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RMC-05-88 **Low Emission - Low Maintenance Burner
Design**

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Summary

In order to meet the ever increasing and strict emission controls on fired equipment, low emission burner retrofits are becoming commonplace. In the past, burner design has focused primarily on achieving emission requirements, almost at the exclusion of future burner maintenance requirements. With so much design focus on meeting emission requirements and none on future burner maintenance requirements, operators struggle with burners that may have met emission targets when initially installed, but quickly became a maintenance burden in order to consistently achieve the required emission levels.

By combining end user field feedback with an understanding of factors that lead to continued burner field maintenance, this paper will demonstrate how low maintenance burner design features can be integrated with low emission burner design requirements and still meet emissions targets. The Zeeco patented next generation *Freejet*TM burner incorporates these low maintenance features.

This paper will review specific low maintenance design features that should be incorporated into the burner design. These features include:

- Review of gas tip design via Computational Fluid Dynamics (CFD)
- Gas tip port selection
- Gas riser review
- Combustion air control mechanism
- Burner tile block.

Incorporating this field feedback into the burner design provides for a reduction in long term cost of ownership as well as a reduction in maintenance requirements to achieve today's emission requirements.

Introduction

- 1) Goals of this paper, questions to be addressed
- 2) Summary of installations to be reviewed (Valero Coker and Dow Cracker)
- 3) Summary statement "Care and attention to low emission burner design can reduce costly burner maintenance and result in sustainable emission control"

Burner Maintenance (or lack thereof) Impact - Issues, Causes, Remedies

Burner maintenance can be driven by many factors. Emission control typically has not been one of the factors until recently. An absence of or a lack of focus on proper burner maintenance can result in several undesired results that include:

- a) Burner Instability – Flames lifting off the burner and lighting intermittently. This creates a safety hazard for operation personnel attempting to adjust the burners via potential flame blowback, or in the worse case, a heater explosion where some of the burners are lit, others have gone out and the firebox fills with unburned fuel gas that ignites explosively, damaging the heater and creating safety hazard for the plant personnel.
- b) Flame Quality – Flames that are not developing in a controlled defined shape and can be damaging to the process tubes via flame impingement. Poor flame quality can cause warping of the heater floor causing damage to the refractory floor, burner tiles, or heater

steel. If the flame quality is sufficiently poor it can also limit the heater throughput via flame impingent on the process tubes leading to coking of the product inside the tubes.

- c) Unsustainable or Higher than Allowable Emissions – In the past, maintenance was driven by a desire to reduce mechanical damage to the heater, flame impingement on tubes that could reduce heater throughput, or safety driven concerns. Now, achieving sustainable emission levels is also required. Continuous Emission Monitors (CEM's) are now placed on many units to continuously measure and report heater flue gas emissions. Prior to CEM's, many heaters were tuned for the annual emission verification test with little preventative maintenance until it was time to achieve the desired emission rates again the following year.



These pictures depict poor flame quality.

Emission Reduction Mandates From All Sides

Today emission reduction mandates come from all directions. Local, State, Federal or EPA, and even Department of Justice (DOJ) are a few agencies mandating emission reduction and the monitoring of fired equipment. As part of many of these mandates, CEM's are required. This new requirement for continuously meeting the emission requirements requires burners that are either consistently well maintained or equipped with features that reduce maintenance requirements to an acceptable level. Burners that incorporate features designed to minimize maintenance requirements should be a major point of review and concern for end user operating companies.

Factors That Lead To Burner Maintenance

Each operating facility has different requisites driving burner maintenance, some of these include:

