ENERGY CONSERVATION IN LEASE CRUDE OIL PROCESSING

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INTRODUCTION

Very little emphasis has been placed on conservation in lease crude oil processing to date. This subject was not a practical consideration until about a decade ago when the value of the energy products began to rise. Since new-oil price decontrols instituted ten years ago, crude oil has risen in value one thousand percent, and natural gas as high as 500,000 percent. This, of course, has whetted our economic appetite to produce and sell more. But even today very little consideration is given to the economics of conserving what we already have. Conservation is lack-luster when compared to the excitement of wildcatting. And yet, conservation is a sure thing. As little as 5% conservation across-the-board could reduce our import oil requirements by over 10% without the speculative gamble or huge capital costs of wildcatting. A grass roots approach to conservation is conservation in the processing of lease crude oil.

CRUDE OIL PROCESSING

Free Water Removal

Processing produced fluids usually requires the consumption of some energy. This energy is typically in the form of BTU's generated by the burning of natural gas inside a heat exchanger we refer to as a firetube, furnace or boiler. This application of heat accomplishes the enhancement of separation of dissimilar phases from crude oil and/or natural gas, enabling us to process produced fluids and gasses with relative ease. The technology of production processing is, for the most part, an accepted part of our basic knowledge. This technology, again for the most part, has been with us for decades. However, any real emphasis on fuel conservation has been with us for less than one full decade. It is not surprising then that the subject of energy conservation, its technologies, hardware and applications, is fairly, if not totally, new to us.

Let us look at the details of crude oil dehydration; the removal of water from crude oil. Water in produced crude oil exists in two basic consistencies: 1) "Free" water: identified as those droplets large enough to freely separate from the crude oil stream; and 2) Emulsified water; the droplets too small to freely separate. While processing technology today tells us we can readily remove free water using "Free Water Knockouts," as often as not we do not. As we see from Figure 1, crude oil can retain from 5% to 55% "water-of-emulsion" after the removal of free water. Since process equipment designed to remove water is conceived with Figure 1 in mind, the typical process vessel will separate effectively 55% water from oil up to its peak rated capacity. In the past this has meant great flexibility in processing fairly large quantities of produced water through one vessel, the typical vertical heater treater. This is so commonly accepted that little thought is given to alternatives, and some resistance is encountered when alternatives are considered. By design, the vertical heater treater heats all the oil, all the water-of-emulsion, and approximately 20% of the free water. The application of Free Water Knockouts, therfore, saves the energy used to heat 20% of produced water commonly processed through heater treaters. To quantify this, let us assume an example lease producing 100 BOPD and 300 BWPD. Heat demands are calculated from the following:

Oil = 150 BTU/BBL/°F T
Water = 350 BTU/BBL/°F T

If we assume a 50°F temperature rise requirement, we see that the water has a total heat demand of 6,125,000 BTU/D. Twenty percent, the conserved amount of this is 1,225,000 BTU/D or 1.225 MCF/D. In terms of cost effectiveness, the payout period for the required free water knockout in this example is just under two years. So, the free water knockout is an important link in our conservation chain. It reduces the amount of process energy in a cost effective manner by removing free water prior to final stage crude oil dehydration.

FINAL CRUDE DEHYDRATION

Final stage crude dehydration in the field is typically accomplished using one of the following types of process equipment.

1. Gun Barrels (Wash Tanks)
2. Vertical Heater Treaters
3. Electrostatic Heater Treaters

Gun Barrels (Wash Tanks)

The Gun Barrel is a large dynamic-flow storage tank, usually one-third filled with produced water and two-thirds filled with crude oil. Crude is introduced into the water phase, rises, slowly entering the oil phase to remain there a calculated eight plus hours. During this rise time, experience has taught us that most water will counterflow down through the rising oil to accumulate back in the water phase. On occasion gun barrel operation is accomplished with little or no energy consumption. However, most gun barrels are designed with stand-by heat exchangers so that heat input is readily available when needed. These are usually internal tube bundle exchangers heated with steam or circulating hot water systems. Some producers using gun barrels use conventional vertical heater treaters as pre-heaters.

Recent papers have pointed out the inefficiencies of gun barrels. Not only are they more expensive than their electrostatic counterparts, their design is such that uniform heat flow and input is extremely difficult to accomplish. The large quantities of oil in storage in today's gun barrels has a value so great that many operations are shying away from this method of crude dehydration. When heat input is required it is instituted at levels so elevated that gross wastes are encountered. These are gravity and volume losses on an order of five times the magnitude of that in vertical treaters. Due to the comparatively enormous size of gun barrels, radiation loss of heat from the shell of the tank is a sizable problem. The only solution here is insulation, a major expense on the typically large gun barrel, and as depicted in Figure 6, the thicker the insulation pad the less heat loss...the more energy is conserved. However, method designs do exist to allow for sizing with much less residence time due to uniform flow characteristics. Not a well researched subject, gun barrels seem to have regained some popularity, not because of their cost effectiveness, but because of outside pressures to conserve energy.

