

## The Level of Base Oil Recovery from Niger Delta Drill Cuttings Using Thermal Desorption Unit

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### ABSTRACT

In bid to determine the level of base oil recovery using thermal desorption unit, a process that provides for waste reduction and recycling, ten samples of oil based mud contaminated drill cuttings were collected from ten oil wells in the Niger Delta area in Nigeria. Composite samples were formed from each oil well sample and a retort analysis was made of each composite sample, to determine the percentage of oil and water in the oily cuttings and the temperature for the thermal desorption treatment of these oily cuttings. The results of the retort analysis showed an average percentage range of oil and water content as 6.93 – 23.93% and 4.00 – 15.00% respectively and presented a suitable temperature range of 325°C – 350°C for the thermal desorption treatment. All the drill cuttings were then treated in a Thermal Desorption Unit (TDU). Another retort analysis was carried out on the processed solids (cleaned cuttings) to determine the level of oil residue, which stood at 0.19 – 0.79%. This is below the regulatory limit of 1%. This study reveals the efficiency of TDU process in the recovery of oil from drill cuttings from the Niger Delta area of Nigeria.

**Key word:** Drill cutting, Base oil, Thermal desorption, Cleaning cutting

### I. INTRODUCTION

#### 1.1 Generation of Drill Cuttings

All the activities involved in the hydrocarbon exploration and production normally have one impact or the other on the environment (Odiete, 1999). 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 (Onwukwe, 2014). Oily drill cuttings cannot be discharged directly into a disposal site, not only because of their adverse effect upon the environment, but additionally because the great value of the oil contained in them. The creation of a single vertical well bore to an average depth of 1000m brings up about 45m<sup>3</sup> of cuttings, including radioactive substances and heavy metals from below, mixed with the chemicals in the drilling fluid (Ormeloh, 2014). Horizontal wells will produce much more of this material as do vertical wells (Ferrari *et al.*, 2000).

#### 1.2 Disposal of Drill Cuttings

Drill cutting is basically a waste product from drilling process and consists of particles from the formation mixed with remains of drilling fluids, chemicals and in some cases oil from the formation. The drill cuttings produced by an oil based drilling fluid are rather heavily contaminated by the oil base which is used for preparing the drilling fluid. When

such drill cuttings are disposed of without recovery of the oil, the disposal often results in the contamination of the environment. It is therefore necessary to take steps to recover this oil in order to reduce the contamination and also save some cost. Drilling fluids, cuttings and well bore clean-up fluids require some form of treatment prior to disposal or recycling as regulatory bodies and oil companies apply higher environmental standards. Moreover, companies spend a huge amount of money buying fresh oil to be used as drilling base. The oily drill cannot be discharged directly into a disposal site, not only because their adverse effect upon the environment, but additionally because of the great value of the oil contained in them. 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 (Onwukwe, 2014). Various approaches have been attempted to remove the oil from the rock such as the use of a high temperature, liquid solvent extraction and soap and water washing (Perry and Griffin, 2001). Drill cuttings injection started in the late 1980's and has now become an industry-accepted solution performed in a wide range of wells and locations (Saasen *et al.*, 2000). However, if re-injection of the waste is not technically or economically feasible, the waste must be treated to

reduce oil concentration prior to final disposal. There is also the risk of groundwater contamination during reinjection (Meinhold, 1999).

### 1.3 Objective of the Study

This study therefore was set to determine the level of base oil recovery using thermal desorption unit before disposing oily cuttings with particular reference to the Niger Delta area of Nigeria. It is also aimed at assessing the efficiency of low temperature thermal desorption in oil and water recovery from drill cuttings from the same region.

## II. METHODOLOGY

### 2.1 Sample Collection

The oil based mud contaminated drill cuttings samples were collected from ten wells across the Niger Delta area of Nigeria. The oil contaminated drill cuttings were transported to the facility in specially designed, water-tight, leak-proof skips.

### 2.2 Retort Analysis Prior to Treatment

A retort analysis was carried on the samples to determine the level of base oil contamination of the cuttings. Samples from the same well were bulked together to form a composite sample. A retort analysis was made of each composite sample to determine the percentage of oil and water in the oily cuttings at 345°C.

50 grams of the bulk sample was heated at 345°C for one hour, to vaporize the liquid components which were then condensed and collected in a graduated cylinder. Liquid volumes were determined from reading the oil and water phases on the graduated cylinder. The total volume of solids, both suspended and dissolved, was obtained by noting the difference of the total sample volume versus the final liquid volume collected. The percentage of oil and water in the oily cuttings were thus noted (Table 1).

### 2.3 Thermal Processing

The samples were treated in a Thermal Desorption Unit (TDU). Thermal Desorption process is suited to processing a wide range of oil contaminated waste cuttings and extracting, through a distillation process, and recovering any hydrocarbon content, which will evaporate at temperature below 325°C. Hydrocarbons are volatilized from oily solids in a closed chamber using controlled heat. The dry boiling point of base oil is 327° C (Ormeloh, 2014).

