Purge gas recovery in ammonia plants

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Abstract

In old ammonia plants the purge gas of synthesis loop after recovering of ammonia content in a flash drum are vented; whereas, in new ammonia plants there are the subunits to recover the NH_3 and H_2 content of purge gas and then use the retentive gas as a fuel in furnaces. The installation of a purge gas recovery unit not only will increase ammonia production capacity but also it will be beneficial and will save considerable amount of NG (as a common fuel) and decreases CO_2 emissions compare with older ammonia plants. Hereby in this article, the advantages of the retentive gas using as a fuel gas has been considered and economical and environmental benefits earning by CO_2 emissions reduction also has been computed.

Keywords: recovery, retentive gas, NG saving, CO_2 emissions

1. Introduction

Chemical industries are the emission sources of many air pollutants and greenhouse gases in particular. However, this emission could be largely reduced by separation and reuse of some streams.

Ammonia plants are among highest energy consuming plants in the petrochemical industries. On the other hand, the greenhouse gases such as CO_2 and CH_4 are produced in relative large amount during chemical and physical processing. Recovering the waste gases and recycling to the process or fuel gas result in saving some energy and reducing greenhouse gas emissions. The fresh make up gas supply to the synthesis loop usually contains small quantities of inert gases such as methane, argon and helium. These gases are inert so then tend to concentrate in the synthesis loop and must be removed to maintain the loop stream concentrations and material balance [1]. As shown in figure 1, the gases called purge gas are a branch of recycle flow of ammonia converter and are removed.

The purge gas contains hydrogen, nitrogen, ammonia, methane and argon. Although it is considered as a pollutant to the environment, it comprises materials with relative high heating value. By the way, it contains large levels of ammonia and hydrogen that is valuable gas for the process. For these reasons, it is important to design an industrial and economic method to recover hydrogen and ammonia contents of the purge gas and then to use the retentive gas as fuel in furnaces.

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There are several methods that have been developed for hydrogen and ammonia recovery from purge gas. A common method is based on adsorption and regeneration cycles. A selective absorbent captures ammonia and subsequently it is regenerated by fresh synthesis gas as main aspects of this process [2]. An alternative way is hydrogen recovery using one of the metal nitrides like $LaNi_5$, FeTi or Mg_2Cu as reversible and selective adsorbent in the form of ballasted pellets [3-5]. Selective gas permeation utilizes membranes and can be applied to separate hydrogen from gas mixture [6-7].

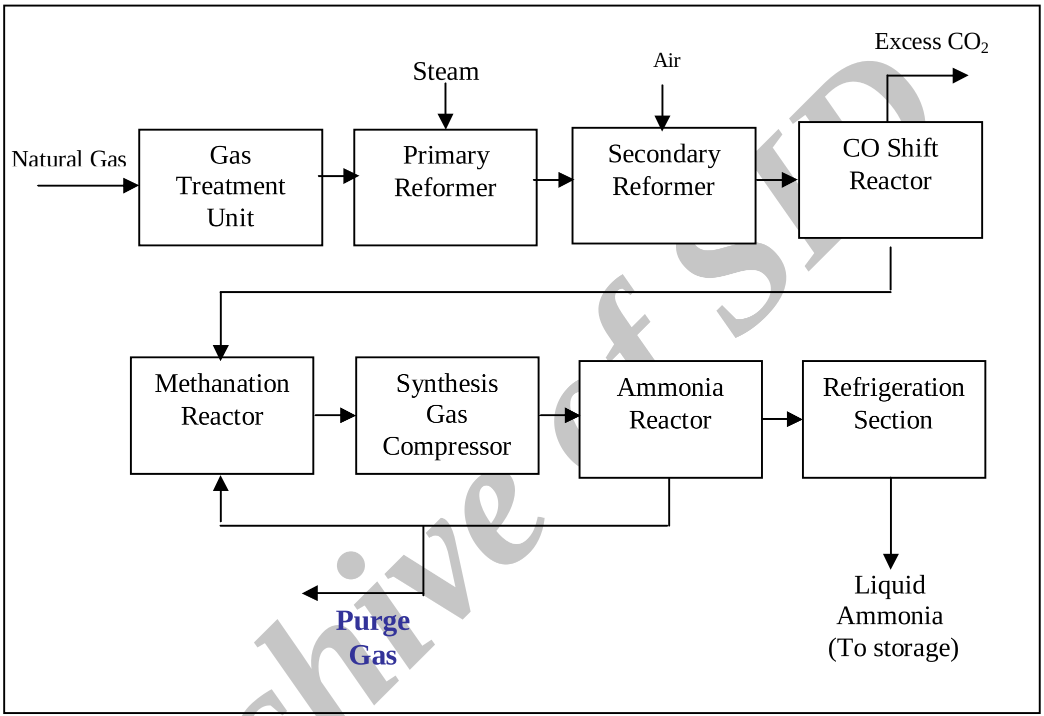

Figure 1- a block diagram of ammonia plant and purge gas position

The purpose of this work is to introduce a process that is capable of recovering ammonia and hydrogen from ammonia plant purge gas. In advanced plants, ammonia and hydrogen contents of purge gas will recover and finally retentive is gas used as fuel in furnaces. It can save some amount of NG and avoid their conversion of additional fuel to the greenhouse gas carbon dioxide.

