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Solar Operated Oil Skimmer

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Abstract
Oil is one of the precious crude and being used in routine applications of human life. During the years of recent decades, world has witnessed many oil spillage tragedies and subsequent damage to alive and environments. Oil spills into rivers, bays, and the ocean most often which are caused by accidents involving tankers, barges, pipelines, refineries, drilling rigs, and storage facilities. Every year 100 million US gallons of oil spillage takes place. Clean up and recovery from an oil spill is difficult and depends upon many factors, including the type of oil spilled, the temperature of the water (affecting evaporation and biodegradation), and the types of shorelines and beaches involved. These spills may take weeks, months or even years to clean up. To separate the mixed oil from the water, industries widely use various types of oil removing methods. Herewith the objective of this project is to design and conduct efficiency studies of disc type oil skimmer. It is a method which can be used for the purpose of recovering oil from the water surface when it is spilled in a water bodies due to accidents or leakage. The basic principle used in this method is that oil has greater affinity towards some materials rather than water. Hence, when came in to the contact with such material, oil sticks to its surface and hence can be removed off from the surface of water.

Keywords - *Disc type Oil Skimmer, Oil, Principle of Skimmer, Solar Operated, Spillage.*

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I. Introduction

Today world requires speed in each and every field. Hence rapidness and quick working is most important. Now-a-days for achieving rapidness, various machines and equipment are being manufactured. In such a modern era of liberalization, small-scale industries are contributing in a big way to the growth of the country. But during the growth of the country these industries sometimes ignore the safety norm regarding wastage disposal contained with oil. Oil spillage also occurs due to accidents, maybe due to carelessness or unavoidable natural events.

Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Oil floats on saltwater (the ocean) and usually floats on freshwater (rivers and lakes). Very heavy oil can sometimes sink in freshwater, but this happens very rarely. Oil usually spreads out rapidly across the water surface to form a thin layer that we call an oil slick. As the oil continues spreading, the layer becomes thinner and thinner, finally becoming a very thin layer called a sheen, which often looks like a rainbow.

These spills tend to be very harmful because of the sheer volume of oil released at once, and they pose a serious threat to marine animals and seabirds. Such disasters frequently bring attention to issues with safe oil handling, which can lead to reforms in petroleum regulation. We use a lot of oil and it needs to be transported. The US uses 710 million gallons per day. In fact, every 22 minutes, the US uses up what spilled in the Exxon Valdez spill. The world uses 2.73 billion gallons (2,730 gyms full) per day. Every day 31.5 billion gallons of oil are at sea being transported.

Many countries has made stringent safety norms for waste water disposal contained with oils mainly typically from petrochemical and process industries a so that such industries are equipped with such kind of oil skimmers to separate oils from disposal water.

1. CLEAN-UP METHODS

1.1. Chemical Methods (Dispersants): Dispersants can be used to dissipate oil slicks. Chemicals such as detergents, break apart floating oil into small particles of drops so that the oil is no longer in a layer on the water's surface. These chemical break up a layer of oil into small droplets. These small droplets of oil then

disperse and mix with the water. However, laboratory experiments showed that dispersants increases toxic hydrocarbon levels in fish by a factor of up to 100 and kill fish eggs and affects marine life.

1.2. Physical Methods (Burning): Burning is a technique which involves controlled burning of oil that has spilled from a vessel or a facility. Burning oil can pollute the air. Burning of oil lead to formation of nitrogen dioxide and carbon monoxide which causes respiratory problems, heart conditions and lung damage. Burning oil produces carbon dioxide gas. This is a greenhouse gas that contributes towards climate change.

1.3. Biological Methods (Bioremediation): Bioremediation refers to the use of specific microorganisms to metabolize and remove harmful substances. Adding fertilizers or microorganisms to the water where the spill is located can speed up the breakdown process. Different types of bacteria, archaea, algae, and some species of plants are all able to breakdown specific toxic waste products into safer constituents. A drawback to adding fertilizers is that it increases the growth of algae and also consumes high amount of oxygen. It requires proper knowledge and planning since not all bacteria can be introduce to the polluted site.

1.4. Skimmers

To overcome the above limitations, skimming technique is used to remove oil from water surface. These techniques can be divided into two types,

- Non-Oleophilic

Non-oleophilic techniques include weir skimmers relying on gravity, suction systems, and mechanical skimmers, which physically lift the oil with scoops, or grabs.

- Oleophilic

Oleophilic skimmers recover oil based on the properties of specific materials, which have greater affinity for oil than for water. Oleophilic skimmers usually achieve the highest ratio of recovered oil in relation to entrained water, also referred to as the recovery efficiency, compared to other skimmer types. Oleophilic skimmers reach their highest efficiency when handling medium viscosity oils.

