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RESEARCH PAPER

Influence of monoethanolamine on thermal stability of starch in water based drilling fluid system

NASIRI Alireza[1], AMERI SHAHRABI Mohammad Javad[1,*], SHARIF NIK Mohammad Amin[2], HEIDARI Hamidreza[3], VALIZADEH Majid[4]

1. Department of Petroleum Engineering, Amir Kabir University of Technology, Tehran, Iran;
2. School of Mining Engineering, College of Engineering, University of Tehran, Tehran, Iran;
3. Department of Chemical and Petroleum Engineering, Sharif University of Technology, Tehran, Iran;
4. Research Institute of Petroleum Industry, Tehran, Iran

Abstract: To improve the thermal stability of starch in water-based drilling fluid, monoethanolamine (MEA) was added, and the effect was investigated by laboratory experiment. The experimental results show that the addition of monoethanolamine (MEA) increases the apparent viscosity, plastic viscosity, dynamic shear force, and static shear force of the drilling fluid, and reduces the filtration rate of drilling fluid and thickness of mud cake apparently. By creating hydrogen bonds with starch polymer, the monoethanolamine can prevent hydrolysis of starch at high temperature. Starch, as a natural polymer, is able to improve the rheological properties and reduce filtration of drilling fluid, but it works only below 121 °C. The MEA will increase the thermal stability of starch up to 160 °C. There is a optimum concentration of MEA, when higher than this concentration, its effect declines.

Key words: monoethanolamine; starch; drilling fluid additives; water-based drilling fluid; thermal stability

Introduction

One of the most important factors that determines the success of a drilling operation is the appropriate selection of a drilling fluid. The drilling fluid composition in each operation is determined based on the situation and necessities[1]. Polymers are one of the additives in the drilling fluids that their specific characteristics have made them an inseparable component of these fluids. Starch is a natural polymer that is extensively used in the drilling industry, due to its solubility in water. The main duty of starch is reducing the fluid loss. Moreover, since starch swells in water, it is able to improve the viscosity of fluid. One of the main disadvantages of starch is being inefficient in high pressure and high temperature (HPHT) condition; so many researches have been done for improving thermal stability of starch[2]. C. G. Zhang (1986) was the first to use pregelatinized starch as an additive for improving rheological properties of drilling fluids[3–4]. Etherified starches was used for increasing solubility and viscosity of starch in drilling fluid by O. B. Wurzburg (1986)[5]. Increasing amylopectin level of starch was studied for improving thermal stability of starch by Ward, I. et al.[6–8]. Nowadays, due to the drilling into the deeper depths with high pressure and temperature is more under consideration[9], further improvement of the thermal stability of starch in drilling fluid is needed. The new additive mono ethanol amine (MEA) is added in the drilling fluid to enhance the starch thermal stability, which has been experimentally studied.

1. Experiments

1.1. Preparation of mono ethanol amine

Mono ethanol amine (MEA) is a substance that is produced from reaction of liquid ammonia with ethylene oxide, as shown in Fig. 1. This system needs a pressure of 5 to 7 MPa to preserve ammonia in liquid form. During the reaction, ammonia reacts with one, two or three ethylene oxide molecules to finally produce monoethanolamine (MEA), diethanolamine (DEA), and triethanolamine (TEA). Therefore, the

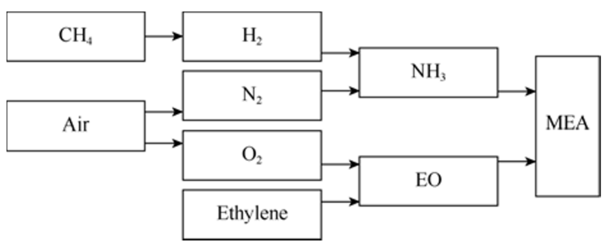

Fig. 1. The process of MEA production from methane and air[10].

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*** Corresponding author.** E-mail: Ameri@aut.ac.ir

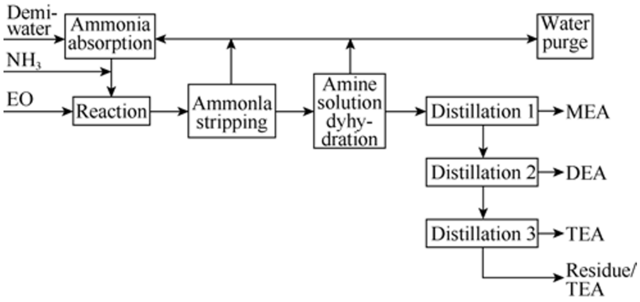

Fig. 2. The procedure of MEA distillation and purification[10].

