2005 Prize of the Chairman of ECCJ

Energy Conservation through JIT (Just-In-Time) Operation of Air-Conditioning Units

JIT ... Supplying necessary items, in necessary amount, at necessary timing

Toyota Motor Hokkaido, Inc.
Facility Group 1, Productive Maintenance Support Division

◎ **Keywords: Rationalization of conversion to electricity motive power, heat, etc. (Electric power application equipment, electric heating equipment, etc.)**

◎ Outline of Theme

We worked on the project to have our air-conditioning operation practice be shifted to running the equipment only during the plant's operating hours in collaboration with production department (a shift to Just-In-Time operation). Fulfilling an environmental standard for mist in the plant, we successfully developed and implemented energy conservation activities and achieved a large improvement effect.

◎ Implementation Period of the Said Example

April 2004 – July 2005

- Project Planning Period April 1, 2004 – May 31, 2004 Total of 2 months
- Measures Implementation Period June 1, 2004 – April 30, 2005 Total of 11 months
- Measures Effect Verification Period May 1, 2005 – July 31, 2005 Total of 3 months

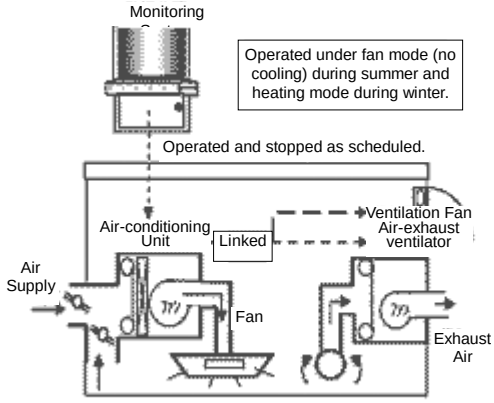
◎ Outline of the Business Establishment

- Items Produced Automatic transmissions, transfers, aluminum wheels
- No. of Employees 2,396
- Annual Energy Usage Amount (Actual results for fiscal year 2004)

  Energy usage when converted to crude oil 66,917 KL/year

◎ Process Flow of Target Facility

Fig. 1 shows the outline of the facility of our project. Air-conditioning units in the plants of Toyota Motor Hokkaido are operated and stopped as scheduled under control of a monitoring system. The units are switched to fan mode (no cooling) during summer and heating mode in winter for environmental control of mist and room temperature in the plants.



		No. of Air-conditioning Units (units)	Output per Unit (kW)	No. of Air-exhaust Ventilators (units)	Output per Unit (kW)	No. of Ventilation Fans (units)	Output per Unit (kW)	No. of Exterior-air Supply Fans (units)	Output per Unit (kW)	Total Output (kW)
第1	熱処理	3	37	4	45					291
	A541	7	37	10	45					709
	NF1次	5	45	4	55					355
	NF2次	2	45	1	55			1	30	175
	U340	8	45	9	55			1	30	885
	T/C	5	45	4	55					355
第2	鍛造	7	37	1	18.5	84	1.5			404
	加工	7	37	1	18.5	56	1.5			336
	塗装	10	56			28	1.5			342
第3	[illegible]	6	45			54	1.5			345
	[illegible]	2	45			7	1.5			101
	合計	56		34		208		2		4,297

(Note) The air-exhaust ventilators and ventilation fans are operated in conjunction with the air-conditioning units.

(Fig. 1) Outline of the Process Chart and List of Air-Conditioning Equipment in the Plants

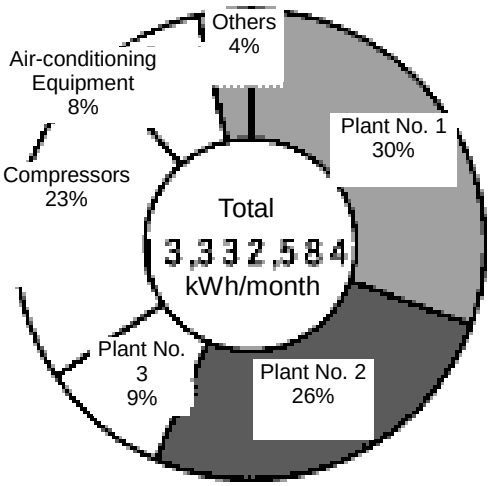
1. Reasons for Theme Selection

After obtained ISO14001 certification in 1999, the company has been actively promoting energy conservation activities as an entire company project. Among various electric consumptions, compressors account for the largest portion except for the power used for manufacturing in the three plants. For the compressors, some activities to prevent air leakage and measures to lower air-supply pressure in order to reduce the electric consumption were already implemented. Considering the above, we determined to work on, this time, the electricity used for air-conditioning, which accounts for 8% of total consumption.

