Analysis of Thermal Desorption System for the Chemical Treatment of Old Storages of Oil Based Mud

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ABSTRACT

This paper presents an analysis for the chemical treatment of OBM (Oil Based Mud) used in the drilling process in the oil and gas industry. The analysis is based on OBM stored at ENI (Italian National Energy) gas fields at Bhit mount district Jamshoro since the last ten years that has been chemically and physically deteriorated. Characterization of various OBM samples was performed and these samples were processed in order to evaluate the best characteristics of the OBM for optimum treatment results. The OBM treatment process involves the separation of hazardous fluid (such as diesel or mineral oil) from solids Due to the lean quality of the OBM, the dust separation process in the cyclone caused blockage in the cyclone. This paper suggests a remedial way by means of installation of a hammer stick in the cyclone dust collector to overcome cyclone blockage. The analysis is performed to compare the pressure drop and the dust collection efficiency in the cyclone with and without the hammer stick. The post-installation experimental results showed that hammer stick can improve the cyclone dust collection efficiency without blockage of the cyclone.

Key Words: **Oil Based Mud, Drill Cuttings, Thermal Desorption System, Cyclon Dust Collectors.**

1. INTRODUCTION

During exploration in oil and gas fields, well drilling processes result in the production of large quantities of drill cuttings. These cuttings obtained during drilling process are mixture of clay, rock-chips and the drilling fluid. Drilling fluids in the form of drilling mud are used during drilling process to control the subsurface pressure, provide lubrication during the drilling process, maintain temperature, retain stability of the well bore, and carry cuttings to the surface. Mud is pumped through the hollow drill string from surface which exits through nozzles in the drill bit, and finally the mud returns to the surface through space between the drill string and the walls of the hole as shown in Fig. 1 [1]. During the drilling process the drill cuttings enter in the mud flow and are carried to the surface.

Drilling muds are made up of various base fluids such as water, mineral oil, diesel, or a synthetic compound [2]. For deep and directionally drilled wells, the industry mainly

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relies on OBMs. OBM performs well during the drilling process but may be subject to more complicated disposal requirements [3-4].

OBMs are either diesel oil based or low toxicity muds. Diesel oil based muds contain significant amount of toxic aromatic compound and may have harmful effects on the local environment. As a result, the discharge of OBMs or their cuttings is prohibited [5].

This research paper is aimed at discussing the issues regarding the treatment of OBM stored at ENI gas fields Bhit mount district Jamshoro, Sindh. Though several methods are available for the treatment of retrieved oil based cuttings, thermal desorption process have been used for the treatment of OBM. This process is comprised

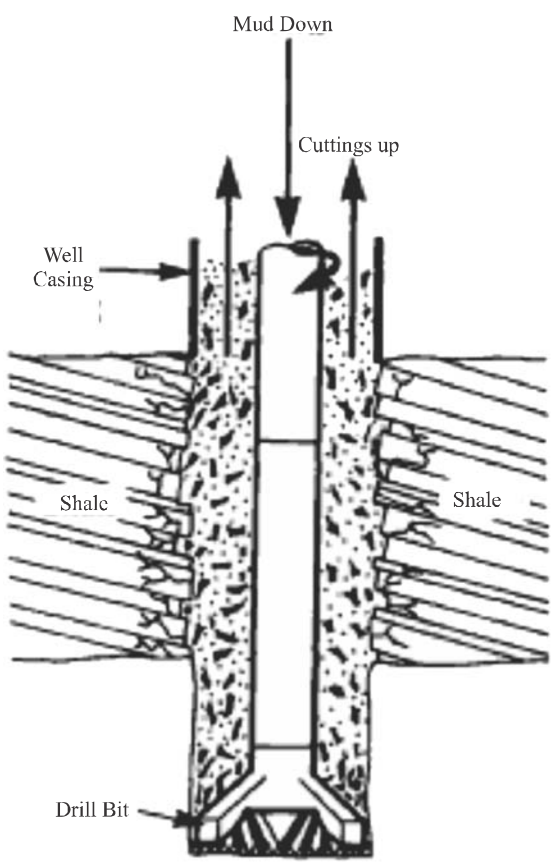

FIG. 1. DIAGRAMMATIC REPRESENTATION OF TYPICAL CUTTING DISCHARGE AND DRILLING OPERATIONS [1]

of a non-oxidizing method to vaporize volatiles and semi-volatiles through the application of heat. Although, various thermal desorption processes are available for the treatment of drilling wastes, such as thermal phase separation, thermal distillation, thermal plasma volatilization, and modular thermal processors. The current study is limited to thermal desorption under modular thermal processors, which is the advance version of the TDS (Thermal Desorption System) [5-7]. The unit operating under this system is shown by the flow diagram given in Fig. 2.

