Design and Fabrication of Belt Type Oil Skimmer

S. Siva[1]
[1]Student,
Department of Mechanical Engineering,
Excel Engineering College, Sankari – 637 303

P. Praveen[2]
[2] Faculty,
Department of Mechanical Engineering ,
Excel Engineering College, Sankari – 637 303

P. Tamil Selvan[3]
[3] Student
Department of Mechanical Engineering,
Excel Engineering College , Sankari– 637 303

Abstract— **During the recent decade, World has witnessed big oil spillage accidents into ocean and made huge impact to the environment. Apart this, sometimes Oil is getting spillage through being the results of chronic and careless habits in the use of oil industries and oil products. It is estimated that approximately 706 million gallons of waste oil enters the ocean every year; whereas more than half of that sourced from land drainage and waste disposal. Offshore drilling & production operations and spills or leaks from ships or tankers are typically contributing less than 8% of the total whereas routine maintenance of ships (nearly 20%), onshore air pollution & hydrocarbon particles (about 13%) and natural seepage from the sea floor (over 8%). This has caused ever lasting damage to aquatic life. To separate the mixed oil from the water, industries wide various type of oil skimmers are getting used. The belts absorb the oil from water which can be scooped out and collect into a vessel by providing piping arrangements. The collected oil can be reused for many purposes.**

Keywords— Belt Oil Skimmer; Functions of Oil Skimmer; Design of Oil Skimmer

1. INTRODUCTION

Oil is one of the precious crude and being used in many routine application of human life. Since most of the oils are toxic so quite dangerous for alive when it comes to direct contact with them. During the years of recent decades, world has witnessed many oil spillage tragedies and subsequent damage to alive and environments. Many countries has made stringent safety norms for waste water disposal contained with oils mainly typically from petrochemical and process industries so that such industries are equipped with such kind of oil skimmers to separate the oils from disposal water. The continuous removal of oil from process fluids; increases the life of the fluid; resulting of:

a) Reduce the machine fluid refilling cost.

b) Improves the disposal water quality.

2.COMPONENTS DESIGN

A) Tank Frame

The frame is placed inside the tank dipped in a mixture of oil and water with length measuring 0.99m, breadth measuring 0.695m and height 0.400m. Maintaining the Integrity of the Specifications

B) Motor Supporting Plate

The plate is placed above the Tank Frame on which the wire motor is placed. The thick iron plate was needed to withstand the bending of the motor shaft. It has 0.375m length, 0.255 m breadth and 0.008m thickness

C) Pulleys Supported By Pillow Block Bearings

The shafts are mounted between the Pillow block bearings. Further grooves are cut on the shaft (circular cut out) to accommodate the belt and knurling is made on the circular cut out to prevent the slipping of the belt.

D)Selection of Belt Material

The oil lifts through belt by having the it's materials following inherent properties:

- Belt material is selected according to its polar & non-polar properties. Water consists of polar molecules as H+ and OH- whereas oil doesn't have any polar molecules hence it reacts as non-polar element.
- Polar & non-polar molecules attract towards their respective elements and bond with it. Moreover to these, Oil is lighter in density as compare to water so always oil floats on it. Hence water and oil form a separate layer in the reservoir.
- Belt material has been selected in such a manner so it can react as a non-polar element and oil gets attract toward it and get stick on it which permit us to easily lift the oil through belt. Here we are selecting the belt materials of polymers (non-polar). like, Cotton, Steel, Rubber, Polyurethane, Oleophilic.
- Adhesive property of oil is greater than water so we select such a material for the belt having adhesive property greater than water and having close to oil, hence it can easily absorbs oil over the belt which ultimately gets separate from water. Since water having poor adhesive property, it doesn't stick much to belt and remains in the reservoir.

3. MANUFACTURING & ASSEMBLING COMPONENTS

Manufacturing of various components has been done by following best of the industry standards and get assembled to function properly. Following are some of photographs of oil skimmers.

