CONVERTING REFORMER FURNACES TO FUEL OIL FIRING

By:

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Conversion of some of the gas-firing reformer furnaces of ammonia plants to fire fuel oil is now under way; it is also being actively studied for others. The circumstances which are responsible for such conversions have been well publicized. All major ammonia producers potentially face this situation.

The reformer furnaces of the present generation of ammonia plants play a dual role. In addition to their basic function of synthesis gas generation they also contribute significantly, together with extensive waste heat recovery, to supply of power steam. Accordingly, the vital nature of making a major change in the energy supply can not be overstated. A comprehensive review of what conversion involves is certainly warranted.

Primarily, a fundamental aspect of conversion is attributable to the functioning of these furnaces as very large reactors. Process considerations and the components utilized require carefully controlled, uniform heat liberation. Although total heat release for process purposes ranges from 275 MM to 800 MM BTU / HR., a plurality of relatively small liberation burners is employed. These have ratings of from 0.8 to 4.0 — 4.5 MM BTU / HR. Certain furnace designs place them in close proximity to the catalyst tubes in which the gas reforming reaction occurs. This is illustrated by Figure 1, an interior view of a gas-fired Terrace Wall furnace. By contrast, conventional large scale utility steam generators are adapted for high release firing of lower grade fuels, usually with bushy flame characteristics. Figure 2, a view of the interior of this type of furnace, depicts such firing from the customary large burners. It is quite apparent from these examples that severe constraints apply for converting reformer furnaces from gas to oil firing because of their proscribed approach to energy release.
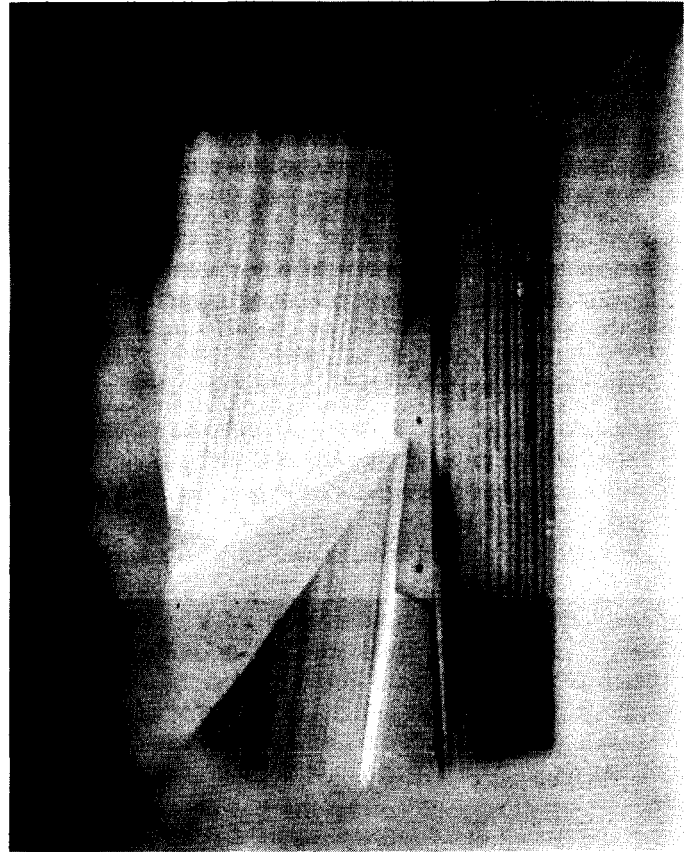

FIGURE 1

For typical reformer furnaces, shown by Figures 3 and 4, gas firing simplified matters considerably; availability of gas offered little incentive for firing oil. It is to be noted that ammonia plants require outside fuel input other than for the purge and vent gas they produce. Burning these in

FIGURE 2

any case will provide, at most, no more than 15 to 20 per cent of the fuel required, usually less. In many plants where nitric acid is produced from the basic ammonia product, it is advantageous to use the ammonia unit purge gas in the nitric acid units rather than as fuel in the reformer furnace. Altogether, such dependence upon natural gas as fuel has led to an industry-wide problem of major proportions.
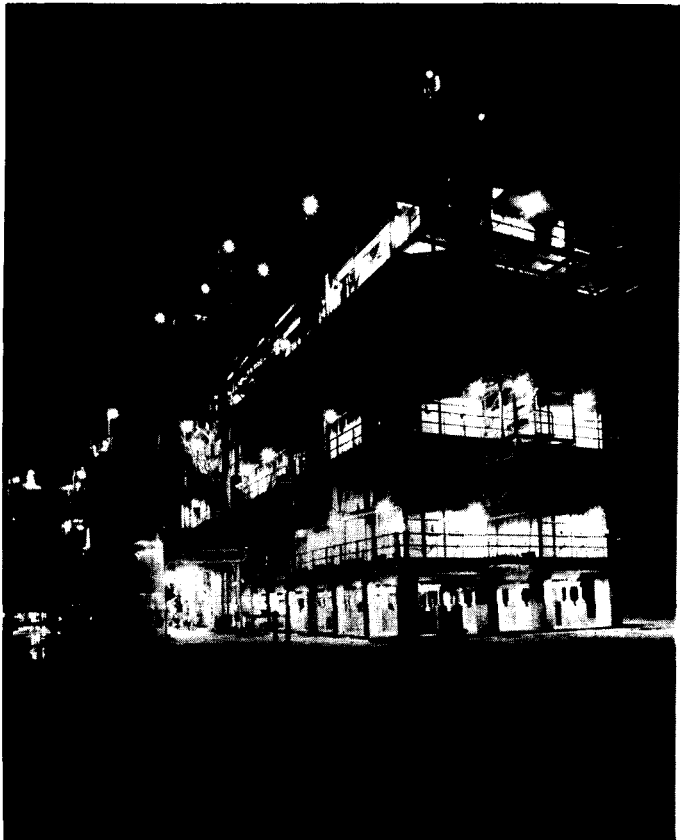

