2006 Prize of the Chairman of ECCJ

"Reduction of Air Conditioning Electricity by Remote Monitoring System for Special Air Conditioning"

Denso Corporation, Nishio Factory
Diesel Injection Manufacturing Department
Manufacturing Planning Room, Profit Making Group

◎ **Keywords: Others (Improvement of monitoring system, enhancement of heat exchange efficiency)**

◎ Overview of Theme

This factory is doing processing and assembly of ultra-precision parts. It has special air conditioning rooms (constant temperature rooms) where an air conditioning system for making the temperature and humidity of the room constant throughout a year is continuously operated, consuming a great deal of energy. In doing the maintenance for the special air conditioners this time, we, as identified above, built a system for always monitoring the operation state of the chillers in light of energy conservation, and, as a result, we became able to implement the maintenance of the chillers in a timely manner. So we could realize energy conservation by enhancing the operational efficiency and raise the level of the preventive maintenance. We would like to report these activities as the theme of this case study.

◎ Implementation Period of the Case Example

- Project Planning Period — January 2005 – March 2005
- Measures Implementation Period — April 2005 – July 2005
- Measures Effect Confirmation Period — August 2005 – March 2006

◎ Outline of the Business Establishment

- Items Produced　Fuel injection products (diesel injection, gasoline injection), heat exchangers
- No. of Employees　7,000 (As of April 1, FY2006)
- Annual Energy Usage Amount (Actual results for fiscal year 2005)

Electricity	231,040 MWh/year
(Private generation	170,759 MWh/year)
A heavy oil	66,938 KL/year

◎ Overview of Target Facilities

The overview of the special air conditioner as the target equipment of this case study is shown in Fig. 1. Our division has 4 works in Nishio and Zenmyo factories and there are 10 large special air conditioners in those works as shown in the figure. In the system, the chiller makes chilled water and the water's chilled air is used to control the temperature and humidity of the rooms.

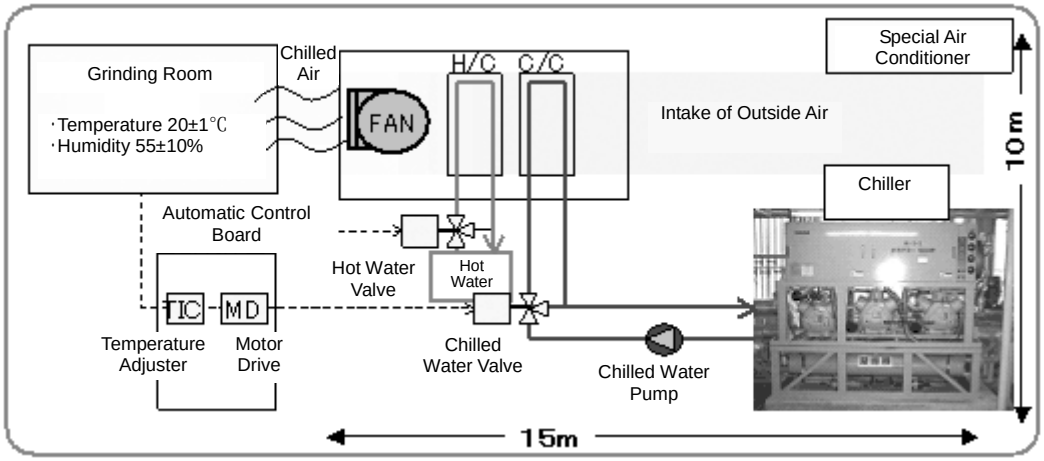

Fig. 1 Special Air Conditioner and Chiller

1. Reasons for Theme Selection

(1) Background of Activities

In the company's environment policy "Eco-vision 2005", the company set up a high target

aiming to reduce the company's CO_2 emission by 10% from the level of 1990 by 2010 and the entire company is challenging to achieve the target. According to the company's policy, we, this division, are trying to reduce the energy cost which is linked to the emission of CO_2. To be more specific, we are promoting these activities as the activities of the Profit Making Group as shown in Fig. 2.

