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Simulation and optimization of a condensate stabilisation process

N. Rahmanian [a,*], L. Sakinah Bt Jusoh [b], M. Homayoonfard [b], K. Nasrifar [c], M. Moshfeghian [d]

[a] School of Engineering, Faculty of Engineering and Informatics, University of Bradford, BD7 1DP, UK
[b] Chemical Engineering Department, Universiti Teknologi PETRONAS, Tronoh, 31750 Perak, Malaysia
[c] Department of Chemical Engineering, Shiraz University of Technology, Shiraz, Iran
[d] PetroSkills, John M. Campbel, Katy, TX, USA

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ABSTRACT

A simulation was conducted using Aspen HYSYS® software for an industrial scale condensate stabilisation unit and the results of the product composition from the simulation were compared with the plant data. The results were also compared to the results obtained using PRO/II software. It was found that the simulation is closely matched with the plant data and in particular for medium range hydrocarbons. The effects of four process conditions, i.e. feed flow rate, temperature, pressure and reboiler temperature on the product Reid Vapour Pressure (RVP) and sulphur content were also studied. The operating conditions which gave rise to the production of off-specification condensate were found. It was found that at a column pressure of 8.5 barg and reboiler temperature of 180 °C, the condensate is successfully stabilized to a RVP of 60.6 kPa (8.78 psia). It is also found that as compared to the other parameters the reboiler temperature is the most influential parameter control the product properties. Among the all sulphur contents in the feed, nP-Mercaptan played a dominant role for the finishing product in terms of sulphur contents.

1. Introduction

Natural gas condensate (also called condensate, gas condensate or natural gasoline) is a liquid hydrocarbon. However, gas condensates are often present as gas when produced from natural gas reservoirs. Based on the Schlumberger Oilfield Glossary (2012), this mixture of hydrocarbon liquids has a low density (high API gravity) and will condense out of the raw gas if the temperature is reduced to below the hydrocarbon dew point temperature of the raw gas.

Condensates produced from reservoirs contain a large amount of light components that would flash off at low pressure and high temperature causing the loss of valuable compounds, poising safety risk and polluting environment. These conditions are not ideal for condensate storage and transportation. Therefore, condensate stabilisation needs to be done prior to its further processing (Campbell, 2014; Rahmanian et al., 2015). Tahouni et al. (2014) studied effect of increasing flow rate on condensate stabilisation unit (CSU) in the same gas field. They showed that by applying the optimum pressure drops method for debottlenecking of this unit, after 20% increase in throughput, utility consumption can be maintained at existing level, if 1554 m^2 of additional heat transfer area is installed. They have not shown if Reid Vapour Pressure (RVP) specification can be maintained during summer while they discussed that there is no issue with RVP if the heat transfer area can be utilised.

The objective of this paper is to simulate and validate an industrial scale of a CSU and to study the influence of operating conditions on the quality of the product in terms of (RVP) and sulphur content while maximizing the liquid recovery.

2. Literature review

2.1. Natural-gas processing

Fig. 1 shows the overall block flow diagram of natural gas processing starting from the natural gas well to the onshore processing plant including Condensate Stabilisation Unit (CSU) and the Back-up Condensate Stabilisation Unit (BCSU) in the South Pars project, Iran.

* Corresponding author.
E-mail addresses: rahmaniyan@yahoo.com, n.rahmanian@bradford.ac.uk (N. Rahmanian).

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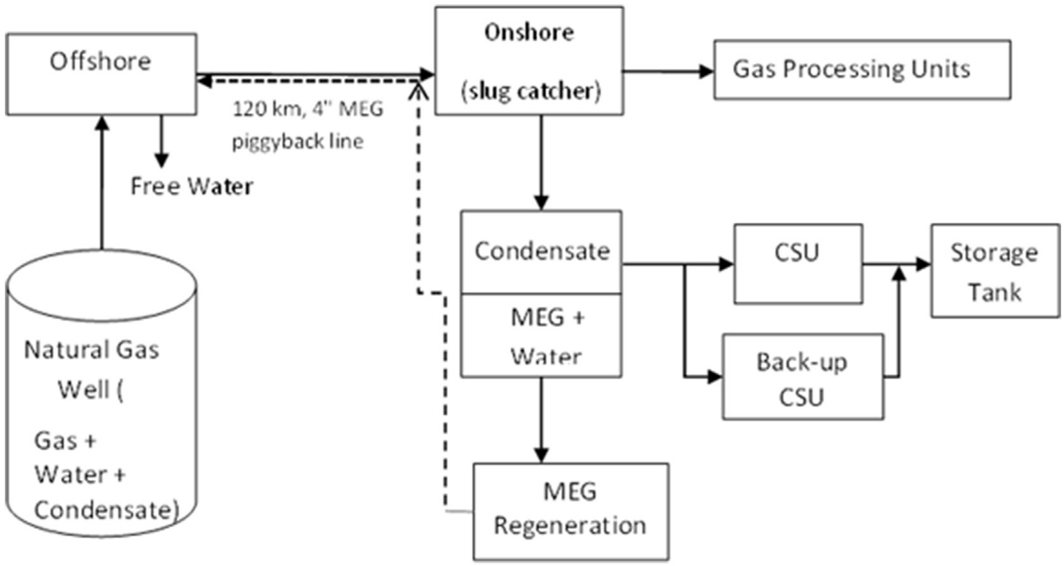

