Real Time Visual Analysis and Monitoring of Feed Waters for Optimization of Treatment Regimes

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Abstract

Effective monitoring of intake and effluent flows presents a difficult challenge to the water treatment industry in many ways. Real time knowledge of water condition can inform downstream or upstream processes how to change treatment regimes to affect a consistent, positive outcome in relation to standards. FOG's are a constant headache in wastewater treatment. Particulate can build in pipelines causing significant flow reductions and overflows. Water drawn from rivers, lakes and shed areas for human and industrial uses can become laden with particulate due to weather or other natural events which can overload filtering capacities intended to purify the water prior to use. Invasive species such as the zebra mussel can collect at intake and outlet pipes and reduce volume flows. Vision technology can provide real time monitoring solutions and, in addition to providing a visual verification of process conditions, has resolved the longstanding fouling issues instruments have generally had in extreme processes. Analysis of particulate based on size, shape and percent solids can indicate varying conditions of feed water to operators who can then optimize treatment or close intakes while the upset conditions prevail, thereby preserving water quality. This technology also provides the user with visual verification of process conditions and together with Ethernet transmission protocol, view and analysis can be provided at any point throughout local or wide area networks.

Introduction

The introduction of contaminants into waste water and feed water streams is a major concern for treatment facilities, private and public alike. Monitoring these streams in order to detect upset conditions can improve process functions in a number of ways. Feed waters and waste waters can carry high levels of various particulate that can clog pipe lines and filters as well as overwhelm treatment capacities resulting in under treated water being released into drinking water supplies and public waterways. Vision technology offers the capability to view and identify upset conditions in real time through a rugged process package which sustains a continual view of the pipe line. Particulate analysis identifies quantity and quality of content in the stream which is invaluable in treating the water, protecting the process equipment and identifying sources of contamination.

Vision System Fundamentals

Vision systems operate on the same principle as the human eye – brain interaction. Objects can be visualized because they have different color characteristics than their surroundings or they reflect light differently than their surroundings. When these differences are detected the brain forms an image that represents the object in the field of view. The Close Coupled Device (CCD) and software components of a vision system perform the same analysis of the view. At the edge of an object, where the reflected light toward the CCD is often less intense than in the center of the object, the pixels that receive the edge light register lower intensities than pixels that receive light from the body of the object. The software then forms an image of the object. From this image size, shape and color information can be determined as well as density of solids and oils in suspension.

The key components of a good vision system include the following; high resolution camera and lens, bright, controlled illumination and rugged process connection hardware that can sustain operation in the extremes of environmental conditions. High quality and resolution of the camera and lens system is obvious. Illumination might also seem obvious, but there are several characteristics of a good lighting system that are required to produce good vision analysis. In addition to having high intensity for darker, particle laden fluids the illumination level must be controlled within a very narrow range. If lighting levels fluctuate the perceived particle size of an object will change. This result is evident if one looks at objects in a very dimly lit room. Their boundaries are difficult to define and locate. Lighting controlled within 5% will likely produce results only accurate to 5%, and so it is important to eliminate variation in light intensity.

In order to have the camera, lens and light ultimately function well requires that the process connection have the capability to survive in a clean state in the process environment. Fused glass to metal construction is a proven technology that is capable of providing a consistent and clean view of the process. When compared with a normal process connection composed of a glass viewport sealed with a gasket, the fused type connection has no sites where particulate can get trapped and build up to obscure the lens. The fused glass to metal construction is also a highly polished surface that is difficult for particulate to adhere to, and so in a flowing system the connection windows remain clean over very long periods of time. Figure 1 illustrates the comparison of a fused glass to metal connection versus a standard type connection.