- a) Refinery Fuel Gas Components – Some facilities have heavy hydrocarbon fuel gas streams that are mixed with natural gas as a make up fuel gas for the volumetric requirements of the facility. Some of these heavier HC's tend to revert back to a liquid state as the fuel header pressure is lowered near the burners. Un-insulated fuel gas lines in cold environments tend to make this heavy HC drop-out a potential problem. Some of the refinery fuel gas system components tend to promote scale build up in the fuel gas lines. This scale can end up at the burner orifices. Many of the fuel gas lines in refineries are decades old and have substantial scale buildup, which provides an almost never ending source of scale particles to be sent downstream to the burner orifices. Installing a fuel gas knockout pot, strainer, and or coalescing filter can greatly reduce maintenance caused by poor quality refinery fuel gas. Proper sloping of the fuel gas lines back to the KO pot, proper fuel gas take-off point from the fuel header, and even slight heating of the fuel gas to ensure gaseous state also promote better fuel delivery to the burners. Burners firing natural gas typically require much less burner maintenance.
- b) Refinery Burner Maintenance Programs – Different facilities have different philosophies concerning burner maintenance. A few facilities provide dedicated cleaning crews on a regular basis to do only burner maintenance to ensure good burner performance. Most facilities however, leave this critical maintenance up to whatever contractor staff is available with the plant. This floating surplus of contractor staff often has little, if any, specific training in proper burner maintenance procedures, thus the effort does not result in any sustainable burner performance improvements. Allowing the burner vendor to train contractor personnel on the proper burner cleaning procedures is a minimal investment for achieving improved burner performance. Most burner vendors should provide this service at no cost or for a nominal fee. Burner vendors can also provide a video tape showing proper cleaning procedures. This will ensure that new contractor staff assigned to burner maintenance will have some familiarity with critical procedures. If consistent burner maintenance can not be achieved with internal resources, outsourcing this service to the burner vendor is the best alternative for achieving good burner performance.
- c) Combustion Air Sources – Burners that have preheated combustion air tend to have more maintenance requirements if the fuel gas risers are exposed to the preheated combustion air source. If the risers are exposed to hot enough combustion air streams, some HC cracking inside the risers can occur even before the fuel reaches the burner tips. Fuel gas cracking inside the fuel risers can lead to gas port plugging.
- d) Heater Service – The severity of service of the heater can also influence the maintenance requirements for the burners. Burners subjected to high firebox temperatures such as ethylene plant cracking furnace applications which require very specific flame profiles and heat flux requirements, usually require more maintenance attention than those in cooler less severe reboiler type applications. Fuel gas streams in ethylene plants also tend to have a greater potential for compressor oil carryover, which when exposed to elevated temperatures in an improperly designed burner gas tip, can create gas port plugging.

- e) Burner Design – Understanding the maintenance requisites for fuel gas and combustion air delivery systems, and addressing those requirements in the burner design is what this paper will address. Rather than just continuing to design burners to achieve low emission almost at the exclusion of the long term maintenance requirements, burner vendors should address maintenance issues in the initial design. Some burner vendors are reluctant to address these maintenance issues because of the impact on revenue from aftermarket or spares replacement sales. They continue to provide equipment that does not incorporate features to reduce the maintenance or spares requirements.

Maintenance Items on Burners and What Can be Done to Minimize or Eliminate Them

- a) Metal in the Throat of the Burner – Many burner designs add metal devices in the throat of the burners to promote mixing via combustion air swirling or to create a flame stabilization zone. The metal in the throat of the burner has two major drawbacks. Any bluff body placed in the throat of the burner blocking free area must be compensated for by making the throat area larger to compensate for that blocked area. Larger burner diameters are more expensive to install and are therefore not conducive for retrofit applications or tight burner to burner spacing requirements. Any burner that relies on metal stabilization device in the throat area is susceptible to instability once that metal has deteriorated by flame impingement. Even if the metal in the throat is of an upgraded material or increased thickness, eventually the burner stability could be compromised as this metal degrades. A burner design that requires no metal in the throat for combustion air swirling or stabilization is optimal; the Freejet™ design incorporates such low maintenance features and has a very small footprint, usually smaller than the burners it replaces.
- b) Exposed Gas Tips – Exposing gas tips to the radiant firebox increases the likelihood of maintenance. Keeping the gas tips embedded down low in the burner tile provides lower gas tip temperatures and thereby reduces the potential for maintenance. In high temperature applications, such as an ethylene cracking furnace, even with upgraded gas tip material, exposed tips will not stand up to the severe service for any duration. It is best to keep tip exposure to the radiant firebox to a minimum. The Freejet™ design incorporates this feature, with gas tips that are embedded in the burner tile.
- c) Large Mass Gas Tips – Gas tips that are substantial in physical size have a much greater surface area exposed to the radiant firebox temperatures. Keeping a low mass of metal profile helps to protect the gas tip from the radiant firebox temperatures. A low mass tip also ensures high velocity through the tip and provides cooling to the gas tip surface area. The Freejet™ burner gas tip is a very low mass tip and is the only patented gas tip on an ultra low emission burner.

