OIL SPILL DETECTION ON DESALINATION SECTOR

DUBAI – UAE

A. Abstract

Oil spill has been a major problem to today's world, as it is one form of water pollution, where it is defined as the spillage of oils such as petroleum in the marine environment done by human activities. Oil spill can be caused by leakage from crude oil in tanks and pipelines, railcars, offshore platforms, and wells [1]. This has affected many desalination plants which generate freshwater to be closed down. The UAE government is implementing a National oil spill contingency plan with procedures to help prevent oil spills, before conducting the cleaning process [4]. With the benefits of Pyxis, the oil spill can be detected via thermal infrared imagery and by polarimetric imagery resulting in a clear imagery of oil spill as compared with traditional infrared and radar technologies. This advanced technology is based on advanced thermal cameras providing enhanced contrast details that clearly differentiate between oil spills and water [2]. Pyxis can be used at any time of the day, even in cloudy weather, or at night. Although radar scanners can detect oil spills, on a wavy water surface radars may detect oil spill look-alikes, such as algae, which may provide false alarms [3]. With Pyxis, the advancements of technologies are capable to identify the difference between oil spills and look-alikes.

1. Introduction

In recent years, oil spill has become one of the major environmental problem to desalination sectors. It occurs when oil, including petroleum and hydrocarbon, contaminates the seawater and pollutes the marine environment. Usually, oil has become one of the main energy sources worldwide, as it is transported from one place to another via ships across the sea, or by pipelines by land [5][6]. The density of oil is less than that of water, as most types of oil floats on the surface of the water. Some types of oil have a higher viscosity that sinks in lakes and rivers [7].

There are many causes of oil spilling. Most often, oil spills occur due to human accidents, but can also happen due to fatigue loading where cracks begin to initiate in the aged pipelines as oil begins to leak [8]. This has affected many desalination plants, where they are used to help sustain the environment by providing fresh water to humans, especially poor people. Desalination is a process of extracting salt, other minerals and some debris from water. With oil being present in lakes or in the sea, the process of desalination would be challenging. Since most types of oils do not get mixed with water, thanks to their lower density, they typically cannot be extracted via the desalination process. Desalinated water containing oil would also affect the marine ecosystem, as well as human and animal ecosystems, as it eventually may lead to water scarcity [9].

Despite oil is risky in many complex societies, there are many solutions of cleaning oil spills to prevent water pollution. Using oil booms, skimmers, and sorbents is one of the most common methods of cleaning up oil spills [10]. Of course, prior to performing the cleaning up process, oils needed to be detected. With these oil spills clean-up solutions, several technologies can detect oil spills on the water surface or at a depth. Two common examples of oil spill detection solutions include the usage of thermal infrared sensors and radar sensors. Both technologies play an important role in desalination sector, as they are designed to locate the leakage, making it less complicated to clean up the oil spill. Each method has its own benefits and drawbacks, besides both technologies provide benefits in controlling oil spillage in different ways, with respect to desalination facilities.

2. Factors of oil spill detection

Since the introduction of the first desalination plant back in the 1960s [9], the desalination process has become one of the main sources of fresh water. The desalination process has played an important role for water distribution over the past decades; however, they usually consume a lot of energy [11], and with oil being present, it would heavily affect the performance of desalination plants. Due to the harmful effects of the oil spill pollution in the marine environment, the oil spill detection is crucial, especially when locating the polluted areas, and to monitor the oil spillage, predicting whether or not it will pass through the desalination plants [12]. For instance, satellite-based remote sensing oil spill detection systems are used to indicate precautions and to identify the start point of oil spill that caused the pollution. This system is beneficial for detecting oil spills remotely using radar sensors, as it can protect the desalination plants from possible further oil spill and help control the oil spill hazard through the marine environment. Remote sensing is typically used to determine any unwanted leaks of discharges from ships or oil vessels. Remote sensing helps reduce the mortality rate of seabirds due to oil spillage [13]. Each system is required given with respect to its function, depending on the oil spill intensity.

Other oil spill detection methods based on remote sensing include the usage of infrared sensors to detect oil spills that emit infrared radiation [13].

Figure 1: Aerial View of Deepwater Horizon Oil Spill Being Detected [13]

3. Oil Spill Detection Technologies

3.1 Common Detection Methods

Typically, the most common types of sensing technologies used for oil spill detection are the radar sensing data, and the infrared sensors, both of which come under the technology of remote sensing system, as they are useful to prevent any further oil spill from passing through the desalination facilities.

