1.2.3. Optimization of Natural Gas Fired Burners for Energy Efficiency

Description
Natural-gas fired heaters are used throughout the oil and gas industry for process heating, tank heating and line heating applications. Burner optimization helps ensure efficient use of fuel gas. Typically, the first step in burner optimization is a pre-inspection or pre-audit of the existing burner configuration. This inspection usually involves the completion of a combustion efficiency test and an emissions/exhaust analysis by a qualified service company. The condition of the equipment and the combustion efficiency test should be used to inform the extent of the modifications that can be made to improve energy efficiency, safety and regulatory compliance.

One of the most common sources of reduced efficiency is excess air in the combustion process. Therefore, reducing excess air is a key strategy to improve fuel use efficiency. However, doing so may impact nitrogen oxide (NOx) emissions on a volumetric basis since dilution air is reduced. To achieve optimum efficiency levels, the heat transfer area should be properly designed based on the fire tube size, fire tube materials, process fluid, stack diameter and length. It is also important to stabilize the firing rate using the appropriate process controls. A new electronic burner management system (BMS) will help to control air-fuel ratios and manage process control set points.

For complete burner upgrades, the existing fuel train and BMS can be removed, decommissioned, and replaced with a new CSA-B149.3 code-compliant1 fuel gas valve train. The new valve train would be installed with a new burner assembly (which may include an optimizer nozzle), a control panel, and pressure and temperature switches. The new BMS and fuel train must be tested to ensure the system and all components are working correctly before assembling and installing new burner internals. The burner can then be tuned for stability, efficiency, and optimal emission levels. A final combustion efficiency and emission analysis should be completed and all shut downs and controls should be function tested. Proper tuning is one of the most cost-effective ways to improve burner efficiency. Due to production declines, burners are often oversized for the application, so right-sizing burners may achieve additional savings and improved process control.

A good target efficiency benchmark for common burner types in upstream oil and gas applications ranges from 72%-83% (CETAC-West, May 2008)2.

Baseline:
The baseline is the combustion of natural gas (fuel gas) in a fired heater operating at the heater’s original configuration prior to any modifications made to improve burner efficiency. Direct greenhouse gas (GHG) emissions result from the combustion of fuel gas or propane to operate the burner. Fuel gas usage will vary based on the heating load requirements and ambient temperatures. Therefore, the baseline emissions are burner- and process-specific and depend on the operating characteristics and performance requirements of the underlying process utilizing the heat output from the burner.

---

1 CSA-B149.3-10 provides requirements for fuel-related components and accessories and their assembly on appliances & equipment utilizing gas.
Technology Group
Burners, Heaters, and Boilers – Recommended Practices

Site Applicability
The best approach for identifying candidate burners for energy efficiency improvements is to complete annual combustion efficiency tests, burner inspections, and tuning. An older burner can still be tuned to achieve target efficiency.

Emissions Reduction and Energy Efficiency

Estimating Gas Savings:
Most burner retrofit projects have achieved an average 5-20% improvement in fuel efficiency. In the case of one large producer, burner upgrade projects typically delivered between 10-20% improvement in fuel efficiency. Fuel gas savings from the company’s 110 retrofit projects averaged 2.2mcfd, but significant variability occurred from burner to burner. The average burner size was approximately 400,000 BTU/hour for these projects. Fuel gas savings vary depending on burner size, so the best method to estimate fuel gas savings is to have a qualified combustion specialist perform pre- and post-audit inspections on the burner, including pre- and post-combustion efficiency tests.

Measurement:
In Alberta, a site fuel gas meter is required whenever fuel gas usage is >500 m³/day. However, the fuel gas used by burners is usually just one component of overall fuel gas usage, and larger equipment, such as engines, usually burns significantly more fuel gas. In the conventional upstream oil and gas industry fuel gas usage is rarely measured at the individual unit operation/process or burner level. Therefore, it is necessary to complete short duration field measurements or use engineering estimates, or a combination of these approaches, to determine the specific fuel gas savings from a burner optimization project.

Net GHG Emission Reductions:
The net GHG reductions from a burner upgrade project are determined by comparing the pre- and post-retrofit gas savings. The estimated savings will depend on operating hours, firing rate, and other factors, so it is best to have a qualified combustion expert complete the analysis.

A Simplified Formula to Estimate GHG-Emission Reductions:
Net GHG Emission Reductions = (Estimated Gas Savings in m³/year) * (Fuel Combustion Emission Factor in kg CO₂e/m³ natural gas) * (0.001 t/kg)

As there is no dedicated Alberta Offset System Quantification Protocol for burner upgrade projects, it is unlikely this type of project will generate offsets. However, carbon tax savings may be achieved by reducing fuel gas usage (e.g. in BC presently, in Alberta in 2023, or where applicable in other provinces in the future).

