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The use of low temperature thermal desorption technology in the treatment of drill cuttings

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Abstract

One of the management strategies in handling drill cuttings is the use of low temperature thermal desorption technology which goal is to produce oil-free solids for disposal by distilling off the oils from the cuttings and recovering the oil to be reused as drilling fluid. A retort analysis was carried out on the oily and cleaned cuttings to determine the percentage of oil and water content at the temperatures of 350°C and 500°C.The percentages of oil in the oily cuttings are 11.2, 19.4 and 9.6 at 350°C and 13, 14.6 and 23.0 at 500°C and the percentages of oil in the cleaned cuttings were 0.24, 0.21 and 0.23 at 350°C respectively. The concentrations of chlorides and heavy metals are 820 and 0.002mg/l respectively. The result obtained meets the regulatory requirement of oil on cuttings (OOC) of less than 1% by weight, eliminating future environmental liabilities. This study reveals the efficiency of TDU process in the recovery of oil from drill cuttings.
Keywords: drill cuttings, low temperature thermal desorption unit, oil base mud, retort analysis.

1 Introduction

Oil well drilling operations require the use of drilling mud to aid the drilling process. Drilling fluids 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. 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 [1]. The industry is working with regulators to achieve continuous

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improvement in its environmental performance, with the ultimate goal of zero discharge. The use of pseudo oil based mud (POBM) has led to improved shale stability and enhanced drilling rates particularly where polycrystalline diamond compact (PDC) drill bits are used [2]. An average drilling performance improvement of 49% was reported by Zupan and Kapila [3] for 311.5mm hole sections in the areas he analyzed. These two characteristics of POBM; better hole stability and faster penetrating rate plus its lubricating nature combine to give superior overall drilling performance [1]. Oil based mud is frequently used for drilling the more difficult exploratory and development wells and such generates large volumes of oil-based formation cuttings [4]. Environmental regulations require that these cuttings be cleaned before their disposal. In many parts of the world today both onshore and offshore drilling operations must have a process in place to ensure cuttings are cleaned properly [5]. To remove these hydrocarbon-based fluids, a technique called thermal desorption is employed. The goal of this technology is to produce oil-free (ultra-low TPH) solids for disposal by distilling off the oils from the cuttings and recovering the oil to be reused as drilling fluid.

Low-temperature thermal desorption (LTDU) also known as low-temperature thermal volatilization, thermal stripping and soil roasting is a remedial technology that uses heat to physically separate petroleum hydrocarbons or oils from oil based drill cuttings or soil [6].

2 Objective of the study

The study aimed at assessing the efficiency of low temperature thermal desorption in oil and water recovery from drill cuttings and to produce oil-free drill cuttings, to meet regulatory requirement for disposal.

3 History of low temperature thermal desorption unit

LTDU was first used at an onshore facility to treat oil- based mud (OBM) and cuttings from an offshore rig on the East Coast of Canada [7]. This new generation technology has enabled operators to not only meet aggressive oil-on-cuttings discharge limitations but also reduce costs through the recovery and reuse of spent base fluid. This technology is a different process from incineration because it uses heat to physically separate the contaminants from the cuttings while incineration uses heat to destroy the contaminants [8]. The low thermal desorption unit (LTDU) provides an environmentally friendly treatment process for oil contaminated drill cuttings as well as settlements contaminated with hydrocarbons. The thermal desorption unit process is briefly described as an indirect thermal stripping process (meaning that the drill cutting will be heated in a controlled chamber, which enables the extraction and recovery of the liquids (oil and water) from the drill cuttings) [2].

