Experimental Analysis of Rotating Disc Type Oil Skimmer

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Abstract- *Recently in many industries like manufacturing industries, automobile parts manufacturer, locomotive repairing shop, west water treatment plants and machining shop, mining industries, etc. use the oil skimmer to separate the oil from the water. The investigation of multidisc oil skimmer is on arrangement leads to a conclusion about the interference effect between adjacent discs directly on the oil recovery rate (M.S. Christodoulou). The performance of this devise depends on the large no. of a parameter. This paper is based on experimental analysis which shows that how to over-come these effect. So that aim of the study was a comparison between two experimental data with and without horizontal swirl motion. Based on the calculation of making swirl motion in fluid the result will show the rather change in oil recovery rate.*

Keywords- disc type oil skimmer, multi disc skimmer, oil water separator, aluminum disc, fabrication, experimental analysis.

I. INTRODUCTION

In today's world, environmentally and economically conscious seek to recycle and reuse both water and oil. The very first step in any recycle and reuse process is to separate the oil from the water. The separation of oil from the mixture of oil and water is a tough task and environmentally significant practical problem.

A method firstly introduced in the 1950s, and now routinely used in many separation applications where one kind of liquid floats as a continuous film (ex. Oil film) on the surface of another liquid (ex. Water), it consists of one or more circular discs having diameter of around 300 to 800 mm (Cormack, 1983; Marcinowski,1976; and Thomas, 1977). which are mounted on a horizontal drive shaft and it is operated by AC or DC power as per the requirement of the system. Rotation of the shaft moves the clean disc surface down through the film and causes the oil stick to the disc.

When this attached layer of oil is brought out above the free surface, it can be removed by a scraper device (generally of rubber material) and transferred to the storage tank by the gravitational effect, or by pumping. Such kind of skimmers is accepted as environmental protection devices and find application for oil recovery in such marine oil spill as well as industrial wastewater treatment systems.

The performance of this type of skimmers is depended upon the major parameters like disks diameter, disks material, depth of immersion, rotating speed, oil-water ratio, and properties of the oil. Clearly, the oil collection capacity of a skimmer depends upon the number and size of discs. previously experimental data for a commercial disc system was presented by (Thomas and Devia) who tested the device in various oil for different rotational speeds and for varying thickness of the oil film. Their experimental shows that serious limitation in performance exists.

Many commercial systems employing this principle already exist. There are still required some improvement which can enhance the performance of such kind of skimmer. We are introducing the one more parameter that is putting the extra rotor or impeller which will be used to produce the swirl in the mixture of oil and water.

The main concept behind this is to anyhow to make the fluid to come in motion so that fluid at far from the disk, is easily get towards the disk and oil recovery rate will be going to be affected. Such kind of action is already employed in a belt type oil skimmer as. We didn't find any data regarding such system use for the disk type oil skimmer. So the experimental method is developed in this research, which shows the experimental setup and the procedure to do the analysis on such kind of system.

II. LITERATURE REVIEW

After studied some kinds of literature about design, construction, and working of oil skimmers. Many parameters have been considered for the design, construction and working of oil skimmer such as oil recovery rate, rotor speed, material selection for a disc, shaft speed, depth of immersion, etc. after studied this literature we noted out problems in those machines/invention/ideas.

1. We study literature By A. M. Najar and J.T.Turner (Enhanced oil recovery using the rotation of disc skimmer) in

which a systematic pro-gram of measurements has been established how the recovery rate of the skimmer system is influenced by both the characteristics of the oil film and the geometrical detail of the discs. Large improvement in recovery rate for the modify T-disk section was achieved.

2. Another literature N. Windiaksana, A A Yudiana (Analysis of the effectiveness of oil spill recovery using disc type of oil skimmer at laboratory scale) based on the experimental data, the slope angle of wiper or the wiped area will not affect the amount of recovered oil.

3. M. S. Christodoulou, J.T.Turner, S.D.R. Wilson (A model for the low to moderate speed performance of the rotating disk skimmer) in which theory and experiment are compared for a disk of radius 150mm rotating in oil of viscosity 30cs it is clear that agreement is much better for the large depth of immersion because the tail losses were smaller and the neglect of centrifugal effects.

4. M. S. Christodoulou, J.T. Turner (experimental study and improvement of the rotating disk skimmer) shows the further investigation of multidisc arrangement leads to the conclusion about interference effect between adjacent discs which have a bearing on the design of practical skimmer system.

