OIL SKIMMER DRONE

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Abstract - *Recently in Mumbai, there occurred 2 cases of sever oil spill near sea shore affecting most of the aquatic life of the area. Also fishing and tourism were affected by this spillage. The environmental effects of such oil spills are not negligible as this is a global problem now days. Every year, there is 100 million US gallons of oil spill. This is equal to 100 large size gymnasium halls. The numbers though could not tell the actual harm caused to the environment by such oil spill as it is in numerous. So there is need of an effective way to clean this oil from the surface without actually wasting it. Now, in industries, to separate oil from other things like coolant and water, we use oil skimmers. There are various methods for this, of which disk type oil skimmer is one of the majorly used. This is because of its simple working and very high efficiency of around 90-95%.)*

Key Words: Oil Skimmers, Oil Pollution, Oil Spill, Oleophilic, Nylon 6

1. INTRODUCTION

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.

Oil pollution occurs in harbor basins when leaks from shore facilities for the supply of diesel fuel to fishing vessels find their way into the harbor water; when vessels pump out oily bilge water in port; when used engine oil is dumped overboard and when an accident results in leakage of fuel oil. A fishery harbor which is contiguous with the main harbor also faces the risk of major oil spills if the main port is a transfer point for crude oil or refined products from oil tankers.

The oil skimming is the operation of removing or separating the oil from the oil polluted water. Oil being the lighter element as compared to coolant mixed with the water, it floats over the coolant. The endless belt running over the roller is adjusted such that the belt will violently smash the layer of the mixture coolant. The oil being the lighter and sticky will stuck to the belt. The belt then is rubbed against the resting scoop or the container where the oil is collected after separation.

2. LITERATURE REVIEW

Hyung-Min Choi et al., [1] studied about Oil sorption capacities of various natural and man-made fibrous sorbents were compared in a simulated seawater bath containing oil. Natural sorbents such as milkweed, kapok, cotton, and wool showed higher sorption capacities than man-made sorbents such as polyester, polypropylene, viscose rayon, nylon 6, nylon 66, and acetate. Sorption capacities of the natural sorbents were over 30 g oil/g fiber. No definite advantages were observed using man-made bicomponent and biconstituent fibres over regular man-made fibres with respect to their sorption capacity.

Victoria Broje, et al., [2] reviewed that for a thicker oil slick and low viscosity oil, the Neoprene was slightly more efficient than polyethylene drums. For 25 and 50 mm oil slicks, the difference between materials was about 20%. The difference between materials was much more pronounced in the case of 10 mm oil slick (up to 100%). For thin slicks, polyethylene was found to be most efficient as it entrained the least amount of water in most cases. A lower temperature increases the recovery rates of Endicott oil by increasing its viscosity and allowing for a thicker oil film to form on the recovery surface after withdrawal. The more viscous Hydro Cal oil recovery was a stronger function of oil slick thickness than temperature.

3. METHODOLOGY

Oil and grease remains on the water surface. They do not mix with water. Separation of it is based on the surface tension, specific gravity and viscosity of them.

Skimmer unit has special purpose belt, which is rotated by mechanical means such that it just touches the surface of water. The oil and grease particle stick to the belt material and travels with the belt to scrapping arrangement where scrapping of oil and grease occurs .This unit mainly consists of rectangular frame. At the top surface of frame, motor and gearbox are fitted. At the bottom surface of frame, driven shaft is fitted with tightening arrangement. This arrangement is provided for the movement of the shaft as per the requirement. One drum each is fitted on the two shafts. On these drums oil removing belt of Nylon 6 is placed. With the help of tightening arrangement the belt is sufficiently tightened so that it will not slip. And also it gives an advantage for the adjustment of unit as per the level of water flow. The motion of motor shaft is given to gearbox, which reduce the speed. This reduced speed is given to the driver shaft through sprocket. The upper shaft is rotated, because of these drum revolves. When the belt is immersed in water, oil and grease get sticks to the belt material. Oil is carried by the belt to the scrapping arrangement, where scrapping of oil and grease occurs and they are collected in barrel through collector pipe. The belt after scrapping again goes to the downward in water channel. This cycle is repeated continuously.

