**2007 Prize of Director General of Agency for Natural Resources and Energy**

# Energy Conservation through Introduction of Highly Efficient Air Separator and Use of Large Compressor

Air Water Inc. Plant Division

Onsite Department, Wakayama Manufacturing Plant, Manufacturing Section

◎ **Keywords: Others (rationalization of introduction of highly efficient facilities and use of highly efficient equipment)**

## ◎ Outline of Theme

A significant amount of energy was conserved by introducing highly efficient compressors to raw material air compressors and oxygen compressors as well as by introducing a highly efficient cryogenic air separator that adopts a raw material air preprocessing system and packing tray method.

Furthermore, energy was further conserved through diverting the large raw material air compressor, which became redundant due to the introduction of a highly efficient cryogenic air separator, to compressor for compressed air only, thereby making it possible to terminate the operation of the compact compressors scattered throughout the manufacturing plant.

## ◎ Implementation period for the Said Example

April 2003 through December 2008

- Project Planning Period: April 2003 through December 2004 Total of 14 months.
- Implementation period: July 2004 through February 2006 Total of 19 months.
- Effect verification period: March 2006 through December 2008 Total of 33 months.

## ◎ Outline of the Business Establishment

- Production items: Gas and liquefied gas.
- Number of employees: 32 persons.
- Annual energy consumption: 438,946 Mwh/year (actual record for 2006).
- Type 1 Designated Energy Management Factory.

## ◎ Process Flow of Target Facility

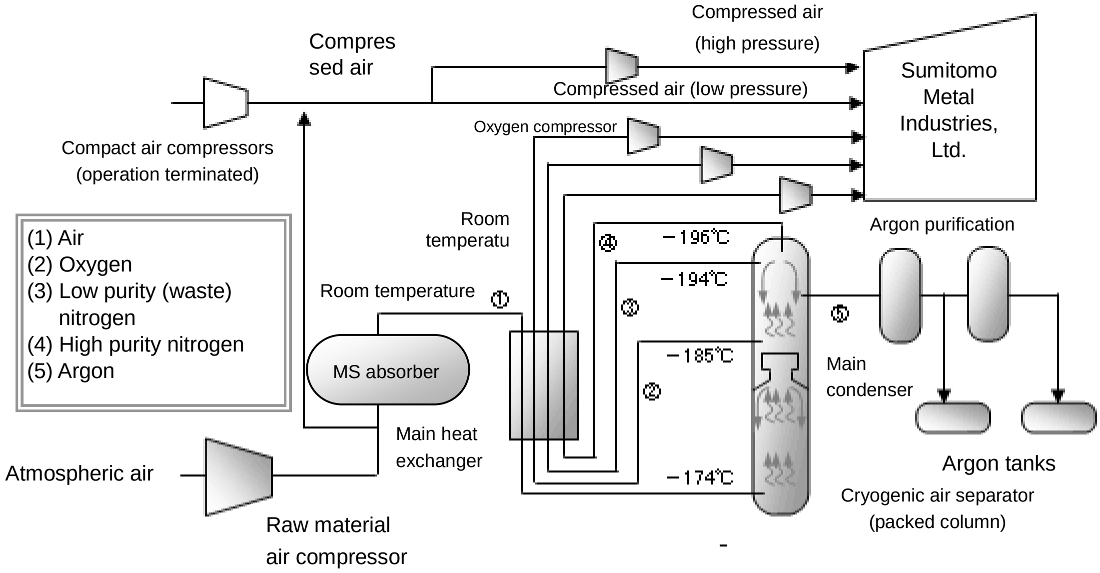



Figure 1: Cryogenic air separator flow diagram

## 1. Reasons for Theme Selection

As the energy conservation activity in line with a voluntary activity plan formulated by the Japan Chemical Industry Association, to which this company belongs, company set the target to reduce energy intensity by 90% from 1990 figure by the year 2010 through making every effort. . This energy conservation project contributes to a reduction of energy intensity of the factory by 11.9 %, therefore the project offers the greatest contribution to the global environment among various energy conservation activities we promote.

