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ANALYSIS OF THE EFFECT OF PRESSURE AND AIR FLOW RATE ON THE PURITY OF NITROGEN GAS PRODUCTS PRODUCED BY THE PRESSURE SWING ADSORPTION (PSA) METHOD AT PT. ARUN GAS PERTA

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ABSTRACT
Nitrogen is a basic compound in the chemical industry. Nitrogen is an inert gas compound so it is suitable for various applications covering various aspects of manufacturing, processing, handling and shipping chemicals. The aim of this research is to analyze the influence of impurities, pressure and air flow rate on the purity of nitrogen gas products produced using the Pressure Swing Adsorption (PSA) method, then carry out a comparison or simulation of actual field data with Aspen Adsorption V.10. The research method used is descriptive qualitative, the data in this research is field operational data and data collection techniques are carried out periodically through data log sheets. From the research results, it was found that Purity in October to November 2023 on October 5 and 27 was 99.98%, with a flow of 52.2 Nm3/h, while for November there was 98.01% (purity) with flow 105.0 Nm3/h. And after carrying out simulations using Aspen Adsorption V.10 and varying the input data, Purity was obtained at 99.98%, 99.97%, 99.91% with a flow of 100 Nm3/h, 150 Nm3/h, 200 Nm3/h or 0, 4461 kmol/s, 0.6692 kmol/s, 0.8992 kmol/s in Aspen Adsorption V.10 applications.

Keywords: Nitrogen, Pressure Swing Adsorption (PSA), Aspen Adsorption, Carbon Molecular Sieve (CMS)

1. INTRODUCTION

One of the most abundant chemical elements in the Earth's atmosphere is nitrogen gas (N_2) which has various important properties and characteristics. As a non-reactive gas or inert gas, which means this gas tends not to react with chemical substances. This makes it useful in a variety of industrial applications. Nitrogen has a melting point at -195.8 degrees Celsius (^oC) at a pressure of 1 atm.

Nitrogen is usually obtained from free air, this is because the air content consists mostly of nitrogen, namely 78%. In general, nitrogen is separated from air using the cryogenic method. This method is carried out by reducing the temperature until it reaches a very low temperature. However, this method has the disadvantage of wasting a lot of energy by converting gas into liquid, and a lot of pure gas is wasted during the process. As technology develops, the nitrogen production process also develops. This is proven by the emergence of non-cryogenic technology in the form of membrane systems and Pressure Swing Adsorption systems (Krabiell and Schulte, 1993).

Pressure Swing Adsorption (PSA) technology is a technology that separates air using an adsorption method. In this technology, air is separated based on differences in adsorption equilibrium and differences in diffusion levels (Schtoter, 1993). In the PSA system there are two adsorbers which contain adsorbents in the form of Carbon Molecular Sieve (CMS). At high pressure CMS will absorb oxygen and allow nitrogen to pass through to the desired purity level (Ivanova, 2012).

PSA technology originally came from laboratory studies from Skarstom in 1960, and Montgareuil and Domine in 1964. The change from laboratory scale to industrial scale has tended to be slow, but has been growing over the last few decades. Pressure swing adsorption (PSA) is a technology used to separate several types of gas from gas mixtures according to the molecular characteristics and affinity of the adsorbent material. Special adsorption materials, such as carbon, are used as molecular sieves, making it easier to absorb the main gas at high pressure. The next process is the swing process, which is the process of changing from high pressure to low pressure to desorb or release compounds absorbed by the adsorbent material.

Nitrogen production, previously using the cryogenic method, using the Pressure Swing

Adsorption (PSA) method, is an obstacle that must be faced due to the insufficient purity and flow rate of nitrogen gas for operational needs at PT Perta Arun Gas. There are several equipment used to produce nitrogen gas using the PSA method, namely compressors, air dryers, filters and adsorption columns. The purity and mass flow rate of nitrogen gas are very dependent on the reliability of the equipment mentioned above. There are several obstacles that cause the supply of nitrogen gas to be inadequate, namely due to the influence of pressure and air flow rate entering the adsorption column.

