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Oil in Water Detection

Outline:

Introduction to Oil in Water Detection Analysis
Equipment for Various Applications
Analysis Demonstration
System Features and Benefits

Introduction:

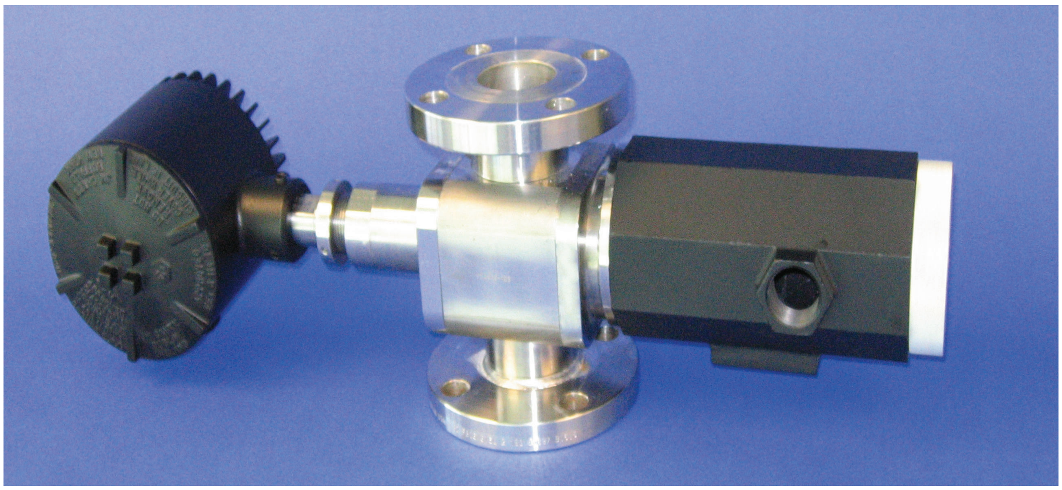
Detection of remnant oils in environmental water returns is essential in the prevention of contamination of environmental waters. Sources of contamination are all around us in the industrial and commercial sectors and regulatory entities are increasingly requiring resources be channeled into prevention of discharges as a preferred alternative to post discharge clean up.

As you probably already realize, oil is a ubiquitous commodity in our mechanized society. Machines of all types and sizes use oils to lubricate moving parts. Oils are often used as cooling agents as well. Due to imperfections in equipment seals as well as the inevitable break downs, these oils find their way outside the oil containment chambers and into associated water systems or directly to the environment. Some common sources of contamination include:

- Fuel Transfer Stations
- Fuel storage drainage systems
- Combined Oil/Water cooled machinery
- Oil/Water separation processes
- Ship bilge water
- Vehicle wash-down stations

Vision technology has some unique capabilities in detecting contamination in a water flow based on electronic imitations of the human eye / brain interaction. The camera sensor consists of a CCD device which contains wide arrays of pixels that change output depending on the light input to them. When a particle or other image is “seen” by a vision system, what is actually happening is the particle or image is reflecting light differently, or at different wavelengths (colors) than it’s back ground and so these differences combine to form the image on the screen pixel by pixel. Once the image is formed the software can size and count the oil droplets in each frame. Conversely, a vision system can be used to differentiate between droplet formations and solid, non oil particle formations and handle those detections separately.

Equipment:
Equipment requirements for oil/water analysis applications range from lab based, to in line to submerged. Some may even perform surveillance type analysis from above a body of water. The following images illustrate systems that can be used in these various situations:



In line analyzer with flanged pipe connections. Common installation

Lab based, or at line flow through cell unit.

