
MIDDLE EAST
FLARING
SOLUTION

CLAYTON A. FRANCIS, ZEECO, USA, DISCUSSES HOW HIGH PRESSURE AIR ASSIST SYSTEM FLARING TECHNOLOGY CAN RESOLVE THE CHALLENGES POSED BY A MIDDLE EASTERN ENVIRONMENT.

It is not uncommon for new operational regulations and initiatives to present a serious challenge to the preferred practices of the hydrocarbon industry. The divide between the two provides an arena for innovation where the most creative and capable engineering minds try to reconcile the industry and the regulatory perspectives. The new high pressure air assist system (HPAAS) flaring technology demonstrates the development of such a solution to satisfy both sides.

The function of a flare is a safety relief device in which toxic and combustible gases are disposed in a manner that is safe for the plant and the people within it or in close proximity. Therefore the flare is necessary safety equipment for hydrocarbon production, transport, and processing. Even with the tremendous advancements that have slashed flaring rates and impacts, flares will be longstanding fixtures across producing landscapes. Out of concern for the impact they have, pressure continually mounts to reduce the effects of flaring by increasing destruction efficiencies, reducing utility consumption, and especially by reducing visible emissions. For industry, regulators, and vendors alike, opportunities will always remain to advance flare operation and design.

As refineries, plants, production, and transport units age, upgrading technologies is the desired alternative to the capital expenditure required to replace entire flare systems. Engineers from Saudi Aramco partnered with Zeeco to develop their flare

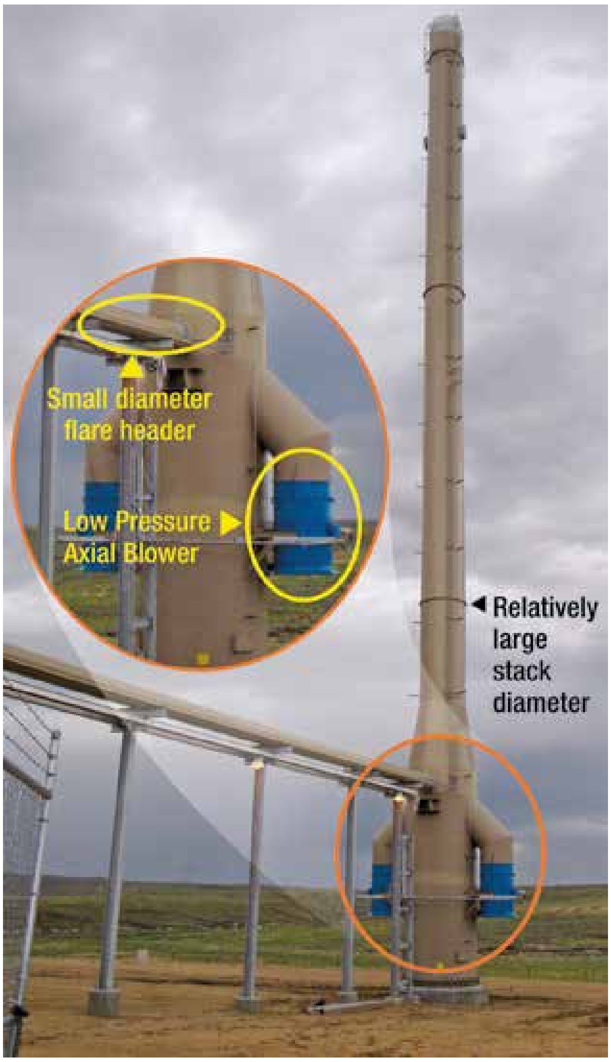

Figure 1. Typical air flare configuration.

technology specifically targeted to eliminate smoke in an efficient, economical manner in areas without access to steam and without the need for a new flare stack. The new HPAAS technology utilises super sonic air injection in a manner that can be easily adapted to retrofit and upgrade outdated, smoking technologies. The application of HPAAS is proven to bring exceptional value to the user in both operational and monetary terms.

Drivers for change

Operational standards throughout the petroleum industry are continuously evaluated and updated in favour of practices that relieve environmental impacts. This is true of flaring and is especially true in the case of smoking flares. The impetus for change often comes in the form of environmental regulations, but it can also stem from monetary drivers or public perception.

Visible for kilometers and omnipresent, elevated flares are a billboard that cannot be turned off. Due to this high visibility, the fire and any smoke emitted from flares attract the acute attention and concern of all parties who wish to mitigate inefficiencies and emissions in the industry. Whether or not the level of attention given to flares is justifiable, the flare is becoming a lightning rod driving change in flaring technology.

