Improving Your Profits With Short Cycle Adsorption Units

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Today gas has a value far beyond the wildest dreams of gasmen of 15 years ago. And because gas streams with a high liquid content are getting scarce, the gas industry is required to do the best possible jobs on those streams which are available.

Whether a gas stream is 6 MMSCFD or 600 MMSCFD, some form of hydrocarbon recovery process will be considered during the investigation of the stream's economic potential. In many instances this study will result in the use of a short cycle dry desiccant unit manufactured by one of the major equipment firms. Thus, to realize the greatest profit from the gas stream careful equipment selection is certainly the first step.

EQUIPMENT SELECTION

The whole economic success of the project is at the mercy of the gas sample and its analysis. Certainly the wells must be flowed sufficiently long enough to stabilize the conditions and assure that a representative sample has been taken. Too, the test separator should be run as close to normal operating conditions as possible, and accurate sampling and measurement of test separator liquid as well as of the separator gas should be made.

If possible, the samples should be analyzed by mass spectograph, but a carefully run chromatographic analysis is usually satisfactory for the gas. Since adsorption units are primarily used on lean gas streams, accuracy in determining the small fraction of one per cent C6+ or C7+ in the gas is most critical. But it is surprising how often carelessly taken data are sent to equipment manufacturers by people willing to spend tens of thousands of dollars for a unit which is to be sized and designed on the basis of this data.

The analysis from the laboratory will usually show the GPM content of the gas on a "per component" basis. For a quick evaluation of the stream, one adds the isopentane and heavier GPM and calculate the gallons available:

$$\frac{(\text{GPM})(\text{MSCFD})}{42} = \text{BPD}$$

One should be able to extract a liquid product equal to approximately 85 per cent of the iC5+ fractions. The least expensively stripped down short cycle unit will cost about $40,000; however, major oil companies with their more stringent specifications and additional shut down devices will find this minimum cost to be more like $50,000. And, if the number of BPD available as calculated above cannot support this size of investment, then one should look no further.

Assuming that this first hurdle has been cleared, a second brief evaluation should be made. If the iC5+ GPM is 0.35 or less, then one is in the economic range of an adsorption unit. From 0.35 to 0.5 GPM is a zone which – depending on other factors such as gas volume, distribution of components in the gas, taxes, available markets, location and the like – may still be in the range of the adsorption unit. Certainly, if adsorption is not economical in this range, it is only because some competitive process can do the job for less investment; over 0.5 GPM iC5+ one is probably in the range for economical extraction by low temperature separatorion, oil absorption, or both.

If it is assumed that adsorption is the process for one's stream, a good job description outlining the scope of the project and giving all pertinent facts is required. A check list of data needed is shown in Fig. 1.

A set of mechanical specifications should be prepared covering the degree of quality that is required and accessory items that are acceptable. One should not load down the unit with unnecessary alarms, shut-down devices, automatic bypasses and the like, for, aside from the cost itself, operators tend to depend on the safety devices rather than give the proper attention to maintenance of the unit. Thus, when the safety devices are called upon to act, they may well be inoperative from rust or corrosion resulting from neglect. Instead one should spend his money on items most likely to increase revenue or decrease operating costs. However, one must make sure that the cost is not out of line with the revenue or savings to be gained.

One must be certain that the equipment manufacturer knows about the special items that he wants or about the special considerations required by the lease location. Nor does one tie the manufacturer so tightly by specifications that he cannot offer one the results of his own engineer's creative thinking. One may miss some good new ideas by designing the job for him.

One should also take a good look at the manufacturer's standard unit and standard accessories before he asks him for a unit designed to his specifications. And one must overcome his own equipment prejudices; he may save money.

The approach must be realistic. A 20 psi pressure drop limitation may sound generous and is, after all, a minor item; however, a 20 psi pressure drop may determine the whole design. It may force the manufacturer into the next size larger piping and valves, increase the tower diameter, limit the tower height, increase the heat exchanger size, and, in the end, cause the manufacturer to charge more money. In an adsorption unit, a 35 psi pressure drop at 800 psig operating pressure is reasonable, but 70 psi is better if one can afford it. To be safe, one should specify the maximum allowable ΔP that one can stand, and he should keep in mind that, regardless of the design pressure, the manufacturer must size the equipment for his operating pressure. A 1200 psi design pressure will cost a large sum if the operating pressure is 300 psi.

