APPLICATION OF THE CONCEPT OF CIRCULAR ECONOMY TO DRILLING MUD DESIGN

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Abstract - Oil and gas exploration and production involves processes that use a variety of equipment and materials, but at the same time generate hazardous and non-hazardous waste. As an energy-intensive, linear economic model is unsustainable, the industry is increasingly turning to a circular economy (CE) model and ecodesign products and services to reduce resource use and encourage later reuse, re-design, recovery and recyclability of materials. Increasing the use of secondary raw materials is in line with the European Commission's Circular Economy Action Plan. Accordingly, it is planned to explore the possibilities of applying the concept of circular economy in petroleum engineering. The article provides a comprehensive literature review of the use of waste materials in the design and adjustment of various properties of drilling muds. The main scientific contribution of this research is reflected in the expansion of scientific knowledge related to the possibility of applying the concept of circular economy in the reuse of waste materials from other industries in the oil industry.

Keywords - Oil and Gas, Circular Economy, Drilling Mud, Waste Materials

I. INTRODUCTION

Currently, many researchers around the world are developing and implementing the concept of the circular economy in various spheres of life and economic activities, and this research is focused on processes in petroleum engineering, exploration and exploitation of hydrocarbons and geothermal energy. The reason for this is that in the mentioned technological processes there are numerous possibilities for the application of the concept of circular economy, which, among others, include preventive measures to prevent generating certain types of waste and to reduce the toxicity and volume of unavoidable waste by using of various waste materials as drilling mud additives to adjust the desired properties. Many commercially available water-based mud additives fall into the category of non-degradable and environmentally hazardous materials (Zheng et al., 2020). Also, used mud represents the second largest volume of waste generated during the exploration and production of oil and gas (Haut et al., 2007; Gaurina-Međimurec et al., 2020). In some locations, there are other options for dealing with these types of waste, such as injection into deep underground formations (Gaurina-Međimurec et al., 2020), but reducing the amount of waste generated to the lowest possible value must be a priority. Given the current situation, there is a need to find and create new environmentally friendly additives that can provide all necessary properties of the mud at the level of current commercial additives, but with minimal impact on the environment (Zhang et al., 2014). Therefore, much research is being conducted on the use of food waste (Haider et al., 2019) and other types of biodegradable waste as additives that could be used for this purpose. The article provides a brief overview of the types and functions of drilling muds and commercially available additives for their preparation and adjustment of their properties. In addition, it provides a comprehensive literature review of the use of waste materials in the design and adjustment of various properties of drilling muds.

II. DRILLING MUD TYPES AND FUNCTIONS

In the process of drilling a well, different drilling muds (drilling fluids) can be used, which according to the continuous phase are divided into water-based mud (WBMs), oil-based muds (OBMs), synthetic-based muds (SBMs) and gaseous media (air drilling fluids). In practice, various water-based muds are mostly used. They are based on water, either fresh water, seawater, or prepared brines. In general, WBMs are satisfactory for the less-demanding drilling of conventional vertical wells at medium depths. Oil-based muds are prepared by using diesel oil or mineral oil as continuous phase. OBMs are intended for for greater depths or in directional or horizontal drilling, to improve wellbore stability and lubricity. SBMs are an emulsion of synthetic fluid, salt water and additives, with synthetic fluid being a continuous phase and brine being a dispersed phase. Synthetic fluid consists of synthetic organic compounds (instead of petroleum or diesel oil): esters, ethers, olefins. Synthetic-based muds were developed in response to environmental concerns over oil-based fluids. Air drilling fluids, such as mist, foams, and stiff foams, are used in only very specific, limited applications (i.e. low pressure zones, fractured/cavernous formation).