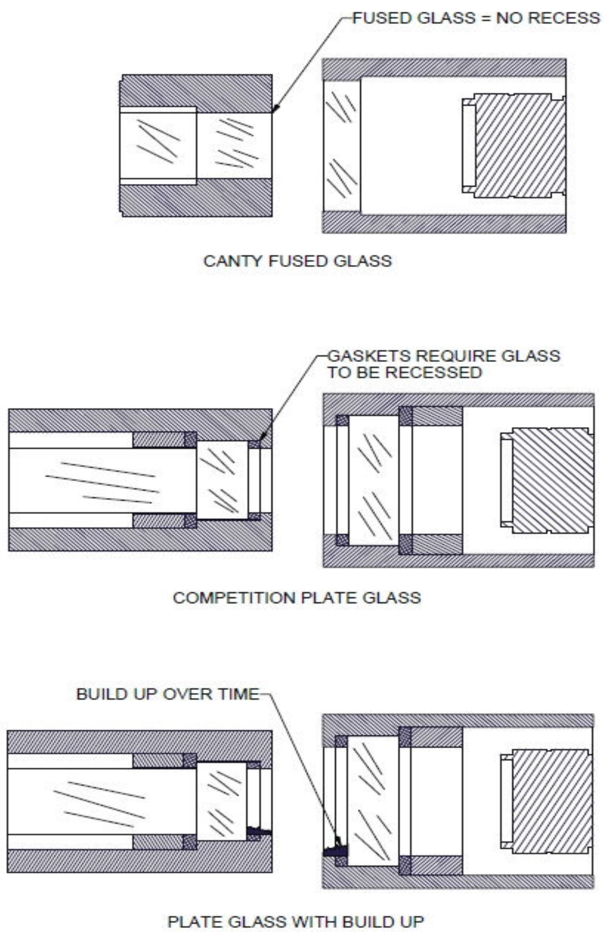

Figure 1. Process Connection Windows

Industrial Water

Uses for water in industry are varied and require different levels of purity. In addition to water intake for use as a feed stock or cooling fluid, waste waters must also be purified for return to the environment. In all these instances water must be treated so it can then be properly used in an efficient, safe manner.

Waste Water

A primary issue that causes continuing problems with piping systems is the introduction of fats, oils and greases (FOG's) to the waste water collection system. This is an industrial, as well as residential, problem. Remediation systems are generally not required or used in private residences and so the resolution of the issue is left mainly to good practice by homeowners. Industrial sources generally have higher FOG concentrations and are required to have systems in place to capture FOG's. Typical sources of industrial FOG's are shown in Table 1 [1].

Table 1. Industrial Sources of FOG

Industry	Type of FOG
Vegetable oil refining	Vegetable
Soap manufacturing	Vegetable and animal
Milk processing	Animal
Dairy products, including cheese	Animal
Rendering	Animal
Slaughterhouse and meat packing	Animal
Candy manufacturing	Vegetable
Food preparation	Animal and vegetable
Eating establishments	Animal and vegetable
Laundry	Animal, vegetable, and petroleum
Metal machining	Petroleum
Metal rolling	Petroleum
Tanneries	Animal and vegetable
Wool processors	Animal
Petroleum refineries	Petroleum
Organic chemical manufacturing	Petroleum, animal, and vegetable

The collection and treatment of FOG's in these, and all, industries must be functional and controllable for the effort to be successful. This paper deals only with the treatment of collected wastewaters for which various regimes are commonly used to separate FOG's from wastewater including grease traps and other chemical separation methods. Visual monitoring of the effluent from these processes on a continuous, real time basis can greatly assist in determining the efficiency of the process and lead to better maintenance practices and more effective results.

To demonstrate the capability of vision technology to inform operators of process conditions some examples will be cited. In the oil refining industry it is common for feed stocks of crude to contain large quantities of water mixed in with the crude and other constituents. This water must be separated, as it has no useful purpose in the final refining product, and returned to the environment. Various separation and distillation processes are used to accomplish this task. The following image, Figure 2, shows the produced water from the separation processes and any remaining oil content [2]. The vision software is also able to differentiate between oil droplets and solid particles by shape. The primary information of percent oil in the water is required to ensure that only clean water is returned to the environment, however the additional information on solids is important to the process as well. Similarly, refined fluids such as gasoline, jet fuel and diesel show up as droplets when present in water and can be detected.

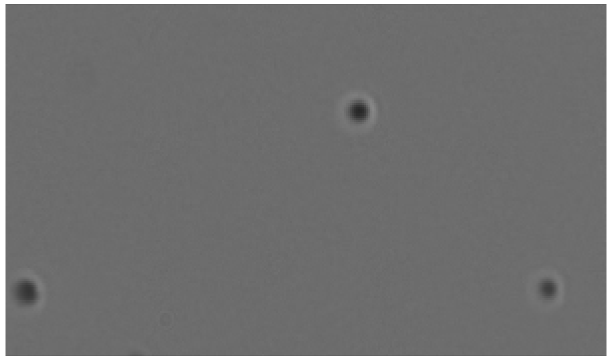

Figure 2. Oil in Water

A second example is included to demonstrate the detection of FOG's from a food manufacturing facility which produces oils and animal fats as waste products. The release of these waste products causes major headaches for publicly owned treatment facilities. Detection of poor separation performance at the source is critical to preventing release of FOG's into the public system. Installation of a vision system can monitor treatment performance in the environment due to the robust connection design that is sustainable in extreme processes carrying material such as crude oils, cooking oils and associated process solids. Figures 3 and 4 show various concentrations of FOG's and suspended solids within the waste product.