The purity and flow rate of nitrogen gas that is adsorbed on the Pressure Swing Adsorption (PSA) column will not be optimal if the compressed air still has a lot of impurities, so the flow rate must be adjusted to maximize absorption in the adsorption column in order to obtain a high percentage of purity of the resulting nitrogen gas. Nitrogen supply will be a big obstacle if there is a loading/unloading process for LNG ships, LPG ships and PT Medco EP Condensate Unloading which is carried out simultaneously.

Through this research, it is hoped that the need for nitrogen in LNG tank facilities, Berth/Loading/Unloading LNG, LPG Plant, dry gas seal compressor, Medco Condesate Facility, etc. at PT Perta Arun Gas can be managed more efficiently, effectively and sustainable. This research will support efforts to improve sustainability and operational safety in the storage and transportation of LNG, which is a key component in the global energy industry. Therefore, the study/analysis of the influence of pressure and air flow rate on the purity of nitrogen gas products produced using the Pressure Swing Adsorption (PSA) method at PT Perta Arun Gas has significant relevance in the context of the energy and environmental industry.

2. RESEARCH METHODS

2.1 Place and Time of Implementation

Research and data collection was carried out in October – November 2023 at the nitrogen plant unit (PSA System) of PT Perta Arun Gas.

2.2 Name of Process Equipment Unit

The Process Equipment Unit that will be evaluated is the Pressure Swing Adsorption (PSA) NGP300+ column

2.3 Performance Indicators

a. Calculating the purity of nitrogen gas products

b. Calculate the product flow rate of nitrogen gas
c. Calculating the desorption time of CMS adsorbent
d. Compare manual data with data obtained by Hysys simulation.

2.4 NGP300+ equipment performance evaluation design plan

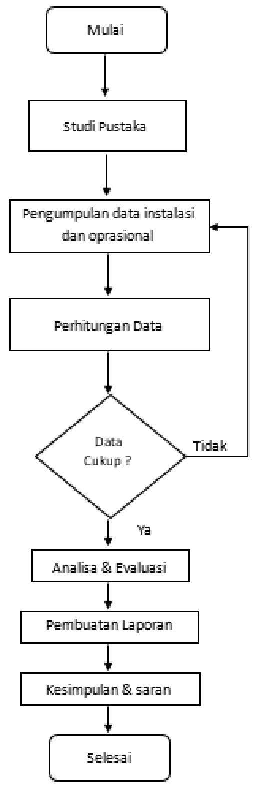

Figure 1. PSA Equipment Performance Evaluation Planning

2.4.1 Calculation of purity of nitrogen gas products

The purity of nitrogen gas in the pressure swing adsorption (PSA) process can be calculated using gas composition data at the output of the PSA unit. To calculate nitrogen purity, it is necessary to know the concentration of nitrogen (N2) in the outlet gas and measure it in mole percentage (mol%).

Following are the general steps to calculate the purity of nitrogen gas in the PSA process:

a. Nitrogen (N2) concentration monitoring: monitoring of the nitrogen concentration in the output gas stream from the PSA unit is carried out. This monitoring can be done using field recording or log sheets.
b. Conversion of concentration to mole percentage: if the nitrogen concentration is measured in weight percentage or in other units, it is necessary to convert it to mole percentage. This can be done by calculating the ratio between the number of moles of nitrogen (N2) to the total number of moles of gas in the stream. using the formula: Mole Percentage of N2 = (Number of Moles of N2 / Total number of moles of gas) x 100%
c. Determination of nitrogen purity: the purity of nitrogen in the PSA outlet gas stream can be calculated by subtracting the mole percentage of other substances (usually oxygen, argon, or other gases that may be present in the stream) from 100%. in other words, if you only have data on the concentration of nitrogen (N2) and the concentration of other substances (for example, oxygen or argon), then you can calculate the purity of nitrogen as follows: by using the formula: Purity of Nitrogen = 100% - Concentration of Other Substances.

2.4.2 Calculate the product flow rate of nitrogen gas

To calculate the flow rate of nitrogen gas products in the Pressure Swing Adsorption (PSA) process, it can be calculated based on the composition of the output gas flow, the total flow rate of the incoming flow, and several other factors.