This change is coming quickly and steadily to the Middle East. While limitations on emissions and smoking flares legislated around the world may not apply to all locations in this region, other influencers may have a similar, nearer term effect. International and financial institutions have formed coalitions to incentivise the operational changes. Some of the most influential companies in the industry have enacted internal protocols that exceed government or international standards to demonstrate their commitment to environmental concerns. It is conceivable that additional operators in the Middle East will necessarily revise flare design and operation protocols in the near term whether driven by regulation, incentive, or their own initiative.

Previously, the second revision of The Royal Commission for Environmental Regulations (RCER)[3] issued operational protocols and standards for the Jubail and Yanbu industrial areas to specifically address emissions and air quality. The initiative requires normal flare operation to be completely free from smoke emissions and significantly restricts the allowed frequency and length of permitted process upsets. In these industrial areas, dozens upon dozens of flare tips are in constant service. When a regulation such as RCER is enacted, the conversion of existing non-smokeless flares becomes a priority for the operators. In the common case where a flare is already in existence, retrofitting a smokeless technology in a cost and utility efficient manner can be a challenging endeavor. Failure to do so, however, can result in penalty by fines. These range in magnitude from minor charges of US$ 1000 to one time penalties in excess of US$ 100 000.[9]

The drivers for change do not have to come from within a country's borders. An international initiative by the World Bank seeks to minimise the loss of natural resources and reduce the environmental and climatological impact of flaring and venting associated with the production of crude oil.[2] The Global Initiative on Natural Gas Flaring Reduction (GGFR) was formed with the purpose of changing public policy via monetary incentives within producing countries with active flaring practices. The combination of monetary incentives and aforementioned legislative penalties are targeted to bring about the desired change in operational procedures and parameters.[8] Part of the initiative recognises that the formation of smoke when flaring represents incompleteness in combustion, and as a result the environmental impact of a smoky flare is greater than that of a smokeless one. While varying from country to country, the result of the GGFR initiatives could lead to more stringent smokeless requirements. These procedural changes become complex and expensive to retrofit to existing equipment.

Either as a result of the aforementioned external influences or by their own internal prerogatives, company operational procedures often require improved smokeless performance for flares. To be congruent with the RCER and other internal initiatives, Saudi Aramco has published stringent flare operation protocols in their engineering standards specifications SAES-A-102.[5] According to this standard, all flares with a throughput of up to 1 million ft^2/d are required to be smokeless for all normal operations. Flares exceeding that flow rate are required to have a flare gas recovery system installed to mitigate flaring almost entirely. The enactment of this specification has massive implications when applied to the numerous flares already in existence without the necessary utilities installed to achieve smokeless combustion. When an international company implements a similar initiative, the impact is felt on operations in multiple countries.

All three drivers of change, regulatory, incentivised, and internal, apply to most of the Middle East including the countries of Egypt, Iraq, Kingdom of Saudi Arabia, Kuwait, Oman, Pakistan, and Qatar. Even if such operational requirements are not affecting a particular site yet, it is a reasonable assumption that they will be in the near future.

The initiatives to reduce smoking flares are greatly impacting the Middle East; however, nowhere in the world is it more challenging to accommodate increasing smokeless flaring capacities. Steam injection is used worldwide for the smoke suppression of heavy hydrocarbon flares. In these applications, steam is injected as a transport media to inspirate and mix air at the insipient region of the combustion zone. However, since water is a premium commodity in the Middle East, a need exists for a suitable alternative to steam assisted flaring. The mechanical injection of air by means of fan or pressure blower is well known and proven smokeless technology in the industry. Though typical air assisted flares do not require water, a scarce resource, the initial capital cost of the equipment is comparably quite high since the configuration normally requires axial flow of the air and gas, i.e. a stack within a stack. This makes retrofit applications nearly impossible; upgrading a smoking flare to air assisted often requires an entirely new flare system with an installed weight nominally three to four times greater than the unassisted alternative.

Many valid technological options for smokeless flaring exist for capital projects, but what kind of financial commitment will it take to upgrade the hundreds upon hundreds of flares in existence? Until HPAAS was developed, the financial burden of meeting the revised operational standards was perceived as too steep to enact wholly.

