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Cutting Evaluation of HPWBM Drilling Mud Using CCI, CTR, and CCA Methods in Directional Well G at 17½ inch Hole Interval in Field S

(Evaluasi Serpih Batuan Lumpur Bor HPWBM Menggunakan Metode CCI, CTR, dan CCA Dalam Sumur Berarah G Pada Interval Lubang 17½ Inch Di Lapangan S)

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Abstract
The quantitative analysis of cutting removal used in this study uses three methods, namely Cutting Carry Index, Cutting Transport Ratio, and Cutting Concentration in Annulus. This method is used to determine whether the composition of the mud used is maximal or not, starting from the maximum content of solids that can be carried in 1 gal to the viscosity and also the flow pattern of the fluid in order to successfully bring the cutting to the surface. Where these three methods have standardization to determine the cutting can be lifted, including for the cutting carry index method the value must be more than 1, for the cutting transport ratio the value must be greater than 50%, and for cutting concentration in annulus the value must be less than 5%. After analyzing the lifting using the three methods above, it can be seen the parameters in the successful removal of the cutting. These parameters include the physical properties of the fluid which include the value of density, plastic viscosity, and also the yield point, while other parameters such as drill bit speed, mudflow velocity, and cutting diameter are also important parameters in a successful borehole lifting. From the observations of this study, we can conclude that the use of mud in well G field S has been running optimally. The calculation of the cutting lift has met the standardization limits. This study also carried out sensitivity analysis as a source of future literature, so that sensitivity analysis parameters can be used if you want to do a well development. This study shows an analysis of cutting lift on a 17.5inch Route at a depth of 825ft - 2581ft, with an average drilling slope of 4 degrees per 100 ft.

Keywords: Cutting Carry Index; Cutting Transport Ratio; Cutting Concentration; Annulus; Directional Well

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Analisis kuantitatif pengangkatan cutting yang digunakan dalam penelitian ini menggunakan tiga metode yaitu Cutting Carry Index, Cutting Transport Ratio, dan Cutting Concentration in Annulus. Cara ini digunakan untuk mengetahui apakah komposisi lumpur yang digunakan sudah maksimal atau belum, mulai dari kandungan padatan maksimal yang dapat dibawa dalam 1 gal hingga kekentalan dan juga pola aliran fluida agar berhasil melakukan pemotongan. ke permukaan. Dimana ketiga metode tersebut memiliki standarisasi untuk menentukan pemotongan yang dapat diangkat, diantaranya untuk metode cutting carry index nilainya harus lebih dari 1, untuk cutting transport ratio nilainya harus lebih besar dari 50%, dan untuk konsentrasi cutting di anulus nilainya harus kurang dari 5%. Setelah dilakukan analisa pengangkatan dengan menggunakan ketiga metode diatas maka dapat diketahui parameter keberhasilan pengangkatan pemotongan. Parameter tersebut meliputi sifat fisik fluida yang meliputi nilai densitas, viskositas plastis, dan juga titik luluh, sedangkan parameter lain seperti kecepatan mata bor, kecepatan aliran lumpur, dan diameter pemotongan juga merupakan parameter penting dalam keberhasilan pengangkatan lubang bor. Dari pengamatan penelitian ini dapat disimpulkan bahwa pemanfaatan lumpur di sumur G lapangan S sudah berjalan secara optimal. Perhitungan cutting lift telah memenuhi batas standarisasi. Penelitian ini juga melakukan analisis sensitivitas sebagai sumber literatur masa depan, sehingga parameter analisis sensitivitas dapat digunakan jika ingin melakukan pengembangan sumur. Studi ini menunjukkan analisis cutting lift pada Route 17,5 inci pada kedalaman 825ft - 2581ft, dengan kemiringan pengeboran rata-rata 4 derajat per 100 ft.

