Greenhouse Gas Regulations – All Pain and No Gain
Charles T Drevna

Refinery Energy Losses Due to Fouling in Heat Exchangers
Francesco Coletti and Sandro Macchietto

Process Simulation for Improved Energy Efficiency, Maximised Asset Utilisation and Increase in Feed Flexibility in a Crude Oil Refinery
Zoltán Varga, István Rabi and Klara Kubovics Stocz

Emerging Markets in the Middle East for New and Existing Liquefied Natural Gas Projects
Fereidun Fesharaki, Alexis Alk and Noelle Leonard

Corrosion – Issues and Solutions for Hydrocarbon Refineries
François Ropital

www.touchoilandgas.com
Reducing Emissions in Plant Flaring Operations

a report by
Brian Duck
Line of Business Leader for Flare Systems, Callidus Technologies by Honeywell

Since 2006, one of the largest integrated energy and chemical companies in the world has actively pushed toward optimisation and upgrading of pipelines, refineries and petrochemical plants in China for the purpose of minimising energy consumption, lowering emissions and maximising production.

The Goals

Saving energy and reducing emissions are the internal requirements for every division of this major corporation. To achieve the public goals, the company set, they issued a five-year plan entitled ‘Methods of Energy and Water Saving Management’, which was applied to all operating equipment in the 13 company-owned oil and gas fields, the 22 refineries and three pipeline companies.

The plan for the refineries focused on key areas such as improving energy efficiency, utilising the latest technologies and reducing greenhouse gas emissions. The company also created a ‘Green Team’ with the objective of achieving zero injury, zero pollution and zero accidents for all production facilities. These Green Teams advocated the company’s new Health, Safety and Environment (HSE) culture by eliminating energy-consuming and highly polluting production equipment and facilities that fell behind in the use of technologically advanced equipment.

Reduce Emissions

Three new petrochemical and refining plants were installed, including the 10 million ton oil-refining project in Dushanzi. One goal of the new plant was to reduce emissions of CO₂, SO₂ and NOₓ by 130 million tons per year. Among the ten projects implemented in this new plant for the reduction of pollutant emissions were the adoption of zero flaring, the reduction in loss of product from the flares through flare gas recovery systems (FGRSS) and the reduction in the use of steam and water in the plant through the installation of the latest generation of steam-assisted flares.

Historically, losses from flares are the single largest cost in a refinery or chemical plant. Losses to the flare include process gases, fuel gas, steam, nitrogen and natural gas. Proper operation and maintenance of flares systems helps reduce the losses from flares. Eliminating leaking valves, efficiently using fuel gases required for the proper operation of the flare and controlling the steam to achieve smokeless burning all contribute to reducing flare losses. Modifying start-up and shutdown procedures also helps to reduce flare losses, but new technology in flare tip design offers the greatest reduction in flare loss.

Equipment Selection

When it came time to select flare equipment for their new ethylene plant in Dushanzi, the company wanted the latest technology to maximise the operating efficiency of the flare system. They turned to an international combustion company, recognised for their expertise in flares and FGRS – Callidus Technologies by Honeywell.

Smokeless Flaring

The company designed, built and tested two flares and two FGRSS on a fast-track basis to enable installation during the plant start-up in 2009. The flares and FGRSS were installed on the northern and southern sections of the plant. The northern flare was designed to flow more than 3,500,000 lb/hr at the maximum rate and is thought to be the largest smokeless elevated flare in the world. The south flare was designed to flow almost 2,000,000 lb/hr. Each flare is 155 metres tall and both flare stacks are mounted on the same derrick structure. Figure 1 shows the flare systems and derrick support system. The stacks are demountable from grade so that the tip from one flare can be maintained or replaced while the other flare remains online. The mounting of the risers permits the flare burner to be lowered to grade without the use of a crane. Since the stack is lowered to grade, no personnel are required to climb the stack beyond the first riser section to perform the needed maintenance. This makes servicing the flare much safer and since one flare remains in service, the need to shut down the plant is eliminated, saving both time and money.

Drawing upon the observations of field engineers and maintenance technicians familiar with the failure modes of conventional flares removed from service for repairs, new approaches to flare tip metallurgy, structural design and weldment fabrication have been developed. The resulting flare burner design employs a high-density tube configuration, which introduces air into the flare envelope to improve combustion at reduced steam flow, thereby lowering operational noise while increasing efficiency. This allows minimum steam consumption while optimising smokeless capacity.