FIGURE 3

This brief summary explains why conversion of the present generation of large capacity ammonia plant reformer furnaces from gas to oil firing is not a simple matter. Only the major difficulty has been cited. Others of lesser importance, but also of substantial magnitude, will be introduced later in this discussion. Conversion of reformer furnaces from gas to oil firing can be characterized as easier said than done.

Work to date on plant conversions has disclosed general unfamiliarity with oil burning technique and practices throughout the industry. It is thus appropriate to present a brief review of the fundamentals to facilitate understanding of what conversion involves.

FIGURE 4

BURNER TYPES AND PRACTICE

Prior to discussing the various liquid fuels and limitations which prevail in their use, also other related matters, the types of oil burners will be described. These fall into two general classifications, fluid assist or atomizing, and mechanically atomizing. Most liquid fuels fired are of heavier grade than motor gasoline, which for automobile engines is vaporized into the air to provide the combustion mixture. Their volutility characteristics preclude vaporization. The function of the oil gun of a burner is to disperse the oil into a fine mist of tiny droplets.

Atomizing or assist type guns illustrated by Figure 5, usually utilize steam, but in some cases air, to promote formation and dispersion of these fine oil particles. Both the oil and steam, under pressure, are combined in the body of the gun prior to passage through a small nozzle which performs the atomizing function. The spray mixture then passes through distribution ports of the tip for purposes of achieving good flame pattern. A primary air register surrounds the gun to direct a regulated quantity of air directly into the spray to facilitate ignition. The balance of the combustion air passes through secondary registers, and in very large burners even tertiery registers, to envelope the ignited spray and complete combustion. By this means flame is established and propagated. Good combustion is essential to minimize soot formation and unburnt oil droplets,which lower efficiency, in that the full heating value of the oil is not realized. These also foul the tube banks through which the combustion gases pass, impairing heat transfer effectiveness.
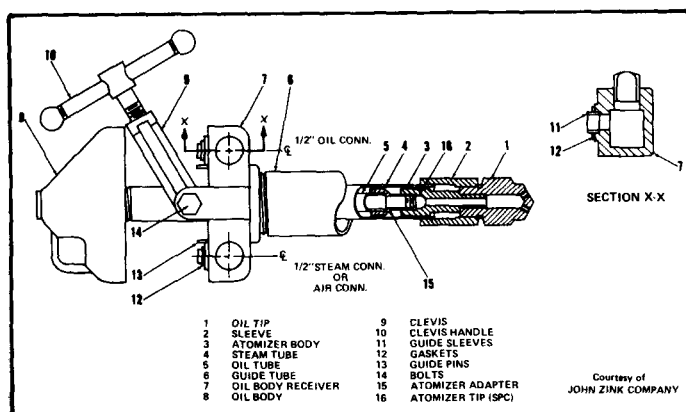

FIGURE 5

1	OIL TIP	9	CLEVIS
2	SLEEVE	10	CLEVIS HANDLE
3	ATOMIZER BODY	11	GUIDE SLEEVES
4	STEAM TUBE	12	GASKETS
5	OIL TUBE	13	GUIDE PINS
6	GUIDE TUBE	14	BOLTS
7	OIL BODY RECEIVER	15	ATOMIZER ADAPTER
8	OIL BODY	16	ATOMIZER TIP (SPC)

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Mechanically atomizing oil guns rely on the effect of high pressure alone to achieve droplet formation. They are better suited to lighter grades of oil and are quite sensitive to fouling. A number of tiny holes are utilized in the burner tip for breakup of the oil into the desired mist. Primary and secondary registers again provide air for ignition and proper combustion. Any foreign material in the oil, or oil of poor quality which may congeal in the holes, causing plugging, will affect flame pattern and proper combustion. Obviously, mechanically atomizing oil guns lack the effect of the atomizing steam or air as a means of maintaining clean ports besides aiding formation and dispersion of the droplets. Mechanical atomizing dispenses with the additional piping system and source of supply for the atomizing agent, but requires a high pressure fuel supply. Because of the limitations cited, it is in limited usage.

Only nominal pressure is required for firing gas, higher for air inspirating types of burners than for raw gas burners. Steam or air atomizing oil burners require pressures of up to 150-160 psig; mechanically atomizing burners require several hundred pounds pressure. Good mixing is required for gas, as well as oil, but is much easier to achieve. Heavies in gas will plug burners more likely with raw gas type than air-inspirating, but the incidence of burner fouling is considerably less. Fires are much easier to adjust, and excess air can be safely carried at lower levels, 10 per cent to 15 per cent, compared with 20 per cent to 30 per cent, unless gas heating value is variable. In both cases firing rate is controlled by pressure but there is much greater latitude with gas, affording a higher rate of turndown. For oil burners this is limited to about four to five. However, the unvarying heating value of oil is a distinct advantage, contributing to stability of operation, as compared with gas fuel when it varies. Also, heavier grades of oil will require heating to maintain viscosity on the order of 3-5 centipoises, for fluidity characteristics ensuring good atomization.

