Improving Hole Cleaning on High Angle Wells

by

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CHAPTER 1

INTRODUCTION

1.1 Background

Hole cleaning is the ability of a drilling fluid to suspend and transport drilled cuttings from down hole (bit face) to the surface. While several parameters/factors can affect hole cleaning efficiency such as; fluid viscosity (μ), annular velocity (Va), angle of inclination (α), and drilled cuttings size and shape. The following figure demonstrates the process of hole cleaning in an annular section of a high angle (deviated) well:

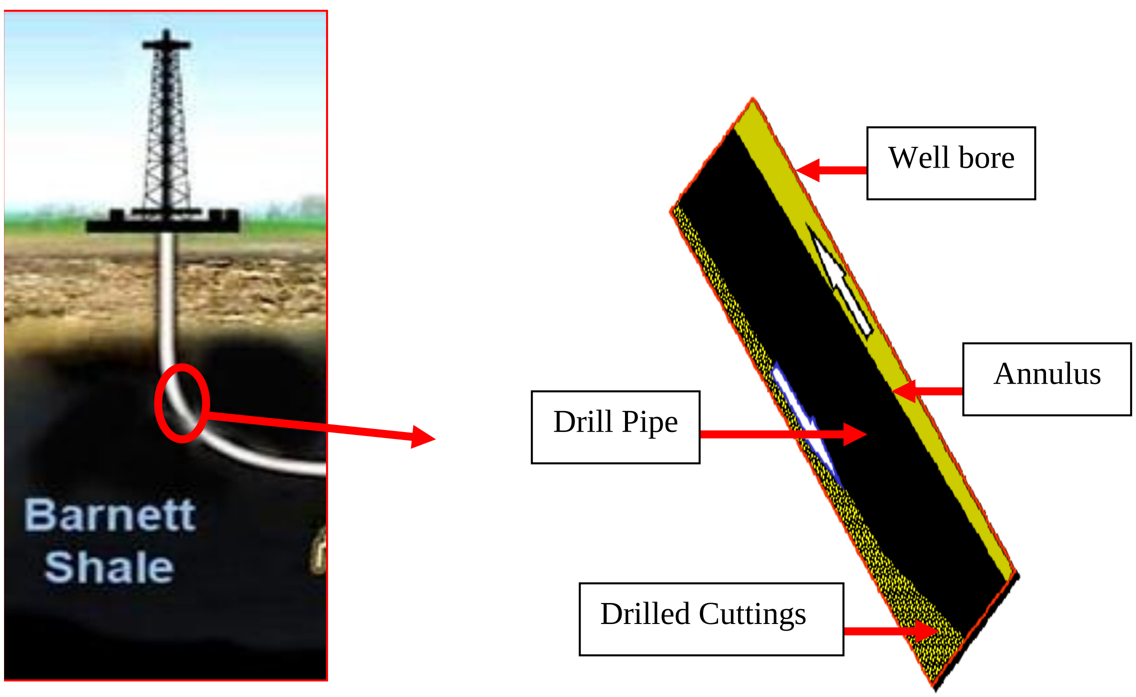

Figure 1.1 Annular section of a deviated well

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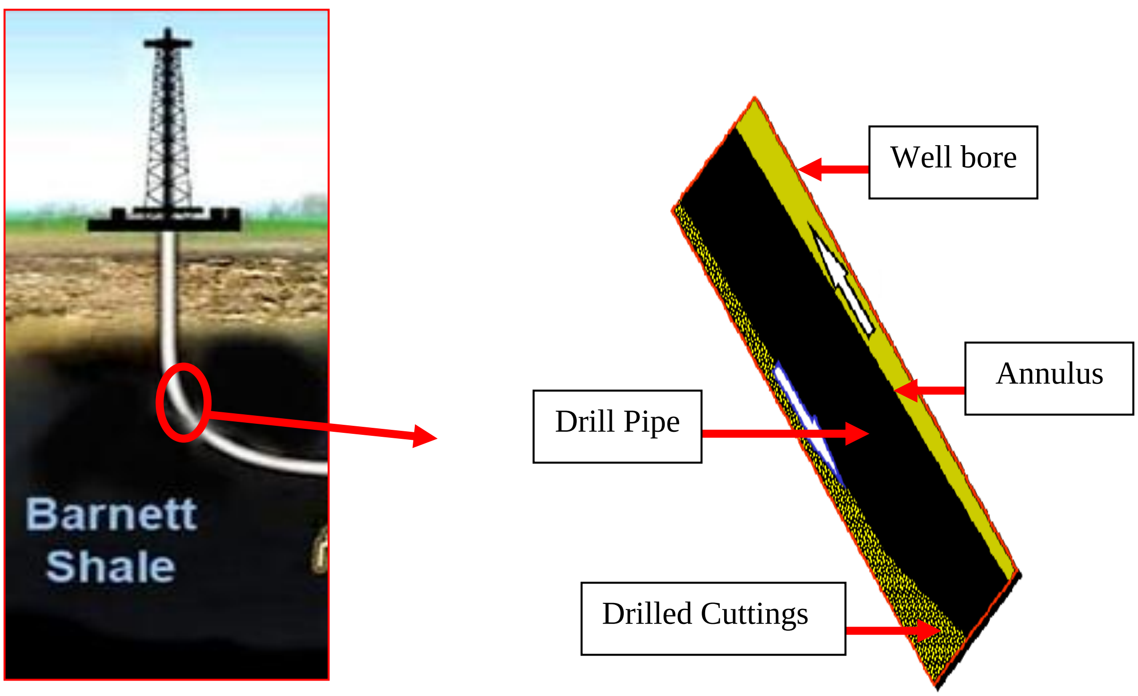

Figure 1.1 Annular section of a deviated well

Inadequate/poor hole cleaning is a major problem in drilling operations. Poor hole cleaning will lead to a number of drilling problems namely; excessive over pull on trips, high rotary torque, stuck pipe, formation break down, slow rate of penetration (ROP), and lost circulation. This in turn, will lead to higher drilling cost.

1.2 Problem Statement

Poor hole cleaning becomes a serious issue specially when drilling high angle (deviated) wells because, drilled cuttings tend to settle on the lower side of the well bore which may lead to other drilling problems such as suck pipe. By increasing hole cleaning efficiency we will speed up the drilling operations, and therefore, reduce the total cost to drill one well.

Extensive studies were carried out by many researchers either experimentally or through simulation. Researchers were focusing on tackling poor hole cleaning issues for both vertical and horizontal wells. The use of CFD simulation was introduced lately in the 1990s after it had been globally recognized that software such as FLUENT can actually produce reliable and accurate results. However, previous simulation works were only targeting vertical and horizontal wells. This study is the first attempt to use CFD simulation to virtually examine drilled cuttings transportation on high angle (deviated) wells.

1.3 Objectives and Scope of Study

1) To determine the effect of cuttings size and shape on the efficiency of hole cleaning.
2) To measure the effect of different angles of inclination (α) on the efficiency of hole cleaning.
3) To determine the optimum annular velocity to be used to improve the efficiency hole cleaning on high angle wells

This project is divided into two main parts. The first part is aimed to design a computational model using GAMBIT 2.2.30 software. And the second part is to simulate the designed model using FLUENT 2.2.16 software to study the effect of the parameters mentioned above (refer to objectives) on the efficiency of well hole cleaning.

1.4 Significance of the Study

For any company to be successful as well as profitable, operation cost should be minimal. Drilling is one of the costly operations in oil and gas industry. This study has a significant value since it can help to optimize/maximize the drilling operation by eliminating the occurrence of severe problems such as poor hole cleaning.

CHAPTER 2

LITERATURE REVIEW

According to Piggott in 1941, cuttings with volume up to 5% can be transported safely, but a higher concentration might cause hole trouble. He introduced the concept that turbulent flow induces turbulent slip velocities and suggested that laminar flow in the annulus will result in more efficient transport [2].

Zeidler and H. Udo in 1970, developed mathematical model to predict the volumetric cuttings concentration in a vertical well bore. It showed that the predicted concentration is high at low fluid velocities while drilling is in progress. The model determined accurate values of cuttings concentration, provided that the laminar fluid velocity is at least twice the particle settling velocity [2].

Sifferman, et al in 1973, carried out a full scale steady state operation with a 140 ft high oil field derrick as the main frame. 12-in ID casing was used with 3 ½ in drill pipe. Four different mud weight (10 ppg, 12 ppg, and 15 ppg) and water with three different sizes of simulated chips 1/16 in, 1/8 in, and ¼ in were used for the experimental study. They reported that cutting transport efficiency increases as fluid viscosity increases. In laminar flow cutting transport is 85 % to 90% of the theoretical values based on the terminal slip velocity of the cuttings. In turbulent flow, cutting transport is around 75% of the theoretical value.

Also they concluded that the transport ration increases rapidly with increase in annular mud flow rate then begins to increase slowly in the mud flow range of 200 to 400 gpm. Moreover, they reported that the cutting size had moderate effect on cutting transport [2].

