Adaptation of Thermal Desorption in the Treatment of Oil Based Drill Cuttings

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***Abstract*— Drill cuttings represent one of the most significant waste streams in the upstream oil and gas industry, and they require effective and efficient treatment and disposal. The industry is working with regulators to achieve continuous improvement in its environmental performance, with the ultimate goal of zero discharge. Drill cuttings may be contaminated in either water based mud (WBM) or oil based mud (OBM). Drill cuttings from OBMs are typically hydrocarbon contaminated and will require the filtering of contaminants prior to disposal or reuse. This study investigated the effectiveness of treating oil contaminated drill cuttings using thermal desorption method. Sample of drill cuttings were collected from a field drilling operation in the Niger delta. The initial oil content was about 21.8% and after treatment in the thermal desorption unit the resultant dry drill cuttings (ash) oil content was 0.33%. This meets the regulatory requirement of oil on cuttings (OOC) of less than 1% by weight, eliminating future environmental liabilities. Also, laboratory testing showed that the recovered base-oil is remarkably similar in composition to the original diesel in composition and that it can be used in an identical manner.**

***Index Terms*— drill cutting, drilling waste, oil mud treatment, thermal desorption.**

I. Introduction

Oil well drilling operations requires the use of drilling mud to aid the drilling process. Muds are circulated through the drill bit to lubricate and cool the bit, control the formation fluid pressures and to aid in carrying the drill cuttings to the surface, where the mud and cuttings are separated by mechanical means. The drilling processes are characterized with the generation of drilling waste, whether on land or off shore. Drilling waste and its treatment is of increasingly concern to oil operator and environmental regulators. These wastes, which typically include drill fluid cuttings and drilling mud are hazardous and should be treated before disposal. The adverse effects of the discharge from drilling operations are of great concern because of the effect of drill cuttings (which can be water based, oil based, and synthetic based mud) on the immediate environment [1].

The first step in managing drilling wastes is to separate the solid cuttings from the liquid drilling mud. Once solid and liquid drilling wastes have been separated, companies can use a variety of technologies and practice to treat the wastes before disposal. The traditional management practices can be grouped into: waste minimization, recycle/ reuse, and disposal. Some disposal methods for oil-based cuttings are becoming unacceptable and uneconomical [2]. Operators are required to reduce oil on cuttings (OOC) to less than 1% by weight [3].

Until the 1980s, there was little or no drilling-waste-management as we know it today [4]. In offshore operations, cuttings and excess drill fluids typically were discharged overboard, spread on the lease sites or buried in land operations. There were little, if any, regulations regarding disposal of these materials. Because of increased global awareness and understanding of environmental issues in the early 1990s, the effects of drilling operations and drilling wastes became a subject of interests to operators, service companies, and regulators. Early regulations typically restricted what could be disposed of by setting limits on oil or chloride content or the location of disposal sites.

In many instance, the oil companies operating in the Niger Delta region of Nigeria are required to adopt good oil-field disposal practices as prescribed and approved by the Directorate of Petroleum Resources (DPR), the regulator of the Nigerian petroleum industry. In line with this therefore, the DPR have emphasized the implementation of the following guidelines and standards by the oil operators as requirement for discharge of oil base mud (OBM):

i. To discharge, must submit proof that OBM has low toxicity to DPR with permit application. Discharges will be treated to DPR's satisfaction.
ii. OBM must be recovered, reconditioned, and recycled.
iii. Oil on cuttings (OOC), 1% by weight.
iv. On-site disposal if oil content does not cause sheen on the receiving water.
v. Cuttings samples shall be analyzed by Operator as specified by DPR once a day.
vi. Point of discharge as designated on the installation by shunting to the bottom.
vii. DPR to analyse samples at its own discretion for toxic/hazardous substances.
viii. Operator to carry out first post drilling seabed survey 9 months after 5 wells have been drilled. Subsequent seabed surveys shall then be carried out after a further 18 months or further 10 wells
ix. Operator must submit to DPR details of sampling and analysis records within 2 weeks of completion of any well.
x. Inspection of operations shall be allowed at all reasonable times.

