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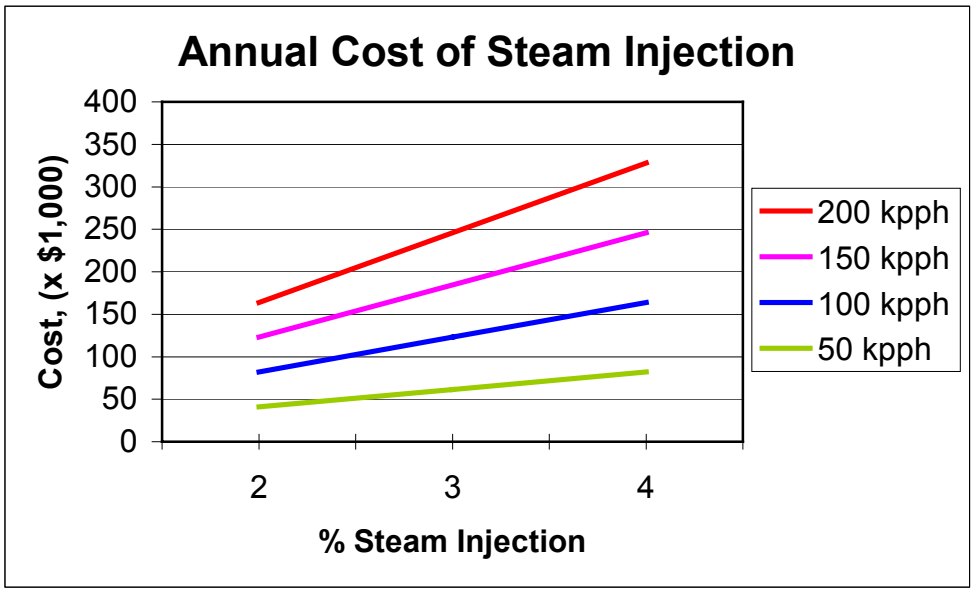
TECHNICAL BULLETIN #20-103

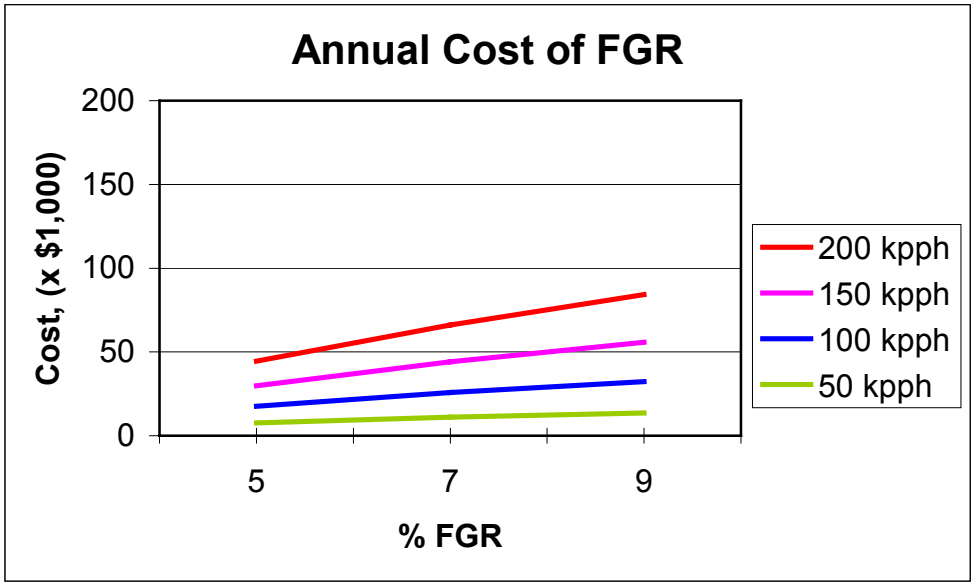
Steam Injection vs. FGR for the Reduction of Thermal NOx

Introduction

Flue gas recirculation is a common method employed to reduce thermal NOx. Steam and water injection are other available methods, and in some cases can be used in conjunction with FGR. The operating cost associated with steam or water injection is very expensive, and even more when combined with FGR. When using the graphs below, please note that 4% steam injection equates to 9% FGR and results in the same thermal NOx reduction.

Cost Comparison





Situation

Flue gas recirculation is in common use today to achieve controlled reduction of oxides of nitrogen. Burners are developed to remain stable while using various amounts of FGR. In all cases, the result is the reduction in peak flame temperature causing reduced thermal NOx emissions. With the reduction in flame temperature, the heat absorption in the radiant section of a boiler furnace is reduced. If the reduction in heat absorption is not recovered in the convection section of the boiler, thermal efficiency reductions will occur. In most cases, the addition of FGR will cause stack temperature to rise yielding reduced unit efficiency. The cost associated with these stack losses is small when compared to the cost of added fan horsepower required to pump the FGR. In most cases, fan horsepower cost is two to five times as much. The total cost of unit efficiency reduction and FGR fan horsepower is calculated and presented in the graph on the previous page.

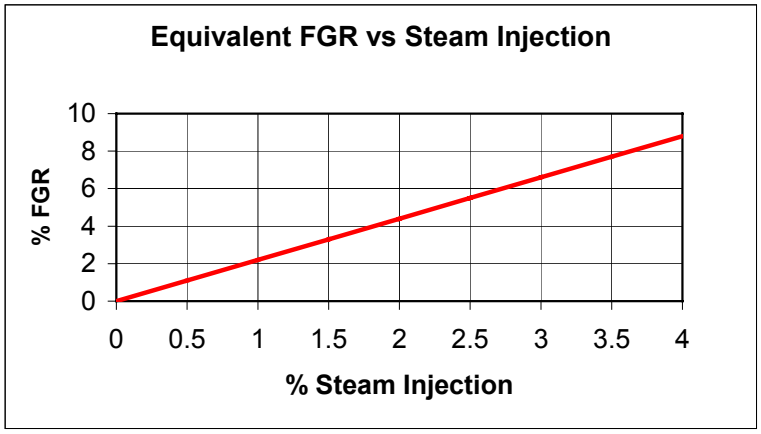
The use of steam injection is less common than FGR due to higher operating costs. Steam and/or water injection is very expensive by comparison. Steam is injected into the flame and will produce similar reduction in peak flame temperature as FGR, lowering thermal NOx. The cost of steam injection is based on the increase in natural gas fuel required to produce the extra steam for injection. For simplicity sake, the graph on the previous page does not include the cost of water treatment, pumping, and atomization, which can be considerable.

The graph below compares equivalent amounts of steam injection and FGR, which will result in the same flame temperature reduction.

Reference Data

The cost comparison is based on the following:

- 1000 Btu/lb Steam
- 82% Boiler Efficiency
- $4.00/million Btu Natural Gas
- Natural Gas Heating Value at 22,222 Btu/lb
- Air to Fuel Ratio 15.75
- Boiler Operation 8400 Hours/Year
- Boiler Efficiency Loss at (0.0325 x % FGR)
- $0.10/KW-Hour Electrical Fan Motor Cost
- 15% Excess Air (Steam Injection and FGR)
- Combustion Air at 70 deg F
- FGR Temperature at 350 deg F
- Forced Draft Fan Efficiency 65%
- Fan Motor Efficiency 92%
- Job Site Elevation at Sea Level



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