2006 Prize of the Chairman of ECCJ

Making of Less Energy Consumption Perfect Line Pursuing Minimization of Electricity for Motor

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Energy Session Group

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

◎ Overview of Theme

It was difficult to improve the existing production line for energy conservation, because it required much modification cost. So, working with relevant internal departments and equipment manufacturers, we made the energy investment less by making a system in which we could incorporate the know-how on energy conservation and the energy conservation design into the equipment from its designing phase. Meanwhile, we measured the power wave and made the energy analyze on the one cycle of each motor used for cutting machines, hydraulic pumps and coolant pumps which were the electricity using equipments in the cutting work line. By doing so, we could develop the energy conservation control having good energy efficiency and make the less energy consumption perfect line whose energy intensity was less than half the conventional line.
Here, the less energy consumption means the energy conservation activities based on the JIT concept.

◎ Implementation Period of the Case Example

December 1, 2004 – March 31, 2006

● Project Planning Period	December 1, 2004 – March 31, 2005
● Measures Implementation Period	March 1, 2005 – March 31, 2006
● Measures Effect Verification Period	January 10, 2005 – March 31, 2006

◎ Outline of the Business Establishment

- Items Produced Brake parts for cars
  Tandem master cylinders, disc brakes, proportioning valves
- No. of Employees 910
- Annual Energy Usage Amount (Actual results for fiscal year 2005)
  Electricity: 100,957 MWh
  LNG: 19,192,000 Nm^3/year
  LSA: 3,806 KL

◎ Overview of Target Facilities

Table 1 show the production processes for brakes, where we took the energy conservation measures for the new transfer machine in the cutting work process.

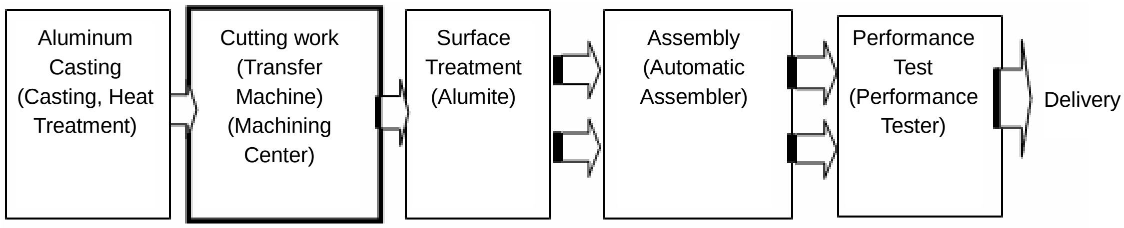

Fig. 1 Brake Production Processes

1. Reasons for Theme Selection

To make the energy conservation improvement for the production equipment such as cutting work process line whose electricity usage accounted for 46% of the total electricity usage of this factory, we had to recover the investment cost within 3 years, but we felt it was difficult. Under the circumstances, the company established an important energy conservation policy aiming to “adopt the energy conservation into newly installed lines” to accelerate the energy conservation further. So we started to construct the less energy consumption line by adopting the energy conservation design with less energy conservation investment into the new line from its designing phase.

