Rheological Properties of Drilling Mud Consist of CMC Which is Made by Carton Waste and Chemical Additive of Na2CO3 for Reducing Lost Circulation

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Abstract. The Drilling process has the most important main objective is to reach the reservoir zone safely, quickly, and economically. The important component in the drilling process is drilling fluid commonly called by drilling mud. The drilling mud design needs to be properly planned to avoid problems during drilling. The research was conducted for testing the drilling mud rheology by using CMC from carton waste with the addition of Na2CO3, this research was conducted with several scenarios, which in each scenario have different levels of CMC and Na2CO3, from each result scenario can be seen in the value of density, viscosity, mud cake, pH, and filtrate volume of each mud. Thus it can be seen the best mud rheology from the addition of CMC waste carton waste and Na2CO3 to the drilling mud. The results of this research is the addition of CMC waste carton and Na2CO3 in the dominant drilling mud to rheology and additive function of CMC in increasing the viscosity were in 5 gr sample with 4.5 gr of Na2CO3 addition, with density value: 8.75 ppg, viscosity: 26 cp, mud cake: 0.54 cm, pH: 1, and filtrate volume: 4.42 ml.

Keywords: Drilling Fluid, Drilling Mud, Rheology.

1. Introduction
Drilling mud is a liquid consisting of a mixture of various materials that are used during drilling. In the beginning of the drilling process only use air to remove cutting, then with the development of the drilling technology, mud began to be used. To improve the characteristic of mud, chemicals were added, it is a liquid in the form of mud, made from mixing of liquid, solid, and chemical substances (Agung & Hamid, 2015). Drilling mud has numerous functions (i.e lift cutting, cool and lubricate bit and drillstring, controlling formation pressure, giving the wall to the borehole with mud cake, etc) (Rachid El Bousbi, 2017). The drilling mud will be circulated from the surface through a drillstring, exit through the chisel and rise to the surface through the space between the outer diameter of the drillstring (Kaswir, 2005). Mud contains 75% liquid, reactive solid, inert solids, chemical.

Carton is the commodities that are used in daily needs, nowadays life can not be separated from the carton which is mostly made by woodcut from trees that exist in the forest. Thus the more wasteful the community use carton, the more trees will be hewed to be used as the raw
material (Bulan, Hakim, & Sucipto, 2015). Carton waste at this time is still largely regarded as environmental waste (Dahlan, 2011). Carton waste can be changed into a useful product, reducing the use of new raw materials, renergy use, pollution, and land damage. Therefore, in order to avoid undesirable problems, it is necessary to process and use the carton waste into reusable materials.

CMC (carboxymethyl cellulose) is a cellulose derivative resulting from alkalization and carboxymethylation which is soluble to air. There are many studies that show the production of CMC from agricultural waste as a source of cellulose. CMC (Carboxymethyl cellulose) is produced by cellulose plants such as cotton linters and wood pulp (Mandal & Chakrabarty, 2011). The composition of raw materials and lignocellulosic waste can be seen in the following Table 1.

| No | Source       | Cellulose (%) | Hemicellulose (%) | Lignin (%) | Extracts (%) |
|----|--------------|---------------|-------------------|------------|--------------|
| 1  | Hard Wood    | 45-50         | 24-40             | 18-25      |              |
| 2  | Soft Wood    | 45-50         | 24-40             | 18-25      |              |
| 3  | Cornocob     | 45            | 35                | 15         |              |
| 4  | Wheat Straw  | 30            | 50                | 15         | 5            |
| 5  | Newspaper    | 40-55         | 25-40             | 15-30      |              |
| 6  | Pulp Cane    | 40-50         | 23-35             | 18-24      |              |
| 7  | Cotton       | 95            | 2                 | 1          | 0.4          |
| 8  | Carton Waste | 68.4          | 11                | 11.4       |              |

Source: (Mandal & Chakrabarty, 2011)

The most important property of CMC (carboxymethyl cellulose) is its ability to increase viscosity in the liquid phase (Gao, 2016).

CMC is also made by cassava peel in combination with H$_2$SO$_4$ through alkalization and etherification method (Endah Wahyuningsih, 2019). Water hyacinth is also used as the base material to make CMC (Adis Mahendra and Mitarlis, 2017). These CMC have not implemented in drilling fluid. Sugarcane have been used for making CMC and tested in laboratory scale (Kafashi, Rasaei, & Karimi, 2017). The reason for choosing carton waste to be used as CMC is a material that is basically made from plants or wood pulp which contains a lot of cellulose, so it is good if this carton waste is used as CMC (Benyounes, Benmounah, & Boumerdes, 2013).