The goal of this paper is to produce oil-free drill cuttings, to meet regulatory requirement, for disposal by distilling off oils from the cuttings through a thermal desorption process, and recovering oil to be re-used in the preparation of a fresh drilling oil-based mud.

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II. THERMAL DESORPTION

The treatment of drill cuttings may involves using thermal desorption method among others. Thermal desorption is the separation and recovery process resulting in three stream; water, oil and solid. The process is to heat the waste material to a specified temperature (or sequence of temperatures) in order to change the physical state of the volatile contaminants (i.e. from liquid or solid to gas); vaporising them from the material in order to facilitate their removal and subsequent recovery, whilst preventing their destruction.

The heating volatilizes liquid and the vapour is cooled and separated into water and oil phases [5]. The liquid phase can be recovered and made into a new drilling-fluid system or used as a fuel source respectively, while the solids could be disposed of or reused [6]. It is safe, reliable and economical [7].

Thermal desorption process generally operates at lower temperatures than waste incineration (usually below 200-400°C). Figure 1 shows a schematic of a typical thermal desorption treatment process of oil contaminated drill cutting; the treated solid wastes are collected and allowed to cool before being sent for disposal or recovery.

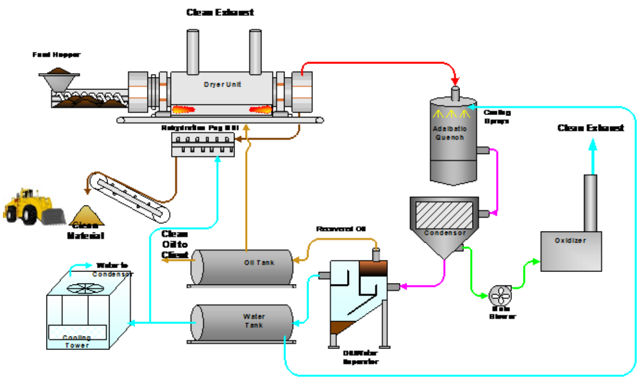

Fig. 1: Schematic of a oily drill cutting typical thermal desorption treatment process

A. *Treatment of Oil-Based Drill Cuttings*

Hydrocarbons that are used as the base-oil for drilling fluids contain relatively short-chain, small molecules that do not crack at the temperatures normally reached in thermal desorption units. Carbon compounds in the C_{20} to C_{30} range, which exist in this fluid, can crack at temperatures as low as 650°F (343°C).

However, operating the unit at a lower temperature so close to the actual boiling point of the oil would increase the required cuttings residency time in the TDU and therefore could negatively impact treatment rates. From a process perspective, the best scenario was to operate at highest possible temperature without cracking the oil.

III. METHODOLOGY

Sample of drill cuttings from oil based drilling mud were collected from a field drilling operation in the Niger delta. The samples were collected after drill cuttings and liquid drilling wastes have been separated. In the pre-treatment stage, the weight and relative percentage of each component of oil, water and solids in the drill cuttings was determined as shown in Table I. The treatment was done according to the procedure described by TWMA [8]. The treatment of the drill cuttings produced three distinct components: oil, water and solid. A Retort analysis to verify the volume of oil in the dried ash was conducted at this point.

Table I: Pre-treatment Analysis of Drilled Cuttings

Drill cutting Component	**Percentage /Weight**
Oil	30%
Water	25%
Solids	45%
Density	14.5ppg

A. *Retort Analysis*

A retort analysis provides a means for separating and measuring the volumes of water, oil and solids contained in a sample of drill cuttings. A known volume of sample is heated to vaporize the liquid components which are then condensed and collected in a graduated cylinder. The total volume of solids, both suspended and dissolved, is obtained by noting the difference of the total sample volume versus the final liquid volume collected. Calculations are necessary to determine the volume of suspended solids since any dissolved solids will be retained in the retort. Relative volumes of low-gravity solids and weight materials may also be calculated.

IV. RESULTS

The result of the retort analysis is shown in the tables II and III. They were obtained from heating a representative sample of oil-based drill cuttings and dry cuttings (ash) in the retort kit at 800°F for 45minutes respectively.