Hussain et. al in 1983, carried out a series of experimental study of drilled cutting transport using common drilling fluid. An annulus with a nominal length of 50.2 ft, an

ID of 5 in. and inner core consisted of 1.2 in. OD steel tubing was used for the study. They reported that an increase in both the annular velocity and yield point will increase the efficiency of hole cleaning [2].

Okranji and Azar in 1985 reported that the YP/ PV ratio should be as high as possible to better hole cleaning [2].

Martin et. al in 1987 concluded that the particle transfer rate depends to a large extent on the flow rate. When the flow rate is too low, the particle is no longer separated in the annulus [2].

Seeberger et al in 1989 reported that the low shear viscosity parameters should be evaluated to obtain good hole cleaning [2].

Gavignet and Sobey in 1989 presented a two layer cutting transport model on slurry transport. They assumed that the cuttings had fallen to the lower part of the inclined well bore, and had formed a bed that slips up the annulus. Above this bed, a second layer exists of pure mud. Eccentricity is taken into account in the geometrical calculations of wetted perimeters and an apparent viscosity can be calculated for non Newtonian muds using rheogram written in polynomial form [2].

Becker et in 1989 studied experimentally the effects of viscosity and gel formation on cutting transport properties in deviated wells for fifteen different water based drilling fluid systems viscosified with bentonite and polymers. They reported that the hole cleaning performance correlated to the 3 rpm shear stress measured on a VG meter. They also observed that the cuttings bed size was reduced if the shear stress at the actual pump rate was increased [2].

Sharma in 1990 extended Gavignet and Sobey's modeling approach by separating the particle layer into two separate layers. This allows having at the same time both a stationary and sliding beds [2].

Martins and Santana in 1992 presented a two layer model that is more versatile than Gavignet and Sobey's model, because it allows particles to be in suspension in the upper layer. The mean particle concentration in this layer is calculated from a concentration profile that has been obtained from solving a diffusion equation [2].

Belavadi and Chukwu in 1994 used experimental flow loop with transparent acrylic casing- drill pipe annulus. Four different weights of bentonite mud samples (8.9 ppg, 9.3 ppg, 12 ppg, and 13 ppg) with cutting chips of graded sizes small, medium, and large were introduced into the annular column from the bottom section of the transparent acrylic pipe. They used a non dimensional approach and observed that an increase in the flow rate at higher fluid densities greatly increase the transport ratio. This effect is almost negligible when using low density fluids transport large size cuttings. They reported that the fluid density to viscosity ratio concept can be applied to control drilling through sensitive formations. A small increase in the fluid density to viscosity ratio results to a rapid decrease in the transport ratio. Similarly, a small increase in the drag coefficient on the cuttings results to a large increase in the transport ratio [2].

Larsen et al in 1997 developed a new mathematical method for estimating the minimum fluid transport velocity for system with the inclination between 55º to 90º. They found that the model worked fairly well within inclination angle 55º to 90º, and there were no correlation factors yet for inclination less than 55º. From the Larsen method it was known that there are three parameters which affect the determination of minimum fluid annular velocity for inclined hole as following; inclination, rate of penetration (ROP), and mud density [2].

Walker and Li in 2000 used a flow loop that consisted of 20 ft long transparent Lexan pipe with a 0.5-in ID to simulate the open hole and a 2 3/8-in steel inner pipe to simulate coiled tubing. Three different types of mud (HEC, Xanvis polymer, and water with particle sizes ranging from 0.15 mm to 7.0 mm) were used for the study. They reported that fluid rheology plays an important role for solid transport and to achieve optimum results for hole cleaning, the best way to pick up solids is with a low viscosity fluid in turbulent flow but to maximize the carrying capacity a gel or multiphase system should be used to transport the solids out of the well bore [2].

Hyun et al in 2000 formulated a mathematical three layer model to predict and interpret the cuttings transport in a deviated well bore from horizontal to vertical during coiled tubing drilling. The model predicts based on the simulation are in good agreement with the experimental data published by others [2].

Md Wazed Ali in 2002 reported that for the same drilling fluid horizontal well has better hole cleaning then vertical well. Also he claimed that the effectiveness of a circulating fluid in removing drilled cuttings is not only dependent on the rheology of the fluid, but also on whether the fluid is in laminar or turbulent flow. Furthermore, for a tested particle sizes ranging from 0.10 in to 0.275 in, he concluded that the hole cleaning efficiency is party dependent upon the particle’s size

Referring to the findings above, this simulation base project will focus totally on improving hole cleaning on high angle wells using Computational Fluid Dynamics (CFD).

Annular pressure loss (ΔP) is the amount of pressure drop in the annulus [1]; it is one of the important boundary conditions that the author uses as an input to FLUENT 6.2.16

simulation software. The following are the two most commonly used models to calculate the annular pressure loss:

2.1 Bingham Model

$$\text{Annular pressure loss (KPa)} = \frac{\mathbf{L * Q * PV}}{\mathbf{408.63 * (Dh+Dp) * (Dh–Dp)3}} + \frac{\mathbf{YP * L}}{\mathbf{13.26 * (Dh–Dp)}}$$

Where:

L: Length of section (m)

Q: Flow rate (L / m)

PV: Plastic Viscosity

YP: Yield Point

Dh: Hole diameter (in)

Dp: Pipe outer diameter (in)

2.2 Power Law Model

$$\text{Annular pressure loss (kPa)} = \frac{\mathbf{fp * v^2 * \rho * L}}{\mathbf{1800 * (Dh - Dp)}}$$

Where:

f_P: Friction factor in the pipe

v^2: Average velocity in the annulus (m / s)

ρ: Mud density (kg / m3)

L: Length of the section (m)

D_h: Hole diameter (mm)

D_p: Pipe outer diameter (mm)

CHAPTER 3

METHODOLOGY

To carry out this study, a computational model was designed using GAMBIT 2.2.30 software to represent a setup of a hole/casing with a diameter of 9.875 inches and a drill pipe with a diameter of 5 inches. After that, a Cooper mesh was generated in the annular section, since it is the area where the fluid flow will take place. Then, the model was imported into FLUENT 6.2.16 software where discrete phase model was selected to inject cuttings into the fluid flow at the inlet. FLUENT 6.2.16 was chosen as a solver, because it enabled the author to measure the effect of different drilling parameters (i.e. annular velocity, angle of inclination etc…) on the efficiency of hole cleaning. The following are brief description/definition of parameters considered in this study:

3.1 Cuttings Size

Three different cutting sizes were studied. These were 2.54 mm, 4.445 mm, and 6.985 mm. for small, medium and large cuttings respectively. The three cutting sizes are of the same density which is 2.57 gm/cc. Limestone was the source rock for all three cutting sizes. It was decided that the three cutting sizes should have the same density to better understand the effect of cuttings size and shape on the efficiency of hole cleaning.

3.2 Cuttings Shape

Practically, drilled cuttings could have different shapes and sizes depending on the types of formation to be penetrated and the drilling fluid used. Experimental work has shown that drilled cuttings shape does influence the efficiency of hole cleaning. It is believed that drilled cuttings with bigger cross-sectional/projection area will have a better hole cleaning or rather better cuttings transport. In this study, different drilled cuttings with different shapes (shape factors) were chosen and simulated and their effect was reported.

3.3 Angle of Inclination (α)

It is believed that different inclination angles will have different effect on the efficiency of hole cleaning. As part of this study a set of inclination angles were be studied closely and their impact on the efficiency of hole cleaning was reported. For the sake of this study, the author had used angles of inclination ranging between 10 to 25 degrees.

3.4 Annular Velocity (Va)

Annular velocity is the speed at which a drilling fluid moves/transport in the annulus. It is important to monitor fluid annular velocity to assure that the hole is being properly cleaned of cuttings, and other debris while avoiding erosion of the borehole walls. The annular velocity is commonly expressed in units of feet per minute, meter per minute, or even a gallon per minute (GPM). In this study, the author had used annular velocities ranging between 600 to 900 gallon per minute (GPM).

3.5 Tools and Equipment Required

The following are the tools/softwares used through out the study:

- GAMBIT 2.2.30 software
- FLUENT 6.2.16 software
- Microsoft Excel software

GAMBIT 2.2.30 and FLUENT 6.1.16 are Computational Fluid Dynamics (CFD) simulation softwares. The author had chosen CFD simulation, because it is simple, accurate, fast, and easy to use. CFD is a powerful computational modeling tool, it has a wide range of applications, for example; modeling fluid flow and heat transfer in complex geometries.

