Originally appeared in:
HYDROCARBON PROCESSING

June 1997 issue, pgs 97-104.
Reprinted with the publisher's permission.

Optimize Fired Heater Operations to Save Money

Use these guidelines and case studies to reduce energy use and extend equipment life

***A.Garg**, Furnace Improvements, Sugar Land, Texas*

Fired Heaters are an essential component of most process plants. They are primarily used to heat all types of hydrocarbons and also hot coils, steam or air. Fired heaters are major consumers of energy and even the smallest efficiency improvements can save thousands of dollars. Typically, most fired heater operations can be optimized to save money.

Guidelines for optimizing fired heaters are presented here. Case studies also illustrate improvements made to some fired heaters. These improvements can save money by reducing energy use and extending the equipment's life.

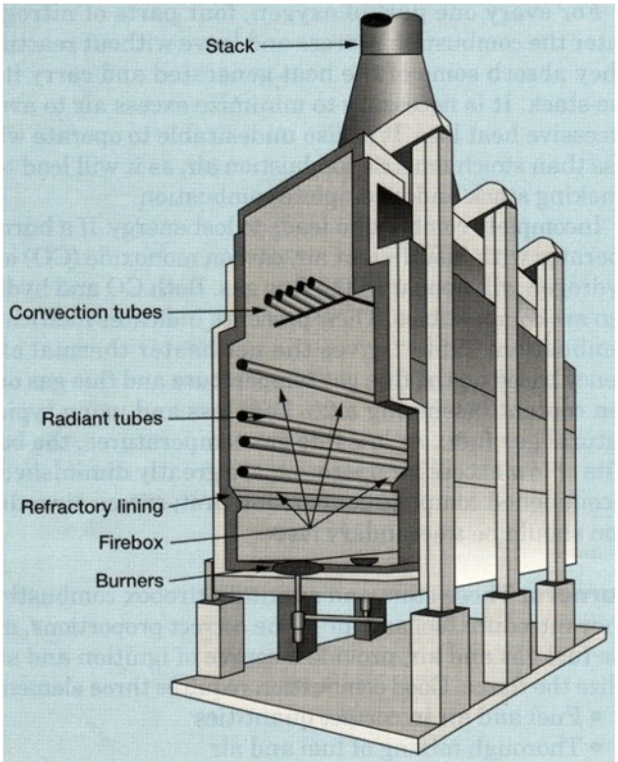


Figure 1: An inside view of a typical horizontal tube heater (reproduced from API-573, 1st edition)

In the refining industry, typical energy consumption is approximately 0.32 MMBtu/bbl of crude oil processed. This translates into 2,667 MMBtu/hr of crude oil processed. This translates into 2,667 MMBtu/hr for a 200,000 barrel-per-day (bpd) refinery. Even a 1% improvement in thermal efficiency translates into energy savings of $600,000 per year. Ethylene plans (22MMBtu/ton of ethylene) and ammonia plants (28.5 MMBtu/ton of ammonia) are equally energy intensive.

Usual problems observed in fired heaters include:

- High excess air operation
- Fouled convection sections
- High stack temperatures
- Overfiring
- Bad flames/flame impingement

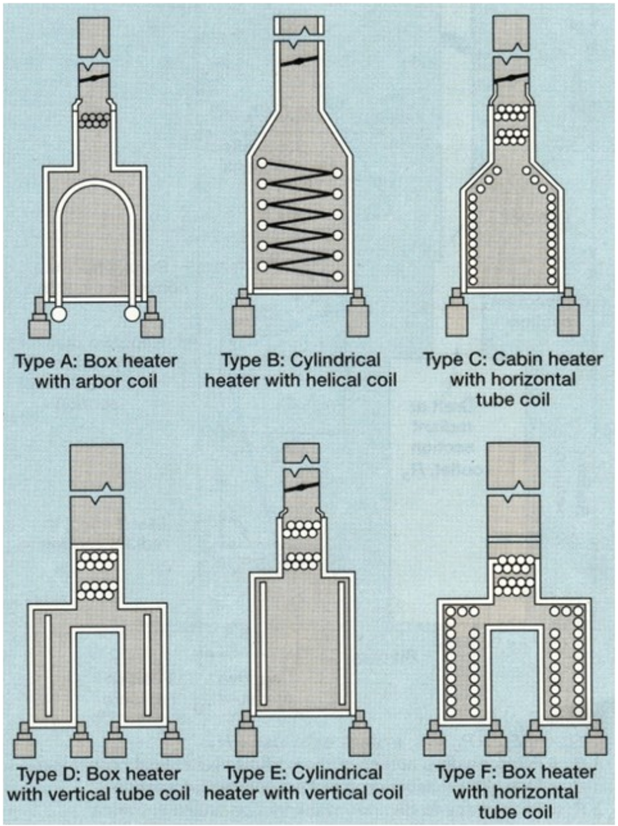


Figure 2: The different types of fired heaters (reproduced from API-560, 2nd edition,, September 1995)