Kata-kata kunci: Cutting Carry Index; Cutting Transport Ratio; Cutting Concentration; Anulus; Sumur Berarah

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I. INTRODUCTION

The use of drilling mud, also known as drilling fluid, is an important component in a successful drilling operation [1]. This drilling fluid is divided into two parts, namely mud filtrate and mud cake, the difference is that mud filtrate is the meaning of fluid mud (fluid phase in drilling mud) while mud is the particles in the drilling fluid itself such as barite, bentonite, calcium carbonate and others [2, 3]. The main function of this drilling mud is to clean the drill cuttings (hole cleaning) left at the bottom of the borehole so that it rises to the surface, and prevent fluid loss and pressure loss so that the formation pressure and drilling fluid remain stable [4,5]. Therefore, several parameters must be considered from the drilling mud including; density which

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affects the ROP (Rate of Penetration), Rheology (viscosity, yield point, and also plastic viscosity) which affects the speed of removal of drill cuttings, fluid flow rate (flowrate) which affects the direction of flow in the annulus of the borehole [6-9].

The process of removing cutting or hole cleaning from a drilling operation is divided into three methods where there are CCI (Cutting Carrying Index), CCA (Cutting Capacity Annulus), and CTR (Cutting Transport Ratio). These three methods can be used as an indicator of the success of a cutting removal. The CTR value is the success value where the mud can lift the cutting from the bottom of the drilling hole, This value is closely related to the transport speed and fluid velocity in the annulus, where the optimal mud has a value greater than 90%. The CCI value is the lift value for the cutting itself where this is influenced by the specific gravity of the mud and also the annular velocity, the value for the CCI itself must be greater than 1 to conclude the successful removal of drill cuttings from the bottom of the borehole value in CCA where this value is to find out how clean the cutting removal takes place, the CCA value itself ranges from 1 to less than 5%. If this value exceeds 5%, it indicates that the wellbore is full of cuttings, removal of drill cuttings that are not clean can cause other problems such as regrinding and build-up of drill cuttings on the chisel (bit balling) [10].

II. METHOD

In making this analysis there is also a flow chart of the three drilling cutting methods used, namely the CCI, CTR, and CCA methods. In the calculation CCI the first step is to determine the n and Kcci values of the PV (plastic viscosity) and YP (yield point) values. The minimum flow rate, hole-size, and OD pipe function to determine the value of the annular velocity so that the annular velocity and mud weight values can be used to determine the CCI value. The CCI value that has been obtained from the quantitative results will be compared with the standard value, if the CCI value is >1 then the drill cuttings will be lifted optimally, while if the CCI value is less than one then the drill powder settles.

Calculation of the CTR and CCA methods are interdependent where the CTR value can be used to determine the CCA value. The value of n, k, OD pipe, and annular velocity serves to determine the value of annular viscosity. The value of annular viscosity, the density of drill cuttings, the diameter of drill cuttings and the density of mud serve to determine the value of slip velocity in which Vslip must be corrected based on the drilling inclination angle. Thus, the corrected slip velocity value can be used to determine the CTR value. Furthermore, the accumulation of the CTR, ROP, and Qmin values of the minimum flow rate will be able to obtain the CCA value [10].

The above describes the flow diagram of the removal of drill cuttings using 3 methods. These methods include CCI, CCA, and also CTR. Where the symbol of a circle represents the start or end of a flow chart, a parallelogram represents the data to be input later, a rectangle represents the result. The output of the parallelogram and the rhombus represent a choice in the flow chart as shown in Figure 1 that there is a branching between “no” and “yes” decisions. All these flowcharts must be interconnected by marked with arrows and arrows that must touch each other [10].

The stage of work or implementation to determine the removal of drill cuttings using the CCI, CTR, and CCA methods has been made in the form of a chart or image in the form of a downward groove starting from top to bottom the last one. The required variables are also listed in the chart or flowchart. If in the final result the answer is yes, then the removal of drill cuttings has been successful, while in the final result the answer is no, the removal of drill cuttings is not successful [10].

III. RESULTS AND DISCUSSION

Drilling on the 17.5-inch route is carried out by installing a 13-3/8” surface casing, where later this casing will be continued to intermediate depths. During the drilling activity, the drill bit used is a PDC (Polycrystalline Diamond Compact) drill-bit, with the drilling fluid used here is HPWBM [11]. This 17.5-inch route drilling is directional or horizontal drilling with a maximum inclination of 20° from the center of the drilling.

