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Energy Conservation of Compressed-Air Supply Equipment

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◎ **Key Words: Rationalization of conversion of electricity to power and heat**
(Electric power applied equipments, electric heating equipments)

◎ Outline of Theme

Energy conservation has been implemented in the Shiga first plant where energy conservation is an urgent need by improving efficiency of compressed-air supplying equipment which accounts for about 25% of electricity consumption. As a result electric power consumption of the entire Shiga first plant had been reduced by 2%.

◎ Implementation Period for the Said Example

June 2005 ~ March 2007

- Planning Period: August 2004 ~ May 2005
- Implementation Period: June 2005 ~ September 2006
- Verification Period of Effectiveness: July 2005 ~ March 2007

◎ Outline of the Business Establishment

- Production items: Automobile engines
- Number of employees: 3,752
- Annual energy usage (Type 1 designated energy management factory)
  - Electricity 447,047 MWh
  - Fuel 96,554 kL

◎ Overview of Target Facilities

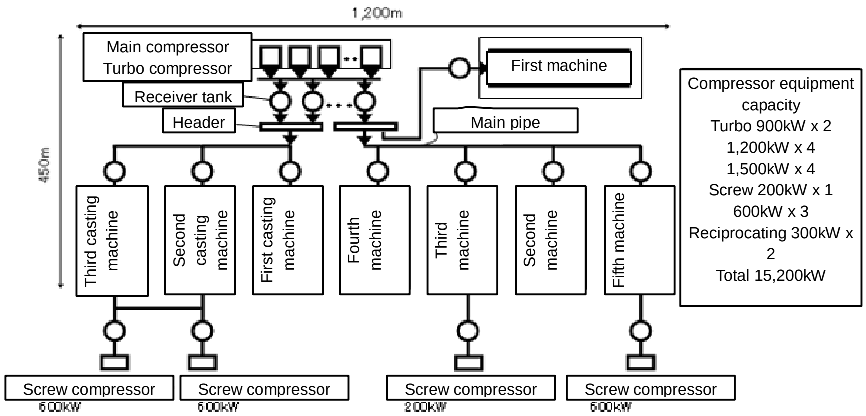


Fig. 1 Compressed-air supply equipment

1. Reasons for Theme Selection

A focus was placed on energy consumption of the compressed-air equipment

Reason:

In the Shiga first plant which produces automobile engines, electric consumption of the compressed-air equipment accounts for 25% of the entire electric consumption. Therefore, energy conservation by improving its efficiency was planned.

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

Electricity accounts for about 60% of primary energy used in the Shiga first plant (see Fig. 2). Moreover, the compressed-air equipment accounts for about 25% of electric consumption (see Fig.3).

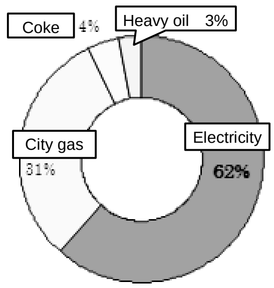


Fig. 2 Ratio of primary energy cost
(Shiga first plant)

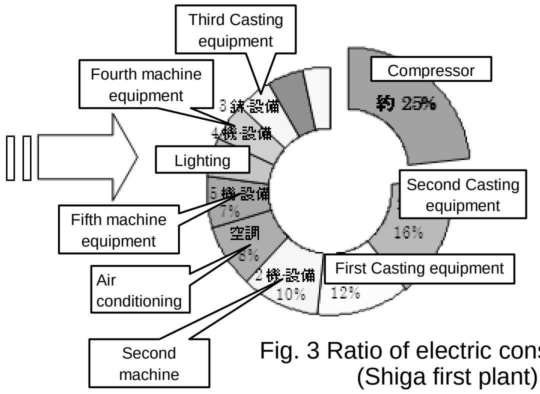


Fig. 3 Ratio of electric consumption
(Shiga first plant)

(2) Analysis of Current Situation

The reason why compressors account for the higher ratio of electric consumption in the Shiga first plant is attributable to low efficiency of compressors. The factors of their low efficiency were elucidated by using a fishbone diagram shown in Figure 4. As a result, we decided to carry out improvements focusing on three points: [1] pressure loss to the plant is large, [2] equipment working under appropriate pressure has not been used, and [3] power of dehumidifiers is large.