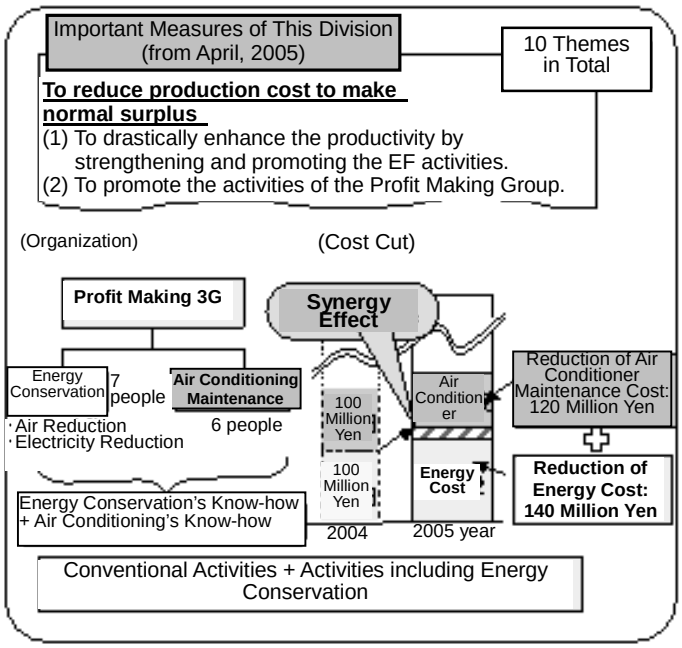

Fig. 2 Background of Activities of This Time

In the Profit Making 3G, there are Energy Conservation Team and Air Conditioning Team which is responsible for air conditioning equipment maintenance by us. Although the Energy Conservation Team and the Air Conditioning Team had made certain progress individually in FY2004, both teams decided to work together for making more progressive results by the synergy effect through combining conventional activities with energy conservation activities in FY2005.

When we looked into the energy costs of FY2004, we found that the electricity accounted for 80% of the total, as shown in Fig. 3. Of it, the air conditioning equipment which is unique to the diesel engine accounted for as much as 27%. Of it, the special air conditioning equipment accounted for 52%. The owned units of the special air conditioning equipment which our division has is the most in our company, so we decided to try to reduce the energy cost of the special air conditioning equipment.

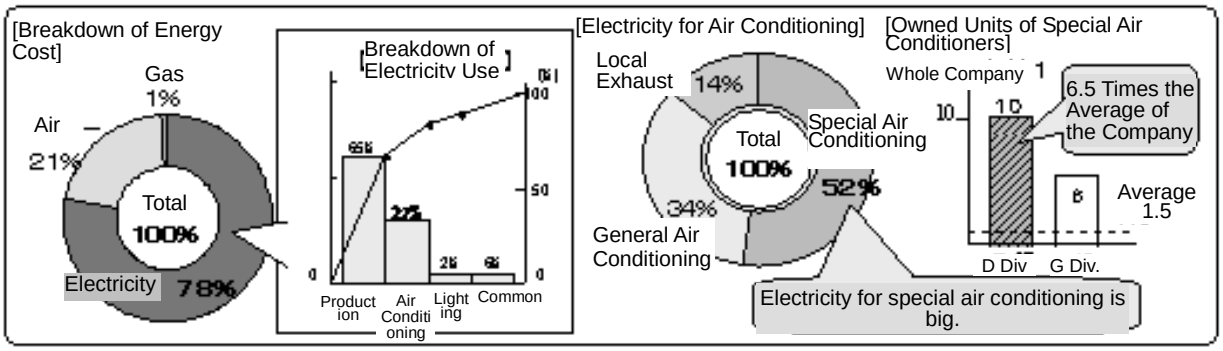

Fig. 3 Energy Cost of FY2004

(2) Reasons for Theme Selection

In the past, the energy conservation activities for air conditioning were implemented mainly by introducing the inverter control. As a result, although the general air conditioners achieved the reduction as much as 21%, that of the special air conditioners remained as low as 6%. So we focused on the special air conditioners and studied many reduction proposals as shown below. As a result, it became possible to implement the proposal [1] to [3], but as far as proposal [4] about chillers is concerned, it turned out to be beyond the capacity of the Energy Conservation Team, because it required knowledge and know-how of the chilling cycle. So it was decided that we, Air conditioning Team, take the initiative in trying to “reduce the electricity of chillers”.

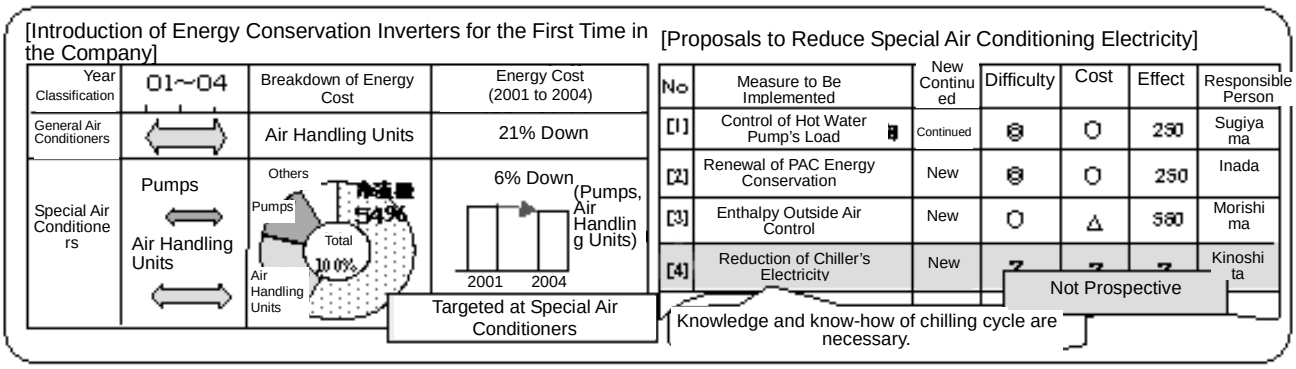

Fig. 4 Energy Conservation Activities for Air Conditioning done so far

2. Target Settings

As Fig. 5 shows, we set up the target aiming to reduce the electricity of chillers not standing goal yet by “13 million yen a year” to make reduction level of the electricity for special air conditioners the same as the general air conditioners.

