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RESEARCH ARTICLE

Laboratory Study On The Utilization of Jackruit Skin Waste Into Carboxymethyl Cellulose and Their Effect On The Rheological Properties Of Drilling Mud

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Abstract

The value rheology of drilling mud must be in accordance with the conditions of wellbore that do not lead to the occurrence of the problems at the time of drilling. One of the efforts to improve the rheology of drilling mud is by adding Carboxymethyl Cellulose (CMC) which is useful for increasing viscosity and binding water. This study aims to identify the effect on the use of CMC originating from jackfruit skin to the rheological properties of drilling mud. Jackfruit skin is an underutilized organic waste and the structure of jackfruit skin contains 50-55% cellulose. Manufacturing phase of synthesizing CMC skin jackfruit includes the process of delignification, alkalization, carboximetilation, and sieve sample to be powdered CMC and subsequently carried out the test of plastic viscosity, yield point , gel strength by using a Fann VG Meter and mud cake using a marsh funnel and volume filtration using a filter press . The added mass of CMC jackfruit skin were varied from 1 g, 2 g, 3 g, 4 g to 5 g. The results suggest that the addition of jackfruit skin CMC has an effect on the rheology of drilling mud. Increasingly many additions additive CMC skin jackfruit who use the increasingly high- value rheology mud drilling were obtained. Furthermore, the addition of CMC jackfruit skin starting from 1gr – 5 gr meets the API 13, a standard for the value of yield point/viscosity plastic, plastic viscosity and maximum volume of filtrate. While the value of gel strength which meets the API 13 A is with the addition of CMC jackfruit skin as much as 5 grams.

Keywords: Carboxymethyl Cellulose (CMC), Jackfruit Skin, Drilling Mud

1. Introduction

Drilling mud rheology is considered as one of the critical aspects to determine the success of drilling operations (Li et al., 2015). The success of a drilling operation depends on the use of the drilling fluid used, where a good composition of a drilling mud makes it possible to reduce drilling operating costs (Benyounes et al., n.d., 2015). To improve the efficiency of drilling operations, drilling fluid must have the properties of rheological (viscosity, the value of yield point , shear stress and the gel strength), prevention of fluid loss, stability under certain temperature and pressure under operational conditions, as well as having the ability to minimize contamination with other types of fluids such as salt water, calcium sulfate, cement, and potassium (Fink, 2012) .

The rheological properties of drilling fluids must be monitored frequently during drilling operations to avoid problems related to changes in physical properties, such as yield point and viscosity values which are often associated with problems with inefficient / removal of cuttings and loss of mud fluid into the formation which is a serious problem to be evaluated in improving the efficiency of wellbore cleaning (Elkatatny et al., 2016). The addition of Carboxymethyl Cellulose (CMC) to the drilling mud resulted in a significant increase in viscosity changes, as well as a substantial increase in yield point value (Ghannam, n.d., 2014).

Research on the use of bagasse as CMC and its application to the thickening time test showed that the addition of CMC additives to cement suspension was shown to increase the thickening time by 66%. The research (Ghannam, n.d., 2014) proved the addition of 0-50% CMC, the suspension bentonite can increase the shear stress and apparent viscosity. Based on the information at the top of the research is going to utilize the materials of organic as additive CMC for mud drilling which according to (Ghannam, n.d., 2014), drilling mud with the addition of CMC were extracted from the bark of jackfruit is recommended to optimize the rheological properties of the suspension fluid. The content of cellulose which is contained in the skin jackfruit (KN) has potential to be used as an ingredient raw manufacture of CMC. According to the central statistic of Plant Fruits and Vegetables Indonesia 2017 Annual crop production in Q1 jackfruit in Riau region is as much as 4,596 tons and 4,313 tons in Q2 .

Besides being used as a mixture of animal feed (Agustono et al., 2017) jackfruit skin waste has not been utilized optimally by the community so that it has the potential to be used as a drilling mud CMC additive. Laboratory scale research was conducted to determine the effect of adding jackfruit peel CMC additives to the rheological value of drilling mud so that later it can be applied in the oil and gas industry.

2. Methods

Preparation of tools and materials are early step that made prior to the implementation of laboratorium test. There are 2 stages in this research where the first is the manufacture of CMC based basic skin of jackfruit and the lab nature test of rheology with the addition of additives CMC- based basic skin of jackfruit. The jackfruit skin used for own content of cellulose which contains cellulose is characterized by elements of C (Carbon).