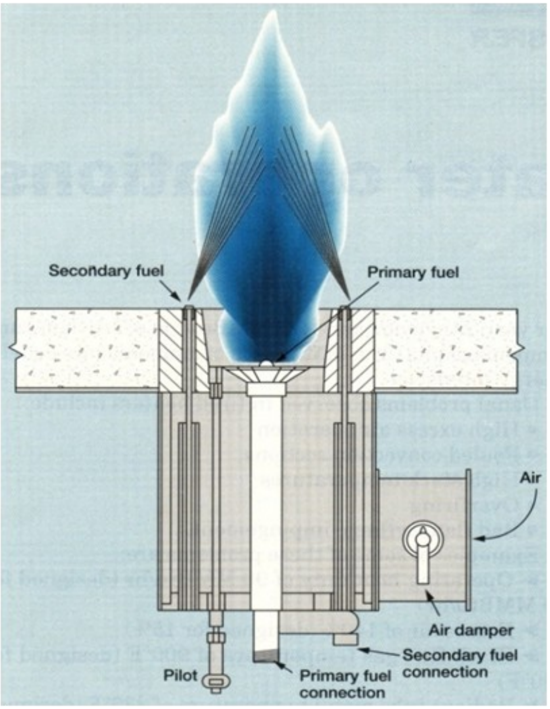


Figure 3: Typical staged fuel gas burner (reproduced from API-535, 1st edition, July 1995)

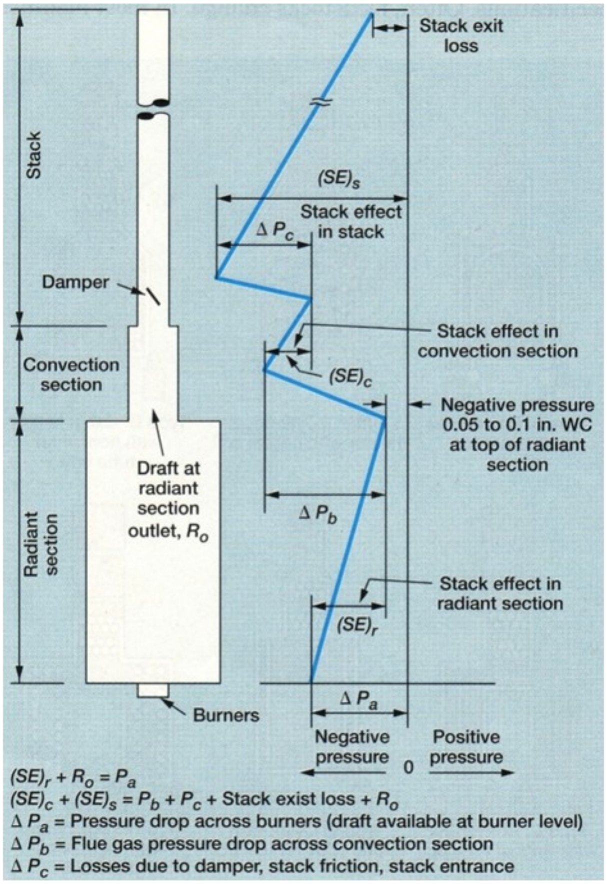


Figure 4: Typical draft profile in a natural draft heater (reproduced from API-535, 1st edition)

Examples of some of these problems are:

- Operating heat duty of 90 MMBtu/hr (designed for 50 MMBtu/hr)
- Excess air of 140% (designed for 15%)
- Stack flue gas temperature of 900°F (designed for 530°F)
- Radiant tube metal temperature of 830°F (designed for 450°F)
- Burner flame lengths of 20 to 25ft (designed for 12 ft).

Fired heaters usually operate above the original design specifications. Often, feedstacks change. In most instances, plant capacity is increased and the fired heater must work harder to deliver the duty. In a few instances, due to a process change, the heater may be working in turndown conditions.

Fired heaters are large and complex pieces of equipment. A typical new fired-heater installation is fitted with an air preheating system and a NO$_x$ reduction system.

FIRED HEATERS

A fired heater consists of three major components: heating coil, enclosure and combustion equipment. Fig. 1 provides a cross-sectional furnace view. The heating coil consists of tubes connected together in series that carry the charge being heated. Heat is transferred to the material passing through the tubes.

The enclosure consists of a firebox. It is a steel structure lined with refractory material that holds the generated heat. Burners create the heat by combusting fuel, either oil or gas.

The heating coil absorbs the heat mostly by radiant heat transfer and convective heat transfer from flue gases, which are vented to the atmosphere through the stack. Burners are located on the floor or sidewalls. Combustion air is drawn from the atmosphere. For increased heat recovery, an air preheater or waste heat boiler is installed downstream of the convection section. Instruments are generally provided to control the fuel firing rate and flow through the coils to maintain desired operating conditions. Fig. 2 shows different types of furnace configurations.

Combustion - Burning or combustion is an exothermic reaction resulting from rapid combination of oxygen with fuel. Most fuels contain hydrocarbons and some sulfur. Since perfect mixing of fuel and air is not possible, excess air is needed to ensure complete fuel combustion. Excess air is expressed as a percentage of theoretical quantity of air required for perfection combustion.

For every one part of oxygen, four parts of nitrogen enter the combustion process and leave without reacting. They absorb some of the heat generated and carry it to the stack. It is necessary to minimize excess air to avoid excessive heat loss. It is also undesirable to operate with less than stoichiometric combustion air, as it will lead to a smoking stack and incomplete combustion.

Incomplete combustion leads to lost energy. If a burner operates with insufficient air, carbon monoxide (CO) and hydrogen will appear in the flue gas. Both CO and hydrogen are combustibles. Their presence indicates inefficient combustion. Table 1 gives the net heater thermal efficiency based on the flue gas temperature and flue gas oxygen content (assuming a 2% heat loss and using typical natural gas fuel). At low flue gas temperatures, the benefits of low excess air operation are greatly diminished. I recommend complete combustion first; excess air reduction should be a secondary issue.