3.6 Advantages of Using CFD Modelling

CFD modeling can be used to handle the following:

- Two and three dimensional flow
- Incompressible or compressible flows
- Steady state or transient analysis
- Laminar or turbulent flows
- Newtonian or non Newtonian flows
- Convective heat transfer, including natural or forced convection
- Radiation heat transfer
- Flow in porous media
- One phase or two phase flows
- Stationary or rotating reference frame models
- One dimensional fan/heat-exchangers performance models
- Two phase flows with complex surface shapes

3.7 Assumptions and boundary conditions

The following are the assumptions and the boundary conditions which will be used in this project

- Fluid flow is laminar
- The flow is fully developed
- Two phase fluid flow

- Non Newtonian flow
- Drill pipe outside diameter is 5 inches(=127mm)
- The well bore inside diameter in 9 7/8 inches(=250.825 mm)
- Fluid velocity at the walls (well bore and drill pipe) is zero
- There is a pressure drop across the length of the section
- Annular fluid velocity (Va) is known
- The drill pipe is stationary (not rotating)
- The drill pipe is positioned at the center of the well bore
- The analysis will be conducted per hundred meters length of the well bore.
- There is no energy or mass transfer between particles
- The impact force effect is neglected between particles
- Drilled cuttings have the same density

3.8 Procedure of Modeling Using GAMBIT 2.2.30 Software

The following is the step by step procedure that shall be used to design the model in GAMBIT 2.2.30 software:

1) Draw two concentric cylinders:

I) Key in the radius of casing in meters
II) Input the height of the well bore and then click apply
III) Key in the radius of the drill string in meters
IV) Input the height of the well bore and then click apply

This step will enable us to draw two concentric cylinders representing the casing and drill string setup. Please refer to the figure below for further assistance.

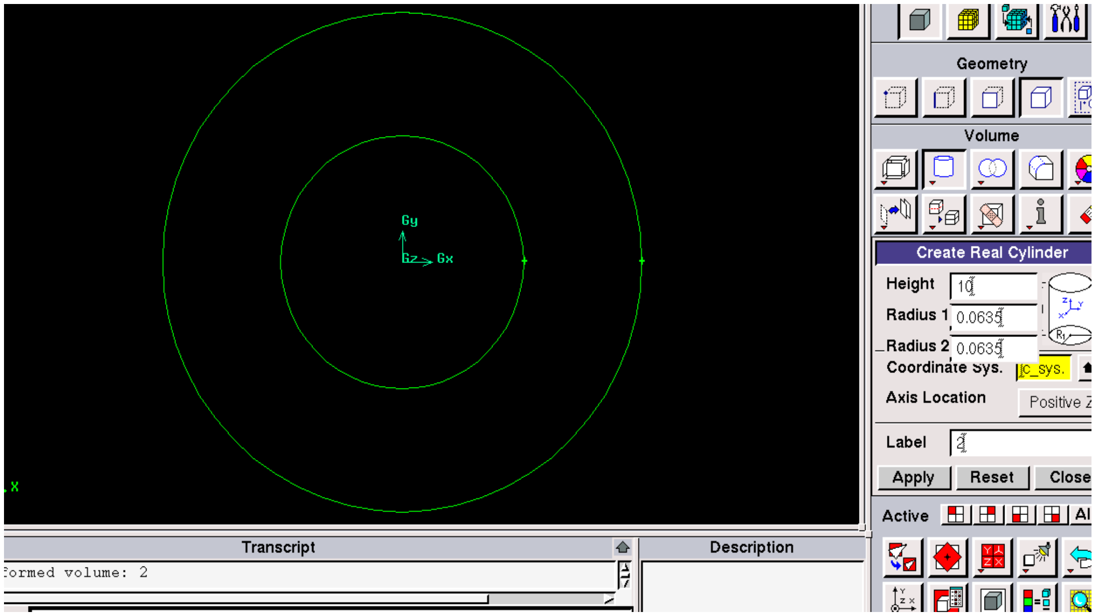

Figure 3.1: How to draw two concentric cylinders in GAMBIT 2.2.30

2) Subtraction:

I) Click the subtraction icon

II) Select the volume to subtract from

III) Select the volume to be subtracted

IV) Click apply icon to execute the subtraction command

This step is aimed to distinguish the area where the fluid flow shall take place. Please refer to the following figure for further illustration.

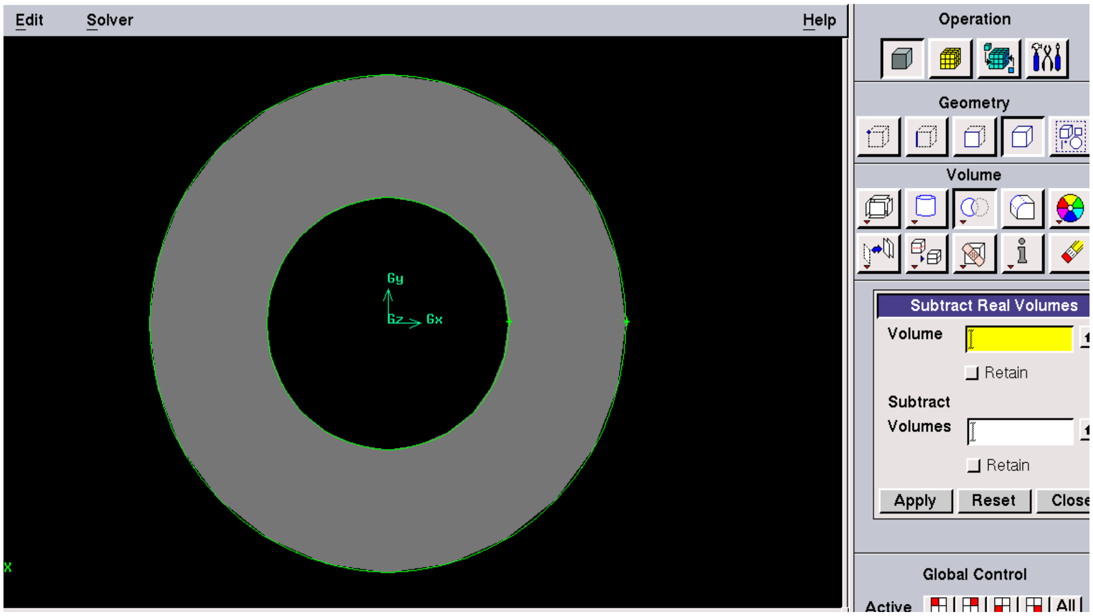

Figure 3.2: Annular area where fluid flow will take place

3) Meshing

I) Select one face to be meshed

II) Select the type of meshing to be used

III) Specify the spacing to be applied while meshing the model

IV) Click apply

V) Select the volume to be meshed

VI) Select the type of meshing to be used

VII) Specify how much spacing is needed to mesh the model

VIII) Click apply

Meshing is carried out so that the model is divided into small discrete elements/cells. These tiny cells are essential and their size will affect the accuracy of the simulation later on. Hence, it is advised that someone should optimize the meshing in order to obtain accurate results. The following figure demonstrates the steps involved to do meshing.

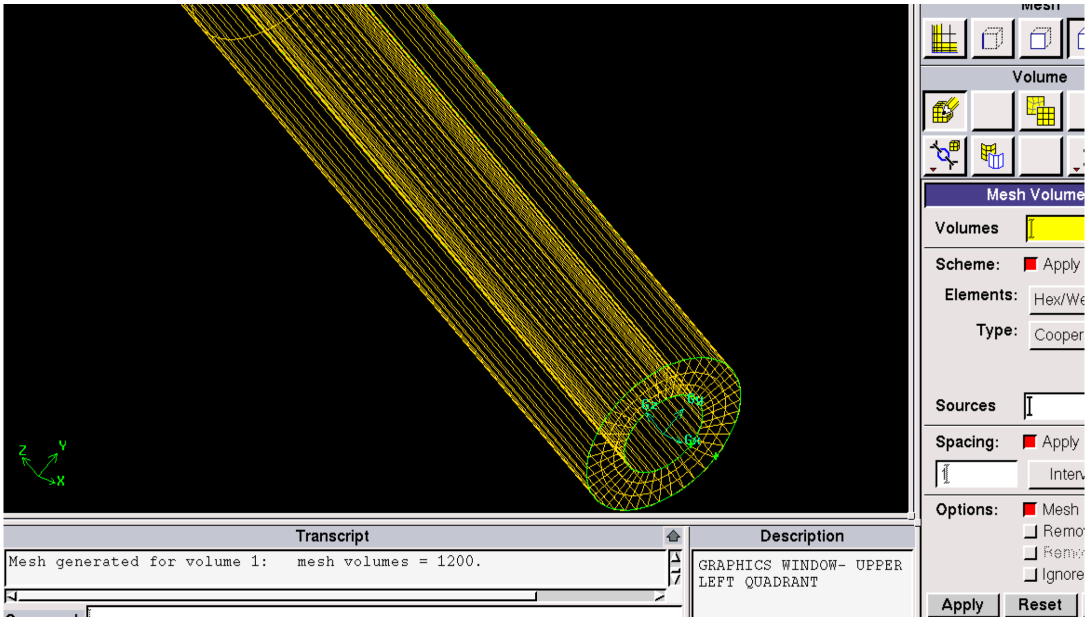

Figure 3.3: Meshing the model using GAMBIT 2.2.30

4) Specify the boundary conditions in GAMBIT 2.2.30:

I) Click on Zones icon

II) Specify the boundary conditions at the inlet and the outlet

III) Specify the boundary conditions at the inner and the outer walls

IV) Click apply

V) Export the mesh to FLUENT 6.2.16 software

VI) Close GAMBIT software

The flowing figure shows how to specify the boundary conditions in GAMBIT software.

