THE USE OF POLYPROPYLENE BEADS IN TRANSPORTING DIFFERENT SIZES OF CUTTINGS IN WATER-BASED MUD

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This special work is dedicated to my lovely parent, Halimah Bte. Mohd Din and Hamzah Bin Talib as well as my beloved siblings. Also, I thank God for the many blessings that He has continued to bestow upon me.

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ABSTRACT

It has been commonly acknowledged that a good wellbore cleaning is highly essential to cut off the unnecessary spending in drilling operations. There are many new technologies that have been introduced to address the poor wellbore cleaning issues. In this study, the experimental investigation focused on the use of polypropylene-based polymer beads as a mechanism to enhance cuttings transportation in water-based mud. The primary objective of this study was to observe the performance of the polymer beads in lifting the different sizes of drilled cuttings in water-based mud. The cuttings lifting rig was equipped with a 13 ft long and 2 in ID acrylic pipe with a 0.79 in inner pipe OD with no rotation. The tests were conducted using a 11 ppg water-based mud (PV = 12.5 cp, YP = 14.5 lb/100 ft^2) and constant annular velocity of 0.78 m/s at ambient condition. Six different sizes of drilled cuttings, ranging from 0.50 to 3.34 mm, were used and the lifting performances were done at five different angles, i.e., 0^o (vertical), 30^o, 60^o, 75^o, and 90^o (horizontal). Over 250 tests have been carried out. It was divided into two phases of run, namely test run using basic water-based mud and test run using drilling mud containing 1% (by weight) of polymer beads. The experimental results showed that the cuttings transport efficiency with the presence of polymer beads in basic water-based mud was better than basic mud especially in a vertical hole. In terms of drilled cuttings sizes, however, the drilling mud with polymer beads was found to have transported better the smaller drilled cuttings than larger one. Despite a relatively low recovery at highly deviated angles, the use of polymer beads has shown some improvements in cuttings transport.

ABSTRAK

Pembersihan lubang telaga yang baik sememangnya diketahui ramai bolehmengurangkankos operasi penggerudian. Sesungguhnya banyak teknologi baharu yang telah diperkenalkan bagi menangani isu pembersihan lubang telaga. Dalam kajian ini, tumpuan diberikan terhadap penggunaan butiran polimer berasaskan polipropilena sebagai suatu mekanisme untuk meningkatkan pengangkutan rincisangerudi dalam lumpur dasar air. Objektif utama kajian adalah untuk mengkaji prestasi butiran polimer dalam mengangkat rincisan gerudi yang berlainan saiz dalam lumpur dasar air. Rig angkat rincisanyang digunakan dalam kajian adalah dilengkapi paip akrilik sepanjang 13 kaki dengan diameter dalam 2 inci, dan mempunyaisatu batang paip pegun yang berdiameter luar 0.79 inci. Ujian telah dilaksanakan pada keadaan ambien menggunakan lumpur dasar air berketumpatan 11 ppg (PV = 12.5 cp, YP = 14.5 Ib/100 kaki^2) dengan halaju anulus malar yang bernilai 0.78 m/s. Rincisan gerudi dengan enam saiz berlainan, iaitu dari 0.50 mm hingga ke 3.34 mm, telah diuji kesannya pada kedudukan sudut paip yang berbeza, iaitu, 0° (tegak), 30°, 60°, 75°, dan 90° (mendatar). Lebih 250 ujian telah dilaksanakan yang mencakupi dua fasa, iaitu fasa pertama melibatkan ujian yang menggunakan lumpur dasar air, manakala fasa kedua mencakupi ujian yang menggunakan lumpur dasar air yang mengandungi 1% (berdasarkan berat) butiran polimer. Keputusan kajian menunjukkan bahawa kecekapan pengangkutan rincisanbagi lumpur dasar air dengan butiran polimer adalah lebih baik daripada lumpur dasar air terutama dalam lubang tegak. Walau bagaimanapun, dari segi saiz rincisan gerudi, lumpur dasar air yang mengandungibutiran polimer telah berjaya mengangkut rincisan gerudiyang bersaiz kecil dengan lebih baik berbandingrincisan yang bersaiz besar. Walaupun kadar perolehanadalah agak rendah pada sudut yang menyimpang dari tegak tetapi penggunaan butiran polimer telah menunjukkan peningkatan dalam pengangkutan rincisan gerudi.

