Process Intensification Quick Scan of the Linde ASU LF 41 IJmuiden

Public Summary

Background information

Objective of the quick scan is to assess, whether process intensification can be applied in certain parts of the process. Both short term and medium/long term implementation is taken into account.

Overall impression

IJmuiden produces:

Oxygen ,Nitrogen, Argon, Pressurised Air, liquid N liquid Oxygen and liquid Argon.

Oxygen is produced on a dedicated basis for Corus for steel production. A large part of the pressurized air is also used by Corus. These products are produced in 4 units each differing in size and age (LF31, 32 and 33 and LF41). A new fifth unit (LF 51)is under construction on site.

Although the name “Air Separation Units” suggest otherwise, heat exchange of hot and cold streams is the essential part of units LF31-33 and LF41-51.

Power consumption by the various compressors applied is the major part of operational cost of the units.
Reduction of energy consumption by reduction of compressor power consumption therefore is a main target for Linde plant management.

Approach

With the representatives from Linde, R. van Opbergen and G. J. Bruijnes, we analyzed LF41 and the nitrogen and oxygen compression and evaporation grids on unit operation level and discussed present operation, issues and bottlenecks.

We have looked into unit LF41 and the distribution grids in two ways:

a) **Short term empirical:** What can PI equipment that can be purchased improve in certain parts of the process?
b) **Medium/long term fundamental:** how can PI measures / technology create a dramatic improvement in energy efficiency?

PI- Quick Scan:

Procedure:
The information received from the customer is further analyzed. Information consists of:

- Flowsheets presented to PI team during the analysis meeting and sent afterwards as pdf’s
- Information given orally during the analysis meeting on April 15th 2008

On basis of the received information the process is assessed on potency for PI-improvements on the short and long term.

Score:
The overall potency of the ASU process for Process Intensification has been judged as:
Low to Average for the short/medium term and average to high for the long term.

Bottlenecks in the process are:

1. The turndown ratio of the first air compressor.
2. The power consumption of first air compressor
3. Breakthrough of any water or carbondioxide ending up as solids somewhere downstream in the units. Clogging and subsequent blocking of product flows is the result
4. Duration of the startup sequence: starting at ambient temperature it takes 24 hours to get all temperature levels right; then it takes another 48 hours to generate sufficient liquid levels in all columns. Overall startup time is 72 hours.
5. The large number of product pressure levels and the various sizes and ages of the compressor trains applied; what happens with pressure levels of the delivered products in the grid.

1. <u>Short term PI proposals</u>

Ad 1. Bypass operation to increase turn down up till now has been avoided for safety reasons. Applying a bypass may be tried.

Ad 2.

a) It has been discussed what the effect will be of operating the complete process at lower absolute pressure. The immediate effect will be a lower power consumption of the compressor train . The effect of pressure reduction on the separation efficiency downstream has to be assessed.
b) Contrary to this, the application of expanders to gain mechanical energy from pressurized product flows has been discussed as well
c) Another idea is to install so called “3D-technology” high efficiency blades in the compressor train. Thermodynamic efficiencies may go up from e.g. 67% up to 83 %.

Ad 3. No comment

Ad 4. Importing liquid holdup from other ASU-units may significantly shorten startup time.

Ad 5. Set up an integral program together with customers like Corus and others to produce a master scheme of all grids and pressure levels from start to end; subsequently invite experts in gas transport logistics to come up with a revised scheme that meets requirements such as high reliability and simplicity, low maintenance cost, low power consumption and minimal destruction of pressure energy

2. Medium/long term PI proposals

1. Look into the body of patents (ref. 1, 2):

PI technology	*Number of screened patents*	*Patent holders*	*Remarks*
Enhanced heat transfer	43	Air Liquide, BOC, Packinox, BP Amoco and Mitsubishi	
Reactive absorption	597	**Linde AG** is one of the parties involved among many others like Asahi, BOC, GKSS, Shell Int. Res. Mij.	60% of patents deal with removal of CO_2 from gas streams: we strike the fact that there appear to be a lot of novel absorber designs that combine different unit operations in one piece of equipment.
Extractive distillation	113	**Linde** is on the list of patentholders	
Cryogenic separations	78	**Linde** is on the list of patentholders	Focus is on specs and on reduction of energy/capital cost
Katapak	5	Various	Improvement of gas/liquid mass transfer

We propose to synchronize all internal know how of Linde with the people that have a need to know.

2. Nitrogen pre-separation to produce enriched air without using cold box technology.

   We propose to consider fixed bed swing adsorption of nitrogen at ambient temperatures or application of membrane technology where the smallest of two streams that need to be separated permeates the membranes. Pre-separation at ambient temperatures means a large (nitrogen) flow does not require compression, cooling and heating. It also increases the back end capacity of existing units dramatically.

3. Concept of batchwise heating of produced liquefied oxygen driven by waste heat
   a. For heating liquid oxygen Linde can use waste heat from compressor trains and other sources
   b. During the warming up of oxygen, pressure increases. This pressure can be used to drive expanders.
   c. Overall, the rate of heat input determines the rate of pressure build up and expansion
   d. After a batch has evaporated to produce GOX-4 8 bar oxygen, a next batch may start

From a thermodynamic point of view we expect a combined compression/expansion stage with one axis to have a higher efficiency than the presently separated compression and expansion stages with heat transfer through walls in the cold box and conversion to electricity with efficiency losses.

A one axis setup only has axis losses which are considerable lower than the current losses in the separated compressors and the expander.

Since in fact the compressors and the expander are the only equipment items not integrated in the cold box, a one axis setup may be realized without having to open up the cold box at all.

Recommendations and suggestions for further phases:

1. Synchronize with Linde Technology Department to make sure the relevant (in house) technologies are known to all Linde people that have a need to know
2. Zoom in on options that bring down energy use/cost in a next PI scan
3. Set up a program with support of gas logistics experts to produce a Master Scheme of all grids and pressure levels from start to end (i.e. over the customer fence) to arrive at a simplified revised grid with high reliability and low operational cost
4. Setup a Business Case around a one axis setup with use of waste heat to find out whether this is technically and economically feasible.

References

1. "Summary Sheets Quick PI Patent Scan"; report prepared by H.N. Akse, Traxxys and J. Hugill, ECN; issue date: August 5th 2007; Traxxys code: PI 2007-010 5 5-8-07; Customer: ECN
2. "Summary Sheets Quick PI Patent Scan; part 2"; report prepared by H.N. Akse, Traxxys; issue date: November 6th 2007; Traxxys code: PI 2007-010 9 6-11-07; Customer: Platform Ketenefficiency