These systems have been widely used to monitor and detect oil spills over the past decades, as they are available in many different configurations. Optical imaging technology uses infrared sensors to indicate an oil spill. They provide valuable information, allowing the differentiating between the oil spills and water surface features such as algae blooms. This technology can also identify oil spills at fine levels, which also provides a rough estimation on the oil spill thickness. Typical thermal sensors are used with wavelength ranging between 8 and 14 μm, ideal for detecting oil spill and estimating oil spill surface thickness [14].

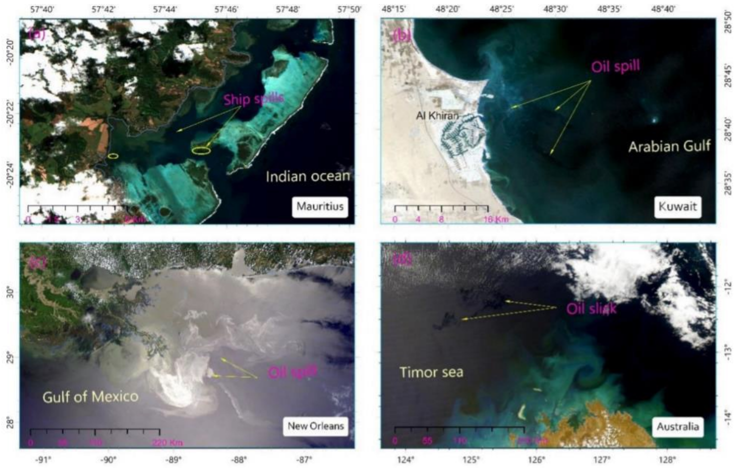

Figure 2: Oil Spill as indicated by Optical Images [14]

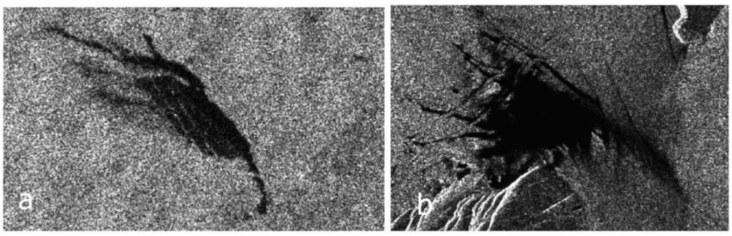

Figure 3: Confirmed Oil Spill detected by SAR image (a), and Oil Spill Lookalike captured in (b) [15]

Despite the advantages that optical images provide for oil spill detection, there are some limitations, especially to infrared sensors. Optical imaging work best on a typical daylight and clear sky conditions, providing best imaging results, especially when near desalination facilities. At night, and during bad weather conditions, the optical imaging sensing would not be able to detect spillage properly due to the lack of sunlight. Hence, this has made optical imaging less widely used in oil spill studies [14].

The second type of remote sensing involves radar-based technologies. Unlike the infrared sensing technologies, radar-based technology can work in any weather conditions, even at night [18]. However, radar-based indication systems can only detect oil spillage when wind speed ranges from 2 m/s to 10 m/s [3][15], or when waves are present. Two examples of radar-based type are known as the synthetic aperture radar (SAR) and the side looking airborne radar (SLAR) [13][14].

Both SAR and SLAR technologies use microwave sensors to detect any sign of oil spill during daytime by capturing two-dimensional images [15]. The difference between these two technologies is that SAR is satellite-based remote sensing data, which uses extensive electronic imaging to generate high-resolution images, whereas SLAR is an airborne-based technology system that uses a horizontal antenna to capture images along the flight path. Unlike SAR, SLAR cannot generate the highest resolution images, as it may have a shorter capture range. Therefore, SLAR is a better option for using in airborne oil spill detection system. On the other hand, SAR is extensively used for oil spill detection since it is independent from sunlight and is beneficial for all radar satellites, since they capture oil spills and oil spill lookalikes.

