ASSESSMENT OF THE FRICTION AND WEAR BEHAVIOR OF DRILLING TOOLS

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SEPTEMBER 2012

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By

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Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Petroleum Engineering)

SEPTEMBER 2012

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CERTIFICATION OF APPROVAL

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Approved by,

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(Dr M Nur Fitri bin Ismail)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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AZRUL AZWAR BIN SAMSUDDIN

ABSTRACT

Directional drilling has been used in the oil and gas industry for such a long period. This technique usually cost the downhole drilling companies on such damages upon the downhole tools. The damages are almost likely due to the friction and wear behaviour resulted between the downhole tools and the wall of the bore hole. In this thesis, an assessment on one of the factors will be done, which is the drilling fluid. In this experiment, different kind of drilling fluid will be used through the experiment, in order to get different wearing behavior. The experiments will be done using the pin-on-disk test, with some minor modifications, and fabrication on the rig or its components. The results will then be tabulated into with respected to the type of drilling fluid

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Mining and oil exploration environments make severe demands on materials. They are particularly corrosive and mechanically-damaging to the surfaces of machinery. Rock crushing, ore loading, and down-hole drilling environments subject surfaces to abuse, requiring special materials and surface treatments to avoid excessive and costly material wastage. Dominant wear modes include impact wear, abrasion, and slurry erosion. Solving such wear problems reduces the use of resources, avoids costly equipment shut-downs and improves the competitiveness and energy-efficiency of U.S. industry. As more demands are made on mining equipment to increase productivity and to extract minerals from increasingly lower ore concentrations, new alloys and surface treatments are needed.

Due to the characteristics of the downhole which are mostly allow the friction between the drilling tools and borehole walls cause the wearing effects on the tools. Continuous and repetitive action are essential in this kind of activity, thus, increase the effect of the wearing on the tools. However, the wearing effect also depends on several factors, but, the author will focus on manipulating only on few factors only, instead, fix the other variables.

1.2 Problem Statement

This project will only examine on some of the factors that will help in the friction and wear behaviour of the down hole tools during.

i- Excessive bit wear in the wellbore – no early prediction on the wearing behaviour on the bit during the activity of drilling

1.3 Objectives

The main objective of this project or thesis is :

- To come out with a tabulation reference of the wearing behaviour for the drill bit used in this experiment.

The objectives of this project are :

- To analyze on the wearing properties and behaviour on different Drilling fluid. The drilling fluid used in the experiment will be differ - different type, formulation

1.4 Scope of Study

The study will mainly focus on the type of drilling fluid used as the lubricant for the drilling process. For this, the Pin-on-Disc rig will be used throughout the experiment with same parameters, but vary in the drilling fluid. The literature review will present the previous work that has been done.

CHAPTER 2

LITERATURE REVIEW

The literature will be focusing on all of the elements that are going to be take considered in order to have this test.

2.1 Friction

Friction is the resistance encountered by one body in moving over another when subjected to applied normal load (see figure 3.1). Due to the friction, a force will be produced, which is called as the friction force, F_f. F_f is a force that resisting the relative motion of solid surfaces, fluid layers, and material elements sliding against each other.

In force, N, i.e, F_f /N is defined as the *coefficient of friction,* μ which can be either kinetic, μ_k or static, μ_s frictional coefficient. In addition, the F_f is opposite to the applied force, F as what is seen in the figure 3.1, the has F_f the direction to the right of the sliding plane, whereas F is in the direction to the left.

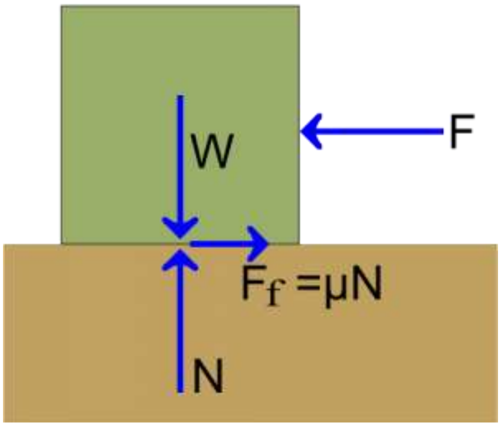


Figure 2.1 *Schematic of a body sliding on a plane*

Friction is not a fundamental force but occurs because of the electromagnetic forces between charged particles which constitute the surfaces in contact. Because of the complexity of these interactions, friction cannot be calculated from first principles, but instead must be found empirically.

There are several types of friction:

- **i-** **Dry friction** resists relative lateral motion of two solid surfaces in contact. Dry friction is subdivided into *static friction* between non-moving surfaces, and *kinetic friction* between moving surfaces.
- **ii-** **Fluid friction** describes the friction between layers within a viscous fluid that are moving relative to each other
- **iii-** **Lubricated friction** is a case of fluid friction where a fluid separates two solid surfaces
- **iv-** **Skin friction** is a component of drag, the force resisting the motion of a solid body through a fluid.
- **v-** **Internal friction** is the force resisting motion between the elements making up a solid material while it undergoes deformation.

Static friction or static frictional force is the friction result when frictional force produced is equal to the applied force, $Ff=F$, thus, cause no movement or sliding of the object on the sliding plane. Static frictional forces from the interlocking of the irregularities of two surfaces will increase to prevent any relative motion up until some limit where motion occurs.

As for kinetic friction or kinetic frictional force, it is the friction formed when there is sliding or movement by an object, prior to the collision with the surface of contact. In this case, the applied force is much greater than the frictional force, thus, cause the object to move. It is that threshold of motion which is characterized by the coefficient of static friction, μ_s. The coefficient of static friction is typically larger than the coefficient of kinetic friction, μ_k

In addition, the friction cause from the kinetic/movement contact will eventually converts the kinetic energy into heat energy. In consequence, as illustrated by the use of friction created by rubbing pieces of wood together to start a fire, it will result in some property, dramatically. Kinetic energy is converted to heat whenever motion with friction occurs, for example when a viscous fluid is stirred. Another important consequence of many types of friction can be wear, which may lead to performance degradation and/or damage to components. Friction is a component of the science of tribology.

