Bilge Oil-Water Separator

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Abstract

This paper provides a way to extricate water from its immiscible mixture with oil which is present at the bilge, the lower compartment of a ship while retaining oil and directing it to a waste-oil tank for purification and hence reuse. In this project, we propose to separate oil and water by electronic means, by use of a microcontroller that is interfaced with an oil sensor and relays. The water obtained after separation will be free of oil and other pollutants and can be pumped out into the sea without causing any harm to the marine ecosystems. The advantages that the proposed method offers over traditional ones along with an overview of the systems currently being used for this task along are also enlisted.

This project will be in conformation with International Standards such as MARPOL (Marine Pollution) and MEPC (Marine Environment Protection Committee) which forbid the ships from directly pumping out the water (containing oil) from the bilge of the ship because of its insalubrious effects on the marine life of the ocean.

Keywords-*Bilge, Electronic method, Marine ecosystems, Oil-sensors, Oil-water separators*

1. Introduction

An oily water separator (OWS) is a piece of shipboard equipment that allows a vessel's crew to separate oil from bilge water before the bilge water is discharged overboard.

Bilge water is an almost unavoidable product in ship operations. Bilge water that is generated in proximity to shipboard equipment (such as in the engine room) often contains oil and its direct discharge would result in undesirable transfer of waste oil to the marine environment. By international agreement under the MARPOL convention, vessels need to be fitted with an oily water separator to remove oil contaminants before bilge water is pumped overboard [1],[2],[3].

Oily water can be found onboard every vessel. It is drained to the bilge tank and has to be treated in an oily water separator before it can be discharged into the sea. If not, the oily water pollutes the marine environment.

For the shipping industry, the biggest challenge with bilge water arises from malfunctioning water separators. These are used to separate oil from water before the cleaned water can be discharged. Bilge water that has not been going through an oily water separator is a bad pollutant to the marine environment and may therefore never be discharged overboard[4]. When cleaning the engine room, oily water is produced. Oily water is also generated from separators and condensate from A/C units. Depending on the design and function of the ship, bilge water may also contain traces of detergents, solvents, chemicals and particles. Oil in water occurs typically in marine bilge systems and waste water from industrial processes. The discharge of oil in water is generally undesirable because it harms the environment, so regulations on contamination levels are increasingly strict [5]. In many industrial processes, detergents and high-pressure washing causes oil to mix with water. In marine bilge systems, oil is mixed with water and other materials in the bilge water tank. In the light of such occurrences, International Maritime Organization has made it mandatory for vessels to reduce the amount of oil in the bilge water of the ship to less than 15ppm, before releasing the latter into the ocean[6],[7],[8].

As an extension to the application of this project, we have also introduced a temperature sensor which can be very useful in certain temperature critical operations, where if the temperature exceeds a particular value, the liquid must be drained out immediately. A computer interface is also implemented which can be used to design applications and keep track of the status of the entire system without any manual interference.

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2. Systems presently used

2.1. Gravity Separator

Gravity separators are the most commonly used OWS. They operate on the simple principle that if a mixture of oil and water is allowed to settle down in a large tank, oil being lower in density than water automatically rises upward and forms a thick layer above the water surface. The surfaced can be skimmed off and the separated water is pumped overboard. The model of a basic gravity separator is shown in the figure below.

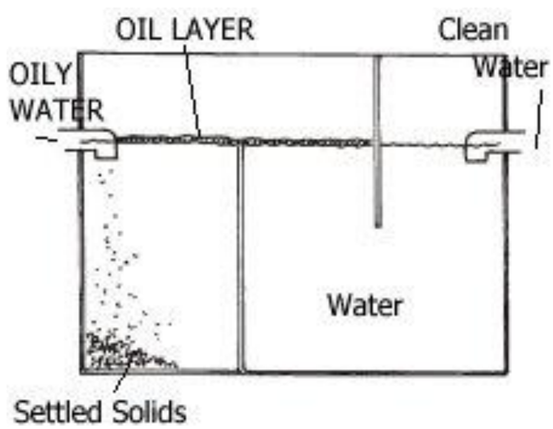

Figure 1. Basic Gravity Separator

This technique is the simplest of all the oil-water separator methods. However, it has some major drawbacks. The first disadvantage is that the degree of separation offered by this method is very low, rarely less than 15p.p.m, which is not acceptable since it is hazardous for marine ecosystems [9].Further, these separators require huge tanks which make the system bulky and intractable.

