Considerations for Flare Gas Recovery Design in Khangiran Gas Treating Plant

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Abstract

Khangiran Gas Treating Plant designed by American Davy PowerGas Inc in 1977, was to flare all flashing gases before 2011 that was guessed to be 1 percent of its NG production. Environmental and economical concerns led to plan a conceptual design project on its recovery. Because of the high extent of CO_2, the flare gas flow rate could not be measured via conventional monitoring methods- for example ultra-sonic. Beside successful efforts on measurement that led to reliable methods and also a novel measuring apparatus, a comprehensive design was raised to achieve a near zero-flaring condition. The plan consists of three main steps: 1- establishing a 5 barg header to collect and use H_2S-free and enough-pressure streams as a supplementary fuel gas, 2- establishing a 6.5 barg header and an amine tower to collect and refine sour and enough-pressure streams and then, adding to the 5 barg header, 3- compressing the remained low-pressure streams from the seal-pot to the 6.5 barg header. These steps will cause to achieve 50, 25 and 25 percent of the final recovery goal, respectively and to reduce 167000 tons/year CO_2 emission. Currently, the first step has been completed and the basic and detailed design of the second step has been carried out by consultant.

1. Introduction

Off spec gas of oil and gas refineries send out flare to burn them. Flaring may occur during routine operation, depressurizing of unit for maintaining, malfunction of PSVs, valves and drains or controlling crisis. Therefore flare system is one of the most essential units at any refinery. Although flare system object is safety and security for personnel and equipments but it produces large amount of toxic gas like NOx and SOx, greenhouse gas like CO_2 and CO. Further large amount of energy wastes by burning gas at flare. Recently, in order to prevent energy loss at flare systems zero flaring projects have been developed to minimize flare gas flow rate. The first step of any FGR project is determination of flow rate, compositions and their sources.

SGPC has able to receive 48 MM m3/day and produce 42 MM m3/day. Also Gonbadli dehydration unit processes 7 MM m3/day. SGPC has two independent flare nets and includes three stacks. Main flare gas streams are from GTUs, stabilizers, sour water regeneration unit, topping and utility. Now output gas from flash drums use as fuel gas for incinerators of SRU. In this project flare gas specifications were quantified then FGR methods were reviewed and appropriate method was simulated by Aspen plus simulator.

2. Theory

Generally flare gas sources can be classified two classes:

1) Off spec gas from various points of units that permanently send out to flare
2) Steams from defected valves, drains and PSVs and depressurizing of units that are temporary.

FGR project objective is recovery of permanent stream and stream through the defected valves. Table 1 shows permanent flare gas sources.

Table1. Permanent gas stream to flare

Unit	Equipment	No. of points	Control valve
GTUs 1-5	Flash Drum	5	PV-116
Stabilizer 1,2	First Flash Drum	2	PV-400
Stabilizer 1,2	First and Second Flash Drum	2	PV-401
Sour Water Regeneration	Surge Drum	1	PV-402
Sour Water Regeneration	accumulator	1	PV-403
Topping 1,2	Distillation Column	1	PV-304

As it is obvious, twelve source of permanent gas there are. Exact data from flare gas specs is a basic key of design. Table 2 shows compositional analysis and flow rate of gas.

Table2. Volume Flow rate and compositional analysis of permanent flare gas

unit	*Flare gas stream source*	*Average flow rate (Sm^3/hr)*	*Average composition (mole percent)*		
			CH4	CO2	H2S
GTUs (Flash drums)	State 1: With sweetening at flash drum tower	5*1233	68	31	37 ppm
	State 2:Without sweetening at flash drum tower	5*1954	40	52	5.2
Sweet stabilizer	First flash drum	422	93	1.6	0
	Second flash drum	38	90	3.8	0
Sour stabilizer	First flash drum	1347	90	5.7	0.26
	Second flash drum	135	69	22	2.9
Sour water regeneration	Surge drum	1630	85	9	3.4
	Accumulator	15	27	21	49
Topping	Distillation columns	56	30	7.8	2.3
All units	Defected valves	4114	89.9	6.5	3.5
Total	State 1	13922	79	17.5	1.5
	State 2	17527	61	32	4.1

As table 2 shows, one of most important sources of flare gas is output gas from GTUs flash drums. As mentioned essential step to carry out FGR project is thorough review and study of various experiences over the world. Next section will present a review on FGR units at different points of world.

3. Review of FGR technologies

FGR has been begun and developed recently at developing countries. At several years ago with global decision to reduce greenhouse gas and CO2 emission, these projects have been supported and funded by United Nations.