Vertical Heater Treaters

The most common of the above is the vertical heater treater. It is also the largest energy consumer. By design, most vertical heater treaters utilize the heater in the water phase. As we have seen above, this heating of water consumes nearly 2½ times as much energy as heating only oil would. Furthermore, water phase heating tends to foul the heat exchange surfaces with mineral salts. These salts form a natural insulation barrier, increasing the amount of energy consumed. Using state-of-the-art analytical equipment a recent operations survey of over 100 vertical heater treaters showed a net average thermal efficiency of under 30%. This was increased to an average of over 65% by proper tuning of the burner system. Clearly, the method of operation, as well as equipment design, has a significant effect upon energy usage and conservation in the vertical heater treater.

Electrostatic Heater Treater

The electrostatic heater treater uses a high voltage, low current electrical field to coalesce small droplets of emulsified water into large enough drops so that they separate from the crude oil much like free water. These treaters accomplish crude dehydration with much lower heat input requirements and by their design conserve energy. The heater in the electrostatic treater is located in the oil phase, rather than in the water phase. As previously suggested, this minimizes the heat input requirements to accomplish dehydration. It also all but eliminates the energy robbing insulation blanket of mineral salts so typical of water emersed heaters.

Crude oils previously dehydrated at 110°F are being effectively dehydrated at 80°F and below today, conserving over 25% of the heat energy otherwise used. In addition to heat energy conserved, lower treating temperatures result in larger quantities of higher gravity crude. We see from Figure 4 that a 30°F lower treating temperature results in approximately .2 API increase and from Figure 5, a corresponding increase in volume of .3%. Higher gravity product and more of it obviously result in greater at-home satisfaction of our own energy needs...the real payoff of conservation.

THE HARDWARE OF CONSERVATION

We have seen that the proper applications of processes and equipment can and are conserving energy. As has been hinted, the heaters in our industry are major consumers of energy. Since the heaters we employ have been with us for several decades, it is not surprising that we tend to take them for granted. And yet, the selection and operations of the heater system and its many components may alter the efficiency of the heater drastically over its typically long life. As was pointed out earlier, the system designed for 75% net thermal efficiency may be found to operate at less than 30%. And selecting the wrong system may mean starting with a design efficiency of 50% or worse. Many extra long term operating dollars may be spent operating a poorly conceived system, where a few extra dollars could have purchased an efficient system to begin with.

Most of today's heaters employ natural draft venturi-type burners, such as the one pictured in Figure 7. While these are relatively inexpensive compared with forced draft burners, their inefficiency may cost many times the hardware value in unnecessarily consumed energy. In the natural draft burner a small change in fuel input or air intake alters all the characteristics of heat exchange.

The method of controlling the heater in its operation is also quite important. Thermostats may throttle fuel input uniformly and efficiently or react slowly or on an on-off basis. Unmatched thermostatic controls and fuel valves may result in uneven burning, flame-outs, and wasted fuel. Pilot systems may consume very little energy or may be misapplied and provide much of the process heat. All in all, the hardware plays a major role in the scheme of conservation.

THE FUTURE

Energy conservation in lease crude oil processing in the future will change the course of vessel design, selection, economics and operations. State-of-the-art microelectronics have made it possible for this industry to nearly totally automate lease processing facilities. With this automation comes continuous monitoring and adjusting of all parameters consistent with smooth, efficient operations. As the emphasis shifts toward efficiency and conservation, we will see a shift in operations philosophies. The lease operator or pumper will no longer be just one rung from roustabout. We will recognize that this person is the guardian of the industry's product...and ultimate income...and conservation. The hardware will be purchased with the state-of-the-art technology in mind. More forced draft burners will be installed replacing natural draft systems. All burner systems will be routinely adjusted and their performance monitored. As more and more micro-processors scan operations flame out detectors will relight pilots or shut down defective systems alarming and identifying problems for repair technicians. The future will be geared to conservation and efficiency as a result of the cooperative efforts of technology, electronics, systems selection and maintenance.