Before analyzing the cutting removal using the CCI, CTR, and also CCA methods. First, the interpretation of the supporting variables for the removal of this cutting is carried out, including; drill mud rheology, cutting density and diameter, inclination angle, rate of penetration and rate per minute. The reading of these supporting data variables is obtained from DMR (Drilling Mud Report) data. Table 1 shows the variables used to obtain the calculation of cutting lift analysis on the 17.5-inch route at a depth of 1889-2564 ft on June 16, 2018.

From the above variables, further analysis can be carried out to obtain other supporting parameters, so that the removal of cuttings using the CCI, CTR method, and also CCA on route 17.5-inch at a depth of 1889-2564 ft is possible. The next calculation is to calculate values such as annular area point, annular volume, velocity average, critical velocity, and slip velocity. The results of these calculations can be seen in the Table 2.

The results of the calculation in Table 2 show the value of Vann (average annular velocity), Vcrit (critical velocity), and also the type of flow from each depth of BHA (Bottom Hole Assembly). The comparison between the Vcrit and the Vann will

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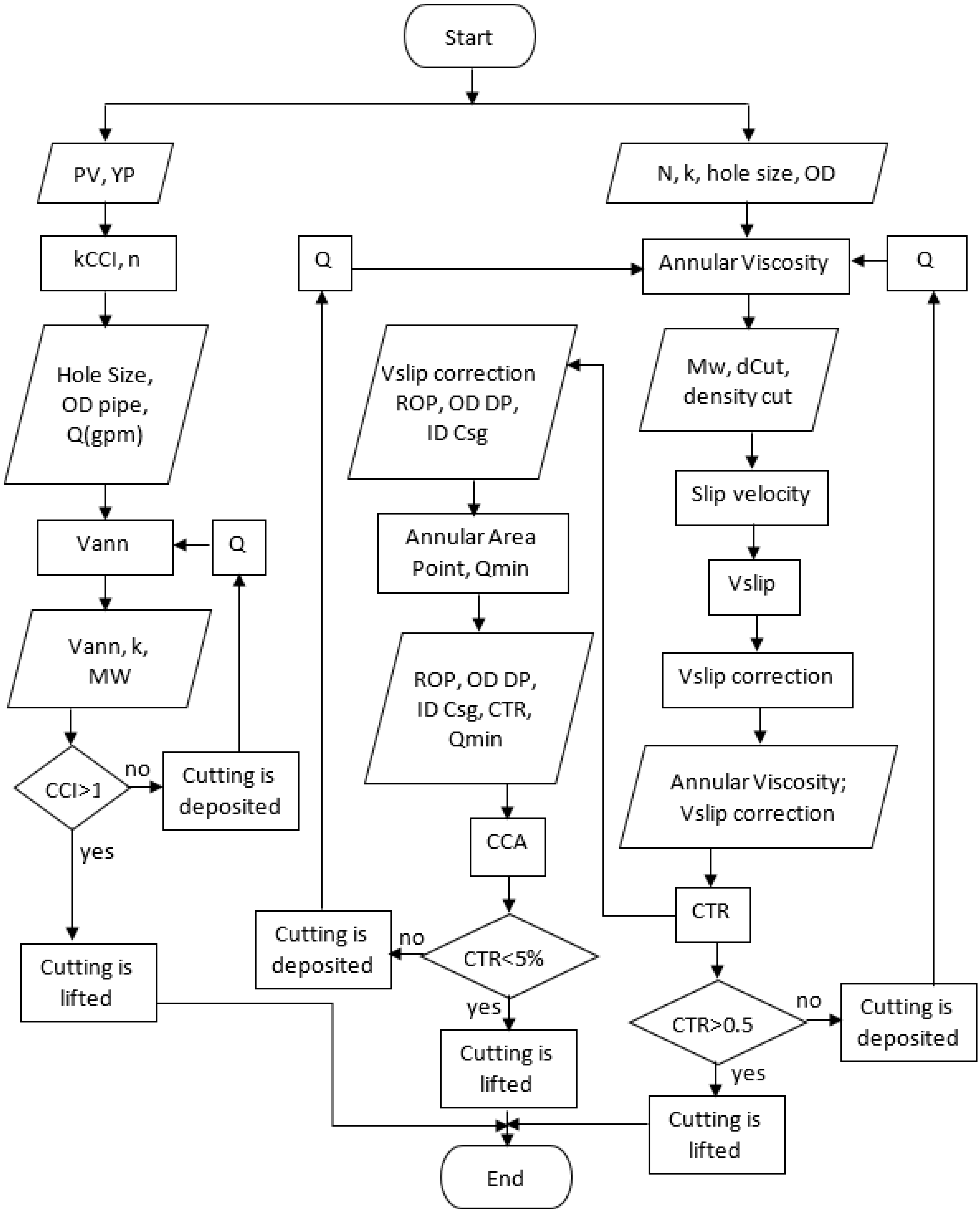

