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Investigation on New Innovation in Natural Gas Dehydration Based on Supersonic Nozzle Technology

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Abstract

According to growing of demand for natural gas in global markets, it causes to modify and intensify its process. Indisputably, the existance of water in natural gas has so long been a controversial issue in gas industry and removing water from NG becomes a big deal, indeed. Gas dehydration is the most essntial and important way to solve this problem and there are several approaches to attain this aim. Among these methods, dehydration of natural gas with supersonic nozzle is an effictive method which is more efficient way than other methods. The main advantages of this method are its small size that is big deal for off-shore units because of limitation of location and also low operating costs with no deleterious environmental impact. In this study at first we examined some important methods for gas dehydration and then we proceed the details of supersonic nozzle method, and finally we compare it with other methods and conclude its unique advantages as abest method for gas dehydration.

Keywords: Dehydration, Hydrate, Natural Gas, New Technology, Supersonic Technology

1. Introduction

Dehydration process is an essential part of gas processing in offshore units which avoid several important problems in gas processing. The problems encompass erosion, fouling, gas hydrate and such like. There are the varity of methods for gas dehydration in gas industry but some them are most important compare to others like adsobrtion, adsorbtion and direct cooling for instance, due to absorption preocess the amin part is uing di-ethylene and glycoles that are used for withdrawing water content in gas. One of the modern high technology intersted to developed target ingredients from natural gases supersonic-technology. If we using a convergent-divergent Laval nozzle, the supersonic flow is produced. The components of C3+ are heavy and when mixed with condensed drops, they are separated from the natural gas flow in the supersonic nozzle.

Under action of centrifugal forces, we can separated the condensate drops with target ingredients condensed in the supersonic nozzle is carry out. This means that flow swirling at the supersonic nozzle entry.

The supersonic-high technology have many advantages as compared with old technologies. Some of these differences are list in below:

- Small size of the hydrocarbons separation from natural gas.
- Decreased space requirements.
- High portability.
- Decreased handling.
- Decreased installation costs.
- Decreased costs of operating.
- No harmful environmental impact.

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- No demand for routine maintenance[1].

2. Gas Dehydration

Natural gas can carry certain amounts of water in the vapour form. Water is a contaminant in natural gas and its concentration increases with temperature or equally with reduced pressure. Physical appearance of gas hydrates is like packed snow. The conditions at which hydrates start to solidify, and become a cause for trouble, depend on many factors including but not limited to gas temperature, pressure, composition, and the water content. Therefore it is very important to develop techniques to prevent hydrate formation. The following methods have been conventionally used for hydrate prevention like identifying the temperature at which hydrates formation and keeping the gas above this temperature, reducing pressure and therefore reducing the possibility of hydrate formation, adding hydrate inhibitors to the gas, which in tum will either reduce the temperature at which hydrates are likely to form or the rate at which they form and reducing the water content of the gas and therefore reducing the possibility of hydrate formation. This process is called gas dehydration which is reported by Michalnetusil et al[2] in their article.

2.1 Problems with Water in the Gas

As mentioned before there are some amount of water in gas which is named water content and in the cold region as the ambient temprature of fell down and decrease under the dew point temprature of water, the small moleculars of water which are in vapor phase in pip,beging to condence and aggregate to big one and cause to form methane hydrate that is in solid form and this small solid particle which are crystal, beging to make large partile and if they be in the way of natural gas which consist of H_2S and CO_2 can cause several serious problems like corrosion and erosion.

3. Supersonic Separation

We can use the 3S technology to exploit target component from natural gases. Basis of this high technology, is realted to the cooling of natural gas in a supersonic swirling gas flow. Following thermodynamics devices is similar to the supersonic separator:

- Turbo expander.
- Combining expansion.
- Cyclonic gas/liquid separation.
- Tubular device.

For transforing the pressure to shaft power, we can used the turbo expander. Also, using of the supersonic systems in industry is one of the best methods to remove compressible vapours like as natural gas liquids or water from a gas stream.

In the 3S-technology, under action of centrifugal forces, separation of condensate drops with target ingredients condensed in the supersonic nozzle is carry outed. The two phase mixture continues its supersonic swirling now and under the influence of the strong inertial force, the droplets will collide with the wall and merge. A thin film of water will form around the swirling gas which then will be separated by means of a vortex finder as in cyclones. The gas is now dry, and will slow down in the diverging part of the nozzle, regaining almost 70% of its original pressure.

