April 2013

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Recommended Citation

NAIDU, B.SOMI; NAIDU, M.K.; and RAO, S.SRINIVASA (2013) "DESIGN OF SHAFT-BLADE ASSEMBLY FOR EFFECTIVE UTILIZATION OF MUD USED IN OIL AND GAS DRILLING," *International Journal of Mechanical and Industrial Engineering*: Vol. 2 : Iss. 4 , Article 4.

DOI: 10.47893/IJMIE.2013.1102

Available at: <https://www.interscience.in/ijmie/vol2/iss4/4>

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DESIGN OF SHAFT-BLADE ASSEMBLY FOR EFFECTIVE UTILIZATION OF MUD USED IN OIL AND GAS DRILLING

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Abstract:- Mud has prominent role in drilling operation, it enhances to protect the drilling well from blowout by obstructing the formation pressure and failure. It gives exact information about presence of formation gasses and fluids at every part of the drilled hole. It's very essential to maintain mud with different proportions to have proper and un-interrupted drilling process. Because estimating earth formation is of much difficulty and active mud should readily available at every instant. In order to have proper and un-interrupted drilling process and to maintain mud with different proportions mud activating devices viz., mud-agitator and mud gun are used in existing mud tanks. On observation it is found that nearly 33% of mud in the tank is not influenced with these activating devices. Due to which the flow of mud from the tanks to the drill string is not in exact composition and also there is accumulation of mud chemicals^[17] at the bottom of the tank which causes several problems. This paper emphasizes the design of shaft-blade assembly which runs horizontally along the length of the tank in order to activate mud in that tank effectively. The shaft-blade assembly was designed and analyzed in the ANSYS and from the results it was found that the stresses in the shaft-blade materials are well within the limits for the proposed design. Economic aspects of the design are also discussed in this paper at the end.

Keywords:- Mud, Mud-Gun, Mud-Agitator, Shaft-Blade assembly, cost analysis.

INTRODUCTION TO MUD

Extracting oil and natural gas from earth ore involves technological process called drilling. Because estimating earth's formation pressure is of high difficulty, hence minute and precise care is taken in every aspect of drilling. Drilling process involves estimating formation pressure, un-interrupted drilling, time to time monitoring about the drilling process, testing intermittently for the presence of oil and natural gas and safe drilling throughout the process.

The traditional drilling process involves a fluid to fulfill all the above conditions called mud[1]. It has prominent role in drilling operation, the physical properties of drilling fluid (density, viscosity etc.,) or rheological properties contribute to:-

1. Provide pressure control to prevent an influx of formation fluid.
2. Provide energy at the bit to maximize Rate of Penetration (ROP).
3. Provide wellbore stability through pressured or mechanically stressed zones.
4. Suspend cuttings and weight material during static periods.
5. Permit separation of drilled solids and gas at surface.
6. Remove cuttings from the well.

Each well is unique, therefore it is important to control these properties with respect to the requirements for a specific well and fluid being used. The rheological properties of a fluid can affect one aspect negatively while providing a significant positive impact with respect to another aspect. A balance must be attained in order to maximize hole cleaning, minimize pump pressures and avoid fluid or formation influxes, as well as prevent loss of circulation to formations being drilled.

In the literature several studies were made on the rheology and hydraulics of drilling fluid systems. Hamed and Belhadri developed water based mud systems using two biopolymers, which are xanthan gum and scleroglucan, generally proposed for high permeability reservoirs or for complex geometries such as horizontal wells and found that non-Newtonian rheological behaviour can be described well by the three parameter in Herschel-Bulkley (modified power law) rheological model. Zhou and Shah[2] investigated experimentally the rheological properties and friction pressure losses of several common well-drilling, completion, and stimulation fluids. These fluids include polymeric fluids—Xanthan gum, partially hydrolyzed polyacrylamide (PHPA), guar gum, and hydroxyethyl cellulose (HEC), bentonite drilling mud, oil-based drilling mud, and guar-based fracturing slurries. Rheological measurements showed that these fluids exhibit shear thinning and thermal thinning behaviour except the bentonite drilling mud whose viscosity increased as the temperature was raised.