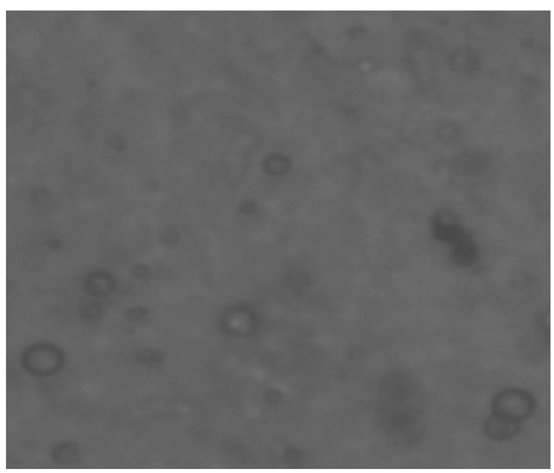

Figure 3. Typical FOG, High Concentration

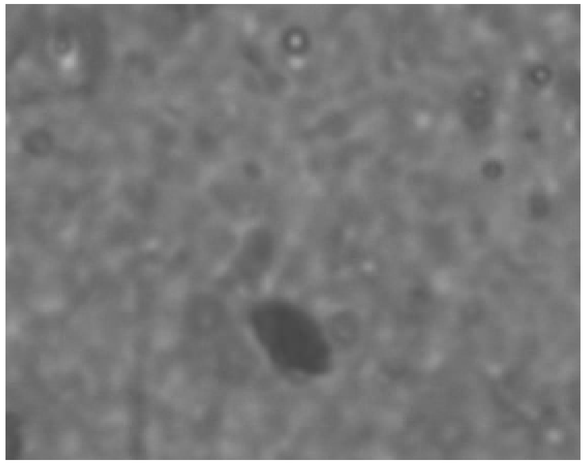

Figure 4. Typical FOG, Low Concentration

The spherical droplets with transparent centers are oils. The non spherical particles are solids. A normal flow of water with a very small amount of particulate would appear much more like Figure 2.

Potable Water

Water for human consumption is drawn from several sources including natural lakes and rivers, runoff collection sites (reservoirs) and ground waters. Although treatment regimes vary depending on water source quality and security, a typical process (Fig. 5) might include a sedimentation cycle whereby suspended impurities are chemically captured and separated from the water, a filtration process that further removes small particulate and a disinfectant stage where chlorine or other chemicals are added to the water to kill dangerous bio-organisms.

Upstream Analysis

Prior to allowing water into the treatment facilities analyses can be performed to determine the condition of the source. The use of vision technology at this stage can offer some advantages over other technologies in identifying the particulate content of the water in addition to measuring its quantity. Visual analysis can categorize particles by size, shape and color which can assist in identifying particular components. Oils and other contaminant fluids will exist in a distinct, spherical shapes. Organisms may also be identified in this manner. In addition, this type of information can be used to model water flows and predict best and worst times for water intake.