2.2 Wear

Talking about wear, it is one of the parameter or element that is essential for this project. In materials science, wear is erosion or sideways displacement of material from its "derivative" and original position on a solid surface performed by the action of another surface.

Wear is defined as the progressive damage involving material loss, which happens on the surface of contact between two object (same concept as friction), which is the result of relative motion to the adjacent working parts [3]. In other words, it is the interactions between surfaces and more specifically the removal and deformation of material on a surface where both object meet, as a result of mechanical action of the opposite surface. Wear can occurred due to some phenomena such as adhesion, delamination and abrasion. Aspects of the working environment which affect wear include loads and features such as unidirectional sliding, reciprocating, rolling, and impact loads, speed, temperature, but also different types of counter-bodies such as solid, liquid or gas and type of contact ranging between single phase or multiphase, in which the last multiphase may combine liquid with solid particles and gas bubbles.

Previously due to the fast execution, the contact found in impact wear was referred to as an impulse contact by the nomenclature. Impulse can be described as a mathematical model of a synthesised average on the energy transport between two travelling solids in opposite converging contact. There are a few type of wear, such as :

i- Cavitation wear is a form of wear where the erosive medium or counter-body is a fluid.

ii- Corrosion may be included in wear phenomenon, but the damage is amplified and performed by chemical reactions rather than mechanical action.

Under normal mechanical and practical procedures, the wear-rate normally changes through three different stages(ref.4):

i- Primary stage or early run-in period : surfaces adapt to each other and the wear-rate might vary between high and low.

ii- Secondary stage or mid-age process : a steady rate of ageing is in motion. Most of the components operational life is comprised in this stage.

iii- Tertiary stage or old-age period : the components are subjected to rapid failure due to a high rate of ageing.

The secondary stage is shortened with increasing severity of environmental conditions such as higher temperatures, strain rates, stress and sliding velocities etc. In explicit wear tests simulating industrial conditions between metallic surfaces, there are no clear chronological distinction between different wear-stages due to big overlaps and symbiotic relations between various friction mechanisms. Surface engineering and treatments are used to minimize wear and extend the components working life.

2.3 Drill bit

Drill bit is the main component in a drill string, that will rotate, and eventually crushes, drill the formation to the targeted point and depth. There are several types of drill bits, such as Tricone, PDC, and multiple tricone. For this experiment, the materials are from the rotary tricone drill bit type [4].

Bits are available in a bewildering array of types, from a number of manufacturers. Before looking in detail at bit performance considerations, it may be helpful to present a quick overview of these types.

We can group bit types into two basic categories:

i- Rolling cutter bits, also known as roller cone bits, consist of cutting elements arranged on cones (usually three cones, but sometimes two) that rotate on bearings about their own axis as the drill string turns the body of the bit. The principle types of rolling cutter bits are milled steel tooth, or "rock" bits (Figure 3.2 , soft formation type, and Figure 3.3 , medium formation type), and tungsten carbide insert, or "button" bits (Figure 3.4 , soft formation type, and Figure 3.5 , hard formation type).

Figure 2.2 *, Soft formation type*

Figure 2.3 *Medium formation type), and tungsten carbide insert*

Figure 2.4 *Soft formation type*

Figure 2.5 *Hard formation type*

ii- Fixed cutter bits, also known as drag bits, consist of stationary cutting elements that are integral with the body of the bit and are rotated directly by the turning of the drill string. The principal types of fixed cutter bits are :

a. steel cutter (i.e., "fishtail" bits)
b. natural diamond
c. polycrystalline diamond compact (PDC)
d. thermally stable PDC (TSP)

While steel cutter drag bits have some use in soft, unconsolidated formations, this discussion focuses mostly on diamond fixed-cutter bits, which have a much wider range of applications. Examples of these bits are shown in Figure 3.6 (natural diamond) and Figure 3.7 (PDC).

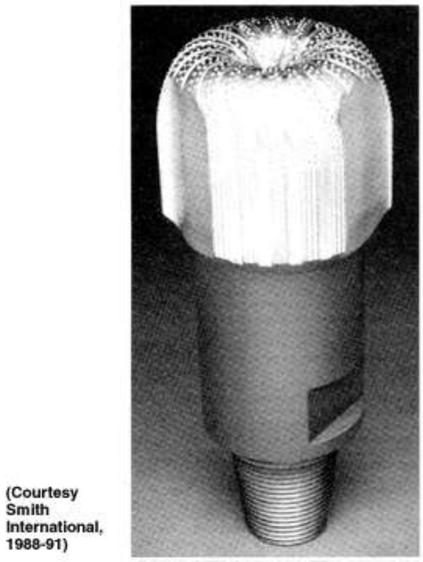


Figure 2.6 *Natural diamond*

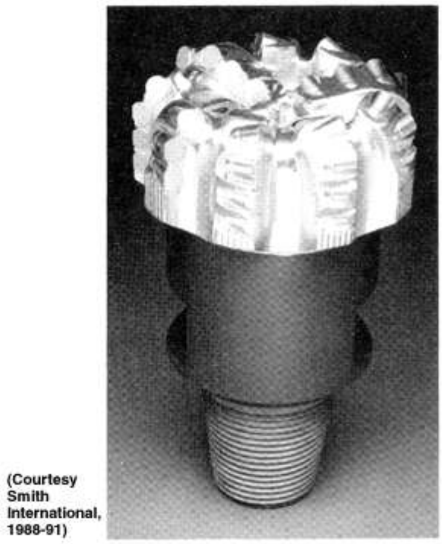


Figure 2.7 *PDC*

2.4 Wear mechanism

There is no simple relationship between wear and any other materials property [2]. In order to understand the mechanism dependant counter measures on can follow the very (!) simple model of Archard (1959). Archards equation (not law!!) is

$$W_s = \frac{W}{s} = k\,\frac{F_N}{H_W}$$

The wear rate W related to the wear path s is proportional to the normal load FN and the hardness of the worn surface HW and a factor k. k describes the probability to generate a wear particle during the path s and contains all constants and variables of a tribosystem

CHAPTER 3

METHODOLOGY

The project serves as the experiment to collect data on the drill bit to be used in the experiments, based on certain criteria, that are served differ from each other. In order to understand the concept and mechanism of the drill bit better, and to be able to work smoothly, information from journals and books are collected as much as possible as reference in completing the work. Besides, I also have Dr Fitri's PhD thesis as reference, since the thesis is was about tribology also.