Fig.(1) represents pumping of drilling mud from tanks to drill string, to hole and in return to the shale shakers.

Figure 1

Fig(2) Represents pipe assembly and mud circulations inside the hole.

Figure 2

MUD ACTIVATING DEVICES

1. Mud Gun

Mud gun[7] are meant to provide supplemental or primary mixing in mud tanks depending on the number being used and the pit size. They are best used in tank corners to keep solids from settling and a mud agitator is placed in the tank center.

Mud guns are to be located in the tank corners. The centerline of the nozzle is to be located about 6" off the tank bottom.

2. Mud Agitator

The mud agitators[6] are high-efficiency mud-mixing units offered in a wide array of custom sizes and configurations to accommodate virtually any mud tank. Both horizontal and vertical drive configurations are available for all sizes of mud agitators. The horizontal drive is designed for installations having limited space above the mud tank.

Figure 3

Fig(3) Vertical Drive With Straight Impeller (Typical Derrick Mud Agitator)

The mud agitator stirs a mud slurry to maintain suspension of solids. The agitator is mounted on top of the mud tank and has one or two impeller(s) immersed in the mud slurry. The impeller shaft is directly coupled to an electric drive motor that is available in several horsepower ratings from 3 (50Hz only) to 30 (60Hz). Impellers are available in diameters ranging from 20" to 52" to meet the needs of various size mud tanks.

The mud agitator is operated by a 3-phase induction motor. Drive motors range from 5 to 30 horsepower for the 230/460Vac 60Hz power configuration and 3 to 25 horsepower for the 190/380 50Hz power configuration

Design of shaft-Blade assembly

Though there are mud guns and mud agitator's, to activate the mud, there is certain portion in the mud tank which is not influenced by these activating devices. Hence this portion of mud tank is having in-activated mud. This in-activated mud promotes in settling of the chemicals at the bottom of the tank creating a differential chemical composition throughout the tank. This in-activated mud is carried to the drill string followed to the drill bit, where its functioning is severely affected. On observation, in mud tank there's a provision to run a horizontal shaft-blade assembly through the length of the tank. Such an arrangement at proper elevation can activate that portion of the tank which is generally a dead zone. This assembly runs horizontally along the length of the mud tank with three bearing supports at the partition. Each blade assembly consists of four blades and four such assemblies are located through out the length of the shaft.

On economic considerations, the amount of chemicals wasted due to this in-active mud is primarily calculated. The cost of chemicals wasted per tank for a location is amounting to around Rs.51,000/- (Rs. Fifty one thousand). If the drilling rig, works at least for a span of one year in five locations, the total cost of chemicals lost amounts to Rs.2,55,000/- (Rs. Two lakh fifty five thousand). To reduce this wastage of mud it is proposed in this paper to design a horizontal shaft-blade assembly

Once the economic aspects are cleared the design of the shaft-blade assembly is taken into consideration.

This paper emphasizes on three aspects.

1. Design of shaft.
2. Design of blade.
3. Economic aspects of chemicals wasted and cost of equipment.

But before getting into the complete design, the following design criterion need to be noted.

Mud with density 1668.1 kg/m^3 is chosen in order to design the project for high mud weight. The Standard D.C Motor with speed reduction gear box used to

mud-agitator is selected for calculation towards failure criterion.

The total provision for the assembly to accommodate w.r.to Length x Width x height is taken into consideration. With which the size of shaft and blades are primarily considered.

Design of Shaft:

1. Appropriate material is selected to meet the design standards and availability of the material.
2. Failure stresses are obtained by applying the different loading conditions on the shaft.
3. Loads calculations are done on the shaft by using Ansys 12.0
4. Forces taken into account are Torque, weight due to blades and buoyancy force acting on the shaft as it is submerged inside the mud.
5. The deformation and Von-mises stresses are within the limit. The loading conditions are applied to different cross-sectional pipes and the best in economic and safe design is selected.
6. 2D beam element is chosen to descritize the domain.
7. Fig.4 is Ansys generated image illustrating the deformation and max stress induced in the shaft when applied with given boundary conditions. 3" Schedule40 pipe is found to be of optimum size.