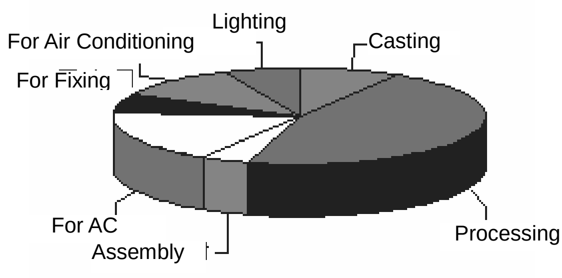

Fig. 2 Use of Electricity – FY2005 –

2. Understanding and Analysis of Current Situation

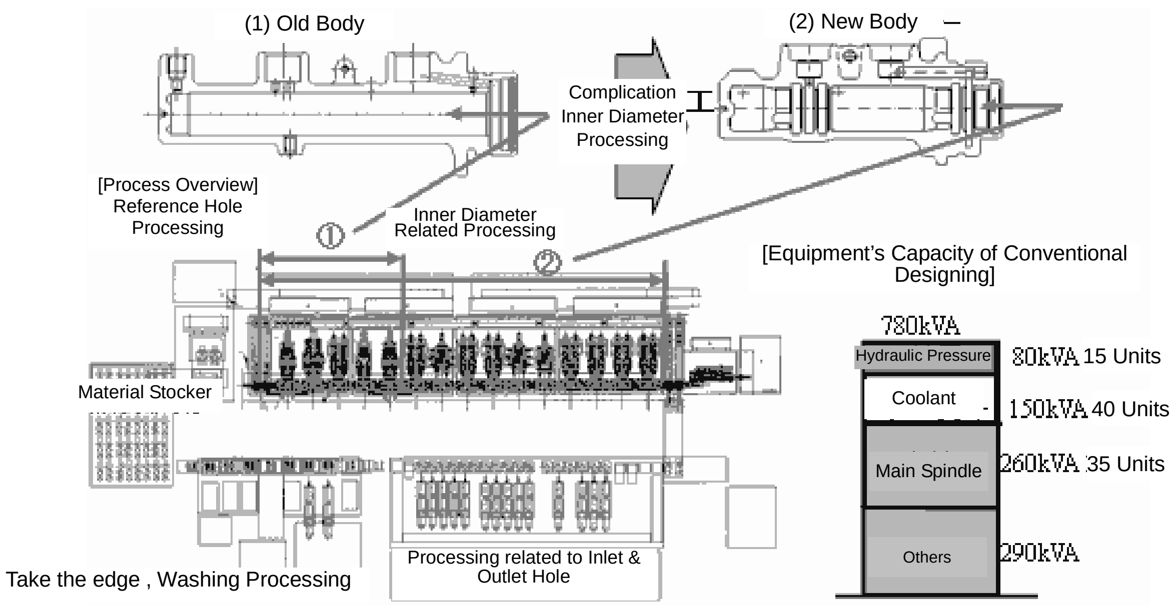

Fig. 3 Overview of New Product Processing

(1) Understanding of Current Situation

The number of the cutting work processes of the planned cutting work process line became 3 times of the old processes and the equipment capacity became as much as 780kVA, because the speed became faster and the body's inner diameter became complex. It was used mostly by the motors of the hydraulic, the coolant, the spindle and etc.

(2) Analysis of Current Situation

We analyzed the early MP activities to adopt the energy conservation design and found that there were following 2 problems.

[1] When designing and making the equipment, the capacity and the quality of the equipment are studied preferentially and the consideration to energy conservation is lacked.

[2] Although most of the electricity is consumed by the motors, there are few energy conservation items.

To cope with these problems, we planned the following action.

[1] To make a system in which we can adopt the energy conservation design working with the relevant internal departments and equipment manufacturers.

[2] To develop less energy consumption control (items) by measuring and analyzing the power wave of one cycle of individual motors.

3. Progress of Activities

(1) Implementation Structure

The "planned cost realization project for new products" (slim activities) started aiming to realize the cost planning which incorporated the SE (production design) for new products. We participated in it as its energy team and started the energy conservation WG consisting of the production engineering and maintenance members of the factory's energy working group as one of the energy conservation activities.

The main activities and the schedule (progress) of the energy conservation WG are shown in Fig. 4 below.

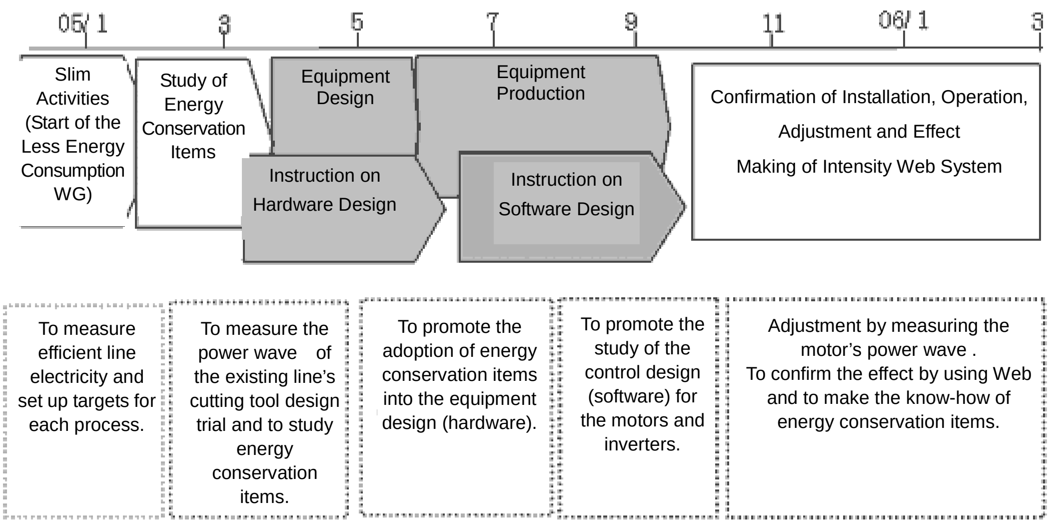

Fig. 4 Activity Schedule of Energy Conservation WG

(2) Target Settings

From among similar products, lines and equipment capacities, we studied the intensity of an equivalent line as a reference and set up a target aiming to reduce the intensity of the existing line by 50% presuming that the machine time was 10 seconds and the operation rate is 85%.

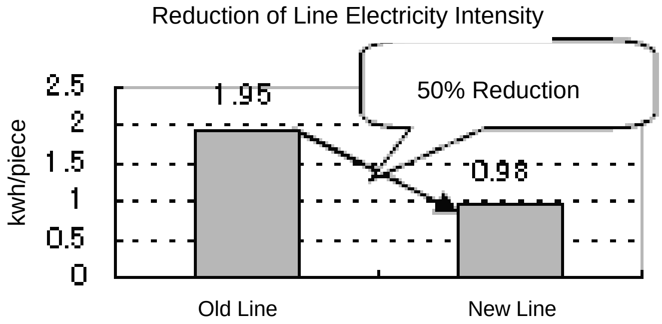

Fig. 5 Target Settings

4. Details of Measures

(1) Activity Tool of the Energy Conservation WG

Although we made the WG for the purpose of adopting energy conservation design when making the equipment, there was no opportunity for the equipment manufacturers to join us and study the matter. So we started the study meetings and used e-mail to exchange information with the equipment manufacturers, and there was certain achievement. So we hereby introduce the activity tool we used.