This same approach can be cited in regard to skids. Insistance on skid dimensions designed to conform with normal highway limitations may cost for extra flanges and piping or may result in units so campact that normal maintenance on valves and such is almost impossible. On large units one will find it cheaper to omit skids for towers but to retain skid control for valve manifolds, exchangers, and scrubbers.

Also, one should avoid buying more equipment than he needs, but he should get enough to do an adequate job. He should record the temperature from each tower and the hot regeneration gas from the heater. A recording flow controller on the regeneration gas is also needed because this controller will give the operator, in his absence, a printed record of how the unit performed. There is little need, however, to record the temperature of the inlet gas, sales gas, or regeneration gas to the heater unless it is in conjunction with a flow meter used as a basis for payment. One should also provide thermometer wells where check temperatures are needed without putting a thermometer into each of them. As a rule, two thirds of the thermometers are broken off by the end of the first month.

When one asks a manufacturer to bid on a job, one must give him enough time to do the job right. Four weeks will usually allow sufficient time (counting the travel time through the mails) for most equipment quotes; but, if you has asked for several alternates, special design work, or a turnkey quote, then six weeks should be allowed. Why so much time? Manufacturers seldom have men idle who can immediately get onto the inquiry, so they must be given time to finish one job before starting on another. Also, the prime contractor may have to go out for bids on some components, and his suppliers want a little time, too.

Quotations on adsorption units cost from $200 to $1200 each, depending on size, detail, and the scope of the job. Estimates, on the other hand, cost from $10 to $50 and are usually accurate within 5 to 10 per cent on units which are close to the manufacturer's standard. If one needs a budget figure, he should ask for an estimate. Suppliers realize that these estimates are necessary and are most appreciative of one's understanding of their problem.

The job of evaluating quotations on adsorption units is no easy task, for cost, recovery, quality of materials, unit design, flexibility, delivery and service all are important. No simple "rule of thumb" can be offered here; however, some of the more common pitfalls can be mentioned.

Because of the limited knowledge of adsorption by the industry, some companies tend to judge the adequacy of a manufacturer's proposal solely by the quantity of desiccant that he is exposing to the gas stream in lbs per day; however, this tendency is not only misleading but has also resulted in oversizing equipment. Two manufacturers of short cycle adsorption units use part activated carbon and part silica gel in their towers. Activated carbon weighs 28 lb/cu ft as compared to 45 lb/cu ft for Davison silica gel and 50 lb/cu ft for Mobil Sorbead. For some hydrocarbon components activated carbon has a greater activity per cu ft than have the two silica gel based desiccants. Therefore, to make a comparison on a pound for pound of desiccant basis would lead to erroneous conclusions.

Also, all process methods are not the same. Because of the "resaturation effect" of the open cycle regeneration system, a three tower conventional adsorption system is only about 80 per cent as efficient in desiccant usage as is an equivalent two tower closed cycle system. Some manufacturers have attempted to compensate for this difference by using 20 to 25 per cent more desiccant, and it soon became apparent that customers unaware of the efficiency difference assumed that with the more desiccant exposed to the gas stream per day the more product one could recover. This method of evaluating equipment has, in some instances, led manufacturers into offering greatly oversized equipment.

The following comparison illustrates this point more positively:

In each case the gas stream was the same in composition, volume, pressure and temperature. Also, the tower size and desiccant capacity were identical in each case. Too, all units illustrated were open cycle systems. Only the time cycle was varied:

	Case I	Case II	Case III
Cycle Time, Minutes	48	30	20
Relative Exposure, Per cent	100%	160%	240%
Recovery of 12# RVP Product, BPD	73	74	71

Recovery varied less than 5 per cent although desiccant exposure in Case III is 2.4 times that in Case I. And one can see, in comparing Case I with Case III, that, if a unit is properly sized for the liquid content of the gas, additional desiccant exposure uses fuel but gets no more production. Too, a comparison of Case II and Case III shows that excessive desiccant exposure begins to decrease recovery after the optimum has been reached.

