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Influence of operational parameters on the recovery rate of polyester resin surface of locally designed drum oil skimmer

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Influence of operational parameters on the recovery rate of polyester resin surface of locally designed drum oil skimmer

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Abstract. The development in the industry makes the process of transferring oil between countries a necessity. There has been massive pollution in the rivers environment resulting from the leakage of oil from oil ships, the transfer of factories and workshops wastes to rivers, which posed a great danger to human life and living creatures. Therefore, it is necessary to direct attention to save the aquatic environment from pollution as the process of collecting oil manually is insufficient and slow. In the present study, the drum skimmer is manufactured with a polyester resin surface. This material is characterized by its adhesive effectiveness to liquids and availability. Operational parameters such as viscosity, temperature, and drum rotation speed are investigated using designed and fabricated drum skimmer. The experimental results showed that the fluid viscosity has a high effect on the recovery rate. Also, the recovery rate increases as the drum rotation speed increase. Moreover, the best improvement in the recovery rate is obtained at the maximum temperature.

1. Introduction

In recent years, the world has witnessed leaks of oil, which is a major threat to the aquatic environment and may cause permanent damage. Different types of belt skimmers are used, and their performance is compared. These belts separate the oil from the water, so oils can be reused again [1–4]. To find the best solutions to eliminate oil pollution resulting from spillage of crude oil, shipwreck, and damage to oil pipelines, mechanical disc type oil skimmer designed to separate oil from the water surface. This mechanical equipment can be enhanced by changing the disc materials [5,6]. Broje and Keller [7], presented a study on spill recovery and its relationship of recovery rate to the operational parameter (temperature, oil slick thickness, and drum rotational speed) of oleophilic drum skimmer. By replacing the drum surface with aluminium, polyethene and Neoprene. It was found that the choice of drum surface material can increase the recovery rate by about 20%. In order to enhance the recovery rate to get rid of oil spills, the weir skimmers create a vortex inside the weir, which in turn reduces the oil viscosity and increases the oil slick thickness [8]. It has been observed that improving the surface engineering of the drum skimmer increases the recovery rate three times when examining different types of oils, especially diesel oil [9]. A sorbent material of polyurethane sponges treated with silica solution was prepared to clean up the oil spill. This prepared material has a high absorption capacity since 1g of this substance absorbs 100 g of oil. The developed sorbent great absorption properties compared to the commonly used polypropylene [10]. The main goal of the present study is to provide an effective technique to separate the oil spilled from the water with minimal effort by manufacturing a skimmer made of locally available polyester resin to reduce the cost.

2. Design, materials, and Liquids

2.1. Oil skimmer design and fabrication

For the construction of an economic drum oil skimmer, two major points must be taken into consideration. The first one is the fabrication of the frame and the relevant structure from locally available materials. That will reduce the cost in an effective way especially with low skilled workshop labor that can manufacture the machine effortlessly. Second is the cost of the coated material for drum which is a polyester resin material. Polyester resin is cheap, locally available, and has high water resistance, which is one of the main advantages of this material.

Cylindrical shape of the drum with a diameter of 30 cm and 1 mm plate thickness is made. The total length of the cylinder is 75 mm. The ends of the cylinder are plugged with two plates, and the aluminium shaft was firmly attached in the center of the cylinder figure1(a). The cylinder is completely dyeing with fiberglass and then painted with four layers of polyester resin material figure 1b.

(a) (b)

Figure 1. (a) Manufactured drum, (b) First coating layer with polyester resin on fiberglass and before polishing.

An electric motor which fixed to one end of the cylinder is used to rotate this cylinder. The rotation speed of the motor is controlled by a variac transformer and measured using a TASI digital tachometer TA8141 model with measuring rang of 2.5 rpm - 1000 rpm and ±0.05%+1-digit accuracy.
Spilled oil is carried by rotating the drum skimmer. The oil stuck to the drum surface is removed by a plastic scraper attached to the recovery product collection basin. Similar drum skimmers from equipment companies can be provided for prices above 6000 USD. However, 80% less cost of the locally designed and manufactured drum skimmer with Polyester resin.

2.2. Tested oils
It is necessary to understand the physical processes of the oils associated with the behavior of oil adhesion on the drum surface, which is important in choosing the most effective way to recover the oil. The oil properties and the surrounding conditions determine the behavior of the oil during the test. The great diversity in oils between light oils (low viscosity) and heavy oils (high viscosity) depends to a large extent on the physical properties represented by oils viscosity that has a significant impact on recovery rate time and oil recovery rate. The oil properties change with surrounding conditions such as temperature and do not take a steady trend. Three types of oils were used namely heavy diesel oil (HD), light diesel oil (LD) and crude oil (CO). The oils properties are listed in Table 1. The effect of different properties of these oils on the recovery rate is studied.