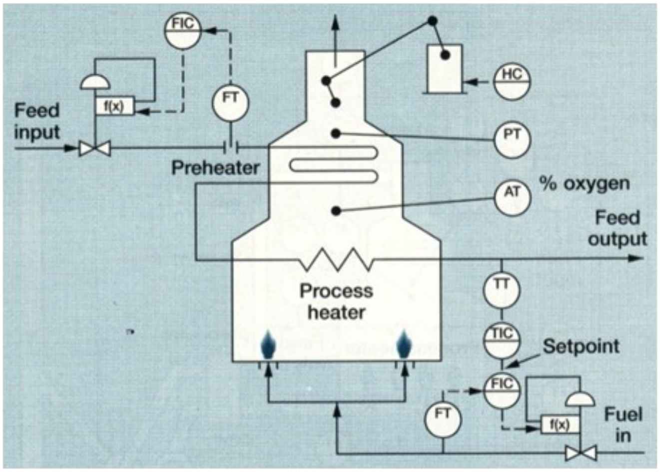


Figure 5: Conventional heater control scheme

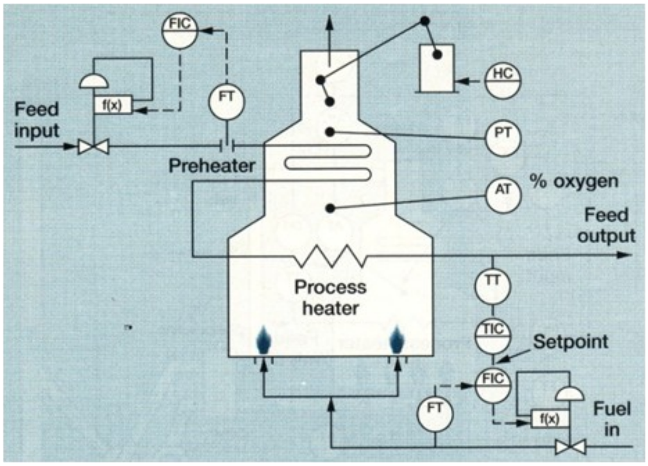


Figure 6: Feedforward control scheme

Burners - These start and maintain firebox combustion. They introduce fuel and air in the correct proportions, mix the fuel gas and air, provide a source of ignition and stabilize the flame. Good combustion requires three elements:

- Fuel and air in correct quantities
- Thorough mixing of fuel and air
- Sustained ignition of this mixture

Burner air register and gas tips control the amount of air and fuel injected into a burner. Fuel gas pressure and air draft provide energy for mixing fuel and air. Burner tiles provide a hot surface for stabilizing and sustaining ignition and provide a flame that is the required shape. The different types of burners available are classified by the fuel burned, air supply or NOx emissions. A typical burner sketch is shown in Fig. 3.

Draft – Hot flue gases inside the firebox and stack are lighter than the cold ambient air. This results in a slightly negative pressure inside the furnace. Combustion air is drawn into the burners and hot gas flows out the stack due to this pressure differential. While passing through the convection section and stack, flue gases encounter friction resistance. Sufficient stack height is provided to overcome these losses and ensure that pressure is always negative inside the firebox. Four types of draft exist.

Natural Draft is the most common type. Air is drawn into the furnace by a draft created by the stack. The taller the stack, the more draft available.

Forced Draft – In this type of system, air is supplied by centrifugal fan commonly known as a forced draft (FD) fan. It provides for high air velocity, better air/fuel mixing and smaller burners. The stack is still needed to create a negative draft inside the furnace.

Induced Draft – When the stack's height is inadequate to meet the draft requirements, an induced draft (ID) fan can be used to draw flue gases out of the heater. Negative pressure inside the furnace ensures air supply to the burners from the atmosphere.

Balanced Draft – When both FD and ID fans are used with a heater, it is known as a balanced draft system. Most air preheating installations are balanced draft.

The heater's arch or convection section inlet is the highest pressure point and thus, is used as a control point. A typical value of 0.1 inches water column (in WC) is maintained at the arch.

A high draft leads to more combustion air drawn into the firebox. Conversely, insufficient draft may lead to positive pressure inside the firebox leading to flue gas leakage from any openings. Fig. 4 shows the typical draft profile across a heater.

FIRED HEATER CONTROLS

Process Side – Fluid heated inside the tubes must be controlled for efficient heat transfer and to minimize tube fouling and coking. Flow distribution at the inlet is very important. All fluid passes should have an equal amount of fluid flowing through the tubes. In most liquid or fouling services, it is important to have an individual pass flow controller to avoid flow imbalances due to coking or localized overheating. A simple control scheme is shown in Fig. 5. Another variation is to use feed forward control. Any load change in the feed minimizes the outlet feed temperature variation.

A number of modifications can be made to this scheme. A common variation is a control scheme where the individual pass outlet temperatures are controlled to ensure a uniform outlet temperature (Fig.6). This scheme works fine as long as the service is not fouling. With coking or fouling services, it does not work satisfactory because it tries to reduce the flow in the pass that is coked and the situation becomes even worse. The pass tends to coke even more at reduced flow.

Fluid flowing through the tubes should have an adequate pressure drop in the fired heater to ensure good fluid distribution in a multiple- pass heater. If the pressure drop across the heater is low, then there is a change for a flow imbalance and the pass may run dry.

Flow regime and coil velocities at the outlet in vaporizing services must be watched. If the tube experiences slug flow or high velocities, then there could be a problem and the tubes will start to vibrate or they can have erosion failure. Table 2 provides a troubleshooting guide for fired heaters.

Case Studies

1. A refinery heater was designed as a four-pass heater in the convection section and a two-pass heater in the radiant section.