Besides using the journals and technical paper in preceding this project, the experiment will be done using the pin-on-disc (PoD) tribometer rig. As introduction, PoD rig is a machine that is used to test various kind of tribology; frictions and wearing behaviour on various materials. The rig can be modified to preferable set up so that different kind of test can be done.

This is the Gantt Chart for this project :

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
1	Project Work Continues	■	■	■	■	■	■	■	Mid-Semester Break								
2	Submission of Progress Report									●							
3	Project Work Continues									■	■	■	■	■			
4	Pre-SEDEX												●				
5	Submission of Draft Report													●			
6	Submission of Dissertation (soft bound)														●		
7	Submission of Technical Paper														●		
8	Oral Presentation															●	
9	Submission of Project Dissertation (Hard Bound)																●

● Suggested milestone

■ Process

Table 3.1 *Gantt Chart FYP II*

GANTT CHART FYP : ASSESSMENT OF THE FRICTION AND WEAR BEHAVIOR OF DOWNHOLE TOOLS

No	Activity / Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
		18 Sept - 23 Sept	24 Sept - 30 Sept	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 31 Oct	MIDSEM BREAK	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	16 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 21 Dec
1	Experiment I: Wearing effect on teeth															
	i- Preparing the P.o.D															
	ii- Testing															
	iii- Data compilation															
	iv- Analyzing															
	- Wear Rate															
	- Pictures															
2	Experiment II: Wearing effect on different drilling fluid															
	i- Preparing the P.o.D															
	ii- Testing															
	iii- Data compilation															
	iv- Analyzing															
	- Wear Rate															
	- Pictures															
3	Experiment III: Wearing effect on different RPM															
	i- Preparing the P.o.D															
	ii- Testing															
	iii- Data compilation															
	iv- Analyzing															
	- Wear Rate															
	- Pictures															
4	Report Writing															
5	Poster Preparation															
6	1st draft Final Report															
7	Presentation															
8	Technical Paper															
9	Final Draft Final Report															

Table 3.2 *Gantt Chart This Project*

Figure 3.1 is a DUCOM PoD rig that is available in Universiti Teknologi PETRONAS. The rig now is in a set up for a tribology test on wearing effect using different lubricator. In figure 4.2, the pin is installed fix at one place, and a disc plate is placed under it. The disc will rotate based on the rotation per minute (RPM) or velocity that is controlled. In addition, the rig is controlled using software in the computer, and at the same time, the result or data will automatically read, and recorded into the computer directly.

Figure 3.1. *DUCOM Pin-on-Disc rig*

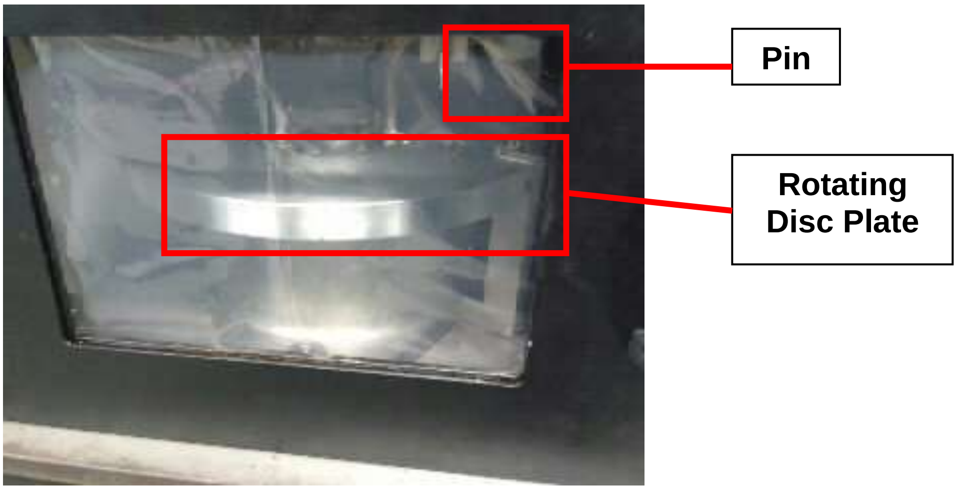


Figure 3.2 *The position of the pin and the disc*

3.1 Sample and Others Preparation

As for this project, a few modifications on the existing PoD rig need to be implemented. This is due to the procedure and materials used in this project differ from the existing tribology test. The main components that will need modifications are the pin and the rotating disc plate.

1- Pin

The test done will focus on the wearing behaviour on the teeth of the drill bit. The drill bit used is the roller cone bit. Instead of use the whole bit, test will only use the teeth of the bit.

For this experiment, the teeth will be in pin form, and it's in cylinder shape, with dimension of 6mm diameter and 12mm height. The material used for the pin is mill steel, and there are 5 samples of this pin.