Drilling muds serve many functions while drilling such as: cleaning the working surfaces of drilling tools and the bottom of the well, controlling

formation pressures, transport cuttings from the bit up the annulus to the surface, suspending the drill cuttings while drilling is paused and when the drilling assembly is out of hole, sealing permeable formations, avoiding formation damage, cooling and lubricating the bit, transmitting hydraulic energy to downhole tools and the bit and, perhaps most important, containment of swelling and collapse of drilled rocks, maintaining wellbore stability, enabling the necessary measurements, reduction of the required power for lowering and pulling out drilling tools, and running of casing string, increase the rate of penetration and so on (Pašić et al, 2020; Medhi et al., 2020; Ikram et al., 2021; Li et al., 2021). Figure 1. represent schematic overview of the most important functions of the mud.

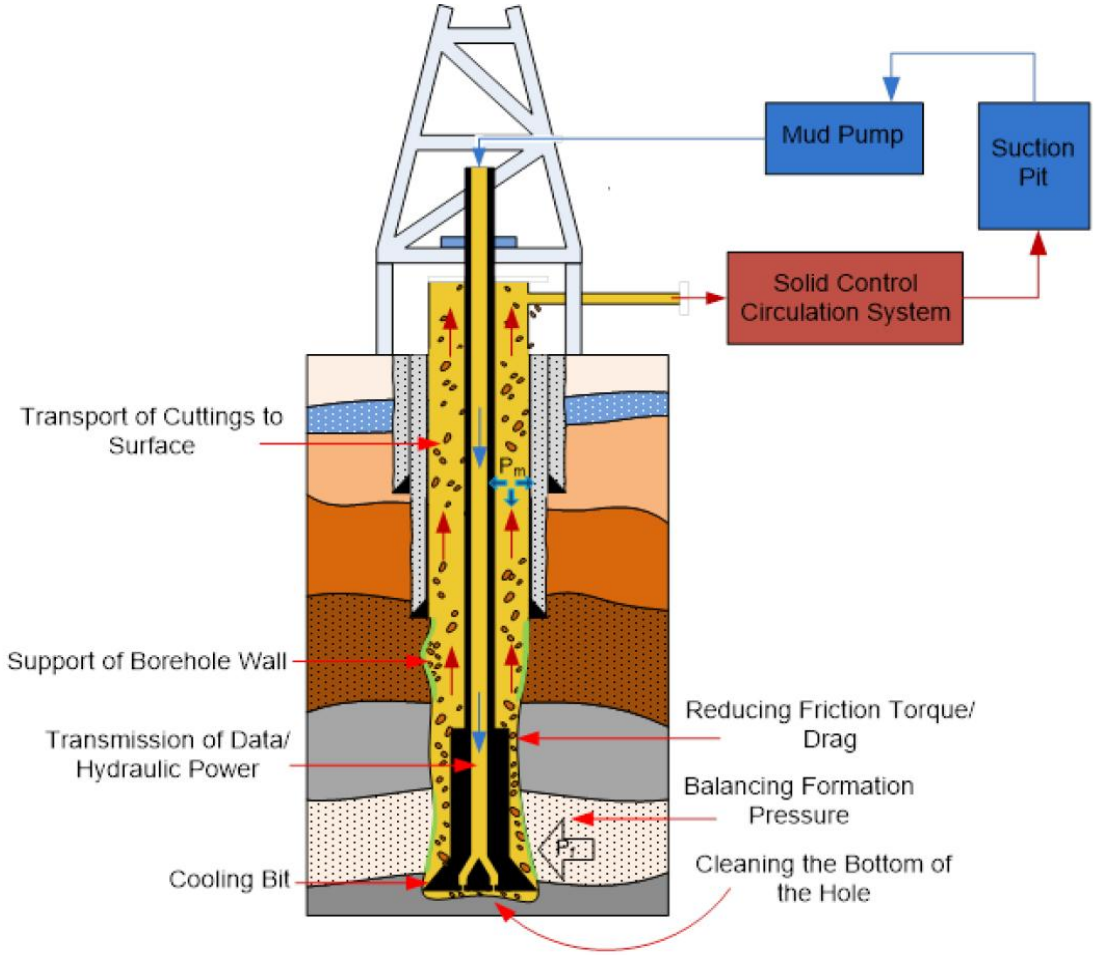


Figure 1. Drilling Mud Functions

III. DRILLING MUD COMPONENTS

The composition of all drilling muds is strictly regulated, and in some cases, in environmentally sensitive areas, the use of certain additives is restricted or prohibited, and the use of environmentally friendly and biodegradable additives is required.