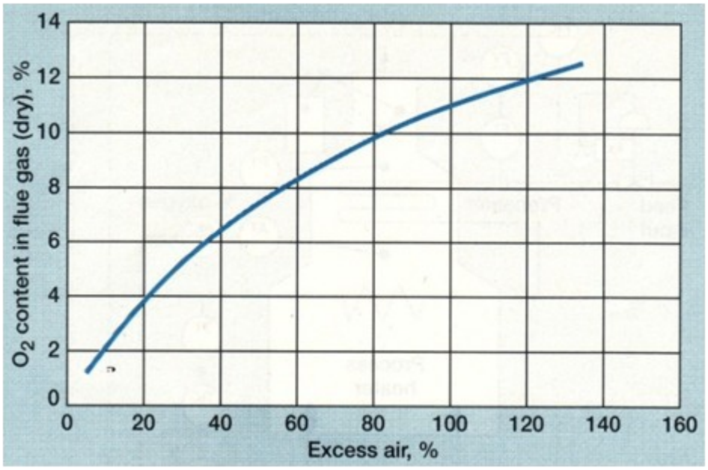


Figure 7. Excess air vs. oxygen content in flue

The client did not have an individual flow controller on each pass (one flow controller for each radiant pass was installed) and had no way of knowing the fluid distribution in the convection section. Fluid pressure drop in the convection section was low. The problem was corrected by installing restriction orifices in each convection pass inlet to increase the pressure drop and equalize the flow.

2. A vertical cylindrical crude heater had an outlet elbow failure due to high tube velocities. The solution was to replace the last 6-in. tube and elbow with an 8-in. tube in both passes.

3. A heater had severe vibration problems at the convection-to-radiant crossover. High vaporization and high velocities were found to be the cause. High vaporization was caused by steam injection into the fluid at the convection inlet. The convection tubes were 4 in. and the radiant tubes were 6 in. The recommendation was to change the steam injection point from the convection inlet to the radiant inlet.

4. A refinery heater was experiencing severe tube vibrations in the heater's arch section. A heater analysis revealed slug flow in two tubes located at the arch. Replacing the two 8 in. tubes with 6 -in. tubes solved the problem.

Firing Controls – Three major parameters that should be controlled and monitored are:

- Fuel gas/fuel oil pressure
- Excess air
- Furnace draft

Fuel Pressure – One of the simplest schemes for controlling fuel pressure is shown in Fig.5. The feed output temperature controller provides the set point for the burner fuel pressure controller. Sometimes the feed outlet temperature is directly connected to the fuel control valve. If the heater is fired with more than one fuel, then one of the fuels is base loaded and set at a constant firing rate while the second fuel under control takes load fluctuations.

Excess Air Control – Excess air control essentially involves answering three basic questions:

1. How much excess air is provided?
2. How much excess air should be provided?
3. How efficient is the combustion equipment?

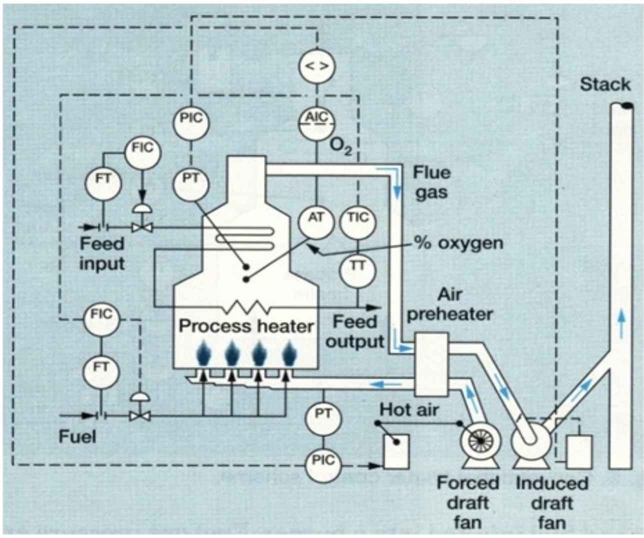


Figure 8. Balance draft control scheme.

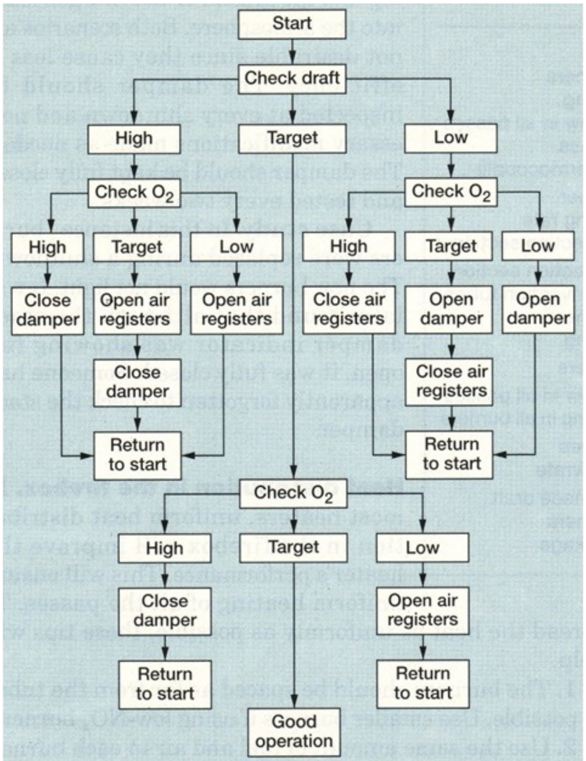
Flue gas analysis provides an answer to the first question. The oxygen concentration in the flue gas is an indicator of excess air to the combustion process. Fig.7 shows the relationship between oxygen content and excess air for a typical fuel gas.