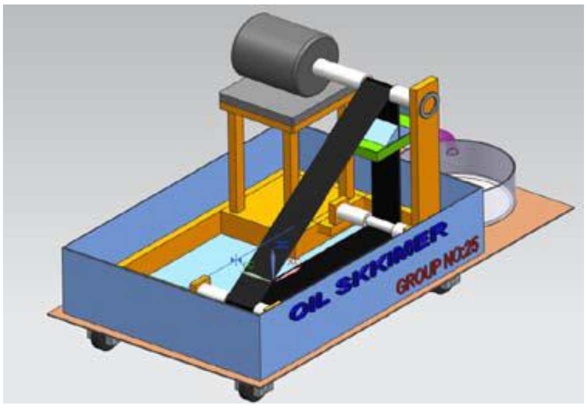

Figure 1: 3D CAD model of oil skimmer conceptual model

Figure 2: Actual snap of oil skimmer model

4. HEAVY OILS PROPERTIES

Heavy oils are defined as asphaltic, dense (low API gravity), and viscous oils that are typically composed of relatively low proportions of volatile compounds with low molecular weight such as benzene, toluene, ethylbenzene, and xylene (BTEX). They also typically contain some two ring napthalenes and high proportions of high molecular weight compounds. The high molecular weight compounds can be paraffins (straight chain alkanes), asphaltenes (aromatic-type hydrocarbon), resins and other compounds with high melting points and high pour points (Chevron, 2006 and Hollebone, 2006). Paraffins tend to act as solvent molecules for a mix of high molecular weight compounds and actually help improve the overall flow characteristics of the oil (viscosity). Some, but not all, heavy oils contain moderate to high levels of asphaltenes (Chevron 2006). These asphaltenes can become problematic if they precipitate out and build up on equipment. The density of the oil is the result of a large proportion of a mixture of complex, high molecular weight, non-paraffinic compounds and a low proportion of low molecular weight, volatile compounds. Heavy oils typically contain very little paraffin and the quantity of asphaltenes can vary greatly (Chevron, 2006 and Hollebone, 2006).

A number of heavy oils have been characterized in past laboratory studies (Jokuty *et al*., 1999; Wang *et al.*, 2002; and Wang *et al*., 2004.

The properties of residual fuel oils and bitumens (including Orimulsion, a fuel comprised of approximately 70% bitumen, 30% water and a small quantity of surfactant) are relatively similar. Table 2 shows that the five oils compared in this table have very similar properties and composition in terms of hydrocarbon groups. In fact, in most cases, the properties are within 10% of each other despite the widely-separated origin and processes of preparation.

Heavy oils have been found to lose as much as 20% by mass through evaporation (Wang *et al*., 2002), though heavy fuel oils such as Bunker 6 (Bunker C) types may only weather by a few percent (Jokuty *et al*., 1999). Bitumens have been found to lose very little if any mass through evaporation. At the end-state of weathering, light ends (<C20) are completely removed, and high-ring number PAH, asphaltenes, paraffins and resin components are enriched in the residual oil. Densities may approach or slightly surpass the density of fresh water 1.00 rams/millilitre (g/mL) or 62.4 lb/cubic foot, and viscosities may rise by two orders of magnitude or more.

A) Heavy Oils Behaviour

Heavy or high density oils (API gravity less than 22) are produced from residues of various refinery processes and primarily used to run boilers for power generation and to propel tankers and other large vessels (EIA, 2006). Similar to crude oils they continue to be shipped worldwide for consumption. The characteristics of high density oil when spilled, however, ifferentiate them from crude oils in the affect that their behavior will have on required response techniques and clean-up operations.

High density oils typically have higher pour points, which is a measurement indicated by the temperature below which the oil becomes a semi-solid and will not flow. Because of this, high density oils are typically shipped in a heated state to allow loading and off-loading of product. This phenomenon can help recovery efforts because the oil will have a tendency to form large mats of varying thicknesses as it cools provided the sea is calm and personnel have access to the oil before wind and waves break-up the mats into tar balls of varying sizes.

Heavy oils also tend to have high viscosities when compared with lighter oils. The actual viscosity range is quite wide as indicated in the previous tables, with dynamic viscosity (cP) typically starting in the thousands ranging up to over one million, depending upon the actual starting oil, temperature, weathering, and emulsification. This will be more pronounced in colder waters and during winter months. Higher viscosities will have an impact on pumping as higher viscosity fluids will resist flow.

Heavy oils with high pour points and high viscosities will have less of a tendency to spread which will aid recovery efforts when containing and controlling a spill. It may be possible to recover semi-solid product in calm seas – although spill incidents rarely happen during ideal weather conditions. Heavy oils also tend to be sticky in nature, which can prolong the cleanup operation by adding to the decontamination process. Clean-up may be difficult once the oil impacts shorelines, although emulsified oil may tend to adhere less than non-emulsified oils.

Identifying and assessing where the oil is situated can be difficult from the air or even from craft on the water if over-washing or partial sinking occurs. Movement may be difficult to predict as wave action may carry the oil below the surface. After oil is submerged little weathering will take place. The most important process that affects the density of the spilled product is the uptake of particulate matter (Fingas *et al.*, 2006) which will impact the ability of the oil to resurface. Due to the density of heavy oil and the low level at which it will float the surface, an assessment of the thickness of oil atches to provide an estimate of the quantity will be very difficult to provide.

