Engineering Consulting & Training Services

CARMAGEN Engineering, Inc. eNewsReport

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Lowering Your Facility's Carbon Footprint

By Lester W. Davis, Jr.

A facility's carbon footprint is related to the CARBON emitted to the atmosphere. There has been pressure in recent years to lower the amount of carbon emitted from industrial facilities. Expectations are that this pressure will continue via increasingly stringent legislative mandates that facilities must meet.

The energy needed to drive most refining and petrochemical plant processes is provided in a Fired Heater through the combustion process. This energy is known as HEAT. Heat is transferred to the process by two heat transfer mechanisms: radiation and convection. The carbon emitted during the combustion process is in the form of carbon monoxide (CO) and carbon dioxide (CO_2). CO is not a factor when the combustion process is performed adequately (i.e., with sufficient O_2 and air/fuel mixing). The stoichiometric combustion process for the fuel methane, CH_4, which is common in natural gas, is defined as

$$CH_4 + 2O_2 \text{ --> } CO_2 + 2H_2O$$

This simple correlation shows that when additional CH_4 (fuel) is required, additional carbon (CO_2) will be emitted, thereby increasing the facility's carbon footprint.

To satisfy a given process condition, the process is required to absorb X MBTU/per unit time. The amount of heat resulting from the combustion of methane (known as Heat of Combustion), is about 913 BTU/ ft^3 or 21,520 BTU/lb. Therefore, a process requiring an absorption rate of 100 MBTU/hr will require about 1,095.3 ft^3/hr of methane. However, the amount of methane actually consumed during the combustion process depends on the thermal efficiency of the fired heater.

Thermal efficiency is impacted by the following variables:

1. Excess O_2
2. Air infiltration
3. Draft at radiant section exit
4. Possible presence of a combustion air preheater (APH) and its operations

Upcoming Training Courses held in our NJ offices

- Course 1304, *Layer of Protection Analysis (LOPA)*, March 23-24, 2011
- Course 910, *Process Plant Piping System Design and Maintenance*, March 30-April 1, 2011

For more information, see our website at www.carmagen.com.

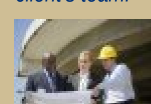
Work Highlights

Process, Operations, & Safety

Provided a number of hydrotreating unit performance modeling and revamp screening assessments for a major licensor.

Provided process planning assistance for various refineries, including lubes production and clean fuels. Work also utilized PIMS linear program modeling.

Provided consultation on revamp of quench tower fractionation and internals revamp, plus participated in vendor review meetings and equipment selection as part of client's team.



Providing on-going plot plant and facilities layout support for multiple projects for major refiner and chemicals producer.

Excess O_2/Air Operations

For an oil refinery with a throughput of about 150 kB/D, a saving of about 100 to 200 k$/yr can be achieved with a 1% decrease in excess O_2. This is based upon a fuel cost of about 2$/MBTU. The recognized wet excess O_2 levels for a natural draft fired heater with manual control of the stack damper and burner air registers are in the range of 3.0 to 3.5%. A natural draft fired heater equipped with automatic draft and O_2 control can operate at 1.5 to 2.0 % excess O_2. It is recommended that an O_2/combustibles analyzer be installed when targeting an O_2 operation of 2.0 % or lower. Also, the fired heater should be tested to determine its minimum O_2 capability.

Air Infiltration into the Convection Section

Fired heaters typically operate under less than atmospheric pressure or under negative pressure. During unit start up when a burner is initially placed into operation, the hot flue gases which are lighter than air will naturally rise through the stack, creating a draft. Thus, the term NATURAL DRAFT OPERATION arises. The natural draft pressure is at its lowest where the flue gas is transitioning from the radiant section to the convection section. If there are any openings in the fired heater casing, ambient air will be infiltrated or leaked into the fired heater. The air infiltrated must be heated up to the stack temperature or the process will be cooled. Therefore, additional fuel will be required to prevent this from occurring (which of course increases both the cost of fuel required and the carbon emitted).

At this point, we have the same situation as discussed above: a high O_2 operation resulting in a low efficiency. Air typically enters the fired heater casing through tube penetrations such as convection section return bends, crossover tubes leaving the convection section and entering the radiant section, and of course radiant tube outlets. The excess O_2 levels should be measured using the same portable O_2 analyzer below and above the convection section. Use of the same portable analyzer will provide consistent readings whether on a wet or dry basis and the built-in analyzer tuning.