2. Research and Methodology

This research was conducted at the Petroleum Engineering Drilling Laboratory of the Islamic University of Riau. The first step that must be prepared are the equipments such as Digital Lead, Measuring Cup, Stopwatch, Cup and Mud Mixer, Mud Balance, Fann VG Meter, Filter Press, Calipers, and pH Meter. The second step that must be prepared before conducting this research is the preparation of tools and materials, the main material of this research is CMC that was made by carton waste, figure 1 show the process of making CMC from carton waste:
The concentrations that have been used for Na$_2$CO$_3$ are 0.5, 1.5, 3.5, 4.5 gr which is combined with CMC carton waste and mud density, and the result of Density, Viscosity, Mud Cake, pH, Filtrate between CMC carton waste and CMC Industry will be compared and analyzed.

3. Main Result
This research was conducted by using carton waste materials, NaOH, H$_2$O$_2$, Acetic Acid, Na$_2$CO$_3$, Alcohol 70%, Methanol Ethanol, bentonite, and water. Laboratory studies conducted by researchers constitute mud rheological testing by adding CMC which is made by carton waste and Na$_2$CO$_3$ mixture. The addition of Na$_2$CO$_3$ in CMC carton waste is an auxiliary medium for CMC carton waste in increasing the viscosity of mud because Na$_2$CO$_3$ has good compounds for increasing viscosity and are very soluble with water.

The purpose of this study is to determine the rheological effect produced by CMC of carton waste with the addition of Na$_2$CO$_3$ to drilling mud and to conduct a rheological comparison between mud with the addition of industrial CMC, with mud rheology by adding CMC to carton waste added by Na$_2$CO$_3$ by comparing Density, Viscosity, Mud Cake, pH, and Volume Filtrate. Na$_2$CO$_3$ can be used.

3.1. Mud Density
In this research mud that has been used is water based mud, the results of mud density are shown in Table 2:

| No | CMC Weight(gr) | Mud Density + CMC Carton Waste + Na$_2$CO$_3$ (ppg) | Mud Density + CMC Carton Waste + Na$_2$CO$_3$ | Mud Density + CMC Carton Waste + Na$_2$CO$_3$ | Mud Density + CMC Carton Waste + Na$_2$CO$_3$ |
|----|----------------|------------------------------------------------|----------------------------------|----------------------------------|----------------------------------|
|    |                |                                                 | Na$_2$CO$_3$ (0.5 gr) | Na$_2$CO$_3$ (1.5 gr) | Na$_2$CO$_3$ (3.5 gr) | Na$_2$CO$_3$ (4.5 gr) |
| 1  | 1              | 8.33                                           | 8.63                             | 8.65                             | 8.68                             | 8.71                             |
| 2  | 3              | 8.52                                           | 8.64                             | 8.66                             | 8.69                             | 8.73                             |
| 3  | 5              | 8.55                                           | 8.65                             | 8.67                             | 8.70                             | 8.75                             |
Table 2 shows that the results of the density between mud using industrial CMC and mud using carton waste CMC have closed range. In mud using industrial CMC, the density increases if the weight of the CMC sample is increased, thus this mud can be used to overcome fluid lost when operated because CMC can improve the weight of the mud density. By using 5 gr of CMC Carton Waste and 4.5 gr of Na$_2$CO$_3$ obtain 8.75 ppg. Effect of adding CMC with 10 gr and 20 gr make the density value 8.6 ppg (Al-Hameedi et al., 2019).

3.2. *Mud Viscosity*

The result of viscosity are shown in Table 3:

Table 3. Mud Viscosity

| No | CMC Weight (gr) | Mud Viscosity + CMC Industry (cp) | Mud Viscosity + CMC Carton Waste + Na$_2$CO$_3$ (cp) |
|----|----------------|----------------------------------|--------------------------------------------------|
|    |                |                                  | Na$_2$CO$_3$ (0.5 gr) | Na$_2$CO$_3$ (1.5 gr) | Na$_2$CO$_3$ (3.5 gr) | Na$_2$CO$_3$ (4.5 gr) |
| 1  | 1              | 8                                | 7                    | 8                    | 10                    | 12                    |
| 2  | 3              | 15                               | 13                   | 15                   | 17                    | 19                    |
| 3  | 5              | 21                               | 19                   | 22                   | 24                    | 26                    |

Table3 shows that the results of the viscosity have close range between CMC Industry and CMC Carton Waste added by Na$_2$CO$_3$. Industrial CMC, on observation mud by giving CMC levels of 0.5, 1.5, 3.5 and 4.5 gr of Na$_2$CO$_3$ make the viscosity increase. 5 gr of CMC Carton Waste and 4.5 gr of Na$_2$CO$_3$ obtain 26 cp. CMC makes viscosity of drilling fluid becomes higher (Hall, Deville, Araujo, Li, & Rojas, 2017) According to the research that have been done by utilizing sugarcane as CMC improved the viscosity by up two times (Kafashi et al., 2017).