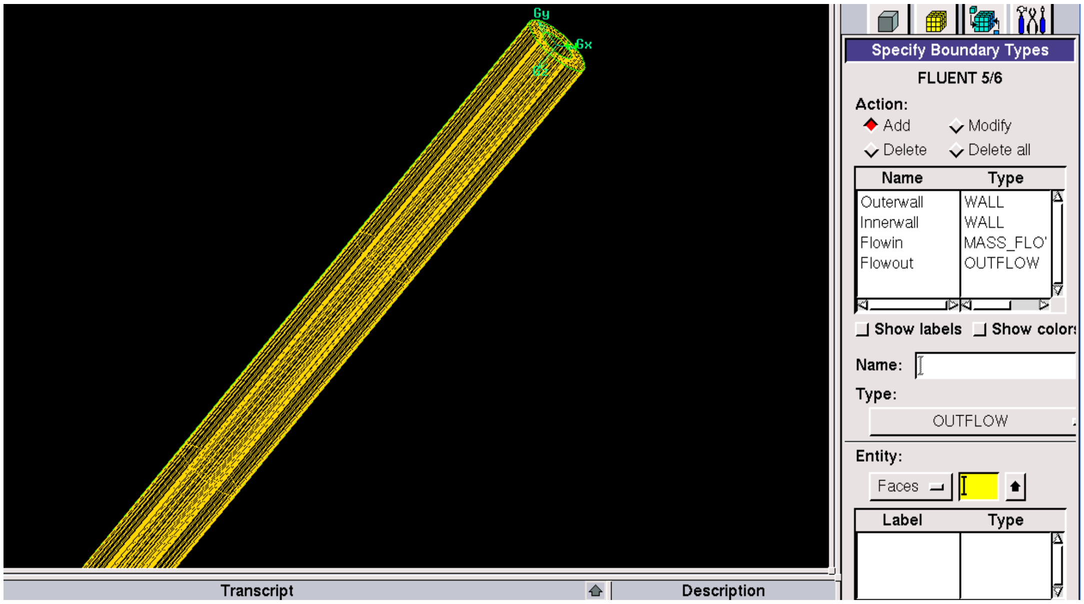

Figure 3.4: Boundary conditions

3.10 Flow Chart of the Project

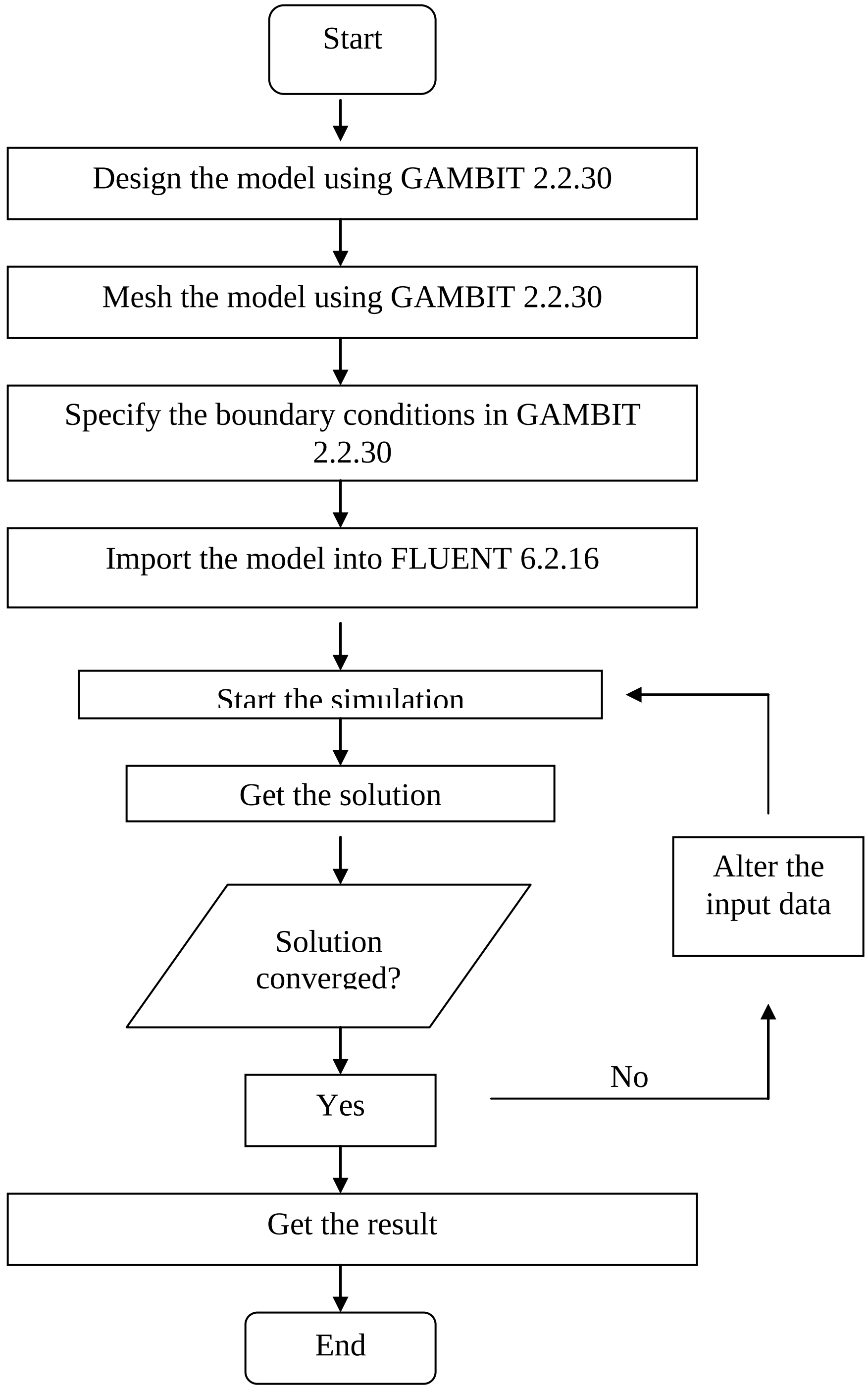

Figure 3.13: Flow Chart of the project

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Design Result:

An annular section of the drill string was designed using GAMBIT 2.2.30 software. The model could be designed using other software such as CATIA, but it was realized that GAMBIT 2.2.30 was simpler and easier to be used. The following figure show different views of the model.

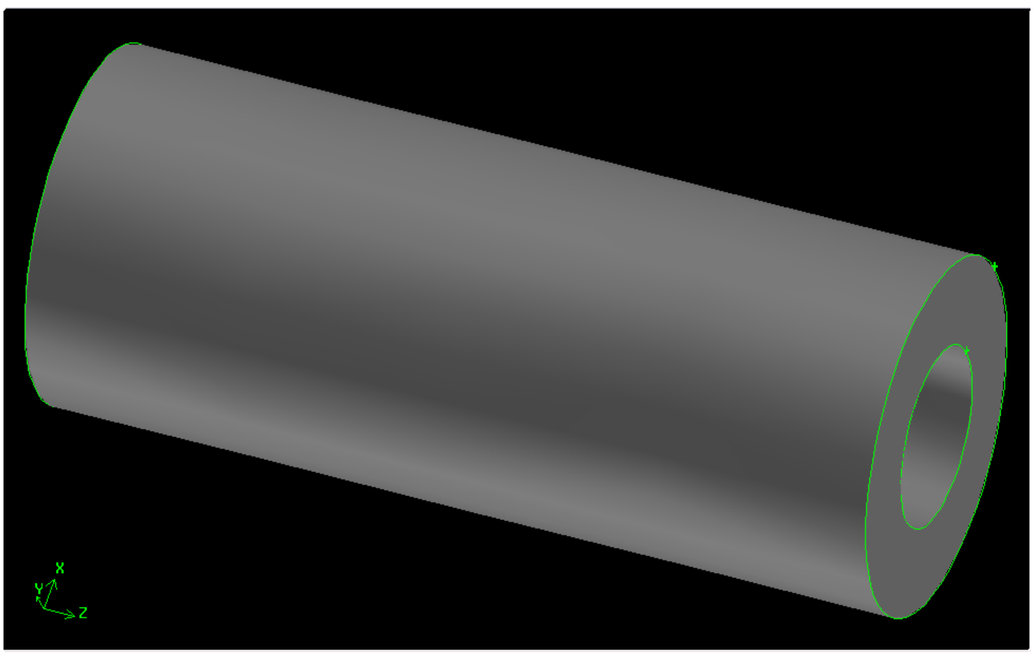

Figure 4.1: A model designed using Gambit 2.2.30

4.2 Meshing Result:

After the model was designed, the author has used GAMBIT 2.2.30 software again to do meshing. The model was divided into 10 small and equal segments to enhance the accuracy of the simulation. The following figures show the result of the meshing process.