III. APPARATUS

Components	Specification
Disc	2mm thickness, 300mm diameter, aluminium
Tank	L×B×H , 90×40×35cm
Oil collecting tank	L×B×H , 38×8×5cm
AC motor	1400rpm, 0.37kw, 0.5hp
DC motor	12V dc motor
DC battery	12V, 1.3AH dc battery
pulley	12 inch diameter, cast iron pulley
scraper	iron and rubber scraper
Bearing	UPC 204
Impeller	Mixer-grinder impeller
Digital tachometer	To measure rotation speed of disc
Speed variant	To control speed of Ac motor

IV. WORKING PRINCIPLE OF DISC OIL SKIMMER

The disc is mounted on horizontal shaft and shaft is connected with motor. Disc material is such adhesive to attract the oil. Due to the properties difference of two different liquid (oil and water), oil is stick on the disc when it rotates at its low to optimum speed it can be easily separate out by the scrapper to the storage tank.

V. EXPERIMENTAL SETUP

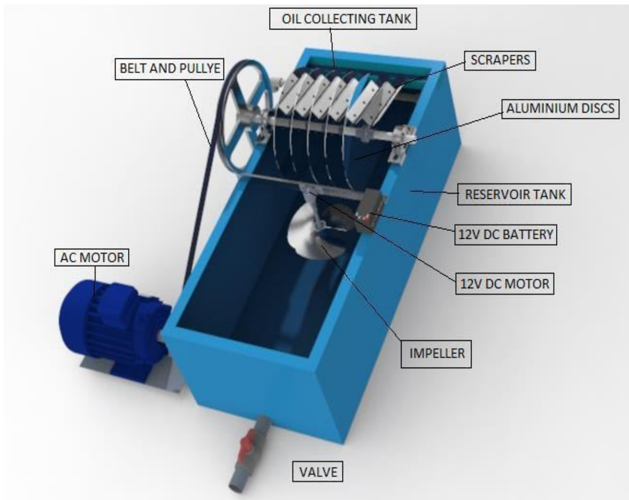


FIG.1

The essential feature of the Experimental setup is presented in figure one Aluminium discs of 300 mm diameter and 2 mm thickness mounted on the Aluminium shaft. Aluminium was determined to be the best overall material, other material offer proved better in the dipping test although usually by only the slightly of percentages. However, from a cost standpoint, weight standpoint, case of handling, machinability and reliability standpoint Aluminium was the most advantageous material as mention in a book by S.T. Uyeda (recovery of floating oil rotating type disc skimmer).

The disc was tightly mounted and concentrically aligned on a rotating shaft. At one end of the shaft is supported on bearing and another end was connected to the 12-inch pulley through bearing. Belt and pulley drive is used to rotate a 5 no. of discs. The whole setup is run by the 0.5Hp single-phase AC motor which is connected with the speed controller to operate the system at variant speed. Rubber scraper is used to holding both sides of the disc tightly to remove maximum oil. The dragged out recovered oil into inclined trays. They direct the recovered oil into the portable container. Occasionally, however, during the course of measurements of the oil recovery rate (ORR) and the oil

recovery efficiency (ORE) in a subsequent step, the falling oil from the trays is relevantly directed to gather into a small portable container instead of the main reservoir versus appropriate elapsed time using an accurate digital stopwatch.

VI. EXPERIMENTAL PROCEDURE

At the beginning of each set of experiment the main reservoir is filled with water up to the certain level so that depth of immersion of disc is 25mm constant throughout the each process. We used the oil has viscosity of 121 cst at 38 degree Celsius.

Step 1:

A removable scale with 1 mm in accuracy is temporarily attached to the face surface of the tank in a vertical position with its relative zero position the meniscus line. Then, the intended oil of 1 litter under investigation is slowly poured into the reservoir on the water surface so that oil film thickness is (2 to 3 mm). Disc spacing 50mm constant throughout the process. (Using reference No.1)

Step 2:

We conduct the first test in which discs is rotate constantly at 50 rpm measured by tachometer and we measured the time for collection of 500ml oil without making swirl in reservoir.
Then again starts the test with swirl motion for the same 50 rpm and check the time for recovery of 500ml oil.

Step 3:

The same test procedure we follow for the increasing speed of 60,70,80,90 and 100 rpm of disc with and without swirl motion in reservoir. Form the obtained data we can analyse the above test and able to plot the graph of ORR vs Rotational speed.