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LIST OF ABBREVIATION

^oC	=	Degree celcius
% wt	=	Weight percentage
^{o}	=	Degree
>	=	More than
<	=	Less than
ρ_s	=	Density of solid
ρ_i	=	Density of initial mud
ρ_f	=	Density of final mud
ρ_{mud}	=	Density of drilling mud
μ_{mud}	=	Plastic viscosity of drilling mud
μ	=	Viscosity
μ_{eff}	=	Effective fluid viscosity
μm	=	Micrometer
cp	=	Centipoise
C_D	=	Drag coefficient
CTE	=	Cuttings Transport Efficiency
d_p	=	Particle or sand diameter
ft/s	=	Feet per second
ft/min	=	Feet per minute
ft	=	Feet
F_g	=	Gravitational force
F_b	=	Buoyancy force

F_d	=	Drag force
F_l	=	Lift force
F_{van}	=	Van der waals force
g	=	Grams
g/cc	=	Grams per cubic centimeter
hp	=	Horse power
in	=	Inch
ID	=	Inner diameter
kW	=	Kilowatt
lb	=	Pounds
ml	=	Milliliter
mm	=	Millimeter
m/s	=	Meters per second
MAV	=	Minimum annular velocity
Ohm-m	=	Ohm meter
OBM	=	Oil-based mud
OD	=	Outer diameter
ppg	=	Pounds per gallon
PV	=	Plastic viscosity
PVC	=	Polyvinyl chloride
rpm	=	Revolution per minute
Re	=	Reynolds number
ROP	=	Rate of penetration
v_{mud}	=	Velocity of flowing mud
v_{sl}	=	Particle slip velocity
V_s	=	Volume of solid
V_f	=	Final volume of mixture
w	=	Watts
WBM	=	Water-based mud
WBMPB	=	Water-based mud with polymer beads
YP	=	Yield point

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CHAPTER 1

INTRODUCTION

The aim of this chapter is to introduce the research project and to outline the research themes that guide the study. The research presented in this thesis is rooted within the existing decision theory and oil industry literatures. It gives an alternative solution in wellbore cleaning and hence provides solutions to drilling problems.

1.1 BACKGROUND

Drilling is one of the risky businesses and it requires high capital cost in the upstream business. The increase of the drilling cost especially in drilling a deviated well is due to the increased number of occurrence of several wellbore problems. One of them comes from poor wellbore cleaning jobs (Yu *et al.,* 2004). Due to the complexity of the behavior of the flow in annulus, numerous researches on wellbore cleaning have been carried out since 1980s in order to understand the problems and hence to seek the effective methods and solutions to the problems. In Malaysia, most of the reservoirs are unconsolidated or poorly consolidated. With the increasing number of horizontal and highly inclined wells drilled through these types of reservoirs, smaller-sand-sized-solids transport is becoming a main concern during drilling operations (Duan *et al.,* 2009).

Having a good combination of drilling fluid rheology and other parameters is important in drilling to ensure that transportation of cuttings from the bit up to the surface can be done as effectively as possible.

Failure to remove the drilled cuttings would lead to the accumulation of drilled cuttings in an annulus or low side of hole if it is a deviated well. The formation of plugs of cuttings impedes drilling and gives rise to high over pulls, loss circulation, continuous need for operations such as back reaming, stuck pipe, difficulties in logging, poor cementing jobs, reduction in rate of penetration, faster bit wear, losing control of the bottom hole pressure, etc. These may lead to the economic penalty. The severity of these problems depends on the amount and location of cuttings distributed in a wellbore (Clark and Bickham, 1994).