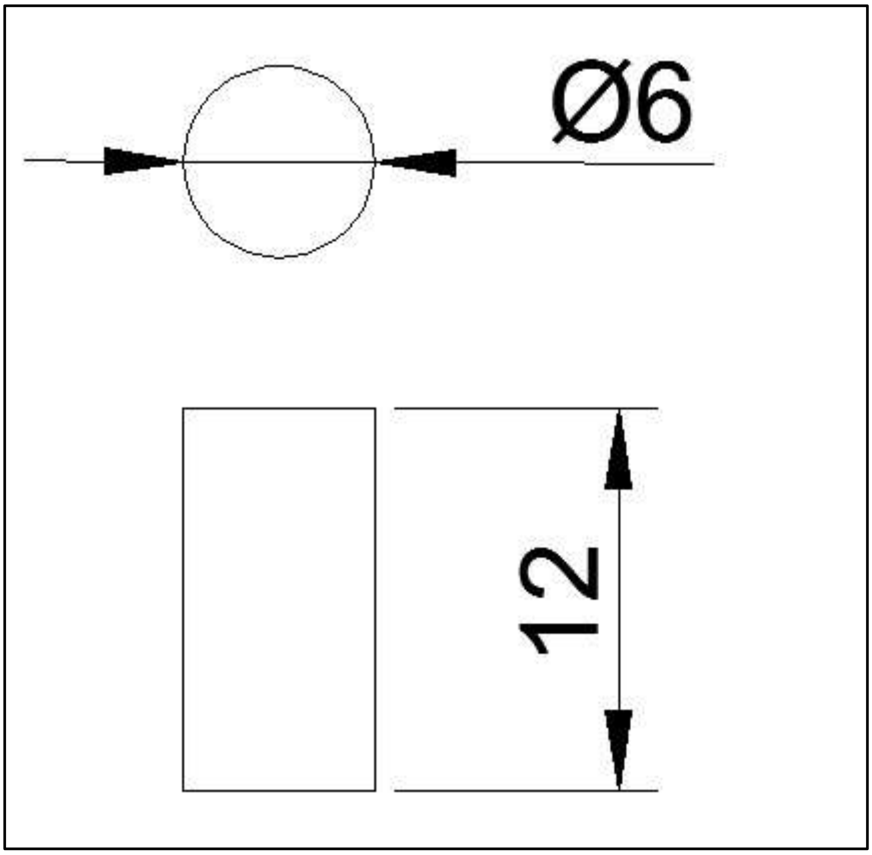


Figure 3.3 *Drawing for pin*

Figure 3.4 *Pin*

Figure 3.5 *Plan View Pin*

Figure 3.6 *Side View Pin*

Figure 3.7 *5 pins*

For the pin holder, author used the holder that is already available in the lab, and with the machine since the slot of the holder, with the pin used for this experiment is fit together.

Figure 3.8 *Pin Holder*

2- Disc Plate

The disc plate is the component in the rig that will act as the wellbore cement. The function of this cement disc is as the fix variable when testing all of the samples. The cement used will be a mixture of normal cementing used in the wellbore. For this part, a supervision or advise from Dr Osman, the head of equipment department will be taken so that, the best mixture of cement will be used throughout the project.

However, due to the fact that the project will represent the wellbore formation, author decided to go for rock type disc, which is in this case, is Granite.

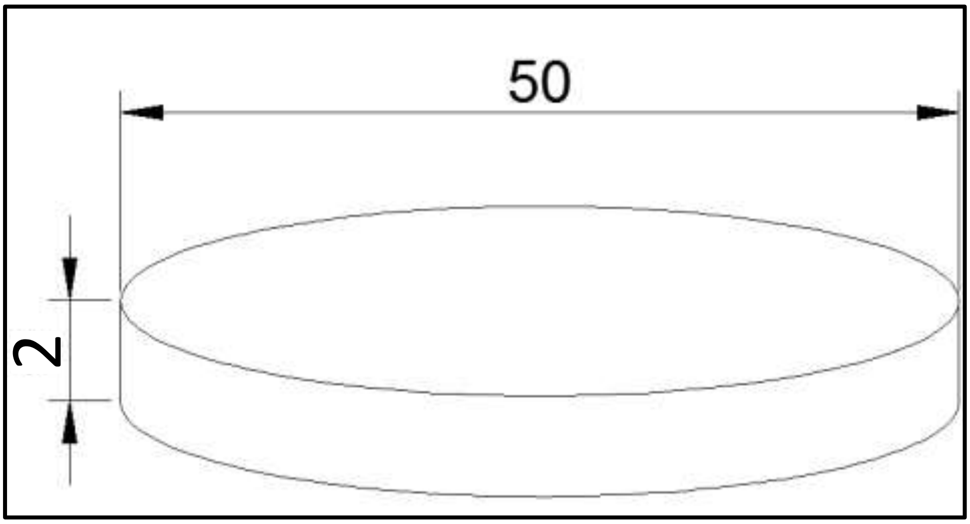


Figure 3.9 *Drawing Disc Plate*

Figure 3.10 Granite Disc Plate

The disc that is being used is the Granite rock – contain quartz, feldspar, mica, and iron ore - cut into disc form with dimension of 50mm diameter, and 6mm thick. The disc is prepared by using the machine that is provided in the Geology Lab at building 16, Universiti Teknologi PETRONAS.

After some modifications done on the 2nd drilling fluid cup, the dimension of the granite disc plate has been changed. This is due to some try and errors with the rig and drilling fluid, and the suitable and final dimension used throughout the experiment is 52mm diameter and 2mm thick.

3- Drilling Fluid "Cup"

The drilling fluid cup is a component that will be used to hold the disc and the drilling fluid. Its function is to ensure the disc to be merging into the drilling fluid, and also to ensure the area of contact between the pin and the disc to be lubricated all the time.

At the side of the component, there are 4 holes with Screw size of M2. The function of the screw is to tighten up the disc in place, so that it will not move together with the pin during the experiment is done.