An item to discuss is use of pilots. These are seldom used in gas fired process furnaces although quite common in industrial gas fired boilers. Also, because of safety regulations, such boilers will be fitted with flame detection and proof devices to prevent full operation until satisfactory combustion has been established. Oil firing usually involves gas pilots with spark ignitors. In process furnaces firing oil with a relatively small number of large capacity burners, pilots with or without ignitors are employed for convenience in lighting-off, which is more difficult with oil than gas. Reformer furnaces, as noted previously, usually have a large number of rather small capacity burners, and dispense with pilots because gas has commonly been fired. The only safety device employed has been a Factory Mutual proof system to insure that all burner cocks are closed prior to admitting gas to the burner manifolds, and proceeding with light-off. Practically all installations to date capable of firing oil have been fitted with combination oil-gas burners which can be lit-off on gas, and the oil in turn lit-off from the gas. A continuous gas pilot system for the large number of burners if solely for oil firing would, in itself, consume a substantial quantity of gas, and is otherwise undesirable. Because of the high firebox temperatures which prevail in reformer furnaces, flameouts are a rare occurance. Fuel cut offs from action of interlock systems in response to detection of other operational deficiencies are more common. If the interruption is of short duration, provided all burner cocks have been closed, light-off of individual gas burners in turn can be done from the hot walls. For re-establishing oil firing, in the interest of safety and expeditiously resuming operation, a light-off device such as an LPG torch, or better still, a hose fitted torch piped for gas and air, commonly known as a "rosebud", should be on hand. To avoid oil spills, verify all burner cocks as closed before fuel oil is re-admitted to the system.

FUEL OIL CHARACTERISTICS

Fuel oils, in common usage fall into two general classifications, deriving from how they are produced in refining. The first classification, distillate oils, reflects that they have been fully in vapor form in the distillation section from which they are recovered by fractionation. When withdrawn in liquid form, they may even be steam stripped to drive off entrained lighter material, thus controlling initial boiling point. Distillates are the lighter grades of oil.

The other classification, residual oils, implies that these are bottom products, of heavier character. As a general rule, the volatility of petroleum oils decreases as the liquid specific gravity and average molecular weight increases. Residuals have generally been termed "Bunker" oils from their shipboard usage. Obviously, their residual nature indicates that they will probably be of poorer character than the distillates, and will contain whatever remains, so to speak, in the bottom of the pot.

Trade descriptions of these oils are covered in ASTM Specification D396-69 of which Table 1 reproduced herein sets forth their characteristics.

The table omits heating values for which there is a general relationship with the oil specific gravity. The lower heating value of No. 2 oil is 18,000 — 18,500 BTU / Lb.; No. 6 oil, 17,000 — 17,500 BTU / Lb.

Commenting on these, No. 1 oil is almost non-available and is most likely being used as jet fuel. No. 2 is generally available and is the usual domestic fuel oil. Both grades of No. 5 are not in general usage, but possibly in limited availability. No. 4 is used to some extent, is obtainable to a certain degree, and is the heaviest oil that normally can be fired without heating for handling and to insure proper viscosity at the burners. All of these are distillates. No. 6

TABLE 1

DETAILED REQUIREMENTS FOR FUEL OILS[a]

Grade of Fuel Oil	Flash Point, deg. F (deg. C) Min	Pour Point, deg. F (deg. C) Max	Water and Sediment, volume percent Max	Carbon Residue on 10 percent Bottoms, percent Max	Ash weight percent Max	Distillation Temperatures, deg. F (deg. C) 10 percent Point Max	90 percent Point Min	90 percent Point Max	Saybolt Viscosity, s Universal at 100 F (38 C) Min	Universal at 100 F (38 C) Max	Furol at 122F (50 C) Min	Furol at 122F (50 C) Max	Kinematic Viscosity, cSt At 100 F (38 C) Min	At 100 F (38 C) Max	At 122 F (50 C) Min	At 122 F (50 C) Max	Gravity deg API Min	Copper Strip Corrosion Max	Sulfur, percent Max
No. 1 A distillate oil intended for vaporizing pot-type burners and other burners requiring this grade of fuel.	100 or legal (38)	0[d]	trace	0.15	...	420 (215)	...	550 (288)	...	...	...	...	1.4	2.2	...	...	35	No. 3	0.5 or legal
No. 2 A distillate oil for general purpose domestic heating for use in burners not requiring No. 1 fuel oil.	100 or legal (38)	20[d] (−7)	0.05	0.35	...	[e]	540[e] (282)	640 (338)	(32.6)[f]	(37.93)	...	...	2.0[d]	3.6	...	...	30	...	0.5[b] or legal
No. 4 Preheating not usually required for handling or burning.	130 or legal (55)	20 (−7)	0.50	...	0.10	...	...	...	45	125	...	...	(5.8)	(26.4)	...	...	...	...	[c]
No. 5 (Light) Preheating may be required depending on climate and equipment.	130 or legal (55)	...	1.00	...	0.10	...	...	...	150	300	...	...	(32)	(65)	...	...	...	...	[c]
No. 5 (Heavy) Preheating may be required for burning and, in cold climates, may be required for handling	130 or legal (55)	...	1.00	...	0.10	...	...	...	350	750	(23)	(40)	(75)	(162)	(42)	(81)	...	...	[c]
No. 6 Preheating required for burning and handling.	150 (65)	...	2.00[g]	...	...	...	...	...	(900)	(9000)	45	300	...	...	(92)	(638)	...	...	[c]

a It is the intent of these classifications that failure to meet any requirement of a given grade does not automatically place an oil in the next lower grade unless in fact it meets all requirements of the lower grade.