Table1: *Type of Skimmers*

Skimmer		Recovery Rate	Oils	Sea State
Oleophilic	Disc	Dependant on number and size of disc. Tests show grooved disc can be highly effective.	Medium viscosity oils.	Low waves and currents can be highly selective.
	Drum	Dependent on number and size of drum. Tests show grooved drum can be highly effective.	Medium viscosity oils.	Low waves and currents can be highly selective.
	Brush	Throughput dependent on number and velocity of brushes generally mid-range.	Different brush sizes for light, medium and heavy oils.	Can operate under choppy waters.
	Belt	Low to mid-range.	Medium to heavy viscosity	Can operate under choppy waters.
Non-Oleophilic	Weir	Dependent upon pump capacity, oil type.	Effective in light to heavy but not so good in very heavy oils	Operate under calm waters.
	Vacuum	Dependent upon vacuum pump.	Light to medium oils	Used in calm waters.

II. Oil Skimming Indentations And Equations

Oil skimming is basically sticking of oil to some material which is inserted in it. This action can be effectively used as oil can stick to the material but not the other impurities in it. Hence by this principle, Oil can be separated from its containments as well as it can be separated when it is containment.

Oil skimmers are effectively used in various industries for the sake of separation of the coolants especially from water.

Although designs vary, all oil skimmers rely on specific gravity, surface tension and a moving medium to remove floating oil from a fluid's surface.

Floating or sinking oil and grease cling to skimming media more readily than water, and water has little affinity for the media. This allows skimming media in the shape of a belt, disk, drum, etc. to pass through a fluid surface to pick up oil and grease with very little water. This oily material is subsequently removed from the media with wiper blades or pinch rollers.

Oil skimmers are simple, dependable and effective tools for removing oil, grease and other hydrocarbons from water. Often, a skimmer by itself can achieve the desired level of water purity. In more demanding situations, skimming is a cost-effective means of removing most of the oil before using more complicated and costly treatments such as membrane filters and chemical processes.

Disk Skimmers:These skimmers rotate a disk shaped medium through the liquid. Oil is wipedoff and discharged into a collection container in a manner similar to belt skimmers. It is important to consider reach, the portion that actually gets immersed, when looking at a disk skimmer.

III. Calculations

Power of Shaft = P = 10 watt
Power transmitted by shaft,
$P = \frac{2\pi N T}{60}$
Where, N→ Rpm of motor shaft = 30
T →Torque transmitted
$10 \times 10^3 = \frac{2\pi \times 30 \times T}{60}$
T = 3.183 x 103 N-mm
We know that,
No. of teeth on small (sprocket) , N1 = 11
No. of teeth on big (sprocket) , N2 = 13
Ratio = R = 1.18 : 1
Torque on sprocket = 1 × T
$= 1 \times 3.183 \times 10^3$
$= 3.183 \times 10^3$ N-mm
ASSUMPTIONS
Material C45 – 0.45 % carbon
σ_{ut} = 360 N/mm2
FOS = 5
Now,
$\sigma_t = \sigma_b = \sigma_{ultimate} / FOS = 360/2 = 180$ N/mm^2.
$\sigma_s = \sigma_t / 2 = 180/2 = 90$ N/mm^2.
Torque transmitted by shaft,
$T = \pi/16 \times \tau \times d^3$
Permissible shear stress (τ),
$\tau = \frac{0.5 \times \sigma ut}{FOS}$
τ = 36 N/mm^2
Therefore, 3.183 x 103 = π /16 x d3 x 36
D = 7.66 mm.
FOS =2
Dfinal = 12 x 2= 15.32 mm = 20 mm
We select dia. Of shaft = 20 mm.
For 20 mm shaft dia. we select standard bearing from design data book it P204 pedestal bearing
For 20mm Shaft diameter we take standard breaking no. P204
P=pedestal bearing
2=spherical ball
=04=5 * 4 = 20mm

DESIGN OF CHAIN & SPROCKET
We know ,
TRANSMISSION RATIO = Z2 / Z1 = 13/11 = 1.18
For this transmission ratio number of teeth on pinion sprocket is in the range of 21 to 10 , so we select number of teeth on pinion sprocket as 11 teeth.
So , Z1 = 11 teeth
SELECTION OF PITCH OF SPROCKET
The pitch is decided on the basis of RPM of sprocket.
RPM of pinion sprocket = 30 rpm
For this rpm value we select pitch of sprocket as 6.35mm from table.
P = 8.51mm

CALCULATION OF MINIMUM CENTER DISTANCE BETWEEN SPROCKETS
THE TRANSMISSION RATIO = Z2 / Z1 = 13/11 = 1.18 which is less than 5
So from table,
MINIMUM CENTER DISTANCE = C' + (30 to 150 mm)
Where $C' = \frac{Dc1 + Dc2}{2}$
$C' = \frac{25 + 29}{2}$
C' = 27 mm
MINIMUM CENTER DISTANCE = 27 mm

CALCULATION OF VALUES OF CONSTANTS K1 K2 K3 K4 K5 K6
Load factor K1 = 1.25 (Load with mild shock)
Factor for distance regulation K2 = 1.25 (Fixed center distance)
Factor for center distance of sprocket K3 =1.25
Factor for position of sprocket K4 = 1
Lubrication factor K5 = 1.5 (periodic)
Rating factor K6 = 1.0 (single shift)