It can be safely assumed that other factors such as composition, condensation efficiency, and product desired are exerting a significant effect at this point. Obviously, volume, composition and equipment size will affect the optimum cycle time in each instance. In the above, the optimum cycle is closer to 30 minutes than it is to 48 or

CHECK LIST FOR ADSORPTION

1. Company Name
2. Lease or location name.
3. Design pressure of unit.
4. Minimum operating pressure.
5. Maximum gas volume at minimum operating pressure.
6. Operating inlet gas temperature.
7. Design gas volume for maximum recovery.
8. Operating pressure at design gas volume.
9. Is stabilization required?
10. Product(s) desired?
11. Outlet water content, #/MMSCF.
12. Electric power available? Volts, cycles, phase.
13. Water available? Amount? Temperature? Treating required?
14. Gas Analysis, Mol %:
    - N_2
    - H_2S
    - CO_2
    - C_1
    - C_2
    - C_3
    - iC_4
    - nC_4
    - iC_5
    - nC_5
    - C_6
    - C_{7+}
15. Characteristics of C7 : Mol Wt.? Gal/mol?
16. Is free liquid present? Amount? Analysis? Disposition?
17. Equipment quotation?
18. Turnkey quotation?
19. Storage required? How much?
20. Special considerations.

Fig. 1

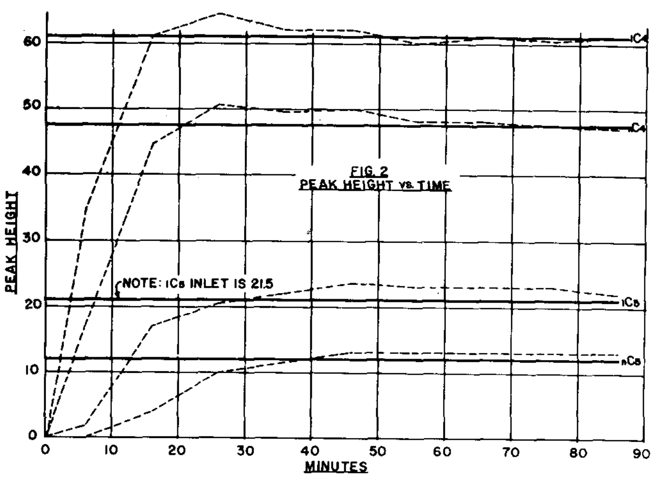

FIG. 2
PEAK HEIGHT vs TIME

20. Smaller towers would have shifted the optimum toward the shortest time, while smaller volume would favor the longer time.

What about the diameter and height of the towers one uses? The liquid load that one expects to remove will determine how much desiccant is required. In about 50 per cent of the cases the vessel size is determined by the volume required to hold all of the desiccant, especially when the gas stream has a sizeable liquid content. In such cases, tall and slender towers are used both for the process as well as the cost advantage to be gained.

On the ultra lean gases, however, pressure drop through the bed is limiting. Thus, the allowable bed depth is determined by the volume of gas flowing per sq ft of cross sectional tower area at flowing pressure and temperature. A reasonable pressure drop limit for minimum desiccant breakage is about 10 psi. It would be a good idea to put such a pressure drop limit in one's specifications and, at the same time, to ask the vendor what the maximum gas capacity of his unit will be with a 10 psi pressure drop across the bed.

INSTALLATION

An adequate foundation must be provided for both the unit and the heater, and the piping must be properly supported and, when recommended by the manufacturer, expansion bends must be included. Expansion bends should be designed for lower stresses than normal because of the frequent temperature cycling inherent in these units. One should forgo the urge to beautify the lease; instead, he should buy an inlet scrubber. The desiccant protection that the scrubber affords is well worth the cost if one saves even one desiccant charge from destruction.

IMPROVING OPERATIONS

After the installation has been completed, the manufacturer will probably furnish a service engineer to check out the unit and start it. At this point the responsibility begins to shift from the manufacturer to the customer, and more difficulty surrounds this portion of the project than does any other. To understand the problems one must look for the reasons behind them, i.e., the nature of the equipment, the nature of lease operations, and the changing economic climate of the gas industry.