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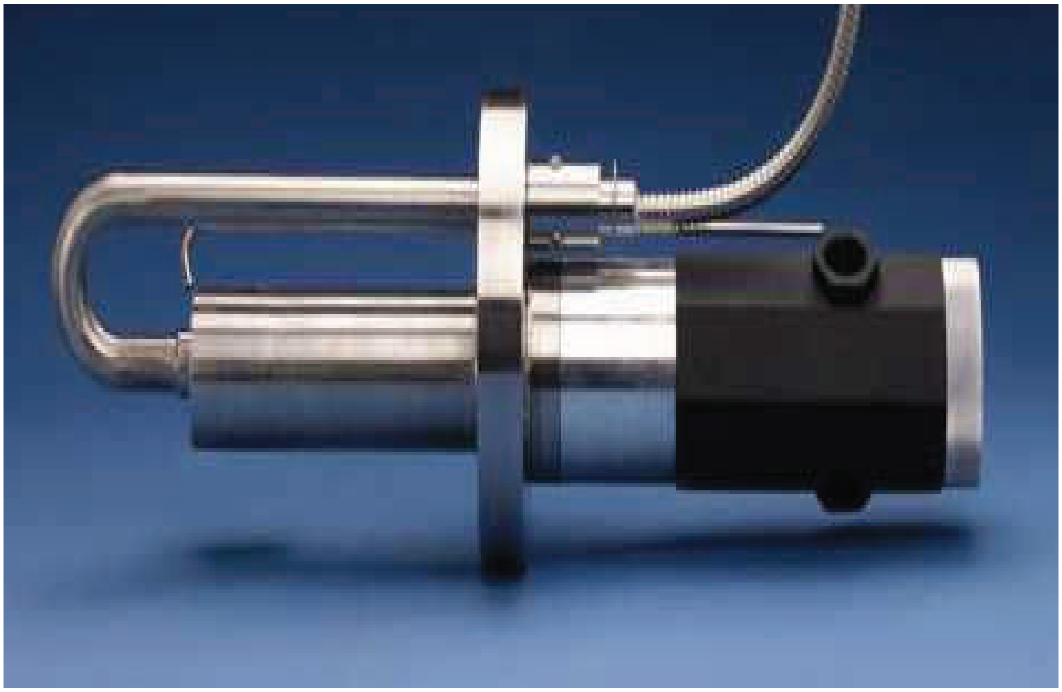


Submersible unit

Each of the units depicted contain three vital components that create a successful vision system. The first is the camera. As technology advances these devices are commonly Ethernet based which is attractive not only because data transmission is over standard network lines, but the image is also available for transmission on a wide basis through the plant and off site as well. This capability allows various functions (Engineering, R&D, Process Control etc…) all to view live images and data at once and enhance process development and trouble shooting.

The second critical system component is the lighting. Proper, controlled lighting is critical to producing a successful system. Drastic changes in illumination cause apparent changes in particle size and quality and must be avoided.

Lastly, having a controlled measurement zone or flow chamber completes the system. Without these three components the system will not function well. With them it will deliver long life and consistent and reliable data.

Demonstration Analysis:

The following is a demonstration of the system capabilities with respect to the analysis of prepared oil in water samples ranging from 1.5 to 100 ppm. The system used for this analysis was a Canty MicroFlow unit. The sample formulations are:

Sample 1   100 ppm
Sample 2   50 ppm
Sample 3   25 ppm
Sample 4   12.5 ppm
Sample 5   6.25 ppm
Sample 6   1. 56 ppm

The sample volume flowed through the analysis chamber where the camera recorded the image detections and the software recorded the particle size and counts. Typical images from the measurement chamber are included for reference. The droplet size ranges from approximately 1 to 20 microns in diameter.