The drilling muds are prepared by adding various additives to the continuous phase (water, oil, synthetic compounds) to adjust the desired properties (density, rheology, filtration etc.) of the mud. The oil industry has developed a number of additives that are used to modify the physical and chemical properties of muds to more easily overcome wellbore problems.

Rheological parameters are plastic viscosity, yield point and gel strengths (10 s and 10 min) and these parameters are especially important since they affect cutting removal from the wellbore to the surface, resistance to drilling flow, and an increase in wellbore pressure, keeping cuttings and weighting additives in suspension during the period of circulation interruption, in addition to cutting release on the surface (Medved et al., 2022).

Filtration is the process of liquid phase separation from a mud into porous formation by the influence of differential pressure, which means that filtration can also be defined as a measure of the mud's ability to cover a permeable formation with a thin and low-permeability mud cake.

Figure 2 shows the most common conventional additives added to water-based muds.

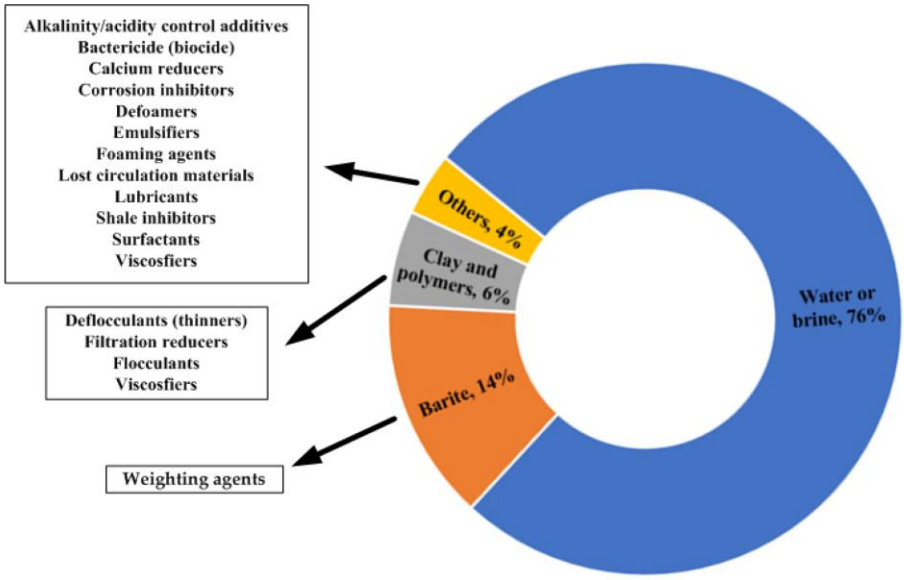


Figure 2. The most common additives that are added to water-based muds (according to IOGP, 2016 and Medved et al., 2022)

IV. WASTE MATERIALS AS DRILLING MUD ADDITIVES

According to the available data, the literature review established that different types of waste that can be used to adjust the properties of mud were tested, and that they were mainly tested in simple water-based muds (bentonite suspensions). Results obtained for this type of measurements currently do not prove the possibility of field application, so can only be used for research purposes. These studies have confirmed that some types of biodegradable waste have a positive effect on mud properties, but this area needs to be explored at a much higher level. Table 1 shows waste materials and their impact on PV, YP and API filtration of water-based drilling muds.

