Selection Of Oil Emulsion Treating Systems

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FOREWORD

Considerable care should be used in the selection and design of oil emulsion treating systems. We will discuss emulsion, how it is formed and treated, the treating systems that are used. When selecting a treating system, consideration should be given the cost of the unit, the effect of scale in the treating section, the effect of corrosion in the treating section and the corrosion effect on the treating unit itself, the use of pressure for gravity and volume control.

EMULSION

If you were to examine closely the contents of a well stream under a microscope, you would see oil and water droplets, solids, such as sand, undissolved salts and metallic oxides. Not all of these components appear in every well stream; however, water droplets are almost always present. Crude oil emulsions consist of these fine water droplets dispersed in oil, and it is known as a standard emulsion. If the oil droplets are dispersed in the water it is a reversed emulsion. This condition is found when the field is a water drive and has almost watered out.

Most well streams contain water droplets of varying size. If they collect together and settle to the bottom of a sample within five minutes, they are called free water. This is an arbitrary definition, but is generally used in designing equipment to remove water that will settle out rapidly. After the free water is removed and the oil then contains less than four to five per cent water, if left standing without rolling or agitation, water will continue to settle out to the bottom of the sample. In most cases, if enough time is allowed, all of the water may settle out from the oil.

In many cases, due to the volume of oil to be handled, settling time is an important and costly item to provide; it therefore becomes necessary to devise a means of speeding up the settling process. Frequently the water droplets remaining after the free water has settled out are too small and the surface tension of the oil is such that the remaining water cannot be removed without some form of treatment. This type emulsion is called a very stable or tight emulsion. If the water droplets vary in size considerably, and most of them are relatively large, the emulsion is called unstable or a loose emulsion.

For our purpose, all water remaining in the crude after allowing it to settle is considered to be in an emulsified state and is to be removed by treating equipment. Treating is simply a system that has been devised to separate crude oil from the water and foreign material carried along with it from the reservoir. In treating a well stream, we "break" the emulsion and separate the good oil from the water, sand, chemical solids and other sediment produced with it.

When oil and water are produced from a well the fluid stream also contains sand, carbon, carbonates, sulfates and many other organic and inorganic materials. These foreign materials become more important as the fluids churn their way up the hole, because of the action of the tubing restrictions, well choke, gas lift valve, or the pump that agitates and blends the oil, water and foreign materials together. The foreign materials act as an emulsifying agent by increasing the strength of the film surrounding the water droplets. Two things are necessary to produce a stable emulsion of oil and water --- agitation and an emulsifying agent.

The important physical characteristics of an emulsion are (1) drop size, (2) film strength, (3) percentage of water, (4) differential density and (5) viscosity.

Drop Size. Small droplets take much longer to settle out. They have a much stronger film strength making them harder to rupture on contact with other droplets. The uniformity of drop size is important. If larger droplets are available upon which smaller ones can build, they will grow to proportions sufficient for separation much quicker than if droplets are of uniform size. Each well is different. The percentage of water produced and the filtering methods will produce drops different in size. These in turn reflect the different types of treating systems, the capacities and the sizes of them.

Film Strength. The film strength of a drop of water will depend on the drop size and the amount and composition of the impurities. To break this film, it is necessary to introduce chemical action and heat to weaken it. Water droplets can then merge upon contact and form larger droplets with sufficient mass to settle out of the oil rapidly.

Percentage of Free Water tends to decrease the despersion, causes a great variation in drop size and increases the possibility and rate of water contact. These factors promote more rapid settling.

Differential Density between the oil and water will effect the time required for treating.

Viscosity of the oil to be treated is an important factor. Viscosity is a measure of the fluid resistance to flow or friction. It is also an indication of how easily water will treat out. A high viscosity (low gravity crude) indicates slow settling, whereas a low viscosity (high API gravity) indicates rapid settling.

There are many other factors affecting the treating problem, such as weather conditions, production methods, etc. All could be discussed at great length but without much definition as to the final effect on the treating problem. The factors and conditions affecting treating illustrates why treating oil is an art, and brings to our attention the facts that must be considered along with the field experience to assure satisfactory treating operations.

STEPS IN TREATING

There are essentially five steps in the proper treating of crude oil emulsions. (1) chemical injection, (2) gas and liquid separation, (3) heat, (4) filtering and (5) settling.

