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メタデータ	言語: English 出版者: 公開日: 2017-10-03 キーワード (Ja): キーワード (En): 作成者: Fudo, Masayuki, Mizutani, Masahiro, Ishida, Hajime, Yoshie, Muneo, Tatsuguchi, Masamitsu, Ono, Shirou メールアドレス: 所属:
URL	http://hdl.handle.net/2297/6768

Development of a handy Oil-skimmer

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Abstract **– Recently marine-pollution by high-viscous oil leaked from wrecked ships has been becoming a serious problem in the world. Japan government is renewing old oil recovery vessels with new concept. The oil recovery vessels are available on the open sea, but unworkable in a narrow space. We have developed a handy oil recovery system which is portable and used for supplementing the weak point of the oil recovery vessel. The system consists of a water jet oil-skimmer and a gravity oil/water separator. The oil skimmer has a high-pressure water jet pump inside the suction mouth and a long shaft which is used as a conduit of the recovered fluid as well as a spring-hanging device which enables an operator to easily manipulate it from the deck of the ship. After 3-year research and experiments, we have completed the system of handy oil-skimmer successfully. The system will be soon installed on our oil recovery vessels.**

Ⅰ. Concept of a handy oil-skimmer system

A man-powered oil recovery mission using buckets or ladles is dirty and heavy work. It was reported that it took a day for one volunteer worker to recover about one oil drum of high-viscous oil in "Nahotoka" oil spill accident. Especially when the mission includes lifting the oil from the sea surface to the deck of the ship, the work is so hard beyond description that

the worker can't go on the job more than several minutes. To improve recovery work efficiently, the system should satisfy the following requirements and conditions:

- *Portability*--- The system should be light in weight and easy to handle so as to allow the operator to carry and move it and continue work for a long time.
- *Oil viscosity range*---The system should recover viscosity of spilled oil from low to high.
- *Sea condition*---The system should work well not only on the calm water but also on the rough sea.
- *Recovery rate*---The oil recovery rate is generally an important factor for the oil-skimmers. But for the supplemental use to support the main oil recovery system, the suction rate of $2m^3/hr$ is enough for recovering the small oil patches scattered around the oil recovery vessels that the main oil recovery system can't retrieve.

Fig.1 shows our basic design of handy oil skimmer system based on the above requirements and conditions.

A water jet pump is selected as a best pumping method, since a water jet pump has a very simple mechanism as shown in Fig.2. Due to its simplicity, the system is expected to have lighter weight. The principle of the water jet pump is that vacuum is induced around high velocity water. In Fig.2, high-pressure water is supplied through the pipe for driving water and injected into the pipe for recovered oil/water in a high speed.

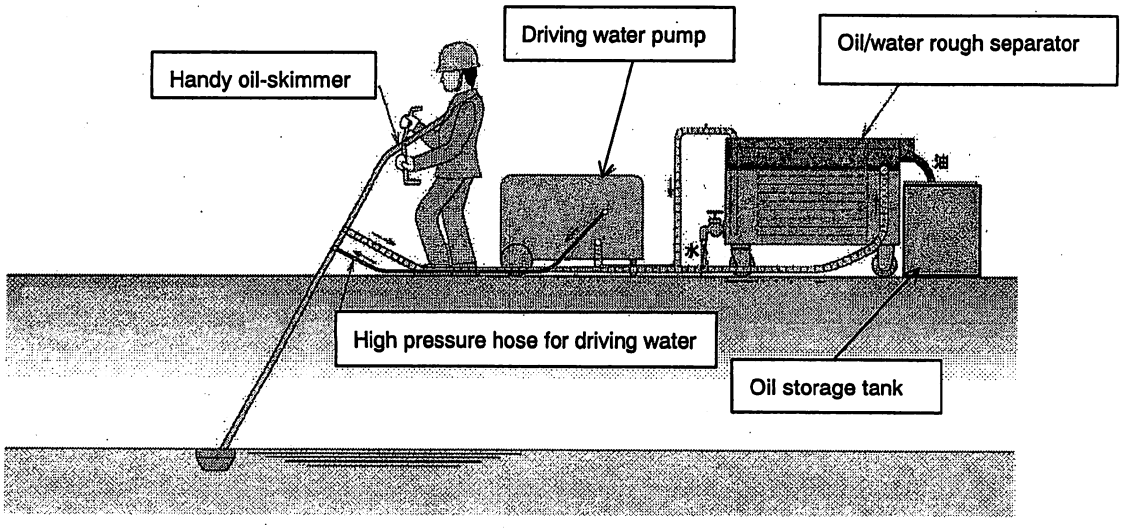

Fig.1 Basic design of handy oil skimmer system

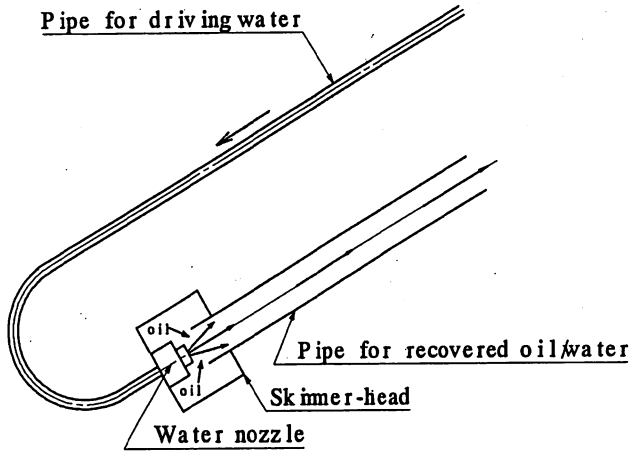

Fig.2 Mechanism of a water jet pump

II. Development and experiments of the system

A. Development of a handy oil-skimmer

(1) Testing-model of a handy oil-skimmer

In the performance test, a test model of a handy oil-skimmer whose total length is about 3.4m was used. Length was determined expecting that the system will be used on a large oil recovery vessel with 1.6m freeboard.