2.2. The API Separator

The API separator designed by the American Petroleum Institute as the name suggests, is a gravity separation device designed by using Stokes law to define the rise velocity of oil droplets based on their density and size. The design of the separator is based on the specific gravity difference between the oil and the wastewater because that difference is much smaller than the specific gravity difference between the suspended solids and water. Based on that design criterion, most of the suspended solids will settle to the bottom of the separator as a sediment layer, the oil will rise to top of the separator, and the wastewater will be the middle layer between the oil on top and the solids on the bottom. Typically, the oil layer is skimmed off and subsequently re-processed or disposed of, and the bottom sediment layer is removed by a chain and flight scraper (or similar device) and a sludge pump. The water layer is sent to further treatment consisting usually of a dissolved air flotation (DAF) unit for further removal of any residual oil and then to some type of biological treatment unit for removal of undesirable dissolved chemical compounds.

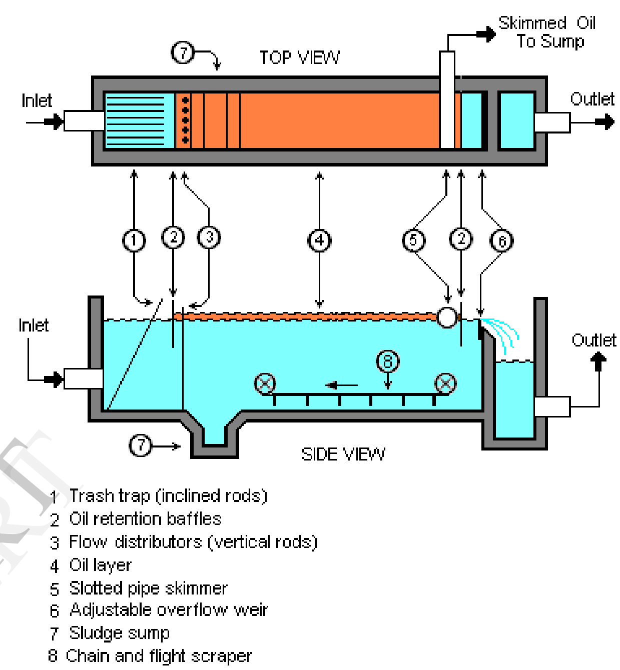

Figure 2. The API separator

This method offers a higher degree of separation as compared to the gravity separators. But it also requires a large area and bulky equipments which need constant maintenance. Sometimes, wind and rain can disrupt the liquid surface, which induces turbulence and interferes with oil skimming. This can be prevented by constructing a roof over the basin, but this is costly. Further disadvantages are that the API separators generally emit an unpleasant odor and the separated oil may require further separation.

2.3. Parallel Plate Separator

Parallel plate separators are similar to API separators but they include tilted parallel plate assemblies (also known as parallel packs). The

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underside of each parallel plate provides more surface for suspended oil droplets to coalesce into larger globules. Any sediment slides down the topside of each parallel plate. Such separators still depend upon the specific gravity between the suspended oil and the water. However, the parallel plates enhance the degree of oil-water separation. The result is that a parallel plate separator requires significantly less space than a conventional API separator to achieve the same degree of separation.