Placement of energy conservation measures for air-conditioning units has been regarded as a difficult issue in terms of maintaining good work environment in the plants, and therefore, tended to be avoided as a theme for energy saving project.

However, we determined to take it up in order to be actively engaged in the energy

conservation activities with a spirit of challenge.

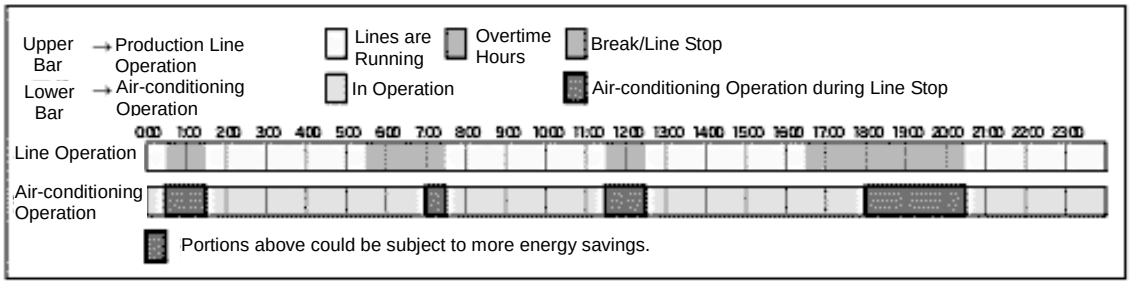


(Fig. 2) FY2003 Electric Consumptions in the Plants

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

Air-conditioning units, which were automatically operated and stopped as scheduled, had some time slots where the units were operated although production lines were not running (hereafter, the “air-conditioning operation during line stop”). (Fig. 3)



(Fig. 3) Operations of Production Lines and Air-conditioning Units on Weekdays (Tue. to Fri.)

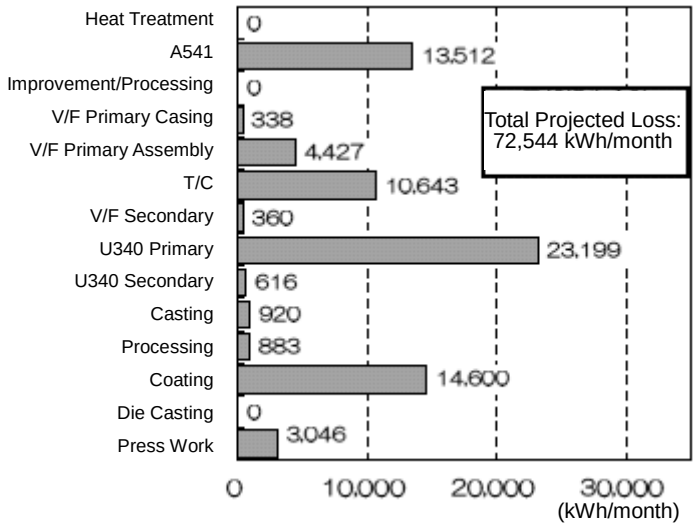
(2) Analysis of Current Situation

Factors and details of the air-conditioning operation during line stop varied among plants and lines. (See Table1)

Fig. 4 shows amount of electricity required for air-conditioning by production line under the air-conditioning operation during line stop.

(Table1) Factors of the Air-conditioning Operation during Line Stop

	Production Lines	Factors of the Air-conditioning Operation during Line Stop
Plant No.1	Heat treatment	Continuous operation with no line stop
	A541	Worsened work environment due to mist Overtime hours are not properly understood. Gap between air-conditioning request form and actual line operations.
	Improvement/processing group	Continuous operation with no line stop
	VF primary casing	Gap between air-conditioning request form and actual line operations
	VF primary assembly	Worsened work environment due to mist. Overtime hours are not properly understood. Gap between air-conditioning request form and actual line operations
		Overtime hours are not properly understood. Gap between air-conditioning request form and actual line operations
	VF secondary	Gap between air-conditioning request form and actual line operations
	U340 primary	Worsened work environment due to mist. Overtime hours are not properly understood.
	U340 secondary	Gap between air-conditioning request form and actual line operations
No. 2	Casting	Gap between air-conditioning request form and actual line operations
	Processing	Gap between air-conditioning request form and actual line operations
	Coating	Quality defect due to mist
No. 3	Die casting	Continuous operation with no line stop
	Press work	Overtime hours are not properly understood.