Oil-recovering capacity is not necessary to be so large, so we set a minimum target point at $2m^3$/hr. Maximum pressure of driving water is designed at 4 MPa considering safety for the workers. Pumping rate is about 6000 l/hr of pure water when the pressure of the driving water is at 4 MPa.

To research the shape of the skimmer-head suitable for the system, oil-recovering experiments using three kinds of basic skimmer-heads were carried out. The test models of the handy oil-skimmer were made of aluminum alloy. 3 types of basic skimmer-head are trumpet type(type 1), pan type(type 2) and dustpan type(type 3) having different oil-holding space.

(2) Oil-recovering experiments

Oil-recovering experiments were carried out on a wavy water surface in a test tank using high-viscous emulsified oil which was made of bunker-C oil and water. Viscosity is about 1 $x10^5$ to $10x10^5$ mPa.s. The type 3 recovered oil twice as much as the other types do. The experiments show that the volume of the temporary storage also affects the recovery performance. The oil recovery sequence using the type 3 skimmer-head is basically a repetition of ladling the oil patches and sucking by the jet pump. The jet pump loses the sucking force when it is exposed to the air. The temporary storage should have the volume large enough for the jet pump to keep sucking liquid until the next ladling. On the other hand, excess of the volume of the temporary storage, which retrieves much water besides the oil while ladling, adversely affects the recovery performance. In the experiment with the wave of about 1.0sec in period, the best performance was found at the storage volume normalized by the pumping rate of around 1.0sec, which mostly corresponds to the wave period.

B. Oil/water rough separator

The only one weak point of the water jet pump is that recovered oil contains much water. For ship use, the free water should be separated to save capacity of oil storage tank. A simple gravity type oil/water rough separator was designed to match with the handy oil-skimmer and performance test was carried out. The average of oil separation efficiency is 97.2% for emulsified oil and 85.5% for bunker-C oil. (Separation efficiency : Percentage calculated, comparing oil fraction before separation and oil fraction after separation) Even for high-viscous oil, the separated oil flows out fluently, because high-viscous oil is mixed with water when passing through the water-jet pump. Inside mechanism of the oil/water rough separator is shown in Fig.3.

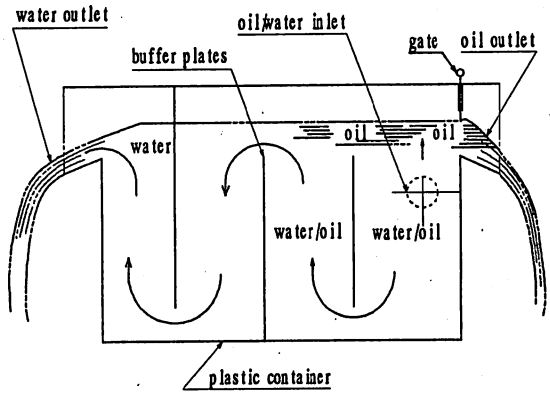

Fig.3 Cross-section of the oil/water separator

C. Skimmer-supporting apparatus

Weight of the skimmer-head at the end of the shaft directly affects how easily the operator can manipulate the system. The operator has to support the cantilever at the other end. Even though the mass of the skimmer-head itself is small, it generates very large torque at the operator's end. The handy oil-skimmer were made of aluminum alloy. The weight of the handy oil-skimmer was slimmed finally to 5 kg, but it was still heavy for a person to handle it for a long time without any supporting device. Three types of supporting apparatus were prepared and tested. "Roller type" is a handling method of putting the pipe of oil skimmer on a roller fixed on the deck floor and manipulating oil skimmer. "Shoulder belt type" is a handling method of hanging oil skimmer on the shoulder using belt. "Hanging type" is a handling method of hanging oil skimmer from the davit on the deck floor using spring balancer. "Roller type" was not usable unless height of the roller can be easily adjusted to match operator's height. "Shoulder belt type" was not suitable, because distance between center of gravity and position of operator's shoulder causes torque force on the hands. But this type is seems to be helpful for using on a flat place like beach. "Hanging type", which consists of a davit and a spring-balancer, was most usable to be used on ship's deck.

D. Transfer of recovered oil through pipe

High-viscous oil recovered with a handy oil-skimmer should be transferred to a storage tank through pipe. After the series of experiments, it proved that driving-water spouted from water jet pump breaks a mass of high-viscous oil to small particles, and disperses them in the water flow resulting in drastic decrease of the friction loss in the pipe.

Ⅲ. Concluding remarks

In this study, a handy oil-skimmer to supplement large oil recovery vessels has been experimentally investigated. The followings are the main conclusions.

i) A water jet pump has good performance for recovering high-viscous oil.

ii) Recovering capacity of a handy oil-skimmer is over 4 m^3/hr with 4MPa driving water pressure.

iii) This handy oil-skimmer shall recover one drum of net oil of which viscosity is 230,000 mPa.s easily and much faster (less than 16 minutes).

iv) Friction factor in the pipe does not matter since the water content lubricates the flow inside the pipe.

v) A simple gravity type oil/water rough separator is very useful to separate oil from oil/water mixture.

vi) A method of hanging the oil-skimmer by a davit with a spring-balancer is very effective.

After 3 years investigation, development of a handy oil-skimmer system was successfully completed. We are convinced that the system will contribute to environmental problem. The developed handy oil-skimmer system (Fig.4) will be soon applied to five governmental ships.

Fig.4 Developed handy oil skimmer system

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2. Author's Photo

3. Author's Biography

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