This process is designed to flash-evaporate the fluid phases from drilling wastes via a combination of electrical and mechanical energy (through a hammer mill). The evaporated fluids are retained and then condensed, allowing selective recovery of the individual fluids (typically hydrocarbons and water). The remaining solids are discharged as an inert powder, and the recovered fluids can be reused or recycled.

2. PROBLEM SUMMARY

The stored OBM at the selected gas field is the OBM prepared for the drilling operations in the last ten years. Due to the lapse of so many years, the accumulated OBM has been deteriorated both physically and chemically. In addition, OBM being of lean quality, creates many problems during the course of its treatment, some of them include:

- The OBM contains very low quantity of liquids; as such it becomes very difficult to process it in the Process mill.
- Some of the OBM contains about 80% or more quantity of liquids such as oil and water and thus cannot be effectively processed.

- ☐ Cyclone of the mill often gets chocked as too much dust flows out of the mill with the evaporated fluid phases, causing the mill to trip suddenly.

3. AIMS AND OBJECTIVES

The objectives of this study are to suggest viable remedies for the problems cited above. Keeping in view the above factors, the following solutions to these problems have been worked upon:

(1) To determine the optimum percentage of water, oil and solids in OBM by mixing different OBM samples collected from the storage.

(2) To suggest modification in cyclone design or an alternative solution to the blockage of cyclone solid discharge end.

4. METHODOLOGY

The methodology adopted for this study is divided into two parts. The first part was purely experimental and required finding optimum mixing ratios of various OBM storages at the plant site that can give best results during OBM processing in the process mill as well as minimum percentage of hydrocarbons in the recovered solids. This experimental part was carried out in the following way:

- ☐ The OBM sample was first taken for its retort test (a test which reveals the percentage of oil, water, and solids present in the mud) before being processed in the process mill.
- ☐ The recovered solids were also analyzed by retort test to check the percentage of hydrocarbons present.
- ☐ OBM samples with different percentage of oil, water, and solids present in the mud were tested for optimum results.

The second part of this research dealt with the issue of cyclone operation. During the OBM treatment, the solid discharge end of the cyclone installed in the mill (Fig. 2) often got chocked. This cyclon choking problem was worked upon for possible design modifications.