(Fig. 4) Electricity Required for Air-conditioning under the Air-conditioning Operation during Line Stop

3. Progress of Activities

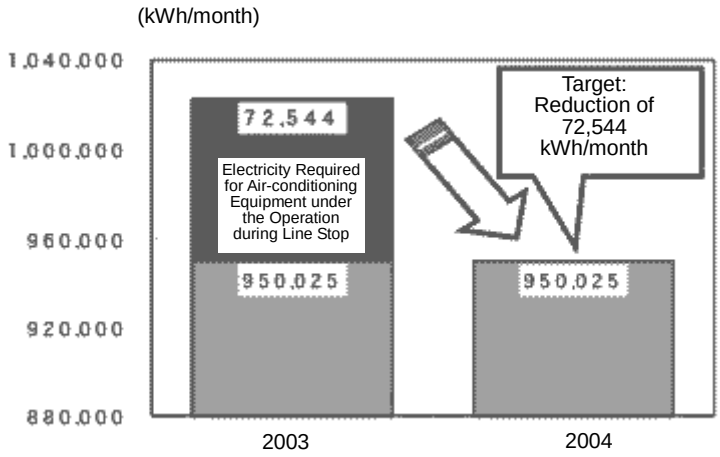
(1) Implementation Structure

Following our motto, "*Genchi Genbutsu*" (making your decision after visiting actual site and see actual items/materials), we visited production department many times, gathered opinions and inputs from workers, and checked operating and overtime hours in order to draft and clarify necessary measures.

With a full focus on environmental aspects, we also measured mist conditions and room temperatures in the plants, closely working with production department to carry forward the activities.

(2) Target Settings

Achievement of energy conservation effect by way of eliminating factors causing the air-conditioning operation during line stop



(3) Problem Points and their Investigation

We determined to take measures, placing the highest priority to "keeping good environment for workers to do their job", after enough research on environmental elements including mist, which was one of the factors of the air-conditioning operation during line stop.

We also aimed to achieve more timely operation (JIT operation) through better understanding of operating hours. Table2 shows the factors and direction of our measures.

Considering the fact that each plant has different factors for the wasteful air-conditioning operation, we determined to carry on the project starting with analysis and implementation of measures on the Plant No. 1, which had the largest electric consumption. As a next step, we planned to expand the JIT project to the entire company, eliminating barriers among workplaces. Since temperature in the plants was not pointed out as a particular issue as we went on the activities, we determined to focus on the measures for mist issues and proper understanding of operating hours.

(Table 2) Factors of the Air-conditioning Operation during Line Stop in the Plants and Direction of Our Measures

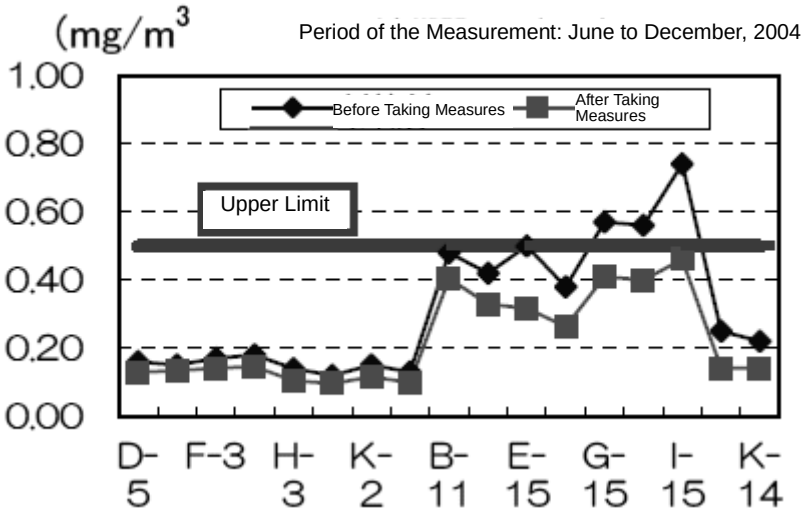
	Factors of the Air-conditioning Operation during Line Stop	Direction of Measures
1	Worsened work environment due to mist	Examine if operation of air-conditioning equipment can reduce the mist, based on measurement results of the mist while production lines are running and after they are stopped.
2	Quality defect due to mist	Prevent the mist from getting inside the coating plant
3	Overtime hours are not properly understood.	Automatically stop production lines through monitoring of electric current of machines per line.
4	Gap between air-conditioning request form and actual line operations	Make air-conditioning schedule consistent with line operation hours.

4-1. Details of Measures

(1) Plant No. 1 - Worsened Work Environment due to Mist

Some points to measure mist concentration level were selected from the places which had some employees usually working and had an average mist level (Fig. 5).