Table 1. Results of Jackfruit Composition

Element	Percentage (%)
C	53.1%
O	41.89%

Making the CMC additives from jackfruit skin consists of delignification process which serves to separate the lignine to cellulose that can be done by addition of acid or base so that it can dissolve the lignine compounds (Nur et al., 2016) . The delignification process in this study is to soak the sample powder that has been sifted with a *sieve* size of 100 mesh into NaOH in a ratio of 1: 6 for 12 hours at room temperature and then wash it using distilled water until it reaches a neutral pH.

Fig. 1. The Process of Immersing Jackfruit Skin Samples in NaOH

Fig. 2. Process of Drying Sample Using a Vacuum

Bleaching serves to whiten the sample so it can change the color of the sample to be brighter. H_2O_2 is used in this process is the oxidation reagent which is used to oxidize the lignin structure so it can break the chain of lignine molecules (Nur et al., 2016). The *bleaching* process in this study was by mixing the sample with a 2% H_2O_2 solution with a ratio of 1: 6. Then heating it at a temperature of 60^o C while stirring for 2 hours and then washing the sample with distilled water until it reached a neutral pH.

Fig. 3. Samples That Have Been Vacuum-Dried

Fig. 4 Sample Immersion Process with H2O2

Fig. 5 Drying of Bleached Samples

Alkalization is a process of developing the structure of cellulose so it can easily substitute CMC reagents into the cellulose structure (Nur et al., 2016). The alkalization process in this study was carried out by placing the sample in the reactor and then adding it with distilled water and 2 propanol then heating and stirring for about 10 minutes at 25^0 C. Then driping 20 ml of 15% NaOH solution and stirring the sample for 1 hour at 80^O C.

Fig. 6. Carboxymethylation process

Carboxymethylation is a process of substitution of anhydroxyl groups in each ahydroglucose unit using carboxymethylation reagents (Nur et al., 2016). Carboymethylation process in this research is to mix the sample and reagents monocloroasetate with different concreations of warming and stirring for 1 hour at 80^OC which aims to change the content of cellulose is still solids into fine fibers. The monocloacetic reagent used here is a mixture of acetic acid and HCL compounds with the same concreations (in this process, 15% is used) as much as 100 ml.

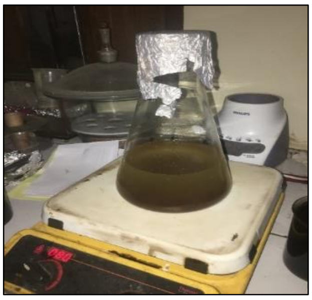

Fig. 7. Heating the sample at 80^o C

After the CMC of the jackfruit skin is obtained, the next step is to tet the rheology of the drilling mud. There are 6 samples tested in this study:

Table 2. Drilling Mud Sample

Sample Name	Mud Composition
S0	Standard Sludge (LS)
S1	LS + 1 gram CMC KN
S2	LS + 2 grams CMC KN
S3	LS + 3 grams CMC KN
S4	LS + 4 grams CMC KN
S5	LS + 5 grams CMC KN

To test the viscosity, plastic viscosity, yield point, and gel strength using Fann VG Meter where the mud is stirred with 600 RPM for 10 seconds. Then let mud sat for 10 seconds the move the rotor to 3 RPM and read the maximum deviation on the ponter scale. Then, stirred back the mud with 600 RPM for 10 seconds then stirred back for 10 minutes and let the mud for 10 minutes and read the maximum deviation after it moved to 600 RPM. The plastic viscosity is calculated using the equation below,

$$\mu_p = C_{600} - C_{300} \tag{1}$$

While the yield point value used the following equation below,

$$Y_b = C_{300} - \mu_p \tag{2}$$

The value of gel strength is calculated by comparing the deviation of time between 10 seconds and 10 minutes.

Fig. 8. Calculating Sample Flow Time for Viscosity

Fig. 9. Sample Experiment Using Fann VG Meter

3. Result and Discussion

Based on the research, the results are followed,

a. Viscosity

Table 3. Result of Standard Mud Viscosity and Standard Sludge + CMC Jackfruit Skin

Mud Composition	Viscosity (second)	Increased Viscosity time By Addition of CMC (%)
Standard Sludge (LS)	18,1	0
LS + 1 gram CMC KN	20,88	15,35
LS + 2 gram CMC KN	24,1	33,14
LS + 3 gram CMC KN	43,57	140
LS + 4 gram CMC KN	66	264,64
LS + 5 gram CMC KN	80	341,98

