 out of 8.00.

After the qualitative and quantitative assessments have been carried out, drill bits are selected based on the cumulative value of each assessment. Based on the results of the assessment, it is determined that Hybrid PDC 1 is the most optimum bit with a total rating of 90 out of 100 and will be used in drilling the AFM basement layer in well AF-02. Hybrid PDC-1 has an aggressive nature that makes it easy to crush rocks, but still has good durability. This is obtained from the combination of the PDC cutter and roller cone it has. Quantitatively Hybrid PDC-1 has the ideal MSE and DSE as well as the best economy with the lowest CPF compared to other bits. The second choice is the Hybrid PDC-2 with a rating of 84 out of 100. The difference between Hybrid PDC-1 and Hybrid PDC-2 lies in the size of the Hybrid PDC-2 cutter which is larger so it is more aggressive. In general, the results of the Hybrid PDC assessment with ordinary PDC are quite significant. The complex nature of the basement rock requires that the bit has the properties of a roller cone and a PDC.

After drilling the basement layer using Hybrid PDC-1 in well AF-02, an evaluation of the ROP, mechanical specific energy, drilling specific energy and drilling costs was carried out. The performance of the Hybrid PDC-1 is compared to the PDC-1 which was previously used in the basement drilling of well AF-01. ROP usage of Hybrid PDC-1 increased 500% when compared to PDC-1 where initially 2 to 3 ft/hr now reaches 10 to 15 ft/hr. This is because the Hybrid PDC-1 has drillbit properties that are more suited to the characteristics of the rock being drilled. This can be seen in the qualitative assessment analysis where Hybrid PDC-1 has a near perfect value while PDC-1 has a low value. In addition, quantitatively the Hybrid PDC-1 is much better than the PDC-1. The MSE and DSE produced by the Hybrid PDC-1 are

750% smaller than the PDC-1 where the Hybrid PDC-1 has a maximum DSE of 425,000 psi while the PDC-1 reaches 3.1 x 10^6 psi. This indicates that Hybrid PDC-1 has a lower effort than PDC-1 to destroy rocks. With the use of Hybrid PDC-1, drilling costs can be reduced up to 2,105,481 USD or six times lower if using PDC-1. This is influenced by the cost per foot of the PDC-1 which reaches 7,015 USD/ft while the Hybrid PDC-1 is only 1166 USD/ft even though the price of the Hybrid PDC-1 is 34,200 USD more than the PDC-1. This research proves not necessarily that equipment that has a higher cost will reduce the economy. It is proven that although the Hybrid PDC-1 is much more expensive than the PDC-1, it has a better economic value.

IV. CONCLUSION

4.1. Conclusion

After conducting research on the selection of the right drill bit for drilling the basement layer in the AFM block, several conclusions were obtained including:

1. Based on the evaluation of the qualitative assessment, the low ROP at the time of drilling the basement layer in well AF-01 was due to the incompatibility of the PDC-1 bit used for the type of rock being penetrated.
2. Based on qualitative and quantitative assessments, Hybrid PDC-1 is the most optimum bit to penetrate the basement layer in the AFM Block.
3. The rate of penetration in the basement layer drilling in well AF-02 using Hybrid PDC-1 is 500% faster than drilling in well AF-01 using PDC 1.
4. MSE and DSE in basement drilling in well AF-02 using Hybrid PDC-1 can be reduced by 750% smaller than drilling in well AF-01 using PDC-1.
5. The cost per foot of drilling the basement layer in well AF-02 using Hybrid PDC-1 is 600% smaller than drilling well in AF-01 using PDC-1, resulting in a cost saving of $2,105,481 .

4.2. Suggestion

After conducting this research, several suggestions were obtained, including:

1. Further research is needed to systematically determine the Hybrid PDC Bit design
2. For exploratory drilling, it is necessary to evaluate several bits from the nearest well which is estimated to have a similar case to be used as a reference in the selection of bits.

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REFERENCES

Abbas, R. K., Hassanpour, A., Hare, C., Dan Ghadiri, P. M. (2014). Instantaneous Monitoring Of Drill Bit Wear And Specific Energy. Society Of Petroleum Engineers.

Al Rubaii, M. M. (2018). A New Robust Approach For Hole Cleaning To Improve Rate Of Penetration. Society Of Petroleum Engineers - SPE Kingdom Of Saudi Arabia Annual Technical Symposium And Exhibition 2018, SATS 2018. Https://Doi.Org/10.2118/192223-Ms

Alexandri, A. (2016). Perencanaan Rate Of Penetration. Forum Teknologi, 06(2).

Alsubaih, A., Albadran, F., Dan Alkanaani, N. (2018). Mechanical Specific Energy And Statistical Techniques To Maximizing The Drilling Rates For Production Section Of Mishrif Wells In Southern Iraq Fields. Proceedings Of The SPE/IADC Middle East Drilling Technology Conference And Exhibition, 2018-Janua. Https://Doi.Org/10.2118/189354-Ms

Amadi, K., Dan Iyalla, I. (2012). Application Of Mechanical Specific Energy Techniques In Reducing Drilling Cost In Deepwater Development. Society Of Petroleum Engineers - SPE Deepwater Drilling And Completions Conference 2012, Akgun 2002, 626–635. Https://Doi.Org/10.2118/156370-Ms

Armenta, M. (2008). Identifying Inefficient Drilling Conditions Using Drilling-Specific Energy. Proceedings - SPE Annual Technical Conference And Exhibition, 7(September), 4409–4424. Https://Doi.Org/10.2118/116667-Ms

Dian Putrie Adila. (2019). OPTIMASI HIDROLIKA DAN EVALUASI KINERJA BIT DENGAN METODE DRILLING SPECIFIC ENERGY TRAYEK 17,5" PADA SUMUR "DN-06" LAPANGAN "ADL-1." Universitas Trisakti.