HPAAS technology

The basis of the HPAAS technology is to transport the injection media in the most compact means and inspirate air as efficiently as possible. Following a brief discussion of the configuration and requirements of a typical low pressure air assisted smokeless flare system, this article will examine the differences in a HPAAS configuration. For low pressure systems typical in the industry, vast amounts of air are utilised to prevent smoking in the flare. Airflow rates ranging from 30 – 50% of the stoichiometric air are required for complete combustion and must be mechanically induced. Due to the large air flow required in a standard configuration, the diameter of the air delivery structure is larger than the gas riser itself. This is designed to reduce the velocity within the stack, minimise the pressure drop within the system and ultimately conserve the capital cost of the blower by minimising its power requirements (Figure 1).

By utilising much higher pressure air than typical designs, HPAAS flare tips utilise air in a manner comparable to steam injection tips. Instead of injecting most of the air required for smokeless flaring, highly kinetic jet streams of air aspirate ambient air into the combustion zone. This configuration is highly efficient in the volume of air used; less than one tenth of the airflow is required compared to low pressure technologies. Additionally, since this minute air volume is injected at high pressures, the delivery of air occurs in a much smaller pipe often of only 2 or 3 in. nominal diameter.[1] The smaller pipe generates several cost savings to the user; the large diameter air ducting stack is eliminated completely, the weight and forces of the stack are minimal and therefore structural considerations such as civil work or guy wires are minimised.

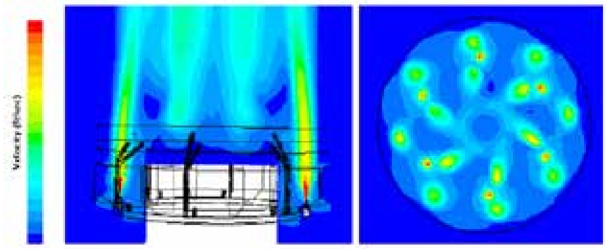

Figure 2. The HPAAS initial design was developed using computational fluid dynamics (CFD) analysis and field testing.

The patented design and layout of the HPAAS injection tips are the crucial elements for delivering the benefits discussed. For the first time in the industry, proprietary supersonic air injection nozzles were developed to maximise the efficiency of the air injected through the system. The jet of air produced by the nozzle creates a turbulent wake, inducing ambient air into the combustion zone. In this manner, the effect of the relatively tiny flow of compressed air is multiplied so that a significant portion of the air required for complete combustion is available at the flare tip exit prior to the formation smoke. In conjunction with using these advanced air nozzles, the correct placement and mixing set up by these tips is paramount to the success of the design. When the combination of induced and injected air reach the flare tip exit, the velocity, angle of approach, and volume have been optimised for interaction with the gases and shaping of the flame. The nozzle placement is refined to ensure the induced air is also fully mixed with the waste gas stream and complete, smokeless combustion occurs (Figure 3).

A specialised windshield is integral to the induction of ambient air. By enhancing the upward draft around the perimeter of the flare tip, the momentum of the air within the windshield overcomes the tendency for flame pull down on the downwind side of the flare. In effect, it shepherds the flame in an upward column and prevents the impingement on the flare tip barrel common to utility flares.

The initial design was conceived by Saudi Aramco through advanced computational fluid dynamics (CFD) analyses (Figure 2) and field testing in select southern area gas oil separation plant (GOSP) locations.[1] Finalisation of the nozzle and windshield layout occurred through extensive full scale testing at Zeeco's Research and Development Facility in Broken Arrow, Oklahoma, under the observation of Saudi Aramco personnel. The combination of live testing validation and CFD modelling rendered a proprietary layout that optimises the overall performance, reliability, and longevity of the flare system.

The supply of air for these systems is most often generated by an air compressor. This is typically welcomed by the user since it is a familiar technology with competitive selection opportunities between many vendors. In tight turnaround situations, temporary air capacity is achievable through portable natural gas or diesel driven compressors. Compressors are easily run in parallel configurations for increased online performance,

Figure 3. Left: Without HPAAS. Right: The same flare, after retrofitting with HPAAS Smokeless Flare Technology. HPAAS uses supersonic air injection nozzles to inspirate combustion air at a much higher efficiency than any previous air assisted smokeless flaring technology.

and if the continuous air requirements of the flare are less than the capacity of the compressor the difference can be piped to the plant for other uses.[1] In ideal circumstances, the location has sufficient plant air to negate the need and cost of the compressor entirely.

Application of HPAAS

The greatest distinction between HPAAS and all other smokeless technologies is the ability to easily retrofit the technology to upgrade existing flares. Previously, integrating an air assist technology was mostly achieved by replacing the flare entirely. In the Middle East or other installations where sufficient steam was not available, new smokeless operation was also unobtainable. Smoking flares subject to scrutiny, sanction, and suspicion were either left in service as is or replaced at a crippling cost since no adequate solution existed in the market.