Skimmers that perform successfully on lighter to medium oils may be rendered ineffective when attempting to collect heavy oils that tend to float low in the water. Even skimmers that rely on oleophilic properties such as drum, disk, and belt skimmers may have difficulty with heavy oils depending upon their design and the viscosity of the product being recovered. High density oils may tend to collect under a stationary skimmer and may result in a large quantity of oil that will resurface once skimming operations are halted.

5. SKIMMERS

Demonstrated the differences between available technologies for dealing with heavy oil recovery. Four units were compared for their ability to collect and process a heavy and extremely viscous product. The results are summarized below. The ERE Skimmer (Dynamic Inclined Plane) incorporates a mesh steel belt with a honeycomb structure which measures approximately 1.53 m x 0.46 m x 0.15 m (Length by Width
by Height - LWH). As the belt rotates, oil is forced down at the water/air interface and is trapped between the belt and lower plate which squeezes oil into the mesh. This device was
able to recover the heavy oil and demonstrated a wide range of influence by pulling the oil in from a wide area due, in part, to the properties of the bitumen

The KLK 602 skimmer uses two counter-rotating non-symmetrical drums which “scoop” the heavy oil. The unit is approximately 2.6 m x 2.6 m x 1.3 m (LWH). Spring mounted scrapers ride the surface of the drums and guide the oil into a recovery canal. This drum skimmer had initial difficulty processing the thin layer of refloated bitumen. As the nonsymmetrical drum (one drum only was operated during testing) rotated in the water, it created small waves that caused the trail of bitumen to “break” and be pushed away from the skimmer. Operating the drum at slower speeds solved most of this problem.

The Hobs belt skimmer extends to overall dimensions of approximately 5.2 m x 1.7 m x 2.0 m (LWH). The skimmer uses a reinforced rotating belt to collect oil and lifts oil up off the surface carrying product to the top of the unit where a mounted scraper causes excess oil to drop off into a trough. The skimmer was able to pick up and process the refloated bitumen, although some build-up was noticed on the belt support rollers which may indicate problems with long-term recovery. The diverter at the end of the unit which directed the recovered oil to a chute cause some build-up of oil, but the retained amount was not considered substantial enough to warrant any design changes.

The GT 185 skimmer was not able to process the refloated bitumen by itself since the bitumen would take too long to “flow” into the weir mechanism. Manually pulling the refloated bitumen into the weir was attempted in order to determine the pumping capabilities of the unit. This manual process was extremely labour intensive and only resulted in the processing of small quantities of oil thus would not be practical as a technique for use during an actual spill response (Cooper and Hvidbak, 2000). Recent testing in February of 2006 involving brush adapters for weir-type skimmers to enhance their abilities to recover heavy, viscous product was performed at Environment Canada’s Environmental Technology Centre. A total of three adapters were tested in two oils with densities very close to 1.0 g/cm3 and viscosities of 50,000 cP and 100,000 cP (SAIC Canada, 2006). The first unit was a Desmi Helix brush adapter (shown in Figure 5) using black rotating brushes configured in a pattern of four double brushes in six general clusters mounted on a circular ring around the weir of a GT-185 skimmer. The brushes aid in the selective collection of oil by pulling oil into the unit, moving the brushes through scrapers which remove the oil and direct it to flow into the hopper.

6. STORAGE

Temporary storage during recovery of spilled oil may present a logistical problem that is compounded by the recovery of heavy oils. Due to the physical characteristics of heavy oil and their tendency to resist flow offloading operations of temporary storage tanks and floating storage bladders can be a slow process. Limitations may be encountered by the size of the fill and drain valves unless the storage units can be lifted to allow the contents to run towards the valves during pumping operations because the heavy oil may not flow easily. Adapting pumping equipment with either heat generating abilities or smaller versions of annular water injection pumping systems may be necessary for offloading of stored product to aintain adequate storage space to keep pace with other recovery operations. Bulk and localized heating through the use of steam coils and steam lances have provided some qualified success in recent testing at the Cenac Towing Company acility and recovery operations concerning the S.S. Jacob Luckenbach. The heat lowers the viscosity of the oil near the pump allowing it to flow into the pump inlet as pumping progresses. In general, pumping into and out of on-board or temporary storage is much more difficult for heavy oil transfers than when dealing with lighter oils. Very limited additional information pertaining to research into the storage of heavy oils was uncovered during this study.