Figure 4

Fig(4) Describes failure criterion for 3"schdl shaft using Ansys

Deformation(D_{max})= 1.4cm(Safe)

Von-mises Stres(S_{max})=69.1Mpa

S_{max} is less than yield strength of steel(250MPa) with factor safety 3.61

Max stress is obtained at the end nearer to the D.C. Motor gear assembly.

8. For smaller sizes in pipes S_{max} and deformation are out of limits. Sizes greater than optimum value were not economically viable.

Design of Blade

Material selection for blade is same as that of shaft. With different profiles of blades available, 'Turbine blade type[5]' is chosen as it is applied to present agitating systems.

The loading conditions are applied on this flat blade of dimension(4mm x 400 mm x 400mm)

1. Blade carries two loads.

(i) Centrifugal force acting on the blade due to rotation given to the shaft.

$$F_c = m \times r \times \omega^2 \quad N$$

(ii). Pressure force acting on the blade due to the mud level. The maximum pressure force on the blade will be when the blade is at the bottom most part of its rotation.

$$\text{Pressure (P)} = \rho \times g \times h \quad N/m^2$$

$$\text{Force (F)} = P \times A \quad N$$

2. Shell 4 node 63 element is chosen for analysis on the blade as it is used for materials with lower thickness values.

Rectangular area with 0.4m x 0.4m is meshed with smart size 1 and boundary conditions with loading data are applied by varying the thickness of the element.

Figure 5

Fig(5) Describes failure criterion for 4mm thick blade using Ansys

3. For 4mm thick blade the deformation and Von-mises stresses were considerably less compared to 2mm thick blade.

The values for 4mm thick blade are:-

Deformation(D_{max})= 1.3cm(Safe)

Von-mises Stres(S_{max})=122 Mpa

S_{max} is less than yield strength of steel(250MPa) with factor safety 2.049.

The max stresses were observed at the shaft to blade junction.

Cost analysis

1. Cost analysis relevant to waste of mud.

The most influencing chemicals which are used daily basis in drilling mud are chosen to calculate the cost. Bentonite, barite, xanthan gum, soda ash, NaOH, Polyanionic Cellulose, Starch were mostly used.

- 2 The percentage chemical composition of the mud is shown in Fig(6)

Figure 2. Composition of a typical water based drilling mud (WBM) and of the additives to a typical WBM.

Figure 6

3. Cost per ton value is taken into account and the loss of mud for 20% in volume is taken into consideration.

Cost analysis of the mud chemicals used in Oil and Natural Gas Drilling					
Dimensions of the tank (10m(Length) x 2.6m(Width) x 2.25m(Height))					
Total accumulated volume of a tank=56.794 cu.mtr=56794 ltr					
Cost of wastage mud is estimated for 20% loss in volume of all chemicals used.					
Water has 76% of composition in the mud for a mud tank					
SNO	Total volume Of tank(cu.mtr)	Name of the Chemical	% volume of Chemical in tank	Volume of Chemical (Cu.mtr) in tank	Loss in volume For 20% (Cu.mtr)
1	56.794	Barite	15.000	8.52	1.70
2	56.794	Bentonite	7.000	3.98	0.80
3	56.794	NAOH	0.456	0.26	0.05
4	56.794	Cellulose	0.456	0.26	0.05
5	56.794	Starch	0.456	0.26	0.05
6	56.794	Soda Ash	0.380	0.22	0.04
7	56.794	Xanthan Gum	0.190	0.11	0.02