Here is how to calculate the nitrogen gas product flow rate in PSA:

a. Monitoring the composition of the output gas (XN2): namely monitoring the composition of the output gas from the PSA unit. This composition is the mole percentage of nitrogen (N2) in the output gas.
b. Total flow rate monitoring (QTotal): namely by monitoring/retrieving data on the total flow rate of the gas (air) flow entering the PSA unit. This total flow rate can be measured in suitable units, such as m3/hour or kg/hour.
c. Calculate nitrogen gas product flow rate (QN2): The nitrogen gas product flow rate can be calculated by multiplying the nitrogen composition in the output stream (XN2) by the total flow rate of the inlet stream (QTotal), using the formula: Nitrogen gas product flow rate (QN2) = XN2 * QTotal
So, QN2 is the flow rate of the nitrogen gas product that comes out of the pressure swing adsorption (PSA) column

2.4.3 The calculation method uses Hysys Simulation

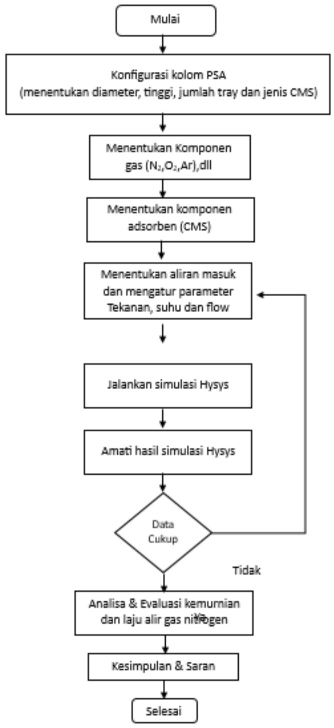

Figure 2. Hysys Equipment Simulation

2.5 Flowsheet/ Drawing Tool

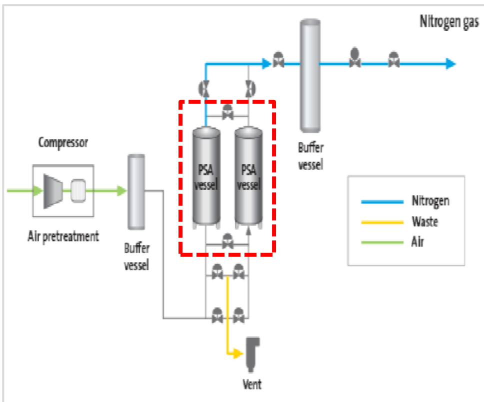

Figure 3 Flowsheet or Process diagram

4. RESULTS AND DISCUSSION

4.1 Observation Data

The research was conducted from October to November 2023 at the PT Pert Arun Gas Nitrogen Plant.

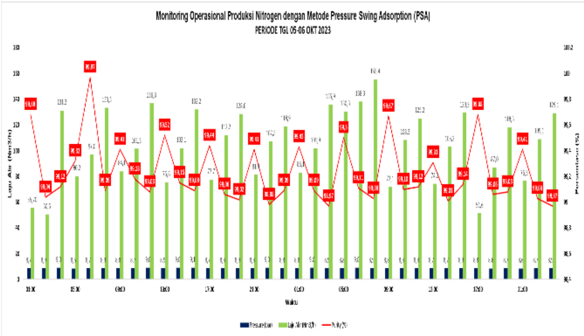

Figure 4. Observation graph of Purity (%) of nitrogen products for the period 05-06 October 2024

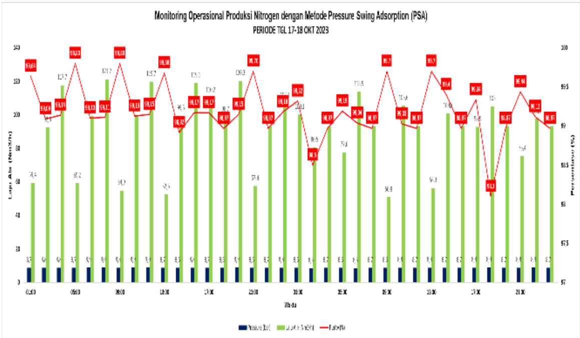

Figure 5. Purity (%) observations of nitrogen products for the period 17 - 18 October 2023