## 2. Understanding and Analysis of Current Situation

The target to reduce energy intensity by 90% from 1990 figure by the year 2010 was already greatly exceeded with a reduction of about 40%. Due to the increased amount of production, however, the actual electric power consumption increased in 2006 by 3 % over that of 1990. In order to suppress the emission of the carbon dioxide, which is the cause of global warming, it is essential to reduce electric power consumption.

It is necessary to set the future targets and to consider the plans for attaining such targets.

# 3. Progress of activities

## (1) Implementation Structure

The Wakayama Manufacturing Plant is playing a central role in this major energy conservation project, as shown in Figure 2, and discussions are being held freely and unrestrainedly among other corporate organizations and group companies to promote this big energy conservation project with becoming unity.

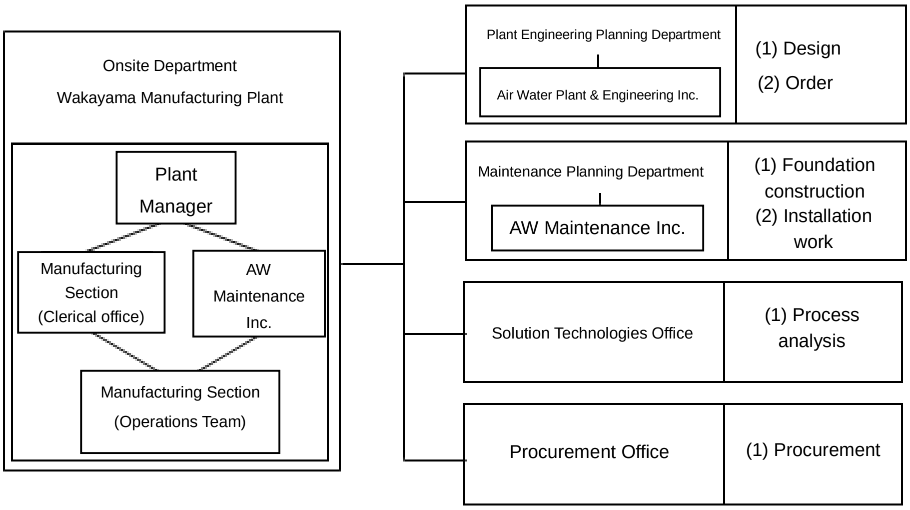



Figure 2: Framework for activities

## (2) Target Settings

[1] The NEDO energy conservation target of 14,000 kiloliters/year, reduction by 6550 kW (energy intensity reduction of 12 %).

[2] A 10 % reduction of the energy intensity of 1990 by the year 2010 is an energy conservation target in line with voluntary activity plans formulated by the Japan Chemical Industry Association.

## (3) Problem Points and their Investigation

As described in Section 2, Understanding Current Status and Analysis, it will be possible to achieve the target in terms of energy intensity, as long as the current trend is maintained.
Since it is critical for the actual electric power consumption to be reduced in order to suppress the emission of carbon dioxide, which is the cause of global warming, it is necessary to set energy reduction targets for the future and consider plans for attaining such targets. It is necessary to reduce the electric power consumption in 1990 (carbon dioxide

emission) by 6 % or less by 2012 in accordance with the Kyoto Protocol. This is the most crucial target for the future.
Since achieving this figure is extremely difficult, drastic structural reforms for energy usage are unavoidable.

For this reason, an energy conservation plan was formulated and put into action, which is introduced as the case example.

[1] Introduction of highly efficient cryogenic air separator

[2] Conversion of large raw material air compressor to a compressor for compressed air only

## 4. Details of Measures

Improvements were made to the operations of three units, plant numbers 10, 11 and 12 (terminating the operation of plant numbers 8 and 9, which had energy intensity) by introducing highly efficient compressors as the raw material air compressors and oxygen compressors, as well as introducing a highly efficient cryogenic air separator (plant number 12) that adopts a raw material air preprocessing system and packing tray method. Also, the highly efficient cryogenic air separator was not merely introduced but its pervasion was also pursued.
Furthermore, through diverting the large raw material air compressor, which became redundant due to the introduction of a highly efficient cryogenic air separator, to compressor for compressed air only, the inefficient compact compressors scattered throughout the manufacturing plant was terminated.