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 is to operate at highest possible temperature without cracking the oil. The process achieves maximum phase separation without exceeding the fractionation point of the base oil. Thermal cracking temperature is a function of molecule size. Larger molecules crack at lower temperatures. 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.

All thermal desorption processes evaporate the oil and water from the cuttings. The heat required to evaporate the oil and water provides enough energy to remove and separate emulsified oil as well. Free and emulsified oil and water are removed by distillation, and in the process, water evaporates first to produce steam. Oil has a higher boiling point and evaporates after the water. The production of steam can also assist in lowering the boiling point of oil.

The process began by the emptying of the skips into the storage coral where the drill cuttings are stored before they are processed in order to return the skips and to allow for regular operation of the plant (Figure 1). The drill cuttings enters the system through a special non-plugging design feed hopper with the use of a loader. The feed hopper is equipped with a weighing device and variable speed auger-feeder that meters the material into the rotary dryer. The system can process a wide range of particle sizes from clay to rock.

The exclusive, stainless steel dryer unit is designed to dry and heat the drill cuttings indirectly through conductive heat transfer. This prevents combustion gases from contacting the cuttings or the hydrocarbon/water gas stream. The externally-heated rotary dryer is sealed on either end to limit oxygen entering the system or vapor exiting the system.

A special cleaning system in the dryer eliminates caking of solids and keeps the material agitated to allow for even heating. The cuttings temperature is increased to vaporize the water and hydrocarbons in the cuttings. The temperature in this particular process is 345°C.

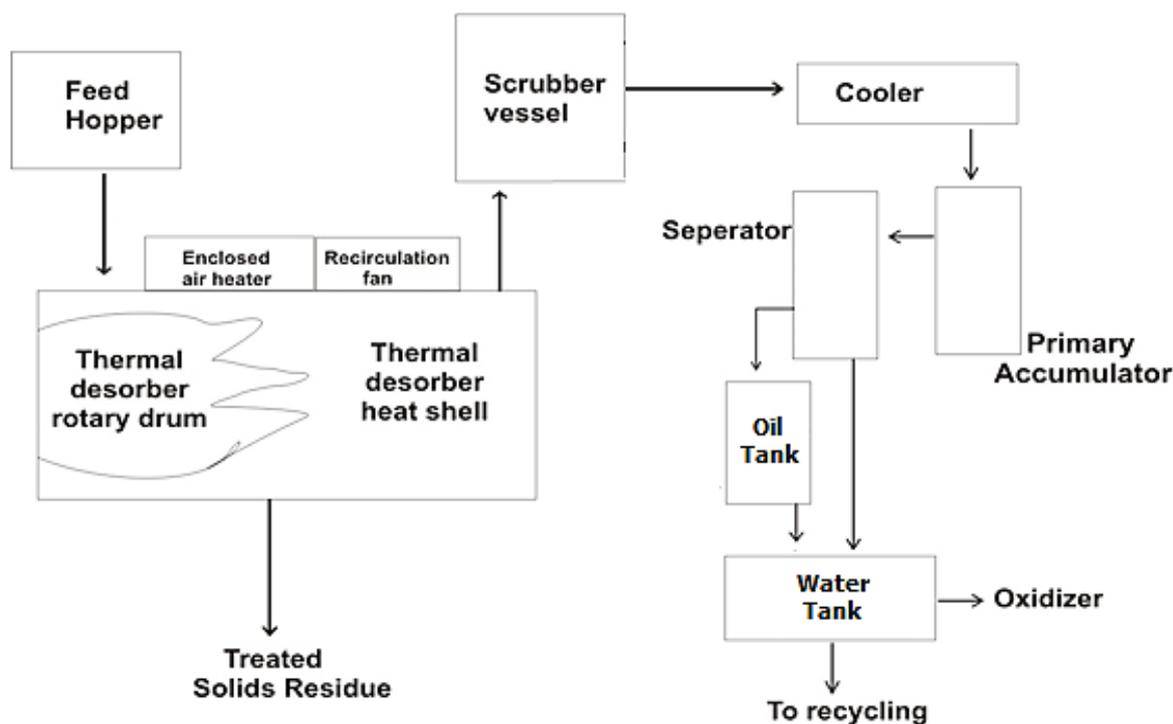


Figure 1: Thermal Desorption Unit Flow Diagram

The hydrocarbon and water vapours pass through a quench-scrubber for particulate removal. At the adiabatic quench, where water is sprayed on the vapour phase, converting it to liquid phase. The pre quench works on the same principle as the quench, but is designed to knock off fine dust particles earlier and pumped to the centrifuge. This stage removes any residual ultra-fine dust particles from the gas-air stream and ensures recovery of a clean, usable oil or synthetic fluid. The scrubbed oil and water gas-stream mix enters one or more condensers to return the oil and water to a liquid state. This unit is for condensing all gasses that were not condensed at the quench process. The cooling tower is a heat exchanger, which cools the water from the quench process.