The optimum excess air for a particular type of burner should be known. It varies from one burner type to another and also depends on fuel type. Optimum excess air is the minimum excess air because it minimizes heat loss to the flue gases, minimizes the cooling effect on the flame and improves heat transfer. With less than minimum excess air, unburned fuel will appear the flue gas. Minimum excess air should be specified by the burner vendor and should be verified during burner testing. Typical recommended values are in Table 3.

Excess air levels in low NO_x burners tend to be higher because NO_x is being reduced by delaying the mixing of air and fuel. In many air preheater installations, where a natural draft burner is used with the air preheater, optimum excess air tends to fall between the natural and FD values. The values recommended are for heaters in good condition and with practically no leakage in the box. Appropriate corrections must be made for old heaters.

Furnace Draft – Flue gas analysis is the single most powerful tool available to maximize combustion efficiency. One improved control scheme automatically controls oxygen in the flue gas by varying the furnace draft. This approach is not very successful, since operators do not want to manipulate the stack damper all the time. The quality of the stack damper operating mechanism was always suspect. In natural draft furnaces, excess air is controlled by adjusting both stack damper and the burner registers.

Control schemes have been installed in balanced draft systems to more accurately control excess air and draft. Some of these schemes involve controlling the air/fuel ratio. Several problems have been experienced in measuring the fuel and air flowrate accurately. With fuel gas, the quality (composition) continuously changes in the refinery. For liquid fuels, the viscosity is so high and temperature dependent that a reliable flow measurement over time is difficult to obtain. Combustion air flowrate is also difficult to reliably measure, as straight run-lengths for instruments are not available except when a venture meter is installed in the FD fan's suction stack. Simple, reliable control schemes will save money and headaches. A typical control scheme is shown in Fig. 8.



High draft = Draft at radiant section exit is higher (greater negative pressure) than the target level.
Low draft = Draft at radiant section exit is lower (smaller negative pressure) than the target level.
Low or high O_2 = Flue gas oxygen content at the radiant section exit is lower or higher than the target.

Figure 9. Natural draft heater adjustment flow chart (reproduced from API-535, 1st edition, july 1995)

An oxygen analyzer and a combustible analyzer should be installed in the arch. A single analyzer can handle both. Excess air should be adjusted so the oxygen level in the flue gas as close to the minimum or optimum excess air level. Combustibles should read close to zero during normal operation. The combustible analyzer should not be used to make excess air adjustments, as is the case in some installations. The presence of combustibles is an indicator of poor combustion. Combustion air should not be controlled using CO or combustibles as a guide. This indicates that either the air is deficient or the combustion equipment is not clean, which is generally the case. Dirty burners or poor oil atomization can easily lead to CO formation.

Case Study: A multicell platformer furnace had a common waste-heat recovery unit followed by a stack. The fired heater operation was never below a 65% excess air level despite the burner registers being closed. It was found that the furnaces had a large common stack, 150-ft high, for environmental reasons.

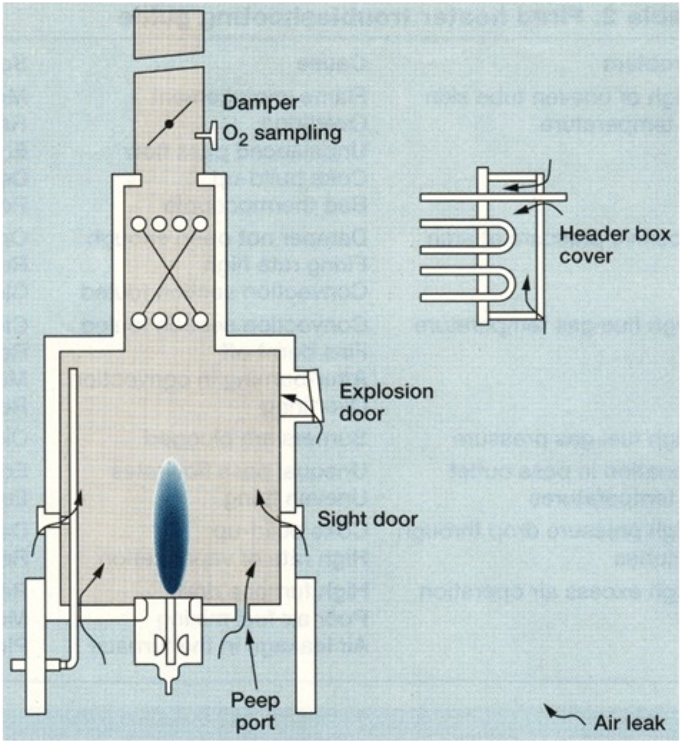


Figure 10. Air leakage in fired heaters.

The large stack was generating almost 0.65 in. of draft at arch instead of 0.10 in. of draft required at the arch. There was no stack damper or any damper in the individual ducts. Result: the client was losing almost $120,000/yr. Modifying the burners cost only $45,000 and the investment was returned in four months.

Draft Adjustment: The arch draft should be kept at a design value of 0.1 in. water gauge. This will ensure safe operation and minimum air leakage. Excess air must be minimized for efficiency improvements. However, sufficient air must be provided to obtain the correct and desirable flame shape and complete combustion. Closing air registers reduces airflow, but increases the heater draft.

Closing the stack damper reduces the furnace draft. To adjust excess air, the stack damper must be adjusted in conjunction with the air registers. A step-by-step procedure to adjust the draft and excess air in natural draft furnaces is shown in Fig.9.

Air Leakage: In most furnaces, the firebox pressure is kept close to atmospheric. Fig. 10 shows the places where air can leak into a heater. As flue gases progress through the unit, the pressure drops and may go down as low as 10 in. WC at a location close to the ID fan suction. The changes of air filtration are highest under those circumstances.