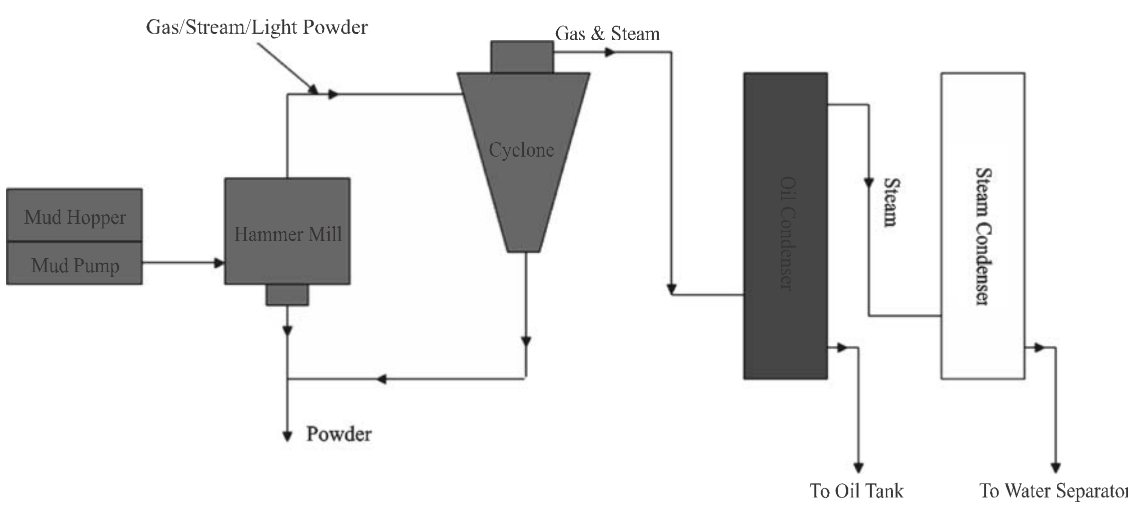

FIG. 2. FLOW DIAGRAM OF THE PROCESS MILL WORKING UNDER THERMAL DESORPTION SYSTEM

4.1 Evaluation of OBM Samples (Part-1)

Various OBM samples were obtained by mixing the OBM taken from different storages that were heterogeneous in nature. Initially the characterization of each OBM sample was performed to evaluate the percentage of oil, water, and solids present in the sample by retort test. All samples were differentiated by the percentages of oil, water, and solids present in the mud. Each sample was processed in the process mill and the characterization of the recovered solids is carried out to check the percentage of hydrocarbons present in the recovered solids to know whether it is suitable for disposal or not.

Table 1 shows the processing results of 19 OBM samples of different composition in the process mill. These results imply that with higher percentage of liquids it is difficult to process the OBM samples in the process mill working under modular thermal processor thermal desorption system. This is because the modular thermal processor thermal desorption system uses a hammer mill that increases the temperature of OBM to flash evaporate the liquids by the friction generated between the mill hammer and the OBM. If an OBM sample does not contain an adequate percentage of solids but contain a higher percentage of oil/liquids, this will cause low friction between the mill hammer and the OBM and will fail to generate the required temperature to flash evaporate the liquids from the OBM sample. On the other hand Table 1 also shows that OBM samples with higher amount of solids (47% or more) are difficult to process, because with higher percentage of solids high friction is produced. This results in over-loading of motor and causing process mill to trip suddenly. Table 1 shows that for uninterrupted operation of the process mill, the best composition of the OBM with allowable percentage of hydrocarbons in the recovered solids ranged as; solids 35-36%, oil 32.5-33% and water 32.5-33%. If the percentage of solids was increased from 36%, the percentage of hydrocarbons in the recovered solids was reduced but the cyclone dust collector started getting choked as higher amount of dust particles flowed toward the cyclone. If the cyclone was fully blocked at its solid discharge end, this also resulted for the process mill to trip in order to avoid any further damage or loss of the mill. Table 1 also shows that cyclone choking issue for the OBM samples containing solids between 38 - 40% could be resolved, this would give best results for the quality of recovered solids.

4.2 Study of Cyclone Dust Collector (Part-2)

Cyclone separators are widely used in engineering processes to separate or recover solid particles from gaseous fluids. The process of gas-solid separation in a cyclone may involve high-temperature, high-pressure and hostile chemical environments. The cyclone installed in the process mill for OBM treatment is a reversed flow cyclone, which is one of the most commonly used industrial cyclones as shown in Fig. 3.

In a reversed flow cyclone, the aerosol particles enter the cyclone at the cylinder top, where the configuration of the entry causes the gas to spin forming a vortex of the particles entrained in the gas, throwing them to the cyclone wall for collection. Below the bottom of the gas exit tube, the spinning gas gradually migrates inward to a central core along the cyclone axis and, from there up, finally come out through the gas exit. Dust collected at the wall descends to the collection trap at the bottom of the cone, primarily due to the downward component of the gas velocity at the cyclone wall rather than the gravity factor.

Many researchers [8-14] have studied the increase in dust collection efficiency and permit the existing systems to handle greater flow rates. Wang, et. al. [11] have proposed that by installing a stick in gas cyclones, separation efficiency can be increased and could also greatly reduce the pressure drop. The current study also proposes a hammer stick that is installed inside the cyclone axially as shown in Fig. 3.

Commercial computational fluid dynamics software "FLUENT" based on finite volume method has been used. The numerical simulation is carried out to analyse separation efficiency and pressure drop in the cyclone with and without the hammer stick.