<u>Line energy conservation map (Fig. 6)</u>

We made a map that shows the energy conservation activities of the line in an easily understandable way. It draws the line layout and describes the target intensity, equipment capacity and energy conservation items as counter measures for each process (for each equipment manufacturer). This map is issued when setting the target, adjusting or deploying the energy conservation items, etc. to promote our mutual training and common understanding.

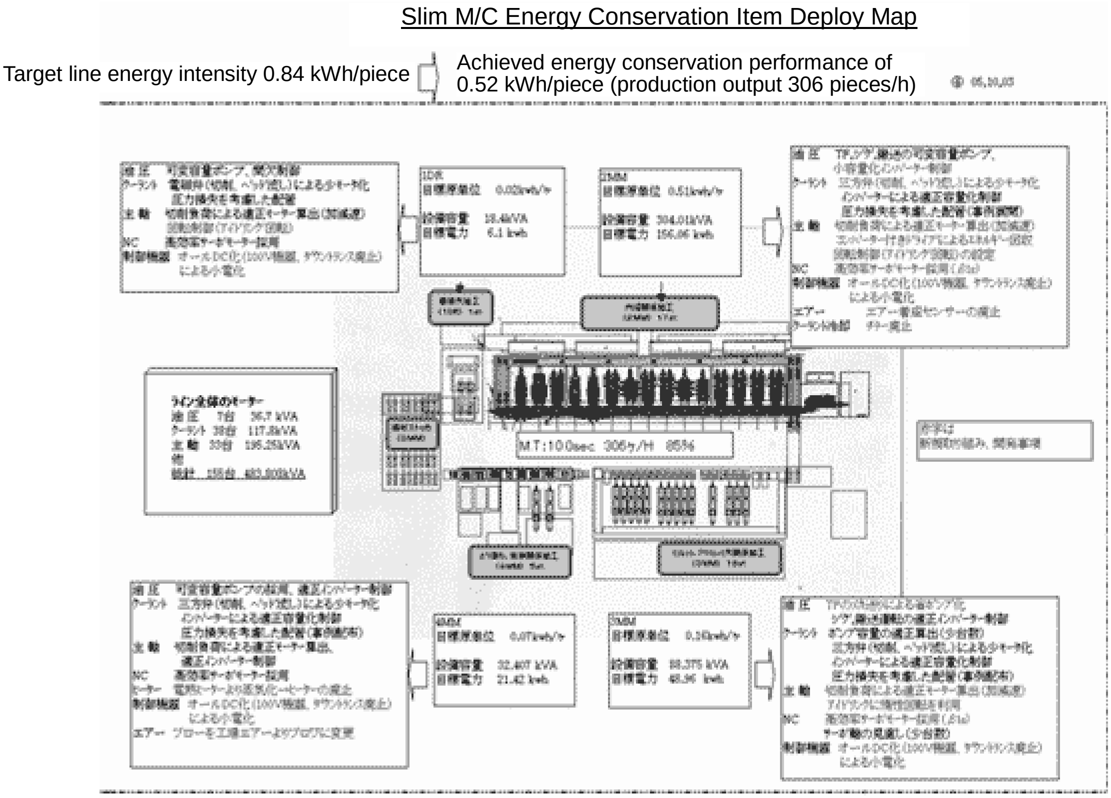

Fig. 6 Line Energy Conservation Map

<u>Research deploy table (Fig. 7)</u>

This is the basic data for the map. It asks each equipment manufacturer to write (declare) the equipment parts, motor capacity and energy conservation measures to enhance their energy conservation consciousness. The energy conservation items are added in red to be used for the instruction and follow-up of the progress.