Although, how to implement, technology and recovery process completely depends on conditions in any installations but introducing with various experiences in this field causes to increase decision-making power. Some implemented projects in other countries are as following:

a. Reliance oil industries (India): sweetening of 2500 MM m^3/day at 6.5 Kg/cm^2
b. Gas refinery of Harza (India): compressing 1000 MM m^3/day and inject to GTUs.
c. Oil field of Al-Noor (Amman): compressing up to 80 Kg/cm^2 and injecting to GTUs.

It should be mentioned that John Zink Co is one of the most well –known companies at design and implementation of flare systems. It is pioneer also at FGR systems.

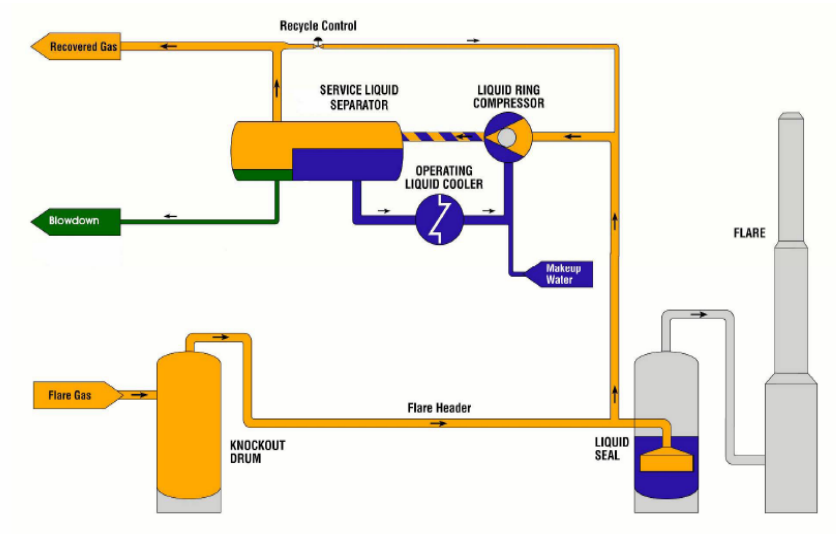

Fig1. Flare Gas Recovery System

In Iran following projects has been carried out:

a. Gathering of gas content of oil fields of Ahwaz: 280000 Sm^3/hr (AMAK project)
b. Gathering of gas content of oil fields of kharg and Bahregansar: 641000 Sm^3/hr
c. Gathering of gas content of oil fields of Siri: 155000 Sm^3/hr

d. Sarkhoon gas refinery are implementing with capacity of 6250 Sm^3/hr. this project compresses output stream of stabilizer from 14 to 75 Kg/cm^2 and injects it to feed line of dehydration unit.

4. Suggested strategy for FGR project

According to various studies and investigations, strategy of FGR is to make singular decision for any flare gas source. Sending out gas to flare causes high pressure drop approximately to atmospheric pressure. So any process operation on K.O.D of flare requires installing compressor. In the other hand, compressors can be pressurize moist, corrosive and toxic gas are high technology and very expensive. Allowing pressure drop and then compressing it to inject flare gas to feed line isn't reasonable.

According to H2S content and pressure, flare gas divide three categories: 1) medium pressure sweet gas 2) medium pressure sweet gas 3) low pressure sour gas. Following sections represent suggestion for recovery of flare gas regarding mentioned conditions.

4.1. Medium pressure sweet gas

Output from flash drum of GTUs (if amine flows through flash drum tower) and first and second flash drum of stabilizer are sweet gas and has minimum pressure of 5 Kg/cm2g.

Table3. Medium Pressure Sweet Gas Specifications

unit	Flare gas stream source	Average flow rate (Sm^3/hr)	Average composition (mole percent)			Net Heating value
			CH4	CO2	H2S	
			%	%	ppm	(Kcal/m3)
GTUs (Flash drums)	With sweetening at flash drum tower	5*1233	68	31	37	5700
Sweet stabilizer	First flash drum	422	93	1.6	0	8400
	Second flash drum	38	90	3.8	0	8200
Average/total		6625	70	70	34	5900

Total flow rate of these streams are 6625 Sm3/hr that collected in a header with 5 Kg/cm2g pressure to recover at FGR unit. Heating value of these flare gas is 65 percent of heating value of refinery fuel gas. Using these streams as fuel for incinerator of SRUs was satisfactory experience. Therefore it recommends that output gas from flash drum of GTUs and stabilizer enter in to a header. This header helps to appropriate distribution between SRUs during the shut-down of either of GTU or SRU.