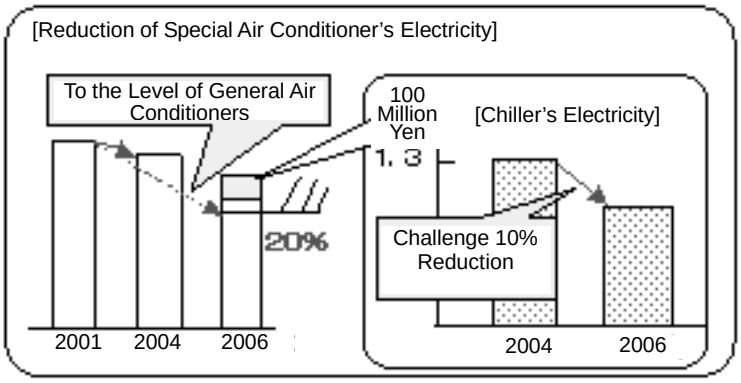

Fig. 5 Target Settings

3. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

As a result of the analysis of the electricity amount used by the chillers, we found that there were 12 chillers of same capacity and the electricity used by them was as much as 130 million yen a year as shown in Fig.6. Besides, if we convert this electricity amount to that of a single unit to see the operational efficiency, it is found that there is big variability of the electricity consumption of each unit and it exceeds the rated electricity.

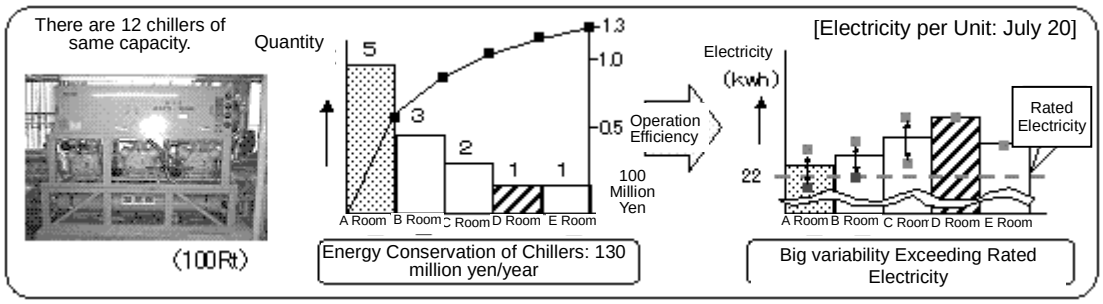

Fig. 6 Chiller's Electricity

(2) Cause of Investigations

We wondered why the electricity differs from each other although they were same type chiller. So we examined the correlation between the electricity and pressure in the chilling cycle such as compression or condensation. As a result, we found there were some chillers which showed the correlation, i.e. their electricity becomes bigger as the pressure becomes higher, but there were others which showed no correlation, i.e. their electricity is big even if the pressure is low. So we examined the cause by the factor of the problem, and we found

that, as we had expected, the correlation was caused by the contamination of the condenser and the non-correlation was caused by the clogging of the expansion valve.

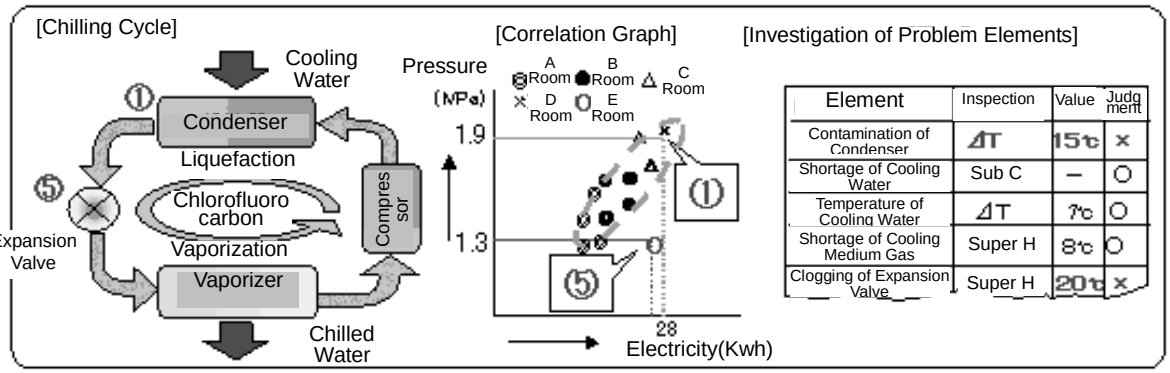

Fig. 7 Correlation between pressure and electricity

(3) Factor Analysis

Let's see the problem according to Fig. 8. First, if the condenser is contaminated, scale is generated in the tube by the heat exchange in the condenser, and it makes the heat transfer worse and the condensing pressure goes up. To explain this with the Ph diagram, as the pressure goes up, compressing work increases and the electricity increases.

As regards the clogging of the expansion valve, as the diaphragm in the expansion valve deteriorates, the follow-up movement of the needle becomes worse and it makes the clogging. Then, the cooling medium's circulation amount becomes less, so the cooling capacity becomes worse and it makes the operation hours longer.