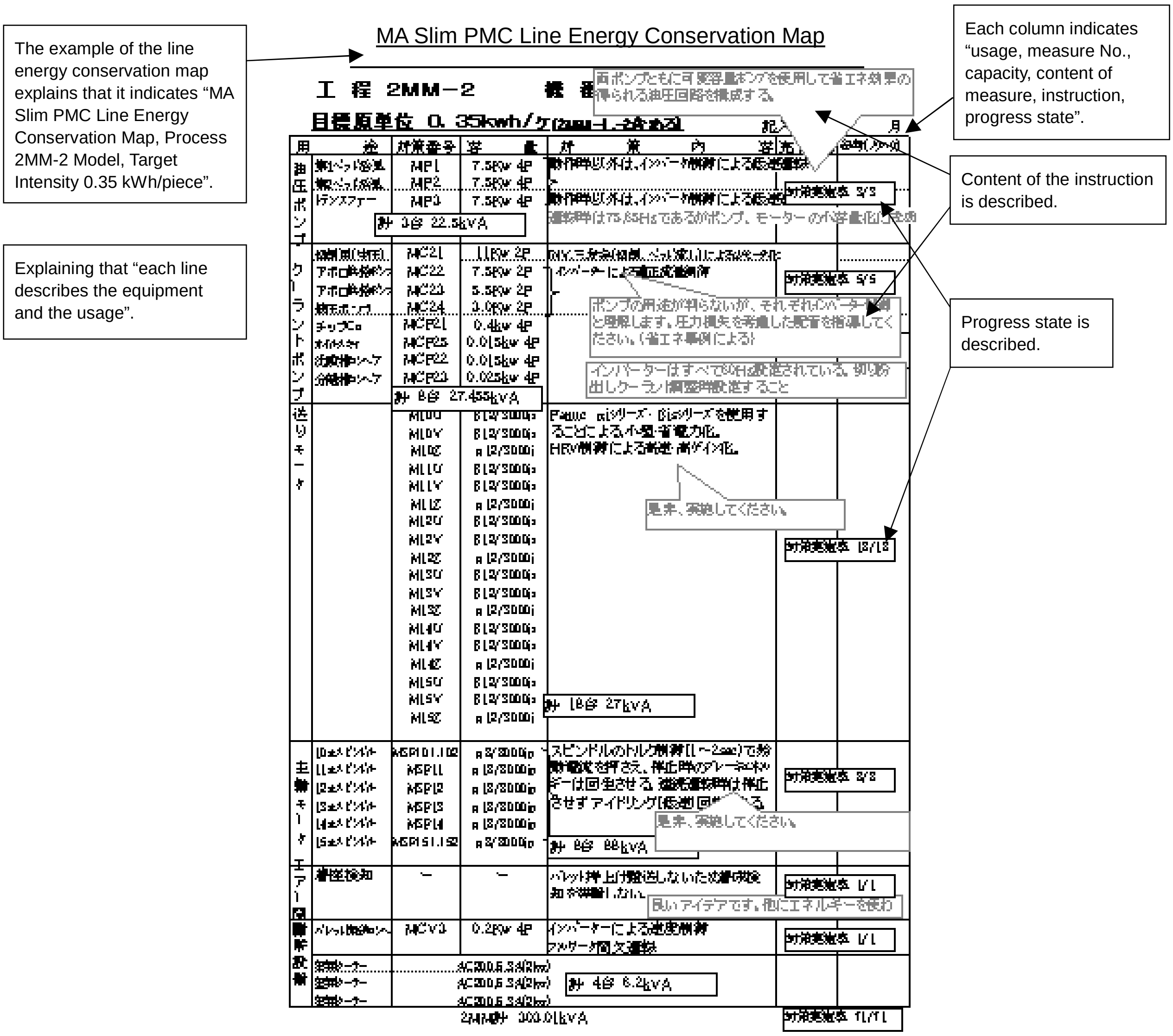

Fig. 7 Research Deployment Table

Analysis of power wave (Fig. 8)

This is the technical documents of the energy conservation items. For the spindle motor, we put the work processing diagram and the motor driving circuit showing the locations for measuring the electricity to the top and the electricity one cycle measurement graph and the control cycle diagram to the center. Meanwhile, we analyzed the energy and described the energy conservation items for minimizing the motor electricity to the bottom. We used this to ask the equipment manufacturers to adopt the energy conservation design into their designing and making of the equipment and to adjust and confirm the equipment. The power wave obtained by the measurement was used as energy conservation know-how.

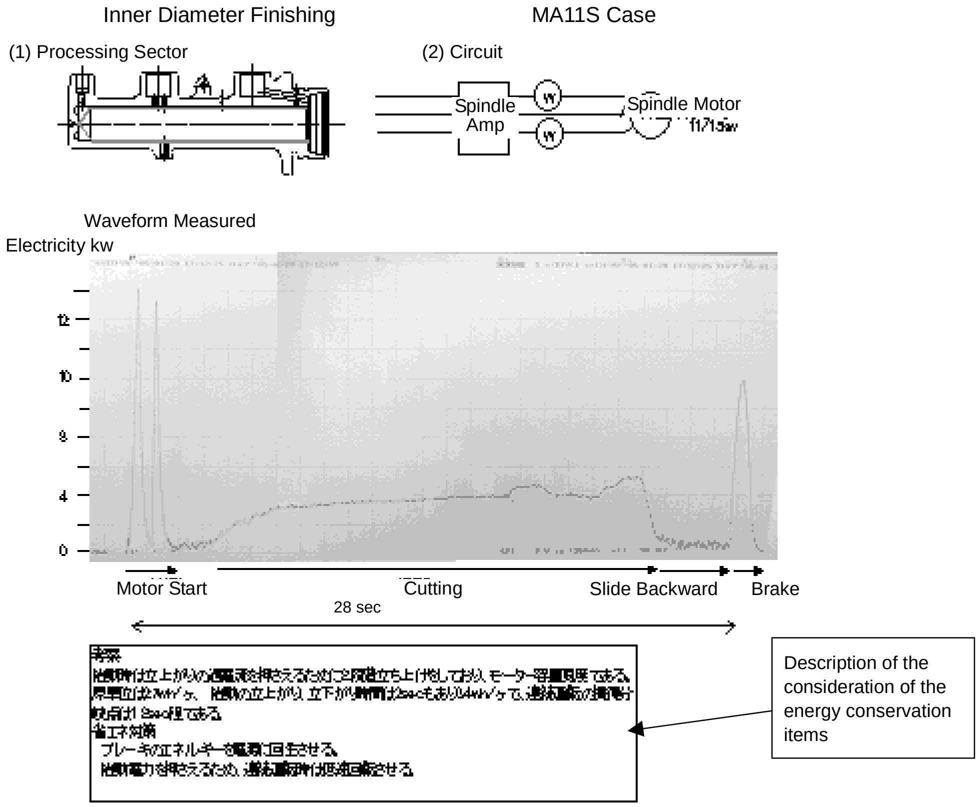

Fig. 8 Analysis of Electricity Wave Form

(2) Case Example of Measures for Spindle Motor

The power wave of the spindle motor indicates that the starting power is big in the similar processing equipment and the test processing of the newly developed cutting tool, as shown in Fig. 9. So we decided to select the energy conservation items taking this starting power as the key point of the energy conservation.