It is very important to understand well every influential parameter that affects the wellbore cleaning. By doing so, non-productive time can be minimized and it indirectly reduces the additional drilling cost. Figure 1.1 shows the identified key parameters which influence the transport of drilled cuttings (Nazari *et al*., 2010). In this study, only two parameters were varied, namely the sizes of cuttings and hole angles of pipe. While to observe the effectiveness of cleaning, polypropylene-based polymer beads were used in mud system. For other parameters, they were kept constant throughout the investigation.

1.2 OBJECTIVE

The objective of this research was to investigate the performance of the polypropylene-based polymer beads in water-based mud in transporting the different sizes of cuttings in a wellbore. In other words, this study only focused on the different sizes of cuttings at different pipe geometry angles. The effect of rotation of drill pipe and wellbore eccentricity, however, were not included in this experiment.

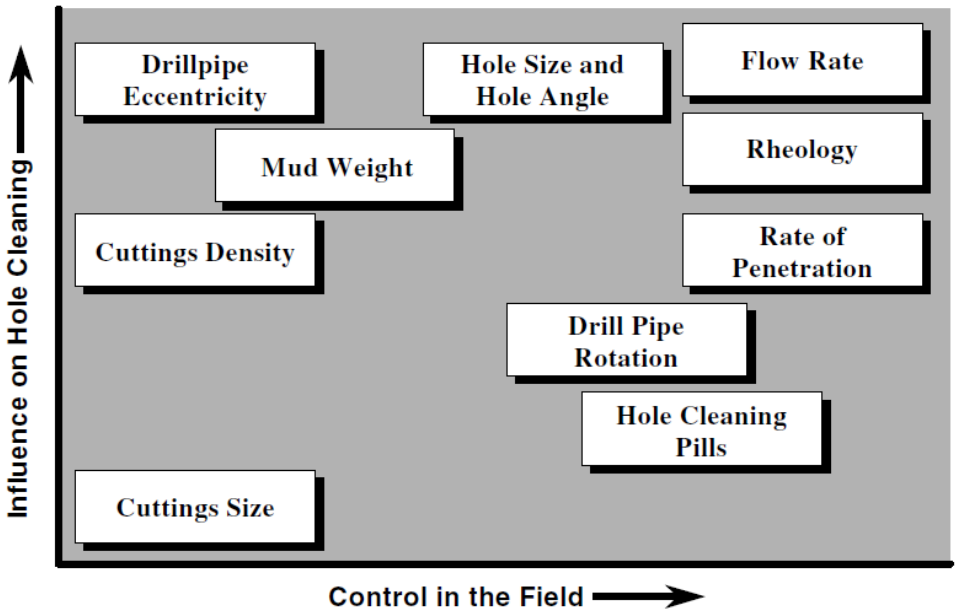

Figure 1.1 Influential key parameters in wellbore cleaning (Nazari *et al*., 2010)

1.3 SCOPE

The following scope of works had been set to carry out the experimental investigation:

(1) Designed and fabricated a separation system to trap different sizes of cuttings and polymer beads.

(2) Modified the flow loop by adding additional lines and water tanks for flushing purposes.

(3) Adjusted the cuttings feed hopper to suitable location.

(4) Sieved the beach sand to separate into six different sizes of sand using sieve shakers.

(5) Measured the density of the six sizes of cuttings and polymer beads, using ASTM D4253-00 (2006).

(6) Formulated water-based mud according to industry specification.

(7) Evaluated the polymer beads performance in lifting the different sizes of cuttings using water-based mud in vertical, deviated (30^o, 60^o, and 75^o inclination) and horizontal condition at a constant velocity of 0.78 m/s.

1.4 OUTLINE OF DISSERTATION

This dissertation is divided into five chapters. Chapter 1 discusses about the objective and scopes of the work. Chapter 2 draws the broad of literature review of wellbore cleanings to provide a brief description of the context of the current study that highlights the parameters and mechanisms in wellbore cleaning. Chapter 3 outlines the methodology adopted in the research. Chapter 4 presents the findings from the experimental works. All data collected from the research works were evaluated and discussed in terms of their appropriateness for the study. Whilst the Chapter 5 primarily brings together the information gathered for the dissertation and sets out the conclusions that have been drawn from the research works. Recommendations or suggestions for the better experiments in the future are also presented in this chapter.

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