The concept of supersonic separators was introduced to the oil and gas industry in 1990s. These separators were immediately identified as reliable devices with no rotating pans that required no chemicals and were capable of unmanned operation. It has been the purpose of a few studies since then to optimize the performance of supersonic separators and to expand their functionality from a dehydration device to a more sophisticated hydrocarbon dew•pointing and NGL recovery device. The following is a quick review of the achievements of these studies. Their study of supersonic separators is tracked back to 1997 and their first full scalc tcst unit became operational in 1998 and in 2003, supersonic separator used in gas conditioning technology. Their proposed design consisted of a supersonic nozzle that incorporated a small blade (supersonic wing) in the supersonic region to create the swirling motion of thc gas and henee benefit from the centrifugal separation of the heavier particles. This design was later improved to include a swirl generator (ring wing) upstream of the nozzle and in the subsonic region. Another group known for their extensive work on the supersonic separators is a group of Russian specialists who named their separator 3-S.

The design of the 3-S separator was similar to the improved Twister design, incorporating a swirl generator upstream of the nozzle. A third Chinese group has also performed studies on supersonic separators. They built a pilot scale test which used wet gas as process fluid which was capable of attaining a dewpoint depression of about

20°C. Their design used a cyclonic swirl generator in the supersonic region. Another study was performed by a group in Newfoundland, Canada on which the current study is based. They performed CFD based predictions of the flow characteristics inside a converging. Diverging nozzle and showed that this method is a valid tool for this type of study by comparing their results with similar published experimental data. They moreover developed a software that linked to a process simulator (HYSYS), was capable of predicting the performance of a supersonic separator under certain operating conditions with much less computational resources than a CFD package which is reported by Bart prast et al[3] in their article. A supersonic dehydration unit may be consisted of several parts, the most important of which is a converging - diverging supersonic nozzle. It is in this nozzle where the condensation or as it may be in some cases, solidification occurs as well as the separation itself. Since the gas mixture is flowing at supersonic velocities, residence time is extremely low in this type of separators and hydrate has no time to deposit along the device. The unit is considerably smaller than conventional dehydration units and therefore suitable for offshore applications. Moreover, the nozzle has no moving parts and is simple to operate which makes it a very good candidate for unmanned operations for subsea application is also important to note that the gas temperature is reduced based on gas expansion principles and requires no external refrigerant. This brings another major advantage over conventional dehydration units in that intensive water dew points, down to 60°C, can be achieved without any use of external cooling. The selectivity of separation is another asset when water is removed

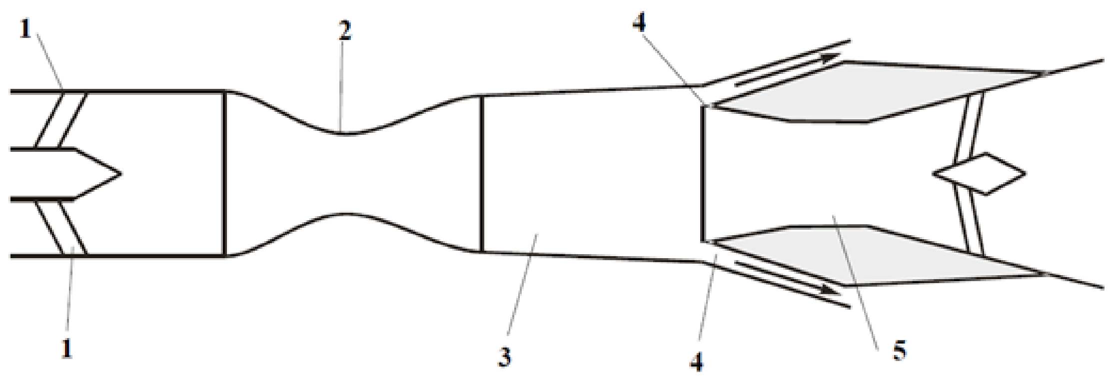

Figure 1. Schematic of suppersonic nozzle separator.

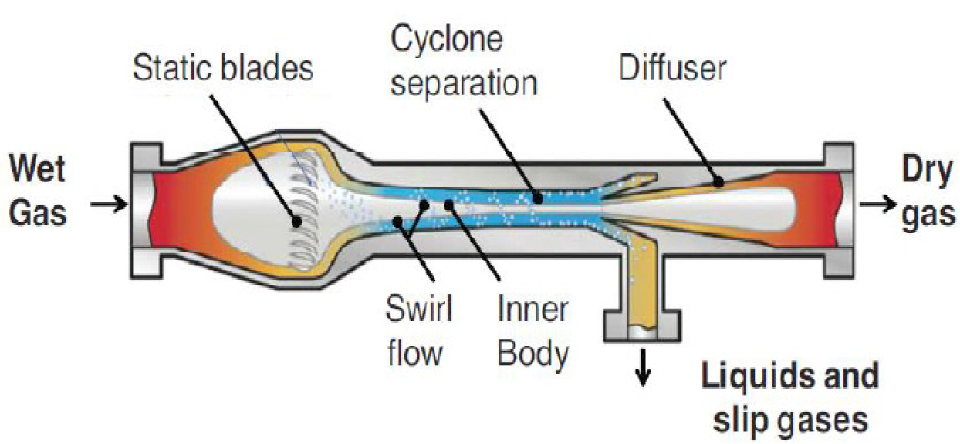

Figure 2. Supersonic nozzle body.