Then, we examined these phenomena from the viewpoint of electricity. If the condenser is contaminated, the electricity area is increased by the increase of the pressure, and if the expansion valve is clogged, the time area is increased by the decrease of the capacity. We found that there was big electricity loss in either case.

We know as a matter of course that the pressure changes, so we implemented the measures from the viewpoint of maintenance. But, we did not know such difference in the electricity caused such a big loss. In other words, if we can eliminate this loss, we would be able to achieve the target. So we decided to review the existing way to preserve the air conditioners.

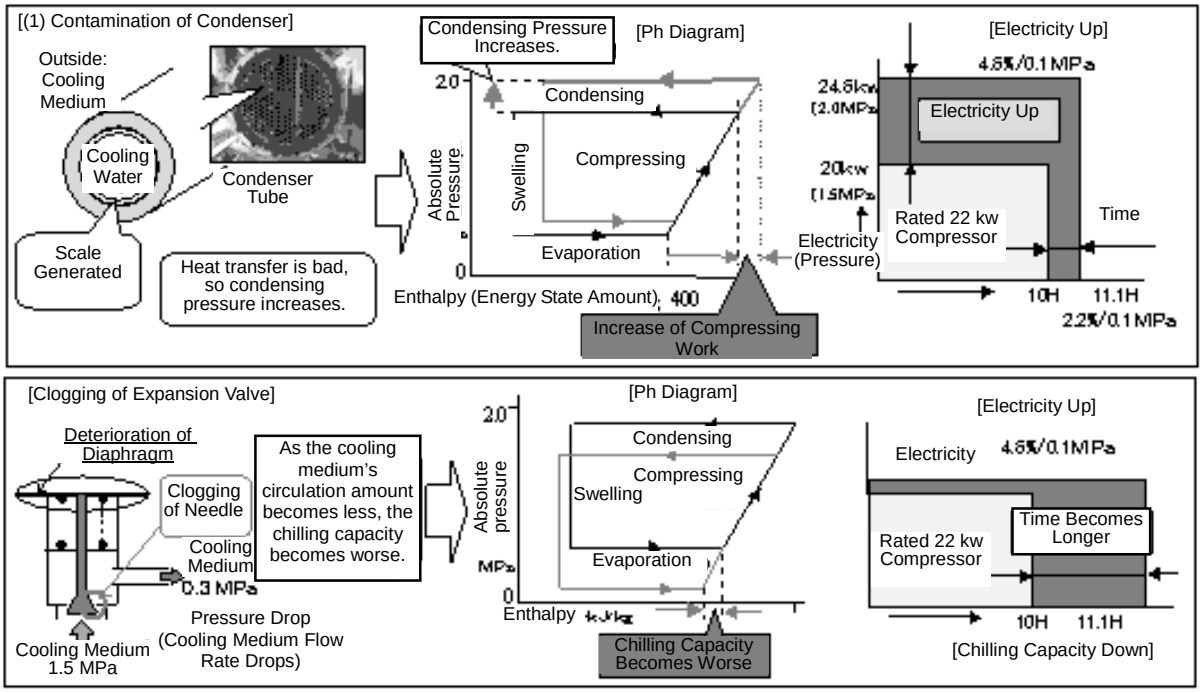

Fig. 8 Analysis of Pressure Abnormal

4. Details of Measures

(1) Conventional Way to Deal with Abnormal Events

Let's see the conventional way in Fig. 9-1 and Fig. 9-2. If the condenser is contaminated, using the pressure information of the daily inspection conducted by the Production Section, the pressure was lowered by doing chemical washing before operating of high pressure limit due to the pressure increases. However, as this process took man-hours for maintenance, the condenser was used as long as possible.

As regards the clogging of the expansion valve, it is judged by the degree of over-heat found in the periodic inspection which we, Air Conditioning Team, are implementing once a year. To be more specific about the degree of over-heat, it is expressed by the difference of temperature between the cooling medium's temperature at the inlet pipe of the compressor and the saturation temperature (the temperature at which the cooling medium turns from liquid to gas in the evaporator), and its proper value is 5℃ to 10℃. Here, if the expansion valve is clogged, the flow rate of the cooling medium becomes less and the degree of the over-heat becomes bigger and goes out of the range of the proper value. This is judged as abnormal. To repair it, the degree of the over-heat must be corrected by adjusting the opening of the needle, etc.

In either case, we used to judge that it was acceptable if we can cope with the problem

before there is trouble of the system. However, this time, we decided to make measures from the viewpoint of energy conservation to eliminate the above mentioned big electricity loss.

