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OFFSHORE DRILLED CUTTINGS MANAGEMENT

1. INTRODUCTION

The search for fossil fuels generates large volumes of drilled cuttings which under certain conditions are defined as hazardous waste, negating disposal at sea. Much of the cuttings end up in landfills.

The types of fluids used in well drilling operations determine to which extent the cuttings are considered hazardous. The main types of fluids are oil based mud (OBM) and water based mud (WBM). Synthetic based mud (SBM) is a third option. The purpose of circulating fluids into wells during drilling operations are several; stabilize the well bore, control subsurface pressure and formation pressure, control well stability and corrosion, cool and lubricate the drill bit, and not the least to carry cuttings to the surface.

OBM is typically based on either mineral oil or linear paraffin, although some areas still use diesel. One advantage of OBM over WBM is enhanced drilling performance, especially in technical challenging environments. A drawback, however, is the toxicity of OBM, prohibiting discharge of cuttings directly from shakers to the marine environment under most regulatory regimes. Drilled cuttings are rocks produced during drilling operations. They become coated with drilling fluids during transport to surface. Typical OBM drill cuttings are composed of 70% mineral solids, 15% water and 15% oil by volume.

2. DRILLED CUTTINGS MANAGEMENT

Historically, offshore produced cuttings have been disposed of at sea. However, environmental laws and regulations have since 1993 prohibited such practice when using OBM, or specifically when drilled cuttings exceed 1% oil by weight (NIVA, 2010). Drilled cutting

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particle size varies with drill bit, well bore length and geological formations, between 10 μm and 20 mm. Depending on the quality of OBM, the geological formations and whether drilling is in hydrocarbon reservoir sections, cuttings are coated with different hydrocarbons including PAHs, PCBs, and heavy metals. Re-injection of cuttings as a slurry into subsurface formations has over the last few years met some challenges due to several cases of loss of formation integrity, leading to leaks and cuttings re-entering the sea bed. Such mishaps have developed into increased focus on design and maintenance of injection wells. However, the method of re-injection is still widely used. Cleaning of OBM cuttings offshore or transport of cuttings to shore are alternative cuttings management practices. For logistics and cost reasons great emphasis is put on offshore waste minimization, including reuse of mud.

The first exploration well on the Norwegian Continental Shelf was drilled in 1966. Until 1980 diesel was used as the continuous phase in OBM drilling. Discharge of drilled cuttings derived from OBM was allowed until 1993 (NIVA, 2010). After 1993 all cuttings from drilling and production of hydrocarbons using OBM has been classified as hazardous.

WBM normally consists of environmental friendly chemicals, classified as green and yellow with regard to environmental toxicity, and are allowed direct discharge to sea. However, in environmental sensitive areas such as the Barents Sea, WBM discharges are prohibited.

Total fluid management (TFM) leads to environmental impact reduction (EIR). Minimization of drilling fluid consumption through for instant reuse of fluids, leads to cost reduction. Volume of cuttings may be reduced through directional drilling and by drilling smaller diameter holes. Choice of drilling techniques that consumes less drilling fluid volumes provides cost savings. Use of fluids and additives with lower environmental impact is also an option. The common weighing agent barite contains heavy metals, and could be replaced by hematite (Fe_2O_3) or illmenite ($FeTiO_3$). The same concern goes for chemical components of drilling fluids; i.e., toxicity, biodegradability, persistence, bioaccumulation and heavy metals.

Oil removed from cuttings opens for a wider variety of reuse of cuttings compared to raw untreated cuttings. Examples of such practice include cuttings in road beds, construction materials, landfill cover and restoration of wetlands. The loss of integrity of wells and reservoirs negates re-injection of cuttings as slurry. For larger field developments where formations suitable for injection are available, this option may be evaluated and become more economical compared to onshore transport and further treatment, despite potential for reuse and recycling onshore.

Treatment of OBM drilled cuttings is initiated offshore by a shale shaker consisting of vibrating screens. Further solids control could include gravitational sand settling, a specialized desander and deciliter as well as centrifuges, all successively removing smaller solids from the mud. The shale shaker is the universal common separation technique for separating fluids from cuttings. Depending on local regulations and oil content on cuttings, available disposal options include discharge to sea, underground injection, and further offshore and onshore treatment. In Norway permits are required for all discharges as well as injection.

Table 1 summarizes three years of accumulated drilled cuttings mass production from the Norwegian offshore petroleum sector. Treatment of offshore generated drilled cuttings is a challenge compared with cuttings generated onshore. After shaker separation of mud and cuttings, the transport routes for the two components include internal transport on the rig itself, from the rig to ship, further transport by ship to onshore receiving facilities, and on to treatment facilities and possible reuse or final disposal. This is a cost issue of great concern; logistics and transportation of offshore drilled cuttings.

Table 1

Tons of cuttings from the Norwegian offshore petroleum sector (Halliburton, 2012)

Year	Cuttings to land	WBM cuttings discharged	OBM cuttings injected
2008	142 142	70 199	228 743
2009	151 704	132 003	252 562
2010	258 482	207 655	125 123

3. SOLUTION

A purpose of the thermo-mechanical cuttings cleaner (TCC) is to convert hazardous oily cuttings into a useful and environmentally safe product. TCC facilities are only located onshore in Norway. However, offshore TCC units are considered by several operators. Cuttings are allowed discharged to sea when no oily fluids are attached. TCC separation is accomplished by generating temperatures of 240–300^{o}C for evaporation of oil and water from the mineral solids. More than 99% base oil recoveries with less than 2% solids are left in recovered oil. The recoverable byproducts include base oil, water and solids; i.e., cuttings. Using TCC offshore eliminates the need for transport of cuttings ashore as well as reduced human and environmental (HSE) exposures; improving health and safety.

A process mill is the heart of the TCC separation process and converts kinetic energy to thermal energy by creating friction in the cuttings. Solids are recovered through an auger system, discharged through a cell valve as dry powder and on to rehydration, with recovery of water prior to disposal. Oil and water flash off as vapors, and are condensed and separated in a condenser skid. The water and crushed cuttings are cleaned to levels below Norwegian requirements for sea discharge, 30 mg/l oil in water and 1% oil by weight on cuttings, respectively.

4. DISCUSSION AND CONCLUSIONS

According to Thermtech (2006) the TCC unit holds several advantages compared to other thermal desorption technologies. This includes small footprint, high mobility and short time for startup. In addition the process chamber has no oxygen sources, is well insulated and requires simple maintenance routines only. The capacity of a TCC unit depends on the energy input as well as the feed composition. The amount of water in the feed will affect the energy required to heat and evaporate the different compounds of the feed. Low water content will obviously yield a higher treatment capacity compared to a feed with higher water content.

Statoil conducted an investigation of the TCC unit as a possible offshore treatment option for drilled cuttings (Paulsen et al., 2003). In the Statoil study different modeling tools were used to predict the environmental impact factor of drilled cuttings discharges. The test feed was TCC treated powder slurry with condensed water from TCC vapor recovery. Due to the inherent safety as well as other beneficial qualities, the TCC is probably the only thermal technology that can be operated on board a drilling rig (Thermtech, 2006). TCC units have been successfully implemented on offshore rigs internationally (Svensen and Taugbol, 2011). However, TCC is only used onshore in Norway, with the intention of going offshore. Experiences from offshore rigs outside Norway indicate that having TCC on the rig reduces environmental impact. It likewise reduces costs affiliated with logistics and transport of drilled cuttings, as well as disposal costs (Svensen and Taugbol, 2011).

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