Table 1: Fired heater thermal efficiency % as a function of excess air and flue gas temperature

Excess air, %	O_2 in flue gas, %	Flue gas temperature, F										
		300	350	400	450	500	550	600	700	800	900	1,000
15	3.00	91.76	90.44	89.11	87.77	86.42	85.06	83.60	80.59	78.11	75.25	72.35
20	3.82	91.52	90.15	88.77	87.39	85.98	84.57	83.15	80.28	77.36	74.40	71.39
25	4.56	91.29	89.87	88.44	87.01	85.55	84.09	82.62	79.64	76.61	73.55	70.43
30	5.24	91.05	89.58	88.10	86.61	85.11	83.62	82.07	78.99	75.87	72.69	69.47
40	6.46	90.58	89.01	87.43	85.84	84.24	82.60	81.00	77.71	74.37	70.99	67.55
50	7.49	90.10	88.43	86.76	85.06	83.36	81.64	79.72	76.43	72.28	69.28	65.63

Table 2: Fired Heater troubleshooting guide

Problem	Cause	Solution
High or uneven tube skin temperature	Flame impingement Overfiring Unbalanced pass flow Coke build-up Bad thermocouple	Modify burners Reduce firing Equalize flow in all passes Decoke tubes Replace thermocouple
Positive pressure at arch	Damper not open enough Firing rate high Convection section fouled	Open damper Reduce firing rate Clean convection section
High flue gas temperature	Convection section fouled Fins burnt off After burning in convection Overfiring	Clean convection section Replace convection Modify burners Reduce firing
High fuel gas pressure	Burners are plugged	Clean burners
Variation in pass outlet	Unequal pass flowrates	Equalize flow in all passes
Temperatures	Uneven firing	Equalize firing in all burners
High pressure drop through tubes	Coke build-up High rate of vaporization	Decoke tubes Reduce flowrate
High excess air operation	High furnace draft Poor air fuel mixing Air leakage in the furnace	Reduce furnace draft Modify burners Plug air leakage

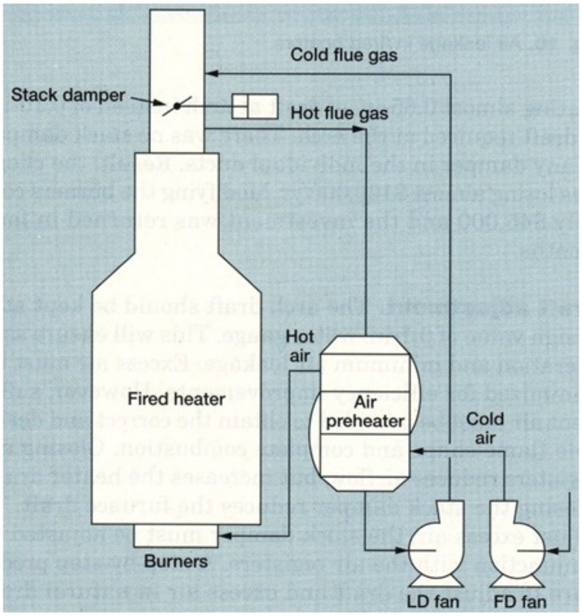


Figure 11. Air preheating sheme

Flue gas O_2 content is best determined as near as possible to the furnace since it will eliminate most of the leakage. A zirconium oxide probe should be used in the heater arch where the temperatures are generally high (1400° F to 1800° F).

To minimize air leakage into the heater, all peepholes must be kept closed. The header box doors must be tightened to eliminate any air leakage. Keep the explosion door closed. Ensure there is minimal air leakage from the tube guide penetrations in the floor.

Damper Operation: Check the stack damper at every shutdown and make sure it is working properly. Natural draft furnaces should be installed with multiple opposed-blade dampers with a rugged operating mechanism.

Damper operation becomes even more critical if the heater has an air preheating system. In this case, a tight-shutoff, quick-acting damper is needed. A number of installations keep the stack damper cracked open to avoid it from getting stuck. However, either cold air starts leaking into the system or hot flue gas leaks into the atmosphere. Both scenarios are not desirable since they cause loss of efficiency. The damper should be inspected at every shutdown and necessary modifications made as needed. The damper should be kept fully close and tested every two weeks.

Case Study: In this instance, burners were replaced during a shutdown. The new burners would not light. It was later found that although the stack damper indicator was showing full open, it was fully closed. Someone had apparently forgotten to check the stack damper.

Heat Distribution in the Firebox: In most heaters, uniform heat distribution in the firebox will improve the heater's performance. This will ensure uniform heating of all the passes. To spread the heat as uniformly as possible, these tips will help:

1. The burners should be spaced as far from the tubes as possible. Use smaller burners if using low- NO_x burners.
2. Use the same amount of fuel and air in each burner. Have equal fuel gas pressure in all the burners. The burner valves should be fully open.
3. For a natural draft heater, the air registers of all burners should be open to the same extent.
4. With FD heaters, burner air dampers should be fully open. The fan suction damper controls the air.
5. With low- NO_x staged air burners, the number of dampers on each burner increases to two or three depending on the design. In this case, all burner dampers should be equally open.
6. Air registers of unused burners should be kept closed.
7. Keep all pass flows equal with a margin of ± 10%.
8. Check all tube skin temperatures frequently.

Burner Operation: Indicators of correct combustion in the firebox include:

- The firebox is clear
- There is no smoky appearance
- Burner flames are steady and well-formed

Check burners regularly for any signs of blockage or unusual flame conditions. If the burner flames are long and lazy, it is a sign of poor mixing. Increasing the air flow to the burner can reduce flame length.