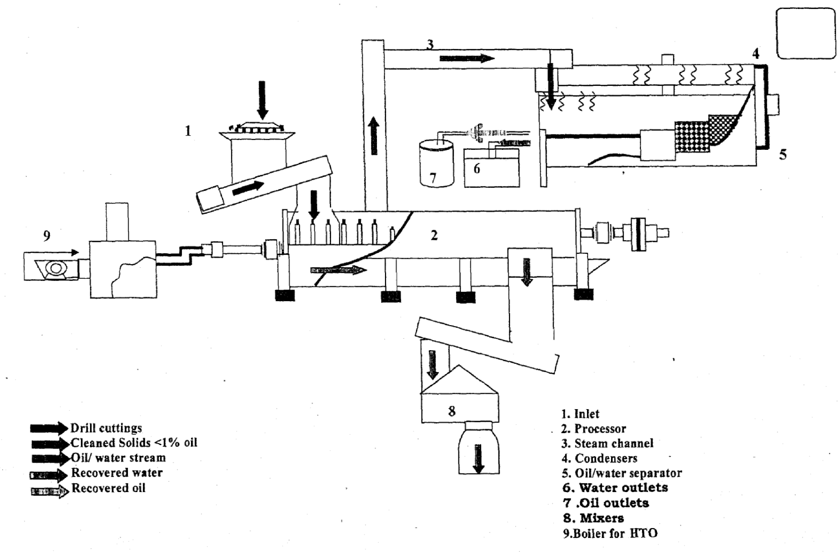

Figure 1: LTDU flow diagram.

3.1 Low temperature thermal desorption process procedure

(i) The cuttings are fed into the feed hopper of the low thermal desorption unit treatment plant using a rotary head forklift.

(ii) The heart of the LTDU is horizontal vessel with a rotating heat exchanger located inside. The heat exchanger is comprised of a hollow shaft and vein through which hot rotating fluid (hot oil) is pumped. The design provides a large surface area for heat transfer to the cuttings being processed. Paddles located on the periphery of the veins convey the cuttings along the length of the processor as the heat exchanger rotates. The processor is capable of processing drilling waste at the rate of 20 to 40 tonnes per hour.

(iii) The heat transfer fluid is heated by 800kw diesel fire boiler located within the processing system. The flow rate and temperature of the heat fluid are controlled by a closed loop system to prevent degradation of the fluid.

(iv) The evaporation of the hydrocarbons and water contained in the drill cuttings takes place between 80 to 280°C and move from the inlet end towards the outlet of the processor.

Airlocks are fitted at both the inlet and the outlet of the processor to prevent the escape of the released vapours. To prevent a flammable mixture forming within the processor as the vapours arise, the processor is purged of any air using nitrogen prior to processing the raw material. The hot vapours released from the raw material are then drawn through a vapour scrubber where the steam and most of the hydrocarbons are condensed.

Any gas not condensed in the vapour scrubs are directed to the boiler for incineration. In the event of a boiler malfunction, gasses that do not condense will be diverted to an activated carbon fitter.

(v) The mixture of water and hydrocarbon condensate generated by process is separated into two streams by multi-stage settlings. To minimize the potential for dust emissions from material handling operations, the cleaned solids arising from the process are moistened using the water recovered by the distillation. There are no discharges to either public sewer or surface water.

(vi) The condensed hydrocarbons are stored in settling tank housed within the processing building.

(vii) The recovered water is used in moistening and cooling down the solids at the outlet end of the treatment unit to prevent dust effect.

(viii) The processed solid is collected and taken to designated construction sites in the free zone or reclamation site for reuse.

(ix) The recovered base oil is taken to the rig site or designated drilling fluid contractor as may be directed by company.

(x) All the operating parameters, temperatures, pressures and the electrical current drawn by the various internal motors are continuously monitored and the data recorded by a computer, which controls the process.

4 Methodology

4.1 Cutting collection

Drill cuttings from shale shakers and centrifuge are collected by empty skips, which are placed at the outlet of the screw conveyer system. The cuttings are transported to the treatment site with Mack Trucks. Samples are collected for testing and analysis using Retort Analysis. The skips are weighed with a weighing balance and off loaded into the treatment bay or stored in the storage bay using a rotary head forklift. The cuttings are thermally processed using a low temperature desorption unit (LTDU).

4.2 Retort analysis

Retort analysis provides a means for separating and measuring the volumes of water, oil and solids contained in a sample of drill cuttings [2]. 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-density solids and weight materials may also be calculated.

4.3 Sampling/analysis of cuttings

A representative sample of oily cuttings was taken from each skip. Individual samples taken from truck load of skips are bulked together to form a composite sample. A retort analysis is made of each composite sample to determine the percentage of oil and water in the oily cuttings.