7. COMMISSIONING & TESTING OF OIL SKIMMER

After assembling all the oil skimmer parts, it was time to do commissioning properly. As a part of preparation, SAE40 oil is filled into the tank. The motor is connected to the ‘Speed Regulator’ through power supply board. The motor starting speed is adjusted to 20 rpm then gradually speed increases. All the set-up was functioning smooth as per expectation. After having successful commissioning of oil skimmer, we conducted multiple testing & note the oil recovery rate per hour using various types oils & belt materials as following. Here we have taken three oil samples of different viscosity.

1) Garage waste oil
2) SAE40 oil
3) Mixture of Garage oil and SAE40 oil

8. RESULT DISCUSSION

A set of experiments has been conducted by using the various oil and different materials of belt to understand the oil recovery performance and viscosity deviation of oils before & after separation.

A) Oil viscosity & efficiency measurement

By using Oswald viscometer, we have measured the resultant oil viscosity of before & after separation. Oil viscosity can be determined through Poiseuille's Law.

B) Procedure

1) Weight accurately of empty pyknometer.
2) Add 10ml water in pyknometer.
3) Calculate the density of water.
4) Calculate the density of separated oil.
5) Calculate the density of pure oil.
6) Determine the time of flow for different oil with the help of Oswald viscometer.
7) Calculate the viscosity of oils.

C) Oil Viscosity and Efficiency Calculations:

By following the above mentioned experimental set of procedure , Oils viscosity and subsequently its efficiency is also measured with reference to water as following,

Table 1: Oil Viscosity and Efficiency

Sr:	Type of oil	Oil viscosity (centi poise)		Efficiency
		Before Separation	After Separation	
1	Garage Oil	50.0	45.2	86%
2	SAE40	161.1	155.8	92%
3	Mixed oil	114.3	103.3	88%

9. CONCLUSION

In this project, we enforced to highlight the function of oil skimmer, its various design aspects and performance. All the results of experimental studies indicate that slight design improvement of typical oil skimmers towards to include additional belt shaft and use of belt with steel material instead of rope; significantly improve the oil recovery efficiency and also its structure became simpler. As practical overview of different oil spillage cleanup method, this paper has illustrated several limitations of these methods and current oil spill technology. Further extensive research & testing can improve the existing techniques and equipment to have better control for oil recovery exercise.

10. REFERENCES

[1] ‘Victoria Broje’ and ‘Arturo A. Keller’, “ Improved recovery of oil spills from water surfaces using tailored surfaces in Oleophilic skimmers, Donald Bren School of Environmental Science & Management, University of California, Santa Barbara.
[2] ‘ASTM.2007.ASTM F726-06’, “Standard test methods for sorbent performance of adsorbents”, American society of testing and materials, West Conshohocken. P.A.
[3] R.S. Khurmi and J.K.Gupta, Machine Design-I, S chand
[4] K Subhramanya, Fluid Mechanics and Hydraulic Machines, Tata McGraw Hill (2012)
[5] ‘S.H. Schwartz’, “Performance tests of four selected oil spill skimmers, in: Proceedings of the International Oil Spill Conference”, American Petroleum Institute, Washington, DC, USA, 1979, pp. 493–496.
[6] ‘S.D. Gill, W. Ryan’, “Assessment of the ACW-400 oil skimmer by the Canadian Coast Guard for oil spill countermeasure operations, in: Proceedings of the International Oil Spill Conference”, American Petroleum Institute, Washington, DC, USA, 1979, pp. 279–282.
[7] ‘I.A. Buist, S.G. Potter’, “Offshore testing of booms and skimmers, in: Proceedings of the Eleventh Arctic and Marine Oil Spill Program (AMOP) Technical Seminar”, Environmental Protection Service, Ottawa, Ontario, Canada, 1988, pp. 229–265.
[8] ‘Eduard Muljadi, Yifan Zhao, Tiam Hua Liu’, “IEEE transactions on industry applications”, VOL.29, NO.3, May/June 1993.
[9] ‘F.X. Merlin, J.H. Andersen’, “Improvement in at sea combating techniques over the last 20 years”, Cen-tre de Droit et d’Economie de la Mer, Universit ´e de Bretagne Occidentale CEDEM/UBO, 1998.
[10] ‘National Research Council’, “Understanding oil spill dispersant and its effects”, National Academic press, Washington, 2005.
[11] K. Deb, S. Agrawal, A. Pratab, T. Meyarivan, “A Fast Elitist Non-dominated Sorting Genetic Algorithms for Multiobjective Optimization: NSGA II,” KanGAL report 200001, Indian Institute of Technology, Kanpur, India, 2000. (technical report style)
[12] J. Geralds, "Sega Ends Production of Dreamcast," vnunet.com, para. 2, Jan. 31, 2001. [Online]. Available: http://nl1.vnunet.com/news/1116995. [Accessed: Sept. 12, 2004]. (General Internet site)