Fig. 3. Mono ethanol amine sample.

ratio of ammonia to ethylene oxide plays a decisive role in the reaction products, in a way that increasing the share of ammonia will produce more MEA. After completing the reaction, the excessive amount of ammonia is removed from the system and also the mixed water is distilled out. Afterwards, based on Fig. 2, the ethanol amines are separated from each other in three separate distillation steps[10–12]. MEA sample is shown in Fig. 3.

1.2. Measuring the filtration rate of drilling fluids

The amount of the filtration rate of drilling fluids is analyzed and determined using the API filter press device. The aim of test is to measure the velocity of the liquid phase of drilling fluid that passes from a standard filter paper in the room temperature at a pressure of 0.69 MPa for 30 minutes, and the thickness of the mud cake on the filter paper.

1.3. Starch structure

Starch is mainly made of two polymers, Amylose and Amylopectin. Amylose polymers that compose about 25 percent of starch have a linear network, and if solved in water, they tend to gel the fluid. On the other hand, Amylopectin polymers compose about 75 of starches and have a branch form network that show less tendency to fluid gelation. Generally, starch cannot improve the fluid rheology in temperatures lower than 94 °C, because that is the minimum required temperature to dissolve starch particles and separate the polymers. The experiments show that starch polymers can preserve their structure to 121 °C. In higher temperatures, the bonds between monomers of Amylose and Amylopectin break and convert to Glucopyranose ($C_6H_{10}O_5$) monomers[2–14], and the starch loss its function.

1.4. Composition of drilling fluid samples

To prepare the experiment fluids, 350 mL of 4% m/m NaCl brine water was used in preparing the samples. 697.6 g barite was used for improving the density (with the density of 2.16 g/cm^3) and 14 g starch for increasing the drilling fluids rheological parameters and reducing the filtration rate of drilling fluids. The polymer dissolution time should be 20 minutes. MEA concentrations used in the drilling fluid samples were 0, 0.5%, 1.0%, 2.0% and 4.0%.

2. Experiment results and discussion

2.1. Effect of MEA on rheological properties and filtration rate of drilling fluids

Since yield point (YP) and plastic viscosity (PV) in Bingham plastic rheology model are effective parameters on the fluid pressure loss, and also are proper indicators for investigating the fluid behavior in annulus, their lower amounts of the standard values will reduce the efficiency of the drilling fluid in carrying the cuttings and performance of the drilling fluid in the annulus space. According to Fig. 4, given the temperature of 121 °C, 149 °C and 160 °C, as the MEA concentration increases, PV increases and then decreases. While rising the temperature to 177 °C, the trend is opposite. This indicates that MEA is able to increase the thermal stability of starch up to 160 °C, and the improvement of starch thermal stability is significant. It should be noted that the optimum MEA concentration is 2 Vol% that compared to other concentrations. The results revealed that the base fluid could preserve its efficiency only at 121 °C (Fig. 5). But, as the temperature would rise to 149 °C, the fluid YP reached 0. This means that starch without MEA would shows its performance only at temperatures lower than 121 °C. Incrementing the concentration would increase the YP.

As shown in Fig. 6, the apparent viscosity increases as the MEA concentration increases. The concentration of 2% was observed as the optimum concentration in the results that are

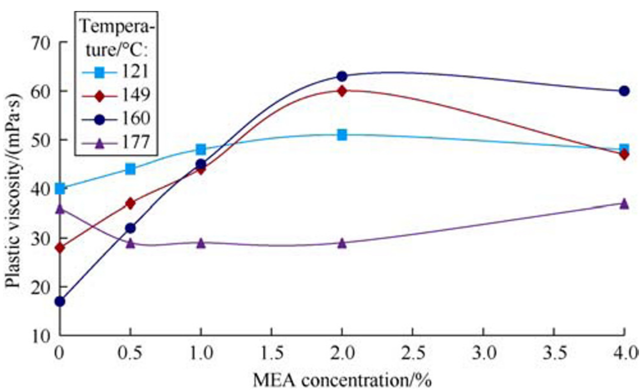

Fig. 4. PV variations for different MEA concentrations and temperatures