After taking some actions on mist generation sources, high mist level on some points detected during the measurements was improved to below the limit (Fig. 6).

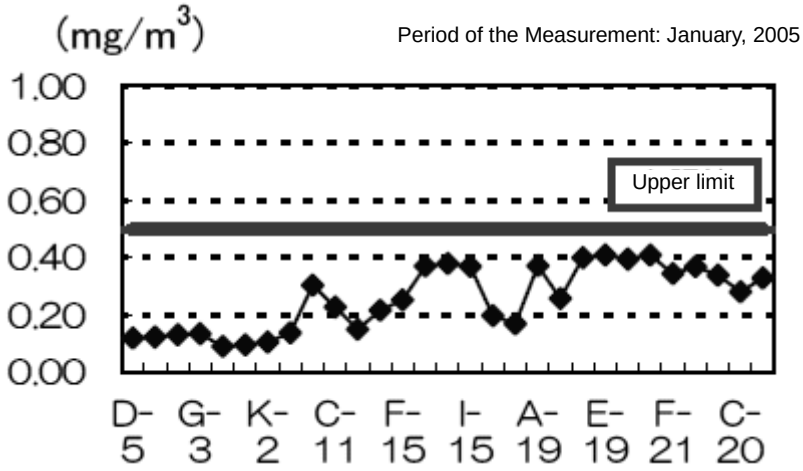


(Fig. 5) Average Mist Level before and after Taking Actions on Mist Generation Sources in the Plant No. 1

(Fig. 6) Measures on Mist Generation Sources

Next step was to see if the mist level could be kept below the limit after stopping air-conditioning units during production line stop. As a result of our research, it was verified that the mist level was fulfilling the required criteria even after stopping the air-conditioning units (Fig. 7).

Based on the findings, we revised the air-conditioning operation schedule so that the units would be immediately suspended when production lines stopped running.



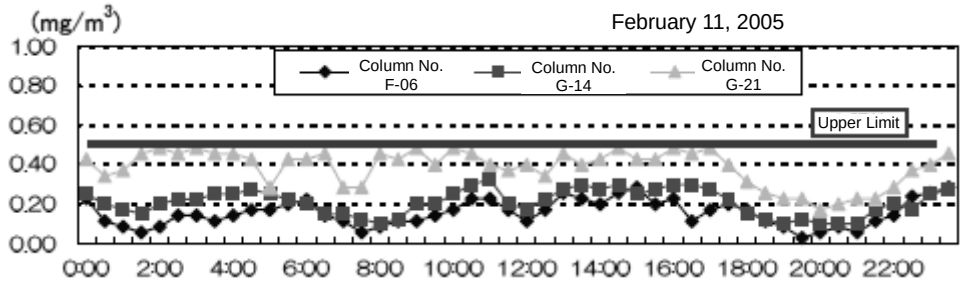
(Fig. 7) Average Mist Level after Stopping Air-conditioning Units in Plant No. 1

(Fig. 8) Measurement of Mist Level

<Future Monitoring Structure>

Since the data of measured mist concentrations collected by the monitoring system was not consistent with the result of actual on-site measurements, the data was not used as supporting data in this project. However, the data shows some favorable responses, indicating that the mist level declined while production lines were not running and increased while they were in operation. Therefore, correlation between the implication and mist measurement results was put under our investigation.

As a result, we successfully developed a structure where continuous mist tendency control could be managed by entering correlation coefficient into computing expressions of the monitoring system. Reliability of the data was verified by checking it against actual mist measurements every 6 months.

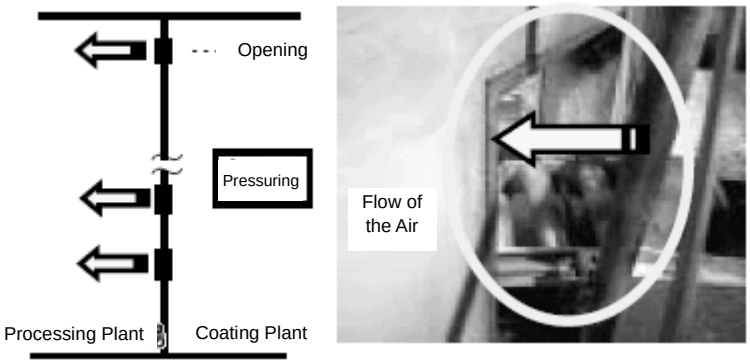


(Fig. 9) Preparation and Maintenance of the Mist Level Data of the Plant No. 1 Collected by the Monitoring System