without the removal of hydrocarbons. This is beneficial in that presence of heavier hydrocarbons increases the gas gravity and reduces the compressibility factor, which results in increased pipeline mass flow capacity. Malyshkina developed mathematical simulations for velocity components, pressure and other parameters as functions of radius for flow within the supersonic separator using the two dimensional Euler model. Qingfcn, Depang, and other colleagues investigated the performance of supersonic separators incorporating a method of particle enlargement to reduce the length of the device. Brouwer, J. M. et al[4,5] used air-ethanol as their medium and water droplets as nucleation centers.

Figure 1 display the shematic design of a supersonic nozzle and Figure 2 shows the schematic of the super sonic nozzle body[6]. These examples which is offered Qingfen Maa et al[7] the probability of increasing the profitability of gas processing plants by means of an cheap modernization figure.

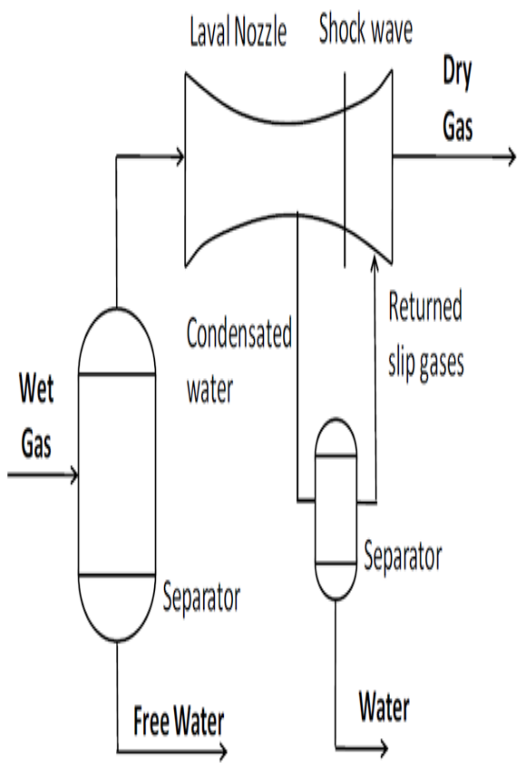

Figure 3. Schematic representation of a supersonic dehydration line.

The picture of a supersonic dehydration line working on the essential described which is reported by Wen C et al[8] and also with Okimoto Fa and Brouwer J. M.[9] here is pictured in Figure 3.

4. Conclusions

There are several processes involved in processing the reservoir fluid into oil, gas andwater. One of the most important processes offshore is gas dehydration, because wet gas increases corrosion and can course plugs from ice or gas hydrate.

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6. References

1. Yamamoto T, Furuhara T, Arai N, Mori K. Design and testing of the Organic Rankine Cycle. Energy J. 2001; 26:239–251.
1. Klingmann M. Supersonic flow separation with application to rocket engine nozzles. Appl Mech Rev. 2013; 10(3):1340–9.
2. Michalnetusil A, Pavel D, Gonzales T. Natural gas dehydration, open access chapter one. Mechanics. 2012; 5(109):76–85.
3. Prast B, Lammers B, Betting M. CFD for Supersonic Gas processing. 5th International Conference on CFD in the Process Industries. 2006; 10(2289):1–6.
4. Brouwer JM, Epsom HD. Twister supersonic gas conditioning for unmanned platforms and subsea gas processing. Proceedings of Offshore Europe Conference. 2003; 2 (19):225:43–9.
5. Brouwer JM, Bakker G, Verschoof HJ, Epsom HD. Supersonic gas conditioning. first commercial offshore experience. Proceedings of GPA Annual Convention. 2004; 10(17):80–98.
6. Wen C, Cao X, Yang Y, Zhang J. Evaluation of natural gas dehydration in supersonic swirling separators applying the Discrete Particle Method. Adv Powder Technol. 2012; 23(7):228–33.

7. Ma Q, Hu D, He G, Hu S, Liu W, Xua Q, Wang Y. Performance of inner-core supersonic gas separation device with droplet enlargement method. Chinese Journal of Chemical Engineering. 2009; 17(9):925–33.
8. Wen C, Cao X, Zhang J, Wu L. Three-dimensional numerical simulation of the supersonic swirling separator. Beijing, China: 20th International Conference on Offshore and Polar Engineering. 2010; 6(17):273–85.
9. Okimoto F, Brouwer JM. Supersonic gas conditioning. World Oil. 2002; 223(8):89–91.