Figure 1. Flowchart of Cutting Lifting Research with Three Methods

result in the type of flow in the annulus, where if the Vcrit is greater than the Vann, it will produce a laminar flow pattern. This is due to the area factor in the series which is adjacent to the diameter of the hole, pump flow-rate, and sludge physical properties (slurry density and rheology). On the other hand, the calculation from the table above shows that the flow pattern obtained is laminar, which means that this flow pattern does not collide with each other and is directed towards the surface. So, that the cutting removal process will be more optimal and minimize the occurrence of problems during drilling such as regrinding or stuck pipe.

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Table 1. Drilling Mud Parameters on the 17.5" Route at a Depth of 1889 ft -2564 ft

Parameter	Value
Mud Density, ppg	10.4
Inclination, deg	15.68
Plastic Viscosity, cp	12
Yield Point, lb/100 ft^2	26
n (Flow Behavior Index)	0.431466
K (Power Law Constant)	2.908
Kcci	1485.871
Cutting Density, ppg	28,0721
Cutting Diameter, inch	0,125
C (concentration), %	0.45
Rate per Minute	40
Rate of Penetration, (ft/hrs)	25
Flow Rate, (gpm)	752

Table 2. Result Calculation of Determination of Flow Type on Route 17.5" at a Depth of 1889ft – 2564ft.

BHA	V_{ann} (ft/s)	Vcrit (ft/s)	Flow Pattern
Sub	1.2892	4,.5658	Laminar
Drill Collar	1.2676	4.5339	Laminar
Jars	1.2676	4.5339	Laminar
Drill Collar	1.2676	4.5339	Laminar
HWDP	1.1126	4.2639	Laminar
Drill Pipe (Cased Hole)	0.9564	4.1460	Laminar
Drill Pipe (Cased Hole)	0.,9238	4.1219	Laminar

The analysis is continued by calculating several parameters again because the G well in the S field is a horizontal well. The initial step is to calculate the V_{slip} (slip velocity) correction to the degree of slope of the borehole, which serves to detect the absence of V_{cut} (cutting that settles) at that degree of slope. In addition to calculating the correction V_{slip} (slip velocity), several calculations were also carried out including V_{slip} based on flow patterns, particle NRE (Reynold number), and pressure loss. The calculation results are given in Table 3.

From the calculation of the analysis shown in Table 3, it can be seen that the NRE value of the particles has a good indication of the results. Where the value is less than 3 which indicates the flow result from the NRE calculation is laminar. This can be obtained because of several calculation parameters whose values are already good, such as cutting density, hole-area, and cutting diameter which is not too large. As for the calculation of Vslip and Vcrit the correction shows a relatively low value, which is good in the process of lifting the cutting. Because it shows that there is no identification of cutting removal failure in holes that have a degree of slope.

Table 3. Calculation of Slip Velocity and Pressure Loss on the 17.5" Route at a Depth of 1889 ft – 2564 ft

BHA	NRE Particle	V_{slip} correction, ft/s	P_{loss}, psi
Sub	0.0029	0.0104	0.1091
Drill Collar	0.0027	0.0101	1.4674
Jars	0.0027	0.0101	0.3913
Drill Collar	0.0027	0.0101	1.5041
HWDP	0.0018	0.0080	6.5311
Drill Pipe (Cased hole)	0.0013	0.0043	12.8934
Drill Pipe (Cased hole)	0.0012	0.0040	10.8085

Furthermore, the analysis is continued with the results of the calculation of the ECD (Equivalent Circulating Density) value on the 17.5-inch route at a depth of 1889 ft to 2564 ft. The purpose of this calculation is to find out whether the formation at a depth of 2564 ft can still withstand hydrodynamic pressure from the mud or not, especially when the density value increases close to the formation fracture gradient. The results of the calculations are given in Table 4.