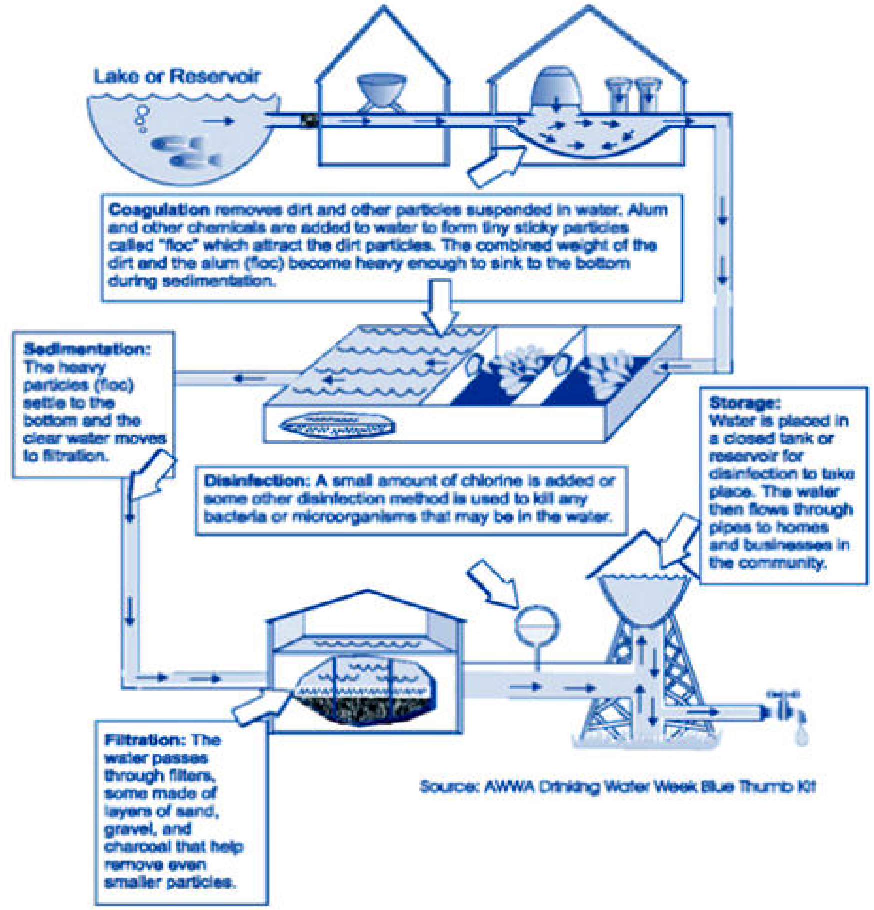

Figure 5. Typical Water Treatment Process

On a macro basis, cameras can be used to monitor the entrances of water intakes for build up of plant or animal life. This information can be used to perform preventive maintenance as needed. An example of this is the primary water intake for the city of Buffalo, New York. Inspections of the intake are not often done due to its depth, and in between inspections zebra mussels had built up in the 12 foot pipeline to the point where the line was approximately 2/3 blocked [3]. With a simple, submersible vision system the detection could have been made, the advance of the mussels stopped and clean out performed inexpensively. Estimates now range from four to five million dollars to restore the intake back to full operating capacity.

In Process Monitoring and Control

There are multiple filtration steps in the purification process (see Figure 1). Vision technology again offers a view and control capacity for the user. Particle counts and shapes can be determined as a way to judge the efficiency of the treatment process by visual means. Systems can be calibrated for different purposes with one goal being the detection of large particulate and another the detection of very small micro organisms which can cause health concerns if they are present in the public water system.

Water leaving a filtration or sedimentation stage is expected to have a defined level of purity, otherwise the process is not running properly and may not purify water as required by the end stages of treatment. Monitoring the particle count or turbidity at these points in real time can provide the control needed to adjust the process to achieve the desired end result. The visualization of the process condition enables the operator to have a high degree of confidence in the instrument analysis.

Water leaving the treatment facility must be pure and safe for consumption. A vision system can monitor the outflow on a continuous basis and detect any lingering contamination due to particulate or micro organism. This inspection stage is expected to have very few, if any, detections of particulate. The shape and size of particulate can help identify its status. As detections are made the images can be analyzed for type and recorded for inspection in order to assess the final quality of water leaving the facility. Figure 3 shows images of E-coli cells obtained using a vision system [4].

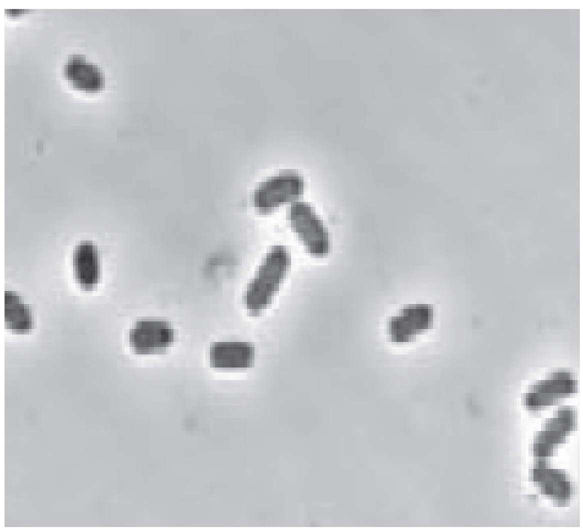

Figure 6. E-coli Organisms.

Conclusion

Vision technology, with its Ethernet based protocol, not only provides a visualization of the process to the operator, but it also provides a way for various engineering disciplines, which may or may not be on site, to immediately see inside a process and not rely on verbal or written assessments of what may be transpiring within that process that is at question. This can greatly assist trouble shooting efforts and restore optimal performance to the treatment process prior to failure.

References

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