Also, during operations, in-house retort analysis was performed every four hours on samples of the cleaned cuttings from the LTDU outlet.

5 Results and discussion

A representative sample of oily cuttings was taken from each skip. Individual samples taken from load of skips are 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.

Table 1: The result of the retort analysis of oily cuttings for Well A.

S/N		**350°C**	**500°C**
1	Full Retort	322.6g	322.6g
2	Empty Retort	272.6g	272.6g
3	Weight of Material	50g	50g
4	Weight of Full Glass	107.4g	109.9g
5	Weight of Empty Glass	94.6g	94.6g
6	Weight of Oil + Water	12.8g	15.3g
7	Weight of water (ml × 1.0)	8g	8.8g
8	Weight of Oil)	8.8g	6.5g
9	Oil (8/3)*100	9.6%	13%
10	Water % (7/3)*l00	16%	17.6%

Table 2: The result of the retort analysis of oily cuttings for Well B.

S/N		**350°C**	**500°C**
1	Full Retort	322.8g	322.8g
2	Empty Retort	272.8g	272.8g
3	Weight of Material	50g	50g
4	Weight of Full Glass	114.1g	1116.3g
5	Weight of Empty Glass	102.5g	102.5
6	Weight of Oil + Water	11.6g	13.8g
7	Weight of water (ml x 1.0)	6g	6.5g
8	Weight of Oil (6–7)	5.6g	7.3g
9	Oil (8/3)*100	11.2%	14.6%
10	Water % (7/3)*l00	12%	15%

Table 3: The result of the retort analysis of oily cuttings for Well C.

S/N		**350°C**	**500°C**
1	Full Retort	322.6g	323.0g
2	Empty Retort	273.0g	273.0g
3	Weight of Material	50g	50g
4	Weight of Full Glass	105.8g	108.6g
5	Weight of Empty Glass	80.1g	80.1g
6	Weight of Oil + Water	25.7g	25.5g
7	Weight of water (ml × 1.0)	16.0g	17.0g
8	Weight of Oil (6–7)	9.7g	11.5g
9	Oil (8/3)*100	19.4%	23.0%
10	Water % (7/3)*l00	32.0%	34.0%

5.1 Low temperature thermal desorption unit operation result

All the oil contaminated drill cuttings are fed via a hopper into the processing unit of the LTDU. They are heated to a temperature of 325°C vaporizing the oil and water.

Table 4: LTDU operation result for Well A.

1	Quantity of treated cuttings in tons	6 18.050
2	Recovered oil in cubic meters	77.5
3	Recovered water in cubic meters	79.1
4	Recovered cleaned cuttings in tons	514.3
5	Oil percentage in oily cuttings	9.6
6	Water percentage in oily cutting	16.0
7	Oil percentage in cleaned, cuttings	0.24%
8	Number of skips used	245
9	Number of hours of effective operations	535
10	Number of hours of downtime	41
11	Average tons of oil cuttings treated per hour	1.2
12	Quantity of recovered oil (in cubic meter delivered)	66.841

Table 5: LTDU operation result for Well B.

1	Quantity of treated cuttings in tons	561.4
2	Recovered oil in cubic meters.	70.4
3	Recovered water in cubic meters	98.1
4	Recovered cleaned cuttings in tons	413.4
5	Oil percentage in oily cuttings	11.2%
6	Water percentage in oily cutting	12.1%
7	Oil percentage in cleaned cuttings	0.21%
8	Number of skips used	205
9	Number of hours of effective operations	2.74
10	Downtime due to Maintenance	599
11	Downtime due to Maintenance	216
12	Number of hours of down time	25
13	Average tons of oil cuttings treated per hour	2.3
14	Quantity of recovered oil (in cubic meter delivered)	70.4

Table 6: LTDU operation result for Well C.