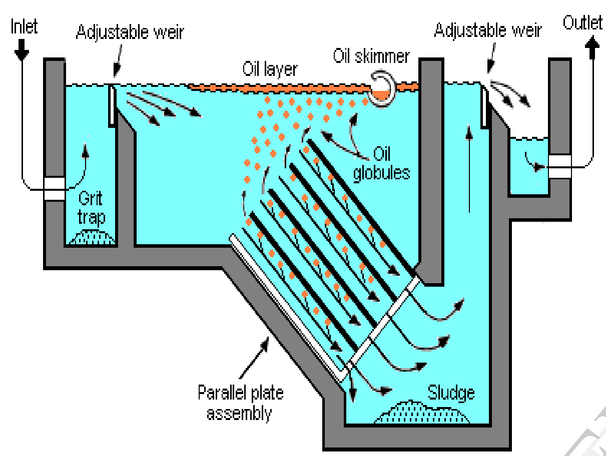

Figure 3. Parallel plate separator

Parallel plate separators however have a major drawback. The oil particles which get accumulated in between the parallel plates degrade the quality of the entire system every tie separation is performed. Hence, the system requires constant cleanup and maintenance. Furthermore, even though the space required is relatively small, it is still considerably large.

2.4. Centrifugal Separators

A centrifugal water-oil separator is a device designed to separate oil and water by centrifugation. It generally contains a cylindrical container that rotates inside a larger stationary container. The denser liquid, usually water, accumulates at the periphery of the rotating container and is collected from the side of the device, whereas the less dense liquid, usually oil, accumulates at the rotation axis and is collected from the centre. Centrifugal oil-water separators are used for waste water processing and for cleanup of oil spills on sea or on lakes.

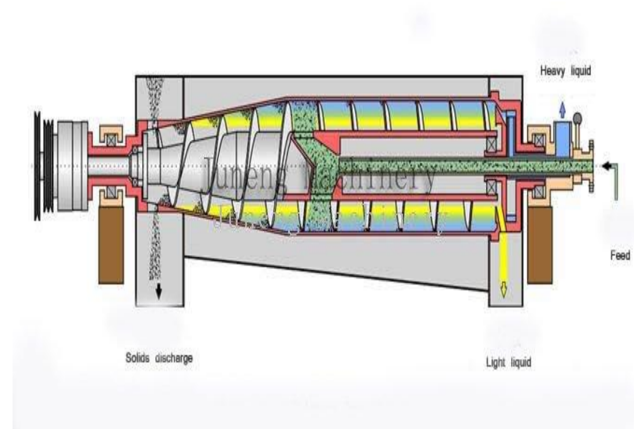

Figure 4. Longitudinal section of a Centrifugal separator

Apart from the obvious disadvantage that these separators are bulky and require a huge area, there is an added problem in the functioning of centrifugal separators that their design works efficiently only when the influent oil/water ratio is under the 25% range. At a 25% oil/water ratio, the central core of oil in the separator occupies half the overall radius. When the influent oil/water ratio rises to 50% the central core of oil will move to occupy approximately 70% of the radius. In one test of the unit where the oil content of the influent was 76%, the water in the effluent oil went up to an unacceptable level of 86% [9], [10].

3. Proposed method

This project proposes to use an electronic method for the separation of oil and water. This is done by using an oil sensor interfaced to AT89s52 family microcontroller. Since the basic task of this Bilge Oil and Water Separator, as suggested by the name, is to enable separation of oil and water, we need to develop a sensor in this regard. The oil sensor for this project has been designed on the principle of the difference in the amount of light allowed by water to pass through it and the amount of light allowed by oil to pass through it. The sensor has been developed using a light detecting resistor as its main component in combination with IC LM324 which is a quad operational amplifier. As crude oil is black in color, the passage of light through it becomes difficult. This property of oily water is tapped and the oil sensor is designed based on the same. A small flash light has been used as light source for demonstration purposes. When a transparent pipe with a transparent liquid like water

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placed in it, is kept over the sensor and light was passed through it, the resistance of the sensor decreased and the voltage obtained across it had a value in the range of 20-24 mV. When bilge oil, which is normally very dark in color, is placed in the transparent container and light was passed through it, the resistance of the sensor increased and the voltage obtained across it had a value in the range of 500-660mV. The obtained results clearly show that the designed oil sensor is efficiently able to discriminate the passage of oil from that of water. This oil sensor is interfaced with an ADC (0808/09) which is connected to the microcontroller. The readings from the sensor are monitored and the separation takes place by directing oil through one pipe and pure water through the other. A wireless system has also been developed using TX/RX 433 pair which conveys the current status of the system from the bilge to the coastguard's cabin. The following figures 5) and 6) show the working of the transmitter and receiver section respectively.