Calculations

Let ρ = Density of water

g = Acceleration due to gravity

v = Volume of the float

r = Radius of the float

h = Height of the float

W = Weight of the system

T_1 = Tension in tight side of belt

T_2 = Tension in slack side of belt

T_R = Torque transmitted by the shaft

θ = Angle of contact between drum and belt

μ = Coefficient of friction between drum and belt

s = Slip of belt

V_D = Linear velocity of drum or shaft

V_B = Linear velocity of belt

v_r = Volume recovery rate

t = Thickness of film

w = Width of belt

N = Speed of rotation of shaft

ω = Angular velocity of shaft

P = Power of motor

R = Radius of the drum

D = Diameter of the drum

1) Balancing of float:

For balance $W = \rho gv$

$\rho = 1000\ kg/m^3$

$g = 9.81\ m/s^2$

$v = \pi r^2 h$

$v = \pi \times (0.08)2 \times 1$

$v = 0.0201\ m^3$

So, $\rho gv = 1000 \times 9.81 \times 0.0201$

$= 197.181$ N (on a single float)

$= 197.181 \times 2$ (for double float)

$= 394.362$ N

$W = 25 \times 9.81$ (mass of the system = 25 kg)

$= 245.25$ N

$\rho gv > W$ so the body will float until $W=\rho gv= 394.362$ N

$W = 394.362/9.81$

$W = 40.2$ kg

So the float can hold a maximum mass of 40.2 kg

2) Tensions on the belt:

$T1/T2 = e^{\mu\theta}$

$\mu = 0.3$

$\theta = 180^0 = 180 \times (\pi/180)$ rad $=\pi$ rad

$e^{\mu\theta} = e^{0.3x\pi}$

$= 2.57$

So, $T_1 = 2.57T_2$

$(T_1 – T_2) \times R = T_R$

$P = T_R \times \omega$

$P = (\pi DN/60) \times T_R$

$T_R = (P \times 60)/ \pi DN$

$= (90 \times 60)/ (\pi \times 0.05 \times 60)$

$= 572.95$ N

So, $2.57T_2 – T_2 = 572.95/R$ N

$1.57T_2 = 572.95/0.05$ N

$1.57\ T_2 = 11459$ N

$T_2 = 7298.72$ N

$T_1 = 2.57 \times 7298.72$

$= 18757.72$N

3) Velocity of belt:

Assuming a slip of 60%

$s = (V_D – V_B)\backslash V_D$

$V_B = V_D - sV_D$

$V_D = (\pi DN/60)$

$= (\pi \times 0.05 \times 60)/60$

$= 0.157$ m/s

$V_B = 0.157 – (0.157 \times 0.6)$

$= 0.0628$ m/s

4) Volume rate of oil recover per turn when shaft is rotating at 60 rpm.Here we assume 1mm thickness of oil film

Volume rate = Thickness of film × Width of belt × circumferential area of shaft × speed rotation of shaft

$v_r = t \times w \times \pi \times d \times N$

$= 0.001 \times 0.1 \times \pi \times 0.015 \times 60$

$= 282.74$ ml/min

4. RESULTS AND DISCUSSION

The spun bond nylon samples used here sorbs oils following a power model. At the lowest fabric densities measured, the fabric sorbed approximately 16x its weight in crude oil and 26x its weight of the more viscous gear lube oil. Sorption of oil for both viscosities is a function of the power of the fabric's area mass density raised to the power of -0.638 for crude oil and -0.62 for the gear lube oil. [3] These powers are almost identical, indicating similar sorption behavior for the nylon fabric.

This indicates that the material properties of the nylon fabric (constant for this experiment) control the value of the exponent of the power function higher basis weight fabrics have a larger mass of nylon packed into approximately the same area as lower basis weight fabrics. Though the lower basis weight fabrics have less total material, they have more void space for containing oil droplets and more available sorbent surface area due to reduced contact between the less dense nylon strands.

Nylon fabric contains oleophilic aliphatic chains which are connected by hydrophilic polyamide linkages. Upon contact with water molecules, the polyamide linkages are solvated while the aliphatic chains in the nylon are available to participate in Van der Waals attractions with the non-polar oil. the emulsified oil initially attracted to the aliphatic chain separates from the nylon as it is repelled by the polarity of the relatively large hydration shell.