b In countries outside the United States other sulfur limits may apply.

c Legal requirements to be met.

d Lower or higher pour points may be specified whenever required by conditions of storage or use. When pour point less than 0 F is specified, the minimum viscosity shall be 1.8 cSt (32.0 s. Saybolt Universal) and the minimum 90 percent point shall be waived.

e The 10 percent distillation temperature point may be specified at 440 F (226 C) maximum for use in other than atomizing burners.

f Viscosity values in parentheses are for information only and not necessarily limiting.

g The amount of water by distillation plus the sediment by extraction shall not exceed 2.00 percent. The amount of sediment by extraction shall not exceed 0.50 percent. A deduction in quantity shall be made for all water and sediment in excess of 1.0 percent.

oil of residual character is the general industrial work-horse, but is presently under a cloud because of environmental pollution restrictions in effect. Sulfur content of No. 6 oil is frequently on the order of 3-5 per cent. EPA standards preclude sulfur content in excess of 0.7 per cent. For use in reformer furnaces, a limitation of 0.5 per cent is desirable, for other reasons.

Certain other aspects of oils are to be noted. There is a certain fixed nitrogen content, mainly in No. 6 oil, some of which will form nitrogen oxides when fired. Such oxides are also formed from the combustion air. Various limitations are now in effect for the quantity so discharged to the atmosphere, quite restrictive in some localities. The latter limit the quantity from a single source to as low as 150 lbs. / hr. total. Fortunately, the combustion characteristics of most reformer furnaces are such that this will not be a problem for the usual installation, as it is for large utility boilers.

A much more unfavorable situation is presented by metal oxides contained in oils, again most prevalent in No. 6 oil. The worst offender is vanadium pentoxide. While this can be handled in industrial furnaces where the tubes are not of high alloy materials and are relatively cool, it is a positive menace in reformer furnaces. This was reported by Williams and Sawyer[1] at the last meeting of this group. At temperature levels of 1500° F or higher, vanadium is a fluxing agent for nickel. Reformer furnaces almost universally have catalyst tubes of centrifugally cast HK-40 with a nickel content of 20 per cent, or even higher nickel content alloys, and have metal temperatures of 1500° F and higher. When vanadium is present in other than trace quantities, 5-10 ppm, tube deterioration of a very high and rapid order can be anticipated, precluding the use of that particular oil. This problem has been countered in large industrial and power boilers with uncooled tube supports by use of 50-50 and 60-40 (chromium and nickel) alloys, but these cannot be considered for reformer tube usage. Besides being extremely costly, they are almost unworkable, and do not have physical properties suitable for such an application.

Other metal oxides, of sodium and magnesium, again mainly in No. 6 oil, also are a problem. Corrosive attack is not so drastic or severe, but laydown at temperature levels of 1100° F and higher is a nuisance, and not easy to remove. In large industrial or power units, this laydown is minimized by operating with extremely low excess combustion air, 5 per cent or less. This cannot be considered a viable practice for reformer furnaces which do not, in general, have the highly sophisticated combustion systems which the other units feature. It is thus unlikely for reformers which will be converted to fire oil, hence content of these metals should be limited to about 20 ppm, maximum.

Other hinderances from the bottom sediment and water, and ash content of oils, will be dealt with elsewhere in this discussion.

Summing up, use of oils up to No. 4 has promising possibilities for reformer furnace conversions. Considerable effort is now being devoted to producing low-sulfur heavy fuel oil, and new refining installations have been and are being made. Despite this, there has been no indiciation of significant improvement from the standpoint of metals content. For this reason, No. 6 oil cannot be considered for reformer furnace usage, unless a day-in day-out reliable supply of satisfactory quality can be arranged.

The information so far presented about oil has dealt with those considered standard. Various other grades are also available, particularly in the vicinity of oil refineries. Diesel oil, which approaches No. 2 fuel oil in characteristics, may be obtainable, and is very satisfactory. Also, other distillates with characteristics in between the standard grades and quite suitable for fuel usage are a possibility. None of these should be overlooked when conversion from gas to oil firing is being considered.

CONVERSION APPROACH

In considering the actual mechanics of undertaking conversion, how this is done will depend upon the type of reformer furnace involved. In the case of the Foster Wheeler Terrace Wall type previously illustrated, actual conversion is very much simplified. The original conception of this design visualized combination firing of either oil or gas. Such burners were developed, and installattons have been in service for over ten years. Figure 6 illustrates a typical combination gas and oil burner. To convert a solely gas fired furnace requires removal of the present burners and burner blocks and replacing them with either combination or only oil firing models. Minor modifications of the terraces are necessary, and the proper piping needs to be installed. Also the available draft must be checked, because for the same furnace duty, somewhat more flue gas characterizes oil firing. This applies for all types of furnaces which may be converted. The burners, themselves, are available in corresponding liberations, with oil guns of flat flame type, compatible with the firebox. In short, from a mechanical standpoint, this can be judged relatively simple. Figure 7 is an interior view of an oil fired terrace wall furnace.

