Install Automated Air/Fuel Ratio Controls

Technology/Practice Overview

Description

Natural gas-fueled internal combustion engines can provide continuous duty operations over a set range of air to fuel ratios (AFR). Low air to fuel mixtures (rich burn) are used when greater horsepower is needed; high air to fuel mixtures (lean burn) are used when lower horsepower and greater fuel efficiency are the goals. Rich conditions result in more unburned fuel emissions (primarily methane), more CO emissions, and fewer NO_x emissions. Lean conditions produce lower methane and CO emissions, but more NO_x emissions. Manufacturer performance curves for standard rich burn engines indicate that when AFRs exceed a value of 18:1 (the stoichiometric AFR is approximately 16:1), temperature, power and NO_x emissions start to decrease. Such engines, equipped with conventional controls that continuously monitor oxygen levels in the exhaust gas with a single sensor, cannot operate for extended periods with AFRs in excess of 20:1. Typically, specially configured lean burn engines (AFRs 20:1 to 50:1) with turbo chargers or pre-combustion chambers are used where low NO_x emissions is the goal.

Natural Gas STAR Partners have achieved significant fuel savings, and reduced associated emissions, by installing automated AFR control systems to automatically adjust and optimize the operating parameters for their natural gas-fired internal combustion engines. Such parameters

Economic and Environmental Benefits

Methane and Fuel Gas Savings

Estimated annual methane emission reductions	*913—12,175 Mcf per engine*
Estimated fuel gas savings	*78 Mcf per engine per day, or 28,470 Mcf per year*

Economic Evaluation (based on fuel gas savings per engine installation)

Estimated Gas Price	Annual Methane Savings	Annual Fuel Gas Savings	Value of Annual Fuel Gas Savings	Estimated Implementation Cost	Payback[1]
$7.00/Mcf	913—12,175 Mcf	28,470 Mcf	$199,290	$138,000	8 Months
$5.00/Mcf	913—12,175 Mcf	28,470 Mcf	$142,350	$138,000	11.6 Months
$3.00/Mcf	913—12,175 Mcf	28,470 Mcf	$85,410	$138,000	1.6 Years

[1] The payback is calculated based on the value of annual fuel gas savings and the estimated implementation cost. The value of the methane savings is assumed to be included in the value of annual fuel gas savings due to the fact that the methane savings are a direct result of avoided fuel consumption.

Additional Benefits:

- Reduced engine fuel consumption
- Lower maintenance costs
- Reduced emissions of CO_2 and criteria air pollutants
- Improved engine reliability and safety

- [x] Compressors/Engines
- [ ] Dehydrators
- [ ] Directed Inspection & Maintenance
- [ ] Pipelines
- [ ] Pneumatics/Controls
- [ ] Tanks
- [ ] Valves
- [ ] Wells
- [ ] Other

Applicable Sector(s)

- [x] Production
- [x] Processing
- [x] Transmission
- [x] Distribution

Other Related Documents:

Reduce Natural Gas Venting from Fewer Compressor Engine Startups & Improve Engine Ignition, PRO No. 102

Convert Engine Starting to Air or Nitrogen, PRO No. 101

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include air manifold pressure and temperature, and fuel delivery to the combustion chambers. Alarm or shutdown triggers can be set to react to various real-time engine operating parameters, which reduces the risk of catastrophic engine failure. Other benefits from optimizing engine operation with AFR control systems include fewer false starts, lower combustion temperature, longer engine life, lower maintenance and fuel costs, and greater safety. Also, according to one vendor, using gas from an area with fugitive hydrocarbon emissions could lead to additional fuel savings as the AFR control system adjusts the fuel intake to account for the additional hydrocarbons in the air intake.

Operating Requirements

AFR control technology can be configured as a stand-alone system, or to interface with most existing electronic control and telemetry systems.

Applicability

Any natural gas fired engine over 1,000 horsepower can benefit from AFR control and optimization systems. Partners report that the greatest opportunities for significant system and efficiency improvements are for rich burn, high-speed, turbocharged engines ranging in size from 1,000 hp to 3,000 hp.

One Partner reduced fuel consumption and methane emissions by installing an automated AFR control system called REMVue, marketed by REM Technology Inc. REMVue controllers monitor several engine parameters and optimize air-fuel mixtures through a combination of electronic controls, use of a high-energy long duration spark to ensure reliable ignition, and other mechanical modifications to the engine. Another Partner purchased and installed new compressor units of 1340 hp and larger that are equipped with Caterpillar ADEM 3 AFR control systems.

Methane Emissions

Unburned fuel from the exhaust stream is a source of methane emissions from natural gas-fueled internal combustion engines. Such emissions are generally estimated using commonly accepted emission factors based on engine type, size, and operating conditions. The Natural Gas STAR Program typically uses 0.24 scf methane per horsepower-hour, based on Volume 11 of the 1996 EPA/GRI Study.

Methane Content of Natural Gas

The average methane content of natural gas varies by natural gas industry sector. The Natural Gas STAR Program assumes the following methane content of natural gas when estimating methane savings for Partner Reported Opportunities.

Production	79 %
Processing	87 %
Transmission and Distribution	94 %

Partners report annual methane emission reductions of 913 Mcf and 12,175 Mcf per unit after installing AFR control systems for compressors. Another Partner reduced fuel consumption by 18 to 24 percent after installing automated AFR controls on 51 new compressor engines in its Gulf of Mexico operations. By reducing the engines' fuel consumption, the Partner estimates average annual methane emissions reductions of 128 Mcf per unit based on AP-42 emission factors[1]. For the 51 engines, the total estimated annual emissions reductions are estimated as 6,528 Mcf.

Economic Analysis

Basis for Costs and Savings

The Partner-reported REMVue installation reduced total fuel consumption for 51 engines by 2,900 million cubic feet (MMcf) during a two-year period. Average fuel gas savings were 78 Mcf per day per engine when adjusted for load (28,470 Mcf per year per engine). This represents a 39 percent increase in estimated fuel savings (based upon a sample inventory, which yielded a pre-job fuel savings estimate of 56 Mcf per day). The total reported implementation cost for the 51 engines was $7.04 million. Capital costs to install an AFR control system on existing engines ranged from $98,000 to $161,000 per unit, with the average cost being $138,000 per installation. At a nominal value of $5 per Mcf, the total reported fuel savings for 51 engines was more than $7.25 million, yielding a calculated payback of 11.6 months.

Discussion

The economics are based solely on the value of the avoided fuel losses and the capital cost to install an AFR control system on 51 engines. The value of other reported benefits including fewer misfires, easier engine starting, more reliable operation, and longer engine life are not captured in this report. The Partner found that

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the additional cost of operating the REMVue systems was offset by reduced engine maintenance costs. A post-audit conducted on 20 percent of the installed base reviewed pre-, post- and post-post-values for fuel consumption, emissions reductions, availability, and economics based on a normalized gas price. The study results show that while NOx emissions were unchanged, significant improvements in air quality management were achieved since unburned hydrocarbons were down 3,549 tons per year (TPY), CO_2 emissions were down 2,309 TPY, and CO emissions were down 83,300 TPY.

[1] 'AP 42' refers to publication AP 42, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary , Point and Area Source, available online from the U.S. EPA Technology Transfer Network Clearinghouse for Inventories & Emissions Factors (www.epa.gov/ttn/chief/ap42/index.html)

[2] All costs presented are in 2010 dollars.