### (1) Increasing efficiency of framework for supplying compressed air by utilizing large air compressors

Compressed air is currently being supplied through two systems. Through cooperation granted by Sumitomo Metal, it is now possible to supply compressed air with a low pressure, except for some destinations that require compressed air with a high pressure. This made it possible to supply an excessive amount of raw material air to the plant as compressed air.
Furthermore, compact air compressors could be taken out of operation by supplying an excessive amount of air from large compressors. Large raw material air compressors have a lot more superior energy intensity than that of compact ones, thereby providing a substantial conservation of energy.
Since the discharge pressure of the raw material air compressor (plant number 12) at the

newly established plant of this division is low, cooperation has been requested of Sumitomo Metal to accept an even lower pressure for the supply of compressed air. (This time: 0.42 MPa → 0.38 MPa)

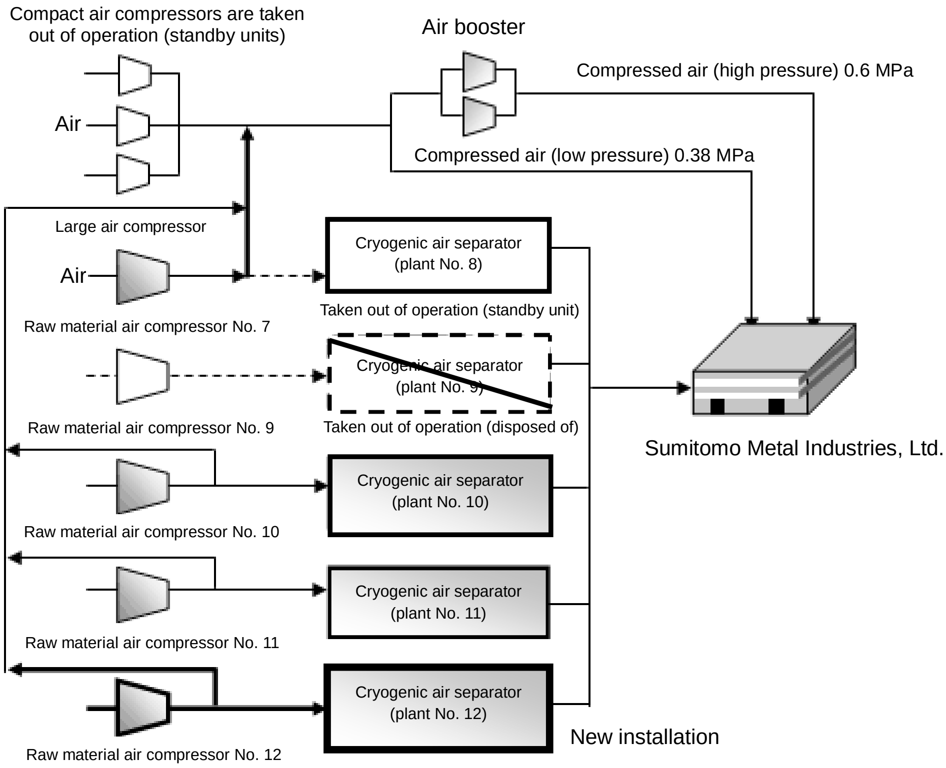
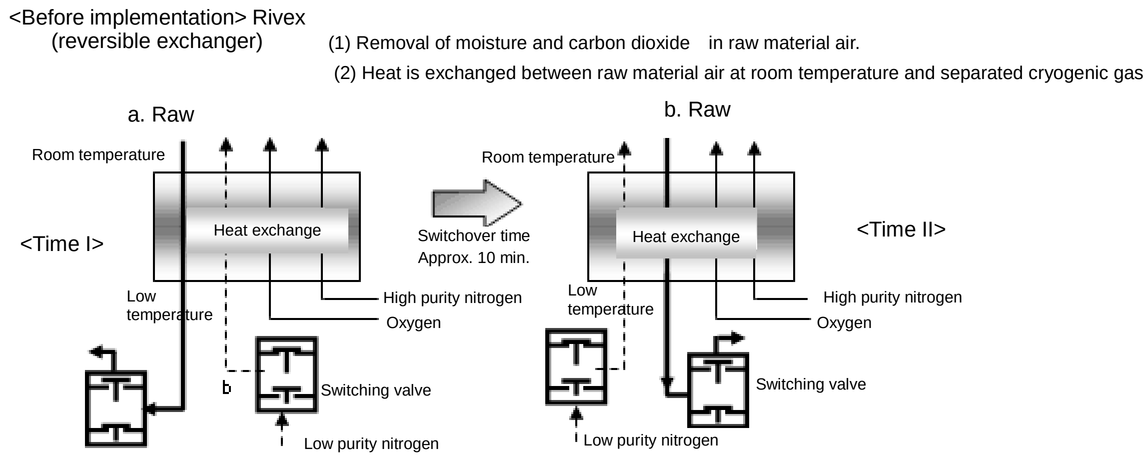



