The Advantages, Challenges and Solutions in Using Contact Sensors for Off-Shore Oil Spill Detection and Layer Build-up Monitoring

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Abstract
Contact sensors utilizing high frequency energy absorption technology have been successfully deployed off-shore for detecting the presence and measuring the thickness of oil spill layers near oil loading jetties, monobuoy terminals, intake heads of desalination plants, water discharge outlets of various industries such as petroleum, power and process, and also in rivers and lakes.

The objectives of this paper:

- List the advantages of using the high frequency energy absorption technology.
- Describe the technology and how it is implemented.
- Describe the challenges in oil spill detection in sea conditions.
- Describe the various solutions used to answer the challenges.

Results:

- Tests in seas with extreme conditions show that the implemented solutions give satisfactory results.

Major conclusions:

- Reliable off-shore detection and thickness monitoring of oil spills using contact sensors with high frequency energy absorption technology is possible and has many advantages.

The Advantages in using contact sensors utilizing high frequency energy absorption technology

- Online continuous detection near the source of the oil spill, provides early warning in order to activate automatic shutdown of the process responsible for the spill or initiating protection of a process that might be damaged by the spill.
- Online oil layer build-up monitoring provides an important tool for assessing the severity of the detected oil spill and deciding on the urgency and response method to be used.
- Ability to follow tidal water level changes and continue detection on waves up to, 6 feet, the height at which oil tankers have to stop oil loading at many off-shore terminals.
- Ability to operate day and night and in all weather and ambient conditions including different light conditions, heavy mist or rain.
- Ability to operate in a wide range of water salinity.
- Ability to zero out an existing oil layer and continue monitoring from a new base line. This eliminates the need to clean the sensor after the oil spill has been removed.

Principle of operation - High frequency energy absorption technology -
The sensing device that comes in contact with seawater includes a high frequency transmitter and two antennas. One antenna is located at the water/air interface and the second one is underwater. A high frequency signal is transmitted through the water between the antennas. The higher energy absorption of the water results in more loading on the transmitter and a higher output signal. An oil layer on the water reduces this loading and the output signal drops down since water absorbs more energy than hydrocarbons or air. When the upper antenna is surrounded by an oil layer or an oil/water mixture, the loading is reduced in proportion to the reduction in water content. This unique patented technique enables the detection of small layers of oil. Furthermore, it enables continuous monitoring of an oil buildup and the measurement of its thickness, up to 20mm.

The high frequency energy absorption technology enables a very sensitive response for thin oil layers (down to 0.3mm), and continuous measurement as the oil layer increases up to 20mm. The graph below demonstrates this.

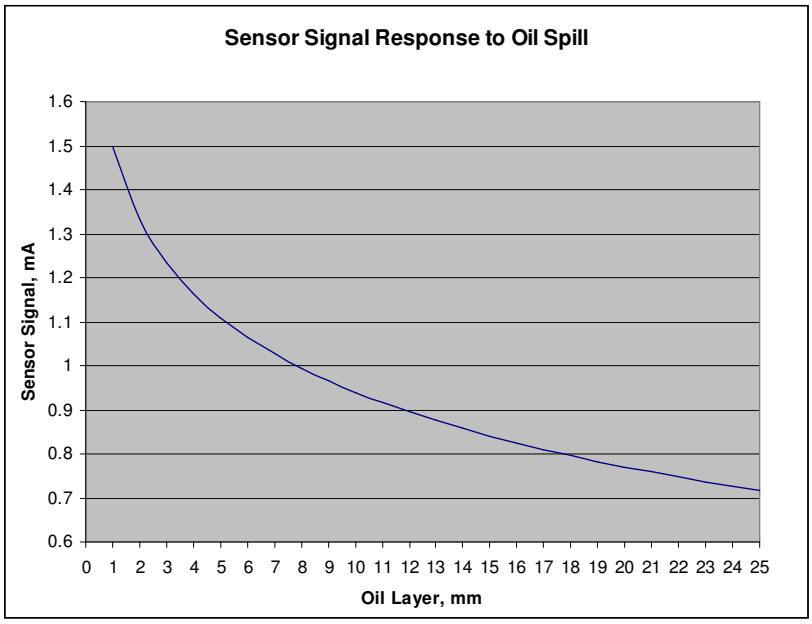

Figure 1 A Graph of Sensor Signal vs. Oil Layer

Implementation of contact sensors utilizing high frequency energy absorption technology for off-shore oil spill detection
The high frequency energy absorption technology is implemented inside a robust sealed sensor that comes in contact with seawater. Since the upper antenna must always be positioned at the water surface, the sensor is installed in the center of a special wave rider buoy that keeps its' position on the water surface, allowing the sensor to follow the waves and tidal changes.