If the force applied by the flowing water upstream of the coalesced oily aggregate is lower than the repulsive force applied by the oleophobic, solvated polyamide linkages, the oily aggregate will be kept from flowing through the hydrated nylon barrier. The oil aggregation increases in size by coalescing oil particles out of the oily water being filtered. Fig.1 shows Sorption of crude oil and gear lube oil onto nylon fabric. The maximum oil retained is referred to as the critical oil exposure volume (COEV), or saturation volume. It is known that COEV decreases with increasing fabric thickness because fluids will take a longer time to diffuse though thicker fabrics. Fig.2 shows that the thickness of the studied fabric increases linearly with respect to basis weight.

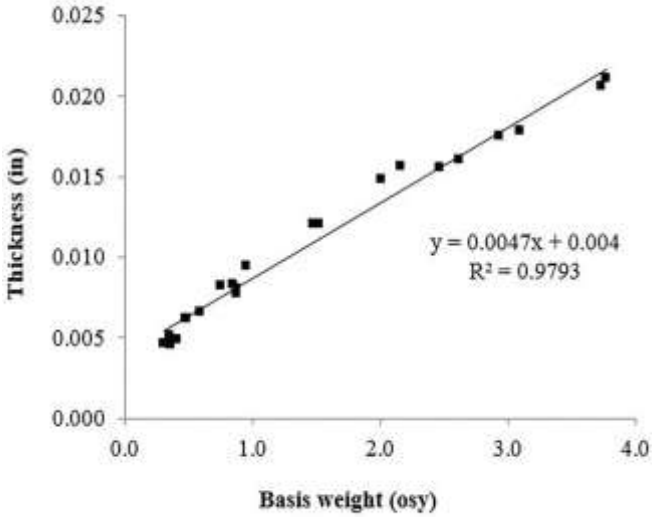

Fig.1: Sorption of crude oil and gear lube oil onto nylon fabric

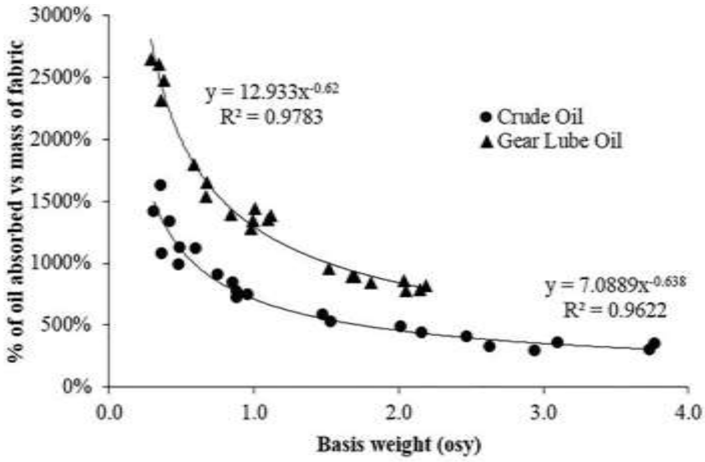

Fig.2 : Thickness of the studied fabric increases linearly with respect to basis weight.

5. CONCLUSIONS

The unique properties of nylon fabric make it an effective material to use to separate oil from water in an oil-in-water emulsion. Field testing has provided qualitative evidence that nylon can be used effectively to contain oil spills in aqueous environments. Specifically, the oleophilic and hydrophilic nature of nylon fabric provides an optimal material to separate oil from water in an oil-in-water mixture. Experiments have determined that nylon fabric is capable of absorbing several times its mass in oil and nylon fabric of lower density separates oil from water with greater efficiency, as predicted by current models of water filtration systems utilizing polymer nonwoven fabrics. This provides containment of oil spill with a new equipment to remediate spilled hydrocarbons and other organic fluids such as crude oil by containing, collecting, and removing these fluids from the environment.

The oil spills have caused a great collision on ecological life around the region of spillage. The main causes of oil spills is because of the carelessness of transporting authority and sometimes due to unpleasant weather causing storm which results in spilling of large tons of oil in water. The spilled oil is waste oil as well as destroys the coastal life around it. It can be concluded that the oil spillage is not only harmful but also results in loss of lives and money. So the recovery of spilled oil is very necessary. Oil skimmer drone is one of the methods of regaining the oil which is spilled. After designing and testing it is concluded that it can regain about more than 90% by using oil skimmer.

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