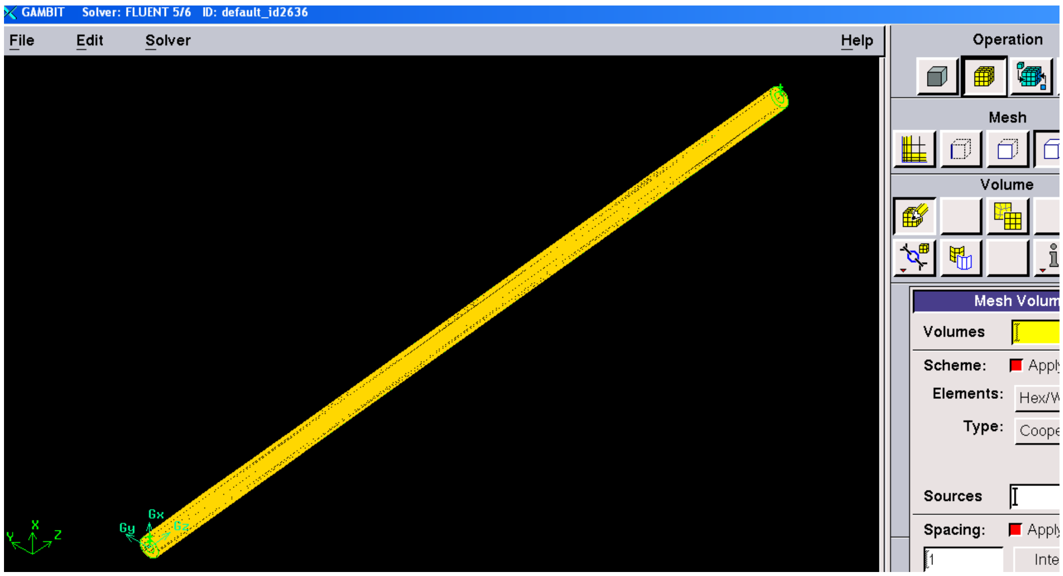

Figure 4.2: Meshing using Gambit 2.2.30

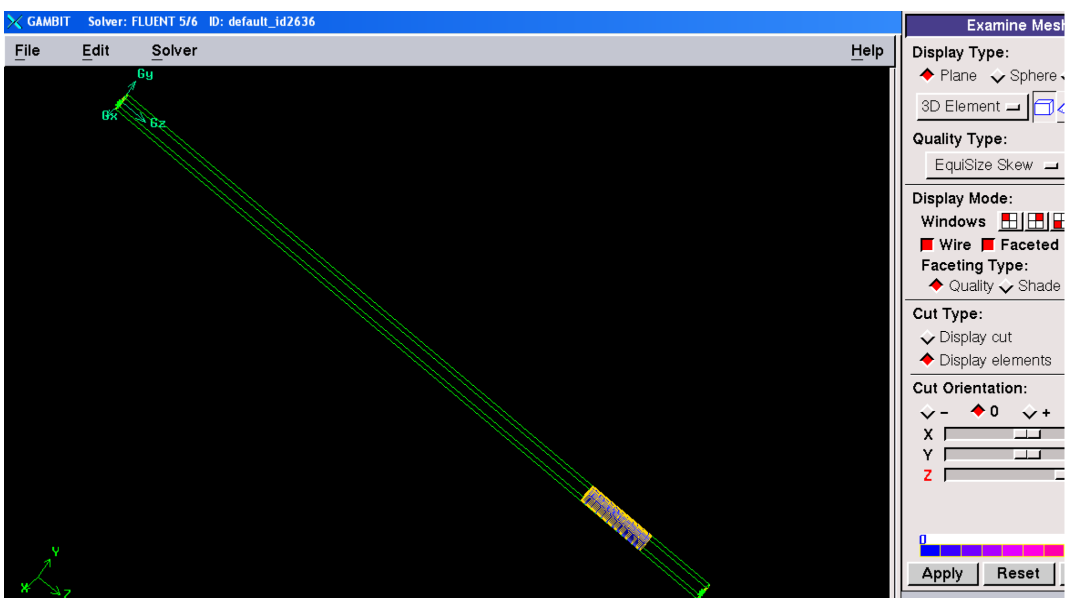

Figure 4.3: Quality of the meshing

4.3 Runs Conducted

4.3.1 Effect of Angle of Inclination:

Several runs were purposely conducted to study the impact of various inclination angles on the efficiency of hole cleaning. A computational model of ten meters long with hole size of 9.875 inches and drill pipe diameter of 5 inches was designed to simulate down hole environment. It was decided that a drilling fluid of constant density of 10 pound per gallon (ppg) shall be used throughout the study. Moreover, drilled cuttings with a diameter of 2.54 millimeters (mm) were injected separately into the fluid flow at a fixed mass flow rate of 0.1134 Kg/s.

Three different inclination angles of 15, 20, and 25 degrees were studies/simulated and their effect on the efficiency of hole cleaning was recorded and plotted as shown in the figure below. As an input to FLUENT software and inline with previous work done by other researchers, the author has decided to assume that the operating pressure of the system is about 35 atm, Operating pressure is the amount of pressure that is needed to circulate the drilling fluid down the hole to the drill bit and back again to the surface. The operating pressure is controlled by many factors including; the mud pump pressure, and the amount of pressure loss (ΔP) in the system.

Testing the effect of inclination angles using FLUENT software was carried by assuming that annular flow rate is the main input to the simulation software. The range/span of annular flow rate was identified by referring to the field data that the author has received form PDOC oil operating company located in Sudan. Practically, the author used to increase the fluid flow rate each and every run and write down the corresponding amount/concentration of drilled cuttings received at the flow outlet.

From the simulation results presented in the figure below, the author has developed the following observations:

1) Different angles result in different cuttings concentrations at the outlet
2) Hole cleaning is improved as we increase the fluid flow rate
3) Hole cleaning efficiency is reduced as we increase the angle of inclination (the well trajectory)

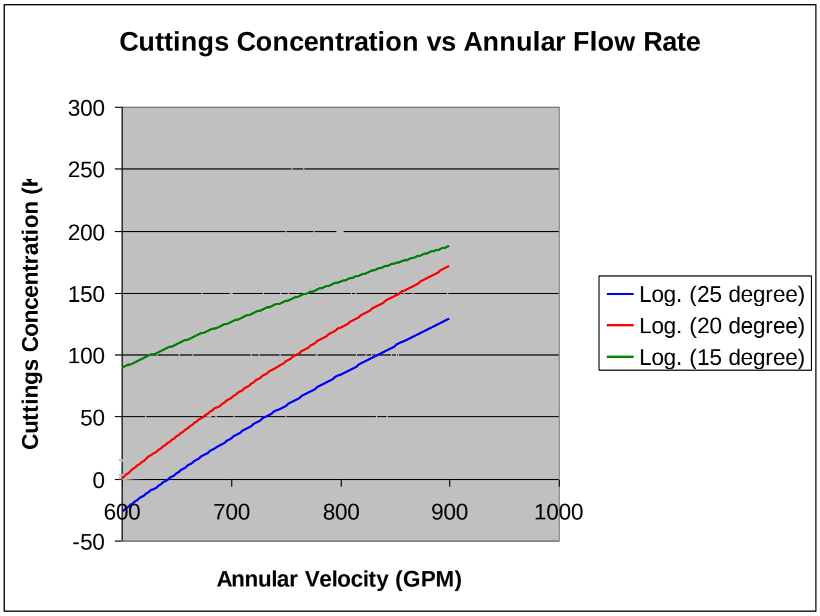

Figure 4.4: Effect of inclination angles on the efficiency of hole cleaning

Note: in the above figure, the efficiency of hole cleaning is measured by the concentration of the drilled cuttings at the flow outlet.

4.3.2 Effect of Cuttings Size:

As one of the objectives of this study, the effect of drilled cuttings size on the efficiency of hole cleaning was examined with the help of FLUENT software. FLUENT has enabled the author to pick/select discrete phase model as a solver. Discrete phase model had an advantage over other methods, because it allowed the author to inject drilled cuttings with various sizes and shapes into the fluid flow. Referring to field data and pervious research in similar topics, it was decided that three cutting sizes of 2.54 mm, 4.45 mm, and 7 mm for small, medium, and large respectively to be studied closely and their results are plotted as shown in the figure below.

Few assumptions were made by the author to reduce the complex computational work carried out by the software, and therefore, result in a shorter time needed for the solution to converge. It was assumed that drilled cuttings are spherical in shape and uniform in size. It was also assumed that the density of the drilling fluid is constant through out the length of the annular section. Furthermore, the hole orientation is set to be at an angle of 30 degree form the vertical axis.