Dupriest, F., Dan Koederitz, W. (2007). Maximizing Drill Rates With Real-Time Surveillance Of Mechanical Specific Energy. Society Of Petroleum Engineers. Https://Doi.Org/10.2523/92194-Ms

Gunawan, F., Krisnanto, W., Mardiana, M. R. Y., Noviasta, B., Dan Febriarto, H. B. (2018). Conical Diamond Element PDC Bit As A Breakthrough To Drill Hard Geothermal Formation In Indonesia. Proceedings Of The IADC/SPE Asia Pacific Drilling Technology Conference, APDT, 2018-Augus, 1–14. Https://Doi.Org/10.2118/191100-Ms

Herianto, Null. (2018). Optimization Of Hydraulic Horsepower To Predict The Rate Of Penetration. American Journal Of Physics And Applications, 6(3), 63. Https://Doi.Org/10.11648/J.Ajpa.20180603.11

Herrmann, H., Dan Bucksch, H. (2014). Drilling Engineer. Dictionary Geotechnical Engineering/Wörterbuch Geotechnik. Https://Doi.Org/10.1007/978-3-642-41714-6_43985

Hughes, B. (1995). Drilling Engineering Workbook. Baker Hughes INTEQ, December.

Hughes, B. (2018). Kymera Hybrid Drill Bit Technology. 2–5.

Hughes, B. (2020). Kymera Hybrid Drill Bits Saved $ 2 Million USD And Enabled Second Well In Tight Seasonal Drilling Window.

Jake, D., Dan Hughes, B. (2017). The Next Generation In Drilling Performance Increases ROP In Challenging Cooper Basin Well.

Jim, O., Dan Osarumwense O.A., A. (2007). Design Index: A Systematic Method Of PDC Drill-Bit Selection. Society Of Petroleum Engineers. Https://Doi.Org/10.2523/59112-Ms

Jiwaldi, J. (2014). Premier Oil Tuna BV 2013 - 2014 TUNA PSC EXPLORATION DRILLING DRILLING PROGRAMME. Premier Oil Tuna B.V.

Long, E. P. (2014). Premier Oil Tuna BV TUNA PSC EXPLORATION DRILLING End Of Well Report. Premier Oil Tuna B.V., October.

Long, E. P. (2022). Premier Oil Tuna B . V . Drilling Programme. Premier Oil Tuna B.V., 2.

Meng, C., Meng, C., Mengci, S., Jinwen, Z., Kai, K., Dan Yucai, L. (2014). Maximizing Drilling Performance With Real-Time Surveillance System Based On Parameters Optimization Algorithm. Advances In Petroleum Exploration And Development, 8(1), 15–24. Https://Doi.Org/10.3968/5537

Mitchell, R. F., Dan Miska, S. Z. (2016). Fundamentals Of Drilling Engineering. In Fundamentals Of Drilling Engineering (Vol. 12). Https://Doi.Org/10.1002/9781119083931

Mohan, K., Adil, F., Dan Samuel, R. (2009). Tracking Drilling Efficiency Using Hydro-Mechanical Specific Energy. SPE/IADC Drilling Conference, Proceedings, 1(March), 493–504. Https://Doi.Org/10.2118/119421-Ms

Noviasta, B., Dan Fidiansyah, A. (2018). Conical Diamond Element CDE Bit Served As A Drilling Optimization Tool For High-Impact Carbonates And Interbedded Formation In Offshore Mahakam Field. Offshore Technology Conference Asia 2018, OTCA 2018. Https://Doi.Org/10.4043/28314-Ms

Pamungkas, Joko. (2004). Pengantar Teknik Perminyakan (Tm-110) Buku Ii. JURUSAN TEKNIK PERMINYAKAN FAKULTAS TEKNOLOGI MINERAL UNIVERSITAS PEMBANGUNAN NASIONAL "VETERAN" YOGYAKARTA.

Rabia, H. (2002). Well Engineering Dan Construction Hussain Rabia. Entract Petroleum, 1 To 789.

Rubiandini, R. (2010). Rotary Drilling Bit. In Teknik Operasi Pemboran (Pp. 1–43). ITB.

Sheng, O. K. (2016). PDC Bit Hydraulic And Mud Rheological Simulation To Model Pressure Drop Across Bit By Certification Of Approval PDC Bit Hydraulic And Mud Rheological Simulation To Model Pressure Drop Across Bit. Universiti Teknologi PETRONAS, January.

Waughman, R. J., Kenner, J. V., Dan Moore, R. A. (2003). Real-Time Specific Energy Monitoring Enhances The Understanding Of When To Pull Worn PDC Bits. SPE Drilling And Completion, 18(1), 59–66. Https://Doi.Org/10.2118/81822-Pa

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