Table IV indicate that the drill cuttings from that well contain **21.8% of oil** which is far greater than the 1% regulatory requirement for oil on cuttings (OOC) prerequisite for discharge of oil base mud. After the drill cuttings have been passed through the thermal desorption unit, the sample of ash that was collected showed that it contained about **0.33% of oil** (Table V). This meets the target for drill cuttings (dry ash) disposal, eliminating future environmental liabilities.

Table II: Results of Retort on Drill Cuttings Sample

Measured parameters	**Measured weight**
Empty Retort Cup	276.4g
Full Retort Cup	320.0g
Empty Cylinder	76.3g
Full Cylinder	94.0g
Weight of Water (ml × 1.0)	8.2g
Retort Used	50ml-OFI-80 Series

Table III: Results of Retort on Dry Ash Sample

Measured parameters	**Measured weight**
Empty Retort Cup	73.6g
Full Retort Cup	88.9g
Empty Cylinder	19.1g
Full Cylinder	21.1g
Weight of Water (ml × 1.0)	1.95g
Retort Used	20ml-OFI165-14 Series

Table IV: Result analysis of drill cuttings components

Parameters	**Values**
Wt. of Sample used	43.6g
Wt. of Liquid Recovered	17.7g
Wt. of Water in Sample	8.2g
Wt. of Oil	9.5g
Oil in Sample	**21.8%**
Water	18.8%

Table V: Result analysis of the treated dry Ash components

Parameters	**Values**
Wt. of Ash Sample used	15.3g
Wt. of Liquid Recovered	2.0g
Wt. of Water in Sample	1.95g
Wt. of Oil	0.05g
Oil in Sample	**0.33%**
Water	12.8%

Further laboratory testing using gas chromatographs to compare the paraffin distribution in the fresh oil and recovered oil by thermal desorption has shown that the recovered diesel is remarkably similar in composition to the original diesel (Figure 2), and that it may be re-used in an identical manner. This proves that there was no appreciable thermal degradation that would have cause cracking of the base-oil during the process. The difference in peak height between the two is due to in-feed sample testing performed using extraction method to remove the oil phase from the cuttings, while whole recovered diesel oil was tested in the second graph using a dilution method. Actual peak heights and position show remarkable similarity between the two samples.

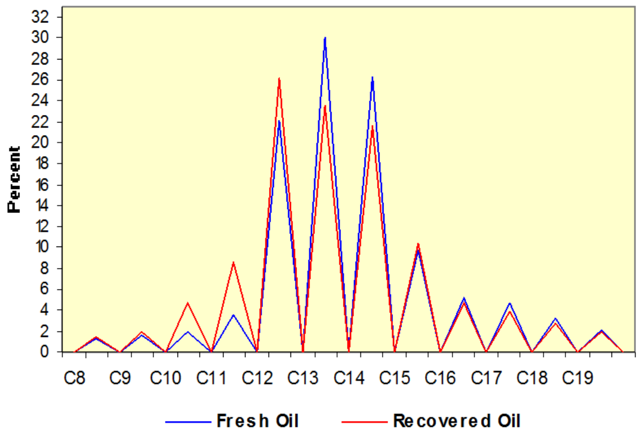

Fig. 2: Gas Chromatograph; fresh oil and recovered oil comparison

V. Conclusion

One of the increasingly concern of the oil and gas operators is to reduce the oil on cuttings before disposal as required by the regulators. Thermal desorption process can thoroughly remove hydrocarbons from drilled cuttings and recover clean base oil. Contaminants can be recovered and recycled into useful products and the clean soil can be returned to the environment reducing future liability.

The recovered oils have several possible uses:

i. Base fluid for the makeup of new drilling fluid,
ii. Fuel for the TDU burners or other processes on site
iii. Feedstock for refined hydrocarbon products
iv. The superior quality of the recovered oil compares favourably to its original state and therefore holds its original economic value.

The treated cuttings have a variety of uses including:

i. Backfill at the site of origin
ii. Fill material for other sites
iii. Concrete or aggregate mix
iv. As a cover for a sanitary landfill

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