To select proper motor capacity, we set up the criteria which could deal with the high-speed processing, so we made the starting time to be 1-1.5 seconds, the starting electricity not to exceed twice the rated capacity, etc.

After determining the starting power and the not-cutting power:

[1] If the inertia revolution energy can be used, ON-OFF control by Mg sw (Fig. 10).

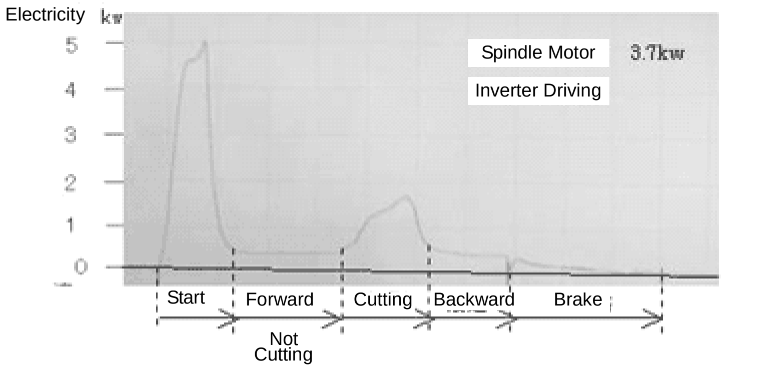

Fig. 9 Power Wave of Hole Processing

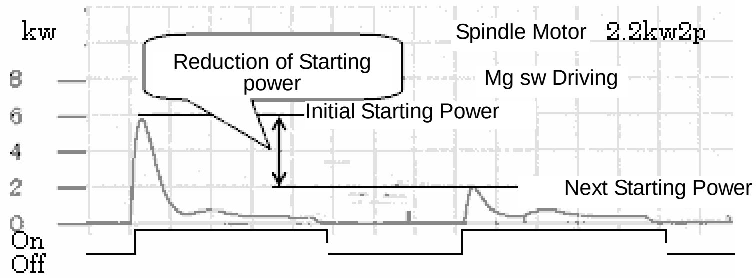

Fig. 10 Case Example of using Inertia Revolution

[2] Reduction of starting power by idling (continuous, low speed).

[3] The power regeneration system was added to the inverter unit (Fig. 11).

In any case, the starting power was cut by 50% creating energy conservation effect. The effect was 7 wh/unit in average, so the intensity was reduced by 7 wh x 33 units = 0.23 kwh/unit in the line as a whole.

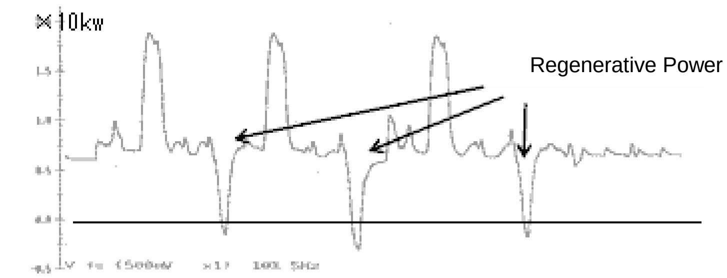

Fig. 11 Case Example of Regenerative Power

(3) Case Example of Measures for Hydraulic Pumps

When designing the system, we worked electrification (motor driven) which could be driven with the 1/5 the energy required for the hydraulic pumps and reduced the number of the hydraulic pumps from 15 units to 7 units.

For the hydraulic pumps, we measured the power wave of the variable displacement pumps (5.5kw) of the existing equipment and analyzed the difference between No.1 pump and No.2 pump (Fig. 12).

[1] The power volume of No.1 and No.2 pumps changes as the flow rate changes according to the number of the actuators and the frequency of the operation, so there is energy conservation effect of the variable displacement pump.

[2] Even if the pump capacity, setting pressure, etc are same, the base power is different. This difference is that of the pressure adjustment relief amount of the reducing valve and it is related to the hydraulic circuit of the reducing valve and the number installed.

Based on this result, we made the concept of the energy conservation items that could enhance the energy conservation function of the variable displacement pump as follows.

[1] To adopt variable displacement piston pumps with highly responsiveness to the high-speed transfer machine whose load changes frequently.

[2] To design a circuit of the pressure reduction valve which can reduce the base power. .

[3] The first inverter control increases the number of revolution for the high-speed operation to prevent the increasing capacity of pumps. (Fig. 13).

[4] The second inverter control decreases the number of revolution to stop the operation and holds the position instead of the pressure.

With the energy conservation items above, we implemented the measures.
The base power was lowered to 1/3 through these activities (Fig. 23).

