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Design and Fabrication of Multi-Disc Oil Skimmer

M. Maruthirao[1], V. Pavan Kumar[2], N.V. Surya narayana[3]
[1]*Research Scholar, Dept; of Mechanical Engineering, ANU, Guntur*
[2]*Assistant Professor, Dept; of Mechanical Engineering, PBRVITS, Kavali, SPSR Nellore (Dt), AP.*
[3] *Assistant Professor, Dept; of Mechanical Engineering, PBRVITS, Kavali, SPSR Nellore (Dt), AP*

***Abstract*—** During the past 40 years, there have been numerous major accidents of oil spill in various countries, mostly as results of ship collisions. There are several methods in handling oil spill accident, in which the most effective methods are using mechanical oil skimmer with disc plate. This will reduce water pollution and saves the aquatic life. Disc type oil skimmer is used to remove the floating oil from liquid medium. The oil is removed from the metal disc and belt through wiping blades. Here we use the skimming medium as Metal disc. The skimming medium runs over the surface of water in which oil brought out with little amount of water. The main purpose of this fabricated skimmer is to purify the water from various dirt oils. The effectiveness of the oil skimmer on handling oil spills is influenced by various factors, such as the depth of the disc submerged or the disc surface area dipped into the oil spill, the area of the wiper sweep, the thickness of the oil on the disk surface, and the rotation speed of the disc. The present study is concerned to estimate the Oil Recovery Rate (ORR) and Oil Recovery Efficiency (ORE). The disc speed, depth of immersion and film thickness are the operating parameters. Speed of the disc can be varied by providing multispeed arrangement. The skimmer is more cost efficient and simple in design in comparing to costly treatments like membrane filters and chemical treatments.
***Keywords*— Oil recovery, Metal disc, Water pollution, Oil skimmer.**

1. INTRODUCTION

Pollution is the most significant danger which threatens the human nature. The most dangerous of these pollutants is oil pollution, because oil pollution threatens the environment as well as economy. It has been studied that recently with increasing use of oil. According to Environmental Protection Agency, almost 14000 oil spills are reported each year in the oceans alone. Many countries have made stringent safety norms for waste water disposal content 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. An oil skimmer is the device that is designed to remove oil floating on a liquid surface. Based on the specific design they are used for a various application such as oil spill response, as a part of oily water treatment systems, removing oil from the coolant and aqueous part washers and collecting fats, mixed oil and grease oil in waste water treatment plant. Water pollution is the release of substances into bodies of water that makes water unsafe for human use and disrupts aquatic ecosystems. Water pollution can be caused by plethora of different containments, including toxic waste, petroleum, and disease-causing microorganisms, water pollution may also include the release of energy, in the form of radioactivity or heat, into bodies of water. Water pollutants come from either point sources or dispersed sources. A point source is a pipe or channel, such as those used for discharge from an industrial facility or a city sewerage system. A dispersed (nonpoint) source is a very broad unconfined area from which a variety of pollutants enter the water body, such as the runoff from an agricultural area. Point sources of water pollution are easier to control than dispersed sources, because the contaminated water has been collected and conveyed to one single point where it can be treated. Pollution from dispersed sources is difficult to control and despite much progress in the

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building of modern sewage-treatment plants, dispersed sources continue to cause a large fraction of water pollution problems.