Chemical Injection is introduced into the well stream to neutralize the foreign material acting as the emulsifying agent and weaken the film surrounding the water droplets. This chemical could act on water in oil or oil in water. The chemical should be injected far enough upstream from the treating equipment to allow good mixing and despersion so that it has sufficient time to exert its influence on the emulsion before entering the treating system.

Gas and Liquid Separation is performed prior to treating to reduce turbulence and agitation in the treating system.

Heat produces three effects on oil emulsions.

1. Increases the effect of the chemical on the emulsion.
2. Reduces the viscosity of the mixture, weakening the film and making it easier for the water droplets to settle out.
3. The energy transferred to the fluid increases the movement of water, causing more washing and scrubbing action between water droplets per unit of time.

Filtering or coalescing is used to provide large surfaces on which the water droplets can collect and merge into particles of sufficient mass to settle out. The filter is used to remove the hard to get traces of water out of the oil. Excelsior has proved to be the best filter medium and is very economical.

Settling. In treating, adequate time must be provided for settling. This should be carried out in a section of the system having as little agitation as possible. If settling the oil at near the treating temperature, the advantage of reduced viscosity and chemical effect can be utilized.

THE TREATING SYSTEMS

There are several types of treating systems used for the application to meet the specific treating conditions. Each of these must provide facilities to perform the different steps of treating oil and still have built into them the protection against scale and corrosion. They should also have economy of operation, insulation and maintenance.

Separator - Heater - Wash Tank System

One of the first treating systems was the simple method of producing the well into an oil and gas separator. The separator is operated at enough pressure to carry the fluid through the heater and on to the flume of the wash tank. The heater in this case could be the direct fired heater. (Pressure shell where the fluid is forced in and out and a thermostatically controlled firetube in direct contact with the fluid.) This familiar type heater is made with a horizontal shell or has the vertical jug appearance. These are direct fired heaters.

The indirect water bath heater could be used and in cases of corrosive fluids, cast iron coils are used. Cast iron is one of our best corrosion resistant metals. The fluid is then passed on to the de-gassing section of a flume which will let the small amount of gas which was liberated due to heating, flash off. The flume takes the fluid to the bottom of the tank and to a spreader. The spreader distributes the emulsion evenly and controls the stream so that it does not roll the rank or churn the oil in the settling section.

Because of the difference in density, the free water will fall to the bottom of the tank and be drained off by means of a siphon. The emulsion is washed through the water section and allowed to settle in the upper part of the tank. The wash tank is tall enough that it will allow the clean oil to gravitate on to the stock tank.

Advantages of this System

1. The separate components can be added as needed.
2. All equipment can be used in corrosive conditions when coatings, cast iron coils and wood or coated wash tanks are used.

Disadvantages

1. High cost of each of the components as they are added to the system. Extensive grade and connection work to install.
2. Possible loss of gravity and volume of oil due to heating beyond vapor pressure of normal stable hydrocarbons not under pressure.
3. Because of the quantity of heat required to heat water, as the water percentage increased the heater soon would be too small.
4. Scale formed in the indirect heater coils or the direct fired heater will cause expensive maintenance.
5. This scale will cause more back pressure on the separator to push the production through the system. This may affect the quantity of production from the producing wells.
6. If the lease has been shutdown and the system has a large wash tank, circulation back through the heater to bring the wash tank up to treating temperature before production can begin is required. This requires waiting time to start up.

Steam Generator - Wash Tank Treater

When treating extremely large unitized leases or production that is so corrosive some of the standard systems cannot adequately be protected, the "Steam Wash Tank" is used. In this system the well is produced into the separator, the gas is vented or sold to the gathering system and the fluid is produced directly to the flume of the treater. The wash tank in this instance is called a treater because it is a unit system. The flash gas is taken out of the stream in the gas section of the flume. There is much less flashing of the gas in this system over the heater system because there has been no heat added to the fluid stream.

From the separator to the stock tanks the fluid is carried by gravity. The treating tank is a standard wash tank, but several accessories can be installed to increase the efficiency and give the system flexibility and economy of operation and maintenance. The fluid travels down the flume and feeds into a specially constructed free water knockout. Free water is taken out of the bottom of the treater. This water, and any future increase in water, will not upset the design heat balance of the heater. The oil emulsion is fed to the heating section by means of a spreader giving direct contact with a set of steam condensing coils, with transite flume and water siphon. The system is as corrosive resistant as we know of today.