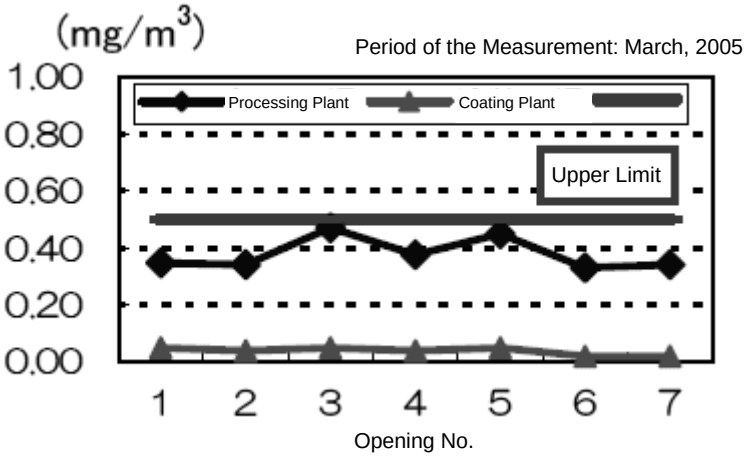
(2) Plant No. 2 – Quality Defect Caused by the Mist

This problem was found in the plant for coating work. Tire wheels are forwarded to the coating plant by conveyers from the neighboring processing plant, through 7 openings on the wall between the two buildings (Fig. 10).

In order to prevent the mist in the processing plant from entering into the coating plant and causing quality defect, air-conditioning units were operated even while the lines were not running, so that the air in the coating plant was kept pressured (Fig. 11)

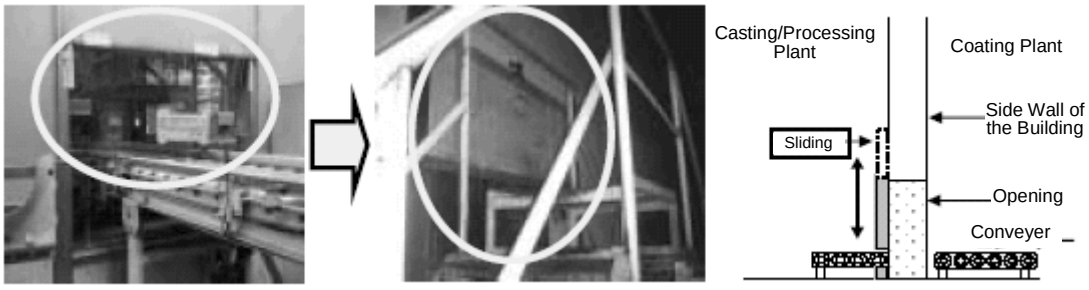


(Fig. 10) Diagram of Openings Layout



(Fig. 11) Average Mist Levels of Processing and Coating Plants

Firstly, we made an experiment in sealing the opening with plastic material (*tafuloido)* and suspending the air-conditioning units while the production line was not running in order to see if any quality issue would emerge. As a result of the two-week study in the experiment, it was confirmed with the production department that product quality would not be impacted by the experimental process. As a measure in this project, we implemented above modification with additional sliding doors on the openings which could be closed while lines were not running and be opened before their operation would start (Fig. 12).



Under Experiment with Sealed Opening

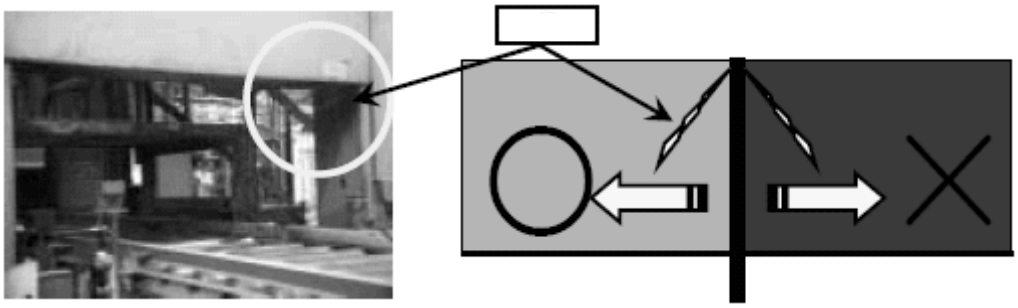
After Implementing the Measure (A door was attached.)

After Installing the Sliding Door

(Fig. 12) Measure against Entry of the Mist

<Future Improvement on the Monitoring System>

We made further improvement on the openings by attaching some strings on their upper edges so that anyone (in the production department and our group) could monitor conditions of the pressured air in the coating plant by checking which direction the strings were leaning to (Fig. 13).