Table 1.properties of oils at 36^{o}c.

Oil type	Density (kg/m^3)	Viscosity (mPa.s)
LD	770	74
HD	840	95
CO	854	360

3. Experimental procedure

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The main purpose of the experimental procedures is to test the device operation and obtain experimental values of drum rotation speed, temperature, and oil viscosity, and study the effect of the variables on the oil recovery rate. Test procedures were summarized as follows:

- The drum skimmer was installed at a suitable height from the oil and water mixture sump (test basin). This height is extremely important to ensure the oil slick contact with the drum surface to remove by a plastic scraper attached to the recovery product sump.
- A known amount of test oil was poured over the water surface in the test basin figure 2. The volume of the spilled oil is determined using a graduated cylinder.
- The power supply of the device is an electric motor. It is necessary to control the speed rotation drum. The test has conducted at three speeds (36, 46, and 56 rpm). In one of the tests, this change in speed was studied on the recovery rate, while the speed was fixed for the rest tests.
- Initially, the operational conditions for the initial stage must be adjusted. The initial conditions of each test had be documented, especially the oil temperature.
- After turning the spilled oil into a recovery basin and reaching a stable condition. The oil recovery time was documented at the end of each test. Although the oil volume is constant for all tests, a change in recovery time was observed due to its close relationship with the variety of operational conditions.
- Finally, after collecting the recovery product (oil and water mixture), the water has removed, and the volume of extracted oil has measured. The recovery rate was calculated by dividing the volume of oil to the total process time.

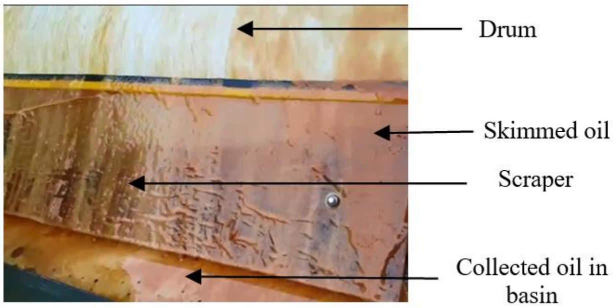

Figure 2. Skimmed oil at medium rotation speed.

4. Results and discussions

The oil recovery rate for all tests has obtained in the same way, which is simply defined as the net oil recovery divided by the recovery time. Figure 3. Represents oil recovery rate with a viscosity at operational conditions of 36ºC and highest drum rotation speed. The results showed that the recovery rate changed significantly with the change of viscosity. The recovery rate increased when viscosity decreased from 360 to 74 mPa.s. The results showed that CO oil had the lowest recovery rate due to its high viscosity which creates a thick layer on the drum surface that is difficult to remove; this requires a longer time to recover spilled oil, which in turn negatively affects the recovery rate. HD oil recovery rate is higher than CO oil and less than LD due to medium viscosity. While the highest recovery rate during the test for LD oil was due to the low viscosity that formed a thin layer on the drum surface within a few times, which increases the recovery rate.

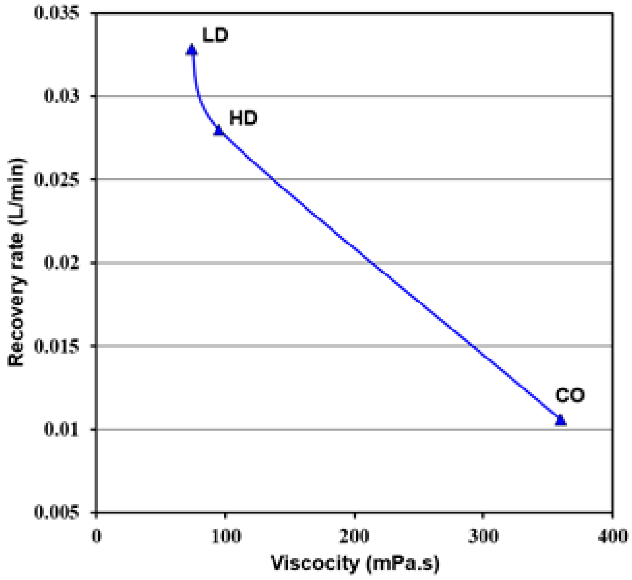

Figure 3. Influence the variation of viscosity on the recovery rate.