The tube inlet venturi design enhances the flare burner’s ability to inspire air via steam in the internal steam/air tubes. Tip design extends the parameters for efficient operation at low noise levels. An increased flow-area acoustical muffler with ceramic refractory lining shrouds steam injection ports, further enhancing noise attenuation.

The flare employs a cast stainless steel segment at the end of the internal steam/air tubes to enhance the service life of the flare tip.
improving the resistance of the internal tubes to collapse, the design eliminates the introduction of the air deep inside the flare, which could have otherwise resulted in internal burning, thermal stress and ultimately, flare destruction. Cracking of the flare burner shell – a common failure in conventional flare design – typically propagates from fillet welds on brackets and attachments joined to the flare tip. To eliminate the stress riser and the resulting crack, the new flare burner uses a circular, plug-welded design, which helps to optimise flare burner service life.

The flare tips use high-stability, low-consumption pilots to reduce the amount of natural gas that is required for operation. The Calidus pilots consume half the natural gas of conventional pilots, saving nearly US$20,000 per year on natural gas costs. The pilot design is extremely stable and can survive winds of more than 160mph and rainfall of over 12 inches per hour. The pilot system incorporates a windshield, strainer and a true premix burner capable of firing in 0% oxygen environments at the pilot tip. This makes the pilot operation extremely stable. The pilot gas tip, flame shield and thermocouple mounting are all investment castings of CK-20 to ensure long life. The placement of the thermocouples is designed to maximise response to all weather conditions and minimise exposure to direct flame. Figure 2 shows the flare system in operation.

Flare Gas Recovery
In keeping with their corporate objectives of achieving zero flaring and reducing fuel costs, visible flame, odours and the auxiliary flare utilities, such as steam, the plant also purchased two FGRSs to complete the flare systems. Numerous studies completed since 2000 have proven that recovering hydrocarbon gases that are normally discharged to the flare is the most cost-effective investment a refinery can make.

Each FGRS for the Dushanzi plant was designed to recover 60 million British thermal units per hour (MMBTU/hr) of flare gas (see Figure 3). The FGRS is a skid-mounted packaged system located downstream of the knockout drum since all the flare gases are available at this single point. Compressors take suction from the flare gas header and compress and cool it for reuse in the refinery fuel gas system. As flare gas flows through the flare header, it is diverted to the FGRS downstream of the knockout drum by a liquid seal vessel and enters the compressor. Typically, a liquid ring compressor is used because the design of the compressor can process two-phase flow that commonly exists in flare headers. The compressed gas is then discharged into a mixed phase separator. The liquid is pumped through a heat exchanger and back to the service liquid inlet on the compressor as shown in Figure 4. The compressed gas is separated from the liquid and is piped to the plant fuel gas header, or other appropriate location.

The compressor recycle valve is regulated with control signals based on the inlet flare gas pressure. This ensures that the flare header is under positive pressure at all times. In the event that the flow capacity of the FGRS is exceeded, the liquid seal vessel will allow the excess waste gas to go to the flare where it is safely burned.
The FGRS system significantly reduced the greenhouse gas emissions from the plant and the harmful impacts normally associated with flaring. By recovering the gases routinely sent to the flares, the plant prevented 32.5 metric tons of NOx, 176.8 metric tons of CO and 67,000 metric tons of CO2 from being emitted into the atmosphere each year. Thermal radiation from the flames was greatly reduced, which resulted in an increase in overall safety of the plant. Light and noise – two other objectionable side effects of flaring – were also greatly reduced.

Besides major reductions in emissions, light and noise, installation of the FGRS allows substantial cost savings because the recovered gases can be used as fuel or process feedstock. Assuming a fuel gas cost of US$5/MMBTU, the plant will save more than US$5,000,000 per year on fuel gas costs if the FGRSs operate at full capacity. With an expected operating cost of US$300,000 per year, the cost of the FGRS could be recouped in less than nine months.

**Results**

Partnering with Calidus Technologies by Honeywell enabled this major corporation to achieve their corporate goals of improving energy efficiency, utilising the latest technologies and reducing emissions for the Dushanzi plant. The Green Team objectives of achieving zero injury, zero pollution and zero accidents were also met with the addition of the demountable stack flare systems and FGRSs. In addition to recouping the cost of the FGRSs during the first year of operation, the company will enjoy reduced maintenance costs of the flare due to the advanced flare design technology and material selection. They will continue to reduce their overall emissions and increase the operating efficiency of the plant.