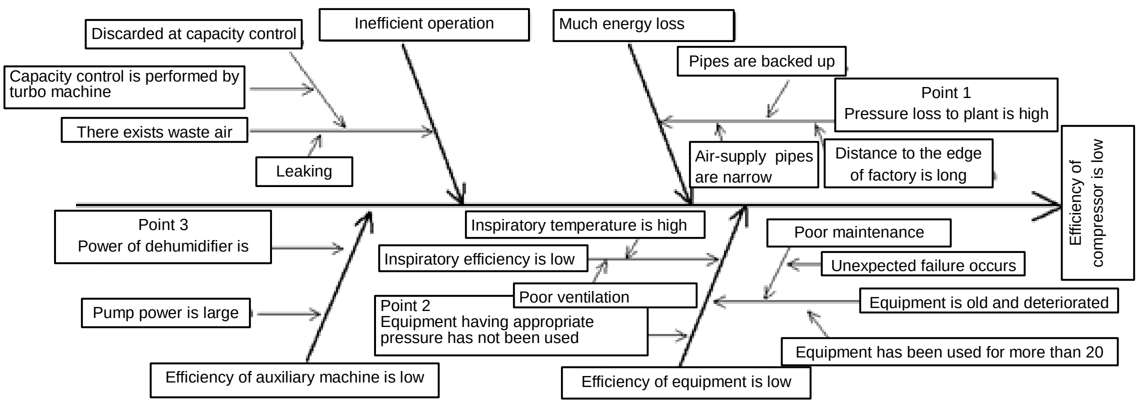


Figure-4 Elucidate the reason by fishbone diagram

3. Progress of Activities

(1) Implementation Structure

There is lots of compressed air-supply equipment in the Shiga first plant whose efficiency is low. Thus, we have made efforts to improve efficiency by whole.

(2) Target Settings

Upon promoting activities, the target was set to raise the efficiency from before improvement efficiency 8Nm3/kWh to 10Nm3/kWh.

(3) Problem Points and their Investigation

The following measures were decided by focusing on the three causes revealed in the analysis of current situations

- Reduction in energy loss and improvement of equipment efficiency
- Selection and installment of highly-efficient equipment
- Development of dehumidifier system of compressed-air

4. Details of Measures

4-1 Reduction in energy loss and improvement of equipment efficiency (Viewpoint [1][2])

(1) Current situations and points of view for improvement

1) Current situations

Compressors are concentrated in the center of the large Shiga first plant with floor area of 658,000m^2 and compressed air is supplied to the edge of plant using long piping. Accordingly, pressure of compressors is set high taking into account pressure drop caused by flow resistance in the piping.

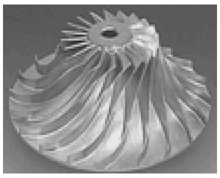
2) Points of view

A focus was placed on the fact that large pressure gap is occurred between compressed-air supply side and end use side, that is to say pressure loss to the edge of factories is large. Therefore, we have taken measures to reduce such pressure loss.

(2) Content of improvement

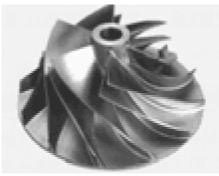
Compressors were newly installed in the fifth machine plant corresponding to the vicinity of the end of the current compressed-air supply piping. These compressors were used to supply compressed-air from the end of pipes to secure the set value of end pressure. This enabled reduction of supply pressure of the main compressor group.

Moreover, as lowering in the set pressure of the main compressor group became possible, it also became possible to lower the designed pressure of compressors from 0.69MPa to 0.56MPa by replacing impellers of the four conventional turbo compressors (1,200kW x 4 units). This resulted in improvement of equipment efficiency. (Figure-5)



Impeller before change

Designed pressure 0.69MPa



Impeller after change

Designed pressure0.59MPa

Fig.5 Change to low-pressure impeller

(3) Results

Comparison of equipment efficiency before and after the replacement of impellers of four turbo compressors (1,200kW) and lowering of designed pressure from 0.69Mpa to 0.56Mpa is shown in Table 1. Moreover, Figure 6 shows changes in characteristic curves owing to the impeller replacement. These efforts have led to a successful increase in supply air volume with the same electric consumption and improvement of equipment efficiency by 12%.