Figure 3: Framework for supply of gas

## (2) Increasing efficiency by adopting raw material air preprocessing system

Losses arising from switching the reversible heat exchanger and liquid oxygen adsorber were eliminated by the adoption of the raw material air preprocessing system, resulting in an improvement of the product recovery rate.




※ The alternated switching of gases from route a and b is performed by time control, with the moisture and carbon dioxide from the eliminated raw material oxygen scavenged outside of the system with a low purity nitrogen.

Figure 4: Swtchover of Rivex (reversible heat exchanger)

<After implementation>
MS adsorption tower ← Moisture, carbon dioxide gas and hydrocarbons in raw material air are removed.
Main heat exchange ← Heat is exchanged between raw material air at room temperature and separated cryogenic gas.

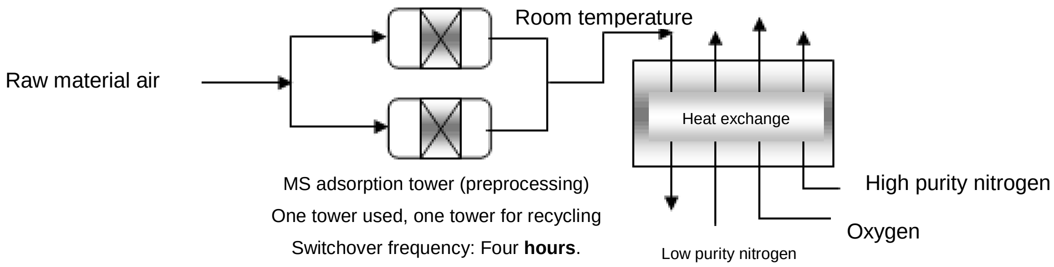



Figure 5: Raw material air preprocessing system and main heat exchanger

## (3) Introduction of highly efficient cryogenic air separator

It was possible to reduce the power of compressors by about 10 %, through the lowering of the discharge pressure of the raw material air compressor, since the introduced packing tray-type (filler) air separator has little pressure losses in comparison with the conventional sheave tray-type (porous plate).