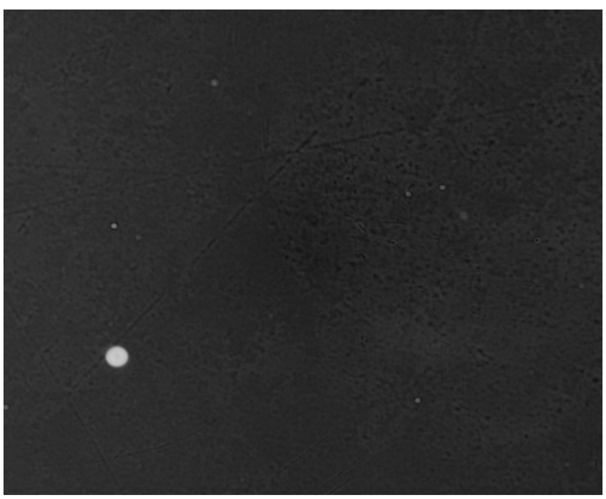


Image from 100 PPM test

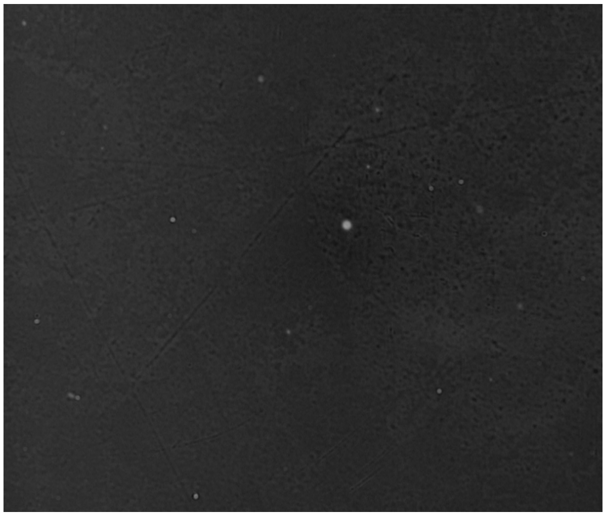
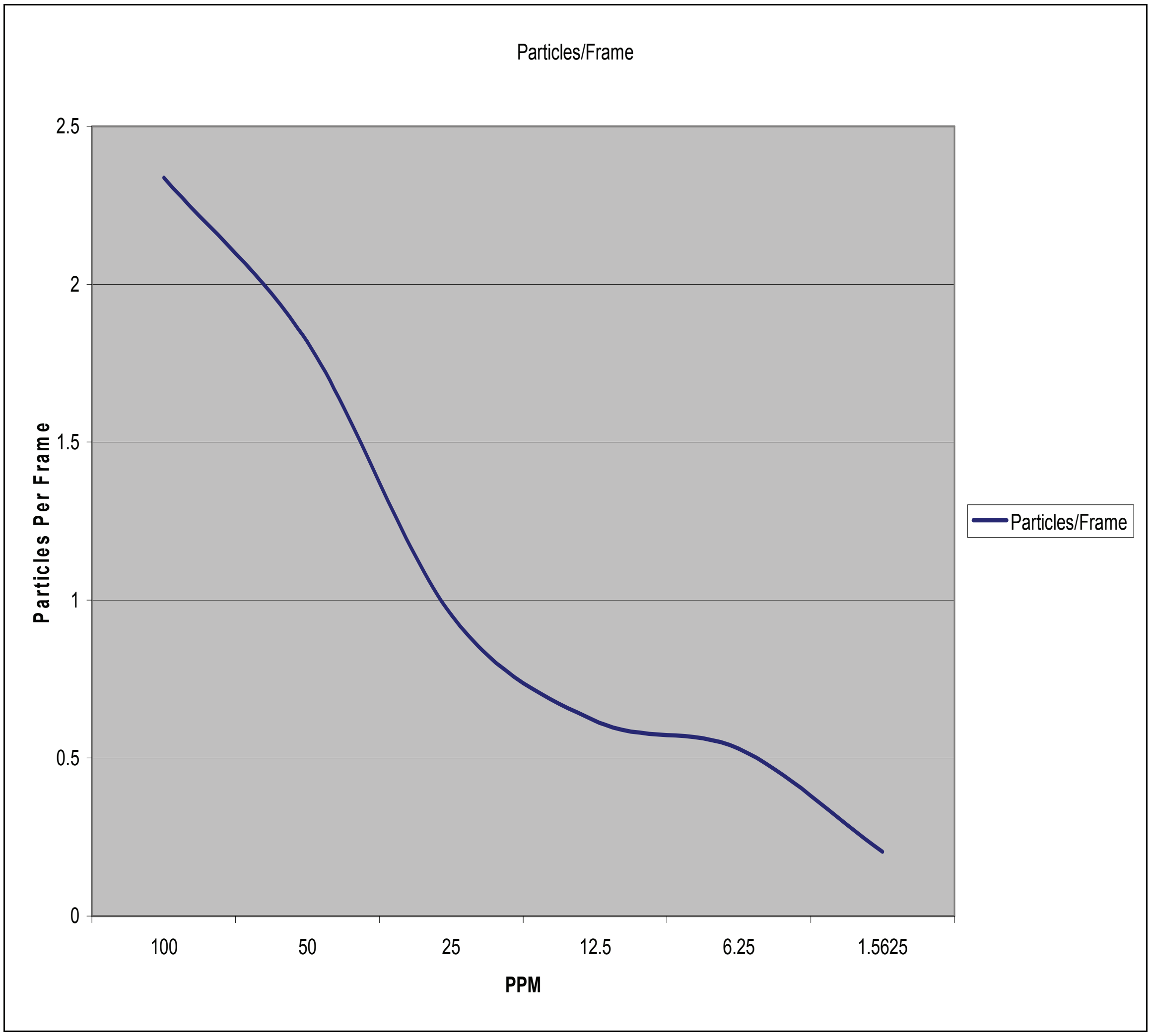