Efficiency improved by 12% by lowering designed pressure from 0.69MPa to 0.56MPa and changing impellers to low-pressure type

	Before replacement	After replacement
Designed pressure	0.69 (MPa)	0.56 (MPa)
Supplied air volume	11,270 (Nm^3/h)	12,810 (Nm^3/h)
Electric consumption	1,160 (kW)	1,180 (kW)
Efficiency	**9.7 (Nm^3/kWh)**	**10.9 (Nm^3/kWh)**

Table 1 Improvement of performance by replacing impellers

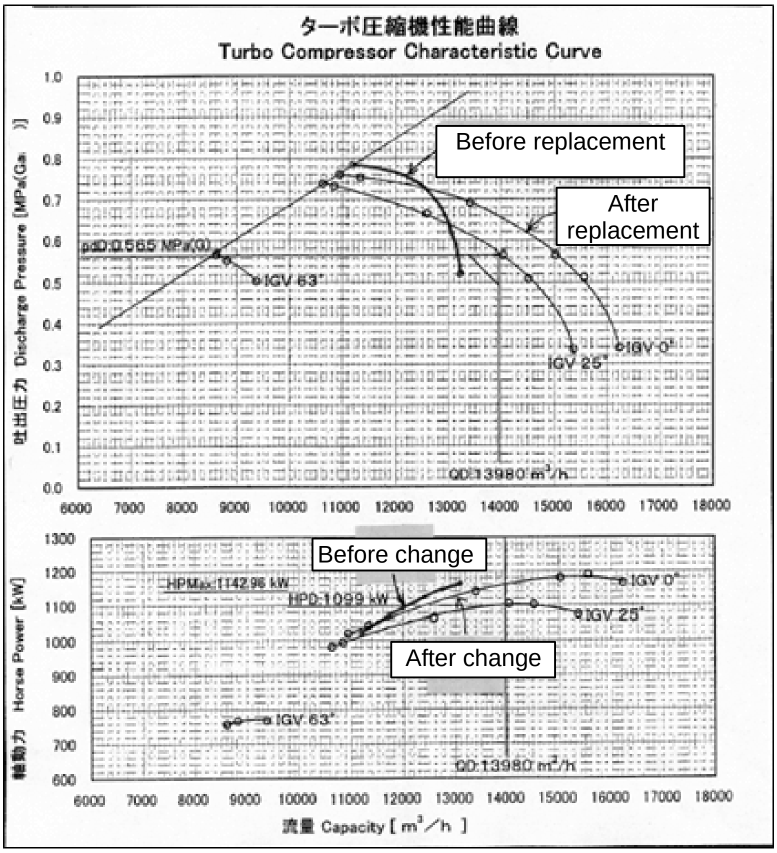


Fig. 6 Change in performance because of impeller change of turbo compressors

4-2 Selection and installment of highly-efficient equipment (Viewpoint [2])

(1) Current situations and viewpoints for improvement

1) Current situations

Most turbo compressors which are major ones in the Shiga first plant have been installed for more than 20 years. Accordingly, deterioration of equipment was found and efficiency of equipment itself was low.

2) Viewpoint

Supply pressure was lowered by introducing highly efficient large turbo compressors and by improving the above-mentioned in 4-1. Thus, further improvement of efficiency was aimed to introduce compressors that suit supply pressure.

(2) Content of improvement

The larger the current compressors are, the higher their efficiency is. Thus, equipment efficiency was improved by introducing large turbo compressors (1,500kW) for base operation, and by changing specific pressure value from the standard setting (0.69MPa) to the special setting (0.59MPa), thereby efficiency of all compressors has improved.

(3) Results

Equipment efficiency has been enhanced by lowering pressure of highly efficient turbo compressors and designed pressure. Table 2 is a comparison table of performance between existing equipment and newly installed equipment. Equipment efficiency has improved by 7.5% from 10.5Nm^3/kWh to 11.3Nm^3/kWh. Figure 7 shows change in efficiency of the entire plant.