CONCLUSION

Conservation in lease crude oil dehydration can best be accomplished by the proper selection of equipment and operating standards. The removal of free water from crude oil plays a significant role in efficient dehydration. Electrostatic treaters have proven to be energy efficient and cost effective. Properly tuned heating systems of the proper size contribute significantly to energy conservation. Smooth operations controlled and monitored by the microprocessors of today and tomorrow will insure conservation in the future.

ACKNOWLEDGEMENTS

The authors wish to thank C-E Natco and Combustion Engineering Inc. for the opportunity of and assistance in the presentation of this paper. We further thank all the producers of crude oil for their cooperation in the trials, experiments, and studies of energy conservation hardware and practices in the real world.

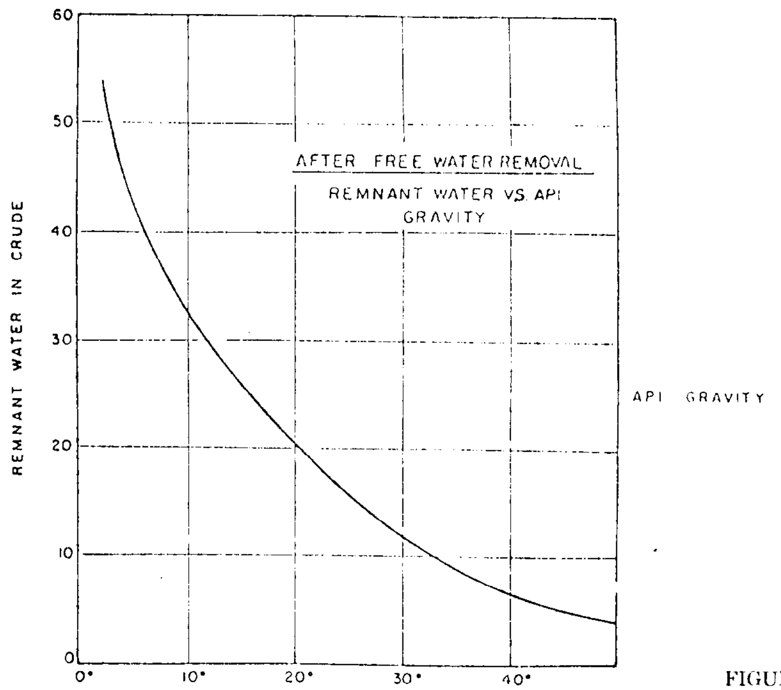


FIGURE 1

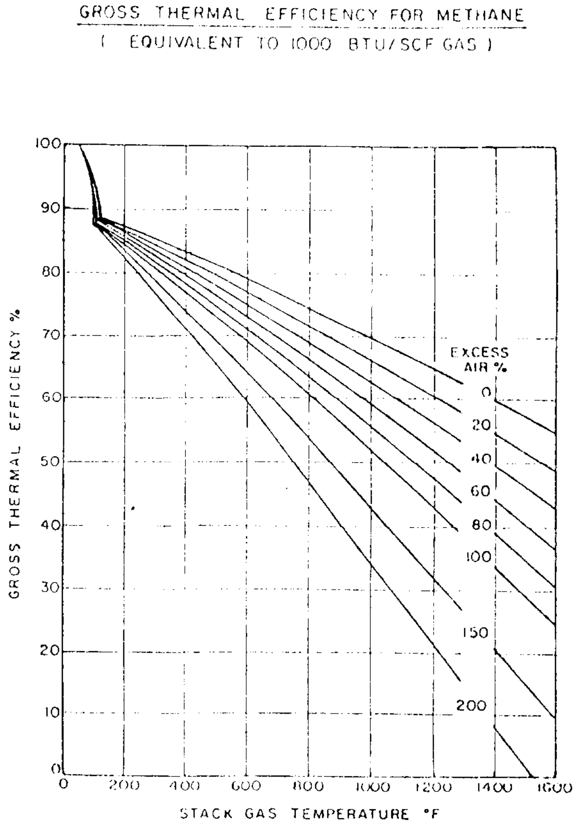
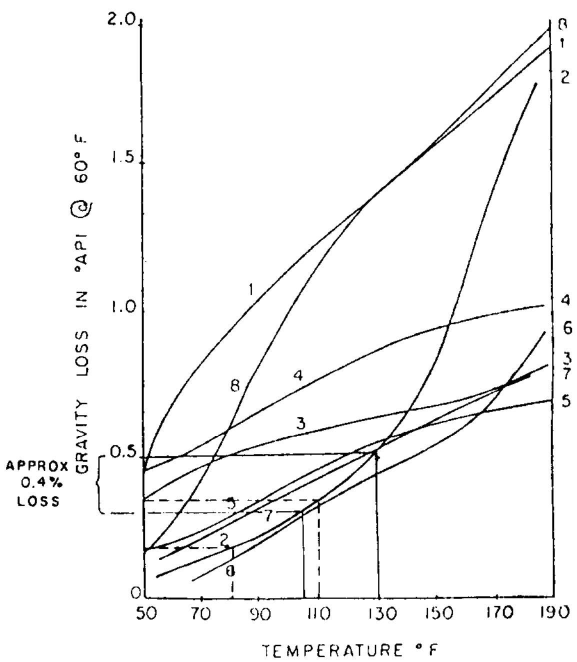