Waste material		Impact
mandarin peel	grass	increase PV and YP, decrease API filtration
green olive pits	saffron purple petals	
olive pulp	Corncob	
sugar cane	coconut shell	
egg shell		
potato peel	palm tree leaves	increase PV, decrease YP and API filtration
pomegranate peel	pomelo peel	decrease PV, YP and API filtration
corn starch	peach pulp	decrease PV, increase YP and API filtration
rice husk ash		decrease PV and API filtration, increase YP
banana peel		PV and YP depend on concentration, decrease API filtration

Table 1. Waste materials and their impact on PV, YP and API filtration of water-based drilling muds (Al-Hameedi et al., 2019 and 2020; Ghaderi et al., 2020; Al-Saba et al., 2018; Zhang et al., 2020; Yalman et al., 2021; Medved et al., 2022)

Figure 3 presents preparation of drilling mud contain waste materials. After the fresh waste has been collected it is kept in the oven at a temperature of 90°C for up to 48 hours to remove the moisture. The dried waste is then ground and sieved to the desired particle size and added to water with other commercial additives (shown in Figure 2) to adjust the drilling mud properties while reducing the negative impact on the environment.

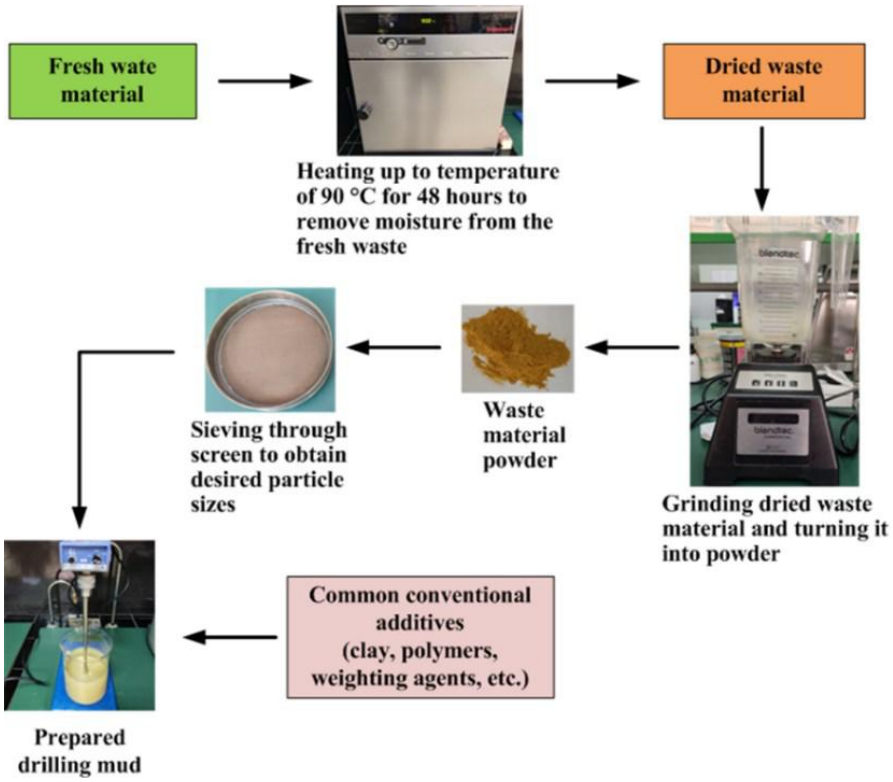


Figure 3. Preparation of drilling mud contain waste materials (modified according to Medved et al., 2022)

V. CONCLUSION

Based on literature overview, the following conclusions can be drawn:

- Waste materials can be added to water-based mud to improve drilling mud properties (rheology and filtration),
- Within the circular economy frame, the use of waste materials in this way leads to a reduction in the total amount of waste,
- The possibility of replacing toxic commercial additives with natural waste materials that are biodegradable and non-toxic, thus reducing the negative impact on the environment during drilling.

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