The author has predicted earlier that drilled cuttings size will have a moderate effect on the efficiency of hole cleaning. It was also believed that smaller drilled cuttings will result in better hole cleaning compared to bigger cuttings. To confirm with these predictions, several runs were conducted for all three cutting sizes, and fluid flow rate was once again taken as the main variable inputted to FLUENT software. The results of the runs are clearly demonstrated in the figure below.

By looking at the following figure, the author has came up with several observations with regards to the effect of drilled cuttings size of the efficiency of hole cleaning. The observations are listed as following:

1) Different cutting sizes resulted in different concentrations at the flow outlet
2) The efficiency of hole cleaning is improved as we increase the fluid flow rate
3) Smaller cutting sizes will have better hole cleaning when compared to bigger cutting sizes

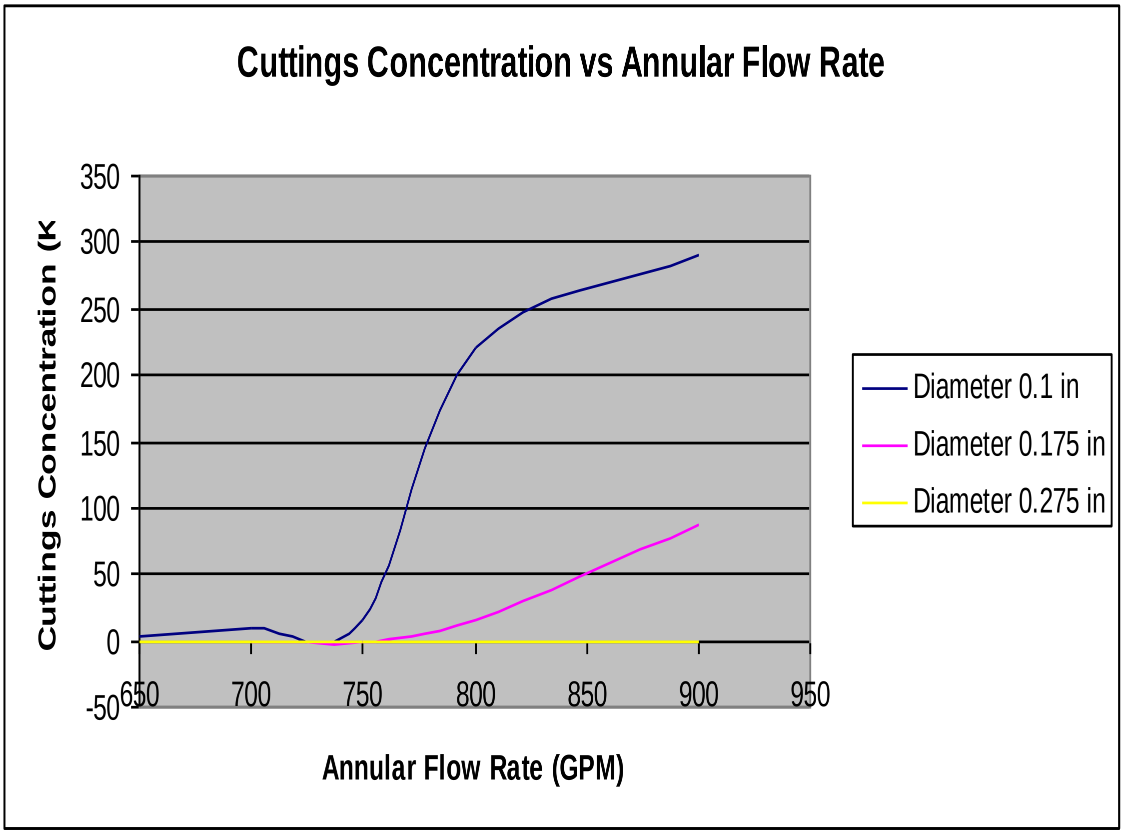

Figure 4.5: Effect of cuttings size on the efficiency of hole cleaning

4.3.3 Effect of Cuttings Shape:

Cuttings shape was taken into consideration, because it is believed that drilled cuttings are produced in different sizes and shapes while drilling depending on the other parameters such as; rate of penetration (ROP), type of intended formation, and drilling fluid properties. To affirm the use of FLUENT software, drilled cutting shapes were standardized and compared to the shape of the sphere, this concept is widely known as the shape factor. The shape factor is simply a measure of the sphereicity of a certain cutting particles, i.e. a cubic shape is known to have a sphereicity of 85 % of that of the sphere.

Three cutting shape factors of 1, 0.95, and 0.85 were selected by the author to be examined and their effect on the efficiency was presented as shown in the figure below. A shape factor of 1 illustrates that the cutting particles are 100 % spherical in shape. Similarly, a shape factor of 0.85 exemplifies that the cutting particles are 85 % spherical in shape. This concept of shape factor has enabled the author to assume certain shapes for the cutting particles and subsequently use FLUENT software to test its impact on the efficiency of hole cleaning.

Referring to the figure below, the author was able to establish several observations and conclusions as following:

1) Different cuttings shapes will result in cuttings concentrations at the flow outlet
2) The efficiency of hole cleaning is improved as we increase the fluid flow rate
3) Bigger shape factors will have better hole cleaning efficiency compared to smaller shape factors

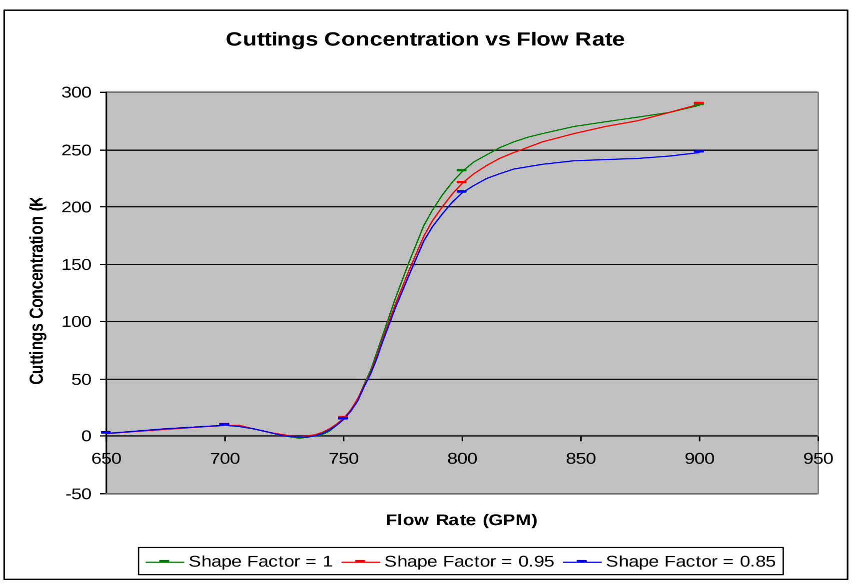

Figure 4.6: Effect of cuttings shape on the efficiency of hole cleaning

4.4 DISCUSSION:

From the results shown in Figures 4.5, 4.6, and 4.7, it was revealed that the efficiency of hole cleaning is greatly affected by the following three parameters:

The first parameter was the angle of inclination of a particular well. After studying three different angles of inclinations of 15 degree, 20 degree, and 25 degree, the study as shown that different angles of inclination resulted in different hole cleaning efficiencies. Also it was notice that small inclination angles had a better hole cleaning when compared to bigger angles. Furthermore, the author came to know that hole cleaning efficiency is greatly improved as we increase the flow rate of the drilling fluid.

The second parameter was drilled cuttings size. Drilled cuttings are normally produced in different sizes and shapes depending on other factors such as the rate of penetration (ROP) [refer to chapter 2]. Therefore, it was crucial to examine the impact of having different cutting sizes on the efficiency of hole cleaning. Subsequently, there drilled cutting sizes of 2.54 mm, 4.45 mm, and 7 mm were simulated using FLUENT software and the following observations were made; 1) bigger cutting sizes will have poorer hole cleaning compared to smaller ones, 2) hole cleaning effect is improved further by simply increasing the flow rate of the drilling fluid.

The third parameter included was drilled cuttings shape (cuttings shape is measured and compared to the shape of the sphere). After conducting the runs, the author has notice that cuttings with bigger shape factor (i.e. shape factor of 1) will have better hole cleaning capability compared to cuttings with smaller shape factor (i.e. shape factor of 0.85). In addition, it was confirmed again that by simply increasing the fluid flow rate we can actually increase the efficiency of hole cleaning. In other word, hole cleaning efficiency is directly proportional to the drilling fluid flow rate.