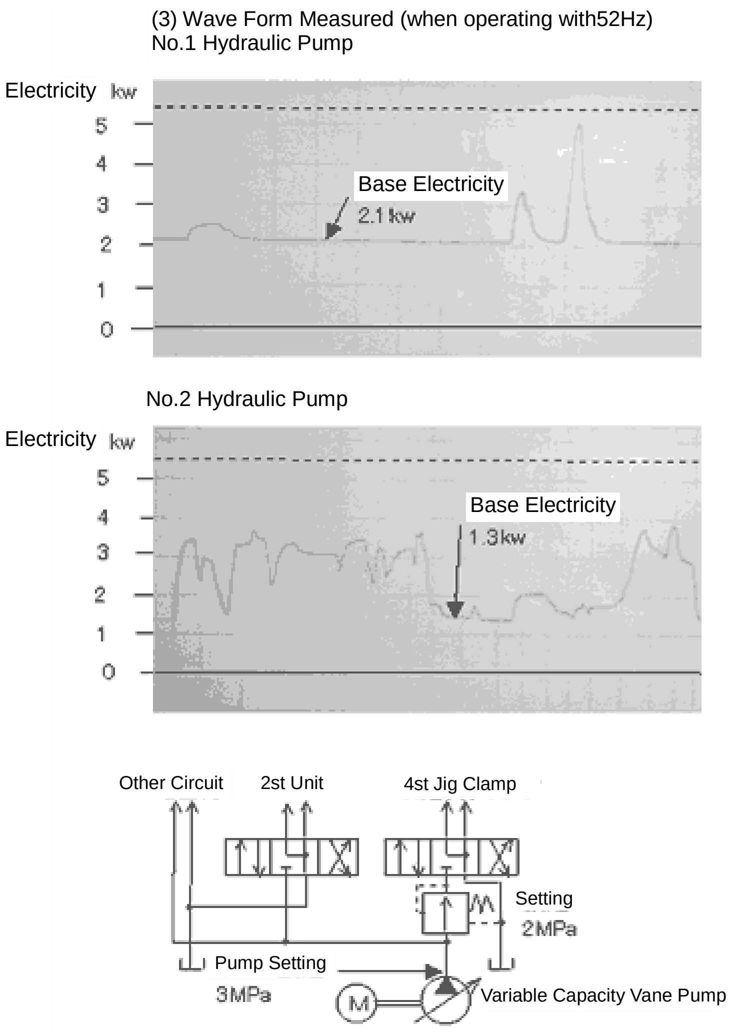

Fig. 12 Hydraulic Pressure Pump's Power Wave and Hydraulic Pressure Circuit

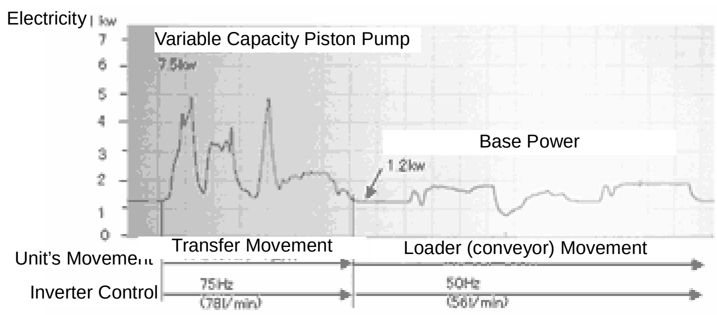

Fig. 13 Measures for Hydraulic Pumps

(4) Case Example of Measures for Coolant Pumps

When designing and making the equipment, we instructed the manufacturer to reduce the pressure loss of the coolant unit, to make the diameter of the tip nozzle smaller and to install the inverter, based on the AMMS "Aisin Seiki equipment standard specifications" and the energy conservation know-how. In this case example (Fig. 14), the pumps were integrated into the cutting part and the washing of the jig and bed by the switching of the 3-direction valve.

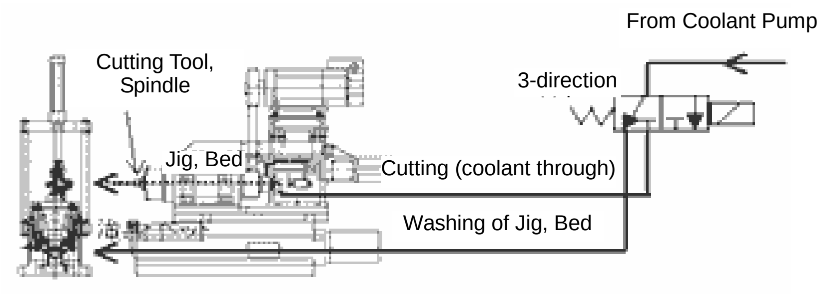

Fig. 14 Case Example of the Use of 3-direction Valve

It was found that there was difference of the power wave of the pump at the adjustment phase between the high-pressure pump and the medium pressure pump due to the pump's characteristics.

So we made the following energy conservation items according to the characteristics and made the electricity of the coolant 1/2 (Fig. 23).

[1] Adjustment method for the pressure and flow rate.

[2] Control method for the start and stop.

[3] Method for using the inverter.