With natural draft burners, increase the primary air and minimize the secondary air to the burners. Primary air mixes with fuel and creates a short compact flame. Excess primary air can sometimes lift off the flame and make it unstable.

For oil firing, flame lift-off can be corrected by increasing the atomizing steam. Table 4 lists some other solutions for possible problems with burner operations.

Case Studies

1. A client bought a new hot-oil heater and found that tube metal temperatures were running high. The oil circulation pump's filters clogged quickly. A check indicated that the tube metal temperatures were running high due to flame impingement. The flames were long due to improper air/fuel mixing. The burners were modified to reduce flame lengths. Tube metal temperatures came down after the burners' modification.

Table 3. Recommended excess air levels

	Natural draft	Forced draft
Fuel Gas	15-20%	10-15%
Light Fuel Oil	20-25%	15-20%
Heavy Fuel Oil	25-30%	20-25%

Table 4. Burner troubleshooting (condensed from API-535, 1st edition, July 1995)

Problem	Cause	Solution
Burners Go Out	Gas mixture too lean Too much draft	Reduce air Close stack damper
Flame Flashback	Low gas pressure High hydrogen in fuel	Raise fuel gas pressure Reduce primary air
Insufficient Heat Release	Low gas flow Burner tip plugged	Increase gas pressure Clean burner tips
Pulsating Fire	Lack of oxygen Lack of draft	Reduce gas flowrate Open stack damper Open burner air registers
Erratic Flames	Lack of combustion air Incorrect burner tip location Damaged burner tile	Adjust air registers/damper Check burner tip location Replace burner tile
Gas Flame Too Long	Excessive firing Poor air fuel mixing	Reduce firing rate Improve burner design

2. One refinery had three reformer furnaces. The furnaces had double-fired tubes with flat flame burners on both sides of the tubes. The client was complaining of flame impingement and that the tubes were always bending. An inspection indicated that the burners were installed perpendicular to the wall instead of parallel. This resulted in the flame always hitting the tubes.
3. A horizontal tube box natural draft heater had 32 flat-flame burners firing on both sides of the tubes. The burners were mounted in a plenum due to noise considerations. The heater was having high and uneven tube skin temperature problems so the client could not achieve uniform firing. Infrared thermograph inspections were done every week and the results were used to adjust the firing pattern without much success. The problems were studied in detail and it was found that poor air-fuel mixing and nonuniform air supply were the problems.

Burners were modified in association with the burner vendor. An old burner was shipped to the burner vendor's testing facility. It was tested before and after modification. The combustion was much improved and uniform. It even led to fuel savings 2% to 3%. Installing two additional air openings on each plenum chamber solved the no uniform air distribution problem.

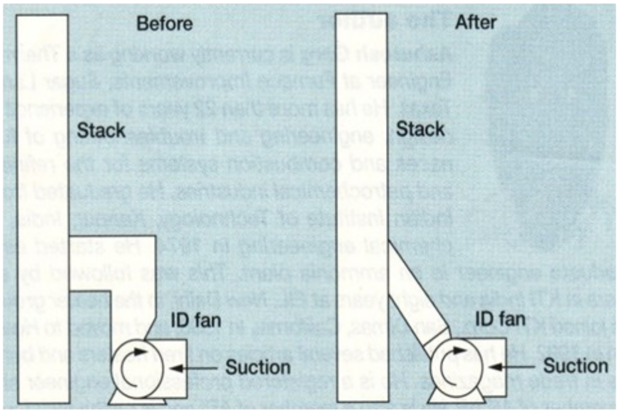


Figure 12. ID fan ducting modifications.

4. A petrochemical plant had a gas heating furnace with an ID fan located on top. It was fired from the floor. The furnace had these problems: long burner flames and positive pressure at arch. The furnace and burner design was studied in detail. The air and fuel were not mixing properly, which resulted in long flames. The burner design was retested at the burner vendor's test facility. Burner modifications were made during a short shutdown and the problem was solved.

   The furnace also had positive pressure at the arch, although it had an ID fan. It was found that the ducting sections of the inlet and outlets were causing a substantial pressure drop. The ducting configuration was modified to reduce the pressure losses.

Pilot Burners: These are provided as a continuous ignition source. In some installations, they are continuously monitored using flame failure devices. Self-inspirating pilot burners are very reliable.

Recently, I encountered a hot-oil heater that had 12 bottom-fired burners, all of which had pilots monitored by UV cells. Any small debris or even an inspect could block the UV cell signal, which caused nuisance shutdowns. The system was modified to put all the UVs in parallel to avoid nuisance tripping of the heater.

UV cells should not be used in a multiburner installation. They are expensive, especially in hazardous locations, and do no serve any useful purpose.

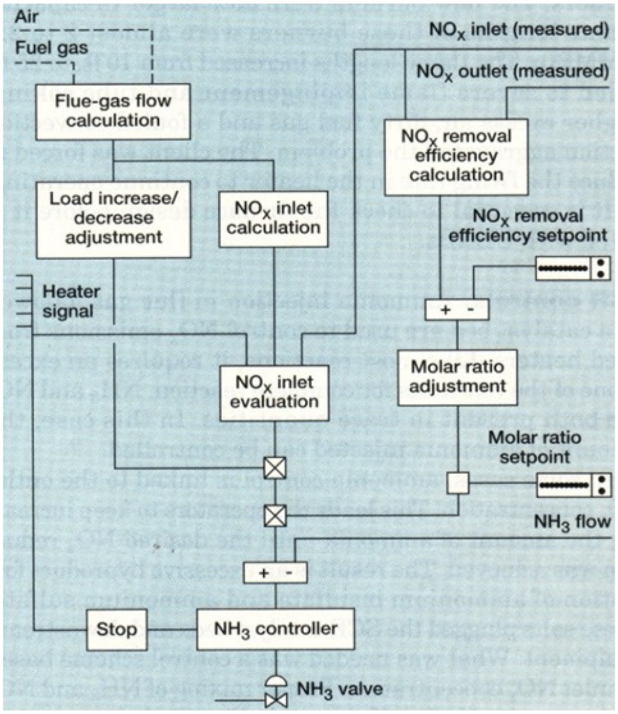


Figure 13. Modified NH3 flow control scheme.