VII. THEORETICAL CALCULATION

Theoretical calculation will be used to identify how much oil can be recovered by the device. This calculation concerned with some parameters, depth of discs, test duration, rotational speed and oil film thickness. So the formula for amount of oil recovered is given by,

- Here, we assumed the oil film thickness of 0.5 mm.
- Depth of immersion (0.02m) is constant through so the area is also remains constant

Area = $\pi(R-r)2$,
Where (R - r) = depth of immersion, n = 2 × no. of disc = 2×5 = 10 Amount of oil recovered (litter)
= n × Area × Rotation speed × time × oil thickness (1)
Oil recovery rate (litter/min) ORR
= n × Area × Rotation speed × oil thickness (2)
=10 × π $(R-r)2$ × N × 0.0005
=10 × π × (0.02)2 × N × 0.0005
= N × 6.28 ×(10)−3 (litter)
= N × C
C = constant = 6.28 ×(10)−3

THEORETICAL DATA SHOWN IN BELOW TABLE

Table: 2

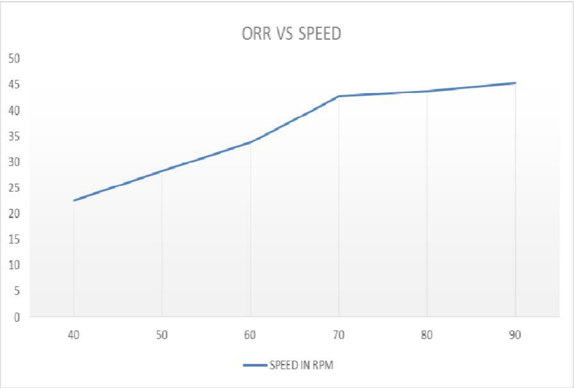
RPM	Theoretical ORR (litter/min)
40	25.12×10^{-2}
50	31.40×10^{-2}
60	37.68×10^{-2}
70	43.96×10^{-2}
80	50.24×10^{-2}
90	56.52×10^{-2}

VIII. EXPERIMENTAL DATA

- Experimental data without making the swirl motion in reservoir tank:

Table : 3

Sr no.	RPM	Time (min)	Actual ORR (litter/min)
1	40	2.21	22.60×10^{-2}
2	50	2.16	28.26×10^{-2}
3	60	1.47	33.91×10^{-2}
4	70	1.17	42.73×10^{-2}
5	80	1.14	43.70×10^{-2}
6.	90	1.10	45.21×10^{-2}

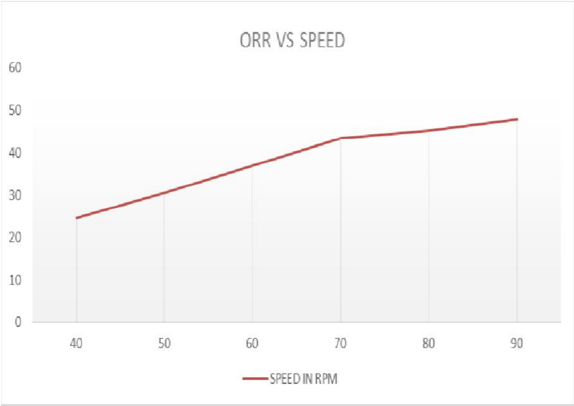


Graph.1

• **Experimental data with making the swirl motion in reservoir tank**

Table : 4

Sr no.	RPM	Time (min)	Actual ORR(litter/min)
1	40	2.03	24.61×10^{-2}
2	50	2.04	30.48×10^{-2}
3	60	1.35	36.92×10^{-2}
4	70	1.14	43.52×10^{-2}
5	80	1.10	45.21×10^{-2}
6.	90	1.04	47.86×10^{-2}



Graph.2

COMPERISION OF TWO EXPERIMENTAL DATA

Graph. 3

Graph 3. Clearly shows the result of whole experiment. There is a gradual increase in oil recovery rate is obtain when compares the two data of experiment, with and without swirl motion.

IX.CONCLUSION

- Based on the result of test there are significantly increasing oil recovery rate when variety of speed being applied for 20mm depth of disc. When 20mm depth being applied will produce the area 12.56$cm2$.
- If the higher rotation speed being applied, the quality of recovered oil will mostly consist with water.
- By comparing the above two different charts we can conclude that the making the swirl motion in fluid will helps to more amount of oil will come in contact with the disc so that gradually increase in Oil recovery rate was found for various speed.

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