CHAPTER 5

CONCLUCION AND RECOMMENDATIONS

5.1 Conclusion

The following conclusions are based on the results obtained in chapter 4:

1. Hole cleaning efficiency is improved as we increase the annular flow rate of the drilling fluid provided that the drilling fluid density is adequate.
2. A well with smaller angle of inclination has a better hole cleaning than a well with bigger inclination angles under the same conditions.
3. The investigation of cuttings size was conducted for 2.54 mm, 4.45 mm, and 7 mm. And the results suggested that there is significant effect of cuttings size on cuttings transport. Fine particles are the easiest to clean out.
4. Annular velocities of 600 GPM to 900 GPM resulted in satisfactory hole cleaning in typical drilling fluid.
5. The effect of the cuttings shape was investigated. And the results had shown that spherical cuttings have the best cuttings transport efficiency. Also as we reduce the sphereicity (shape factor) of the drilled cuttings, it was noted that the efficiency of hole cleaning was decreased.

5.2 Recommendations

Although CFD simulation proved to be reliable as we as capable of simulating annular fluid flow, further improvement and recommendations are needed to bring this study into reality/application. Therefore, the author recommends the following to be implemented in future works:

1) The range of the inclination angles should be broaden so that more angles are examined/studied and therefore more accurate results will be obtained
2) More drilled cuttings sizes and shapes should be included in this study so that more valuable results and conclusions could be attended

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APPENDICES

Appendix A: Sample of PDOC well/field data:

PDOC	DAILY DRILLING REPORT		FIELD / BLOCK	xxx		
			WELL NAME	xxx		
	DATE:	23-Nov-07	Spud Date	Nov 18,2007 17:00 HR		
	Report No.	10	Well Type	Deviated Deve	Plan TD (m)	1380

Rig Name	xxxx	RKB to GL	7.4	[m]	
Type of Rig	Land Rig	RKB to MSL		[m]	
Drilling Contract	xxxx				

M.D. (24:00)	450(TD)	[m]	
T.V.D. (24:00)	450(TD)	[m]	
Total Drilled		[m]	

CSG Data	Last casing
OD (inch)	10 3/4
TOP (m)	Surface
CSG SHOE (m)	449.25
TOC (m)	Surface
LAST SURVEY	0.20 degree @ 449 m
Equiv.Mud Density	At [m]

BOP	Type	Ø [in]	W.P. [psi]
Pipe Rams	Double Gate	13 5/8	5000
[illegible]	Double Gate	13 5/8	5000
Annular Prev.	FH35-35	13 5/8	5000

Drill Parameters	Min.	Max.	Avg.
R.P.M. [rpm]			
W.O.B. [Ton]			
Flow Rate [GPM]			
Pump Press. [PSI]			

Formation	From [m]	To[m]	Lithology

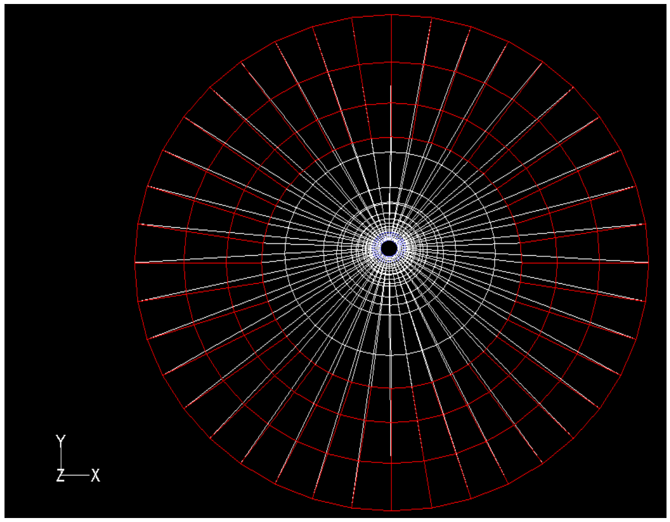
Mud Pump Data	Pump No. 1	Pump No.2	RSPP
Type	F-1300	F-1300	
Speed (SPM)			
Output (bbls/str)	0.124	0.124	
Liner Size(mm)	170	170	

Number of Personnel on Location			
xxxx	45	PDOC	3
Schlumberger/ MI	1	SECURITY	1
DATA LOG	8	xxxx	
Schlumberger/ DD	4	OEPA	
Total		62	

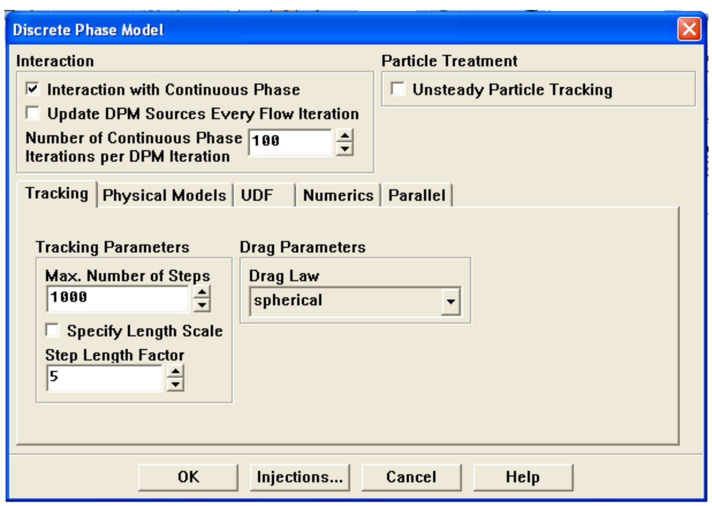
From (hour)	To (hour)	Duration Hrs.	Duration Min.	OPS CODE	OPERATION DESCRIPTION
00:00	02:00	2		PT202	POOH to Run 10 3/4" Casing.(**Hole in good condition**).
02:00	03:00	1		PT204	R/UP to Run 10 3/4" Casing.
03:00	10:00	7		PT204	RIH 10-3/4"casing,k55 # 40.5 ppf-BTC,float collar @ 437.77 m & shoe @ 449.25 m.total 41 jts.
10:00	12:00	2		PT203	Pick up CMT head and CMT line,circulatin clean annular.
12:00				PT203	Cement job,pump spacer 4.0m^3, pressure test to 1500 psi, Drop bottom plug, mix and pump lead slurry 33.6m^3
				PT203	12.6 ppg, drop top plug, pump spacer behind 2.0 m^3, displace with mud by Rig pump 18 m^3 ,displace with water
				PT203	By CMT unit 3.1 m^3,set cementing plug at 1500 psi,release pressure and check flow return - ok ,pump CMT and
	13:30	1	30	PT203	Displace with full return. Cip @ 13:30 Hrs.
13:30	00:00	10	30	PT203	WOC (While WOC L/D 8" DC).

Appendix B: Procedure of simulating using FLUENT 6.2.16

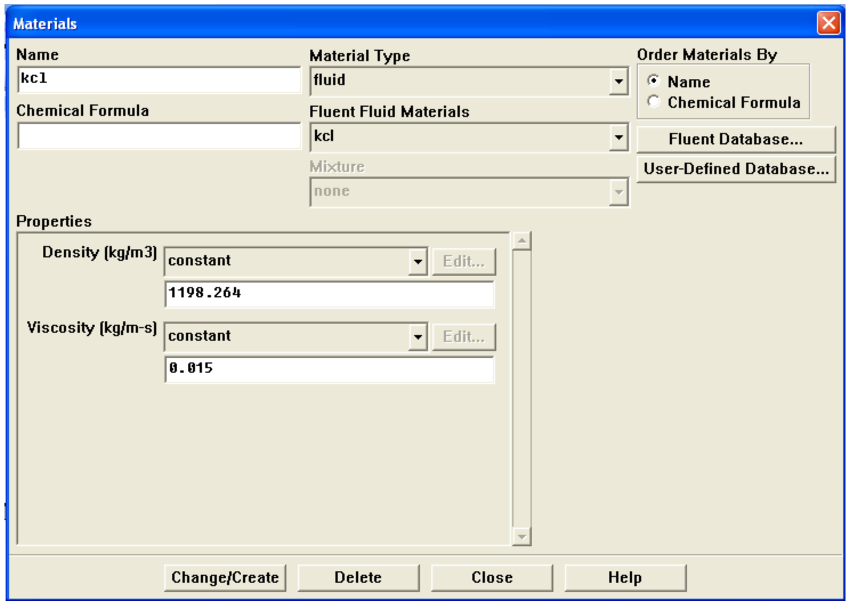
(1) Display the grid to check the quality of the meshing