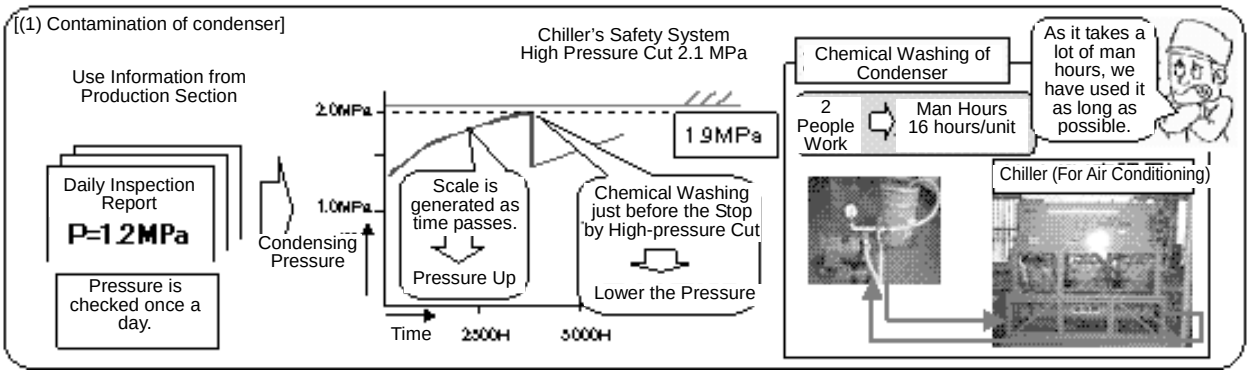

Fig. 9-1 Conventional Way to Cope with Abnormal Contamination of Condenser

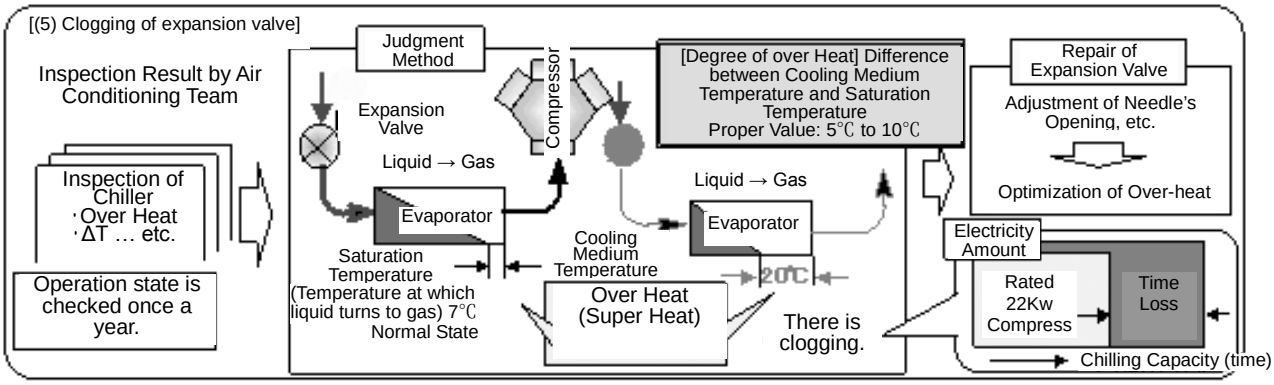

Fig. 9-2 Conventional Way to Cope with Abnormal Clogging of Expansion Valve

(2) Study of Energy Conservation Measures

As Fig. 10 shows, if we look at the problems on a long term basis, it is found that, in case of the contamination of the condenser, if we use the pressure information of the Production Section's daily inspection only, we cannot follow the change of the pressure caused by the outside air temperatures changes. So unless we know it when the pressure increases in the summer, there is loss for as long as one year. Similarly, in case of the clogging of the expansion valve too, we cannot know when trouble happens with the inspection we implement once a year, so there is loss until the next inspection.

In other words, it is impossible to know the trouble which causes electricity loss with the current daily inspection or periodic inspection. So together with the Production Section people, we decided to study the way with which we can know the trouble in a timely manner

using our periodic inspection which can know any trouble.

In the course of the study, there were ideas such as making the inspection by the Air Conditioning Team more frequent or adding new items to the daily inspection by the Production Section. But all of them were likely to result in the increase of man-hours, and the Production Section insisted that it was impossible to make another load. So we came up with the idea to see the possibility of “using the existing remote monitoring system” which we had maintained since 2002, and we decided to study the improvement of that idea.