Fig. 1. Block Flow Diagram of the natural gas processing in the South Pars project. (Rahmanian et al., 2015).

Rahmanian et al. (2015) described the whole process flow diagram of this and for brevity purposes not repeated here. In brief, upon reaching reservoir fluids to the onshore gas plant, the mixture of gas, condensate, water and MEG would first be separated into two streams; a gas stream and a liquid stream in a large figure-type slug catcher. The gas stream is sent to the gas plant to be further processed. The liquid stream which comprises of condensate, MEG and water is further separated into a stream of condensate and a stream of MEG and water in the slug catcher by the proper level controller. The mixture of MEG and water is treated in the MEG regeneration unit where the MEG would be regenerated and then recycled and reused in the pipeline. The condensate would be sent to the CSU. This is where the stabilisation process takes place under normal process conditions. During shutdown of CSU, a parallel unit i.e., BCSU will be brought to operation to avoid interruption of condensate production and overall onshore gas plant shutdown (Rahmanian et al., 2015).

2.2. Condensate stabilisation

Campbell (2014) stated that there are two main methods for the stabilisation of condensate. They are multi-stage separators and fractionation which are described briefly in the following section.

2.2.1. Flash vaporisation

The method of multi-stage separators utilizes the density difference between the vapour and liquid phases. The vapour phase of the condensate is flashed off by gradually lowering the pressure of the liquid streams during each stage (Benoy and Kale, 2010). The liquid mixture is partially vaporised and then equilibrium between the vapour and liquid would be reached when the two phases are in equilibrium at the temperature and pressure of separation (Geankoplis, 2003).

Fig. 2 shows the process flow of condensate stabilisation through a two-stage flashing (Benoy and Kale, 2010). This method falls under the multi-stage separators (flash vaporisation) technique. It can be seen in Fig. 2 that the process of flash vaporisation would usually comprise of two or three separators. The number of separators depends on how many stages of flashing are required to achieve the desired RVP.

The method of stabilisation through flash vaporisation is an old technology and may not be used in a modern gas plant. However, it can be used as a back-up condensate stabilisation unit (BCSU) in the event of a shutdown of the main CSU (Rahmanian et al., 2015) and is a cost-effective method for the condensate stabilisation. Fig. 3 shows an example of a BCSU in Iran's Phases 6, 7 and 8 gas plants (Esmaeili, 2010). In oil production facilities, the feed normally go through multi-stage separation first to remove the bulk of gases and if it does not meet the RVP, then we send the oil through a stabilized column. Condensate stabilisation using stabilisation (stripping) column stabilisation even though is more effective but more expensive and requires heating medium which not be always readily available at the production sites.

2.2.2. Stabilisation by fractionation

The second and most popular method of condensate stabilisation in gas industry is by fractionation. In this process, light fractions are removed from the condensate so the finished product will be composed of the heavy fractions which are mainly pentanes and heavier hydrocarbons. Thus, the bottom product obtained is a liquid that can be safely stored at the atmospheric pressure. This stabilisation technique is more effective than the multi-stage separators method and is more economically viable.

Fig. 4(a) and Fig. 4(b) show two examples of process flow of condensate stabilisation through fractionation proposed by Mokhatab et al. (2006) and Benoy and Kale (2010), respectively. In these processes, the feed first enters the inlet separator. The inlet separator here has the same function as in flash vaporisation where it removes entrained water from the condensate. In the feed drum, any light components would be separated from the feed and sent to the fuel gas system. The hydrocarbon condensate then enters the stabiliser column on or near the top tray. This column basically acts as a stripper where the light components are removed from the condensate (Mokhatab et al., 2006) by supplying heat in the reboiler.

For a better separation, a refluxed distillation tower could be used. The process flow diagram of refluxed distillation stabilisation is shown in Fig. 5 (Benoy and Kale, 2010). It can be seen that the early part of the process is similar to stabilisation through fractionation.

The difference between Fig. 4(b) and Fig. 5 is in the location of the feed tray and also the existence of the reflux section in the