In general, the calculation of the ECD value has a greater value compared to the initial density value when the drilling mud is inserted. This is because the density value has been influenced by the rock density value, in another sense it is influenced by solids in dissolved elements. The ECD value in the above calculation is quite good because the value is greater than the initial mud weight value, which indicates that the cutting is well mixed and can be lifted. This is influenced by the value of plastic viscosity that can unite the cutting and drilling mud fluids.

Table 4. ECD Calculations on Route 17.5" at a Depth of 1889 ft – 2564 ft.

$P_{hydrodinamic}$, psi	Total Pressure Loss, psi	ECD, ppg
1409.5076	22.8964	10.5717

After getting all the variables and also the supporting parameters to analyze the cutting lift. then the calculation of the removal of cuttings on the 17.5-inch route from a depth of 1889 ft to 2564 ft, using three methods, namely; CCI, CTR, and CCA. The results of the calculations are given in Table 4.

Table 5 Calculation Result of Drill Cutting Lifting with Three Methods on Route 17.5" at a Depth of 1889 ft – 2564 ft.

BHA	Length MD (ft)	CCI	CTR %	CCA %
Sub	9	2.9882	99.1906	0.4510
Drill Collar	120	2.9381	99.1975	0.4510
Jars	32	2.9382	99.1975	0.4510
Drill Collar	123	2.9382	99.1975	0.4510
HWDP	492	2.5789	99.2830	0.4508
Drill Pipe (Cased Hole)	972	2.2169	99.5498	0.4506
Drill Pipe (Cased Hole)	816	2.1414	99.5633	0.4506

In the Table 3, it can be seen the results of the calculation of cutting removal from well G field S on the 17.5-inch route, in the first interval from 1889 ft to 2564 ft where the calculation of cutting removal is carried out on each of the BHA series. The value obtained from the CCI calculation shows that it is still within the safe limit of 1 where in this calculation the average value is 2.67. The CTR calculation has a value above the drinking limit, which is above 50% with an average CTR value of 99.3%, and the CCA cutting method is still classified as very good with an average of 0.45% where it is known that the maximum limit of the CCA value must be less than 5%. From the results of the calculation of cutting removal using the three methods, it can be concluded that the drilling of the well G field S on the 17.5-inch route at the first interval depth was lifted perfectly. This can be obtained due to several factors, one of which is the use of HPWBM at the time of drilling which is already in the good category. The factors are the physical properties of the mud (mud weight and rheology), and drilling parameters (rate of penetration, rotation per minute, and cutting density). Where on the 17.5" route, each of these factors has a value for the physical properties of the mud; density values from 8.5–10.5 ppg, plastic viscosity values 8–13 cp, yield point values 17–30 lb/100ft2. As for the drilling parameters; the RPM value has an interval of 40–112, the ROP value is 4–37 ft/hrs, and the mud flow rate has an interval of 652–990 gpm. In the use of these component factors, the value is a good category so that the results of lifting the cutting at this depth have good results.

IV. CONCLUSIONS

Analysis of cutting removal using well G field S on the route with a depth of 17.5-inch with a depth interval of 1889 - 2564 feet, influenced by several factors, one of which is the value of the physical properties of the mud flowrate and the rheology of HPWBM polyamine affects the success of cutting removal. To prove the rheological value of the mud is appropriate or not, the calculation of the ECD value is carried out, where if the ECD value is greater than the initial mudweight before being circulated, it is concluded that the cutting rock is well mixed in the mud, increasing the density value The study used 3 methods as parameters for the success of cutting removal including CCI > 1 where the value on the 17.5-inch route was 2.677, CTR > 50% wherefrom the calculation the value was 99.31% and, method of CCA < 5% which obtained 0.451% of the calculation results. Therefore, it can be concluded that the cutting has been lifted optimally.

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