These are some furnace varieties, both Foster Wheeler and of competing manufacturers, which employ a flat wall with the burners similarly disposed in horizontal layers. The burner blocks penetrate the walls and the gas heads fire up along the walls. These models also can be converted with almost equal ease. An oil gun of side penetra-

tion type, firing at right angles to its direction of installation has been developed. This is available for making such conversions, and, again, compatibility is afforded.
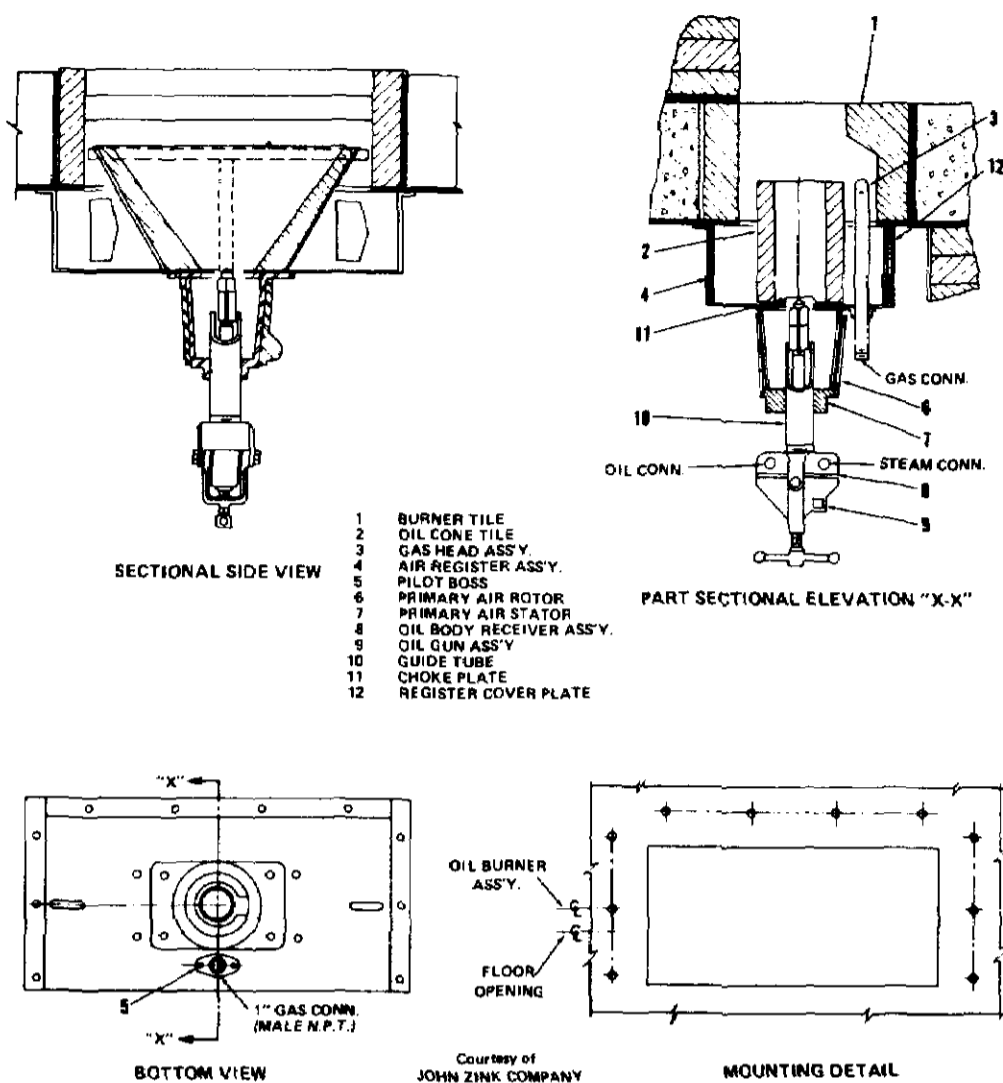
FIGURE 6

SECTIONAL SIDE VIEW

PART SECTIONAL ELEVATION "X-X"

1 BURNER TILE
2 OIL CONE TILE
3 GAS HEAD ASS'Y.
4 AIR REGISTER ASS'Y.
5 PILOT BOSS
6 PRIMARY AIR ROTOR
7 PRIMARY AIR STATOR
8 OIL BODY RECEIVER ASS'Y.
9 OIL GUN ASS'Y
10 GUIDE TUBE
11 CHOKE PLATE
12 REGISTER COVER PLATE

BOTTOM VIEW

Courtesy of
JOHN ZINK COMPANY

MOUNTING DETAIL

FIGURE 7

Another model of furnace in large usage, the top fired type, featuring burners firing downwards between rows of tubes, of which the M. W. Kellogg Co. furnace is characteristic, also has been adapted for oil firing. The reference relative to vanadium attack of high alloy tubes previously cited also reports operation of one of these furnaces firing either No. 2 oil or gas. It mentioned that only a portion of the burners were combination type but that the intention of the operators was to so convert additional burners to increase oil firing capability. Also, this reference mentioned burner plugging, which will be dealt with further along in this presentation. The ability of this furnace to fire oil is thus established.

The particular installation reported upon was built originally for combination firing. The bulk of these installations are for firing gas solely. It will be difficult but by no means impossible to convert them for oil firing because of the roof construction which features a suspended arch. Removal and replacement of the arch will be entailed in order to effect the burner change. Regardless, this large group of ammonia furnaces also can satisfactorily be converted to fire oil.