With the advent of a small bore air utility line and a HPAAS flare tip of equitable size to the old tip, existing flare stacks can be reused with no structural modifications. The tips are configured to be direct bolted replacements to their predecessors; the only welding required is simple utility bracketing along the flare stack. If the compressor is located near the flare stack, horizontal piping and supports are minimised. Power, piping and controls to the compressor, buffering tank and control valve are simplistic and inexpensive. With all of the simplifications to the equipment, turnaround installations have been achieved in as little as two days providing significant down time savings to the user.

When compared to the alternative configuration of non-assisted smoking flares, the HPAAS technology can bring added robustness and longevity to the flare tip. Unassisted utility tips often have a flame profile that is dominated by the effects of crosswind. As the diameter of a flare tip increases, a more severe low pressure zone is formed along the downwind side of the tip. This pulls the flare gas down into the zone and allows the flare flame to stagnate on the tip barrel and ancillary equipment. Prolonged operation in this state commonly damages pilot and thermocouples beyond use as well as cracking or buckling the barrel. As mentioned previously regarding the combined effects of the windshield and injection nozzles, the aspirated air momentum overcomes the crosswind effects. The flame shape is controlled to flow up and away from the flare tip exit, thus protecting the equipment and adding operational life to the tip. In some services, non-assisted utility flares often receive sufficient damage to render the pilots and/or tip inoperable within two to three years. In contrast, when HPAAS tips were used to replace them, the same flares operated at the same installation for five years without damage to the pilots or a reduction in service life. The additional expected lifetime brings further monetary savings to the user in yet another way by reducing replacement cycles and required turnarounds.

Unlike steam and axial airflow, the HPAAS can run momentarily without air with no immediate mechanical degradation.[1] However, in a steam assisted flare, the steam injection equipment is located very near to the combustion zone, so a continuous minimum flow rate is required to remove the heat of the flare flame. Other low pressure air assist technologies introduce the air and flare gas axially at the flare tip exit, and similarly require a minimum flow to prevent mechanical harm to the equipment. In both configurations, running without the smokeless assist media even for momentary periods of time can thermally stress and crack the equipment. Only the HPAAS technology injection nozzles are located below the flame sufficiently far to allow brief upsets to the air supply without instantaneous harm.

Conclusion

To date, there are dozens of HPAAS tips in use throughout the Kingdom of Saudi Arabia, allowing operators to meet the objectives of smokeless flaring. In addition to the ultimate objective of improving the environmental impact of their operations, this technology helps erase the visual stigma of a smoking flare from the horizon. Operators now have a tool to address the immediate need to satisfy the latest in environmental protocols and standards with manageable resource requirements. This tool is versatile enough to rectify the primary problem of smoking while providing advantages over other technologies at the initial installation, operation, and replacement costs. Fortunately, the HPAAS upgrade is becoming widely available just as environmental practices and regulations tighten across the Middle East.

References

1. MASHOUR, M., SMITH, S., PALFREEMAN, N., SEEFELDT, G., AFRC 2010, 'Success Stories: Saudi Aramco High Pressure Air Assist System (HPAAS) for Smokeless Flaring.'
2. World Bank, 2004, Regulation of associated gas flaring and venting: a global overview and lessons from international experience. Global gas flaring reduction - a public-private partnership: No. 3.
3. The Royal Commission For Jubail and Yanbu, 2004, Royal Commission Environmental Regulations 2004, Section I.
4. Presidency of Meteorology and Environment (PME) website: http://www.pme.gov.sa/en/env_regul.asp
5. Saudi Aramco Environmental Standards Committee. 31st July 2012. SAES-A-102 Ambient Air Quality and Source Emissions Standards.
6. AL-TIJANI, A.H., Saudi Aramco, 2010, Flare Minimization Roadmap in Saudi Aramco, http://spatialco.com/download/benchmarking2010/Kuwait_GasFlaring_Reduction_Abdulaziz_Aramco.pdf
7. Saudi Aramco Corporate Flaring Task Team, Flaring Minimization Roadmap, http://www.saudiaramco.com/content/dam/Publications/Environews/Environews%20Winter%202008/SA_Flaring.pdf
8. FARINA, M.F., GE Energy, 2010, Flare Gas Reduction: Recent Global Trends and Policy Considerations.
9. The Royal Commission For Jubail and Yanbu, 2010, Royal Commission Environmental Regulations 2010, Penalty System, Section III.