4.2. Medium pressure sour gas

These streams include outlet gas from first flash drum of sour stabilizer (8.5 Kg/cm2g), outlet from surge drum of sour water regeneration unit (8 Kg/cm2g) and flash drum of GTUs (if amine don't flow through the flash drum tower)

Table4. Medium Pressure Sour Gas Specifications

unit	**Flare gas stream source**	**Average flow rate (Sm^3/hr)**	**Average composition (mole percent)**			**Net Heating value**
			CH4	CO2	H2S	
			%	%	ppm	**(Kcal/m3)**
Sour stabilizer	First flash drum	1347	90	5.7	0.26	7600
Sour water regeneration	Surge drum	1630	85	9	3.4	7300
Average/total		2977	87	7.5	2	7400

It is assumed that output gas from GTUs is sweetened but if sweetening isn't performed, these streams inject to medium pressure sour gas header.

Output of this header enters in to FGR sweetening unit and sweetened gas injects into header of fuel gas of SRU incinerators. Regarding to high flow rate of sweetened gas, portion of it will consume at utility and power plant boilers.

4.3. Low pressure sour gas

Accumulator gas of sour water regeneration unit, upstream of topping unit, second flash drum of sour stabilizer and streams from defected valves are in this category.

Table5. Low Pressure Sour Gas Specifications

unit	Flare gas stream source	Average flow rate (Sm^3/hr)	Average composition (mole percent)			Net Heating value
			CH4	CO2	H2S	
			%	%	ppm	(Kcal/m3)
Sour water regeneration	Accumulator	15	27	21	49	5400
Topping	Distillation columns	56	30	7.8	2.3	12600
Sour stabilizer	Second flash drum	135	69	22	2.9	6800
All units	Defected valves	4114	88	6.5	3.5	7400
Average/total		4320	86.4	86.4	3.6	7440

Regarding to variable flow rate, low pressure and being sour, to recovery of these streams must compress by special secure safe equipments.

Gas exiting from K.O.D of flare before entering seal pot, compresses up to 7 Kg/cm2 then cools and separates its liquids. This stream is sweetened and finally inject into header of SRUs incinerator.

5. FGR sweetening unit simulation

As was explained at previous sections two categories of sour gas with flow rate of 7300 Sm3/hr will be sent to FGR sweetening unit.

Table6. Feed Specification of Sweetening Unit

	Flare gas categories	Average flow rate (Sm^3/hr)	Average composition (mole percent)			Net Heating value
			CH4	CO2	H2S	
			%	%	ppm	(Kcal/m3)
1	Medium pressure sour gas	2977	87	7.5	2	7400
2	Low pressure sour gas	4320	86.4	7	3.6	7440
	Average/total	7927	86.6	7.2	2.9	7420

New gas sweetening unit should able to receive maximum flow rate of flare gas, so simulation has been carried out for 10600 Sm3/hr (mole percent of CO2, H2S is 16.1 and 3.2 respectively) using Aspen plus. Fig 2 shows a schematic view of simulated unit.