The remaining group of furnaces in large usage, of which Selas furnaces are representative, is of the type which employs a large number of very small burners, disposed uniformly over the side walls. These burners are of a special short, or no-flame type, which fire directly at the tubes. The large number of burners, by itself, poses a problem. However, the greatest difficulty is the configuration and orientation of the burners, which is not very well suited for oil firing. At the time of writing it does not appear that a proven burner has yet been developed for the full range of oil fuels which could be installed accompanying, or in place of, the gas burners. Such development work has been under way. A burner which is limited to firing No. 2 oil at the heaviest, or lighter material, is available, and could be fitted in place of the gas burners with some changes in mounting. These require a pressurized air system which is a considerable drawback. In various instances the wall burners have been supplemented by floor or roof oil burners firing along the walls. This measure provides a portion of the liberation, and would alleviate, but not fully solve, the situation.

What seems to offer the best possibilities would be to use the floor burners mentioned, and in place of the wall burners, use the wall penetration type previously cited. One or more layers of these could be installed, and the regular burner openings closed off with refractories. This, although quite laborious, would also solve the problem.

Another important aspect of these conversions requires consideration. Many ammonia primary reformers utilize auxiliary firing. The purpose is to increase steam output,

or superheat of steam otherwise produced. It is not needed for process requirements. Furnaces which have their convection banks mounted above the fireboxes are fitted with a firing zone beneath the bank proper. More conventional burners usually are employed for this usage, simplifying the change. What is more apt to be a concern is the auxiliary firebox proportions. Because firing is directed into the large volume of very high temperature combustion gases emanating from the catalyst tube fireboxes, good combustion is not normally a worry. Thus these zones are rather limited in size. In changing over to oil-firing, which of necessity has a very definite flame pattern, improper combustion and impingement on the tubes could result, and must be taken into account. The shortest possible flame is mandatory.

Those furnaces which are top-fired differ in that the heat recovery convection bank is grade mounted, adjoining the reformer proper. What are known as tunnel burners are used. These fire into the interconnecting flue, or immediately before the tube bank. In some cases quite high intensity burners are used. Replacing these with oil burners again introduces the problem of flame characteristics. Whereas many gas applications are relatively flameless, a definite flame pattern always characterizes oil firing. This is only to caution those considering conversion of the need for achieving proper combustion and avoiding flame impingement. Some remodeling of the installation to assure this may be required.

Probably what is the chief drawback to reformer conversion has yet to be mentioned. Beyond doubt, it is the time required, and consequent loss of production. Allowing for the major size of most of the plants, today's ammonia market assures that this will be quite costly. Absolutely minimum time out is essential; whatever measures can shorten this must be adopted. It will be most advantageous·if conversion can be planned for a scheduled shutdown or regular turnaround. Very drastic measures may be justified to assure the availability of components and preparedness for quick installation at such times. Those who have already taken steps towards conversion will testify to the validity of this message.

OPERATING PROBLEMS

Heretofore, only the mechanical problems of conversion have been considered. Other aspects need citing. Varying degrees of extra effort characterize firing oil, as compared with gas firing. Firing oil is a way of life, and it is no accident that gas firing has been so widely used. In addition to what was gas availability until recently, and no economic disadvantage of significant proportions, gas firing makes life much simpler for the operators. Gas needs no special handling and treatment other than a knockout drum in the supply line to drop out moisture and heavy constituents. Burners will plug but only over a long period of time. Cleanoff of the convection bank heat transfer surfaces is rarely needed unless some other improper condition arises, such as spalling of refractories, etc. These points are being noted only to focus attention on the same items where oil is involved.

Proceeding in reverse order variable convection bank cleaning may be expected, depending both upon the oil itself, and how it is handled and fired. It was mentioned earlier that proper combustion was essential to insure little or no unburnt oil droplets, or soot formation. These definitely will deposit on the transfer surface in the convection bank. Such incidence is much more likely with the heavier oils, which will probably contain some ash, as well.

Oil-fired equipment for other services, with expectations of this laydown occurring, is designed to do something about it. Finned transfer surface is avoided, at most studs are used. Soot blower lanes are provided, and the soot blowers installed. Even water wash systems are used. In short, arrangements are made to live with the situation. Few, if any, ammonia furnaces have such facilities. Solid wall convection banks have been used; tubes have closely spaced fins. The necessity of firing the best oil under the most favorable circumstances is clearly indicated.

A convection section rebuild job would be the best way to rectify this, however traumatic the plant shutdown, or costly as well. It is not visualized that this will be done to any great extent. Steam lancing ports may be cut into the walls to permit a manual cleaning job. Although exceedingly laborious, it would help. Water wash systems may also be put in, but will be effective only when the furnace is down. Some oil additives have been developed to minimize these deposits but they are intended for the heavier, lower quality oils. It is evident that everything possible must be done to minimize unnecessary convection bank fouling.

This leads to the burners and their care. It was mentioned previously that the burner tips and ports play a most important role. The reference cited previously for oil firing reported burner plugging. The effect of such plugging is improper combustion, and the result, fouling, also lowered efficiency. It is obligatory that this be handled the best way possible. A substantial number of spare burner guns can be kept on hand in clean condition, racked up by the furnace. As soon as a dirty burner tip is noticed, the gun should be removed, and a clean one installed. The dirty guns accumulate and are cleaned at regular intervals,

then put in the rack, ready for use when needed. The cleanups must be programmed and a cleaning station handy to the furnace provided. Further, it is helpful to give burners a steam purge both prior to lighting-off and before removal from service, by means of cross connecting the steam and oil lines through a block valve.

