

ON LINE WATER MEASUREMENT DEVICES IN LIQUID SERVICE

Class #5235

Kam Mohajer
KAM CONTROLS, INC.
3939 Ann Arbor Drive
Houston, Texas, United States

INTRODUCTION

In today's competitive energy market there is a tremendous emphasis on cost saving and productivity at all levels of the industry. Online water detection provides vital real-time information regarding water concentrations in hydrocarbons empowering the user with the knowledge necessary to maximize efficiencies and cost savings while increasing many safety factors at the same time.

The installation of On-line Water Detectors or OWD's (also called Water Cut Meters) in pipeline or bypass analyzer loop systems has obvious key benefits at any stage involving custody transfer. With today's high crude oil prices, paying for shipped water is a hugely punitive and now unnecessary cost to energy companies. But OWD's can improve, automate and optimize several other key stages leading to refined materials. Chief among those are production and tank water draw automation.

OIL WATER DETECTION TECHNOLOGY

On line water determination is the real-time, continuous measurement of free and entrained water quantities in petroleum and petroleum products, providing true net oil and net water data when paired with flow data. The newest OWD's utilize microwave and optical technology for highly accurate, real-time data. API's Continuous On-line Measurement of Water in Petroleum and Petroleum Products refers to such OWD devices as having an operational range of water concentrations from 0.02% to 100%. Microwave OWD's typically operate in the lower spectrum of the microwave frequency range. Exposed to the flowing hydrocarbon, the microwave antenna measures a function of energy transmission and absorption, and the dielectric values of water and hydrocarbons.

Optical OWD's operate in the IR or NIR spectrum, and measure permittivity and dielectric values and variations in the absorption rates of water as well as hydrocarbon molecules for determining the concentrations of oil and water within the flow. Optical OWD's operate especially well in high water applications.

UTILIZING OWD'S IN PRODUCTION MANAGEMENT

Current levels of demand increase the pressure and importance of every producing well. At the same time, these wells are producing record amounts of water. Higher produced water concentrations combined with increased demand create an imperative for maximizing both the efficiency and automation of production.

Production is *manually* managed by the rotation of "producing" and "shut-in" wells. This system creates a great deal of waste and cost both in terms of produced water and energy utilized. Sampling can be used as a trend indicator, but due to the inherent time delays, is not a precise measurement tool for truly accurate production management. In order to accurately and optimally control production factors, such as shutting in low producing wells at specified water concentrations, real-time information, and thus, on line water detection is required.

The installation of OWD's on each well gives the production operations team the real-time, site-specific data required to automate and monitor production from a central control position. Let's assume there are a thousand wells in a given field. Knowing the exact quantity of oil produced and the specific water concentrations from any well enables the production operations team to shut-in wells with high water production levels and concentrate production on those wells currently producing higher concentrations/volumes of oil and to do so on an as-needed basis. What's more, this process can be informed and enhanced by a wide variety of criteria specific to your needs such as oil-water separation capacity, water-disposal capacity, flow rates, etc.

Oil Production

Optimization Criteria

- Percent oil production per well
(oil concentration)
- Percent water production per well
(water concentration)
- Flow rate
(total oil and water production per well)
- Oil-water separation capacity
- Water disposal capacity
- Water treatment capacity
- Water storage capacity
- Oil transportation capacity
- Oil storage capacity
- Oil market demand
- Energy cost per barrel of produced oil
- Energy cost per barrel of produced water
- Facility maintenance requirements
- Reservoir management
- Corrosion factor
- Chemical injection factor
- Etc.

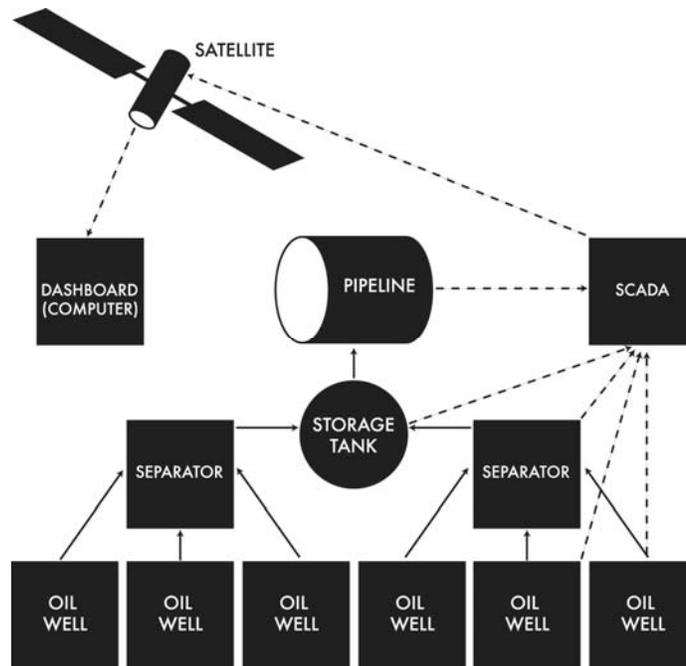


Figure 1: Oil Production Automation

UTILIZING OWD'S TO AUTOMATE THE TANK WATER DRAW PROCESS

Automating the tank water draw process has a number of important benefits, including:

- Ongoing transmix reduction
- Minimizing the need for human site/chemical exposure and associated labor liabilities
- Creates repeatability in the tank water draw operation
- Allows you to perform operation automatically or from a remote location as often as you want
- Creates level loading to water disposal/transmix tank
- Prevents Tank corrosion and costly tank shut downs
- Eliminates inaccuracies, labor costs, and product waste associated with manual operation
- Avoids shipping water

The automation process is fairly easy to achieve using OWD sensors to monitor water and oil levels inside the tank itself and on the water draw pipe. The OWD placed in the tank monitors water levels on an ongoing basis . When the water concentration inside the tank reaches a predetermined high water level, the tank-mounted OWD triggers the opening of an MOV mounted on the tank water draw pipe. A separate OWD sensor located on the tank water draw pipe then monitors the fluid for a predetermined oil concentration. When the fluid reaches that level, the tank water draw pipe OWD triggers the closing of the MOV. This automation process can be overseen from a remote location, and can be used to establish industry best practices for the tank water draw process.

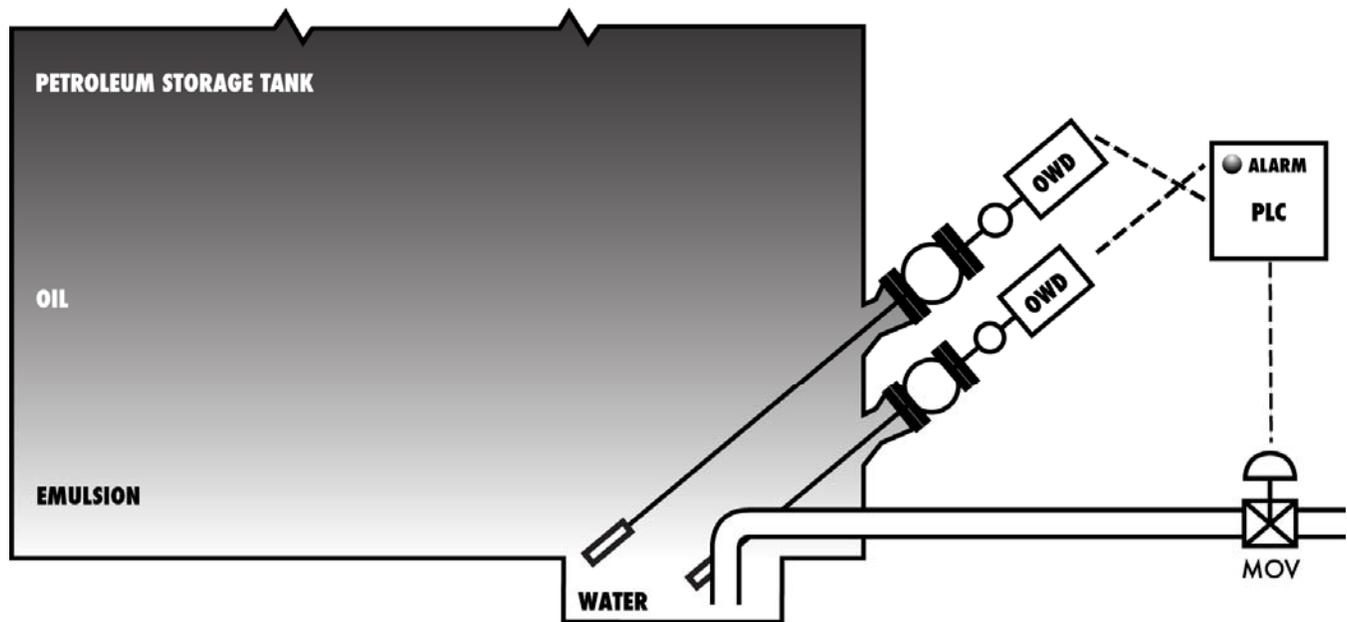


Figure 2: Tank Water Draw Automation

UTILIZING OWD'S IN CUSTODY TRANSFER

Prior to the relatively recent development of microwave or fiber-optics based technologies, product sampling and testing was the only truly accurate method for determining water content during custody transfer. While generally accurate, utilizing sampling delays product delivery and requires interim storage, significantly increasing costs. In addition, even minor measurement inaccuracies correspond to major cost liabilities. If even .05% water escapes detection in a million barrel transaction, at a price of \$50/barrel, the purchased water equates to a \$25,000 loss. Even at relatively low prices, the extreme accuracy of on line water detection quickly pays for itself.

