METHANE FROM FLARING
TOOLKIT

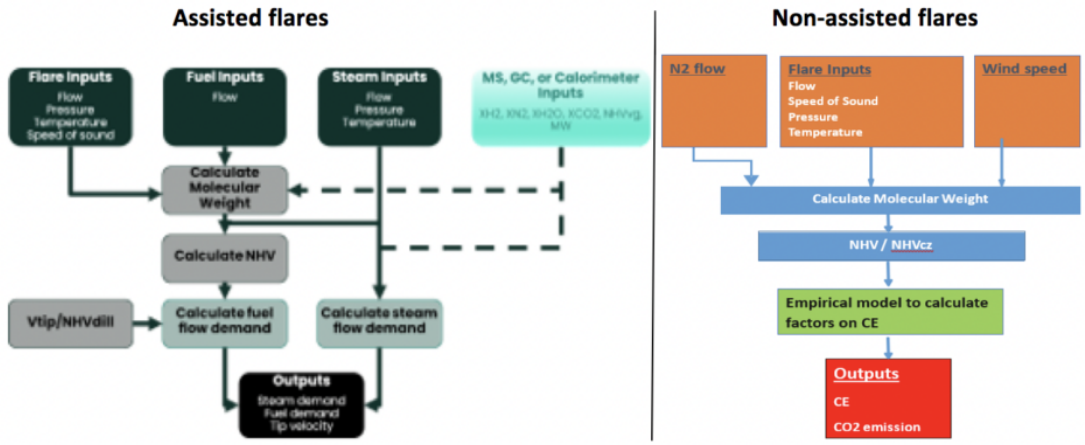
Measure Efficiency: Predictive Analytics

Summary

Predictive analytics describes the process by which measured parameters and models are combined to derive information on flare efficiency. They are analogous to Predictive Emissions Monitoring (PEMS) systems used to track emissions of pollutants such as NOx from gas turbines. For flares, predictive analytics system uses a method based on a and Computational Fluid Dynamics () studies with input data coming from flare gas composition, flow rates, flare design and environmental factors such as wind speed. Predictive systems has the advantage of being permanently installed, providing continuous and near real-time feedback on flare performance, allowing adaptations to be made to maintain efficient combustion. Currently available systems are independent of flare vendor and control system provider.

How it Works

- It collects and calculates all influencing parameters such as **gas at the** (NHVcz calculated from the MW of the gas mixture itself derived from the speed of sound measured by any), flow rate, pressure, temperature, vent gas exit velocity, flare tip diameter, crosswind, nitrogen **purge rate** and gas analysis (if available).
- The algorithms are based on existing experimental studies, such as TCEQ 2010 flare study where samples of the flare plume were extracted after combustion and analysed to measure both CE% and DRE%. This also served as the basis of the EPA properly designed and operated flares that the model uses as well. ?
- CFD studies have been conducted to run simulations using * (EDC) and **Probability Density Function*** (PDF) and have shown strong correlation. The numerical models can be used in combination with the other parameters for both assisted and non-assisted flares. For assisted flares the system automatically provides DCS steam and fuel gas flow set points.
- Provides a real-time CE calculation.
- For optimal performance, it is required to have available process data to pre-program the system for any type of flares even if fine tuning occurs at site during start up and commissioning.



US Patent 10,746,400: Flare Management System and an Associated Method thereof - August 18, 2020

Advantages

- ☑ The CE range is 50%-99.8% with an absolute error of 1.05% for CE% ? 95%
- ☑ Easy to implement and set up, easy to tune to wide variety of flares
- ☑ Flow meter vendor agnostic

- Can work locally and/or be cloud based for unmanned assets
- When there is a single flare boom with a single flame, it distinguishes LP flare from HP flare
- Works with onshore and offshore facilities
- Field proven with installations Downstream (33), Midstream LNG (4), Upstream (2) since 2017
- Provides data on multiple flare parameters, such as flow rate, temperature, pressure, MW
- Underlying measured parameters each have an estimate of uncertainty

Limitations

- Requires an ultrasonic flowmeter on the flare line to feed data to the system
- Inferred measurement (but verified with available online analyzers in Downstream facilities)
- Validation relative to reference methods, such as , is complex

Go Deeper

- Baker Hughes

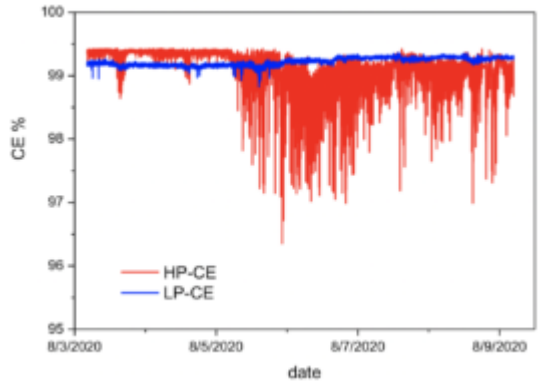
Case study

Assisted flares: 3 US refineries were analysed before and after the predictive system implementation.

	Flare flow (SCFH)	Actual steam flow before (PPH)	Steam flow by system (PPH)	NHVvg (BTU/SCF)	NHVcz (BTU/SCF)	Combustion efficiency	Methane emission (Lbs/hr)
Refinery 1	200 000	7 400	780	478	267	80%	271
Refinery 2	17 000	3 000	280	467	98	59%	45
Refinery 3	16 000	2 020	250	929	251	79%	148
	Flare flow (m3/h)	Actual steam flow before (kg/hr)	Steam flow by system (kg/hr)	NHVvg (MJ/m3)	NHVcz (MJ/m3)	Combustion efficiency	Methane emission (kg/hr)
Refinery 1	5 600	3 360	354	17.7	9.9	80%	123
Refinery 2	476	1 362	127	17.3	3.6	59%	20
Refinery 3	448	917	114	34.4	9.3	79%	67

Assisted flares are often over-steamed leading to **incomplete combustion and CH4 slip**. Here is a flare incident controlled by the predictive analytics system resulting in staying in compliance with the EPA.

Non-assisted flares: Offshore on one FPSO monitoring both LP and HP flares.



The graph represents the CE from LP flare and HP flare.

HP flare CE% from the system has been post-processed to account for N2 input that was not initially available.

Can I measure flare efficiency?

Measure Efficiency: Predictive Feedback and Control

Measure Efficiency: Flare Simulations

Measure Efficiency: Aerial measurement of flare efficiency

Measure Efficiency: Drone equipped with dual CH4 and CO2 sensors

Measure Efficiency: Drone equipped with single methane sensor