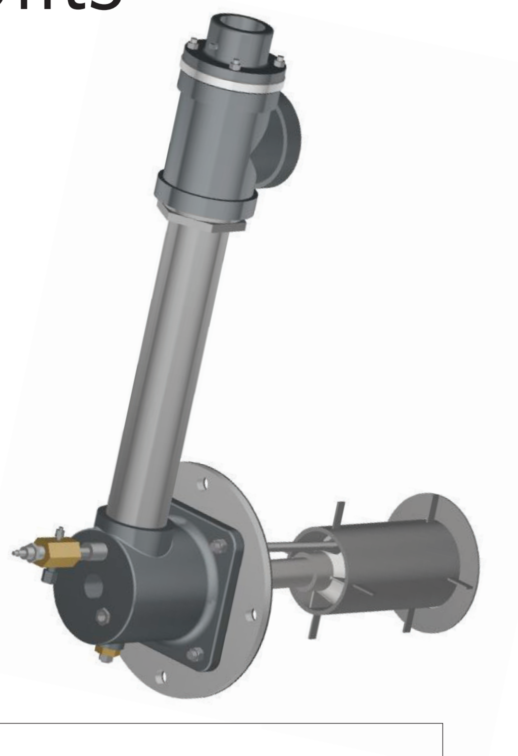
Combustion system retrofits for aluminium furnaces



By **Michael Cochran*** & **Matt Valancius****

Changing demands, with respect to productivity, fuel use, and/or emissions requirements, in an aluminium furnace present the operator with a unique challenge to meet the new requirements.

Generally, retrofitting an existing furnace with better combustion technology is both cost effective, and minimises downtime. Careful study of the existing equipment and process is crucial in order to affect the proper solution.

Cold air combustion to hot air combustion retrofit

For an existing cold air combustion system, the main benefit of converting to a hot air system is lower fuel use because of increased combustion efficiency. Although retrofitting technology has improved dramatically, in many cases minimising the need for modifications to the burner itself, (beware, however, that sometimes the burners themselves may require significant modifications) it is important to evaluate the whole system to account for changes in, for example, flows and pressures.

Design

Aside from the burner itself, which may require varying degrees of modification (consult the burner manufacturer or another qualified engineering company), a complete combustion system review is necessary, paying particular attention to:

- Fan/Blower – Hot air systems generally require lower volume of air, but typically at a higher pressure.
- Orifice plates/metering – lower flows may necessitate replacement of metering devices.
- Flow control valves – without resising flow control valves, turndown and process control may be more difficult.
- Gas regulator – an existing regulator may not function properly at reduced flow.
- Pressure switches – because air and gas pressures may be dramatically different, some pressure switches may require adjustment.

Performance

Table 1 shows the performance of an actual combustion system before and after a hot air retrofit, paying particular attention to the emissions of CO_2 and NO_x on both a lb/MMBtu and lb/hour basis. The required heat did not

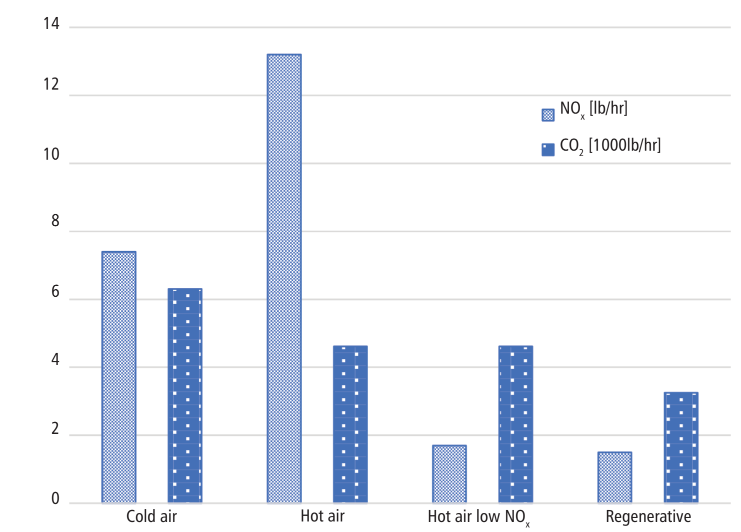


Fig 1. Emissions rates for various combustion technologies

	Cold Air	Hot Air Ultra Low NO_x	
Required Heat	20	20	MMBtu/hr
Air Preheat	100	800	°F
Thermal Efficiency	37.40%	51.10%	HHV
Installed Capacity	53	39	MMBtu/hr
Expected NO_x Average	0.138	0.044	lb/MMBtu
Expected NO_x Rate	7.4	1.7	lb/hr
Expected CO_2 Average	118	118	lb/MMBtu
Expected CO_2 Rate	6,310	4,618	lb/hr
Annual Hours	8760	8760	hours
Expected NO_x PTE	32.3	7.5	tons/year
Expected CO_2 PTE	27,639	20,229	tons/year