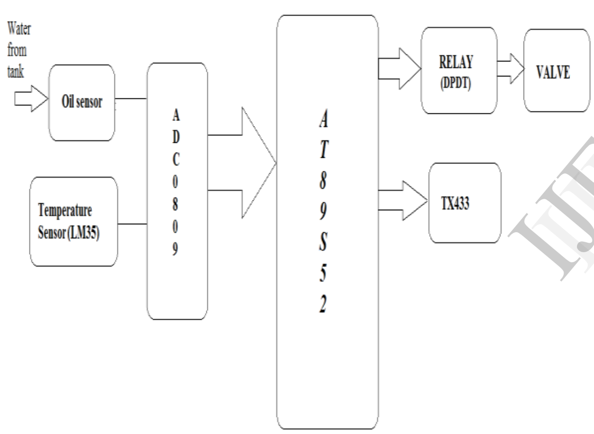

Figure 5. Transmitter section

All the four ports of AT89S52 are used on the transmitter side. Port 0 is used for address lines of ADC 0808/09. Port1 is used for data lines of the ADC, whereas ports 3 and 4 are used reserved for the relay/valve and wireless transmitter tx433 respectively. The functions in the microcontroller are defined such that when the ADC gives a value to AT89S52 which is lower than 100 units (which is taken as the threshold value for water passage), the microcontroller executes the instruction which makes the pin RL2 go high. This pin is connected to the valve which is connected to the outlet pipe. This valve is then opened and the water is extricated thereafter. Since water has to be thrown overboard, this valve is left open at the other end, indicating that the water is now free from the bilge.

Following this process when the entire water in the bilge is drained out, the oil is retained in the bilge. As this oil passes through the pipe, the sensor output increases sharply. This indicates to the microcontroller that oil is now passing through the pipe. This oil is used oil and hence it is directed through the valve to the waste oil tank.

Also, connected to the other channel of the ADC is the temperature sensor LM35. This has been connected to increase the scope of the project, as already mentioned. It may so happen that at certain times, the temperature of the oil or the water may increase to an extent that may cause corrosion of the parts of the ship. Under such circumstances, even if the amount of oil/water in the bilge is under permissible levels, the liquid will have to be drained out to avoid damage of the ship parts.

The microcontroller operates in a similar fashion as with the oil sensor. Again, in the polling mode, the microcontroller waits for data to arrive at the channel number 1 of the ADC 0808[11]. As soon as data arrives, the microcontroller checks the temperature reading as detected by LM35. If this reading is beyond 45 degree Celsius, RL1 is turned high and hence the valve is opened [12],[13]. The liquid at a temperature higher than this is drained out. If the temperature is below this mark, then the liquid inside the bilge is considered to be safe and hence is not drained out of it. 45 degree Celsius has been chosen as a temperature only for the purpose of the demonstration and can be changed as per the industrial application of the system. As the process goes on, the transmitter TX433 connected to the microcontroller takes data from it and transmits this data in the form of radio frequency signals to the receiver RX433. The receiver section is comparatively simpler. Following figure illustrates the working of the receiver side.