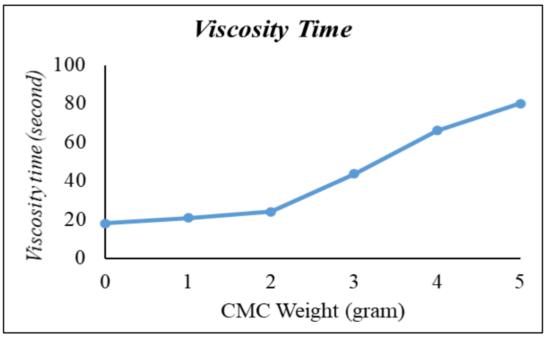

Fig. 10. Viscosity Time vs. CMC Weight

Based on the graph above, it can concluded that CMC that made from jackfruit skin was able to increase the viscosity of drilling mud up to 3 times with the addition of 5 grams of jackfruit skin compared to the initial flow before the standart mud was added to CMC which caused by the alkalinization in plant fiber. The jackfruit peel which causes cracks in the plant structure thereby increasing the absorption of cellulose along with the increase of viscosity which is in accordance of research (Pratama et al., 2017).

b. Yield Point

Table 4. Result of Yield point Standard Mud and Standard Mud + CMC Jackfruit Skin

Mud Composition	Yield Point (lb/100 ft^2)	Increased Yield Point By Addition of CMC (%)
Standard Sludge (LS)	7	0
LS + 1 gram CMC KN	9	28.7
LS + 2 gram CMC KN	13	85
LS + 3 gram CMC KN	14	100
LS + 4 gram CMC KN	18	157
LS + 5 gram CMC KN	23	228.57

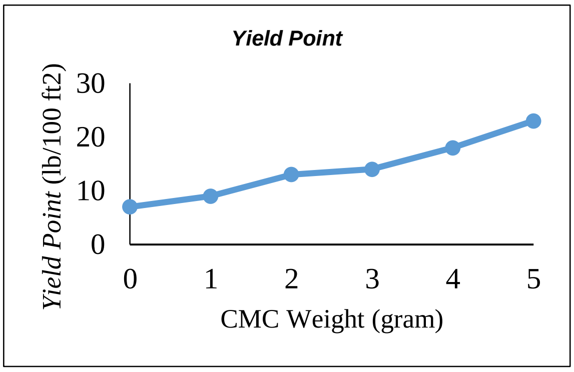

Fig. 10. Yield Point vs. CMC Weight

The yield point resulted from the test above show that the addition of CMC that made from jackfruit skin to standart mud can increase the value up to 2 times with the addition of 5 grams of CMC compared to the initial yield point where this is influenced by increasing number of conditions of total solids contained in the mud system (Wijayanto & Bayuseno, 2016) (Rubiandini, 2009).

c. Gel Strength

Table 5. Result of Gel Strength Standard Mud and Standard Mud + CMC Jackfruit Skin

Mud Composition	Gel Strength (lb/100 ft^2)	Increased Gel Strength By Addition of CMC (%)
Standard Sludge (LS)	0.4	0
LS + 1 gram CMC KN	0.44	4
LS + 2 gram CMC KN	0.5	10
LS + 3 gram CMC KN	0.56	16
LS + 4 gram CMC KN	0.636	19.6
LS + 5 gram CMC KN	0.69	29

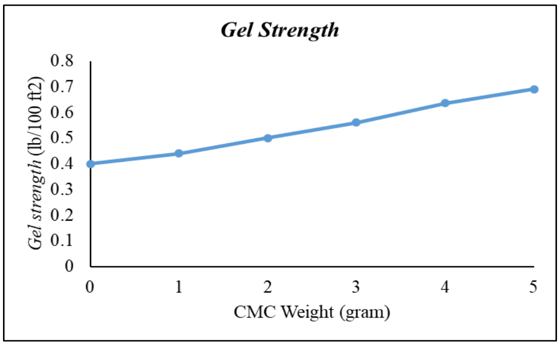

Fig. 11. Gel Strength vs. CMC Weight

Based on the calculations test above, the value of gel strength moves up with the addition of CMC weight of jackfruit skin with an average increase in gel strength per addition of 1 gram of CMC is about 5% . Similar to the *yield point* , the increase in *gel strength* is also caused by an increase in viscosity which is directly proportional to the increase in gel strength (Wardani, 2017).

d. Plastic Viscosity

Table 6. Result of Plastic Viscosity Standard Mud and Standard Mud + CMC Jackfruit Skin