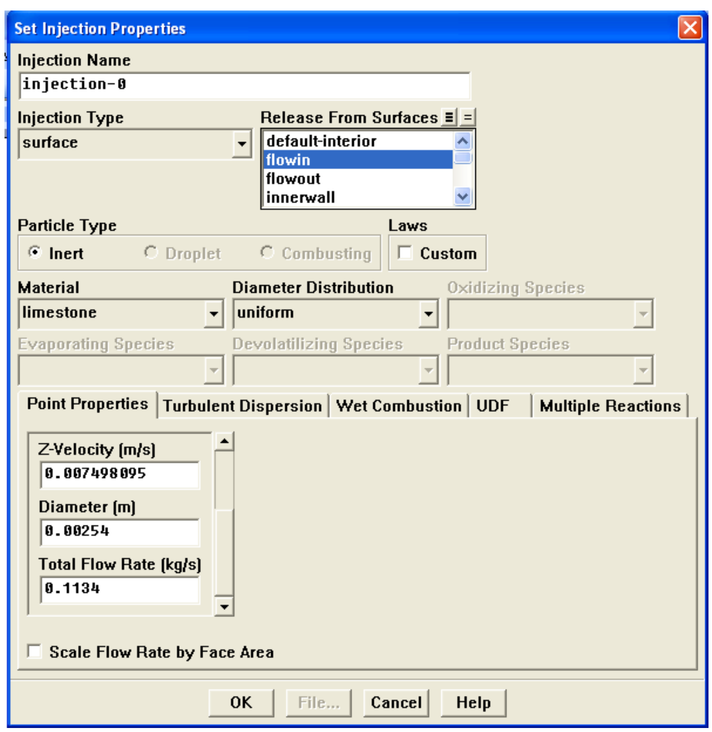
(2) Select discrete phase model as solver



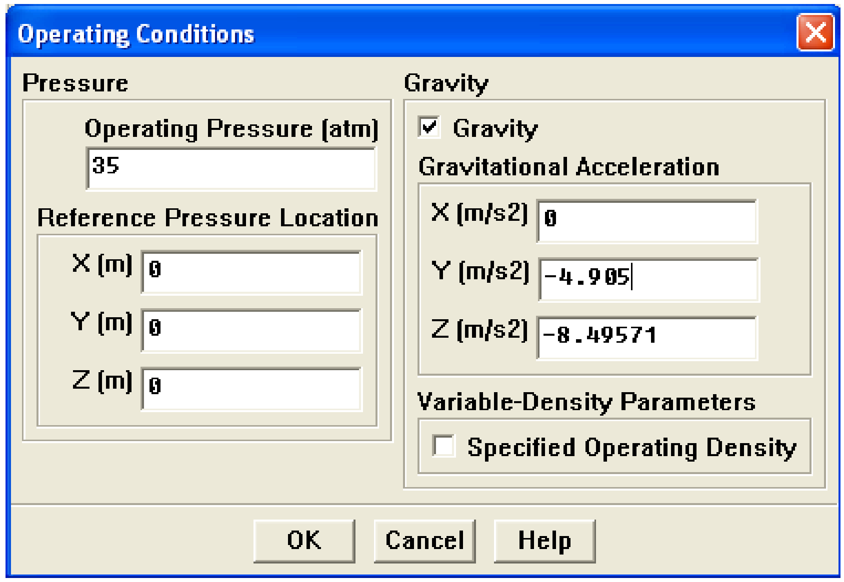
(3) Defining drilling fluid material and properties



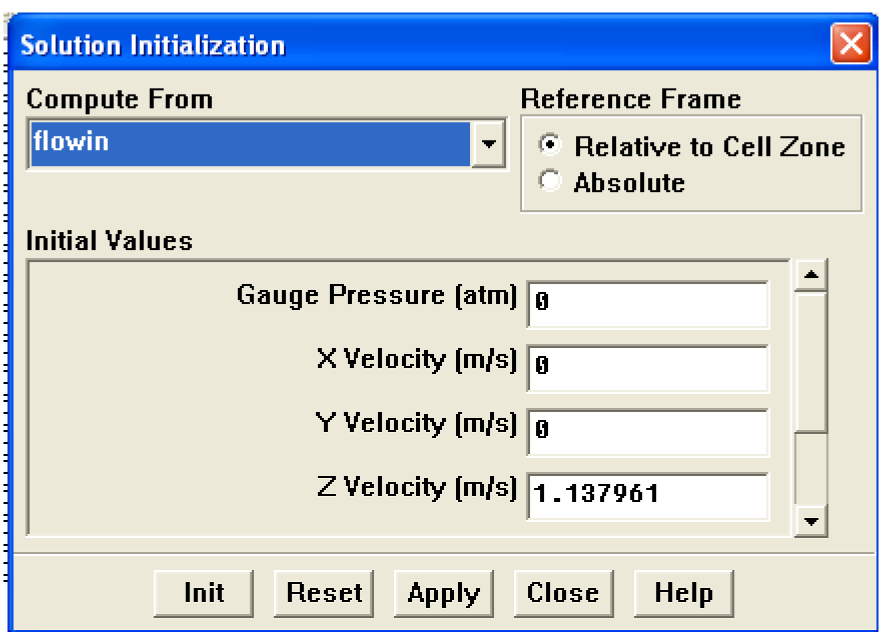
(4) Specify the properties of the injection material



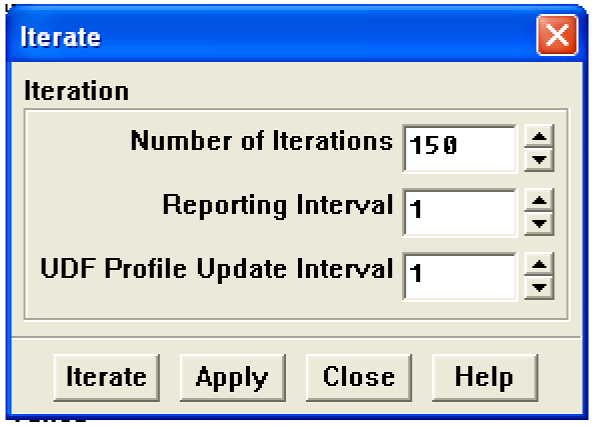
(5) Specify the operating conditions



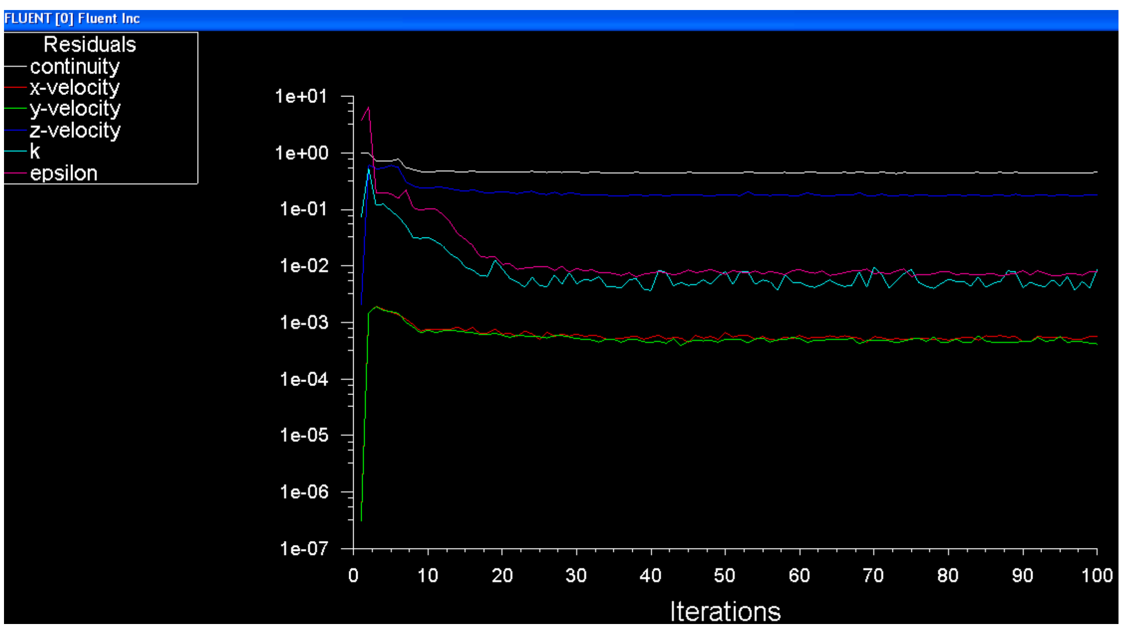
(6) Initialize fluid flow at the inlet



(7) Run the simulation



(8) Display the results



Appendix C: Suggested Milestone for the First Semester

No.	**Detail/ Week**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**SW**
1	Selection of Project Topic															
	- Proposal of the Topic															
2	Preliminary Research Work															
	- Introduction															
	- Objectives															
	- List of references/literature															
	- Methodology															
3	Submission of Preliminary Report															
4	Project Work															
	- Reference/Literature															
	- Defining all the assumptions															
5	Submission of Progress Report															
6	Project work continue															
	- Designing the Model															
7	Submission of Interim Report															
8	Oral Presentation															

Appendix D: Suggested Milestone for the Second Semester:

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	Project Work Continue															
	- Starting the Simulation Work															
2	Submission of Progress Report 1															
3	Project Work Continue															
	- Continue the Simulation															
4	Submission of Progress Report 2															
5	Project work continue															
	-Get Results from the Simulation															
6	Submission of Dissertation Final Draft															
7	Oral Presentation															
8	Submission of Project Dissertation (Hardbound)															