The thermal oxidizer unit oxidizes the mixture and destroys any non-condensable hydrocarbons and ensures clean emissions. The mixture is processed through an oil/water separator and coalesces to separate the mixture into clean water and oil, or synthetic fluid. The centrifuge is used to remove ultra-fine solids from the process while the weir tank as the name implies is made of weir plates, used for typical separation of oil and water. Oil goes on top of the weir, while water goes under. The solids are bubbled using air to the centrifuge sump where they are pumped to the centrifuge.

Processed drill cuttings leaving the dryer and dust leaving the bag-house is mixed with the recovered

water in the pugmill soil conditioner. The added water cools the processed cuttings and controls dust before releasing the ash into the ash pit. Processed cuttings are collected at this point and tested. The processed, conditioned cuttings can then be back-filled or transported offsite for ultimate disposal or recycling. For each 100 tons of drill cuttings treated, Ntukidemet *et al.*, (2002) estimate process recovers on the average between 10 - 15 cubic meters of oil. The recovered oil is very high quality and is suitable for in the fabrication of new drilling mud. The TDU process reduces the waste volume by approximately 20%. The recovered oil is moved to a storage tank and can be used as fuel for the primary burners, recycled into fresh drilling mud, or returned to the client. Testing of recovered base oil has shown no significant degradation or formation of new hydrocarbon chains during the thermal process (Zupan and Kapila, 2000). The water derived from the process is stored in tanks to be reused with fresh water in the process again.

#### 2.4 Retort Analysis after Treatment

Retort was repeated on the clean cutting from the TDU outlet. 50 grams of the bulk sample was heated at 350°C for one hour, to vaporize the liquid components which was then condensed and collected in a graduated cylinder. The percentage oil and water content was noted against the initial content.

### III. RESULTS AND DISCUSSIONS

The thermal desorption treatment of the drill cuttings from the ten wells is presented in Table 1 below. A comparison of the retort analysis before and after the thermal desorption treatment shows that the oil from the drill cuttings was reduced to the barest minimum level ranging from 0.19% - 0.79%

which comply with the stipulated DPR regulation of 1% oil residue in clean cuttings. For every 6.8tons of drill cuttings 1m<sup>3</sup> of base oil is recovered. This is equivalent to base oil recovery rate of 14.70m<sup>3</sup> for every 100tons of contaminated drill cutting. This rate is considered very good when compared to the 10-15m<sup>3</sup> estimated by Ntukidemet al., (2002)

Table 1: Summary of Drill Cuttings Treatment (TDU operations results) of the Ten Oil Wells

Well Names	Treated cuttings (tons)	Recovered oil in m <sup>3</sup>	Recovered water in m <sup>3</sup>	Recovered cleaned cuttings (tons)	Oil % in cuttings before Treatment	Oil % in cuttings after Treatment
Well A	46.80	5.30	4.80	36.78	23.93	0.52
Well B	66.42	13.02	10.96	42.50	10.60	0.79
Well C	55.54	11.00	11.60	33.20	11.47	0.75
Well D	45.89	5.10	4.30	36.50	6.93	0.30
Well E	46.51	6.01	5.25	35.28	8.67	0.20
Well F	46.34	6.20	4.55	35.64	7.33	0.19
Well G	54.64	8.45	7.34	38.88	9.87	0.43
Well H	43.08	6.05	5.95	31.15	10.67	0.25
Well I	49.26	6.10	6.70	36.50	12.07	0.64
Well J	45.28	6.25	6.00	33.10	13.07	0.53
<b>Total</b>	<b>499.76</b>	<b>73.48</b>	<b>67.50</b>	<b>359.53</b>	<b>114.61</b>	<b>4.60</b>

### IV. CONCLUSIONS AND RECOMMENDATIONS

Critical observation of the analytical results have shown that the thermal desorption unit is one of the best technology that can be used to recover oil from drill cuttings. Apart from recovering almost 100% of oil from the drill cuttings, this process also minimizes future environmental liability, reduces land requirements and provides for waste reduction and recycling. The recovered oil is suitable for reuse in the fabrication of new drilling mud. The recovered water in most cases are being reused in moistening the dry processed clean solids to prevent dusting effect during processing. The cleaned cuttings can be reused for construction purposes and backfilling of swampy areas. It is recommended that drill cutting producing companies apply the use of Thermal Desorption Units for the treatment of their oil contaminated drill cuttings to help save cost, reduce wastes, improve public image and also save the environment from contamination.

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