**14000m3/h oxygen generator process flow and characteristics introduction**



The 2 # 14000m 3 /h oxygen generator in Angang Oxygen Plant was installed on April 1 ， 2001 and is expected to be put into operation at the end of August . This set of equipment is completed by China Air Separation Equipment Company. The air cooling system， molecular sieve system and air fractionation system are designed and manufactured by Sichuan Air Separation Equipment Company. The DH-90 turbo air compressor is produced by Shenyang Blower Factory， and the oxygen turbo compressor is produced by Produced by Hangzhou Oxygen Concentrator Factory; 5000 m 3 /h nitrogen compressor and 15000 m 3 / h nitrogen compressor are produced by American Ingersoll-Rand ( INGERSOLL-RAND ) company; two plunger type medium pressure liquid argon pumps and two centrifugal The type circulating liquid argon pump is produced by French company CRYOSTAR ; in addition， it also includes six liquid combined storage tanks with a total of 675m3 designed by China Air Separation Equipment Company. The instrument control system adopts the latest distributed control system TPS of Honeywell ( HONEYWELL ) ， equipped with three operating stations ( GUS ) and three remote monitoring stations (ie PCmachine). The station area project is designed by Wuhan Iron and Steel Design and Research Institute. The circulating water pump room is controlled by PLC . Two 400m 3 oxygen spherical tanks and one 200m 3 argon balloon tank have been added to the spherical tank area .

1. Characteristics of 2 # 14000m 3 /h oxygen generator air separation unit

2 # 14000m 3 /h oxygen generator adopts the process flow of full low pressure molecular sieve adsorption， pressurized turbo expander refrigeration， full rectification without hydrogen to produce argon， oxygen external compression， and argon internal compression. The whole process is advanced， the technology is mature， the operation is reliable， the operation is convenient， safe and low consumption.

1. The pre-cooling system cancels the chiller， and uses nitrogen to enter the water cooling tower to reduce the temperature of the cooling water. Reliable anti-liquid flooding measures are adopted in the structure of the air cooling tower.

2. Argon products are transported by means of liquid compression and then vaporization.

3. The liquid recharge fractionation tower measures are considered in the design to shorten the start-up time.

4. The device has variable operating conditions and variable load capacity， and the variable load range is 80% -110%.

5. A liquid oxygen self-circulation system is set up in the system， and the channel of the main condensing evaporator adopts a special structure to prevent the accumulation of acetylene in the liquid oxygen and ensure the safety of the main condensing evaporator and the system.

6. The upper column， crude argon column and refined argon column adopt structured packing.

7. The pressure nitrogen with a flow rate of 600N m 3 /h drawn from the lower column of the fractionation tower is used as the sealing gas of the oxygen turbine compressor.

8. Use the spare expander and medium pressure nitrogen in the pipe network to produce cryogenic liquid.

2. Main technical parameters of 2 # 14000m 3 /h oxygen generator air separation unit

Compressed air (air parameters of the air compressor system):

Outlet flow 75500Nm 3 /h ( 0 ℃ ， 101. 325Kpa ， dry air)

Outlet pressure 0. 62Mpa

Outlet temperature 98.2 ℃

Process air:

The flow rate into the fractionation tower is 74750 Nm 3 /h

0. 5Mpa ( G ) into fractionation tower pressure

Into the fractionation tower temperature 25 ℃

Fractionation tower system performance indicators:

The five working conditions are listed on the following page:

Working condition I

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| product name | OutputN m 3 / h | Purity | Outlet box pressure / temperature  Mpa（G）/℃ | Remarks |
| oxygen | 15100 | 99.6% of 2 | 0.020/20 |  |
| liquid oxygen | 150 | 99.6% of 2 | 0.14/-197 |  |
| nitrogen | 15000 | ≤ 10ppmo 2 | 0.008/20 |  |
| liquid nitrogen | 0 | ≤ 10ppmo 2 | 0.46/-189 |  |
| liquid argon | 540 | ≤ 2ppmo 2 ， ≤3ppmN 2 \_ | 0.16/-183 |  |

Working condition II

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| product name | OutputN m 3 / h | Purity | Outlet box pressure / temperature  Mpa（G）/℃ | Remarks |
| oxygen | 14220 | 99.6% of 2 | 0.020/20 |  |
| liquid oxygen | 400 | 99.6% of 2 | 0.14/-197 |  |
| nitrogen | 15000 | ≤ 10ppmo 2 | 0.008/20 |  |
| liquid nitrogen | 0 | ≤ 10ppmo 2 | 0.46/-189 |  |
| liquid argon | 510 | ≤ 2ppmo 2 ， ≤3ppmN 2 \_ | 0.16/-183 |  |