Image from 100 ppm test

The data was taken in units of droplets per frame which, in a well mixed sample or process stream, is a good way to monitor the process to indicate contamination levels and trends. All standard data is available such as droplet area, major/minor diameter, aspect ratio, perimeter etc…

PPM	Particles	Frames	Particles/Frame
100	727	311	2.337621
50	563	310	1.816129
25	372	390	0.953846
12.5	230	372	0.61828
6.25	189	357	0.529412
1.5625	66	324	0.203704

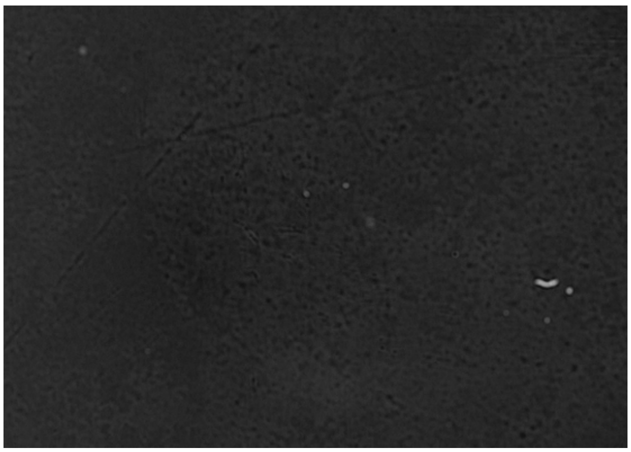
Tabulated data



Graphical plot of tabulated data.

System Features and Benefits:

The question naturally arises, ’How do you know the system is detecting oil droplets?’. The image that follows illustrates this dilemma. The particle on the right of the screen is obviously not an oil droplet. Droplets are spherical or near spherical depending on flow forces acting on them at the time, however they are not long and thin with sharp edges as this particle in question is. to explain how the vision system handles this we need to examine how the software works and how other systems detect particle presence in the flow. As mentioned briefly before this, the software detects changes in how light reflects off different surfaces to allow objects to be distinguished from their surroundings. The measured light intensities are then constructed into a single image in much the same way your brain does it.



Non oil particle

As we know by observation that this particle is not an oil droplet, so too can the software know this by our “teaching” or programming. For simplicity’s sake one can see that if we filter particles bay a 2:1 aspect ratio this particle will not meet the test and the software will not count it. This problem can also arise with respect to air bubbles in the flow which will have the same general shape as the oil droplets. We can filter these too by a different method. Instead of using shape as a filter, we can use light transmission through the particle to distinguish it.

Another question that can arise is ‘What happens if particles get stuck on the lens?’ This can be an issue in dirty process streams. Again, the answer lies in the innate capability of the vision system. When it detects the same particle at the same location it drops that data from further consideration which is what you would do were you manually counting.

The power of vision is apparent. It allows the user to better define and control the process and the resultant data based on knowledge obtained from the live view. Other instruments do not have this capability which leaves a significant margin of doubt in the analysis. For instance, a laser measurement is a single chord measurement across the particle. It gives no shape information and the particle diameter is indeterminate. Conductivity or wavelength sensitive instruments measure the effect on transmitted signals only and provide no particle type information at all.

Lastly, it is important to discuss calibration when considering this type of instrumentation. Because a vision system does not change physically, it exhibits no drift over time and the initial calibration can remain valid indefinitely. Canty recommends at system set up prior to installation, or after installation if you are calibrating on line, a snap shot of the calibration video be taken for future reference. Should a bulb be replaced the initial calibration image can be used to set the intensity level and continue using the same calibration without error.

Typical calibration would follow the test previously reported in the document. Prepare several known samples, turn the system on and run the samples through taking data. Then plot the calibration curve and enter into the software. To do an on line calibration you must have the ability to introduce a known sample to the process line. One way to do this is to provide a shut off from the process on either side of the sensor and open that portion of the line to a side stream through which a known sample can be circulated. Once calibration is complete, close off the calibration line and open the process line.

Summary of System Features and Benefits:

- Visual verification
- System adjustment based on actual view
- Filtering of non droplet for more accurate data gathering
- Elimination of air bubbles and stuck particles
  (or analysis of multiple particles)
- Detections based on count and/or volume
- One time calibration.
- Ethernet image/data distribution