Oil spill lookalikes have a structure similar to actual oil spills. In both SAR and SLAR cases, the look-alike can be mistaken from the actual oil spill due to similar dark patches like crude oil, and similar shape. In addition, most radar-based technologies, including SAR and SLAR, may tend to struggle in capturing fresh oil spills that have a bright structure which is difficult to capture on radar systems, unlike older oil spills which have a darker patch color visible in the image [15]. The fresh oil spills may take long to be detected and eventually when taken on radar imaging, the fresh oil spills are barely visible, as it may take long to turn darker, making it clearly visible on the imaging. Therefore, these technologies may not be beneficial enough to protect the desalination facilities from oil spills.

3.2 Pyxis Detection Method

3.2.1 Pyxis vs Infrared

Though radar and infrared sensing data have been commonly used to prevent further oil spill to occur, there are better solutions for preventing oil spills. At NNTC, we provide advanced technologies, such as thermal polarimetric sensing technology Pyxis. This technology consists of long wave infrared (LWIR) sensors that capture oil spills with higher contrast imaging as compared with other existing infrared technology systems. It offers superior detection as compared to traditional thermal infrared sensors, and detects oil spills at deeper areas, as it can also detect trace amount of oil on the water surface. Another benefit of thermal polarimetric sensors is that they can detect oil spills at night and in some situations where the thermal imagery shows no contrast like on cloudy days [2]. The Pyxis infrared sensor consists of microfiber polarizing arrays, fitted with the microbolometer focal plane array, enabling optical filtering for achieving small size, especially when detecting small trace of oil spills.

The technology behind the Pyxis sensor helps utilize the polarization of light in our environment. When ambient illumination is reflected from an object, the reflected light becomes polarized. Similarly, in thermal infrared, the reflected light becomes polarized, as it gets emitted from both water and oil, depending on each of their material properties. The main factor is that the amount of polarized light does not depend on the temperature. Hence, water and oil may share the same temperature, which influences the contrast in image being captured. Pyxis can measure the polarization, along with the thermal imaging, resulting in a clear, detailed imaging structure [3].

Traditional thermal or infrared sensors detect only temperature differences, so in the afternoon, when the sun heats up the oil, this develops a strong heat signature, which clearly shows on the thermal camera, where oil is warmer than water. However, during sunrise and sunset, at night and on cloudy days, the temperature difference between oil and water is minimal, resulting in no contrast, making oil spillage quite difficult to be indicated.

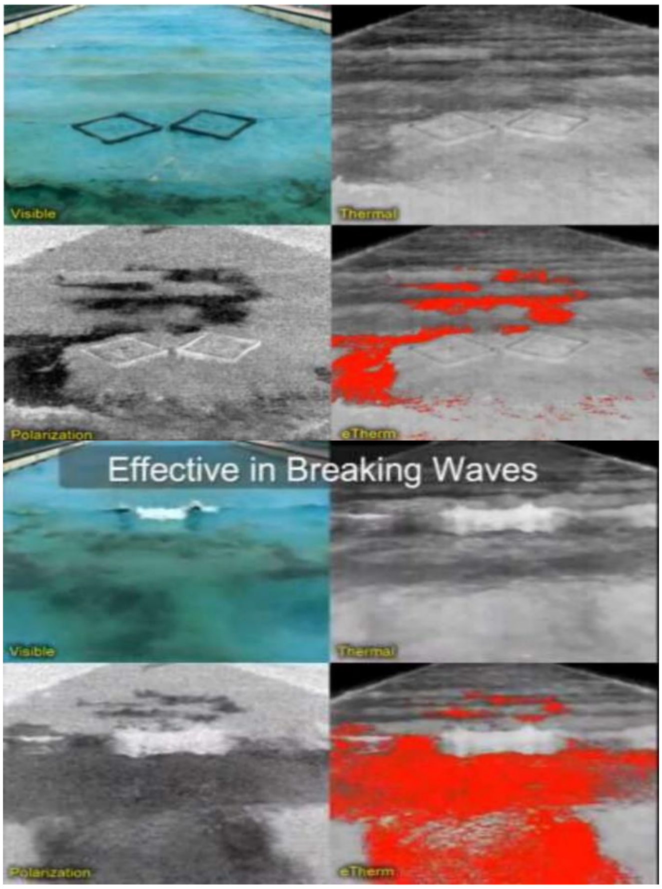

Figure 4: Comparison of imageries of crude oil on water in breaking waves, indicating that oil is clearly detected via eTherm as highlighted in red [3]

Pyxis is a beneficial product that measures the thermal intensity, the polarization magnitude, and direction of the generated electromagnetic wavelength, at any given time. When both polarization and thermal imagery are combined together, they create a special form of imagery called eTherm. This imagery captures the thermal imagery in grayscale, but highlights the detected oil spill in red through polarization imagery.