Working condition Ⅲ

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| product name | OutputN m 3 / h | Purity | Outlet box pressure / temperature  Mpa（G）/℃ | Remarks |
| oxygen | 14250 | 99.6% of 2 | 0.020/20 |  |
| liquid oxygen | 400 | 99.6% of 2 | 0.14/-197 |  |
| nitrogen | 15000 | ≤ 10ppmo 2 | 0.008/20 |  |
| liquid nitrogen | 350 | ≤ 10ppmo 2 | 0.46/-189 |  |
| liquid argon | 0 | ≤ 2ppmo 2 ， ≤3ppmN 2 \_ | 0.16/-183 |  |
| Argon | 520 | ≤ 2ppmo 2 ， ≤3ppmN 2 \_ | 3.0/-183 | Internal compression |

Working condition IV (liquid working condition)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| product  name | Maximum liquid oxygen condition | Maximum liquid nitrogen condition | Purity | out of the cold box  pressure / temperature  Mpa（G）/℃ |
| OutputN m 3 / h | OutputN m 3 / h |
| oxygen | 13050 | 13700 | 99.6% of 2 | 0.020/20 |
| liquid oxygen | 830 | 150 | 99.6% of 2 | 0.14/-197 |
| nitrogen | 15000 | 15000 | ≤ 10ppmo 2 | 0.008/20 |
| liquid nitrogen | 0 | 790 | ≤ 10ppmo 2 | 0.46/-189 |
| liquid argon | 470 | 450 | ≤ 2ppmo 2 ， ≤3ppmN 2 \_ | 0.16/-183 |

Under this condition， two expanders work at the same time， and both use air as the medium. Liquid oxygen and liquid nitrogen conditions are not produced at the same time.

Condition V (maximum liquid condition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| product  name | Maximum liquid oxygen condition | Maximum liquid nitrogen condition | Purity | Outlet box pressure / temperature  Mpa（G）/℃ | Remarks |
| OutputN m 3 / h | OutputN m 3 / h |
| oxygen | 14150 | 15000 | 99.6% of 2 | 0.020/20 |  |
| liquid oxygen | 1030 | 150 | 99.6% of 2 | 0.14/-197 |  |
| nitrogen | 15000 | 15000 | ≤ 10ppmo 2 | 0.008/20 |  |
| liquid nitrogen | 0 | 960 | ≤ 10ppmo 2 | 0.46/-189 |  |
| liquid argon | 530 | 520 | ≤ 2ppmo 2 ， ≤3ppmN 2 \_ | 0.16/-183 |  |

Under this condition， two expanders work at the same time， one expander uses air as the medium， and the other expander uses the user-supplied 8000 m 3 /h ， 1.0Mpa ( G ) medium pressure nitrogen as the medium. The maximum liquid oxygen condition and the maximum liquid nitrogen condition are not produced at the same time.

Note: ( 1) Condition I is the assessment condition.

( 2 ) N m 3 /h is the volume flow at 0 ℃ and 0.1013Mpa ( A )， referred to as the standard state (the same below).

The operation cycle (interval time between secondary heating) is more than two years; the heating and thawing time of the device is about 36 hours; the startup time of the device (from the start of the expander to the oxygen purity reaching the target) is about 36 hours; the working condition range is 80-110% .

3. Process flow of 2 # 14000N m 3 /h oxygen generator

The raw material air is filtered to remove mechanical impurities and dust， compressed to about 0.62Mpa ( A ) by the air compressor， and enters the air cooling tower in the air pre-cooling system， where it is cooled and washed by water. The air cooling tower is cooled by circulating cooling water and low temperature water cooled by the water cooling tower. The top of the air cooling tower is equipped with a free water separation device to prevent the free water in the process air from being carried out of the cooling tower.

The process air at about 14.5 °C from the air cooling tower enters the molecular sieve purification system. The adsorber of the molecular sieve purification system adsorbs moisture， carbon dioxide， hydrocarbons and other impurities in the air. The two adsorbers are of horizontal double bed structure， the lower layer is activated alumina and the upper layer is molecular sieve. Electric heater heating. The switching cycle of the adsorber is 4 hours， and it can be switched automatically at regular intervals. The water content of the air purified by the adsorber is below the dew point of -65°C， and CO 2 ≤ 1ppm.