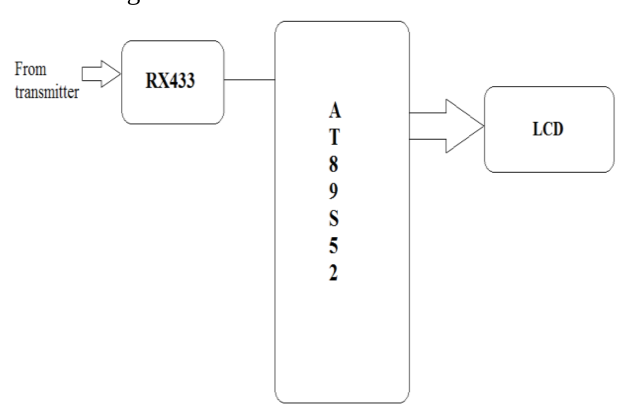

Figure 6. Receiver section

The receiver side however, is less complicated and the only concern on receiver side will be to display the transmitted information correctly so that the coastguard who is on duty may take the necessary actions according to the readings displayed on the LCD that is constantly monitoring the output of the

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oil sensor placed near the bilge. The Rx433 receiver is connected to another AT89S52 which relays the data to the LCD connected to it. The modulation technique used for this wireless transmission of information from the transmitter to receiver is AM (Amplitude Modulation). The reason behind choosing this modulation technique is that the basic purpose of this is to maintain a display so that anyone observing the operations knows the readings of the temperature. This too can be customized as per the required purpose. In addition to this, a computer interface of the system has also been implemented which can be used to design applications which will monitor the performance of the system digitally.

4. Functional flowchart for the sensors

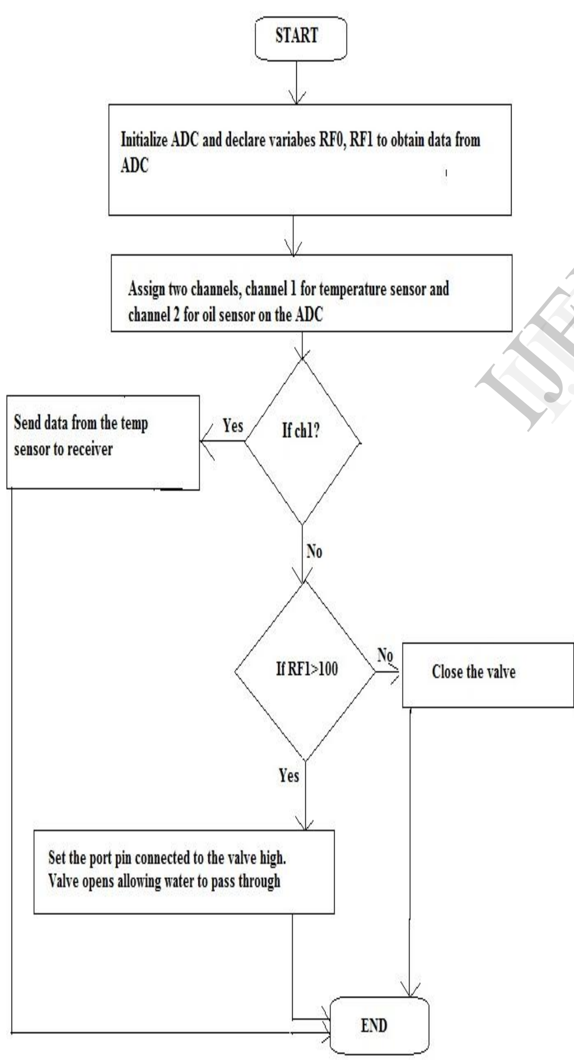

Figure 7. Flowchart for the sensors

In the above flowchart, the value of ch1 i.e variable RF0 is the lower threshold value of the temperature of the liquid passing through the pipe and can be selected according to the system's demands.

5. Results and scope for future work

5.1. Results

5.1.1. Oil sensor testing result.

In water- 20-24mV. That is, when the water was passed through the oil sensor the output voltage was very less, in few mV.

In Oil- 500-660mV. That is, when oil was passed through the sensor, the output voltage increased to hundreds of mV. So when water passes through the sensor then the output voltage is low whereas when oil passes the output voltage is high, thus a threshold value was set to separate the oil from water.