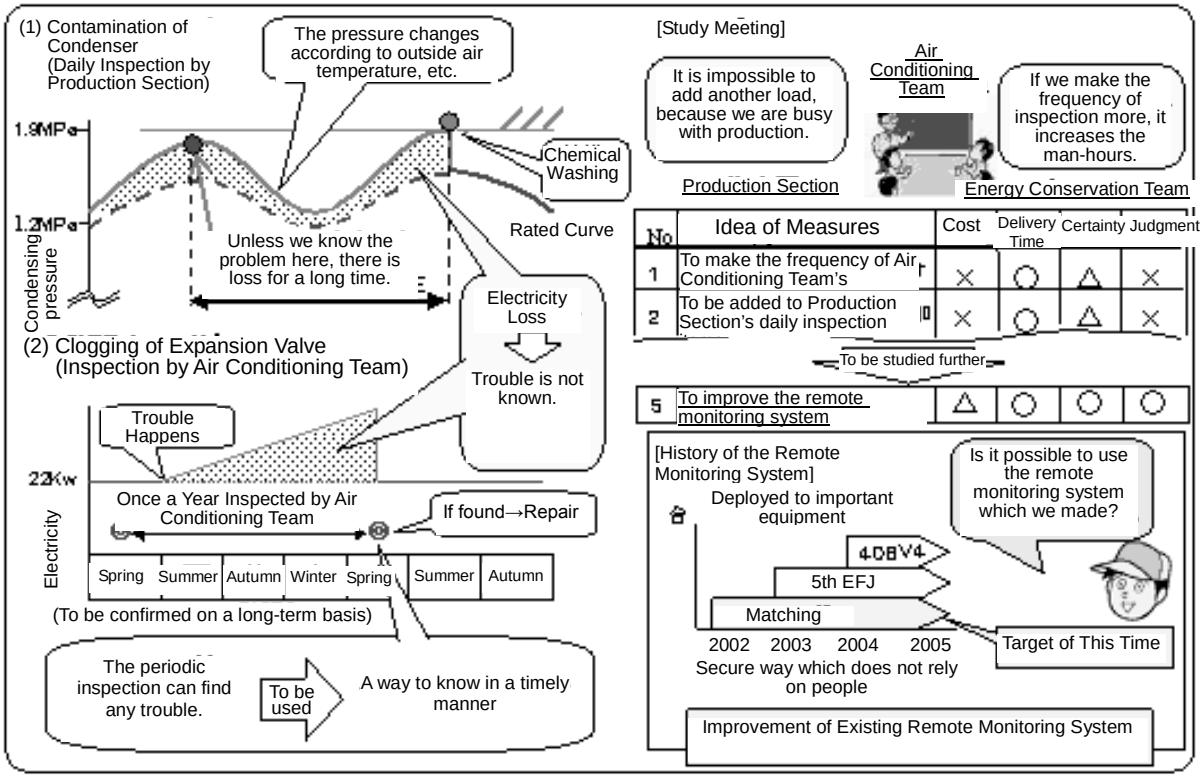

Fig. 10 Conventional Ways

5. Measures

(1) Extraction Issues

As Fig. 11 shows, assuming that every trouble of the chiller is known, we studied the way focusing on the unknown area which was different from the existing systems.

For explanation, we take the above mentioned over-heat for example. To judge the over-heat, it is necessary to know both saturation temperature and the cooling medium temperature. First [1] as regards the saturation temperature, it is converted from the cooling medium’s pressure using the saturation temperature table, so its automatic conversion becomes necessary. Then [2] as regards the cooling medium’s temperature, it is necessary

to add new temperature sensors. We thought that if we can solve those 2 issued, we can achieve the target, so we studied the measures.

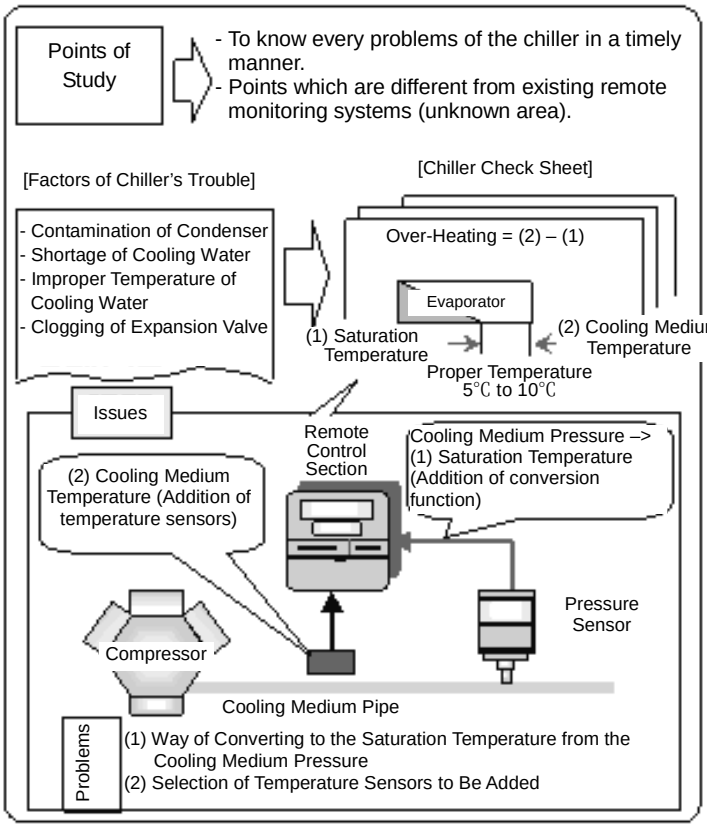

Fig. 11 Extraction Issues

(2) Measures for Issues

Fig. 12 shows the measures taken for the issues. First, [1] regarding the automatic conversion, since the saturation temperature against pressure is determined by thermodynamic nature, we determined to calculate the equation of its graph using Excel's fitted curve. To be more specific, we derived 3 kinds of the fitted curve from the table of the pressure and the saturation temperature, and then select an equation which has least error when calculate the saturation temperature. As a result, a cubic equation was selected and the automatic conversion became possible.

Then, as regards the selection of temperature sensors, we carried out simulation tests with our know-how to confirm the direction accuracy and the tracking accuracy of the cooling medium temperature's change against the start of the actual compressor, and selected A type which was close to the reference.