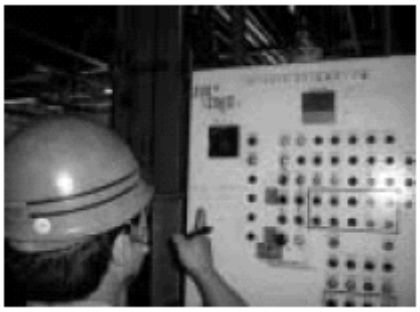


(Fig. 13) Monitoring of Pressured Air Conditions in the Coating Plant

(3) Overtime Hours are not Properly Understood

Overtime hours vary by line and day. The overtime data could be gathered for better understood if our group asks the production department to provide us with the information. However, asking for such information everyday at every shift would be a time-consuming burden for us.

Considering the above, we determined to establish a schedule based on our monthly production plan and make it a rule for the plant workers to inform us if they needed to work unexpected overtime so that we could update the schedule. Additionally, we checked trunk line load numbers of major machinery of each production line and started investigation to see if it would be possible to determine whether workers were working overtime by reading a trend of the electric current (Table3)



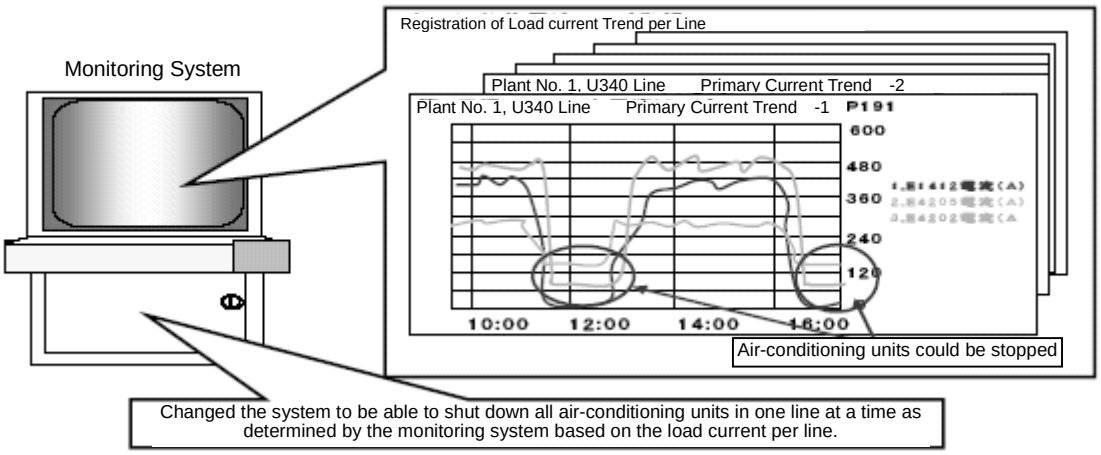
(Fig. 14) Checking the Main Load Current of the Lines

(Table 3) List of Trunk Line Load per Line

Lines	Trunk Line Numbers
A541	EH1AC100
VF Primary Assembly	EH1AD100
T/C	EL1AC506
U340 Primary	EL1AE112
Press Work	EH3AB400

Based on the study results, we entered information of the current trend of each line to the monitoring system and kept monitoring the load current. Workers were required to stop the air-conditioning units upon hearing an alarm set to be sound when the electric current went below a certain level.

Judging from the monitoring for two weeks, it was confirmed that the new practice would cause no problem. We improved our rule from stopping the air-conditioning units one by one to shutting down all the units in one line at a time under the control of the monitoring system.