VELOCITY AND HOMOGENEITY

- Properly homogenizing fluids prior to online measurement is paramount to OWD accuracy. This is achieved through proper installation according to flow direction and rate, and generally through the installation of a static mixing element upstream of the OWD. Guidelines can be found in API MPMS Chapter 8.2. These regulations include:

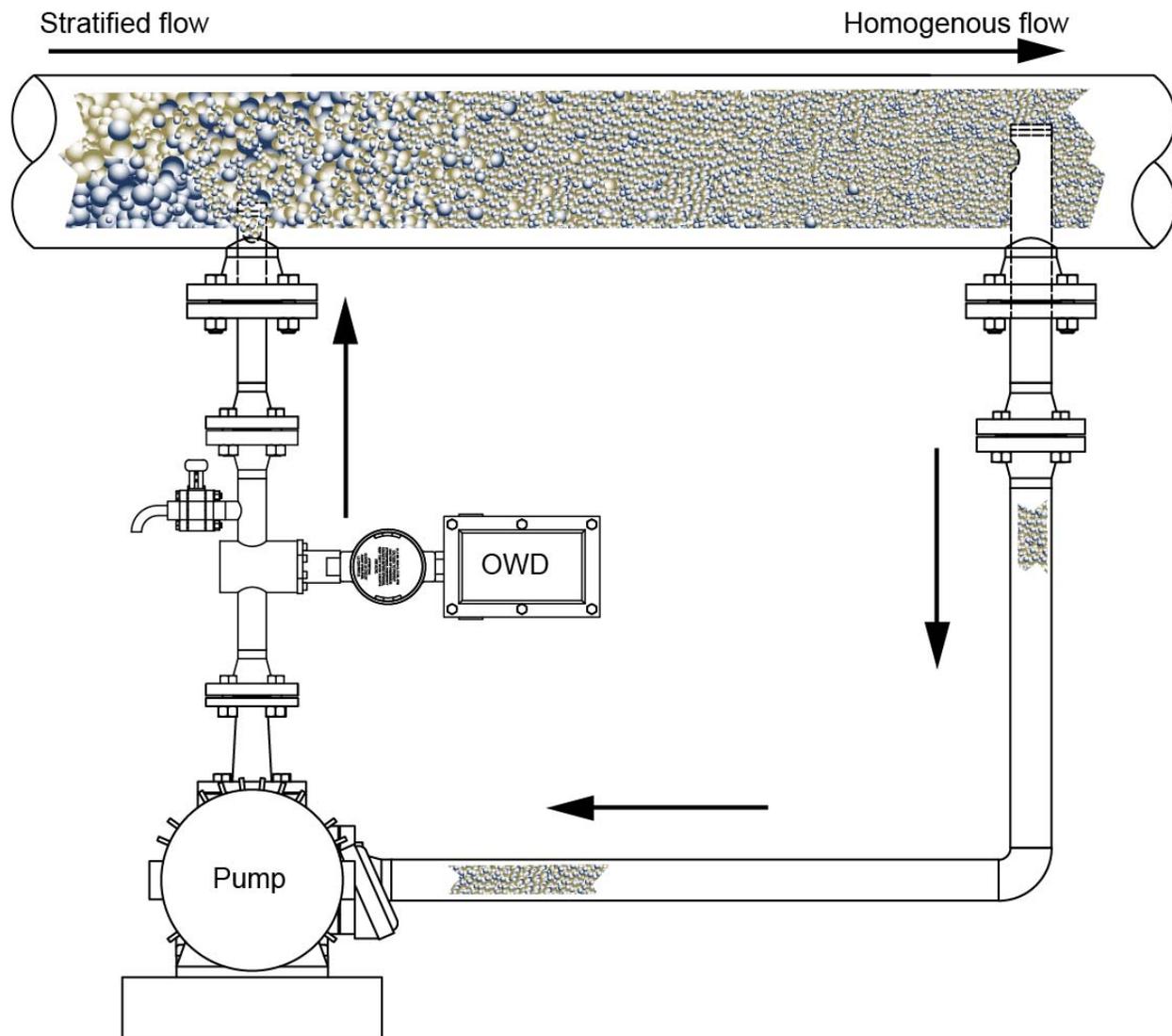
- For Low Range (0 – 5% Water in Oil) OWD's, the sensor must be installed in the vertical down flow with a minimum flow velocity of 4 feet per second. A mixing element is required if the flow velocity is between 4 and 7 feet per second.