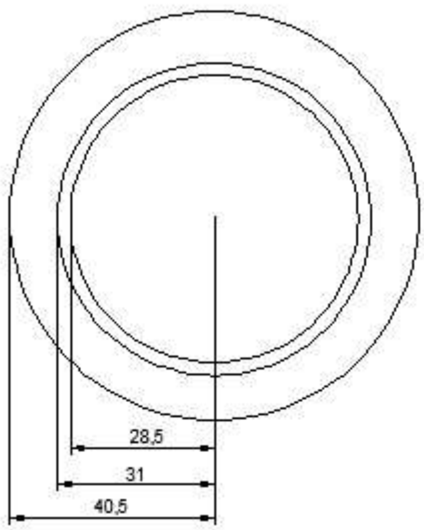


Figure 3.11 *Plan View 1st Prototype*

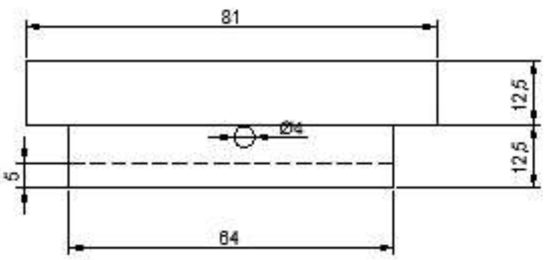


Figure 3.12 *Side View 1st Prototype*

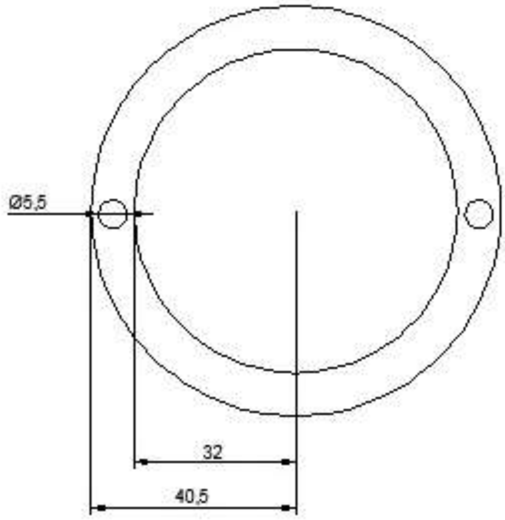


Figure 3.13 *Below View 2nd Prototype*

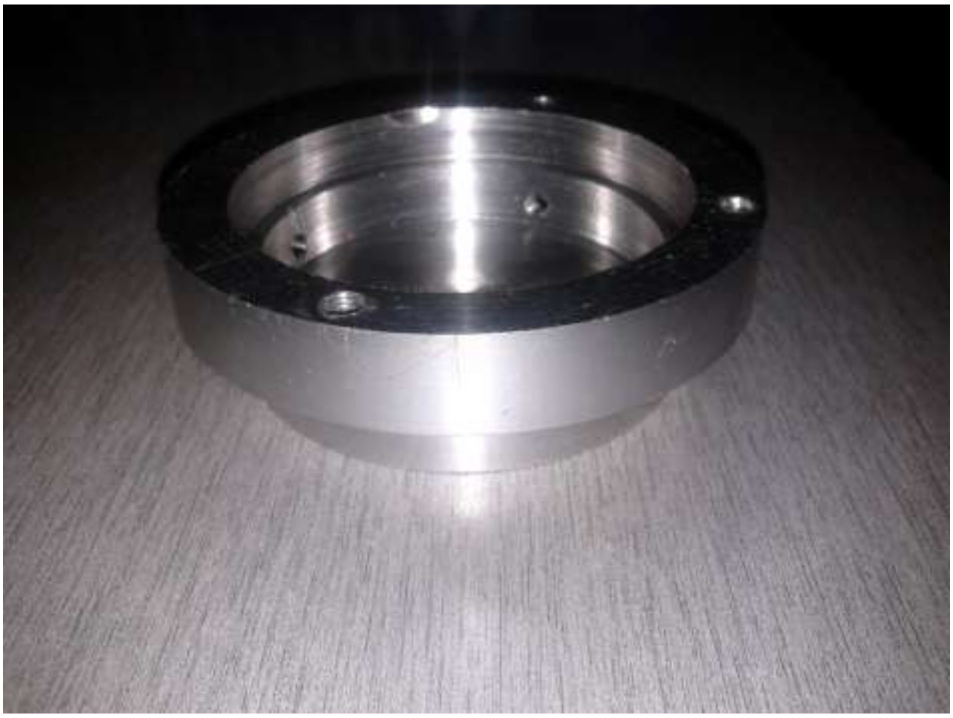


Figure 3.14 *1st Prototype*

Figure 3.15 *Plan View 1st Prototype*

Figure 3.16 *Side View 1st Prototype*

Figure 3.17 *Below View 1st Prototype*

The 1st prototype was fabricated with the material of aluminium. However, after some test, some leakage was found at the screw part. This is due to the fact that the aluminium is ductile, and easy to wear. When tightening, some part inside the holes of the screw damaged, and results in some gaps in side the hole, and thus, consequence in the leakage of the fluid. In addition, the wall of the component at the holes of the screw is not thick enough. that added up in one of the reason why the leakage happened.

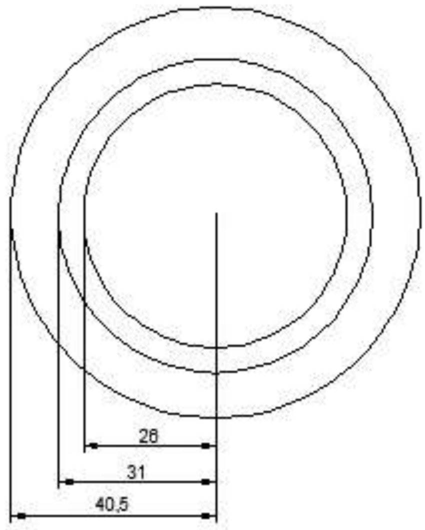


Figure 3.18 *Plan View 2nd Prototype*

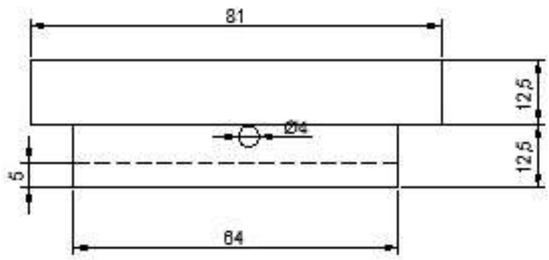


Figure 3.19 *Side View 2nd Prototype*

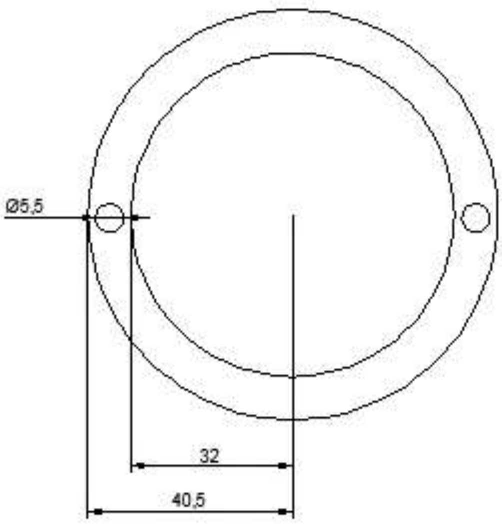


Figure 3.20 *Below View 2nd Prototype*

Figure 3.21 *2nd Prototype*

For 2nd prototype, the material used will be mill steel, as it is not too ductile and will not cause the same problem as aluminium. Besides that, the wall of the lower part will be thicken by 2.5mm