SNO	Name of the Chemical	Density Kg/Cu.mtr	20% volume (Cu.mtr)	Mass(Kg)	Cost in Rs. Per Ton	Cost in Rs. Per Kg	Loss of Chemical in Rs.
1	Barite	4200	1.704	7156.8	3360	3.36	24046.848
2	Bentonite	2400	0.795	1908	1375	1.375	2623.5
3	NAOH	2130	0.052	110.76	15250	15.25	1689.09
4	Polyanionic Cellulose	1600	0.052	83.2	23000	23	1913.6
5	Starch	1500	0.052	78	13375	13.375	1043.25
6	Soda Ash	2540	0.043	109.22	142500	142.5	15363.85
7	Gum	1500	0.022	33	108750	108.75	3588.75
Total loss(Rs.) of mud chemicals per tank for a single location of the drilling rig							50468.888
Total loss(Rs.) of mud chemicals per tank for 'Five' locations of the drilling rig							252344.44
Minimum Estimation that the Drilling rig works atleast for 'Five' Locations in year.							

Figure 7

Fig(7) Furnishes the cost analysis sheet. The total loss of mud chemicals per tank stands at Rs.2,52,344/- without putting an agitator in place. The market price of the designed Shaft-Blade assembly including speed reduction gear box and blades will be around Rs.90,000/-. Hence, there is a direct saving of at least Rs.1,60,000/- (One lakh sixty thousand) per annum per tank.

In a six tank mud system, the design is adopted in three tanks viz., Mixing, Reserve 1 & 2 tanks. As the provision for placing the shaft-blade assembly is not permitted in the other three tanks viz., suction, Intermediate and Shaker tanks. The total saving in cost for a drilling rig is Rs. 4,80,000.00/- per annum.

Typical model of shaft-blade assembly is shown in Fig(8)

Figure 8

CONCLUSIONS

The Max stress and deformation developed in the shaft and blades are within the allowable limits which permit its practical use. The shaft-blade assembly can be adopted in the presently functioning drilling rigs to make their operation cost effective and optimum. This has been proven by the cost analysis of the waste mud and capital cost of the shaft-blade assembly. There is a wide margin between the two expenses.

REFERENCES

- [1]. Experimental investigation of drilling fluid formulations and processing methods for a riser dilution approach to dual density drilling by John Shelton A.S., B.S., Purdue University in West Lafayette, Indiana'Dec2005
- [2]. Zhou, Y., Shah, S. N., 2004, "Rheological Properties and Frictional Pressure Loss of Drilling, Completion, and Stimulation Fluids in Coiled Tubing", ASME, J. of Fluids Engineering, 126,pp. 153-161
- [3]. Operation & maintenance manual of mud agitator - khalsa oil field equipments pvt ltd, India-Edition'1999
- [4]. Blade shape Mixing and agitation manual by pacontrol page 288(point b) and page 291
- [5]. Blade types:- Impeller design for mixing of suspensions Tomas Jirout, Frantisek Rieger
- [6]. Vertical Mud Agitator Mode(DE-AG-V)-Derrick Mud Agitator.
- [7]. 3" low pressure mud gun installation, operation, & maintenance manuaa Max200-PSI-Houston.
- [8]. Mud tank drawings ref. drawings Shiv-vani oil and Gas exploraion services ltd.,2008
- [9]. Drilling Armco well control manual © Oct'2002-Saudi Arabia
- [10]. Handbook of Best Practices for Geothermal Drilling-Sandia report ©Dec'2010
- [11]. Baker Hughes technical Information on drilling-© Sep'2001
- [12]. For calculation Formulas and Calculations for Drilling, Production and Workover Second Edition by Norton J. Lapeyrouse ©2002
- [13]. IADC Drilling Manual eBook Version (V.11) © 2000
- [14]. Rig Train well control manual © 2001- rev3
- [15]. Drilling Engineering Workbook Baker Hughes INTEQ-© Dec 1995
- [16]. Drilling fluid fundamentals Ref:Handbook of Groundwater Development, Roscoe Moss Company, Published by John Wiley & Sons, Inc. 1990.
- [17]. Drilling fluid properties & functions by john h. Berry, p.G. Hydrogeologist /geologist-cetco drilling products©2007.
- [18]. Improving rheological and filtration properties of drilling muds with addition of greek lignite Shale Stability: Drilling Fluid Interaction and Shale Strength Manohar Lal, SPE, BP Amoco ©1999, Society of Petroleum Engineers Inc.