So we solved the two issues and we were convinced that we can implement the measures.

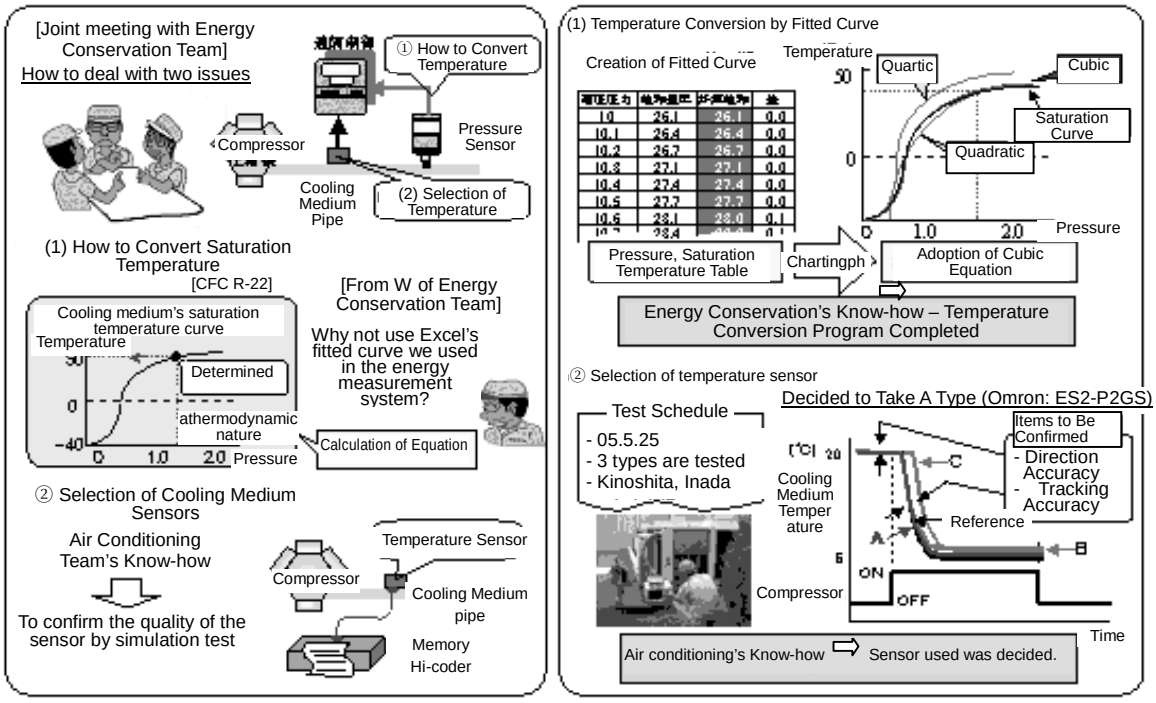

Fig. 12 Measures for Issues

(3) Implementation of Measures

Fig. 13 shows the measures implemented. First, we made the specifications of the system with the instrument makers. Then, we implemented the setting and tests of the equipment and completed the system with low investment. As a result, by using internal LAN, it became possible to recognize the over-heating with the personal computers of the office and, if there is something abnormal, to inform it through e-mails to the personal computer or business cell phones in a timely manner.

As regards the chemical washing, we made an only unit to reduce the man-hours by having one person work and implemented the chemical washing for all of 12 chillers.