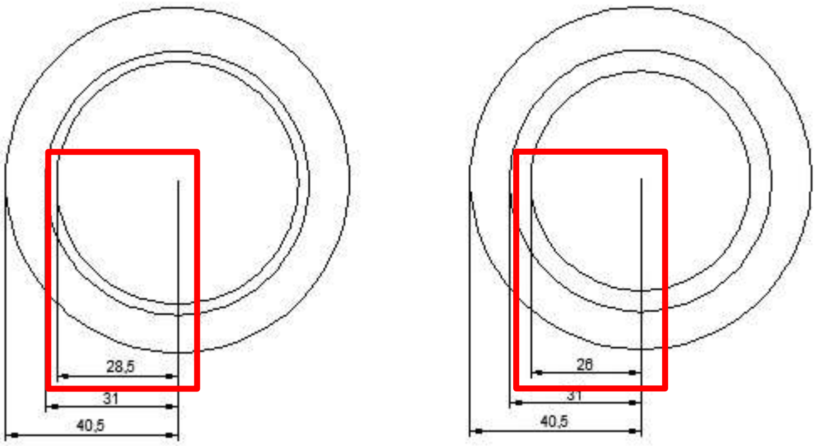


Figure 3.22 *Comparison of 1st and 2nd Prototype*

4- Drilling Fluid

The slurry was a simulated drilling mud, whose composition is given in Table 3.3. This is the basic of the mud which going to be used. In order to get the most uniform distribution, the clay was first mixed in the water until thoroughly dispersed and then the silica was slowly added with continued stirring. Since settling was inevitable between tests, the slurry was agitated just prior to filling the reservoir.

Component	**Composition**
Bentonite	31.8 g
Silica sand	144.2 g
Water	500 ml

Table 3.3 *Composition of Dlurry Mud*

The composition of the drilling fluid will be different for each experiment, in order to find the difference in wearing effect on disc with different drilling fluid

After some try and error, the author have decided to use these 2 types of drilling fluid which are normal water-based mud and water based mud with a fluid loss medium; nut plug. The formulation of these 2 fluids is in Table 3.4.

Formulations	**Water-based mud**	**Water-based mud with Nut Plug**
Water	325.31	325.31
XANTHAN-GUM	0.50	0.50
HYDRO-PAC LV	1.50	1.50
CAUSTIC SODA	2.50	2.50
MIL-BEN	12.00	12.00
MIL-BAR	79.89	79.89
Nut Plug	0.00	10.00

Table 3.4 *Mud Formulations*

Procedure of preparation:

1. Add 0.5 ± 0.01g of viscosifier into 325.31cm^3 of water while stirring. The viscosifier used is xanthan-gum.
2. After stirring for 10 minutes, 1.5 ± 0.01g of hydro-pac is added into the mixture.
3. Next, add 2.50 ± 0.5g of caustic soda into the mixture.

4. After 20 minutes, add 12 ± 0.01g of bentonite into the mixture while stirring.
5. From time to time, remove the container from the mixer and scrape its side with a spatula to dislodge any material adhering to the container walls.
6. After stirring for 25 minutes, add 79.89 ± 0.01g of barite into the mixture.
7. Finally, add 10g of additives after 35 minutes of stirring the mixture. The additives added are either palm oil leaf or nut plug. For every mud formulation, an extra 10g of additives is added until the fluid loss reading remains stagnant.
8. The total stirring time is 45 minutes for each mud formulation.

3.2 Sample Testing

The trial test was be conducted, with and without the drilling fluid "cup", which means, the test was done in dry condition and also wet condition. Data recording will be done using computer connected to the rig. The RPM, disc, pressure, force are constants. For trial, the data used was [12] :

Rotational speed – 120 rpm

Applied load – 10N

Time – 6 minutes per run

Disc Plate – Granite

1. First, the disc will be weighed to get the initial weight of the disc before the experiment. The weight taken should be accurate, with at least 4 decimal places, as the expected wearing behaviour to be small.
2. Then, the pin will also need to be weighed. Same as the disc, the accuracy of the weight recorded should be at least 4 decimal places.

3. The initial weight of both disc and pin will be used later in the result part to calculate, and get the wearing activity that happen on these two contact surfaces; in gram.
4. As for the pin, make sure there is no oil/fluid on it. Any other fluid will affect the experiment's result. To solve this, the pin is clean up the surface of the pin with methanol, and dries it up with dry cloth.
5. After that, install the pin into the holder by placing the pin inside the holder, and tighten up with the screw inside the holder. The pin must be tight enough so that no rotation of pin within, inside the holder will occur. Then, install the holder inside the PoD rig.
6. On the other side, the disc plate will be put into the drilling fluid "cup". The disc is put into the cup, and tighten up so that no rotation of the disc to occur; disc stay still, fix position. After tighten up, drilling fluid will be filled into the cup, until the disc is submerged into the fluid. Then, place the cup into the rig.
7. After set up all the components inside the rig, set up in the software will be done. Using the software, the parameters for rotational speed, time taken and others are keyed in through the computer.
8. Then, the load will start to be put on to the lever. The first load will only be used for the pin and the disc to be in contact; no applied load. As this is only used to let the contact between the pin and disc occur, only small load will be put onto the lever. At the same time, the applied load in the software will be set to zero.