Estimated GHG Emission Reductions:
GHG reductions from 110 burner retrofit projects completed in Alberta by a major producer averaged approximately 43 tCO₂e/burner/year based on average gas savings of 2.2mcfd per retrofit. GHG reductions are site-specific and depend on the type of baseline burner system, the process heat requirements, operating hours, excess air usage, and other factors.
**Economic Analysis**

**Capital Cost:**
Capital costs are site specific, but costs from burner upgrade projects completed in Alberta at 110 facilities run by a major natural gas producer averaged $19,500 with a range from $3,000 to $35,000. These retrofits included many dehydrator re-boiler burners, line heaters, and other process heaters. A major integrated oil company optimized 12 400,000 to 800,000 BTU/hour burners averaged $17,900.

**Operating Cost:**
Operating Costs are typically lower for high-efficiency burners relative to the previous configuration, and uptime may also be improved. Quantitative savings should be estimated on a site-specific basis.

**Payback Period:**
Although project economics are very site specific, it is possible to achieve paybacks of 5 to 10 years from fuel gas savings. However, the best projects will achieve further cost savings and/or compliance benefits by incorporating regulatory upgrades (e.g. to comply with CSA B149.3 regulations) and including upgrades to outdated equipment. Without these additional maintenance and regulatory benefits, most projects would be uneconomic on fuel savings alone at a $2.50/mcf gas price.

**Gas Savings:**
Gas savings are the primary benefit from burner optimization projects and these savings are site-specific. Gas savings from 110 burner optimization projects completed by a major natural gas producer in Alberta and BC averaged approximately 2.2 mcf/d. At a flat $2.50/mcf AECO gas price, these gas savings would be worth about $2,000/year. The results from the oil company ranged from 1 mcf/d to 7 mcf/d of gas savings.

**Carbon Offset Credits:**
There is unlikely to be any opportunity for carbon offsets from burner optimization projects in Alberta, but future carbon tax savings could be ~$1,300/year based 2.2 mcf/d savings per burner and a $30/tCO₂ carbon tax. At present, these carbon tax savings would only be applicable to burner optimization projects completed in BC since BC has a $30/tCO₂ carbon tax in place. The carbon tax in Alberta is not anticipated to apply to on-site fuel gas combustion in burners at oil and gas production facilities until Jan 1, 2023.

**Barriers:**
- Financial barriers - low value of fuel gas makes many projects uneconomic without carbon offsets or other regulatory benefits.
- Capital costs can be high when retrofitting older facilities.
- Limited reserves life in conventional reservoirs makes it hard to justify capital expense of retrofits.
- Unwillingness to modify proven, reliable facility designs.

**Reliability**
High-efficiency burners typically provide high reliability and have been deployed at commercial scales by several large oil and gas producers. Reliability can be further improved through proper tuning and maintenance and the replacement of outdated burner management systems. Adding burner management systems that are tied into supervisory control and data acquisition (SCADA) to include remote start capabilities will also reduce operating costs for unmanned sites.
Safety

The completion of a comprehensive burner optimization program is an excellent time to assess the safety of existing combustion systems. The most common safety upgrades include upgrades to meet CSA B149.3 code requirements, removal of manual lighting of burners, and upgrades to the flame arrestors. This may include inspection of flame arrestor housings and performing a propane flashback test on the flame arrestor.

Regulatory

Future Regulatory Considerations:
Both the Alberta Government and the Federal Government have announced their intentions to tax CO₂ emissions from fuel combustion. In Alberta, a carbon levy came into force effective January 1, 2017, but an exemption applies to “natural gas produced and consumed on-site by conventional oil and gas producers (until Jan 1, 2023).”³ (Government of Alberta, 2017) This exemption is very significant for oil and gas producers since the conventional (non-oil sands) upstream oil and gas industry consumes approximately 7% of the natural gas produced in the province to power its operations. Fired heaters are one of the largest sources of fuel usage, after engines.

From 2021 to 2026, the Federal Canadian Multi-Sector Air Pollutants Regulations (MSAPR) (Government of Canada, 2017) will be phased in to set limits for NOx emissions intensity for new and pre-existing boilers and burners that have a rated capacity of >10.5 GJ/hour. These regulations are applicable to oil and gas operations; however, a large number of burners that have rated capacities of <10.5 GJ/hour will not be subject to this regulatory threshold.

By reducing fuel gas consumption from fired heaters, burner efficiency upgrade projects can be an excellent way to improve energy efficiency. Once on-site fuel gas usage in the conventional oil and gas sector does become subject to the Alberta carbon levy in 2023 (or if it becomes subject to a federal carbon tax), there will be an even greater incentive for producers to improve burner fuel efficiency.

Service Provider/More Information on This Practice

References:


³ https://www.alberta.ca/climate-carbon-pricing.aspx?p184s1