1	Quantity of treated cuttings in tons	644.475
2	Recovered oil in cubic meters	133.2
3	Recovered water in cubic meters	179.1
4	Recovered cleaned cuttings in tons	535.2
5	Oil percentage in oily cuttings	19.4%
6	Water percentage in oily cutting	32.0%
7	Oil percentage in cleaned cuttings.	0.23%
8	Number of skips used	311
9	Number of hours of effective operations	926.5
10	Downtime due to Maintenance	0
11	Number of hours of down time	61
12	Average tons of oil cuttings treated per hour	0.7
13	Quantity of recovered oil (in cubic meter delivered)	118.232

Table 7: Results of laboratory analysis conducted for cleaned cuttings.

S/N	Parameters	Unit	Method	Well A	DPR limits
1	pH		W104	6.95	6 - 12
2	Electrical Conductivity	Mg/cm	W107	11.380	-
3	Salinity as Cl-	Mg/kg	W104	720.0	-
4	Arsenic (As)	Mg/kg	W133	<0.003	5
5	Barium (Ba)	Mg/kg	W133	<0.008	100
6	Cadmium (Cd)	Mg/kg	W135	<0.005	1.0
7	Chromium (Cr)	Mg/kg	W135	<0.002	5.0
8	Lead (Pb)	Mg/kg	W135	<0.01	5.0
9	Mercury (Hg)	Mg/kg	ASTM MD3223	<0.002	5.0
10	Silver (Ag)	Mg/kg	W148	<0.001	0.2
11	Zinc (Zn)	Mg/kg	W135	6.20	50
12	Vanadium (v)	Mg/kg	APHA 3114B	<0.004	-
13	Selenium (Se)	Mg/kg	W135	<0.001	1.0
14	Nickel (Ni)	Mg/kg	W135	<0.004	-
15	Sodium (Na)	Mg/kg	AAS	736.0	-
16	Magnesium (mg)	Mg/kg	AAS	54.0	-
17	Sodium Adsorption Ratio (SAR)	-	Spectrophotometer	9.36	-
18	ESP	(%)	Spectrophotometer	11.360	-
19	Cation Exchange Capacity (CEC)	(Meg/100g)	TITRIMETRIC	20.396	-
20	Oil & Grease	(%)	W130	0.395	-
21	TPH	(%)	W131	0.146	-
22	Calcium (Ca)	Mg/kg	AAS	696.0	-

where: W1 = Work instruction based on "American Society for Testing and Materials ASTM 20th Edition 1999 and American Public Health Association APHA 20th Edition 1998".

6 Discussion

The result of the retort analysis of oily cutting samples made to determine the percentage of oil and water in the cutting show that there was high oil percentage in the cuttings, which is above DPR specification. This is detrimental to the environment if disposed without treatment.

These cuttings were treated using a low temperature thermal desorption unit (LTDU), which minimizes future environmental liability, reduces land requirements and provides for waste reduction and recycling. The treatment resulted in the recovery of base oil, which is suitable for reuse in the fabrication of new drilling mud. The oil content of the processed solids was reduced to about 0.21 percent (%) a figure which is below the D.P.R. requirement of 1%.

Also the results of the third party laboratory analysis of the cleaned cuttings show that the concentrations of hydrocarbons, chlorides and heavy metals did not exceed D.P.R limits.

7 Conclusion

The use of oil base mud has led to improved shale stability, enhanced drilling rate and an average drilling performance of 49% was reported by Zupan and Kapila [3] for 311.5mm hole sections in the areas he analyzed. A new technology called Low Temperature Thermal Desorption Process was introduced which can reduce, the oil content of treated cuttings to less than 1% T.P.H which is in accordance with D.P.R. current limits. The process recovers oil which can be reused in the manufacture of new oil base drilling mud there by reducing the cost of drilling fluid by about 35%. The oil content of processed drill cuttings using Low Temperature Thermal Desorption Unit is below the DPR specification of 1% and the concentration of chlorides and heavy metals did not exceed D.P.R guidelines. The clean cuttings are used for landfills, construction purposes, land stabilization and building up construction sand as in on-fill and backfill. The recovered water is reused in moistening the dry processed clean solids to prevent dusting effect for washing of skips in a close loop process. To date there have been no instance when the concentrations of hydrocarbons, chlorides or heavy metals exceed DPR guidelines. The brand name of the LTDU used is AVA VacuDry Indirect Thermal Desorption Unit. 2007 model.

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