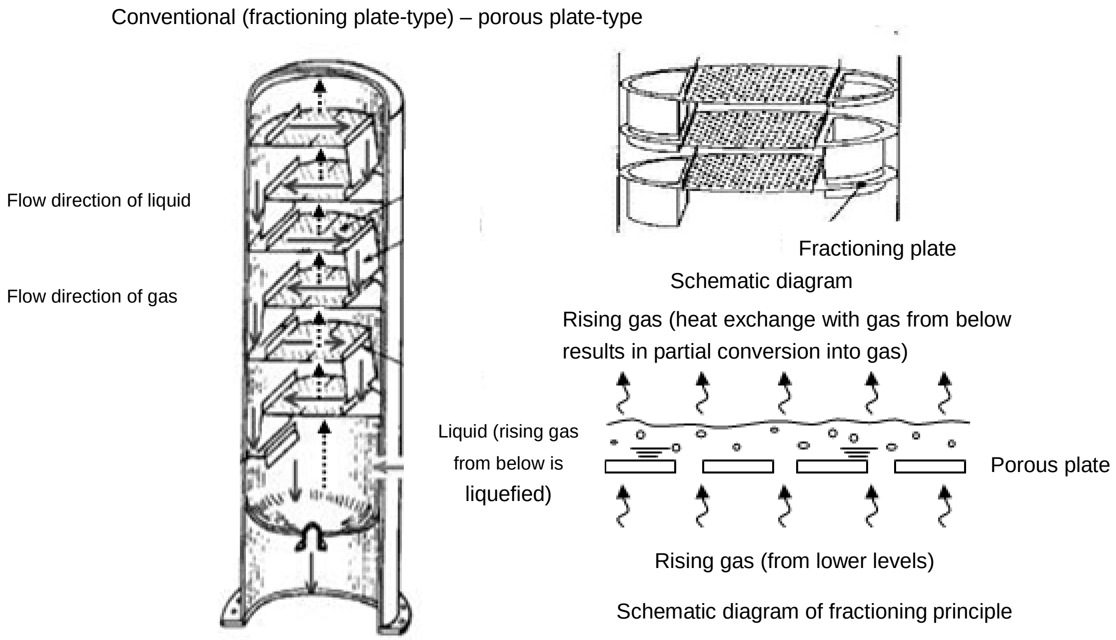



Figure 6: Type comparison diagrams for cryogenic air separators (conventional)

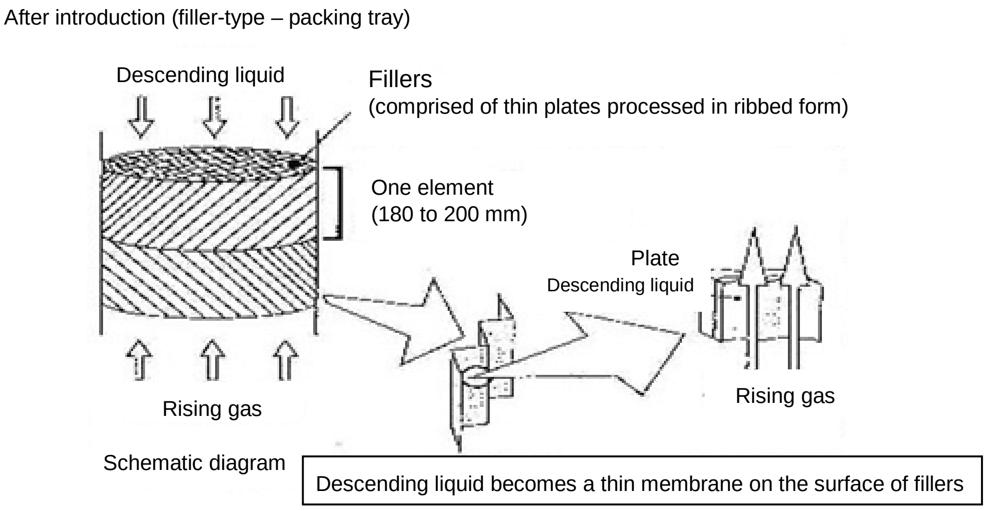



Figure 6-b: Type comparison diagrams for cryogenic air separators (after implementation)

### (4) Energy conservation with adopting of lower purity standard for oxygen gas (99.6 → 99.4 %)

The rated oxygen purity for cryogenic air separator is 99.6 % or more. However, by lowering the purity, it is possible to reduce the amount of raw material air required to manufacture oxygen at 1 $Nm^3/h$.

On the other hand, issues induced by the lowering of oxygen purity at the steel mill were as follows:

[1] A rise of nitrogen concentration in the steel due to a rise in the concentration of nitrogen contained in oxygen gas.

[2] A reduction of the production amount due to an extension in the blowing and welding time.

Such issues were considered and tested in collaboration with Sumitomo Metal, which led to the conclusion that as long as the purity is maintained at 99.4 % or higher, no operational problems occur.