Equipment efficiency of compressors improved by 7.5% by
introducing highly efficient models and lowering design pressure

	Existing equipment	Newly installed equipment
Design pressure	0.69 (MPa)	0.59 (MPa)
Supplied air volume	12,800 (Nm^3/h)	15,600 (Nm^3/h)
Electric consumption	1,223 (kW)	1,381 (kW)
Efficiency	**10.5 (Nm^3/kWh)**	**11.3 (Nm^3/kWh)**

Table 2 Comparison of performance between existing equipment and newly installed equipment

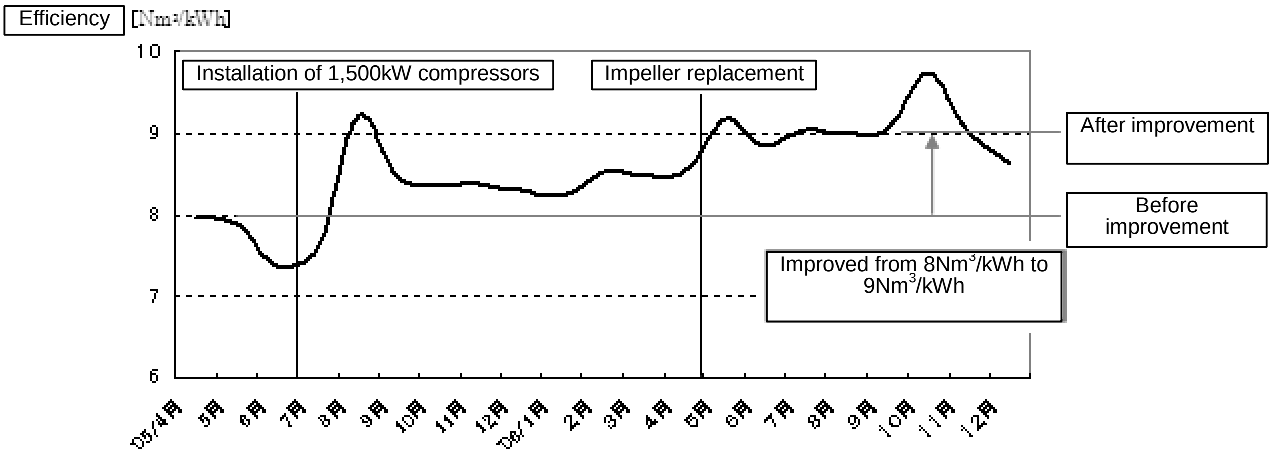


Fig. 7 Change in air efficiency of each month in the Shiga first plant

4-3 Development of dehumidifier system of compressed air (Viewpoint [3])

(1) Current situations and viewpoints for improvement

1) Current situations

Dehumidifiers assembled into the refrigerators have been used to prevent dew condensation of moisture contained in compressed air.
When dehumidification is only required not to build up condensation at the end of point where compressed air is used, excessive dehumidification causes waste.

2) Viewpoint

When temperature in the plant is always higher than ambient temperature, it is necessary to lower temperature to an ambient temperature to prevent dew condensation. For this purpose, use of the cooling tower method which cools air using ambient air is considered.

(2) Content of improvement

Use of refrigerators used as a cooling means for dehumidification was abolished. Instead, “ambient air direct-cooling dehumidifier system” using cooling towers has been developed and introduced (see Figure 8). It becomes possible to cool air down to around ambient air wet-bulb temperature by directly circulating compressed air in pipes for heat exchange inside the cooling towers and allowing ambient air passing through, at the same time spraying water.

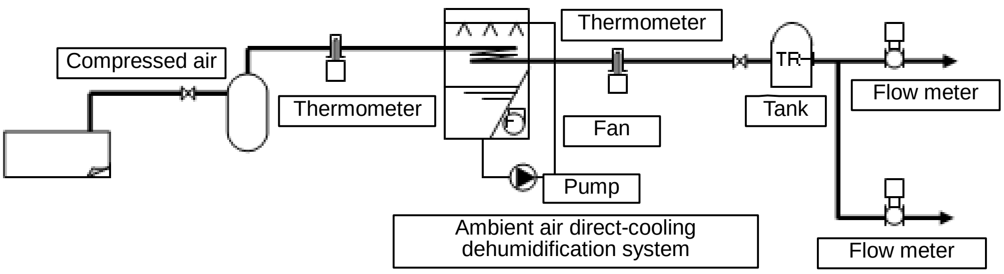


Fig. 8 Compressed-air supply system flow

(3) Results

As shown in Figure 9, cooling effect by the ambient air direct cooling method showed sufficient performance, because air was cooled below ambient temperature. Figure 10 shows the comparison of electric consumption of similar facilities (600kW compressors) using refrigerators. Reduction in electric consumption by 31% was achieved for the total auxiliary machine power including dehumidifiers.