Many companies today are still undecided about the classification of adsorption units: are they gasoline plants or production facilities? Often the selection of the unit is handled by district or division level staff engineers who are experienced in gas and gas treating problems and who will, generally, do a creditable job in determining the economic limits and sizing of the equipment. Then after purchase, the unit is turned over to production people to operate, but this practice, while having merit, introduces two expensive problems: (1) the gas plant people selecting the equipment tend to gold-plate the facility; and (2) production people, on the other hand, will generally operate the unit with the same degree of attention that they give a separator or heater. The reasons for these practices have roots in past economic pressures, pressures which are now changing.

When compared to oil or gas condensate wells, gasoline plants have always been looked upon as long term, slow paying investments. Consequently, gasoline plant people are conditioned to operate their plants to high extraction efficiencies and to continually improve their operation. Thus, since even a single day's shutdown is very expensive, elaborate equipment has been utilized to insure continuous operation; and, during the last few years, as economic pressures have increased, a number of large gasoline plants have become so fully automatic that operators are required only in the daylight hours. Production departments, on the other hand, have never been faced with the need for maximizing the profit from leases. In fact, several of today's major companies began by extracting liquids left in the gas by the producers.

However, with the economic squeeze now being placed on the oil industry, production departments are beginning to realize the necessity for getting the most from their leases. It has been said that, in the oil patch, the pumper has the best job: good salary, regular hours, easy work, and little supervision. The industry has been paying for a skilled worker but quite often has allowed the pumper's job to degenerate to the equivalent of that of a cemetary caretaker. Automation has encouraged this laxity to a point where many pumpers are losing the skills that they had only a few years ago.

One question that comes up with amazing regularity is "Doesn't all this automatic equipment make the pumper unnecessary or at least require less skill?" The answer is "No". Less labor is required in operating the equipment but more skill — a different skill — is required. Certainly the automatic pilot and similar devices on aircraft have not decreased the need for skill on the part of the pilot. If anything, the pilot needs more skill now than he ever did before: in fact he must have a working knowledge of equipment which did not even exist a few years ago. However, this automatic equipment does make it possible for a pilot to fly an airplane carrying five times as many people as did planes of a few years past.

Another question that frequently arises is, "Why not design the equipment to be simple so that skill is not needed? We must, after all, operate with the people whom we now have." In answer, manufacturers have kept these units to be as simple as efficient performance and current knowledge will allow. In short, one must train his personnel to operate the equipment required to do the job if one expects to get the most from his gas stream.

At some place in the agreement made at the time of purchase one has probably stated that the manufacturer will train his personnel in the operation of the unit. However, the clause "to train" suffers from a difference of interpretation between customer and supplier. For example, at least one major oil company has concluded that training personnel is largely their responsibility, but pumpers (and others) know that the service engineer has no authority over them; therefore, they tend to look upon him as one who is to cater to them rather than instruct. Further, the pumper knows the service man will not allow the unit to get into serious trouble so he rely on the service man rather than learn from him. Then when the service engineer packs up to leave, he is suddenly confronted with more questions in five minutes than all those that he had answered since coming onto the lease.

Training should be undertaken by someone who is in the customer's company and who has authority or at least the backing of the local supervisor. The pumper should be trained in the operation, adjustment, repair and/or replacement of every control, valve, relay, and instrument on the unit. He is entrusted with the responsibility of an installation which costs from $40,000 up — the least that the operator can do is see that the pumper is properly trained for the job.

It may also be advisable to have a staff engineer from the home office do the training. If not, a local engineer should undertake to become versed sufficiently in the operation of the unit so he can teach others.

Besides training pumpers, the operations can be improved by the addition of several tools. For day to day operation, a liquid meter is one of the best tools for use in "tuning" a unit to maximum recovery. The meter is installed in the liquid line and between the regeneration gas separator and the dump valve, so the liquid make from each tower can be observed from cycle to cycle. Then, to obtain maximum recovery, regeneration gas flow rates and temperatures can then be varied. Sometimes a removable spool piece is furnished for the liquid line so that the meter can be removed and used at other locations.

The most useful tool which can be used to understand the workings of an adsorption unit is a chromatograph. Certainly, any company with sufficient gas production to warrant an adsorption unit should make a chromatograph available to its personnel. One or more people in each area should be trained in its operation and to the point that comparative analyses can be made.