From the research results from October to November 2023, there was the highest purity of nitrogen products in the period 05 October & 27 November, namely 99.97% with a flow of 97.0 Nm3/h and 99.98% with a flow of 52.2 Nm3/h h. Meanwhile, the lowest nitrogen product purity was found in the period 17 October & 15 November 2023, namely 98.01% with a flow of 105.0 Nm3/h and 91.20 with a flow of 98.9%. This process occurs at a pressure of 8.7 bar to 8.9 bar. In the adsorption process, separation occurs due to differences in the sizes of nitrogen and oxygen gas molecules. CMS which is designed with a pore size of 3.0 Å which is enriched with SiO_2 (silicon dioxide) will absorb oxygen molecules with a size of 2.9 Å while nitrogen molecules are not absorbed because nitrogen molecules are larger than oxygen molecules, namely 3.1 Å. . The adsorption column which has experienced saturation will be regenerated with part of the nitrogen product flow being channeled to the column to be regenerated. The regeneration process is carried out using a depressurization process, namely the process of reducing pressure by opening the blowdown valve in the column adsorption section, as a result, when the pressure decreases, the oxygen attached to the CMS pores is also released into the air through the silencer and the CMS can be used again for oxygen absorption.

The influence of pressure and regeneration time on the production of nitrogen gas is very important. The longer the regeneration time, the purer the nitrogen content produced, this is because during the regeneration process the oxygen bound to the surface of the CMS will slowly be released to the maximum. As can be seen in the field observation graph of nitrogen gas purity, the higher the nitrogen gas production flow rate, the lower the purity obtained, conversely, if the nitrogen gas product flow rate is low/small, the higher the purity obtained.

The influence of the swing column adsorption time (desorption process) on the flow rate of the nitrogen gas product, can be seen in the graph. The higher the flow rate of the nitrogen gas product, the faster the time for the swing column adsorption to absorb oxygen, this is because the pores of the CMS adsorbent are filled with oxygen gas molecules. The CMS capacity in the adsorbent column is 872 liters in accordance with the design data for the NGP300+ adsorption column type.

From the results of observations made using the hysy simulation (Aspen Adsorption V.10) with different variations of incoming air flow rates into the adsorption column using the Aspen Adsorption simulation with a flow rate of 100 Nm3/h, the purity obtained was 99.98%. For a flow rate of 150 Nm3/h purity is 99.97% and a flow rate of 200 Nm3/h purity is 99.91%. There is a difference between the results of observations in the field and the Hysys Aspen Adsorption v.10 simulation due to the condition of the

NGP300+ which has impurities so that performance decreases in producing nitrogen gas.

CONCLUSION

Based on the research data that has been carried out, it can be concluded that;

1. In the pressure swing adoption (PSA) system, the highest concentration or purity was obtained, namely 99.97% with a pressure of 8.7 bar and a flow rate of 97.0 Nm3/h in the observation date period 05 October 2023 at 05.00 WIB on Train/NGP- B.
2. The effect of impurities on the purity of the nitrogen product gas produced is caused by lube oil vapors originating from the compressor. The lube oil vapor will also affect the swing column adsorption time (desorption process), from research data the longest time is 5.25 minutes with a nitrogen product flow rate of 10.0 Nm3/h in the period 23 November 2023.
3. Comparison of calculations using Hysys simulation (Aspen Adsorption V.10) there are differences caused by impurities included in the adsorption column and the differences that occur are not very significant.

SUGGESTION

To obtain maximum nitrogen product purity results, the author recommends;

1. To replace spare parts such as filters periodically in accordance with the required provisions.
2. Preventive maintenance is carried out periodically and on a schedule to maintain equipment reliability.
3. Running hours of equipment should be a priority in monitoring so that it can minimize the low purity of the nitrogen product produced.
4. To regain the purity of the nitrogen product in accordance with the initial design, it is recommended that the CMS adsorbent/absorbent media be tested in the lab to see the impurities involved.
5. To consider and review the suitability of nitrogen production using the PSA method for needs in accordance with the business run by PT Perta Arun Gas.

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