The results of two alternatives are compared, that is, venting purge gas without recovery and burning retentive gas as fuel additive.

2. Selected method

The total flow rate of purge gases in the ammonia plants of Razi Petrochemical Company is 5600Kg/hr whose composition is shown in table 1. In this method, ammonia recovery is done by absorbing and stripping; hydrogen recovery is performed by membrane separation. Ammonia is absorbed by a water flow in a scrubber and withdraws as ammonia solution from scrubber bottom. The ammonia releases from ammonia solution in the stripper.

Remaining gas mixture goes out the top of absorber and enters the hydrogen recovery section. H_2 is recovered during two membrane separator stages. The first stage produces high pressure hydrogen and the output of the second, is low pressure hydrogen. The sum of recovered ammonia and hydrogen amount is 687Kg/hr. The process scheme is shown in figure 2.

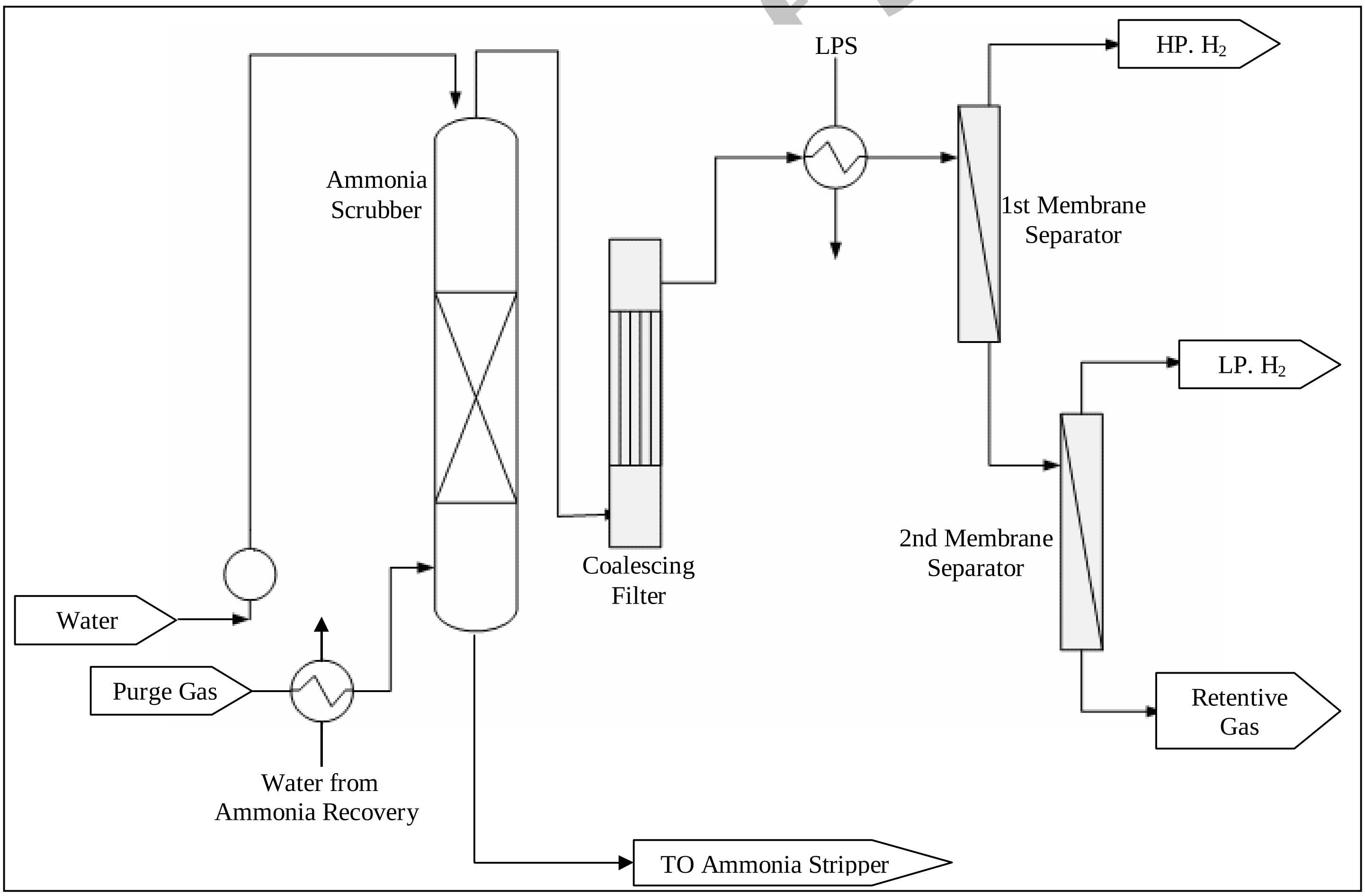

Figure 2- Purge Gas Recovery Unit

As shown in table 1, purge gas contains ammonia, hydrogen, nitrogen, argon and methane of different compositions.

