Automation and Treating of Oil Field Emulsions

By S. L. STENTZ
Stentz Equipment Co.

HISTORY OF OIL TREATING

Emulsions (oil/water mixtures) have been known to exist since oil was first produced. The first early methods for dealing with this problem were to skim the oil from the top of a storage vessel and get rid of the rest by flowing it into streams or storage pits. The early refiners had their problems with handling crude oil containing water, because the expansion of a typical crude oil when heated to 700°F is 60%, while water expands more than 1600 times (160,000%) as steam. Because of this problem, purchasers of crude oil limited the water content of their purchases and developed elaborate systems for dehydrating to be used for charge stock.

During the oil producing years, up until the early 30's, every method known to man was tried to remove water from crude oil. One of the key positions in an oil company in the early 30's was that of oil treater. Many present oil executives moved up through this position in the rise to their present executive offices. Some oil producing companies still retain the position of oil treater on their payrolls, but today they are the exception.

Three Types Of Emulsions

By the middle 30's, engineering studies were carried out to make oil a science rather than an art. It was determined that emulsions (oil and water is suspension) were of three types: 1 a bubble of oil enclosed in an emulsifying agent in a matrix of water; 2 a bubble of water in an emulsifying agent in a matrix of oil; and 3 a combination of 1 and 2. The remaining water and oil readily separated with pressure reduction. These emulsion bubbles were supersaturated with minerals which the crude had dissolved through centuries of contact in the formation. Although many methods of breaking these emulsions were tried over the years, the three methods that stood the test of economy and simplicity were electricity, heat, and chemicals. All of these methods require settling time for gravity separation.

The three methods use the same principle of breaking surface tension of the bubble, so that the water and oil coalesce and separate. After these findings were definitely established and developed, standard units were designed to carry out these basic functions. It was also found that the most economical approach to oil treating was the proper combination of one or more of the treating principles plus settling time.

Although the use of chemicals was still somewhat of an art, the use of heat became highly developed and package treating units were developed. The evolution of the heater treater gave a standard fabricated system that could be shipped anywhere and placed in operation with little expense or time. If the unit was too big nobody heard about it; if too small, it was replaced with a larger one.

PRESENT TRENDS IN TREATING UNITS

In the last ten years, with the advent of premiums for higher gravity, increased cost of gas, and the problems of automation, the subject of oil treating has received more attention. Consideration has been given to the fact that all crude oil emulsions do not lend themselves economically to the same treating cycle. Let us now discuss four factors that must be considered in selecting a unit to fit a specific treating problem.

A. Flume: This area should be maintained at the same pressure as the treating system and stock tanks, to assure maximum separation of entrained gas. Excessive pressure drop beyond this point causes removal of lighter ends which are picked up by the escaping entrained gas.

B. Water knockout section: This should be sufficiently large to give the free water time to settle out and be removed before it can pick up heat from the water wash section.

C. Water wash section: The reason for water in this section is its high heat transfer coefficient as compared to oil. As water is heated, it rises and is hottest at the point "D" where it contacts the emulsion. Four common methods generally used to heat the water wash are discussed in a following section.

D. Water oil interface: An important factor in treating operations is that emulsions settle in oil due to increase in specific gravity over clean oil. At the interface, the emulsions contact the wash water which has risen to the top of the section because it is the hottest. The time requirement to break emulsions with heat varies considerably, even with crudes in the same field. The amount of chemical, and the degree of dispersion in the emulsion, has a definite influence on this time element. This means that the most important consideration in sizing a treater is the available area of this interface. In the case of a 6 foot unit, this area is 28 square feet; in a 10 foot unit, it would be 79 square feet or three times as great.

METHODS FOR HEATING WATER-WASH

There are four common methods for heating the water section. These methods are as follows:

1. Direct fired U-tube: Produced water, because of its environment, usually is very high in carbonates and sulphates. Any heating of this water may cause precipitation of these compounds. Experience indicates

that this precipitation is in proportion to the rise in temperature. Direct firing on metal in contact with this high mineral content water causes excessive scaling, which insulates the metal and causes burnouts.

2. Thermo syphon: This system uses the difference in temperature of the water wash section to move it through the heating cycle. As the water cools, it drops to the bottom of the wash tank, then out to the heater where, as the temperature rises, it moves back into the wash tank. There are two limitations to this method of heating. First, very little power is available to move the liquid, which may cause overheating of the heat generating unit. Gas jets and supplemental power sources are many times used to assist this transfer. Second, the water being heated is formation water usually high in solids, creating the burn out problem outlined previously.

3. Line heaters: These heaters, directly fired, present the same problems as the two systems discussed above; however, this unit is available as an indirect unit where fresh water is heated, transferring this heat to coils which carry the produced fluid from the well to the wash tanks. The limitations of this system are:

a. All produced fluid must be heated (unless a free water knockout is used). This means that when 50% of the produced fluid is water, the line heater must be at least one-third larger than one used beyond a water knockout.

b. During periods of shutdown, the wash tank cools and must be circulated back through the line heater until wash tank temperatures are up before treating can again be resumed. This can become critical because manpower is involved during this warmup and the unit is out of operation.

4. Heat exchangers in wash tanks: To overcome many of the above limitations, a large number of treating units have been installed in recent years using a heat exchanger in the water wash section of the settling tank. Although water has been used, its heat carrying capacity is limited to 1 BTU/#/$^{\circ}$F. rise in temperature. Steam, on the other hand, absorbs 970 BTU/# when increasing through 1°F. from water to steam. This permits radical reductions in the size of units to do the same work. Steam, being uniform in temperature (never over 212° at 1# pressure in this country) cannot cause hot spots or excessive precipitation of solids. Fresh water is used for heating, which reduces corrosion and precipitation to a minimum. Horsepower is also available, which permits removing the gas firing portion of the unit as far from hazardous locations as desired. With free water dropping out in the water knockout section and clean oil moving to the top of the wash tank, a minimum of heat is required. This reduces the load on the heating system, conserves gravity and reduces scaling. This system has limitations also. The scaling problem has not been eliminated. The system is not as portable as some of the other systems.

DESIGN REQUIREMENTS FOR AUTOMATION

The design of a treating system may not be adequate when the above four factors are considered individually. Excess water carryover settles out in the stock tanks. On hand operated leases, this water is drained off or recirculated through the treating unit. Many times, settling tanks or water knockouts are installed to supplement the deficiency in the treating unit.

In the case of automation, these deficiencies cannot be tolerated because they defeat the entire program. Water detection and recirculating equipment is costly, and if the unit does not give clean oil in the first place, recirculation only increases the load on already overloaded facilities. Experience has therefore taught us that proper treater design is one of the critical controlling factors in successful automatic lease systems. Proper treating system selection not only assures clean oil, but permits substantial savings in reduction of tankage and controls.

CONCLUSIONS

In conclusion, it might be well to summarize the ten points to be considered in treatment of oil field emulsions by the application of heat.

1. Economical first cost and installation.
2. Economical operations.
3. Maximum flexibility.
4. Operation simplicity.
5. Minimum corrosion and deposition.
6. Maximum safety from fire and other hazards.
7. As fully automatic as possible.
8. Develop uniform heat distribution throughout the water wash section.
9. Low maintenance expense.
10. Reduce gravity losses to a minimum during treating cycle.
11. Reduce vapor losses to a minimum.