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Project Summary

Industrial Boiler Low NOx Combustion Retrofit Cost Algorithm Development

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This report documents the development of low NO_X burner (LNB) retrofit cost algorithms for industrial boilers. Also included are cost algorithms for overfire air (OFA) and low excess air (LEA) systems. Costs (in 1985 dollars) are estimated for new systems as well as retrofit applications. The boiler sizes evaluated include those with capacities ranging from 10 to 1300 million Btu/hr* heat input.

Included are summaries of the data sources and the methodology used to generate the cost algorithms. The approach to acquire detailed cost data and the available literature sources used as the basis for the retrofit cost estimates are described. Also summarized are the cost algorithm development and the boiler/burner design used to estimate costs on a per burner or overfire air port basis.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Industrial Combustion Emissions (ICE) model has been developed to assess the costs of NO_X controls applied to *existing stationary combustion* sources. However, the cost information in the model needs substantial improvement to provide accurate assessments. Computerized algorithms for low NO_X burners have been developed for large utility-size boilers, but not for industrial-size boilers. Due to major differences in boiler size, number of burners, and control complexity between utility and industrial boilers, separate costs need to be developed for low NO_X burners applied to industrial-sized boilers.

(*) For readers more familiar with the metric system, 1 Btu/hr = 0.29 W.

Procedure

A capital costing format for retrofit NO_X combustion modification controls (for pulverized coal and gas/oil applications) was developed for use by boiler and burner manufacturers. Model boiler sizes of 25, 100, 200, 500, and 1300 million Btu/hr were selected as being representative of industrial boiler applications. Detailed costs for low NO_X burners, overfire air, and low excess air systems were to be estimated for estimated NO_X reductions of 50, 25, (40 for gas and oil), and 10%, respectively.

Since no detailed cost data were obtained from manufacturers in this study, cost algorithms had to be developed based upon cost information available in the literature. Major sources of costs were presented as overall capital costs for a given size unit. To convert these costs to a per burner (or per overfire air port) basis, various utility survey reports and manufacturer contact reports were utilized to develop estimates of the number of burners as a function of boiler size. Other cost data sources include past EPA studies evaluating NO_x controls for utility and industrial boilers. Also, some costs from previous communications with burner manufacturers were utilized.

Results

To estimate the number and size of burners as a function of boiler size, information about several coal-fired utility and industrial boilers was compiled. In the industrial boiler size range, there is a wide range of burner sizes. For coal-fired industrial boilers of capacities from 100 to 1300 million Btu/hr heat input, burner sizes generally range from about 25 to 125 million Btu/hr. Based on this, the default values in the cost algorithms for the number of burners are as follows:

Industrial Boiler Size Range, 10^6 Btu/hr	No. of Burners	Potential Burner Arrange-ments, row x column	No. of OFA Ports (de-fault value)
100 - 500	4	2x2	2
500 - 750	6	3x2 or 2x3	3
750 - 1000	8 - 9	4x2, 2x4, or 3x3	4
1000-1300	12	4x3 or 3x4	4

These design bases allow the conversion of utility low NO_x burner and OFA total system capital costs to a per burner or per OFA port basis. Total capital costs were first converted to a per unit basis. Then, these unit costs were fit to a logarithmic function of unit size. Total industrial boiler system costs can then be determined by multiplying these unit costs by the number of low NO_x burners or OFA ports required for that particular industrial boiler size. For oil- and gas-fired boilers, typically there is a single burner in boilers smaller than 200 million Btu/hr heat input. For larger boilers, the burner pattern is estimated to be the same as that for pulverized coal.

Another capital cost impact of NO_x controls is the effect of staged combustion (both low NO_x burners and overfire air) on packaged oil- and gas-fired industrial boilers. The tight fireboxes and resulting high heat release rates of the larger packaged industrial boilers limit the NO_x reduction and steam production capabilities of those systems.

To keep operating heat release rates at a maximum level consistent with the use of effective NO_x controls, a new packaged industrial boiler equipped with a low NO_x burner or overfire air would have to be built physically larger to maintain the same capacity. Many existing packaged boilers would need to have their maximum firing rate reduced (i.e., capacity derate). Capacity derating is an alternative that also can be applied to new packaged boilers if a physically larger unit could not be shipped (e.g., due to railcar space limitations).

Preliminary analyses indicate that boiler capacity derate is roughly a linear function with boiler size, ranging from no derate at 75 million Btu/hr up to about 40 percent derate at 200 million Btu/hr. For new oil- and gas-fired boilers in this size range, the incremental capital cost of a larger boiler must be added to the capital costs of low NO_x burner and overfire air NO_x controls. For retrofit applications, the derate cost impact was addressed in terms of capacity replacement and NO_x reduction performance: for derate greater than 15%, additional capacity was estimated at full NO_x reduction performance; at derate less than 15%, no replacement capacity was required (resulting in variable NO_x reduction performance).

Essentially no detailed data available on the operating costs associated with the retrofit of NO_x controls to utility and industrial boilers: no additional labor, no additional maintenance, no fuel penalty for low NO_x burners or OFA, and no fuel savings for LEA.

The total annualized costs are the sum of the annual O&M costs and the annualized capital charges. The annualized capital charges include the payoff of the capital investment. The annualized capital charges include the payoff of the capital investment (capital recovery), general and administrative costs, taxes, and insurance. The capital recovery cost is based on the equipment life, real interest rate, and total capital cost. For this analysis, a 10% real interest rate and a 15-year equipment life are assumed. This translates into a capital recovery factor of 13.15%.

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The complete report, entitled "Industrial Boiler Low NO_x Combustion Retrofit Cost Algorithm Development," (Order No. PB 88-239 074/AS; Cost: $12.95, subject to change) will be available only from:
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