Table1- composition of purge gas in ammonia plant (T=-21˚C, P=109.60 bara)

Component	Mol%
H_2	58.15
N_2	19.36
CH_4	14.20
Argon	6.02
NH_3	2.27

The aim of purge gas recovery unit is first to recover ammonia content of gas and then recover hydrogen content with 90% and 99.5% efficiency, respectively and finally use the remained gas as fuel in furnaces.

The rejected gas of second membrane is retentive gas known as waste gas. Its flow rate is 3685.9 Kg/hr. The composition of the waste gas is shown in the table 2. One observes it has enriched in methane, nitrogen and argon.

Table 2- retentive gas composition (T=50˚C, P=102 Bar A)

Component	Mol%
CH_4	33.67
N_2	40.23
H_2	16.65
Argon	9.45

Simplicity, economic advantages, and high efficiency are some reasons to select the process for ammonia and hydrogen recovery. Utilizing this project has some benefits such as saving energy, CO_2 emission reduction and prevention of ammonia losses.

3. Results and discussions

NG is used as the fuel gas in furnaces. Its typical composition is presented in table 3. Heat value of NG is 49767 KJ/Kg.

Table 3- typical NG composition

Component	Mol%
C_1	96.2530
C_2	2.4987
C_3	0.7765
IC_4	0.1379
NC_4	0.2181
IC_5	1.533×10^{-3}
NC_5	0.0699
C_6	0.0127
C_7	0.0317

The heat value of retentive gas is 15000 KJ/Kg, that is, approximately 30% that of NG. If the retentive gas is used as fuel gas, annual saving NG consumption will be about 8847 tons. Another advantage of replacing certain amount of NG by the retentive gas is reducing CO_2 emission that is considered as greenhouse gases. By utilizing this project, CO_2 emission will be reduced about 3900 tons/year. According to CDM law, reducing one tone of CO_2 is taken into account as a CER. Each CER has been evaluated 10$. So value of reduced CO_2 amount of this project is about 39000 $.

Table 4- some properties of retentive gas

Properties	Retentive Gas
Mass Flow (Kg/hr)	3685.9
Heat Value (KJ/Kg)	1.50×10^{4}
NG Saving(Kg/hr)	1117
CO_2 Production (Kg/hr)	2448.6

In this article, the obtained profits of this project are computed by considering CDM. If the purge gas is vented without recovery, not only it doesn't have any benefit, but also it causes to contaminate the environment.

Now the situation is considered in which the purge gas after recovery, namely the retentive gas, is burnt replace of some NG as fuel. Annual earning of recovered ammonia is $3730320/year. NG saving: 8847 tons/year. According to the computation as mentioned above, the profit of the saving NG is $8847 /year. CO2 production after burning is 19392.9 tons/year. CO2 emission difference of two options is 3900 tons/year. The CDM law is applicable to Reduce CO_2 emissions through this method. Therefore, one ton of CO_2

emission reduction can be considered as a CER that is equal 10$. This means $39000/year that is the profit gained by prevention of CO_2 production. Sum of the profit in this option is $/year. The results are shown in table 5.

Table 5- Summary of the benefits of purge gas recovery

beneficial elements	**Retentive gas**
CO_2 emission reduction ($/year)	39000
Saving NG ($/year)	8847
Recovered ammonia ($/year)	3730320
SUM ($/year)	***$ 3778167***

4. Conclusion

In this work, two options were considered, first venting purge gas of ammonia plant without recovery and then burning it after recovery. In the first situation not only significant amount of energy is lost, but also environment is polluted by purging the gases, especially when some amount of CO_2 is emitted without any control. As the harmful effects of the greenhouse gases on the environment have been highly considered, the importance of this subject is quite clear.

On the other hand, the results showed that the obtained profit of the second option is considerable. Despite mostly environmental project, this type of the process due to CDM law is beneficial. By using the process, relatively high amount of ammonia and hydrogen will be recovered, some amount of NG will be saved and eventually some quantity of CO_2 emission will be reduced.

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بازیابی گاز پرج در واحد آمونیاک

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چکیده

در واحدهای قدیمی آمونیاک، گاز پرج لوپ سنتز بعد از بازیابی آمونیاک در یک فلاش درام، به محیط تخلیه می‌شود. در حالیکه در واحدهای جدید، واحد کوچکی در کنار واحد اصلی ساخته می‌شود که آمونیاک و هیدروژن را از این گاز جدا کرده و سپس محتوای باقیمانده در گاز را به عنوان گاز سوخت در کوره‌ها استفاده می‌کند. نصب واحد بازیابی گاز پرج علاوه بر افزایش ظرفیت تولید آمونیاک، از لحاظ اقتصادی نیز به صرفه بوده و همچنین باعث صرفه‌جویی در مصرف گاز طبیعی (NG) و کاهش انتشار CO_2 می‌گردد. بدین ترتیب در این مقاله مزایای استفاده از گاز بعد از بازیابی به عنوان گاز سوخت و همچنین دستاوردهای زیست‌محیطی و اقتصادی ناشی از کاهش انتشار CO_2 مورد بررسی قرار گرفته است.

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