Still proceeding in reverse direction, oil storage and handling practices have a marked effect on burner cleanliness. Whoever supplies the oil stores it in tanks and delivers it either by tank-wagon or pipeline. Accumulations in tankage are almost unavoidable hence some bottom sediment and water may be anticipated. This should be as little as possible. Deliveries as a matter of routine profitably can be sampled and analyzed at regular intervals because suppliers may become careless. Oil supply contracts should provide for a maximum of such contamination. Enforcing this is obviously beneficial.

The storage system itself requires watching, also as a source of accumulations. Tankage blowdown at regular intervals will be helpful, and facilities for so doing provided. Next, the transfer system must have dual filters of no coarser than 50 mesh. These should also be attended to

at regular intervals, as need warrants. Naturally, adequacy and reliability of the oil pumps is highly desirable. For proper operation, looping of the oil line is desirable, with provision for draining and flushing out, particularly when not in service. Sizing should be ample. Further, depending upon the grade of oil and climatic conditions of the installation, heating, insulation, and even line tracing may be indicated. All of these measures are advocated to contribute to continuity and reliability of operation as well as to minimize burner and furnace maintenance. A final cautionary matter is to provide sloped steam lines with drip pockets and blow points thus preventing water slugs to the burners.

Summarizing what has been discussed, it will suffice to state that merely converting from firing gas to oil is only part of the picture. Considerably more will have to be taken into account in order that such operation will be most effective and efficient, and least troublesome. Hence the aim herein has been to present the picture not only of how conversion can be undertaken, but also what else must be done to insure satisfaction.
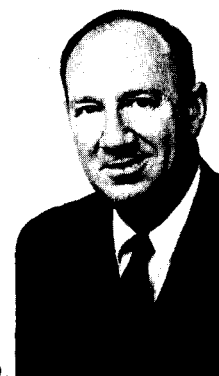
DEMAREST, KENNETH D.

[1]Sawyer, J. G. & Williams, G. P., "Turndown Efficiency of a Single Train Centrifugal Ammonia Plant", AIChE Ammonia Safety Symposium, Vancouver, B. C., 1973.

DISCUSSION

ED JOHNSON, Allied Chemical: When we were burning Bunker C some years ago in our South Point ammonia reformers we found that when we had vanadium we were getting attack, and it seemed to be aggravated by the presence of sodium. Have you found any correlation between the existence of sodium in the attack of vanadium on HK 40 alloy?

DEMAREST: I can't truthfully say that I have but it's quite possible. This is not a simple situation.

JOHNSON: It's very complex

DEMAREST: But the vanadium has definitely been identified as the fluxing agent for nickel.

JOHNSON: We found when we had a vanadium content below one part per million, even with sodium, we were away scot free except that the ash contained in Bunker C oil fouled our convection section. This leads to my second question which is: we found that with any Bunker C we could obtain—and this goes back 10 years ago when you could get some really good Bunker C—that this type of oil had too much ash for what we called our waste heat boilers. I guess you'd call it the convection section now. We'd continually plug up our primary reformer flueside waste heat boilers, because apparently as the gas went through the boiler it also went through the fusion temperature of the ash and we had quite a mess there. How would you cope with this?

DEMAREST: Well, going back to the experience in industrial boilers—and I can assure you we would not build a finned convection bank for this service, at most we'd use studded tubes with plenty of soot blower lanes and adequate soot blowing capacity.

JOHNSON: That might do the job. Our boilers that were giving us trouble were unusual in that they were fire-tubed so that here it was almost impossible to clean them in run. We had a circulating ball system to circulate steel balls and finally we solved it. We went off on to number two oil when the vanadium got too high and solved our ash problem simultaneously.

Q. On your furnace—and this is probably typical of many furnaces—but on your furnace could you actually fire distillate oil or even heavy oil without removing the fin section? There's no way in the world to keep the soot out of that section, is there?

DEMAREST: No. See, we were asked to excerpt our papers. So there's a bit of discussion in the actual paper itself—with the fin tube section only the lightest oil will be suitable, and fired under the best circumstances, which I was trying to emphasize; anything beyond that is going to be quite difficult. It's going to be hard to put in steam lancing doors and to go in there and do something about it.

A water wash is only effective when the furnace is down, and to the best of my knowledge the additives which they have—and they remind me of old-fashioned boiler water compound—seem to be most effective if they are with the heavier fuels. In other words, something built strictly for this type of service would be built accordingly.

But in the meantime I think if people are careful and they follow the—as I say, the prescription of medicine I laid out, they'll be able to get along one way or another.

MARTY FANKHANEL, Heat Research Corp.: I have a comment first with regard to your statement about the Sawyer and Williams paper. I believe the design in this case actually was for 100 percent oil firing and the reference made to an expansion of oil firing in that paper was most likely due to the situation of interruptible gas supply for fuel. It was not a case of a limitation on the capability of fire oil.

In addition, the comment relating to plugging of those burners had to do with the fact that there was an intermittent firing situation. Consequently on some annual or semi-annual basis there was a need to start up a system which had been dormant for a long period of time. This of course created problems with mill-scale, being in piping, and suddenly plugging burners, and of course the usual situation of maintenance. This is a comment, generally.