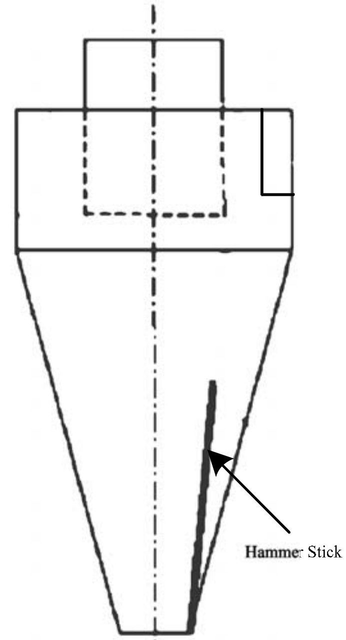

FIG. 3. HAMMER STICK LOCATION IN THE CYCLONE

TABLE 1. CHARACTERISATION OF OBM SAMPLES AND RECOVERED SOLIDS

Sample	Characterization of OBM Samples Used in Process Mill			Characterization of Solids recovered from Process Mill
	Average % of Solids	Average % of Oil	Average % of Water	Average % of Hydrocarbons
1	20	50	30	Unable to process OBM with higher % of Liquids
2	23	50	27	Unable to process OBM with higher % of Liquids
3	30	40	30	2.36
4	30	38	32	2.21
5	33	38	29	1.62
6	33	36	31	1.23
7	35	38	27	0.91
8	35	35	30	0.72
9	35	33.5	31.5	0.54
10	35	32.5	32.5	0.50
11	36	32	32	0.49
12	38	32	30	0.48 (cyclone seldom gets choked)
13	38	30	32	0.46 (cyclone seldom gets choked)
14	40	30	30	0.41 (cyclone seldom gets choked)
15	42	30	28	0.40 (cyclone gets choked less frequently)
16	42	28	30	0.39 (cyclone gets choked less frequently)
17	44	28	28	0.37 (cyclone frequently gets choked)
18	45	28	27	0.37 (cyclone frequently gets choked)
19	47	27	26	Process mill trips due to over loading with higher % of Solids

5. NUMERICAL SIMULATION

In order to represent the practical situation in industry, the simulations are performed using CFD computational tool known as FLUENT. Fig. 4(a) shows the dimensions of cyclone symbolically and numerical values of the reverse flow cyclone geometry are given in Table 2. Grid representation of the computational domain containing 46000 CFD cells is shown in Fig. 4(b). Hexahedron girds are selected for the CFD simulations, with dense grids at the zone near wall and vortex finder and sparse grids at the zone away from the wall. For inlet gas, the pressure and the velocity range is selected as 1 atm and 5-35 m/s, respectively. RSM (Root Sum Square) method has been used to perform simulations. RSM method is widely used for the analysis of cyclon dust collectio and pressure drop as it provide reliable result [8,4]. For details of the RSM, the readers are encouraged to refer to Gong, et. al. [8].

The numerical results are calculated and compared for the two most important parameters of cyclone with and without hammer stick. These parameters are: the dust collection efficiency as shown in Fig. 5 and pressure drop in the cyclone as shown in Fig. 6.

Fig. 5 shows that as the inlet velocity increase the separation efficiency also increase and after the installation of hammer stick, separation efficiency of the cyclone is improved at all the given velocity ranges. Similarly, Fig. 6 shows that with the increase of inlet velocity pressure drop in the cyclone also increases. Also pressure drop in the cyclone is increased after the installation of hammer stick, but the trend of the pressure drop remains same.