The performance of a unit can be accurately checked with a chromatagraph (Figs. 2, 3). In Fig. 2 is shown a two-tower closed system which has been operating on cycle too long. The horizontal lines represent the peak height of the chromatagraph for each component as it is in the inlet gas. The dotted irregular lines are the peak heights of these same components in the sales gas. For any component the area under the horizontal line represents the amount of the component which entered the unit during the cycle. The area under the horizontal line and to the left of the dotted line for the same component represents the amount recovered. Therefore, the ratio of the smaller area to the larger is the fraction of the component extracted.

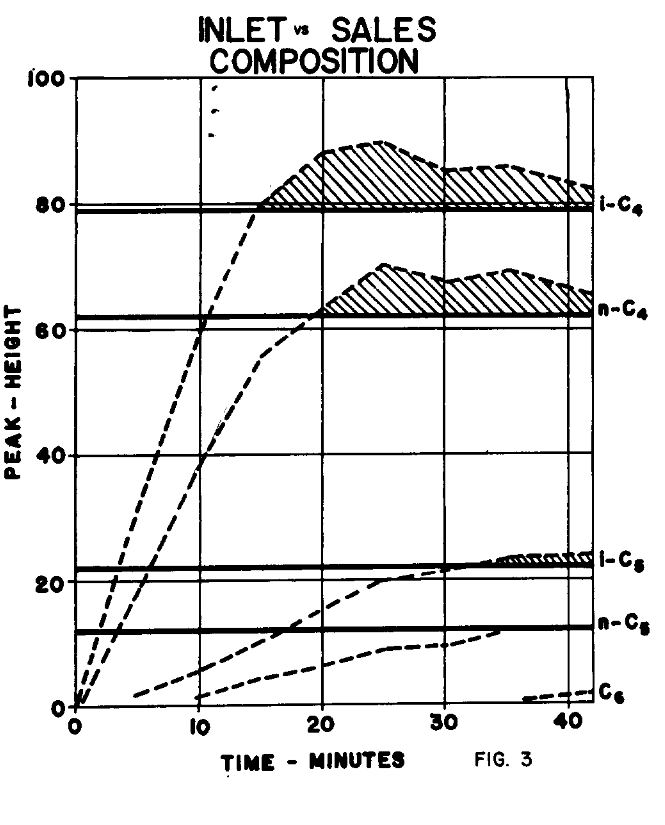

FIG. 3

One should note the shaded area in Fig. 3. Some of the components indicate a higher concentration in the sales gas than in the inlet stream. This increase means that material previously adsorbed is now being rejected from the bed by the encroachment of heavier components. Obviously, the shaded area must be taken into consideration when one calculates the percentage recovery of a component. It should also be noted that nC5 appears in the sales gas stream after the unit has been on stream for six minutes and that no additional material can be adsorbed after forty minutes.

Fig. 3 is also a two tower closed system, but it operates on a 42 minute cycle. In this case nC5 does not appear in the sales gas until after ten minutes and until it has reached the equilibrium point at the time of switching.

Graphs such as these, made every few months, can, by comparison, indicate bed activity decline, inadequate regeneration, inlet gas composition change, and efficiency of extraction.

Production records are kept on most units. But how many are used as production tools? A daily plot of recovery in barrels/million can often spot trouble in the making or often predict the time for bed replacement.

The automatic feature of these units have been oversold to some extent. "Unattended" does not refer to maintenance but daily inspection and a sensible preventative maintenance program can go a long way toward keeping equipment operating at its peak. The short cycle units are simple enough that any man with a reasonable amount of mechanical skill can operate and maintain them, and certainly sufficient spare parts should be kept for vital controls.

Employees have a habit of adopting the attitudes of their supervisors. If the supervisor shows consistant interest in a good maintenance program as a method of getting the most from a unit, then the operator will generally adopt the same viewpoint.