Most of the purified air enters the main heat exchanger in the cold box， and after being cooled by the reflux gas to near the liquefaction temperature ( -173°C)， it enters the bottom of the lower column for the first fractionation. In the rectification tower， the nitrogen concentration in the ascending gas gradually increases after the ascending gas is fully contacted with the downstream liquid and the heat and mass are transferred. Pure nitrogen enters the main condensing evaporator at the top of the lower tower to be condensed， while the liquid oxygen in the main condensing evaporator is evaporated and vaporized; a part of the liquid nitrogen is used as the reflux liquid of the lower tower， and the rest of the liquid nitrogen is sent to the upper tower after cooling and throttling. The liquid air generated at the bottom of the lower tower enters the upper tower after cooling and throttling， and is rectified again to obtain product oxygen， product nitrogen and polluted nitrogen.

Another stream of purified air enters the supercharger to increase the pressure， is cooled by the cooler， and then enters the main heat exchanger in the cold box， and is cooled by the reflux gas to about -107°C and enters the turboexpander. After the air is expanded and cooled， it exchanges heat with the liquid oxygen from the liquid oxygen adsorber in the thermosiphon evaporator， and then enters the upper tower to participate in the rectification.

Under the maximum liquid condition， a stream of about 8000N m 3 /h ， 1.0Mpa ( G ) of nitrogen is drawn from the user's medium-pressure nitrogen pipe network to the supercharger for pressurization and cooling， and then sent to the medium-pressure heat exchanger. Cool to about -115 °C. Most of the nitrogen enters the expander for expansion refrigeration， and a small part of the nitrogen continues to cool and liquefy and enter the lower tower after throttling. The expanded nitrogen returns to the nitrogen heat exchanger for reheating and then enters the user's low-pressure nitrogen pipe network.

Argon extraction adopts the latest technology of fully rectified hydrogen-free argon production. The argon fraction is drawn from an appropriate position in the middle of the upper column and sent to the crude argon column I for rectification to reduce the oxygen content; the reflux liquid of the crude argon column I is drawn from the bottom of the crude argon column II and compressed by a liquid argon pump Liquid crude argon. The gas drawn from the top of the crude argon column I enters the crude argon column II and conducts deep argon-oxygen separation therein. After the rectification of the crude argon column II， crude argon with an oxygen content of ≤ 2ppm is generated at the top of the crude argon column II. The top of the crude argon column II is equipped with a condensation evaporator， and the liquid air drawn from the subcooler is throttled and fed into it as a cold source. Reflux; the rest is drawn from the top of the crude argon column II and sent to the refined argon column. The bottom of the refined argon column is equipped with an evaporator， and the medium-pressure nitrogen drawn from the top of the lower column is used as a heat source to evaporate the liquid argon， and at the same time， the nitrogen is liquefied. A condenser is installed at the top of the purified argon column， and the v part of the liquid nitrogen drawn from the subcooler is used as a cold source， so that most of the rising gas is condensed into liquid， which is used as the reflux liquid of the purified argon column. Rectification to obtain semen argon with a purity of 99.999% Ar at the bottom of the purified argon column， namely the product liquid argon.

In order to reduce the energy consumption of the product， the conveying method of liquid pump compression in the cold box and vaporization of the heat exchanger is adopted .

The low-pressure oxygen from the cold box is compressed to 2.94Mpa (G) by the oxygen turbine compressor and sent to the pipe network. The low-pressure nitrogen is compressed to 1.0Mpa (G) by a 15000N m 3 /h nitrogen turbine compressor and then sent to the pipe network. Another part of the low-pressure nitrogen in the pipe network is compressed to 2.5Mpa (G) by a 5000N m 3 /h nitrogen turbine compressor and then sent to the pipe network . A part of the dirty nitrogen is heated by the electric heater and then goes to the molecular sieve purification system as a regeneration gas source， and the other part of the dirty nitrogen is combined with the surplus pure nitrogen and then goes to the pre-cooling system as a cold source.

The liquid oxygen， liquid nitrogen and liquid argon coming out of the cold box are respectively input into three 200 m 3 normal pressure flat bottom storage tanks through the vacuum insulation pipeline for storage， and three 25 m 3 0.8MPa pressurized tanks are arranged. The low-temperature liquid can be filled into the tanker separately from a 200m 3 low-pressure storage tank and a 25m 3 pressurized tank.