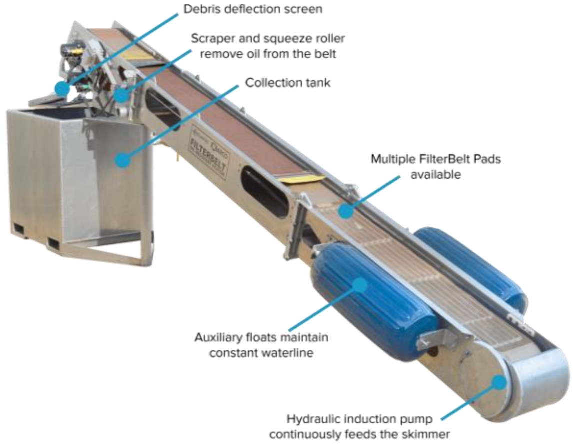

Fig.1.1: Belt skimmer

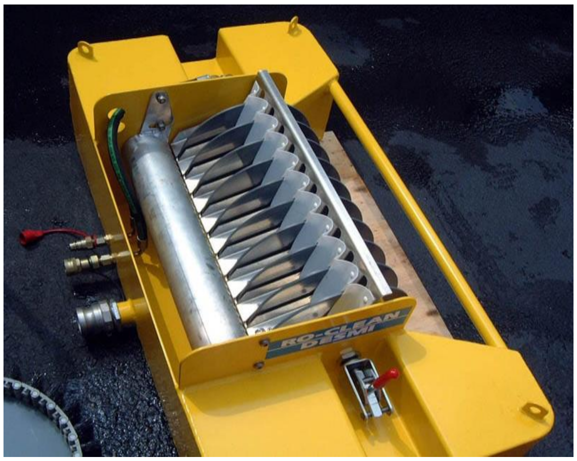

Fig.1.2: Disc skimmer

Fig.1.3: Mop skimmer

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Fig.1.4: Tube skimmer

Fig.1.5: Floating suction skimmer

2. OIL SKIMMING

An oil skimmer is a machine that removes floating oil and grease from liquid. The floating oil adheres to skimming media, such as a belt, tube, rope, mop, or disk. The media then runs back to the machine to be wiped clean. Weir style skimmers use a pump to collect floating oils. The relationship between oil and water in a mixture is well-known and governed by two physical properties:

2.1 Specific gravity

Most hydrocarbons have a lower specific gravity than water. Without agitation, oil separates from the water and floats to the surface. These oils are known as LNAPL's, Light Non-Aqueous Phase Liquid. Oils (and other compounds) that sink in water have a higher specific gravity and are known as DNAPL's, Dense Non-Aqueous Phase Liquid.

2.2 Surface tension and affinity

Normally, oil bonds more tightly to itself and other materials than to water. This affinity, and differences in surface tension between oil and water, cause oils to adhere to a skimming medium. 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 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 floating oil and grease with very little water. This oily material is subsequently removed from the media with wiper blades or pinch rollers.

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Oil skimmers are simple, dependable and effective tools for removing oil, grease and other hydrocarbons from water and coolants. Often, an oil skimmer by itself can achieve the desired level of water purity. In more demanding situations, oil skimming is a cost-effective means of removing most of the oil before using more complicated and costly treatments such as coal escers, membrane filters and chemical processes. Grease skimming involves higher viscosity hydrocarbons. Oil skimmers must be equipped with heaters powerful enough to keep grease fluid for discharge. Typical Applications for Industrial Oil Skimmers If the floating grease has formed into solid clumps or mats, a spray bar, aerator or mechanical apparatus can be used to break up grease mats and facilitate removal.

TYPES OF OIL SKIMMERS

For industrial oil skimming, there are six basic designs commonly used:

- Belt Skimmers
- Disk Skimmers
- Drum/Barrel Style Skimmers
- Mop Skimmers
- Tube Skimmers
- Floating Suction Skimmers

DESIGN AND FABRICATION

Design symbols

σ_b = bending stress
μ = coefficient of friction
θ = arc of contact
W = weight of metal disc
W_p= weight of driven shaft contact pulley
P = motor power
n = speed of motor or speed of driving pulley
N = speed of larger or driven pulley
C = centre distance between the drive and driven pulleys
d = diameter of shaft
d_p = diameter of smaller pulley
D_p = diameter of larger pulley
I = moment of inertia
y = distance from the centre to outer dimension
Z = section modulus
V = speed of v-belt
T_1 = Tension on tight side
T_2 = Tension on slack side
A = cross sectional area
L = length of the V-belt
b = Width of the V-belt
t = Thickness of the V-belt

Design of shaft:

P = 120 Watts
V = 0.314 m/sec
θ= 145^o = 2.5 rad

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$\mu = 0.5$

let's consider the power transmitted, $P = (T_1-T_2)\ V$

$\therefore (T_1-T_2) = P/V = 120/0.314 = 382.16$ N

$T_1-T_2 = 382.16$ …(i)

$T_1/T_2 = e^{\mu\theta}$

$T_1/T_2 = e(0.55)(2.5)$

$T_1 = 3.95\ T_2$ …(ii)

From Eq. (i)&(ii)

$T_2 = 129.5$ N

$T_1 = 511.5$ N

Determination of reaction forces and bending moment:

Considering the vertical forces

Reactions at 'A' & 'B'