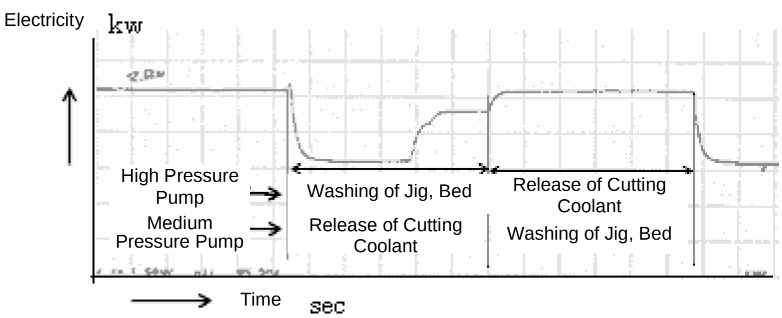

Fig. 15 Difference of Pump's Characteristics

(5) Case Example of Measures for Non-cutting Process

1) Development of high pressure water washing for removing burr

A great deal of energy had been used to remove burrs from the work's complicated inner diameter because it had to use the electrolytic deburring (energizing the electrolyte to dissolve burrs) and wash water bath with a heater in the later process. As a measure, we developed a system which blasts ultra high pressure water through an ultra small nozzle to remove the burrs and to wash the place. And we recovered the heat generated by the high pressure pump for the heater and eliminated the loss of the discharge pressure adjustment (relief) and unloading (drain) by setting the number of revolution through the inverter (energy conservation of 15kwh).

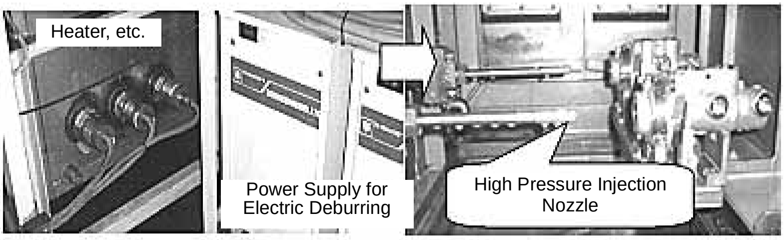

Fig. 16 Development of the System for Removing Burrs with High Pressure Water

2) Blower system for air blow

We studied the possibility to use the blower system whose energy conservation effect had been proved for the work draining process, and chose the Roots blower considering the air pressure and air amount necessary for the draining. To make the equipment, we designed a wider pipe (duct) to reduce the pressure loss and selected a chamber type for the air nozzle. Besides, we decided to set the air volume with the inverter to eliminate deceleration energy generated when stopping the intermittent operation (less energy consumption of 7kwh).

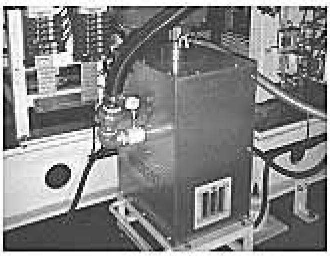

Fig. 17 Appearance of Roots Blower

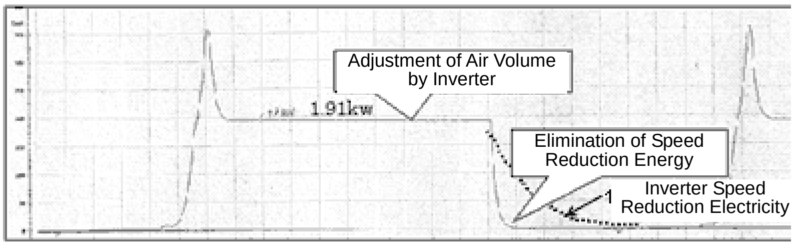

Fig. 18 Power Wave of Roots Blower

3) Abolition of coolant cooling

To process the inner diameter, we had been using the cooling system (chiller 2.2kw x 2 units) to cool the heat generated by the high pressure coolant. The tank was designed to save the space of the coolant tank and drastically reduce the cleaning work (the deposition of chips on the tank bottom was eliminated). And its width became narrower and the height became taller without reducing the tank capacity, further the circulation in the tank became better making the cooling capacity sufficient with the natural radiation. Thus, we could abolish the cutting coolant cooling system (elimination of 4kwh).

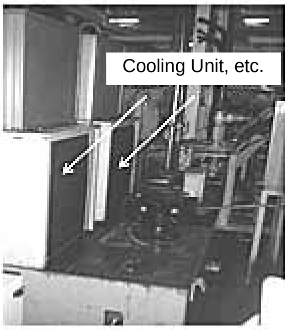

Fig. 19 Coolant Cooling System

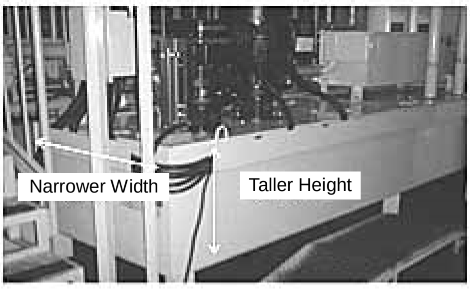

Fig. 20 Coolant Tank Newly Developed

(6) Providing Web Browsing of Energy Management System

Our target is the electricity intensity and this intensity changes as the line's operation rate changes. So we built an energy management system in which users of personal computers (including the line manager) can know the operation state of the line on the internet, including the number of products to be produced and the intensity which changes as time passes. To do so, we, involving all people concerned in the divisions of production engineering, maintenance and manufacturing, challenged the energy conservation activities.