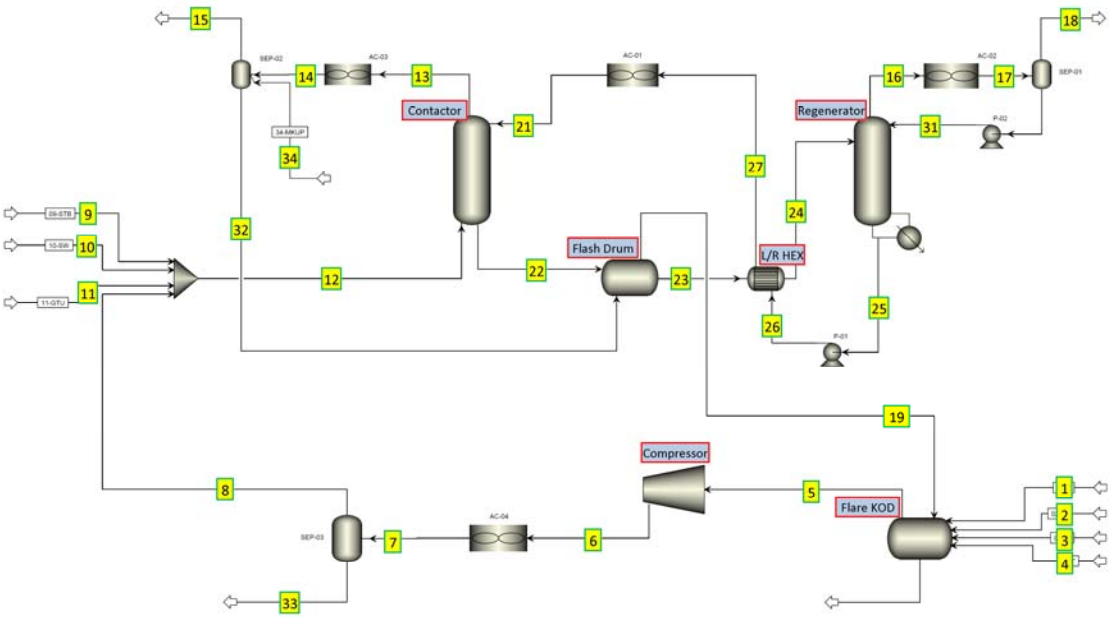

Fig2. Simulated Flow Gas Recovery and Sweetening Unit Using Aspen Plus

Simulation results are as following:

1- Packed column absorber with diameter of 56", height of packing: 8 m, packing type: pall ring 1" and operational pressure: 6Kg/cm^{2}g.
2- Regeneration column with diameter of 1.6 m, No. of tray: 20, tray type: valve tray and feed tray No.: 4.
3- Compressor with compression capacity of 5000 Sm^3/hr from 0.1 to 7 Kg/cm^{2}g (100 psig) and power: 100 Kw.
4- Reboiler for regeneration column with duty of 3 Gcal/hr.
5- Circulations pump for lean MDEA solution from regeneration column pressure to 8 Kg/cm^{2}g with 200 Kw power.
6- Lean/rich heat exchanger with 1 duty of Gcal/hr and area of 50 m^2.
7- Acid gas air cooler duty of 1.2 Gcal/hr.
8- Amine air cooler with duty of 2.5 Gcal/hr
9- Sweet gas air cooler with duty of 0.5 Gcal/hr
10- Air cooler for output gas from compressor with duty of 1 Gcal/hr.
11- Flash drum without tower volume of 5 m^3.

6. Conclusion

Implementation method of FGR at SGPC has been defined at three phase:

Table7. Implemented Method of FGR Project

	Flare gas categories	**Average flow rate (Sm^3/hr)**	**Average composition (mole percent)**			**Net Heating value**	**Recovery method**
			CH4	CO2	H2S		
			%	%	ppm	**(Kcal/m3)**	
١	Medium pressure sweet gas	6625	70	29	34	5900	Complete header line installation and direct consumption of recovered gas at incinerator
٢	Medium pressure sour gas	2977	87	7.5	2	7400	Sweetening at new FGR unit and use as fuel at incinerator and boilers

٣	Low pressure sour gas	4320	86.4	7	3.6	7440	Compressing and sweetening at new FGR unit and use as fuel at incinerator and boilers
Average/total		13922	79	17.5	1.5	6700	-

By implementing FGR project following results will be obtained:

i. Recovery of significant amount of valuable gas and consume it as fuel gas.
ii. Recovery and increase sulfur production.
iii. Reduction of CO_2 and SO_2 emission.

Economical and environmental advantages of FGR project have been presented at Table 8.

Table8. Annual Economical Profit from FGR Project

Flare gas categories		**Fuel gas reduction**				**Sulfur production**		**Pollutant gas reduction**	
		flow rate (MMm3)	Gas price			Weight (tone)	Sulfur price	CO2 (weight)	SO2 (weight)
			Iran (Million Tomans)	America (1000 $)	Europe (1000 $)				
1	Medium pressure sweet gas	38	2660	5244	10032	0	0	70600	0
2	Medium pressure sour gas	21	1470	2898	5544	630	63	39000	1270
3	Low pressure sour gas	31	2170	4278	8184	1650	165	57600	3315
Total		90	6300	12420	23760	2280	388	167200	4585

It should be mentioned that net heating value of fuel gas is 9030 Kcal/m3, gas price in Iran is 700 Rials/m3, in America 0.138 $/ m3 (3.93 $/MMBtu) and

0.264 $/ m3 (7.5 $/MMBtu) in Europe. Sulfur price is 170000 Rials/tone. For calculation of sulfur production and reduction of CO_2 emission, SRU efficiency has been considered %90. So if this project implement completely, its profit will be 60 milliards (by counting sulfur production and fuel gas). Also CO_2 and SO_2 emission will be decreased to 167000 ton/yr and 4000 tone/yr respectively.

7. References

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