Case Study on Optimizing Flare Gas Recovery System of FPSO through FGRC

Introduction

In offshore, Floating Units such as FPSO (Floating Production Storage & Offloading) utilises gas for running its Generators and Boilers. In newly discovered oil regions, the excess gas is either flared off or injected to the reservoir to maintain safe operating environment for pressure vessels. However, in case of marginal fields, where gas production is low, facility is designed for handling a certain amount of gas which is quite low as compared to its initial production phase. Whenever there is surge from wellhead, excess pressure is observed in pressure vessel which is released through PSVs (pressure safety valves), PRVs (pressure relief valves) or BDVs (blow down valves). The released fluid is recycled through KOD (knock out drum) and gaseous portion is sent for flaring. The released gas consists of air pollutants such as CO, CO2, H2S, NOx, and SOx. According to MARPPOL Annexure VI, only a permissible amount of gaseous emission is allowed to prevent air pollution. Therefore, new engineering designs are proposed while constructing FPSO in order to achieve minimum gas flaring and utilizing the same gas for internal consumption.

Process design of flare system of FPSO Armada Sterling is discussed in this technical paper. This FPSO is operating in a marginal oil field located in Bombay High Offshore. Few limitations in existing designs are identified and accordingly changes are suggested to optimise usage of gas for internal consumption and minimize flaring with the help of Flare Gas Recovery Compressor (FGRC). A modified blueprint is also proposed that include provision for gas injection and export for purely oil fields through FGRC.

Overview of FPSO Armada Sterling

FPSO Armada Sterling was designed for handling 50,000 bpd of crude oil (Figure 1). This facility consists of major process modules such as turret & flare system, crude stabilization & produced water system, water injection system, fuel gas and power generation system. Since there is no gas producing wells, facility doesn’t have gas dehydration, injection and export system. Gas evolves from crude when it reaches to slug catcher and conditioned in different vessels before sending to run generators and boilers for producing electricity and steam respectively.

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Figure 1 Technical Specification of FPSO Armada Sterling (Courtesy: www.bumiarmada.com)
Existing Process Design

Slug catcher receives well fluid from PLEM (pipeline end manifold) through oil risers. Once well fluid reaches slug catcher, separation of crude and gas takes place. Crude is sent to HP (high pressure) & LP (low pressure) Separator followed by Electrostatic Coalescer to achieve desired BS&W (marked with blue lines in Figure 2).

On the other hand, gas goes to inlet scrubber for conditioning where liquid droplets are separated from gas. This is done in order to avoid liquid ingress in compressor inlet, downstream of scrubber. After conditioning, incoming gas is sent to 1st Coalescer filter where the liquid particles coalesce and are drained out to drain header. Afterwards gas is sent to fuel gas compressor which compresses it to attain desired pressure before cooling it through a cooler. After cooling the gas is flashed in KOD (knock out drum). In order to maintain safe operating conditions for turbine generators, liquid droplets are further removed before sending to super heater. This action takes place in 2nd Stage Coalescer. Finally, the gas is heated to optimum temperature and sent to Gas Turbine Generators (GTGs) and Boilers for power and steam generations respectively (marked with green lines in Figure 2).

Figure 2 General Process Flow Diagram (PFD)

Excess gas released from pressure vessels such as slug catcher, separators, knock out drums (KODs), etc. is diverted to flare KOD for flaring (Figure 2). Liquid portion is recycled back to the separator (marked with red lines in Figure 2)

Scope for Improvement

As mentioned above, this offshore field has low oil and producing GOR (gas oil ratio) is very low. However, whenever new well is drilled in the region, liquid flow rate increases which in turn increases the gas flow rate. Due to liquid surge, sometimes pressure inside vessel suddenly increases and more gas goes to Flare KOD where again it is allowed to flash, and liquid is transferred back to LP separator (figure 2). On the other hand, flashed gas is not recycled and sent for flaring. This leads to an increased flaring and probable environmental issues.

The emission can be controlled if the flashed gas is compressed and sent back to Inlet gas scrubber upstream of fuel gas compression & conditioning system. The compression can be performed by installing a FGRC designed for recovering the excess gas, before sending to flare. An air cooler installed at the downstream of FGRC will cool down gas prior to sending it to inlet gas scrubber.
Features of Revised Blueprint

A revised process layout has following characteristics which is based on present & upcoming fields:
1. Utilizing flare gas for power & steam generation to improve the efficiency of existing facility
2. Supplying excess produced electricity to unmanned platforms for their operations
3. Creating a provision for gas export & injection for upcoming field.

Few modifications are required in the downstream of Flare KOD (marked with black line in Figure 3).
An ultrasonic flow meter and a flow control valve (FCV) to be installed for measuring and controlling the flow rate of flare gas. A set point is defined below which gas is sent for further recycle and excess is sent for flaring (marked with red line in Figure 3). FGRC is installed downstream of FCV for compression. The compressed gas is sent to air cooler to maintain optimum operating temperature for inlet scrubber.

Prior sending to scrubber, flare gas composition is measured to ensure H2S and CO2 content. If the sour content is less, then gas can be used for rotating turbines, otherwise it will corrode and damage turbine blades. Excess electricity generated is supplied to unmanned platforms for performing drilling operations. This would save the cost of marine diesel oil (MDO) for running generators in liquid mode. Similarly, boilers present in the engine room utilises fuel to produce steam which is used for heating purposes in process side as well as on the lodging side.

On the contrary, high sour content gas is sent to reservoir to promote oil recovery through gas lift. Injecting gas will lower the density and viscosity of well fluid and helps in achieving enhanced oil recovery. For high CO2 producing wells, this layout will help in achieving CO2 sequestration by injecting the same gas into reservoir.

![Figure 3 Modified layout for Flare Gas Recovery](image)

As mentioned above, a provision for exporting & injection is also presented in this design. However, the existing field neither have pipelines for export nor it contains any gas lift system for injection. Hence, the process stated below is only applicable for new fields which either export gas to consumers or have gas lift wells or both.

Gas export or injection is performed on two stages of compression depending on the upstream pressure. Prior to exporting or injecting, pressure is increased in the booster station. Gas is first sent to KOD (knock out drum) for flashing, followed by 1st stage compressor and cooler. Again the gas is sent for 2nd Stage Compression prior to export or injection.
Advantages of Revised Blueprint

In current operating scenario, the proposed design has following advantages

1. Reduction in amount of gas flaring through FGRC
2. Decreasing carbon footprint in the atmosphere
3. Optimising fuel requirements for boilers and generators
4. Minimizing the use for diesel oil for electricity generation for unmanned platforms
5. Increasing the profit from the government based on carbon credit

The design has improvement scope for upcoming or newly discovered fields

1. Improving oil recovery by gas injection through gas lift
2. Increase profit by exporting gas to gas consumers
3. Provision for CO2 sequestration in case of high sour content gas

Conclusion

In the technical paper, few limitations were identified in the process design i.e. though the released fluid (from pressure relieving devices) is recycled back to separator; and there is no provision for recovering gas. Due to absence of flare gas recovery system, gas is direct sent for flaring. Based on those limitations, a revised process flow diagram is proposed which include recovering gas through FGRC and diverting for internal consumption. At the same time, a facility is provided for exporting and injection of high sour content gas.

Acknowledgement

We are very thankful to our mentor Mr Anshuman Sehgal (Asset Integrity Engineer, S P Armada Oil Exploration Pvt Ltd) for his extreme guidance. We would also express our gratitude to EAGE for giving us the opportunity to present our result in this technical paper.

Reference