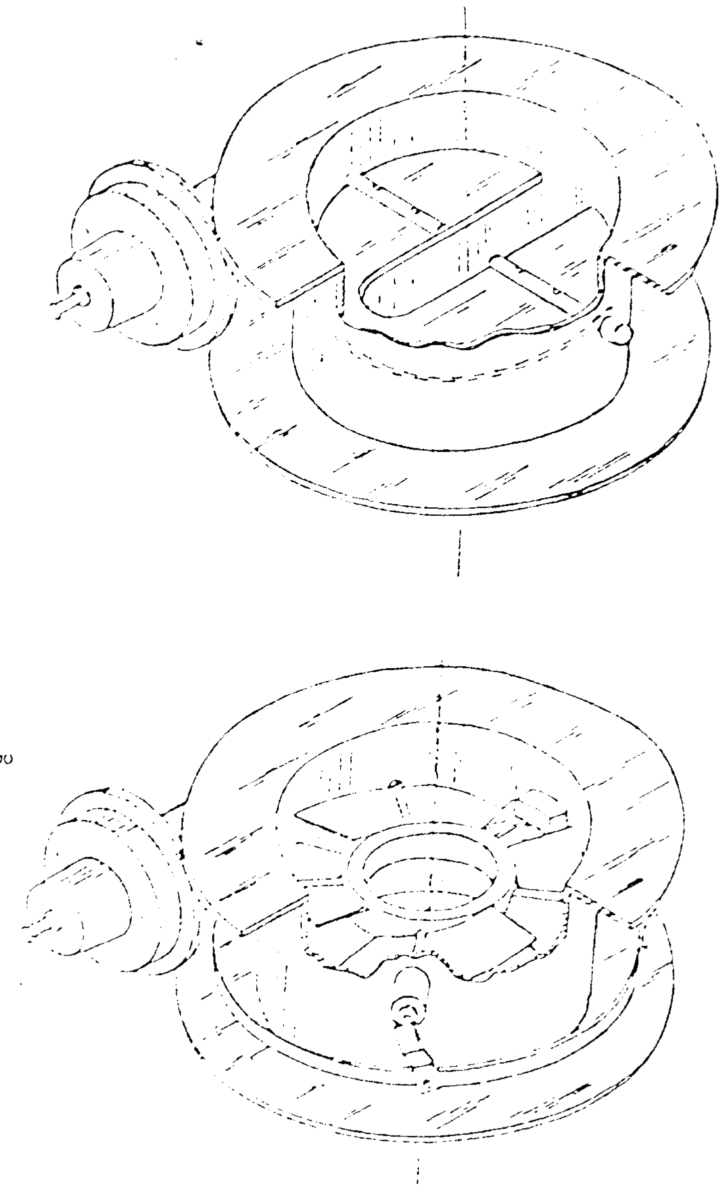
FIGURE 2

(1) 38.0° API Mid Continent Crude
(2) 34.2° API West Texas Composite
(3) 32.0° API Southern, Oklahoma
(4) 31.5° API Wyoming
(5) 28.6° API Sugarland, Texas
(6) 24.4° API Talco, Texas
(7) 33.3° API Southern, Louisiana
(8) 37.2° API Sprayberry, West Texas