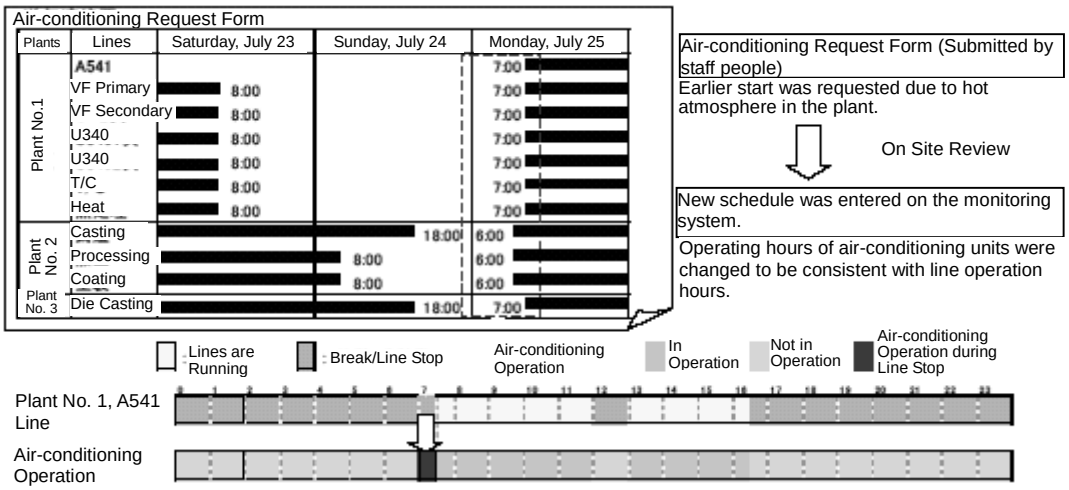
Plant	Lines	Relevant Air-conditioning Units	
No. 1	Heat Treatment	AC-1,2,3	Start and stop the operation of all units in one line at a time.
	A541	AC-4,5,6,7,8,9	
	Improvement/Processing	AC-10	
	VF Primary Casing	AC-11,12	
	VF Primary Assembly	AC-13,14	
	T/C	AC-15,16,17,18,19	
	VF Secondary	AC-22,23,26	
	U340 Primary	AC-19,20,21	
	U340 Primary to Secondary	AC-28,32	
No. 2	Casting	AC-1,2,3,4,5,6,24	
	Processing	AC-7,8,9,10,11,12,27	
	Coating	AC-13,14,15,16,17,18,29,30,31	
No. 3	Die Casting	AC-1,2,3,4,5,6	
	Press Work	AC-8,10	

(Fig. 15) Load Current per Line Recognized by Monitoring System and Shutdown Operation of the Air-conditioning Units per Line

(4) Gap between Air-conditioning Request Form and Actual Operating Hours

On non-business days and the day following those days, air-conditioning equipment was operated/stopped automatically in accordance with a schedule prepared based on air-conditioning request forms submitted by staff people. Knowing the situation that workers in the production department came in earlier to start production lines in the morning following non-business days, the staff used to prepare a request form asking to start operating air-conditioning units earlier than usual on such days (Fig. 16).

Following our visits and reviews on the production floor and interviews with production department, it was determined that air-conditioning would not be necessary except when temperature in the plant was below 19℃ or above 27℃ and, therefore, the air-conditioning could be used in consistent with line operating hours.



(Fig. 16) Gas between Air Conditioning Request and Actual Operating Hours

4-2. Details of Other Measures

While we were working on the improvement measures, another problem was found. It is described below along with our actions taken against it.

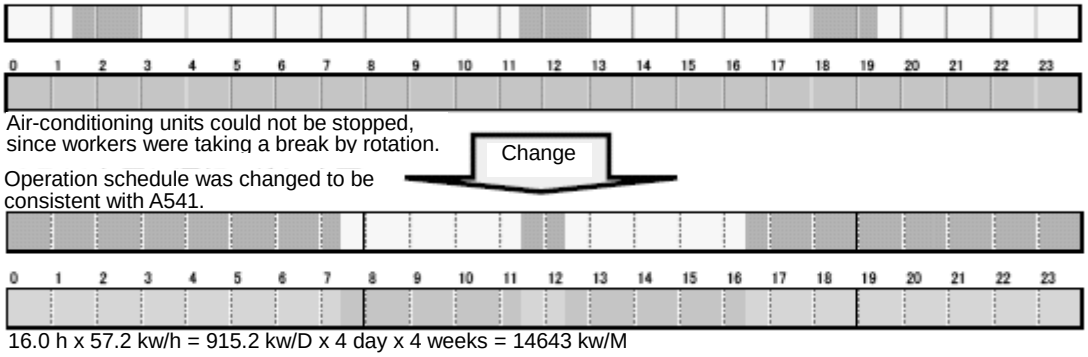
(5) Air-conditioning Unit was not used for Proper Production Line

Since lines for heat treatment are continuously running, air-conditioning units are also continuously operated. Among those units, we found a unit sending air to an aisle where no one was working (Fig. 17).

The air-conditioning unit was altered to send air to A541 line, where some workers were around (Fig. 18).