Table 1. Expected NO_x and CO_2 of Cold Air and Hot Air Ultra Low NO_x burners

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	Cold Air	Hot Air	Regenerative Ultra Low NO_x	
Required Heat	20	20	20	MMBtu/hr
Air Preheat	100	800	regenerative	°F
Thermal Efficiency	37.40%	51.10%	72.60%	HHV
Installed Capacity	53	39	28	MMBtu/hr
Expected NO_x Average	0.138	0.337	0.054	lb/MMBtu
Expected NO_x Rate	7.4	13.2	1.5	lb/hr
Expected CO_2 Average	118	118	118	lb/MMBtu
Expected CO_2 Rate	6,310	4,618	3,251	lb/hr
Annual Hours	8760	8760	8760	hours
Expected NO_x PTE	32.3	57.8	6.5	tons/year
Expected CO_2 PTE	27,639	20,229	14,238	tons/year

Table 2. Expected NO_x and CO_2 of Cold Air, Hot Air, and Regenerative Ultra Low NO_x Burners

change, but because the combustion efficiency increased noticeably, the fuel use decreased by almost 25%, and thus the emissions rate (lb/hour) decreased dramatically.

Assumptions:

2200°F POC Temperature, Natural Gas fuel, 10% Excess air

Regenerative retrofits

A more dramatic conversion, in terms of both fuel savings and productivity increases, is from cold air combustion to regenerative combustion. Generally, such a conversion will approximately halve the fuel use! (Similarly, it is possible to convert from hot air combustion to regenerative combustion with correspondingly less substantial savings.) Recent innovations in combustion technology mean that significant NO_x reductions are possible even though the air temperature increases significantly.

Design

As with any retrofit, it is crucial to perform a full engineering analysis of the entire combustion system to ensure proper performance after a retrofit. As with a hot air conversion, items such as blowers, regulators, pressure switches, metering devices, and control valves require special attention.

Because regenerative systems handle waste gas in an entirely different way, flue modifications are often necessary in applications where furnace pressure is important. Additional cycle valves, a complete exhaust system (including valves and a blower), and cooling air equipment are necessary for any regenerative system.

Furthermore, the burner design is completely different and it is never possible to reuse the burner itself. Finally, the regenerative equipment requires significant physical space around the furnace, although there are accommodations including dual headed burners and roof mounted cases if space is extremely limited.

Performance

Current regenerative technology allows for significant reductions in both fuel and emissions on both a lb/MMBtu and lb/hr basis, as shown in **Table 2**.

Fig 1 shows the relative rates of emissions for different direct-fired combustion approaches. It is clear that the proper selection of a combustion system technology can have a dramatic effect on both carbon dioxide and NO_x emissions.

Assumptions

2200°F POC Temperature, Natural Gas fuel, 10% Excess air

Radiant tube retrofit

Although conversion of aluminium melting furnaces is probably the most common retrofit project, there are steps in aluminium processing that use indirect heat (radiant tubes). It is also possible to retrofit existing radiant tube burners for efficiency and/or emissions concerns. One of the primary concerns is to ensure that the retrofitted burners are compatible with the existing tubes. Otherwise, the project usually becomes untenable because of the enormous capital expenses associated with replacing all of the tubes and furnace structure.

Cold air to cold air low NO_x

Without making any changes to the capacity of the system, it is possible to see significant decreases in emissions by applying low NO_x technology. These kinds of retrofit projects typically have minimal changes to the rest of the combustion system, but, of course, a full system analysis is required.

Design

The key difference when making a change to a low emissions radiant tube combustion system is an increase in air pressure, typically requiring a new combustion air blower as well as air pressure switches and metering equipment. Because the capacity of the burners does not change, the gas system can usually remain untouched. As long as the design of the burners is done carefully, there should be no changes required to the furnace structure or to the radiant tubes.

Performance

Table 3 summarises the performance of the retrofitted system on emissions metrics. Here, NO_x emissions decreased by almost 40%, although there was no change in fuel use, because this particular retrofit did not include any increase in combustion efficiency. Note that there is no change in CO_2 emissions because the capacity of the system did not change.

Conclusion

Changes in either production requirements or emissions limits can often be accomplished by retrofitting existing furnace equipment and are often economically sound choices. Before undertaking any retrofit, though, it is crucial to define the purpose of the retrofit, as well as the scope. A full engineering analysis of all combustion equipment is required to ensure that the new system will perform appropriately. After identifying the proper approach to a retrofit, careful selection of burner and other combustion components can lead to reduction in fuel use, reduction in emissions or increases in productivity at a minimum of cost and with limited downtime to the process. ■

	Cold Air	Low NO_x	
Required Heat	0.5	0.5	MMBtu/hr
Thermal Efficiency	41.0%	41.0%	HHV
Installed Capacity	1.2	1.2	MMBtu/hr
Expected NO_x Average	0.072	0.044	lb/MMBtu
Expected NO_x Rate	0.086	0.053	lb/hr
Expected CO_2 Average	118	118	lb/MMBtu
Expected CO_2 Rate	142	142	lb/hr
Annual Hours	8760	8760	hours
Expected NO_x PTE	0.38	0.23	tons/year
Expected CO_2 PTE	622	622	tons/year

Table 3. Expected NO_x and CO_2 of Cold Air, and Cold Air Low NO_x Radiant Tube Burners