Air Preheater: This equipment improves furnace efficiency, sometimes by as much as 7% to 10%. A typical installation is shown in Fig. 11. One of the common problems associated with an air preheater is cold-end corrosion.

In some installations, the air preheater overperforms for different reasons. This leads to a drop in the flue gas temperature leaving the air preheater. It also leads to cold-end corrosion in the air preheaters' cold section and other downstream equipment due to condensation of sulfur bearing acids. The outlet flue gas temperature should be controlled by adjusting the cold air bypass around the air preheater.

High Pressure Drop: in some installations, limits are reached even below the ID fans' design capacity. Some more common reasons are:

1. High pressure drop across the air preheater.
2. System losses at ID fan suction and discharge ducts that are not taken into consideration. Due to tight plot requirements, the ducts are provided with abrupt bends. In one instance (the fan installation), the discharge duct was causing 4 in. of pressure drop. This was rectified by modifying the fan discharge angle and the connected duct as shown in Fig. 12. Fan performance was restored and even led to power savings of $25,000/yr.

NO_x Reduction- NO_x reduction work requires that correct operating parameters be identified and used as design basis. It is essential that excess air levels be reduced to about 2% to 4% as all NO_x emissions are corrected to 3% O_2. Steam catalytic reforming (SCR) installation requires the correct temperature window for successful operation.

Ultra Low NOx Burners (ULNB) - One vertical cylindrical heater had eight natural draft gas burners installed. During the NO_x reduction, six ULNBs replaced the eight burners. The new burners were 33% larger in capacity. Flame lengths of these burners were almost 2 to 2.5 ft/MMBtu. The flame lengths increased from 10ft. to 25 ft. it led to severe flame impingement and tube coking. Higher excess air, dirty fuel gas and a fouled convection section aggravated the problem. The client was forced to reduce the firing rate in the heater to continue operating. It is essential to check the furnace design before it is fitted with ULNB's.

SCR Controls – Ammonia injection in flue gas followed by a catalyst bed are used to control NO_x emissions from fired heaters. Like most reactions, it requires an excess of one of the reactants for complete reaction. NH_3 and NO_x are both present in trace quantities. In this case, the amount of ammonia injected can be controlled.

In some cases, ammonia control is linked to the outlet NO_x concentration. This leads the operators to keep increasing the amount of ammonia until the desired NO_x reduction was achieved. The result is an excessive byproduct formation of ammonium bisulfate and ammonium sulfate. These salts plugged the SCR catalyst beds and downstream equipment. What was needed was a control scheme based on inlet NO_x concentration. Proper mixing of NH3 and NOx is also required before the reactor. Fig. 13 shows a typical control scheme recommended for SCR ammonia injection.

Final Recommendations – Optimizing fired heater performance is possible by making minor modifications and practicing good housekeeping. Here is a summary of fuel saving tips for fired heaters.

Furnace Fuel Can Be Saved In Two Major Ways:

- Reduce excess air – every 15% reduction in excess air saves about 1% in fuel.
- Reduce flue gas temperatures – every 35°F reduction in flue gas temperature saves about 1% in fuel.

Check Excess Air Levels And Flue Gas Temperature

Recommended excess air level for gas firing is 10% to 15% (2% to 3% oxygen); for oil firing it is 20% to 25% (4% to 5% oxygen). Recommended flue gas temperature is approximately 100°F above the inlet fluid temperature.

The Following Steps Will Help Reduce Excess Air:

1. Maintain a design draft (typical value is 0.1 in.WC at arch).
2. Adjust burner registers and stack damper to control the draft.
3. Shut off air registers for the burners not online.
4. Close all peepholes and doors securely.
5. Close all header boxes in the convection section and radiant boxes.
6. Maintain clean combustion at all times.

These Steps will Help Reduce Flue Gas Temperatures:

- Reduce excess air to burners
- Clean convection section tubes with sootblowers or steam lances.

ACKNOWLEDGEMENT

Based on a paper originally presented at the 1997 Gulf Publishing Co./Hydrocarbon Processing Process Optimization Conference and Exhibit, April 8-10, 1997, Houston, Texas. Figs. 1-4 and 9 have been reproduced courtesy of American Petroleum Institute.

NOTE

All case studies presented here have been developed solely for the purpose of illustrating typical problems and their solutions. Their resemblance to any installation may be coincidental.

THE AUTHOR

Ashutosh Garg is currently working as a thermal Engineer at Furnaces Improvements in Sugar Land, TX. He has more than 22 years of experience in design, engineering and troubleshooting of furnaces and combustion systems for the refining and petrochemical industries. He graduated from Indian Institute of Technology, Kanpur, India, in chemical engineering in 1974. He started as a graduate engineer in an ammonia plant. This was followed by six years in KTI India and eight years at EIL, New Delhi, in the heater group. He joined KTI Corp., San Dimas, California, in 1990, and moved to Houston in 1992. He has published several articles on fired heaters and burners in trade magazines. He is a registered professional engineer and a member of AIChE. He is also a member of API and is on the task force for the new API standard for NO_x Control for fired heaters.