CALCULATION OF VALUE OF FACTOR OF SAFETY
For pitch = 8.51 & speed of rotation of small sprocket = 30 rpm
FACTOR OF SAFETY = 8.55
Now approximate centre distance in multiples of pitches,

$$Ap = \frac{ao}{p}$$

$$= \frac{27}{2}$$

$$= 13.5$$

Now, length of continuous chain in multiples of pitches,

$$Lp = 2ap + \frac{z1+z2}{2} + \frac{\left(\frac{z2-z1}{2\pi}\right)}{ap}$$

$$= 2 \times 13.5 + 12 + 7.50 \times 10^{-3}$$

$$= 39$$

Now, length of the chain,

$$L = Lp \times p$$

$$= 39 \times 8.51$$

$$= 331.89 \text{ mm}$$

IV. Fabrication

Steps included in fabrication of the project:-

1. Fabrication of frame – The frame was formed by welding the flat shaped pipes made of MS material together in order to support the assembly.
2. Mounting of the motor – The DC motor that is to be used is first mounted on the frame by clamping it to one end of the frame on metal plate which is welded to the frame and then connecting it to the motor
3. Mounting of bearings − Bearings were mounted on the frame with the help of nut and bolt arrangement whose required holes were drilled previously on marked positions. After then shafts were inserted into the bearing.
4. Mounting of chain and sprocket– It is the component in our project where once the design procedure for sprocket is completed, sprocket with 11 and 13 number of teeth was purchased. Chain of required length was mounted on sprocket.
5. Fitting of the Oleophilic disc – After that disc made of hardner material was constrained with the help of the bush welded to the shaft.
6. Mounting of solar panel –Solar panel is joined on frame with the help of nut and bolt.

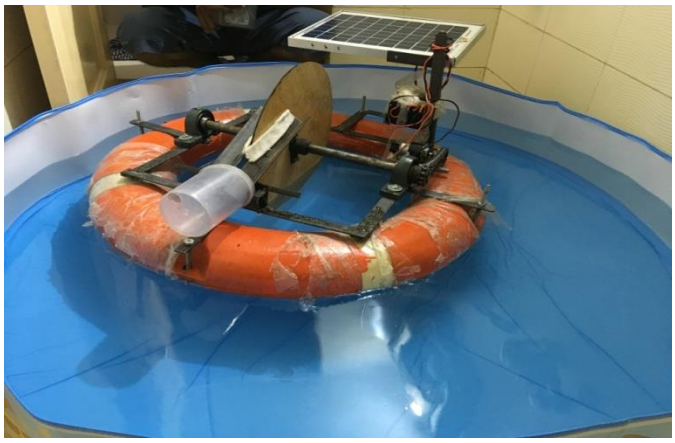

Figure 1:oil skimmer prototype

V. WORKING

The skimming principle, upon which the technique relies, is dependent on three physical properties of oils, namely specific gravity, surface tension and affinity. Most oils have a lower specific gravity than water,

which allows it to separate from water and float to the surface unless agitated. These oils are possible to collect using an oil skimmer. Other oils do the opposite and, if not agitated, sink to the bottom of the water and must be collected by other means than skimming. The light oils, which can be skimmed off the water surface, are possible to collect due to the surface tension and affinity of the oil. Most oils have little or no affinity for water, which prevents mixing of oil and water. As the skimming medium enters the water, the oil wets the surface preventing water from doing the same. Any water on the surface is pushed away as more oil attaches to the surface because of the surface tension of the oil. However, it is important that the skimming medium is not submerged too deep into the water, as it may cause the oil to be washed off the skimming medium and thereby lowering the efficiency.

A number of factors are to be taken into account when selecting skimmers but the most important aspects to consider are the viscosity and the adhesive properties of the oil intended to be skimmed. In open sea spills, other important factors are sea state, currents, and level of debris.

In our project, the necessary power required to run the whole setup is been obtained by the solar energy. The solar panel charges the battery. The battery is further connected to the motor mounted on the main frame. Small Sprocket connected to the motor drives the big sprocket with the help of chain. The big sprocket is mounted on to the main shaft which rotates at a certain speed. The bearings are used to carry the load of the shaft. The oleophilic disc is mounted at the centre of the shaft and is made of hardener material. The rotating disc collects the oil and is collected through the angles placed near the disc into the container.

VI. RESULT

- At 30 rpm of disc rotation, oil removal rate is 0.1875 l/m.
- 1 Litre of oil can be separated in 5minutes and 33seconds.
- For 200 ml of Gear oil to be skimmed, efficiency of our skimmer is 93.65 % for an effective run of sixty seconds.
- Overall efficiency of our oil skimmer is 94.25 %.

VII. CONCLUSION

Among different oil separating methods, higher efficiency of oil removal rate is found by disc skimmer. If the speed of the disc is high, then adhesion properties between disc surface and oil is less, thus less amount of oil is separated from water. Efficiency of the disc skimmer is high comparing the cost and size. The mechanism designed is self-sustaining. With few modifications in design such as increasing the number of discs the efficiency of the skimmer can be improved. The use of complex algorithm and slick thickness sensors, the skimmer can position itself to the location of oil spillage.

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