API GRAVITY LOSS Vs. TEMPERATURE

FIGURE 4



SECONDARY AIR CONTROLLERS

FIGURE 3

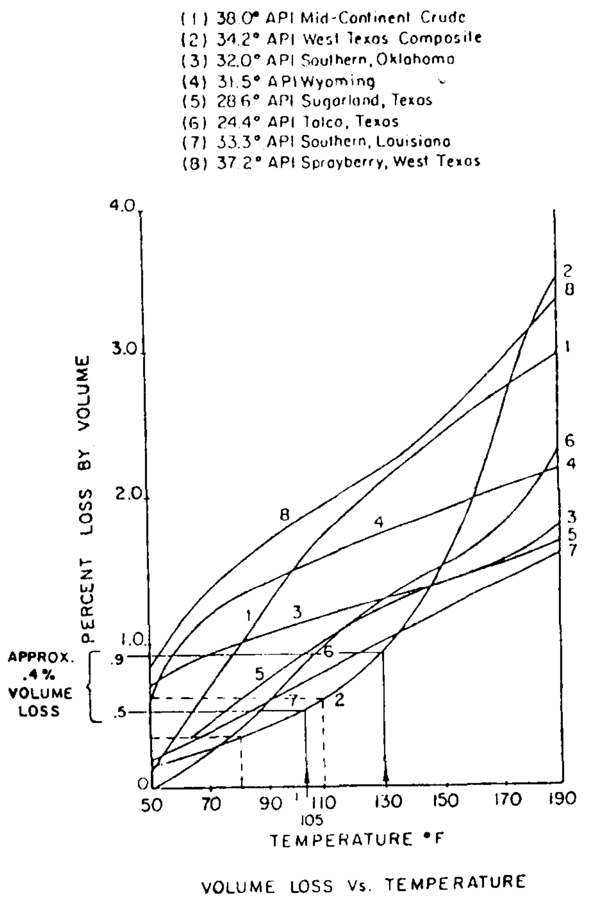


FIGURE 5

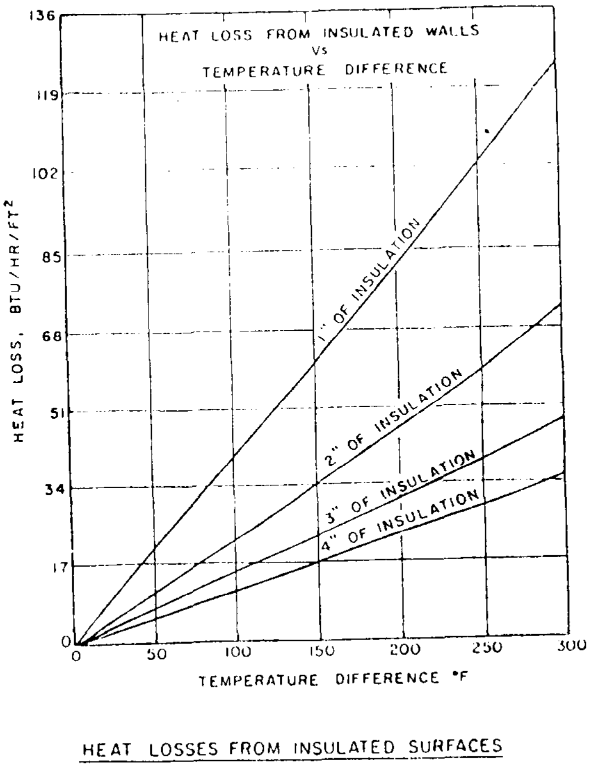


FIGURE 6

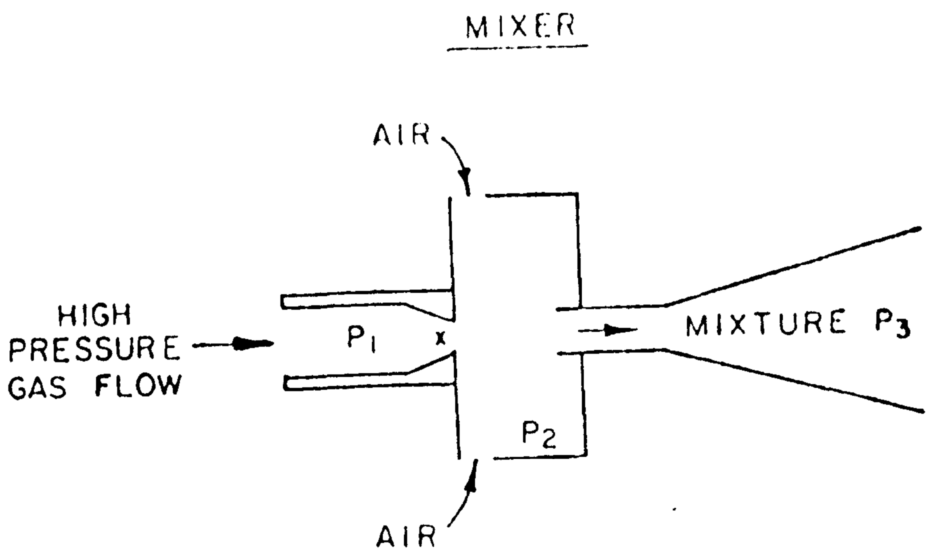


FIGURE 7