Figure 3.23 *Lever on the PoD Rig*

9. Only by then, the applied load will be loaded. Based on Figure 3.20, there are 2 places to place the load. The ratio of the lever is 2:6. Means, if you put 5N load on the left, it will time 2, and if you put on the right place, it will time by 6. That's how the applied load on this PoD rig works. As for this experiment, 5N load is placed on the left place.
10. Then, the experiment is started by clicking start in the software. Through the software, the graph of the experiment is plotted, and the trend of the experiment can be observed.
11. When the experiment ended, take out the disc, as well as the pin from the rig and also from their holder/cup.
12. The pin will then be weighed to find the final weight, after the experiment. But as for the disc, it will need to be left for one day in order to dry it up and remove all drilling fluid inside the granite disc. This is to ensure that the final weight recorded will have the same condition as the initial weight; dry weight.
13. Data for the calculation of volume loss is acquired from the worn region of the sample and from the intact region around it. A reference plane is constructed for the intact surface. Volume loss is calculated from the differences between the interpolated reference plane and the actual worn surface.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Trial

Due to the leakage of the drilling fluid cup, the trial experiment was done only to the dry condition. The result is :

Parameters	Value
Time	0.025 hours
Initial weight of the disc	36.060 g
Initial weight of the pin	1.6462 g
Rotational speed	120 rpm
Applied Load	10N
Final weight of the disc	36.059 g
Final weight of the pin	1.6463 g

Table 4.1 *Result Trial Experiment*

Based in Table 4.1, the weight of the disc has reduced up to 0.001 g. Observation on the trend of the graph, and the lever of the PoD rig which goes up and down (shaking too much), shows that the surface of the disc is not flat, irregular and rough. The result is not accurate, as the surface of the disc should be regular and flat in order to get the same applied load at all point of contact between the pin and the surface. Due to that, lots of weight loss occurs when expected weight will only be as small as 0.00001 g.

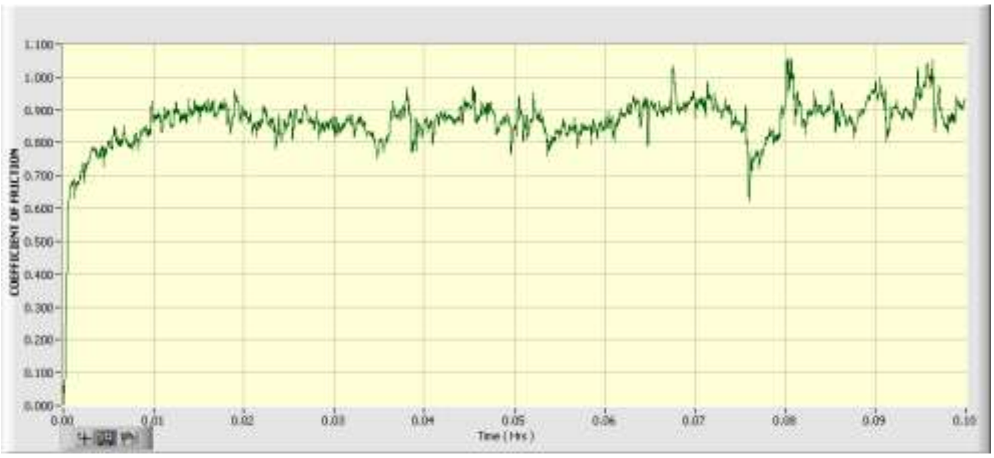
The result for the pin should a little bit increase in the weight; 0.0001 g. Observation on the pin after the experiment shows that, the residue of the wearing activity stick onto the surface contact of the pin. This is normal because of the applied load on the contact push the residue to stick onto the pin. However, the pin didn't undergo any visible wearing, even if any, it will be too small to calculate with standard, normal weight scales.

4.2 Experiment Results

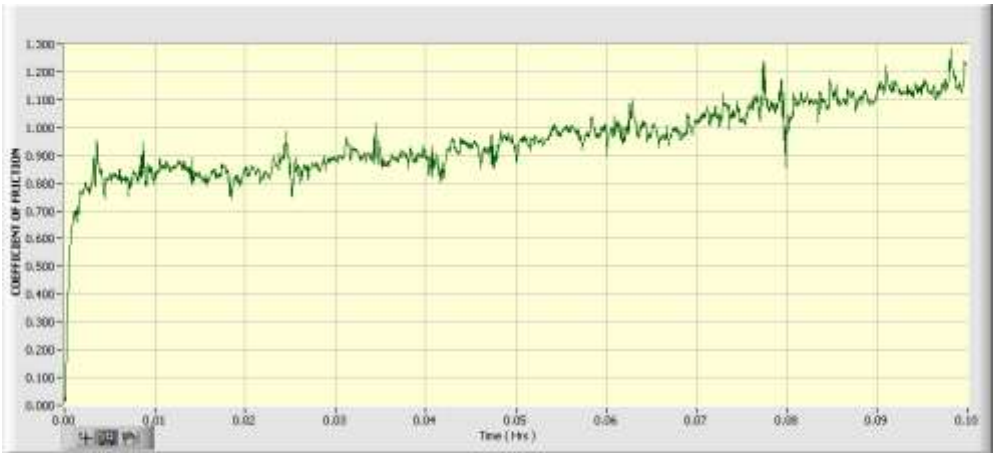
Initial weight of drill bit tooth (g)	Initial weight of granite disc (g)	Type of Drilling Mud	Final weight of drill bit tooth (g)	Final weight of granite disc (g)
2.697	15.756	Water based mud	2.691	15.753
2.687	14.986	Water based mud with nut plug	2.686	14.985

Table 4.2 *Physical results on the drill bit tooth (pin) and granite disc.*

Based in the results recorded using the weight scale machine (Table 4.2), the data is only cover the physical properties of the pin and disc. When using the normal water based mud as the drilling fluid, the wearing effect occurred on both pin and disc is huge. The weight of the pin decreases by 0.006 g, and the weight of the disc is decreases by 0.003 g. As for the one using water based mud with nut plug, the weight decrement of the pin and disc are only 0.001 g.