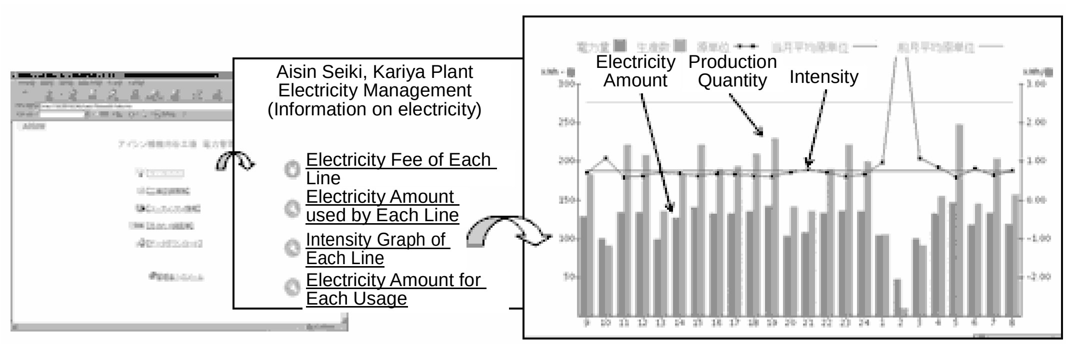

Fig. 21 Web Browsing System of Energy Management

5. Effects achieved after Implementing Measures

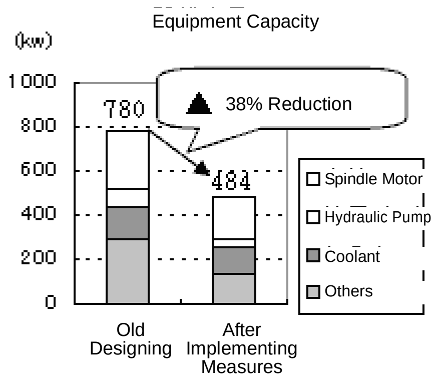

Fig. 22 Reduction of Equipment Capacity

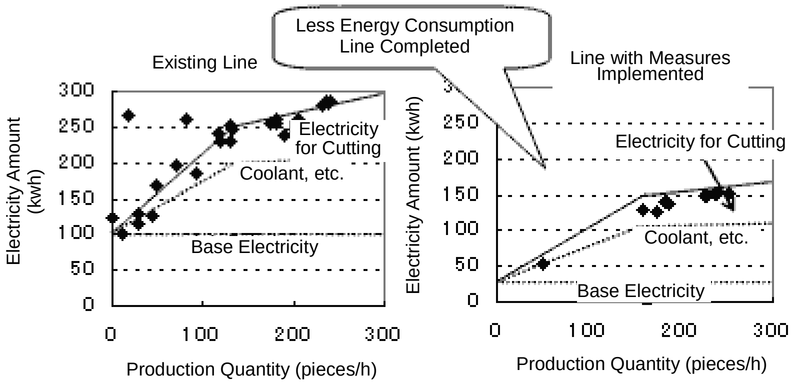

Fig. 23 Comparison of Energy Maps

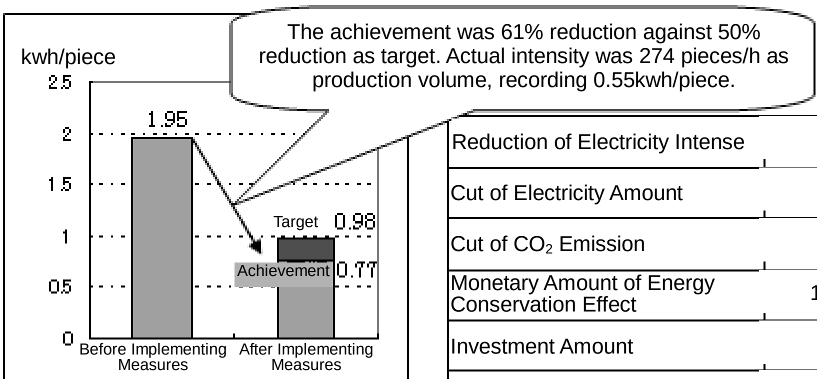

Fig. 24 Reduction of Electricity Intensity (As of March, 2006)

Reduction of Electricity Intense	1.18 kwh/piece
Cut of Electricity Amount	1416 Mwh/year
Cut of CO_2 Emission	540 t-CO_2/year
Monetary Amount of Energy Conservation Effect	16,992,000 yen/year
Investment Amount	8,000,000 yen
Year payback	0.56 year

6. Other Effects

[1] The space was saved by 1/6 compared with the use of the space before implementing measures.

[2] The use of the coolant was reduced by 1/2 (from 380L to 180L) compared with the use before implementing measures.

7. Summary

The energy conservation analysis asking “Where and for what purpose is the energy used?” based on the measurement of the motor’s power wave was to pursue the minimization of motors and, in doing so, we discovered a lot of energy conservation items. So we applied those items to make a new line for the cutting process which use many motors and we could achieve great energy conservation with low investment. We are confident that these energy conservation measures can be applied to other processing lines of this factory or to general processing lines in and out of this factory.

8. Future Plans

The activities of this case study were horizontally deployed to the transfer machine lines and machining lines newly made and those lines yielded more results than the results of this case. We will turn the energy conservation items we obtained in these activities into useful energy conservation know-how and systematize the activities we could adopt the energy conservation into the equipment designing. By doing so, we will further deploy our activities to new equipment and existing equipment as well.