Accordingly, the purity standard of oxygen gas for the implemented cryogenic air separator was set to 99.4 % or more.

### (5) Effects arising from termination of operation of medium and high pressure oxygen plants

The operations of the medium pressure oxygen plant (number 8) and the high pressure oxygen plant (number 9), with an extremely low air separation intensity, were terminated.

Furthermore, the waste disposal of oil absorption mats and lubricating oil became unnecessary as the operation of the high pressure oxygen plant was terminated, making it possible to terminate the operation of the Freon refrigerator (R-22).

## 5. Effects achieved after Implementing Measures

**Targeted figures:**

[1] The NEDO energy conservation target of 14,000 kiloliters/year, reduction by 6,550 kW (energy intensity reduced by 12 %).

[2] A 10 % reduction in the energy intensity of 1990, by the year 2010, is an energy conservation target set in line with voluntary activity plans formulated by the Japan Chemical Industry Association. These targets have been reached, as indicated in the Table.1. As long as the current trend is maintained, the national target which intends to

reduce the energy intensity of 1990 by 10% by the year 2012 will be attained, since the target already being greatly exceeded with a reduction of about 40 %.

Table 1: Results of energy conservation by relevant party

| | | | NEDO standard | | | (Actual record) |
|---|---|---|---|---|---|---|
| | | FY1990 | FY2003 | FY2004 | FY2005 | FY2006 |
| Oxygen consumption | $kNW^3/h$ | 32.3 | 52.0 | 50.2 | 54.2 | 59.0 |
| Energy Intensity (energy unit consumption) | $kWh/Nm^3$ | 1.498 | 1.013 | 1.050 | 0.971 | 0.849 |
| Energy intensity rate | % | 100 | 67.6 | 70.1 | 64.8 | 56.7 |
| Electric power consumption | MWh/year | 423,786 | 462,769 | 461,886 | 461,165 | 438,946 |
| Electric power consumption rate | % | 100 | 109.2 | 109.0 | 108.8 | 103.6 |

Table 2: Crude oil equivalent

| | | | Crude oil equivalent kl/year | Electric power kW |
|---|---|---|---|---|
| Actual recorded figures | Actual consumption for FY2003 | | 117,543 | |
| | FY2006 | Actual consumption (after project implementation) | 111,492 | |
| | | Unit consumption base | 103,341 | |
| Amount of conserved energy (figures provided inside brackets) ← Intensity base | | | 14,202 (14,000) | 6,558 (6,550) |

Table 3: Comparison of unit consumption amounts

| | | Actual record for FY2003 (before project implementation) | Actual record for FY2006 (after project implementation) |
|---|---|---|---|
| Overall Intensity for raw material air compressors | $kWh/Nm^3$ | 0.0880 | 0.0806 |
| Overall air separation intensity for plants | | 0.579 | 0.483 |

## 6. Summary

A subsidy was obtained from NEDO to conduct this project, with the operation of a new plant starting in January 2006. It was possible to attain the energy conservation target of NEDO, in terms of crude oil equivalent , 14,000 kiloliters/year, a reduction by 6,550 kW (energy intensity reduction of 12%) or more.

It was possible to significantly exceed the target for reducing the 1990 energy intensity by

90 % by the year 2010, an energy conservation target set in line with a voluntary activity plan formulated by the Japan Chemical Industry Association, to which this company belongs.
This was possible due not only to the energy conservation activities implemented by the company, but rather, as a result of cooperation with the customer Sumitomo Metal.

## 7. Future Plans

As described in the previous section, the targeted energy intensity has been attained. Due to the increased amount of production, however, the electric power consumption increased in 2006 by 3 % over that of 1990. In order to suppress the emission of carbon dioxide, which is the cause of global warming, it is essential for this electric power consumption to be reduced.
In order to ensure that the target of reducing the 1990 carbon dioxide emissions by 6 % by the year 2012, as stipulated by the Kyoto Protocol, energy reduction targets will be set and plans for attaining such targets will be considered
(For example, the building of highly efficient plants equivalent to the one built for this project or optimized operational combinations with existing plants, etc.).