(Fig. 17) The Aisle to which AC-04 Unit was Sending Air

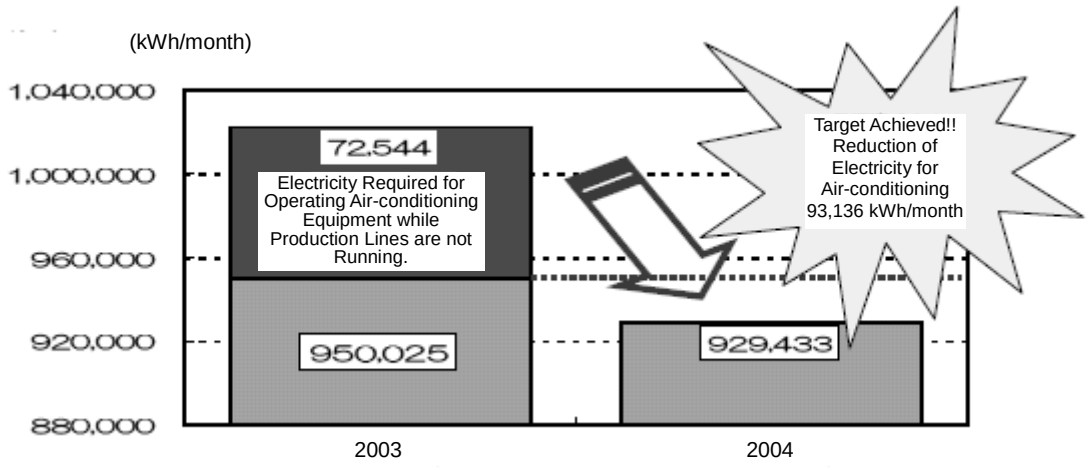
AC-04 unit was kept in continuous operation with an assumption that it was sending air to a thermal treatment line.



16.0 h x 57.2 kw/h = 915.2 kw/D x 4 day x 4 weeks = 14643 kw/M

(Fig. 18) Timetables showing Changes in AC-04 Operation Schedule

5. Effects achieved after Implementing Measures



Please see Table 4 for details of improvement effects.

(Table 4) List of Improvement Effects on Electricity Consumption by Air-conditioning Equipment

(unit: kHz)

	Monday		Tuesday to Friday		Saturday		Sunday		Total Monthly Consumption
	Daily Electric Consumption	Monthly Electric Consumption	Daily Electric Consumption	Monthly Electric Consumption	Daily Electric Consumption	Monthly Electric Consumption	Daily Electric Consumption	Monthly Electric Consumption	
Heat Treatment in Plant No. 1	0.0	0	0	0	0.0	0	0	0	0
A541 (AC-04) in Plant No. 1	514.8	2,059	915.2	14,643	972.4	3,890	0	0	20,592
A541 in Plant No. 1	675.6	2,702	675.6	10,810	0.0	0	0	0	13,512
Improvement/Processing in Plant No. 1	0.0	0	0	0	0.0	0	0	0	0
V/F Primary Casing in Plant No. 1	42.2	169	0	0	42.2	169	0	0	338
V/F Primary Assembly in Plant No. 1	184.5	738	210.8	3,373	79.1	316	0	0	4,427
T/C in Plant No. 1	443.5	1,774	506.8	8,109	190.1	760	0	0	10,643
V/F Secondary in Plant No. 1	45.0	180	0	0	45.0	180	0	0	360
U340 Primary in Plant No. 1	987.2	3,949	1,110.6	17,770	370.2	1,481	0	0	23,199
U340 Primary to Secondary in Plant No. 1	77.0	308	0	0	77.0	308	0	0	616
Casting in Plant No. 2	230.1	920	0	0	0.0	0	0	0	920
Processing in Plant No. 2	220.8	883	0	0	0.0	0	0	0	883
Coating in Plant No. 2	1110.9	4,444	0	0	0.0	0	2539.2	10,157	14,600
Die Casting in Plant No. 3	0.0	0	0	0	0.0	0	0	0	0
Press Work in Plant No. 3	190.4	762	142.8	2,285	0.0	0	0	0	3,046

Total Reduction of Electricity Consumed by Air-conditioning Equipment 93,136 kWh/month

Saved Electricity 1,117,632 kWh/year

When Converted to Crude Oil 283,879 kl/year

6. Summary

As a result of our activities with cross-sectional efforts tackled by the entire company as a team, a significant achievement was gained. Although we needed to spend much time in visiting production floors for review, interviews with workers in production department to get their input, and managing to get cooperation by staff people, what we gained was worth it. Our success was built on many small trials repeatedly made to correctly understand time slots on a timetable and find out unnecessary operations.

7. Future Plans

The JIT operation of air-conditioning equipment we completed will be applied to a new plant to be launched in December, 2005. We will actively work on further energy conservation activities in collaboration with the production department for continuous improvements.