Reducing NOx emissions, even on older heaters

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Many aging furnaces in the refining industry cannot use traditional ultra-low NOx burner solutions and require costly post combustion, selective catalytic reduction (SCR). Next generation technology exists that can reduce emissions on the toughest of applications.

Ralph Ellison once said, “The world is a possibility if only you’ll discover it.” The context of this quote refers to curiosity, exploration, adaptability, risk taking and venturing beyond your comfort zone to realize untapped potential. While the author was tackling more complex

societal issues, his quote still resonates with the challenges within the industry to solve complex problems related to emissions reductions in aging equipment that was not designed to handle the flame volumes of current ultra-low NOx burners.

As a result, refineries are forced to implement selective catalytic reduction (SCR) techniques to reduce emissions, post-combustion. While the SCR can reduce emissions, it comes at a significant cost. Older heaters were not designed to insert a catalyst bed or the ammonia injection grid and require expensive structural modifications to support the elevation of the stack and reinforce its weight with the addition. Also, an SCR requires handling of hazardous materials (ammonia) and ongoing costs with respect to electricity and eventual replacement costs associated with spent catalyst.

With environmental regulations allowing for a plant-wide reduction instead of each point source or emitter, reducing NOx in a plant can come from a variety of solutions, such as apply an SCR to a large NOx emitter, shutting down certain equipment in the refinery, applying burner technology or even buying NOx credits to achieve an emissions reduction target. Many factors such as time to comply, cost, impact on operations and available technology make the reduction of NOx across a site a complex portfolio of solutions vs cost. The obvious goal of deriving the most economical solution while meeting the required NOx emissions is paramount.

To further complicate addressing compliance with NOx emissions, current combustion technologies have limitations and refining industry standards have been written to limit the risk associated with pushing these technologies beyond their well-known operating envelope.

To mitigate issues in operating furnaces, guidelines (such as API 535 and 560) have been established to prevent issues that can damage equipment, shorten run lengths or fail to meet emissions limits required. Typical limitations include:

- Total heater fired duty (Lower Heating Value (LHV)) / Cross Area of the furnace floor (HHI) shall be less than 300,000 Btu/hr/ft^2.
- Flame lengths shall be less than 60% of the radiant coil height.
- Normalized burner to process tube spacing > required, calculated value (BTC).
- Normalized burner to burner spacing > 1 (BTC).

- Acceptable ratio of burner circle diameter / tube circle diameter (BCD/TCD).

Ignoring these limitations can result in flame impingement on the radiant tubes, shock tubes entering the convection section, instability in the flames and higher than expected NOx and CO emissions. A heater designed to the above guidelines will result in burner performance that is predictable and repeatable.

In the table below, the columns with yellow warnings, with the use of computational fluid dynamics (CFD), traditional ultra-low NOx burners can be evaluated, and a potential solution found that will produce expected emissions performance without flame issues.

CASE			API Compliant	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6		
Radiant Height		feet	31.5	37.0	36.3	53.8	40.7	37.5	40.5		
Tube Circle Diameter	TCD	feet	12.42	15.00	9.33	19.10	14.86	14.60	10.50		
Burner Circle Diameter	BCD	feet	4.81	6.50	4.58	10.33	6.92	7.50	5.08		
distance between coil and burner centerline	SBC	feet	3.80	4.25	2.38	4.39	3.97	3.55	2.71		
Number of Burners	#		5	5	5	12	8	8	5	8	4
actual burner to burner spacing	SBB	feet	2.83	3.82	2.69	2.67	2.65	2.87	2.99	3.64	2.37
Single Burner Maximum Heat Release	Qb	MMBtu/hr	6.92	14	6.92	9.75	8.38	7.4	10.95	18.75	10.65
Single Burner Normal Heat Release			6.92	9	6.92	7.82	6.7	7.01	8.8	15	9.5
Total Heater Heat Release @ Normal	Qhtr	MMBtu/hr	34.6	45	34.6	93.84	53.6	56.08	44	120	38
Airside pressure drop	Dp	in H2O	0.4	0.47	0.3	0.65	0.53	0.46	0.51	0.65	0.55
Air Temperature	Tair	deg. F	70	60	70	90	90	105	105	70	70
		deg. R	530	520	530	550	550	565	565	530	530
Heater Hearth Intensity (Maximum HR)	HHI Max		285,743	396,119	505,723	408,169	386,312	353,611	632,289	318,177	496,692
Heater Hearth Intensity (Normal HR)	HHI Norm	Btu/hr/ft^2	285,743	254,648	505,723	327,372	308,866	334,975	508,141	254,542	443,059
normalized burner to burner spacing (>1)	BTB	dimensionless	1.07	1.07	0.95	0.96	0.97	1.07	0.94	0.95	0.79
required normalized burner to coil spacing	BTC	dimensionless	1.30	1.36	1.30	1.62	1.40	1.42	1.35	1.65	1.32
normalized burner to coil spacing	BTC	dimensionless	1.44	1.19	0.84	1.57	1.46	1.33	0.85	1.95	1.18
Actual BCD / TCD Ratio	BCD/TCD	dimensionless	0.388	0.433	0.491	0.541	0.465	0.514	0.484	0.388	0.321
API 560 Minimum Ratio BCD/TCD	BCD/TCD	dimensionless	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
API 560 Maximum Ratio BCD/TCD	BCD/TCD	dimensionless	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.52	0.5

The columns with red warnings typically require additional modifications to the heater such as relocating the burner locations, changing the number of burners or reducing the fired duty of the heater to get the results. For example, the API compliant column represents a new heater built in accordance with API guidelines and will yield predictable results. Cases 1, 4, 5, and 7 have yellow warnings on the HHI might need the burner circle diameter adjusted to get better burner to burner spacing or burner to process tube spacing. Cases 2, 6, and 8 may only be able to be retrofitted with ultra-low NOx burners if the fired duty is reduced and rearrangement of the burners is made. In most cases, traditional burners will struggle to make 0.025 lb/MMBtu (HHV) (20.8 ppm) let alone numbers competitive with an SCR.

Older heaters require a different approach and there is no single solution for all applications. Another viable option is the adoption of next generation technologies like ClearSign Technologies' Core Process Burner. ClearSign's technology is built from a unique adaptation of combustion technology to achieve superior NOx emissions reduction while not necessarily sacrificing capacity reductions due to larger flame volumes than existing equipment. In most cases guarantees can be made to meet 0.006 lb/MMBtu (HHV) (5 ppm) NOx emissions required by furnaces located in the air districts throughout California and some parts of Texas.

ClearSign's Core Process Burner can meet the above projects and meet NOx limits not achievable by existing technologies. The ClearSign Core process burner can be designed to fit into existing cutouts (reducing installation costs) and the flame holder assembly is designed to optimize flame dimensions to fit into tightly spaced furnaces. Not only can ClearSign's burners meet NOx emissions competitive with SCR's, but it can also address issues such as flame impingement (reduce flame volume), and capacity increase (debottlenecking a furnace).

To learn more, visit ClearSign, email info@clearsign.com or call 918-935-5779.

References:

—American Petroleum Institute. (2016). *API Standard 560: Fired Heaters for General Refinery Services* (5th ed.). Washington, DC: Author.

—American Petroleum Institute. (2014). *API Standard 535: Burners for Fired Heaters in General Refinery Services* (3rd ed.). Washington, DC: Author.

—Ellison, R. (n.d.). *The world is a possibility if only you'll discover it.* Quote Meaning. Retrieved June 22, 2024, from https://quotesoftheowl.com/the-world-is-a-possibility-if-only-youll-discover-it-ralph-ellison-quote-meaning/

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