Auxiliary machine power was reduced by 31% by cooling and dehumidifying ambient air using cooling tower instead of refrigerator for humidification

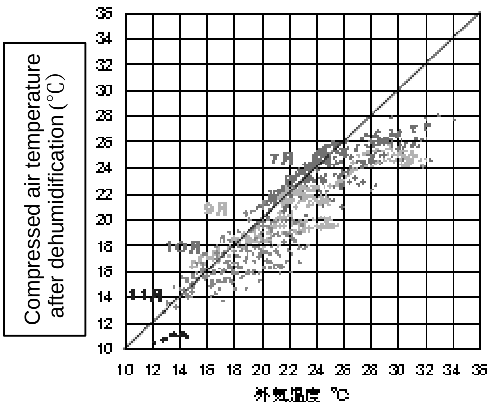


Fig. Figure 9 Cooling effect of compressed air

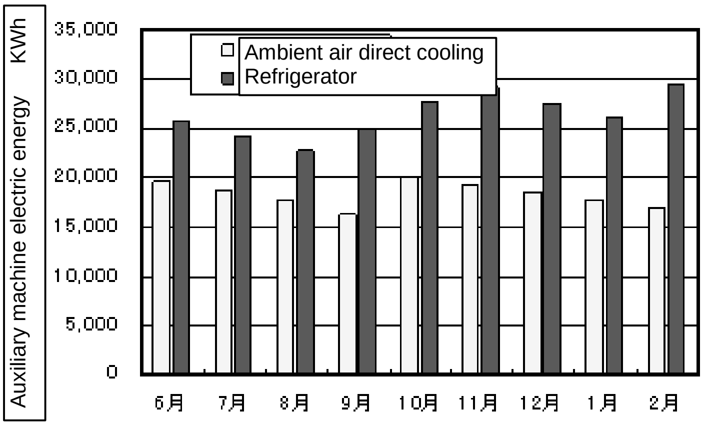


Fig. 10 Power reduction effect of auxiliary machine (600kW compressor)

5. Effects of Measures

[1] Quantity in energy conservation: 3,485t-CO2/year

[2] Amount saved: 95.855 million yen/year

[3] Amount invested: 78.5 million yen/year (additional capital investment for the purpose of energy conservation)

[4] Pay back period: 0.82 year

6. Summary

We have started improving equipment in the order of the sizes of equipment listed as a basic procedure for promoting energy conservation in the plant.

[1] Stop waste operation

[2] Change set value

This includes economical modifications such as lowering the set pressure of compressed air. In recent years, improvement activities have plateaued as [1] and [2] steps have progressed. Thus, we have started capital-investment type improvement.

[3] Renewal and modification to more efficient equipment

This includes the modification of impellers of compressors in 4-1. This activity has already been in the third stage and there becomes few items left on which speed-up of recovery time can be performed. Capacity improvement as well as investment in accordance with renewal due to deterioration is becoming more common.

[4] Change and demolition

A method was changed in 4-3 to the one that does not use refrigerators of dehumidifiers. The ultimate change is to build up a production process, which does not use inefficient secondary energy, like compressed air and steam. However, focus of improvement activities will be shifted to buildup of a simple and slim production process without using energy.

7. Future Plans

Activities to lower the absolute value of consumption energy are performed by continuing the improvement in the manufacturing site where compressed air is consumed. At the same time, activities will continue with the aim of improving usability and production efficiency of the entire air system by strengthening information exchange of equipment in the production site with the supplying side (compressors).
Lowering in pressure of compressed air is only lowering energy potential of compressed air and causes increase in the consumed air quantity. We would like to double the energy conservation effects and achieve the target of 10Nm^3/kWh not by pursuing flashy intensity and efficiency on the supplying side but by matching with the production equipments in consuming side.