As shown in figure 4, the main objective of the test was to study the effect of drum rotation speed on the recovery rate with three oils. The drum rotation speed is (36, 46, and 56 rpm). Figure 4 shows that increasing the rpm could increase the recovery rate, as the largest amount of oil was collected. In most tests, an increased recovery rate was observed as a result of an increased drum rotation speed. The results showed that the recovery rate increased significantly when rotation speed from 36 to 56 rpm due to the reduction in recovery time, which increase the recovery rate. It also turned out that the recovery rate changed significantly with the type of oil. LD oil has the largest recovery rate during the test, because it has less viscosity, as it formed a thin layer on the drum surface that is easy to remove. CO oil is the lowest recovery rate compared to the other oils because it has the highest viscosity which makes the oil very coherent, as it creates a thick layer on the drum surface which requires longer recovery time to remove it compared to the rest oils.

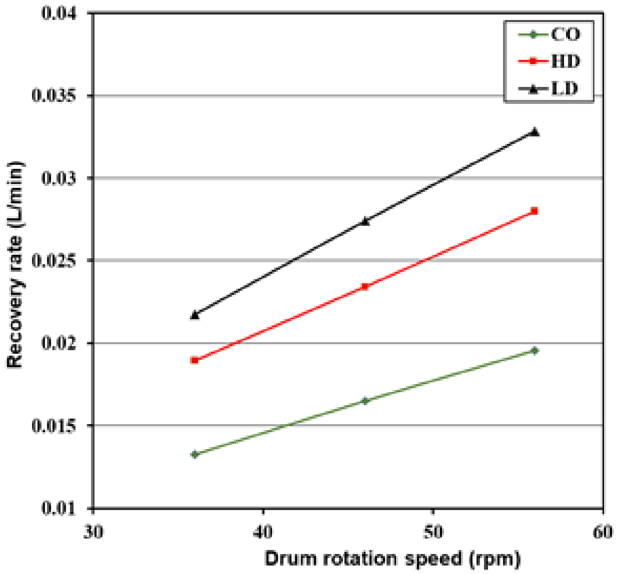

Figure 4. Recovery rate as a function of drum rotation speed.

The impact of temperature on the HD oil recovery rate when the drum rotation speed is established at the maximum is illustrated in figure 5. It observed that the recovery rate increases with increasing temperature due to the decrease in viscosity which brings large amounts of spilled oil to the collection tank during a short period.

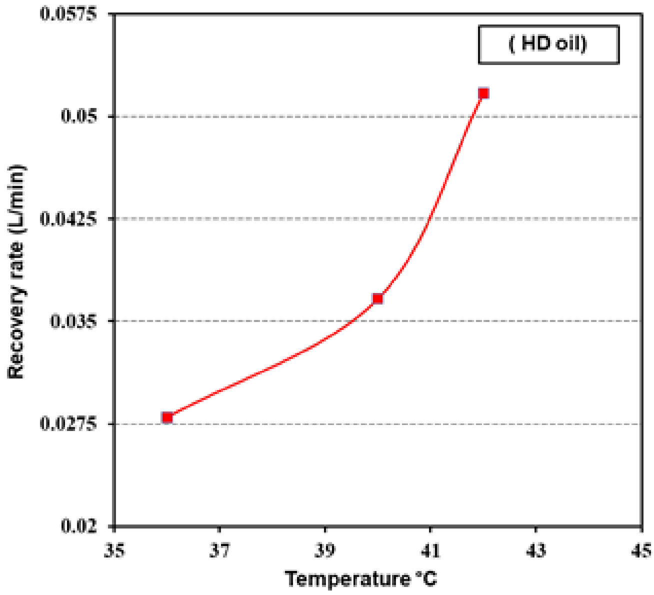

Figure 5. The variation of recovery rate with temperature.

Previous tests showed that viscosity is the most important influence on the performance of the drum skimmer.

5. Conclusions

In this study, the designed and manufactured oil skimmer with Polyester resin drum were utilized to investigate the effect of process parameters on the oil recovery rate. Specifically, the effects of viscosity, temperature and drum rotation have been studied. Based on the finding of the study, three points can be concluded as follows:

- Viscosity can significantly affect the recovery rate, and the LD oil was found the best recovery rate compared to the other oils. The recovery rate increases with decreasing the viscosity.
- The recovery rate is significantly affected by increasing the drum rotation speed, as it is directly proportional to the increase in the drum rotation speed. It is predicted that 56 rpm is the optimum rotation speed.
- The temperature has a significant influence on the performance of the drum skimmer. It was found that the HD recovery rate increased with increasing temperature.

6. References

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