Figure 5: Oil Spill being detected in West of Santa Barbara showing a clear oil spill indication on Pyxis eTherm imagery compared with visible light imagery [3].

Another example of imagery when the oil spill was detected in the West of Santa Barbara in 2015 by Pyxis eTherm as compared with visible light imagery. Oil is roughly visible on the visible imagery where it can be confused with the sun's reflection glint, kelp forest and surface welling. With Pyxis eTherm imagery, the thickest part of the oil sheen is clearly highlighted in red through the filtering provided by the polarization.

3.2 Pyxis Detection Method

3.2.2 Pyxis vs Radar

Oil detection using radar is based on the effect that the oil shares a fine wave structure characteristic on the surface. Radars typically do not function properly when the wind speed is less than 2 m/s, since oil-dampened waves offer lower backscatter than waves without oil. Sometimes, radars may accidently detect oil spill look-alikes, such as natural surface films made by fish, algae or plankton, cold upwelling water, which may interfere with the stability of the air-sea, divergent flow regimes like internal waves, tidal flow over underwater sand banks, and oceanic eddies.

Pyxis recognize these obstacles, thanks to its advanced camera systems that can clearly distinguish the difference between the oil spills and other obstacles. Unlike radar detection sensors, Pyxis can easily identify oil spills in breaking waves and smooth waves, and identify and detect oil spills with wind speeds less than 2 m/s. Pyxis detects a wide range of types of oils, including crude and refined oil, oil interacting with dispersant, emulsified and aged oil, diesel and kerosene, and other mineral oil. Pyxis works well both at day and night, and on cloudy conditions, as it neglects biologicals, and other look-alikes.

3.2.3 Why Pyxis on Desalination Plants

Pyxis offers much more benefits than other traditional oil spill detection technologies. With its advanced technologies like polarization cameras installed on oil platforms, it can help monitor the drilling process in case of any oil leakage. For desalination plants, it is recommended to install polarization cameras and eTherm cameras to detect any oil or other contaminants flowing inside with the seawater, and avoid engine damage [16]. It is best to routinely inspect storage tanks, as implied by law, and to keep spill control equipment readily available in case of any unfortunate oil spill [17], especially near desalination plants.

3.2.4 Pyxis Specifications

The Pyxis LWIR 640-G is a type of drone-based system technology, allowing scanning the surface area. It has 640 x 512 resolution and two cameras with frame rates of 30 Hz and 7.5 Hz, respectively. It can operate at temperatures up to 70oC [3], as it is safe to operate in harsh weather conditions, especially in hot summers in Dubai averaging above 40oC, particularly in periods from May to September. It operates at steady state power at 21oC with around 5 Watts. It is also light in weight, weighing about 184 grams.

4. Conclusion

Pyxis LWIR is an advanced oil spill detection system capable of distinguishing oil spills from other debris in seawater, which can benefit in protecting the desalination plants. With advanced thermal and polarization cameras, Pyxis can easily detect oil spill at any time of the day, and at any weather conditions. It can detect oil spills by both polarization imagery, and eTherm imagery. eTherm imagery clearly indicates an oil spill as the spillage is highlighted in red, which clearly identifies an oil spillage. Pyxis also identifies the differences between oil spills with lookalikes, such as algae on the water surface, as such lookalikes are neglected by polarization and eTherm cameras.

For desalination facility, Pyxis LWIR is a great product helping prevent any oil spills entering the facility. The cameras can be mounted on the desalination facilities, and oil platforms, indicating any sign of oil spills. Oil spills can be cleaned up after detection either by using oil booms, skimmers, and sorbents that help clean up spills [10]. Traditional technologies, namely radar and infrared scanners, may not properly detect oil spills. Therefore, oil spills may reappear unexpectedly, even after cleaning. This could force the desalination plants to shut down. With Pyxis technology, the oil spills are immediately detected. It simplifies the cleaning process of oil spills and protects the desalination plants against any further oil spills.

Book consultation

Pavel Tatarintsev

Office G16, Block 13, Dubai
Knowledge Park Dubai, UAE

info@nntc.digital
www.nntc.digital

NNTC

R. References

NNTC

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