3.3. *Mud Cake*

The result of mud cake are shown in Table 4:

Table 4. Mud Cake

| No | CMC Weight(gr) | Mud Cake + CMC Industry (cm) | Mud Cake + CMC Carton Waste + Na$_2$CO$_3$ (cm) |
|----|----------------|-------------------------------|-----------------------------------------------|
|    |                |                               | Na$_2$CO$_3$ (0.5 gr) | Na$_2$CO$_3$ (1.5 gr) | Na$_2$CO$_3$ (3.5 gr) | Na$_2$CO$_3$ (4.5 gr) |
| 1  | 1              | 0.3                           | 0.34                            | 0.39                | 0.41                      | 0.43                      |
| 2  | 3              | 0.33                          | 0.35                            | 0.43                | 0.45                      | 0.47                      |
| 3  | 5              | 0.34                          | 0.36                            | 0.49                | 0.51                      | 0.54                      |

Table 4 shows that the value of mud cake is increasing due to the fact that a lot of the amount of CMC is added so that the thickness of the mud cake will be increased. The CMC carton waste showed the value if mud cake is increased when the more amount of CMC is added and also showed the influence of Na$_2$CO$_3$ added, which is showed that more levels of Na$_2$CO$_3$ were given, the increase in mud cake will be higher. Utilizing 5 gr of CMC Carton plus 4.5 gr of Na$_2$CO$_3$ make the thickness become 0.54 cm Mud cake increase when CMC added into drilling fluid before the value is 0.19 and 0.214 cm and increased by 0.3 cm when used concentration 1% (10 gr) and 2% (20 gr) of CMC (Al-Hameedi et al., 2019).
3.4. Mud pH
The result of mud pH are shown in Table 5:

| No | CMC Weight(gr) | Mud pH + CMC Industry | Mud pH + CMC Carton Waste + Na₂CO₃ |
|----|----------------|-----------------------|-----------------------------------|
|    |                |                       | Na₂CO₃  | Na₂CO₃  | Na₂CO₃  | Na₂CO₃  |
|    |                |                       | (0.5 gr) | (1.5 gr) | (3.5 gr) | (4.5 gr) |
| 1  | 1              | 6                     | 6       | 5       | 4       | 3       |
| 2  | 3              | 5                     | 5       | 4       | 3       | 2       |
| 3  | 5              | 4                     | 4       | 3       | 2       | 1       |

Table 5 shows that the pH value is getting lower when the amount of CMC is used from industrial CMC. The carton waste CMC shows the reduction of pH value because it is influenced by Na₂CO₃, the more amount of Na₂CO₃ is added, the less pH value of the mud will be. According to the research that have been done, pH value is 5 until 6 after adding CMC with the amount 2.4 gram into drilling fluid (Pica, Terry, & Carlson, 2017).

3.5. Mud Filtrate
The result of filtrate volume are shown in Table 6:

| No | Weight CMC (gr) | Volume of Mud Filtrate + CMC Industry (ml) | Volume of Mud Filtrate + CMC Carton Waste + Na₂CO₃ (ml) |
|----|----------------|--------------------------------------------|-----------------------------------------------------|
|    |                |                                            | Na₂CO₃ (0.5 gr) Na₂CO₃ (1.5 gr) Na₂CO₃ (3.5 gr) Na₂CO₃ (4.5 gr) |
| 1  | 1              | 4.91                                       | 4.89       4.85       4.8       4.6       |
| 2  | 3              | 4.42                                       | 4.76       4.70       4.65      4.45      |
| 3  | 5              | 4.13                                       | 4.62       4.55       4.50      4.42      |

Table 6 shows Table 6 shows the value of filtration volume decreases because the mud is getting thicker, in contrast to the CMC filtration volume of carton waste which decreases the filtration volume influenced by Na₂CO₃ because the thickness of the mud is influenced by the large amount of Na₂CO₃ applied to the mud that will reduce lost circulation and will give the lower value of mud filtrate when lower of weight. The lower volume of mud filtrate is obtain by using 5 gr of CMC carton waste and 4.5 gr of Na₂CO₃ with amount of 4.55 ml. Utilize 10 gr and 20 gr of CMC give lower mud filtrate, which is will give lower value in lost circulation (Al-Hameedi et al., 2019). Filtration loss that is too large has a bad effect on the formation and on the mud itself because it can cause formation damage and the mud will lose a lot of liquid (Fitrianti, 2017).
4. Conclusion
The results of the experiments on the mud with the addition of carton waste CMC + Na2CO3 showed identical result between CMC Industry and CMC Carton Waste which is added by Na2CO3. Moreover, CMC from carton waste give impact to rheological properties. Utilizing of 5 gr CMC and 4.5 gr of Na2CO3 increase the density value 8.75 ppg including viscosity 26 cp, mud cake 0.54 cm, mud pH 1, in contrast the value of mud filtrate will be lower 4.42 ml, by utilizing this chemical component the drilling process can be done in the best plan in order to reduce lost circulation.

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