–For OWD's operating in the Oil Continuous Phase, the sensor must be installed in the vertical down flow. A mixing element is required if the flow velocity is between 4 and 7 feet per second.

– For OWD's operating in the Water Continuous Phase, the sensor must be installed in the vertical up flow. A mixing element is required if the flow velocity is between 4 and 7 feet per second.

– In situations where the flow velocity is less that 4 feet per second, operators may choose to install the a 1" loop. This increases the velocity to an acceptable level to achieve homogeneity.

• The ideal installation for homogeneity is to utilize a measurement or circulation loop with a pump and an OWD, creating a constant velocity above 7fps. A constant velocity above 7 fps satisfies API MPMS Chapter 8.2, and not only creates a homogenous mixture but a consistent oil/water droplet size ratio. Creating a consistent and predictable environment allows OWD's to operate at their highest accuracy without the effects of varying or low velocities and with greatly diminished affects from environmental factors.



Fig

Figure 3: Measurement or circulation loop with an OWD

Additionally, such a loop creates greater accuracy when dealing with water slugs. Typically a water slug changes flow from oil-continuous to water-continuous phases which can affect the accuracy of an OWD. By “level-loading” or averaging the water slug content across multiple readings, a measurement loop maintains operation in the oil continuous phase for more accurate measurement. Similarly, on the liquid discharge leg of a 2-phase separator, flow goes from 100% water, to emulsion, to 100% oil. The emulsion phase can create a statistical ping pong in oil water measurement. The addition of a measurement loop creates a smooth curve accurately representing the emulsion.

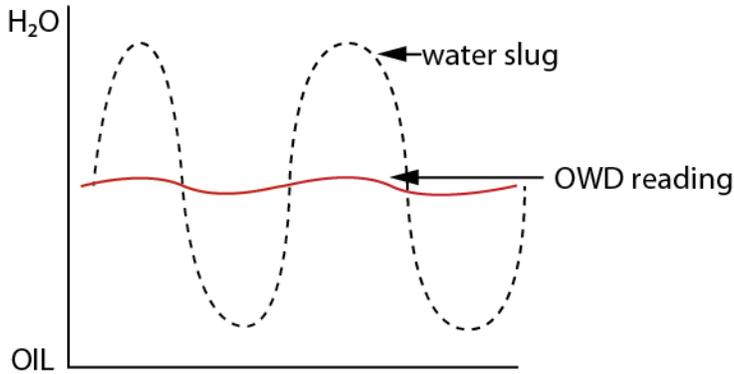


Figure 4: Water slug readings

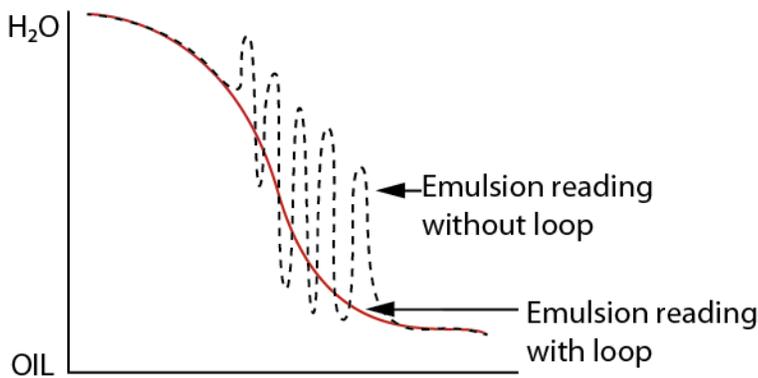


Figure 5: Separator output

ADDITIONAL INSTALLATION CONSIDERATIONS

- In custody transfer situations, OWD data is integrated with flow measurement in order to calculate water content for the entire custody transfer quantity.
- Some OWD's are affected by varying fluid temperatures, densities, salinities, etc. These meters may require ongoing internal calibration and/or additional external instrumentation in order to compensate for such variations.
- Not all OWD's are completely accurate at all water percentages. Site or even well specific data should be considered prior to purchasing an OWD system.
- Data from the OWD is either processed within the unit or sent to an external controller or flow computer. It can be combined with flow meter data and used for reporting, alarms, and automation.

CONCLUSION

Today's OWD technology creates efficiencies, increases safety, and saves money in a variety of applications. Implementing in-line oil-water detection is particularly advantageous in custody transfer, production management, and tank water draw automation. The addition of real-time, site-specific data on oil/water concentrations enables site and operations managers to avoid costly shut downs, manual operations, and excessive energy expenditures.

NOTE: OWD performance can only be determined through testing per API MPMS standards. Please refer to these procedures for all questions regarding performance and installation guidelines.