$\Sigma F_y = 0$

$R_a + R_b = W_1 + W_2 + W_3 + W_4 + W_p = 5.8 + 5.8 + 5.8 + 5.8 + 49 = 72.2$ N

$R_a + R_b = 72.2$

$\Sigma M_a = 0$

$(5.8)(0.1) + (5.8)(0.2) + (5.8)(0.3) + (5.8)(0.4) - (R_b)(0.5) + (49)(0.55) = 0$

$R_b = 65.5$ N

$R_a = 6.75$ N

Bending moment at 'A' = 0 N-mm

Bending moment at 'B' = -2425 N-mm

Diameter of the shaft:

From Bending Equation,

$M / I = \sigma_b / y$

$2425 / (\pi d^4/64) = 0.92 / (d/2)$

$d = 29.94 \text{ mm} \approx 30 \text{ mm}$

$A = \pi d^2/4 = 706.85 \text{ mm}^2$

Design of Belt & Pulley:

Cross Section of belt = B section (From design handbook, Table 24.1)

b = 16 mm

t = 10 mm

Speedof V-Belt:

$d_p = 100$ mm = 0.1m

n = 65 rpm

$V = \pi d_p n/60$ m/sec

$V = \pi(0.1)(65)/60 = 0.34$ m/sec

Diameter of pulley:

N = 20 rpm

$D_p = (n/N)\ d_p = (65/20)(100) = 325 \text{ mm} \approx 315$ mm.(From design handbook, Table 23.13)

$i = d_p/D_p = 100/300 = 1:3$

Length of the V-Belt:

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C = 350 mm

$L = 2C + \frac{\pi}{2}(D_p + d_p) + ((D_p-d_p)^2/ 4C) = 2(350) + \frac{\pi}{2}(300 + 100) + ((300- 100)^2/ 4(350))$

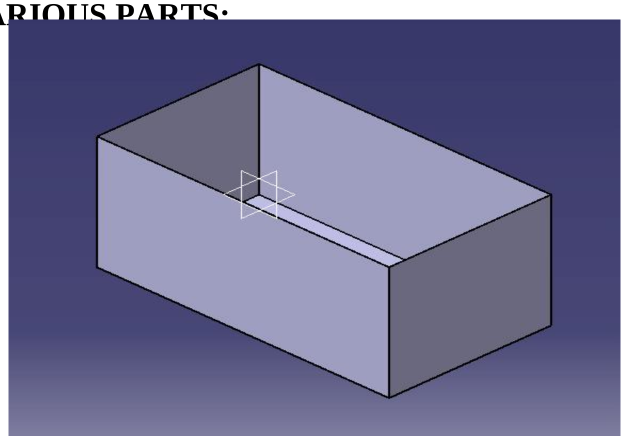
L = 1356 mm

Summary

1. Cross sectional area of the shaft, A = 706.85 mm

2. Diameter of the shaft,d = 30 mm
3. Torque at drive shaft, $T = 57.29\text{x}10^3$ N-mm
4. Weight of driven pulley, W_p = 49 N
5. Bending Moment at driven shaft, M_{Rb} = -242 nm
6. Diameter of driven pulley, D_p = 300 mm
7. Diameter of drive pulley, d_p = 100 mm
8. Speed of driven pulley, N = 20rpm
9. Speed of drive pulley, n = 65 rpm
10. Speed of the belt, V = 0.314 m/sec
11. Distance between drive and driven pulley, C = 350 mm
12. Power of motor = 120 watts (0.15Hp)
13. Speed of motor = 65 rpm

CATIA MODELS OF VARIOUS PARTS:



2.1 tank design

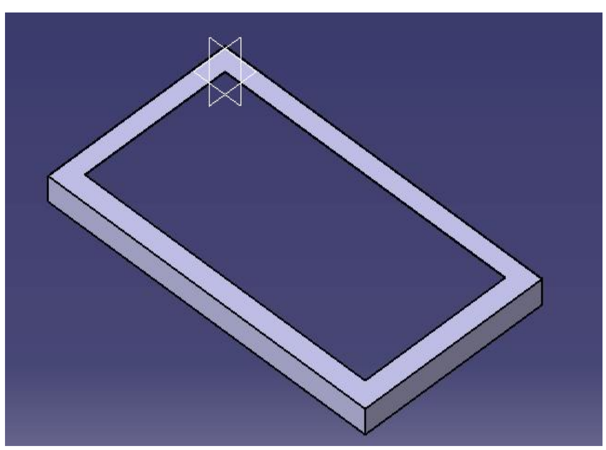


Fig 2.2 Frame design

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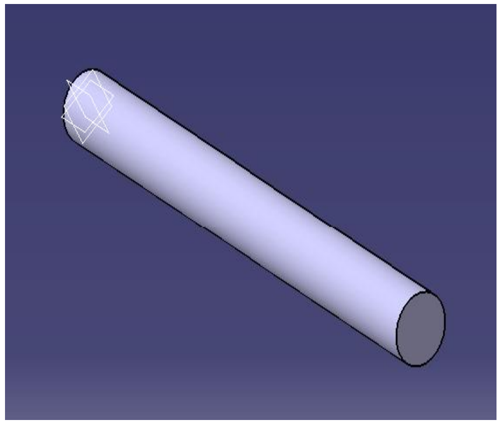