WHAT IS NEW IN ADSORPTION

One can expect continued improvement in adsorption equipment in the future. To this already important process has been added a new wrinkle: the two-stage process. It has long been known that the hydrocarbon and water brought in by the feed gas is adsorbed primarily on the top part of the bed. If the tower is kept on stream too long, the water tends to occupy the bed and force the hydrocarbons out into the sales stream. Thus one should shorten the cycle and stop the encroachment before it gets too far. However, as can be seen in Fig. 3, even at best one picks up less and less of a given component as the adsorption time goes on. When it is time to regenerate a tower in a two or three tower system, the whole tower must be regenerated even though most of the desirable products are in the top half. Approximately 80 per cent of the heat goes to heat the desiccant and the metal parts of the system, but, in the two stage unit, this problem is overcome by regenerating only the top half of the tower — the part with the majority of the product — while the bottom half of the tower retains any product

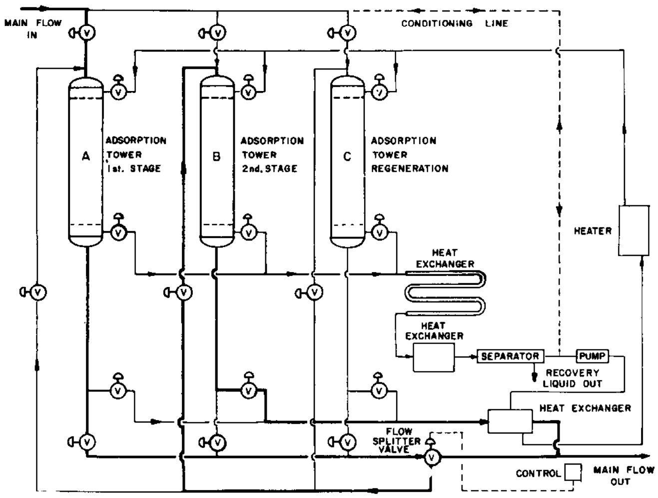

FIG. 4

which may have slipped by the top half. Also, the regeneration heat is not wasted in heating the bottom portion of the bed. In actual practice, the top and bottom parts of the tower are put into two vessels which are side by side, and the gas stream then flows through the two vessels in series.

To get the full picture, one follows the flow diagram (Fig. 4). Feed gas enters Tower A and flows downward; then, leaving Tower A, the gas, now stripped of its heavy ends, is diverted, by a "flow splitter valve", through Tower B. Tower B is hot, having been heated previously during regeneration, and the flow splitter valve, operated by a temperature controller sensing the sales gas temperature, diverts only a portion of the gas through Tower "B" in the beginning. But, as Tower B cools, more and more gas is diverted through it until all the gas from Tower A now flows through Tower B. Then, by the time when Tower "A" becomes loaded and recoverable hydrocarbons begin to slip through, Tower B is cool and ready to pick up this overflow from Tower A. In short, stripped gas from Tower A is the gas that cools Tower B. A separate cooling cycle is not required. Tower C, having been saturated on the preceeding cycle, undergoes regeneration in the conventional manner. Gas from the regeneration scrubber is picked up by the compressor and pumped through the preheat exchanger to the heater. From the heater the gas emerges at 620° F. and enters Tower C, and heating it thoroughly and drives off the hydrocarbons and water. Then the heater is bypassed a few minutes before the end of the cycle, and this process cools the top few ft of the bed and brings the outlet gas from the bed to its peak temperature. Gas from Tower C goes through the air cooled exchanger and gas-to-gas exchanger where the products are condensed, and water and hydrocarbons are separated in the regeneration gas scrubber.

At the end of the cycle, Tower B, which has been preloaded to a slight extent, goes on stream. Tower C is ready to become the second stage in the new cycle, and Tower A begins regeneration.

Four advantages are gained in this process:

1. More efficient use of the desiccant is obtained than can be obtained by either the two tower or conventional three tower unit.

2. More efficient use of the heat is obtained by the possible heavier bed loading (gal/cu ft of desiccant).

3. Heat recovery is accomplished similar to the conventional three tower system.

4. High condensation efficiency is obtained in the regeneration system as it is in the two tower unit.

The appearance of this new process in adsorption will not eliminate the older types of unit, for at this point economics comes in: as in most things, efficiency comes with a price tag attached. The two stage process will generally show its greatest advantage when the diameter of the towers are set by the amount of desiccant required to do the job rather than by the volume of gas flowing. Roughly, a two stage unit can produce almost double the quantity of liquid than can a two tower (single stage) unit with the same size towers. Too, the equipment will cost only about 35 per cent more than will the two tower unit.

The oil and gas industry in the United States is well past the lush period of easy profits when sloppy production methods could be tolerated. Pure economic necessity has made automation of all phases of the oil business important. Certainly, production departments must take advantage of new processes and equipment if they expect to come out on top.