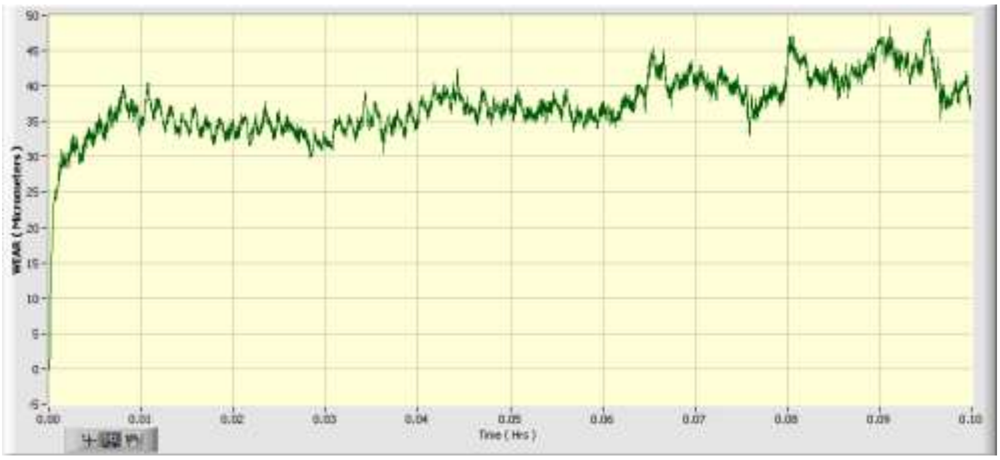
Normal Water Based Mud



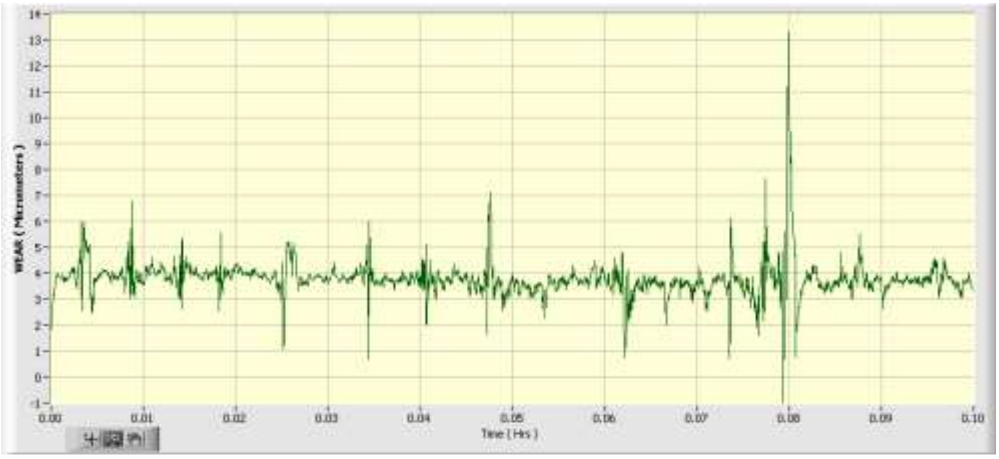
Water Based Mud with Nut Plug

Figure 4.1*Friction Factor*

From the Wudacom 2006 Software, the data obtained are friction factor and wear. The friction factor when using the fluid loss medium (nut plug) is a little bit lower than the one using normal water based mud (without nut plug), based on Figure 4.1. Based on the wear result in Figure 4.2, using normal water based mud can cause wearing up to 40 µmeter of thickness, whereas when using the nut plug, the wear is only at the range of 4 µmeter.



Normal Water Based Mud



Water Based Mud with Nut Plug

Figure 4.2 *Wear*

4.3 Discussions

For a test of only 6 minutes, the wearing behaviour happened on both samples by using normal water based mud can be considered as a huge wear effect as in the real situation. The drilling will be done for continuously, hours. There are pros and cons of using this type of drilling fluid.

For drilling operation, a huge wearing effect on formation is essential as it shows that, by using this fluid, the wearing effect or should the author say, the penetration rate of the drilling string through the formation is high. From the other part, which the pin, it shows that, the pin is having a high wearing effect. This is a con for the drilling fluid, as it represent the high wearing on the drilling bit, in the drilling operation in the wellbore. High wearing behaviour means that, the drilling tool is having a high rate of damaging as it penetrates into the formation.

On the other hand, using water based mud with nut plug give out different results, vice versa with the on using normal based mud (without nut plug). The nut plug, which is a fluid loss medium reduces the friction between the pin and the disc; the surface area contact [13]. Due to that, the wearing effect on the contact is lower, lower than the other fluid. The pros from this is, the pin will have less wearing effect, but, the con is, the rate of penetration into the formation is low.

However, from the friction factor graphs (Figure 4.1), both drilling fluid gives out almost the same value. Both is in the range of Friction factor of 0.9 – 0.11. The results shows that, even slightest different on the friction factor value from one another, gives out a huge impact on the wearing behaviour on the contact surface. The margin between the wear is about 36 µmeter (between 40 µmeter and 4 µmeter) for different drilling fluid.

CHAPTER 5

CONCLUSION

In conclusion, this project will be one of the references for those who want to use different kind of drilling fluid's composition. The drilling fluids can be varied to much more kind, type of composition; so that this project can cover up much more wearing behaviour in different drilling fluid.

Based on the results, the different in formulation of drilling fluids gives different outcomes on the friction factor and wearing activity between the pin and the formation. However, a general hypothesis or conclusion can't be made, as different drilling fluid have their own conditions, which are differ from each other. These results can only be used as reference, in order for the readers to get an overview of the friction and wearing behaviour in various kind of drilling fluid.

For the recommendations, various type of drilling fluid shall need to be tested to get the complete references for all types of drilling fluid. By doing this, the outcomes will cover all the drilling fluid available for drilling operation and also cover both the water based and oil based mud.

The Pin-on-Disc rig wasn't the perfect or the most trusted machine to be used for this kind of experiment. Lots of parameters that should be tested with weren't there during the experiment, such as temperature and pressure. More suitable machine or rig should be used in order to get a better result in the future.

Besides varying the drilling fluid, other experiment as varying the load, pin, or disc can be done. This will make the outcomes of this project to be more universal, and relating to one and other parameters.

Some other recommendations should be done:

1- Run 2 times for one disc. Why? The first run should be used to make sure the surface of the disc that in contact to be in regular, flat surface. After the first run, weigh it back for initial weight, and then install back for 2^{nd} run, which will give the real results.
2- Steel should be used for the drilling fluid "cup" or holder as it is less ductile, thus, probability of having a leakage is low.
3- Use high viscosity of drilling fluid, in order to reduce the probability of leakage in the drilling fluid "cup" or holder.

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