Fig 2.3. Shaft design

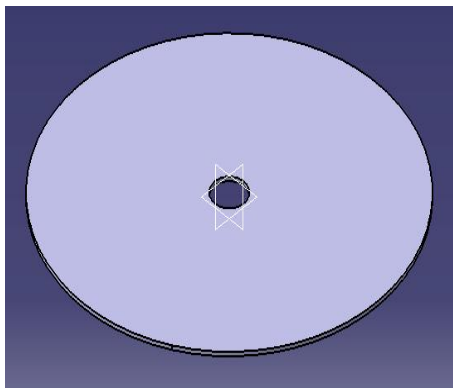

Fig 2.4: Disc design

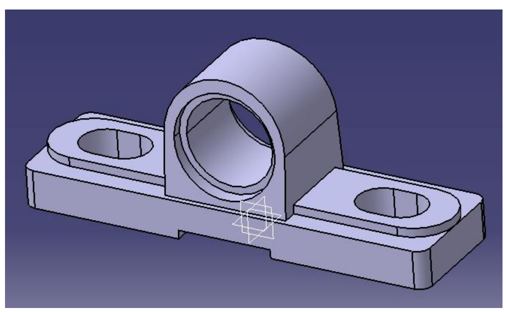

Fig 2.5: Bearing design

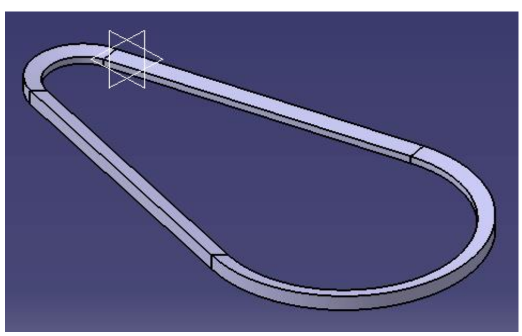

Fig 2.6 v-belt design

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Fig.2.7.Bearings

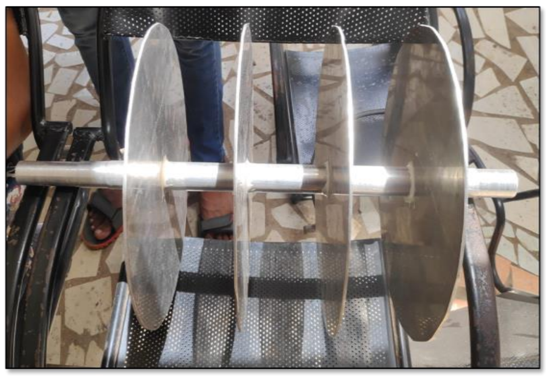

Fig. 2.8 Shaft with discs

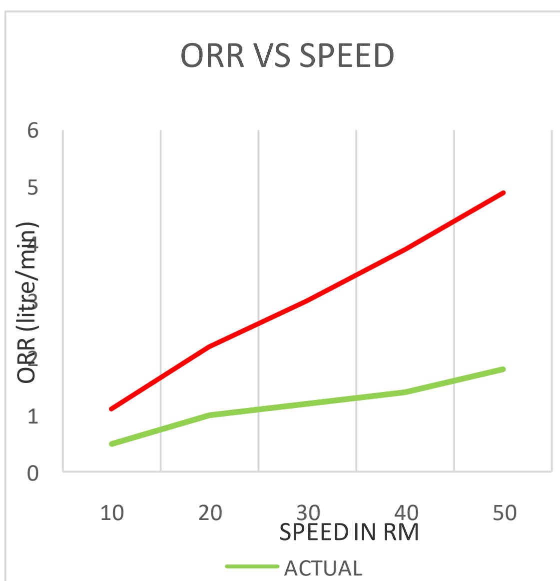

Fig. 2.9 Comparison of actual and theoretical values

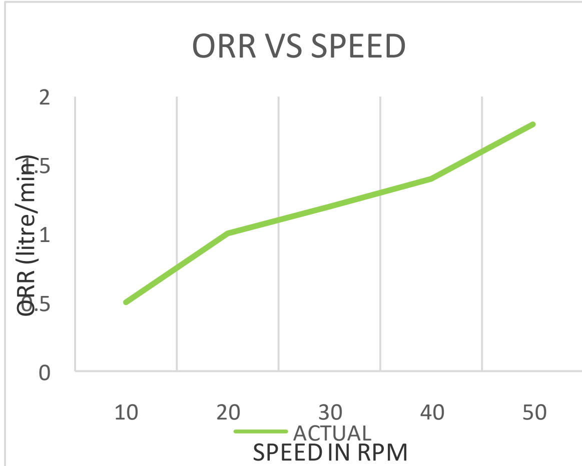

Fig.3.0 Actual graph

TABLE.1 COMPARISON OF BOTH ACTUAL & THEORETICAL DATA

S. No.	RPM	Actual ORR (litre/min)	Theoretical ORR (litre/min)	Efficiency (%)
1	10	0.5	0.6	0.83
2	20	1	1.2	0.83
3	30	1.2	1.8	0.66
4	40	1.4	2.5	0.56
5	50	1.8	3.1	0.58

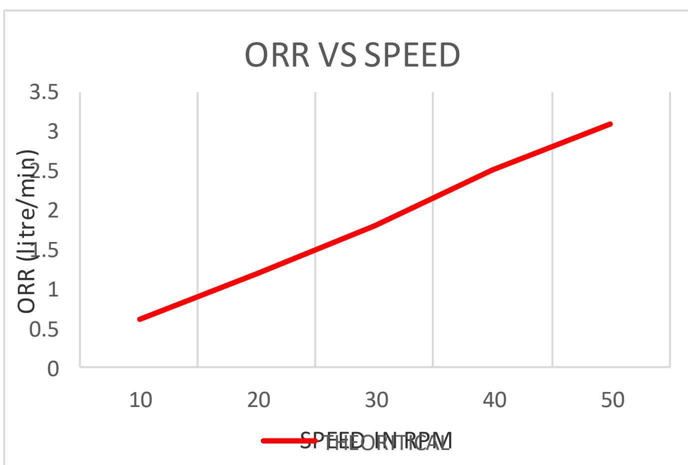

Fig.3.1 Theoretical graph

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S. No.	RPM	Actual ORR (litre/min)
1	10	0.5
2	20	1
3	30	1.2
4	40	1.4
5	50	1.8

Table.2 Experimental Data:

CONCLUSION:

In this project we have found numerous point which need to be booked into while designing the oil skimmer. The changes in the design of skimmer results in huge difference in the oil recovery. Aluminum disc gives better edge in oil recovery all design aspects lead to improvement of oil skimmer. The oil from coolant was easily separated with this machine. This machine overcame many designs hurdle to reach the final stage.

The objective of project multi disc oil skimmer is:

1) Successfully fabricated oil skimmer.

2) Better oil removal rate and less cost.

Our oil skimmer machine is much durable comparing to other methods. Machine is simple we can depend on our oil skimmer for its effective result. Further testing and modification will significantly improve oil recovery process. We consider the experience we got with designing and the machine could help in the industries .As we learnt from all the researches work that there are some important aspects and points that are essential to consider while designing an oil skimmer. The very first thing is the design aspects of the skimmer and rotational speed of the disc is very important and also material which has been used. The slightest changes in the design aspect of the skimmer may cause a huge difference in the oil recovering efficiency of the skimmer. The disc must be of a polar material so that the oil that is a non-polar substance will stick to the surface of the disc. The other crucial thing is the placing of the component parts of the skimmer should be placed significantly.

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