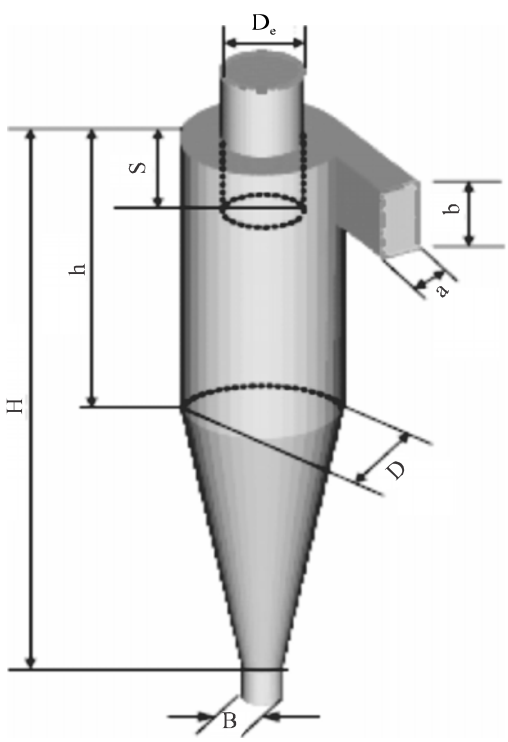

FIG. 4(a). SYMBOLIC REPRESENTATION OF CYCLONE GEOMETRY

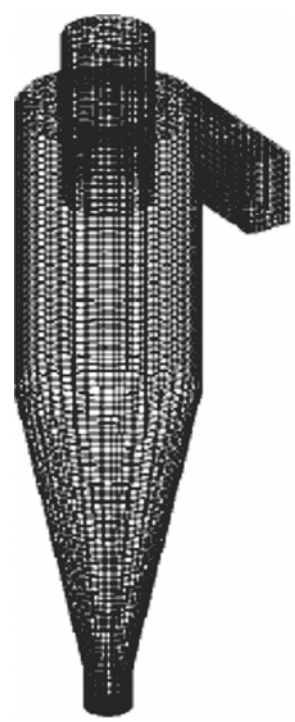

FIG. 4(b). GRID REPRESENTATION OF THE CFD CELLS

TABLE 2. CYCLONE GEOMETRY (VALUE OF D IS NOT DISCLOSED FOR COPYRIGHT REASONS)

a/D	b/D	D_e/D	S/D	h/D	H/D	B/D
0.35	0.30	0.40	0.50	1.4	2.95	0.20

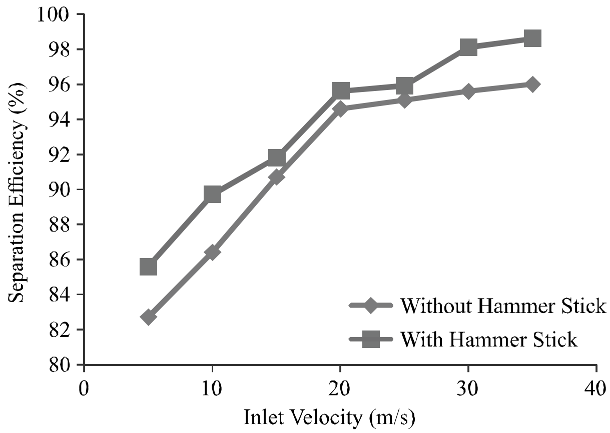

FIG. 5. COMPARISON OF SEPARATION EFFICIENCY WITH AND WITHOUT THE HAMMER STICK.

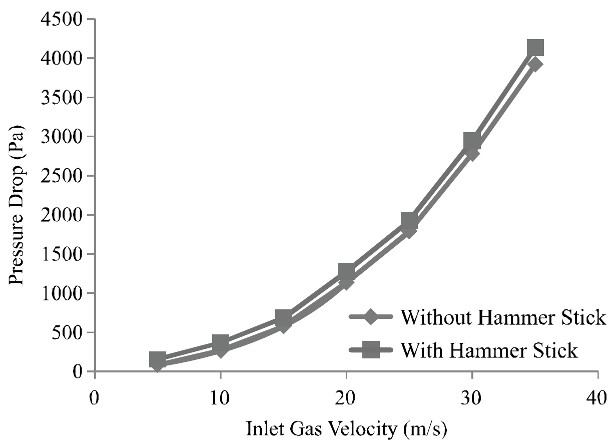

FIG. 6. COMPARISON OF PRESSURE DROP WITH AND WITHOUT THE HAMMER STICK

6. CONCLUSIONS

The analysis of the OBM treatment is performed using thermal desorption unit based on modular thermal processor system. The OBM treatment results are calculated at various OBM samples of different characteristic with an aim of finding the optimum solid, oil and water mixing ratios of the drilling mud for its efficient treatment. The results of this study will help the manufacturer for reassessment, development and to optimize the performance of the process mill used for OBM treatment in order to meet the constantly challenging demands of the industry. Further analysis is performed to resolve the issue of blockage of the cyclone dust collector given the percentage of solids is slightly higher in the OBM used for the treatment. A modification in the cyclone is suggested that proposes the viable installation of hammer stick in the cyclone. Analysis of cyclone dust collection efficiency and pressure drop is performed using RSM. RSM results reveal that with the installation of hammer stick the dust collection efficiency incresed at an average of 2.5% at a velocity range of 5-35 m/s. Furthermore, much improved results were obtained for pressure drop in cycle due installation of hammer stick.

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