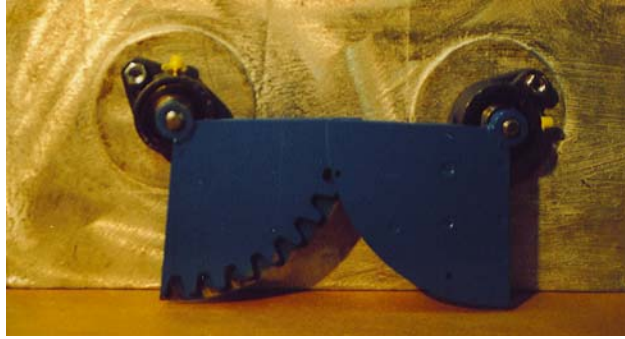
Traditional Gas Tip vs Freejet™ Patented Tip

d) Exposed Risers to Elevated Combustion Air Source or Firebox Temperatures—Not only is gas tip exposure to elevated temperatures a potential problem that leads to additional burner maintenance, but having the actual gas riser exposed to the firebox or preheated combustion air source can also lead to additional maintenance. Risers that are kept cool and out of exposure to the hot radiant firebox and elevated combustion air streams will provide for less burner maintenance. The temperature at the fuel gas riser can be such that fuel gas components can crack and form carbon which can initiate plugging in the riser well before the gas reaches the actual gas tip. The Freejet™ fuel gas risers are not exposed to either the radiant firebox or the combustion air stream thereby reducing the potential for maintenance.

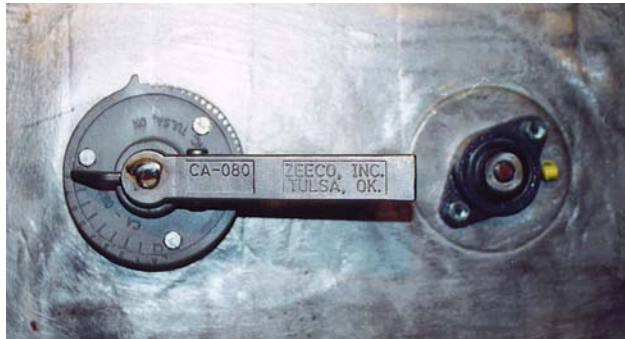


Typical exposed Gas Riser failure

e) Air Delivery / Adjustability – In salt laden geographical area, providing linkage arm coupler type air adjustments tends to lead to additional burner maintenance. The Freejet™ design has a gear driven air adjustment versus the less durable rod end linkage type system and sealed damper bearings versus the less durable coupler and shaft design. The Freejet™ design provides for long term air adjustment capability to ensure the burner is capable of achieving sustainable low emissions.