In addition, I have a few questions for you, Ken. One, you refer to a preferred half percent sulfur limit. I'd like you to comment on the need for that or the desirability of that. And you also mention a vanadium content limit, but you didn't specify exactly what that meant in terms of PPM.

And finally, since this is a safety symposium, I wonder if you'd comment on the subject of flame monitoring of oil firing and the use of—or preference for mechanical safety interlocks in oil firing.

DEMAREST: Well, I'd say that it's almost constituting a new paper. But answering the first part, and they were not questions, they were observations—the tone of my comment was the fact that the ability of that furnace to fire the oil was very well established, and as I read that paper it was indicated that not all the burners were equipped as combination burners, and so I think—well, that will take care of that situation.

And whether it was an interruptible situation or not, the kind of housekeeping I have described is absolutely necessary. Now let's get back to your specific questions. Number one, I think was a matter of sulfur content. Now there, the limitation at 0.5 percent is not for environmental reasons, but what is the peculiar activities of sulfur at a high temperature level in these furnaces, because so operating you get some polymerization and other effects which—this is more from experience than actual data, it is desirable to avoid. And in these particular reformer furnaces—this is a well established history—firing oil up to 0.5 percent sulfur content has been satisfactory.

Now would you repeat your other question?

FANKHANEL: Yes, I referred to the comment about a small amount of vanadium—you didn't indicate exactly what content you suggest as a limitation, say, in terms of PPM.

DEMAREST: Well, in this particular case I would say that most desirably it should be held to not over 5 PPM but definitely not over ten PPM. Now coming back to vanadium, I mentioned in the paper, but did not mention in speaking, that there is quite a movement on foot to produce low sulfur heavy fuel oils now. Major refining installations are being made for this end.

However, I have no information that they are similarly limiting metals content. So in my view I see no future for these oils in reformer furnaces.

FANKHANEL: I had a last question. I know it's a large subject, but as I mentioned it's a safety topic and I wondered if you had a comment on flame monitoring or safety interlocks?

DEMAREST: Well, there is a bit of a discussion about that in the paper. The reformer furnaces present a very difficult problem for flame monitoring because the usual devices are not fully effective due to the hot walls. Now what we call the ultraviolet detector, the purple peeper, can't distinguish between the flame and the wall. Now coming back to safety, flame out in these reformer furnaces is a very infrequent occurrence.

What is much more likely to occur is a cutoff or malfunction in other areas that trips off the SIS system. Now

in this case comparing this with a gas installation—and we have quite a few of them—where the Factory Mutual Burner System is used—you can't come back there until you've proved that the burners are shut off, and if this is of very short duration you can light off from the walls.

Now in the case of oil I can see no use for having the multiplicity of pilots around for all the burners that you have. So someone is going to have to be sure that the burners are all cut off and then you come back with a torch.

Q. What about safety interlocks, Ken?

DEMAREST: Well, I certainly recommend these in any case, but I would say to light off again on oil you've got to do it differently than you do with gas. And you don't want to spill oil all over the furnace either.

Q. In your experience with firing the fuel oil number six, do you have any experience with such fuel with ash corrosion of the lining of the furnace?

DEMAREST: In this case, no. Now I think what you're referring to is that in the mainly refinery practice where many regular heaters have been fired on heavy oil for years, and there's provision for doing this, they have had situations where you have spalling of refractories and that sort of thing, and your sulfurous material gets down behind the refractory and corrodes the casing out.

Now we do not recommend firing that kind of stuff in reformer furnaces to begin with. Or under the same circumstances. Now to my knowledge we have not at any time had a case of casing corrosion in these furnaces, but it is quite common in the normal crude heaters, vacuum heaters and so forth.

Q. I was thinking that the ash might dissolve the actual brick lining. You're probably using a fairly high level refractory in the furnace proper, with the vanadium and other metallic oxides fluxing the refractory.

DEMAREST: Well, I've tried to rule out handling some of those materials because the furnace just can't cope with them. Now answering your question otherwise, the best reference I can give you is an installation which has been operating now in Germany for six years. It's been firing oil in high temperature service through to as heavy as distillate slop, and to my knowledge they have had no corrosion or anything like that.

They've had laydown in the convection bank that they had to clean out but they haven't had actual deterioration.

JOHNSON: In regard to the ash corrosion, we fired oil every winter for about eight years, from 1952 to 1960, and we never had any sign of ash corrosion on the refractory either on gas or oil, and further to what Marty mentioned about the trouble we had with our burners in our Hopewell plant, he's absolutely correct. We did have some trouble switching from gas to oil—due to our seasonal type of firing—switching back and forth—but in addition we found that in trying to get a gas-type flame on Number 2 oil we were exceeding the atomizing steam pressure and in doing the high Delta P cut the burner nozzles from a circle to an ellipse, and when this would happen the oil would dribble out on the wide end of the ellipse and then coke up, but solving this was merely a matter of shifting back to the original design conditions.

DEMAREST: Yes. Well, I think that's a matter of design. Now our burners were designed particularly for this, for the flame pattern. I can tell you—and it's a funny story in our company—New Year's Eve about twelve years ago a bunch of us went down to our pilot plant to see a testing out of a burner because it was going out on a job that was specified; it had to burn 100 percent gas, 100 percent oil or any combination of both.

And to get the proper flame pattern so that the tips didn't interfere, you know, this is a bit of a situation. It isn't something you just go out and get a burner and do.