Mud Composition	Plastic Viscocity (cp)	Increased Plastic Viscosity By Addition of CMC (%)
Standard Sludge (LS)	7	0
LS + 1 gram CMC KN	10	42.8
LS + 2 gram CMC KN	12	71.4
LS + 3 gram CMC KN	14	100
LS + 4 gram CMC KN	16	128.57
LS + 5 gram CMC KN	18	157.14

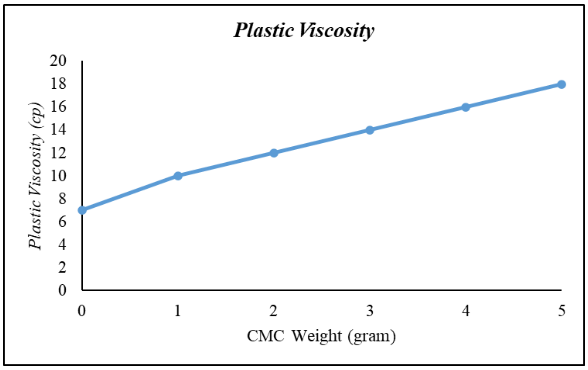

Fig. 12. Plastic Viscosity vs. CMC Weight

It can be seen from the results of plastic viscosity tests above, the increase in plastic viscosity tends to be stable with the addition of 1 gram of CMC jackfruit skin with an average percentage increase of 99.98%. This caused by mechanical friction due to the amount of contact area that occurs between solid particles and the existing liquid phase (Putra, 2015).

e. Filtration Loss

Table 7. Result of Filtration Loss Volume Standard Mud and Standard Mud + CMC Jackfruit Skin

Mud Composition	Filtration Loss (ml)	Decreased Filtration Loss By Addition of CMC (%)
Standard Sludge (LS)	16	0
LS + 1 gram CMC KN	15	6.25
LS + 2 gram CMC KN	14	12.5
LS + 3 gram CMC KN	12.55	21.9
LS + 4 gram CMC KN	11	31.25
LS + 5 gram CMC KN	10	37.5

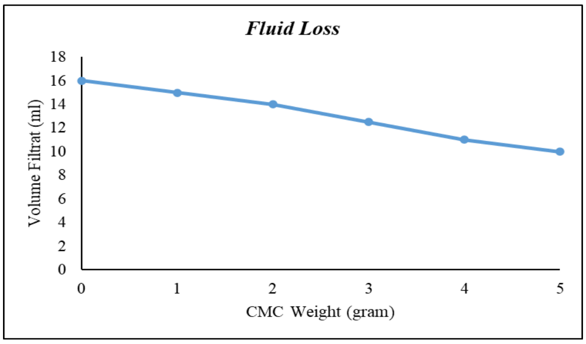

Fig 13. Filtration Volume vs. CMC Weight

Based on the results above, it can be concluded that the use of jackfruit skin managed to minimize the volume of filtrate that separated from the drilling mud up to 37.5% with the addition of 5 grams of CMC. This caused by the addition of CMC which binds water and forms a gel in liquid phase (Endang Bekti1, Yuli Prasetyowati2, 2011) and increases the viscosity of the drilling mud.

f. Mud Cake

Table 8. Result of Mud Cake Volume Standard Mud and Standard Mud + CMC Jackfruit Skin

Mud Composition	Mud Cake (mm)	Decreased Mud Cake Volume By Addition of CMC (%)
Standard Sludge (LS)	0.9	0
LS + 1 gram CMC KN	1,225	32,5
LS + 2 gram CMC KN	1,3	40
LS + 3 gram CMC KN	1,35	45
LS + 4 gram CMC KN	1,425	52,5
LS + 5 gram CMC KN	1,5	60

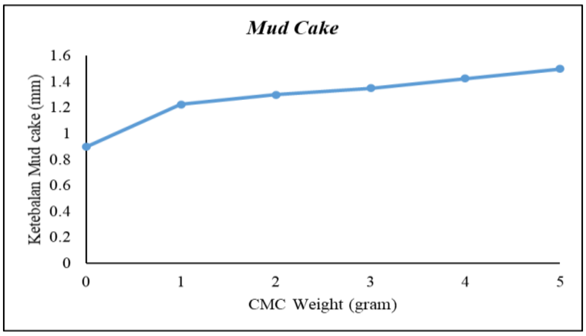

Fig. 14. Mud Cake vs. CMC Weight

Based on the results below, it can be concluded that the use of jackfruit skin in standard mud can increase the thickness of mud cake with an average thickness increase of about 20%. Based on (Apriyanti, 2013) (Hadziqoh et al., 2019), the maximum ideal thickness of mud cake is 3/8 inch or 9.525 mm. When compared with the addition of CMC in standard mud, the test results are still far below the maximum value in previous studies. This caused by the nature of CMC which can change the liquid phase into a gel so that it binds water and solids in the liquid phase (Endang Bekti, Yuli Prasetyowati, 2011) (Endang Bekti, Yuli Prasetyowati, 2011)