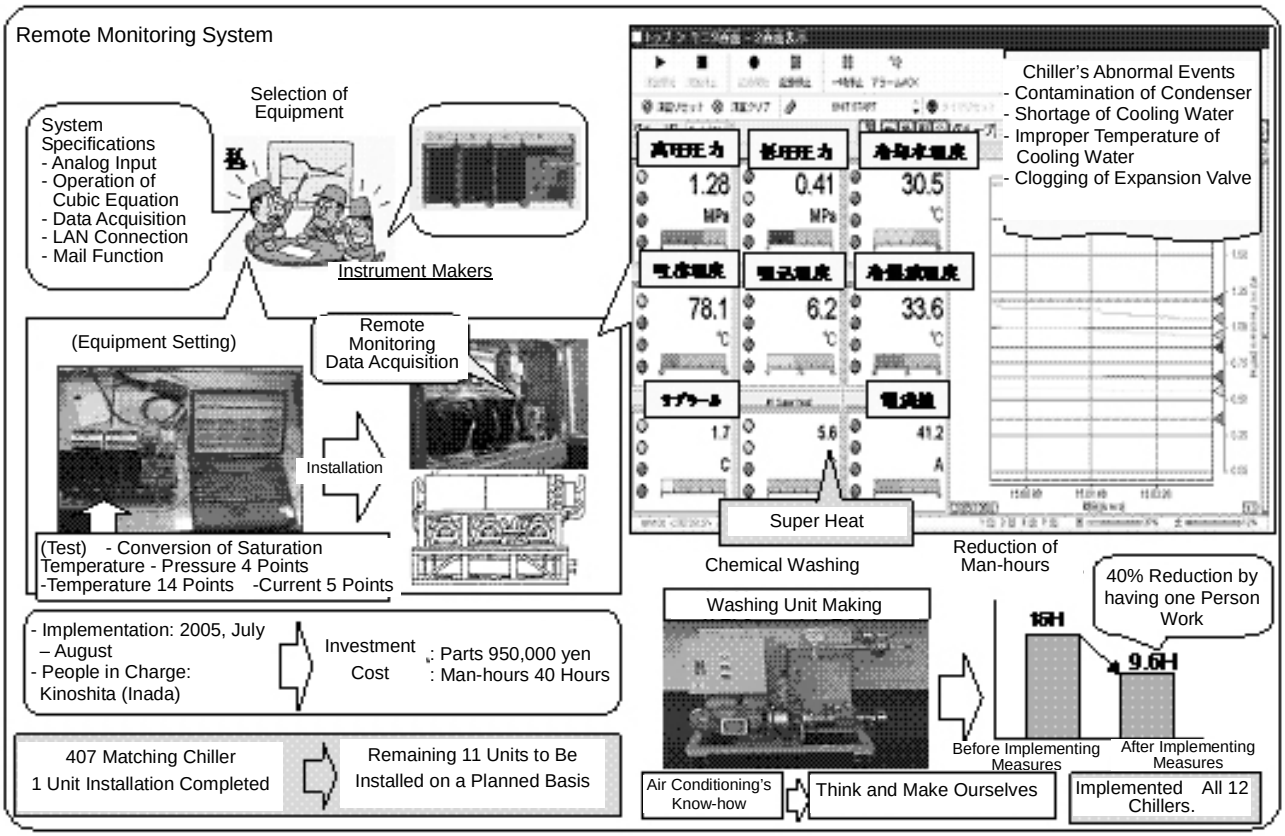

Fig. 13 Details of Measures

6. Effects

Fig. 14 shows the effects. In the energy conservation aspect, we could achieve the energy conservation of 14.3 million yen in a year against the target of 13 million yen by implementing the chemical washing.

As regards the reduction of man-hours, we could reduce 85% because it became possible for us only to check the 5 senses portion of our check sheet thanks to the remote system, and we could reduce the man hours by 206H in a year including the reduction realized by above mentioned washing unit.

Before the improvement, there was fear that the production barrier like defective products processing might occur due to the increase of the room temperature, because we had been monitoring only the temperature and humidity of the room as the terminal side. But, with the improvement of this time which monitors the operation state of the chillers as the upper stream side, the level of the preventive maintenance for the chillers was drastically enhanced. So we could achieve [1] energy conservation, [2] reduction of man-hours and [3] preventive maintenance altogether at the same time, and the Production Section was thankful for that.

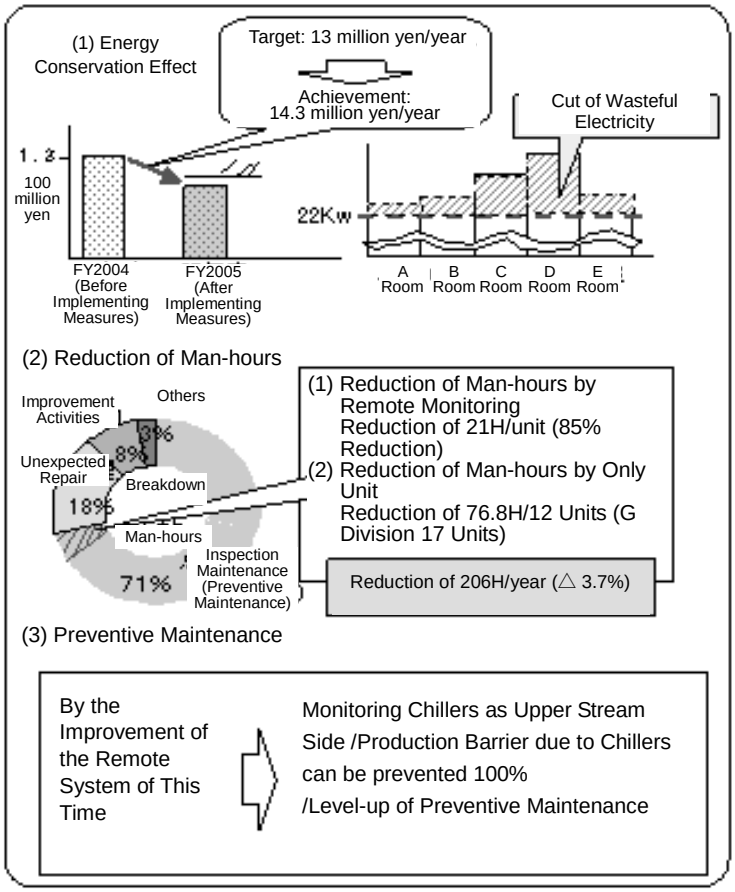

Fig. 14 Effects

7. Summary

In the activities of this time, we could contribute to the profit making with the synergy effect created by working with the Energy Conservation Team and take measures for the chillers which had been left untouched till then.

We will deploy the remote monitoring system of this time to all equipment from now on. We will also continue to promote the reduction of the energy cost and take the initiative in promoting the energy conservation in our company.