BS1

# Novel AGR - EOR Combination for Treating Extra Natural Gas, Saving Energy, Maximizing Oil Production and CO2 Emissions Mitigation

A. Amhamed* (Qatar Environment & Energy Research institute), A. Abotaleb (Qatar Environment & Energy Research institute)

## Summary

Natural gas (NG) processing starts from simple separation and conditioning for pipeline network for further processing, integrated offshore and onshore operations. The treated NG after processing is utilized in different applications including NG transmission distribution networks, fuel source for power generation, the feedstock for petrochemicals, conversion of gas to liquid (GTL), LNG and reinjected for secondary oil recovery. The key factor for those activities is the quality of treated gas.

## Abstract

Natural gas (NG) processing starts from simple separation and conditioning for pipeline network for further processing, integrated offshore and onshore operations. The treated NG after processing is utilized in different applications including NG transmission distribution networks, fuel source for power generation, the feedstock for petrochemicals, conversion of gas to liquid (GTL), LNG and reinjected for secondary oil recovery. The key factor for those activities is the quality of treated gas.

There are different sour gas treatment processes in the industry including absorption by either physical or chemical solutions, membranes or cryogenic fractionation. In fact, most of the current Acid Gas Removal (AGR) unit operation is based on the absorption/desorption process. Furthermore, amine scrubbing has been used on large plants such as coal-fired power plants and has shown a high capability, operation flexibility and smooth retrofit to existing plant. However, AGR systems suffer from several drawbacks; the large amounts of energy required for regeneration of the rich amine, which is equivalent to 60 to 70% of total AGR operating cost, and the relatively low $CO_2$ loading capacity of amines, which requires high-pressure absorber column and high solvent circulation rates and consequently large diameters for absorber and stripper columns[1].

The life cycle of oil production has several stages. The primary stage when the oil flows naturally from wells to surface due to enough pressure differential at existing oil and gas reservoir, typically the oil production at this stage achieve 10 to 25% of the recoverable oil. When the reservoir pressure declines with time and there is no enough pressure differential to produce the oil naturally then the well reaches the secondary stage, at this stage, water or NG is ideally injected to boost the pressure to displace the oil, the oil production at this stage can achieve additional 10 to 20% of the recoverable oil. In the last stage that is known as tertiary recovery; Enhanced Oil Recovery (EOR), the residual oil is recovered by different ways such as hydrodynamics, thermal, chemicals or miscible gas flooding; $CO_2$ injection.

EOR is a technique to increase the oil production by re-storing formation pressure and enhancing oil displacement in the reservoir, when the primary and secondary stages are exhausted and can no longer produce at economical oil. Hence, the main purpose of EOR is to extend the life of unprofitable or depleted fields. However, the decision of EOR process selection and the expected recovery depends on many factors such as reservoir properties, technology used and the economics. In fact, $CO_2$-EOR is currently the most common practiced method, where two injection modes have been utilized for the $CO_2$-EOR. Those injection modes are miscible and immiscible, where supercritical phase of $CO_2$ can easily become miscible and mix to form a single fluid phase at suitable reservoir pressure and temperature, which leads to increase the reservoir's volume. In top of that, the viscosity and surface tension of the original crude oil will be reduced, which facilitate the crude oil movement to flow out of the reservoir. However, a mixed single phase of $CO_2$ and crude oil under certain conditions will not guarantee that CO2 immediately becomes miscible with oil at first the interaction. As a result, from the first contact between CO2 and crude oil, the composition of CO2 is enriched with vaporized light components of the crude oil, which enables the miscibility between oil and CO2 that forms a miscible zone between oil bank and injected CO2.

Minimum miscible pressure (MMP) is the most critical factor for the miscibility process; it is required to achieve miscibility between CO2 and the crude oil. In fact, this pressure is required to increase the density of CO2 to make it similar to the targeted crude oil density. Moreover, the miscible displacement process requires the injected CO2 pressure to be higher than the MMP and definitely, shall be lower than the reservoir pressure. In some cases, the injected CO2 is utilized as an oil recovery technique even when the MMP is not reached. Although, the CO2 will not be totally miscible with the oil, but still partially dissolves into it. The performance in this case will yield less recoverable oil compared to a case that achieves the MMP. In order for the CO2-EOR miscible displacement to be effectively utilized, reservoir key parameters shall be screened, such as pressure, temperature and especially crude oil composition (API gravity).

On the other hand, $CO_2$-EOR potential in Qatar, one of the world's leading oil and gas producers, is extremely immense, where the state economy is highly dependent on oil and gas production. The rapid economic growth has also increased the environmental challenges, where $CO_2$ per capita emission reached a value of 35.73 tons in 2016 [2], placing Qatar at the top of the worlds $CO_2$ emitters per capita. The emitted $CO_2$ was mostly from the energy sector, specifically oil and gas production (flaring). Hence, the region climate is arid, where any further climate change could severely affect the environment, and eco-system, thus $CO_2$ emissions shall be reduced. Notably Carbon Capture storage (CCS) method is very efficient and offers a long-term solution for the $CO_2$ by using the depleted reservoirs as storage for the $CO_2$. In fact, the use and sequestration of $CO_2$ during EOR provides ultimate solution for the emission, since all the utilized $CO_2$ to improve the oil sweep is permanently and safely stored. Given that, the use of $CO_2$-EOR to produce oil results in net reduction in $CO_2$ emission by 0.19 metric tons per EOR barrel[3].

The ultimate aim of this work is enhancing acid gas loading, reducing energy consumption in AGR system and stripping $CO_2$ at high pressure through modifying amine solvent and new AGR process integration system. In top of that, the proposed configuration enables production rate maximization at the tertiary phase by a novel AGR-EOR integration. Typically, $CO_2$ stripped from AGR plants is at low-pressure operation; nearly atmospheric, which contributes to the unviability of low-cost Carbon Dioxide for the implementation of AGR-EOR project. In fact, the condition of the injected $CO_2$ shall be at high pressure.

The proposed novel configuration helps in utilizing the existing AGR to receive more gas, reduce energy and utility consumption and maximize oil production. Moreover, this will positively contribute in climate change mitigation goals as $CO_2$ captured and reinjected in EOR.

A simulation study based on a real NGL plant data with 390 MMSCFD feed sour gas has been conducted using Aspen simulator to evaluate the novel configuration compared to typical AGR system. The obtained results show that with maintaining the same specification of treated gas quality, the acid gas loading increased by Approx. 40%, the amine circulation rate decreased from 522 m3/hr to 295 m3/h. The pumping power decreased by 47%, the external heating steam consumption decreased by more than 25% and the air coolers electrical power and cooling water consumption have been eliminated. Although there is an added compression power but the oil production could be enhanced with 1360 barrel/day. Moreover, A 13.6 MMSCFD $CO_2$ is mitigated and utilized rather than flared to the environment.

## References


[1] Ahmed Abotaleb, Muftah H. El-Naas, Abdukarem Amhamed, "Enhancing gas loading and reducing energy consumption in acid gas removal systems: A simulation study based on real NGL plant data", Journal of Natural Gas Science and Engineering · September 2017, DOI: 10.1016/j.jngse.2017.08.011

[2] IEA. (2016). Key world energy statistics. Retrieved 18/10/2017, from international Energy Agency: https://www.iea.org/publications/freepublications/publication/keyworld2016.pdf

[3] Clean Air Taskforce. (2016, October). Global CCS institute. Retrieved from Set in Stone: https://www.globalccsinstitute.com/news/institute-updates/iea-enhanced-il-recovery-results-significant-net-co2-emission-reduction