The wave rider is equipped with an autonomous solar power supply, signal processor and a wireless data/alarm transmitter for reporting.

The sensor with its wave rider buoy has to be secured in the monitored area; therefore an appropriate mooring system has to be implemented. The mooring system design is dependent on the application and site conditions; however a common mooring frame may be used for many different sites and applications.

Since the sensor can detect oil spills that come in contact with it, and since the monitored area may be larger than just a water discharge outlet, an array of such sensors may be required to adequately cover the monitored area and keep risk management under control.

Challenges in off-shore deployment

1. Sensors may eventually become coated with seaweed, barnacles and biofilm, with maintenance frequency depending on site conditions. A thick layer of barnacles might affect the floatation of the wave rider buoy, while a significant layer of biofilm could decrease oil detection sensitivity of the sensor.
2. Proper mooring is essential for good performance since the upper antenna must always be positioned at the air/water interface. The mooring system should be able to allow free floatation of the wave rider buoy without submerging the sensor, regardless of tidal changes and waves. As a by-product, the mooring frame should protect the wave rider buoy from collision with boats. It should survive extreme sea conditions.
3. Off-shore monitoring is often located remote from any infrastructure to provide it with power supply and data connectivity, and thus independent power supply and wireless data communication is required.

The Solutions

1. The wave rider buoy is painted with an anti-fouling coating to prevent against the accumulation of barnacles. An innovative AutoCleaner electro-mechanical device has been developed to address sensor coating by biofilm – it automatically wipes the sensitive area of the sensor a few times per day to keep it clean. Both solutions have be successfully in use for more than six months in an installation at a tough off-shore site in the Indian Ocean, with hot weather and a lot of marine growth. The sensor performed ell as verified by field tests, and it detected oil without false alarms or manual maintenance. After the test oil was removed (no direct sensor cleaning was used), the sensor again reported a clean water status.

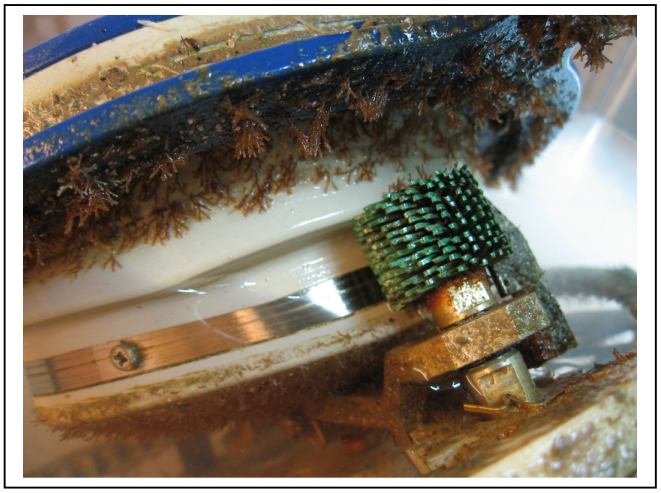

Figure 2 AutoCleaner Device Installed on a Sensor

2. A special type of mooring frame has been designed to enable a wide variety of mooring methods while isolating the wave rider buoy from the coarse forces imposed by underwater sinkers or mooring buoys. Such a mooring frame has been successfully implemented, and survived sea storms in installations at several customer sites in the Indian Ocean.

Figure 3 A Wave Rider Buoy Inside a Mooring Frame

3. The wave rider is equipped with a solar panel, a rechargeable battery and a reliable charging controller for powering the equipment on the wave rider buoy autonomously. A low power consumption design was implemented to allow long term system operation. A digital controller centralizes the operation of the sensor, remote communication and AutoCleaner operation and initiates reports and alarm messaging. The data may be conveyed by a point-to-point wireless system, by a GSM cellular network, or satellite. With a GSM modem, reports and alarms are sent directly to cellular phones of managers, operators, and environmental teams, as well as to a receiver located in the control center to initialize the appropriate response. Relay activation at the receiver is possible for direct shutdown of a spilling process.

Conclusions

High frequency energy absorption technology in contact sensors has proven to be a superior technology over the years in on-shore applications. After the above noted adaptations and improvements, it is now a mature and reliable technology for off-shore applications as well.