5.1.2. Temperature sensor result. When the temperature sensor senses the temperature then it will display the reading on the output LCD screen at the receiver end.

5.1.3. Transmitter and Receiver. The transmitter effectively transmits the sensor output to the receiver which in turn displays all the results on the LCD screen. The coast guard can continuously monitor the operations at his control room without wasting his time to go and inspect the actual site.

5.1.4. Output accuracy. Be it dim light or full illumination, the sensor works accurately in all conditions and thus provides good separation between the oil and water. The water separated from the mixture is tested and the oil contents are found to be less than 15ppm, which is absolutely harmless for the marine ecosystems. The oil can be safely reused for lubrication purpose in the engine. Thus, the system provides an accurate and efficient way of separating oil and water and the by-products can be reused without causing any adverse effects on the system or the environment.

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5.2. Advantages of the current system over existing systems

1. No need of any bulky equipment.
2. It is easy to design and manufacture as all the components are easily available.
3. It is portable and hence can be placed anywhere.
4. The use of a micro-controller increases its scope of applications and modifications.
5. It has low cost of manufacturing
6. The microcontroller can be reprogrammed if any modification is required.

7. Wireless transmission eliminates the need of manual interference.

5.3. Scope for future work

An application based on the readings of the separator can be designed in future. This application will be designed such that the coastguard can monitor the current status of the entire system from his cabin and if necessary, can take corresponding actions if anything goes wrong. This application will make it possible for the coastguard to handle the entire system from one place. Also, a leakage alert function can be implemented based on the same principle as that of the oil sensor. In case of any oil leakage, arrangements can be made in order to check the same.

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6. References

[1] Fact sheet: The Oil/Water Separator Published by the King County Industrial Waste Program retrieved from

http://www.kingcounty.gov/environment/wastewater/~/media/environment/wastewater/industrialwasteprogram/docs/dischlimits/fog/ow_fact.ashx

[2] Donald F. Boesch, Carl H. Hershner, Jerome H. Milgram "*Oil spills and the marine environment*", Ford Foundation, Energy Policy Project

[3] A document on Oil-Water separator policies and standards retrieved from http://charmeck.org/city/charlotte/Utilities/GreaseFree/Documents/Oil%20water%20separator%20Policy.pdf

[4] International Conventions for the Prevention of Pollution from Ships (MARPOL)Retrieved from http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx

[5] International Maritime Organization, A book on Oily-water separators and monitoring equipment

[6] *Separator Design Methodologies* retrieved from http://www.mfe.govt.nz/publications/hazardous/water-discharges-guidelines-dec98/app-5-separator-design-dec98.pdf

[7] Procedure for the Design and Sizing of an Oil/Water Separator Retrieved from http://www.oil-water-separator.hydroflotech.com/Engineering%20Data/Oil%20Water%20Separator%20design%20parameters.htm

[8] Douglas Cormack , *Response to Marine Oil Pollution - Review and Assessment*

[9] Knut Gaaseidnes and Joseph Turbeville, MiljoLab AS, Innherredsveien 10, N-7014 Trondheim, Norway , *IUPAC* ,"**Separation of oil and water in oil spill recovery operations**"

[10] Meikrantz D, CINC, Newbury Park, CA, USA Schardin, C. , Macaluso, L. Federici, A., Sams,H.W.III, *IEEE* ,**High volume centrifugal oil-water separation**,OCEANS '95. MTS/IEEE. Challenges of Our Changing Global Environment. Conference Proceedings

[11] Jivan s. Pranab, Vinod G.Shelake, Rajanish K. Kamat and Gourish M.Naik, *exploring c for microcontrollers*

[12] Sawhney A.K., *A Course in Electrical & Electronic Measurements & Instrumentation* (Dhanpatrai and Sons, 2001)

[13] Nagrath & Gopal ,*A Textbook of Control Systems Engineering* (New age International publications)

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