Draft at Radiant-to-Convection Transition

The draft at the Radiant Section to Convection Section flue gas transition should be minimized to minimize air leakage. The draft at this location should be automatically controlled by the stack damper positioner or the Induced Draft (ID) Fan outlet damper positioner. The draft at this point should be controlled to -0.1 to -0.25 in. H_2O.

Combustion Air Preheater (APH) Operations

The utilization of an APH is germane to lowering your Carbon Footprint. The primary function of an APH is the reduction of fuel usage for the same heat absorption rate. An APH raises the radiant heat transfer rate while lowering the stack temperature. This is accomplished by transferring heat from the existing flue gas to the combustion air. This heat exchange raises the combustion flame temperature, which increases the overall Radiant Section heat transfer rate. However, there are a number of factors that should be evaluated when designing an APH:

- Increasing the Radiant Section heat absorption rate will marginally increase the radiant tube metal temperature.
- Increasing the flame temperature will increase the conversation of N_2 to NO_x.
- Lowering the stack temperature could result in cold end corrosion.

Each of the factors mentioned above can be addressed by considering the following:

- Installation of an APH will marginally increase the heat flux to the lower radiant tubes. Considering adiabatic flame temperatures, we can expect an increase of radiant tube metal temperature of about 5%. There is very little information as to the actual increase. For additional information on this subject, we refer you to the John Zink Combustion Handbook. We also recommend considering performing a Cold Flow Model or a Computational Fluid Dynamics Flow Model of your Fired Heater. The concern here is if your Fired Heater is already near or over maximum design Radiant heat flux conditions, this item is worth a closer look.

- If the NO_x emission from your Fired Heater is of concern, increasing the flame temperature could double these emissions. In this case, the installation of low NO_x burners should be considered. If low NO_x burners are already installed, the increase in NO_x emission will be much less. We suggest consulting your low NO_x burner supplier for additional information.
- Cold end corrosion is a major concern when operating an APH. If the fuel to be fired contains sulfur, dew point considerations are very important. Operating below the dew point will not only do serious damage to the cold end of the APH, but also to downstream equipment such as ducting and ID Fan. The ducting downstream of the APH is typically externally insulated.

Summary

A fired heater is a major factor contributing to the carbon footprint of an industrial facility such as an oil refinery or petrochemical plant. Reducing the carbon footprint is both necessary to meet increasingly stringent legislative mandates, and has the potential to save a facility money by possibly decreasing fuel usage.

There are multiple ways to potentially reduce the carbon footprint of a fired heater, and this article briefly discussed several of them. In many situations, the carbon footprint can be reduced with either no or minimum capital investment. A focused audit done by an experienced fired equipment engineer can quickly identify the potential for reducing the carbon footprint of a fired heater, the various options that might be considered, and their relative impacts and potential costs. Carmagen Engineering has significant expertise that can be applied in this area and has done this at many locations worldwide.

About the Author

Les Davis has over 44 years of experience as a Stationary Equipment Engineer specializing in Combustion/Fired Equipment, 34 of those years with ExxonMobil Research and Engineering. He has provided a significant amount of onsite, technical support to a major refinery covering energy efficiency improvements, carbon emission reductions, capital projects, operations support, and general fired equipment problem solving.

Please contact Vince Carucci (vcarucci@carmagen.com) if you'd like more information on Carmagen's expertise in this area.

Description of our upcoming Course #1304, *Layer of Protection Analysis (LOPA)*, March 23-24, 2011 in our New Jersey offices:

WHO SHOULD ATTEND?

Individuals responsible for managing corporate process safety/risk assessment functions and who wish to assess the potential advantages offered by LOPA. Individuals performing process hazard evaluations or risk assessments. Participants should already have a basic understanding of process hazard evaluation techniques.

TOPICS COVERED INCLUDE:

- Introduction to Process Safety Management
- Introduction to LOPA
- Consequences
- Developing Scenarios
- Initiating and Enabling Events
- Independent Protection Layers (IPL)
- Calculating Frequency of Scenarios
- Decision-Making Using LOPA
- Documentation
- Implementing LOPA
- Other Applications for LOPA
- Advanced LOPA Topics
- Worked Examples

For more information, please contact Pat Terry at pterry@carmagen.com.