The comparison between each values with the addition of CMC using jackfruit skin to the specification 13 A as follows;

Table 9. The Comparison of Yield Point/ Plastic Viscosity with Standard API 13 A

Mud Composition	*Yield point / Viscosity Plastic* ($lb/100\ ft^2$)	API 13 A Spesification Yield Point/Plastic Viscosity
Standard Sludge (LS)	1	Max. 3 lb/100 ft2
LS + 1 gram CMC KN	0,9	Max. 3 lb/100 ft2
LS + 2 gram CMC KN	1,083	Max. 3 lb/100 ft2
LS + 3 gram CMC KN	1	Max. 3 lb/100 ft2
LS + 4 gram CMC KN	1,125	Max. 3 lb/100 ft2
LS + 5 gram CMC KN	1,278	Max. 3 lb/100 ft2

Table 10. The Comparison of Gel Strength with Standard API 13 A

Mud Composition	Gel strength (lb/100 ft2)	API 13A Spesifitcation Gel Strength
Standard Sludge (LS)	0,4	$2/4 - 4/5\ lb/100ft^2$ $(0,67 - 0,8\ lb/100ft^2)$
LS + 1 gram CMC KN	0,44	$2/4 - 4/5\ lb/100ft^2$ $(0,67 - 0,8\ lb/100ft^2)$
LS + 2 gram CMC KN	0,5	$2/4 - 4/5\ lb/100ft^2$ $(0,67 - 0,8\ lb/100ft^2)$
LS + 3 gram CMC KN	0,56	$2/4 - 4/5\ lb/100ft^2$ $(0,67 - 0,8\ lb/100ft^2)$
LS + 4 gram CMC KN	0,636	$2/4 - 4/5\ lb/100ft^2$ $(0,67 - 0,8\ lb/100ft^2)$
LS + 5 gram CMC KN	0,69	$2/4 - 4/5\ lb/100ft^2$ $(0,67 - 0,8\ lb/100ft^2)$

Table 11. The Comparison of Plastic Viscosity with Standard API 13 A

Mud Composition	*Plastic Viscosity* (cp)	API 13 A Spesification Plastic Viscosity
Standard Sludge (LS)	7	Minimum 10 cp
LS + 1 gram CMC KN	10	Minimum 10 cp
LS + 2 gram CMC KN	12	Minimum 10 cp
LS + 3 gram CMC KN	14	Minimum 10 cp
LS + 4 gram CMC KN	16	Minimum 10 cp
LS + 5 gram CMC KN	18	Minimum 10 cp

Table 11. The Comparison of Fluid Loss with Standard API 13 A

Mud Composition	*Filtrartion Loss* (ml)	API 13 A Spesification Filtration Loss
Standard Sludge (LS)	16	Maximum 15 ml
LS + 1 gram CMC KN	15	Maximum 15 ml
LS + 2 gram CMC KN	14	Maximum 15 ml
LS + 3 gram CMC KN	12.55	Maximum 15 ml
LS + 4 gram CMC KN	11	Maximum 15 ml
LS + 5 gram CMC KN	10	Maximum 15 ml

4. Conclusion

Based on research that has been done, the addition of jackfruit skin affects the rheological of drilling mud where the addition of CMC up to 5 grams can increase the viscosity value up to 3 times and the yield point value up to 2 times and reduce the amount of filtrate volume up 37.5% and per 1 gram the addition of CMC can increase the percentage of gel strength value by 5% and the value of plastic viscosity to 99.98% and increase the thickness of the mud cake with an average thickness of up to 20%. In addition, the value of yield point, plastic viscosity, and the maximum volume of the filtrate obtained from the addition of 1 gram to 5 grams of jackfruit skin in accordance with the standards of API specifications 13A. While the standard value of gel strength which is at the standard value of the 13A specifications in the advance of 5 grams of jackfruit skin of CMC Table 11.

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