Freejet™ Gear



Freejet™ Sealed Bearing

Field Application and Feedback on the Freejet™ Design

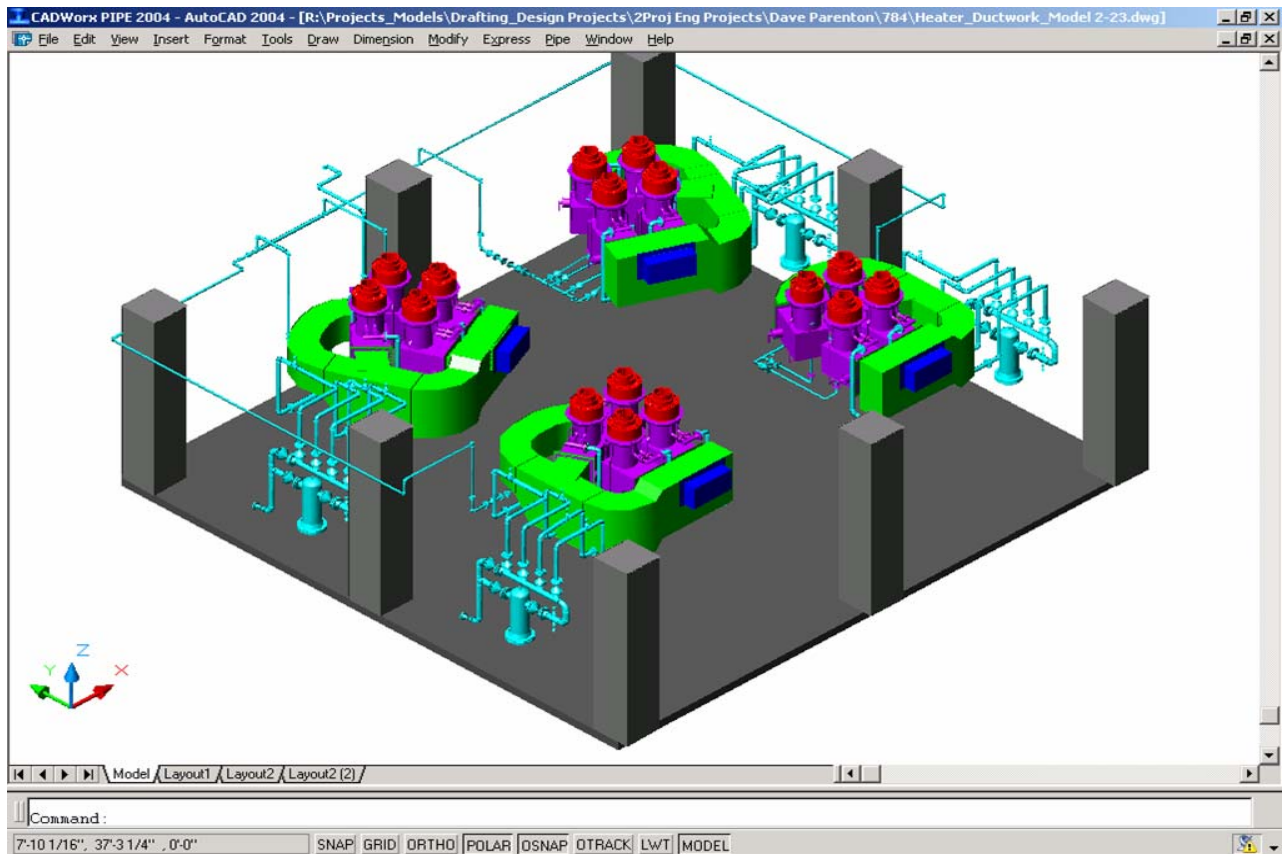
To date over 1200 Freejet™ burners have been sold and installed. Case studies on many of these applications are available for natural draft, forced draft, vertical cylindrical and cabin furnace applications and include contact names and phone numbers. These Freejet™ performance verifications encompass refinery, chemical and ethylene cracking furnace applications.

Valero St. Charles Refinery selected Zeeco Freejet™ burners for their Coker heater, a vertically up-fired, forced draft, air preheat, fired heater for low NOx burner retrofit. This retrofit required replacing the (16) burner layout with a new (64) burner layout to optimize flame profile for the heater configuration. Zeeco Freejet™ burners were installed as well as a new fuel gas filtration system, CEM's emission monitors. In addition, Computational Fluid Dynamics (CFD) was performed to optimize the forced draft air preheat air delivery system.