In the steam treater the tank is usually sized to give six to eight feet of water wash for the oil and six to eight hours settling time for the oil. The steam coils can be placed in the oil to do the heating if there is a severe scaling condition in the water. This system costs 10 to 20 per cent more than the heater method, but the flexibility, maintenance and trouble free operation of the system will soon pay the additional cost back in a short time.

Advantages of this System.

1. The steam treater is as corrosion proof as the industry can build.
2. The system can be sized for new (low water content) production and, as water increases, it will handle large amounts of free water without putting an increased heat demand on the unit.
3. The steam system is closed — no makeup water required, fresh water in the coils and the outside scale problem of the coils can be serviced easily and with very little expense.
4. Higher API gravity and volume of the produced crude because no heat is added before the pressure

is released.

5. The system can be used in multiple units with one steam generator controlling several treaters and designed for large volumes of production.
6. Completely automatic, no warm up time required.

Disadvantages.

1. Cost (multiple units, quality of materials, grade and installation).
2. As production declines, the system is not easy to move and heat loss from treater remains constant.
3. Heating the production without pressure on the system will lose some gravity and volume but not as much as the heater - wash tank system.

The emulsion treater, which is so familiar to the industry, is one of the most flexible and most widely used pieces of treating equipment in use today. The treater combines all of the components of separation equipment, heater and wash tank into one vessel. The treater has become standard. From experience, the use of gas scrubbers, oil spreaders, firetube design, oil diverting baffles, filtering sections, oil settling sections and vapor condensing heads were built into the pressure operated treaters. The treater as we know it today is some 25 to 30 years old.

A lot of headaches and many long days have gone into bringing the treater to its present proficiency. For the vast amount of oil that is produced through the treater in its life time, it is extremely important that all of the components and accessories furnished in the treater, the construction of that treater and its operation be carefully considered. Improper treater design (shorting the treater by leaving out scrubbers, flow control baffles, and quieting chambers) or improper operation could cost the operator three to six per cent of his total recovery from a field.

Flow Pattern

The fluid from the well can be produced directly to the treater. It enters a heat exchanger (optional equipment) where it is preheated to reduce the heat load on the treating section and to allow the light ends to flash off in the separating section under a controlled pressure. The gas that is broken out in the separator section is scrubbed of entrained liquids, just as in the standard separator, to take out any liquid carry over before passing out of the treater to be sold.

The well fluid falls to the bottom of the separator section and is then transferred to the free water knockout section by means of the flume. The free water is taken out from the free water knockout section without being heated. Heat loss to the free water is trapped in the vertical rising emulsion. The oil spreading baffle feeds the oil emulsion droplets through the water wash directly to the firetube. The oil flows around the firetube and vertically through the water wash section.

It is a known fact that treating is done at the innerphase. That is, coalescing of oil to oil and water to water as the two unmixables collect at "inner phase". Here the vertical flow of oil is stopped by the first "flow control baffle" and an inner phase is established. The largest percentage of treating is done at this point. Droplets of oil are then water scrubbed to the second flow control baffle (this second baffle is also the bottom retainer of the filer section). Here the second treating is done, here the "hard to get" has been done. After adequate retention and flow control, the oil is water scrubbed for the last time and travels on to the final flow control baffle.

If the emulsion had been extremely tight the use of filter media in the filter section would be used to bring the oil to pipe line quality or less. The top flow control baffle acts as the top retainer of the filer section and the oil from here passes to the quieting section where it is allowed to settle and cool. Light end vapors that flash off are passed back to the separator section and the heavy ends fall back into the oil.

Oil is "treated" at the inner phase. The flow control baffles that establish these several inner phases do two things — they allow the treater to handle large quantities of production with a modest amount of heat. By controlling the flow so that the oil does not immediately rise vertically to the settling section and out of the treater, the retention time of the treater is increased, the quality of the oil is better and high gravity is retained because of the cooling of the oil before the pressure is released to pass it to stock.

Advantages.

1. Low cost for comparable systems.
2. No warm up time required.
3. Treater can easily be coated for corrosion protection.
4. Lowest installation cost.
5. Equipped with free water knockout for flexibility.
6. Can be used with steam condensing element for scale and corrosion control.
7. Complete range of sizes.
8. Can be moved.
9. Highest possible recovery of gravity and volume due to pressure operation.