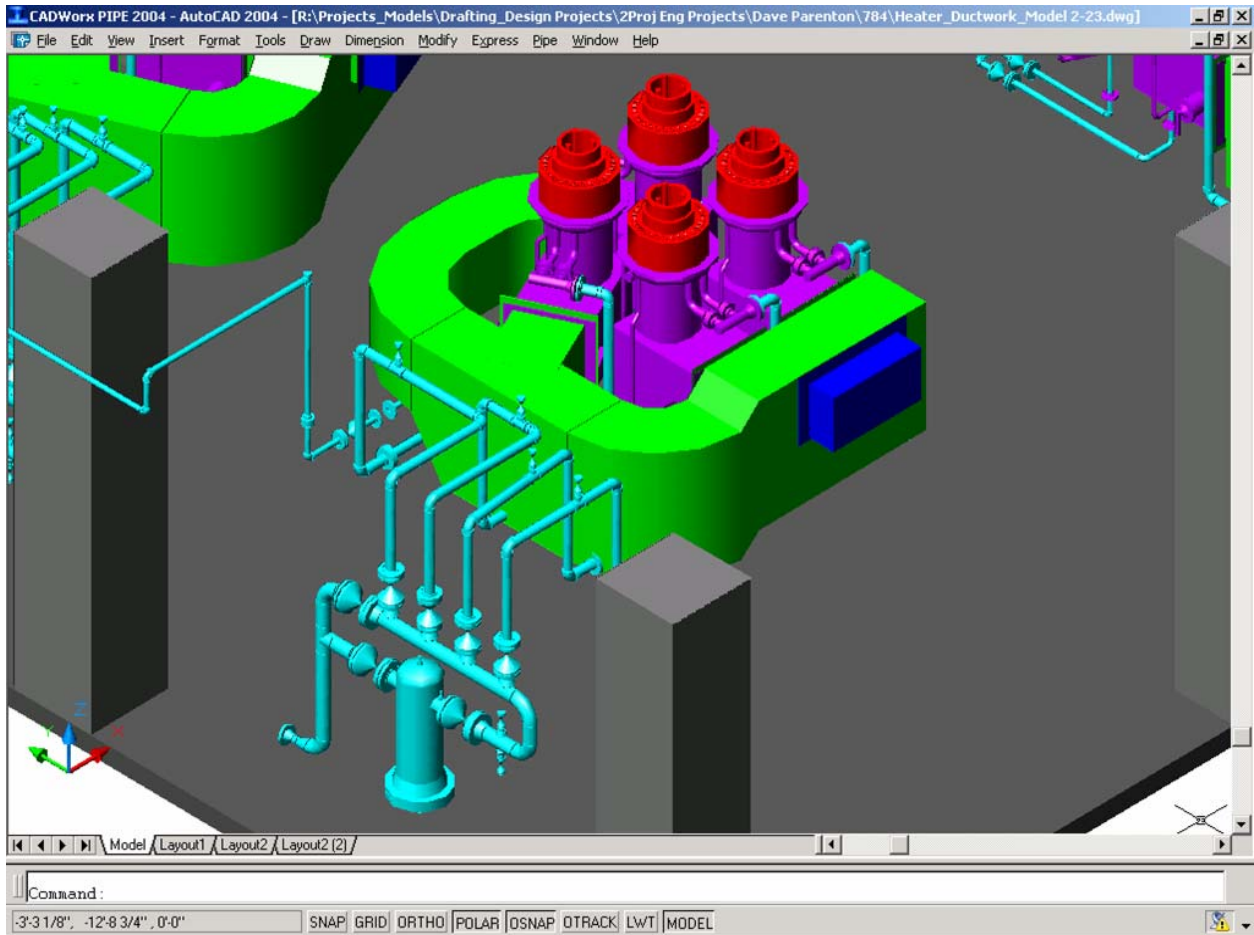
A large vertical, cylindrical vacuum heater was also retrofitted with Freejet™ burners. This heater is a natural draft configuration with high heat release low emission burners as well.

For the Coker application, with 600F air preheat combustion air source, the Freejet™ burners have consistently achieved less than 0.036 #/MM NOx. The heaters are equipped with CEM's for continuous emission monitoring. There has been no burner maintenance or replacement of any gas tips to date for this application.

Freejet™ burners installed during the fourth quarter of 2002 are still operating with no spares or replacements installed to date.



Valero, St. Charles Coker Configuration Cell A



Valero, St. Charles Coker Configuration Cell A



Valero St. Charles Refinery Freejet™ Installation



**Freejet™ Burners in Dow Chemical Ethylene Cracking Furnace
Freeport, Texas**



**Freejet™ Burners in Dow Chemical Ethylene Cracking Furnace
Freeport, Texas**

Conclusion

Incorporating low maintenance design features into the initial burner design will lower the cost of burner maintenance and result in sustainable emission control.

These burner design features include:

- Eliminate metal in the burner throat
- Keep gas tips and risers from radiant firebox exposure
- Keep gas risers out of preheated combustion air stream
- Utilize low metal mass gas tip
- Eliminate small stability / ignition ports and maximize port area in the gas tip
- Design burners for high turndown to eliminate shutting in of gas tips
- Supply single piece burner tile
- Gear driven sealed bearing air damper adjustment

NOTE: CFD material noted in this paper will be presented during the presentation portion of the conference.

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