Econo-Pilot HSP Energy-saving System for Heat Source Water Pumps

- Reducing Electricity Consumption and CO_2 Emission in the Pump -

Tetsushi Onishi [*1] *Hideki Miura* [*1] *Satoshi Kobayashi* [*2]

In the lineup of Econo-Pilot energy-saving system for water pumps, Yokogawa Electric Corporation has released Econo-Pilot HSP for heat source water pumps. This paper introduces its functions, energy-saving effect, and so on.

INTRODUCTION

As part of worldwide efforts to reduce greenhouse gases, several moves are seen in Japan. The revised Energy Conservation Act was enforced by the Japanese government (2009), the Tokyo Metropolitan Ordinance on Environmental Preservation was revised by the Tokyo metropolitan government (2010), and the domestic credit certification system is being introduced. Accordingly, industry and companies are now required not only to reduce greenhouse gases further, but also to report on the results of such efforts.

In the midst of such a situation, companies are seeking for energy-saving targets from both a short-term viewpoint and a medium- to long-term viewpoint. For the short term, the targets are those on individual equipment which prove the effectiveness immediately, while for the medium- to long-term, the targets include the visualization of consumed energy and the continual improvement of the system utilizing the visualization.

Figure 1 shows a pie chart of the energy consumed in office buildings by usage, quoted from "Saving Energy in Offices" by the Energy Conservation Center, Japan (ECCJ). [(1)] Energy consumed for heat sources and heat transportation account for nearly half of the total energy consumption, so there is high potential for saving energy in this area. Focusing on air-conditioner pumps, Yokogawa has developed and released Econo-Pilot. [(2)] Although Econo-Pilot is effective in saving energy, its application is limited because it is intended only for controlling secondary pumps. Yokogawa has therefore developed Econo-Pilot HSP (heat source water pumps) energy-saving system to enhance the applicability, including systems having no secondary pumps. Econo-Pilot HSP controls primary pumps and cooling water pumps for heat sources in water circulation systems such as central air-conditioning systems. When combined with Econo-Pilot, it can save energy throughout the water circulation system. The Econo-Pilot HSP can also be installed in not only buildings and houses, but also factories owing to its applicability to cooling water pumps for production.

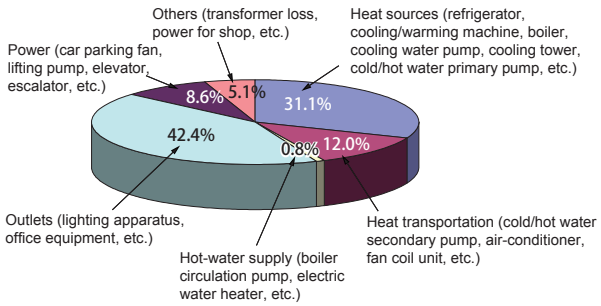

Figure 1 Energy Consumption in Office by Usage

This paper introduces Econo-Pilot HSP and its functions. Figure 2 shows an external view of Econo-Pilot HSP.

Figure 2 External View of Econo-Pilot HSP

TARGETING WATER CIRCULATION SYSTEMS AND CONTROL DEVICES

Figure 3 and 4 show a typical cold water circulation system. Usually, a hot water system requires neither a cooling

*1 Green Factory Solutions Business Center, Industrial Automation Business Headquarters
*2 Systems Business Center, Industrial Automation Business Headquarters

water pump nor a cooling tower. Although the Econo-Pilot HSP is applicable to both cold water and hot water systems, this paper focuses on cold water systems.

In the cold water systems, water is chilled at heat sources to be utilized at heat exchangers in production equipment or air-conditioners. The chilled water is pumped to heat exchangers, heated through heat exchanging and sent back to the heat sources. Then the water is again chilled and circulated. A secondary pump system uses a secondary pump for its circulation, and a primary pump system does not use it.

In most heat sources, the water is chilled by exchanging its heat with cooling water. The cooling water heated through heat exchanging is pumped to the cooling tower, and there it is cooled by heat exchanging with air and then returned to the heat sources. This thermal circulation and exchange is the characteristic of cold water systems.

The primary pump is used for circulating chilled water and the cooling water pump for cooling water. Econo-Pilot HSP controls both types of pumps.

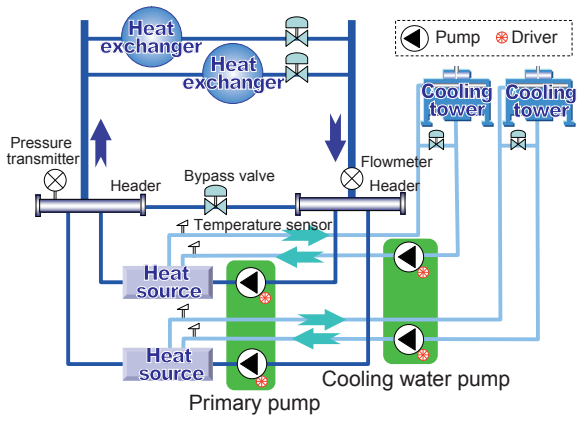

Figure 3 Primary Pump System

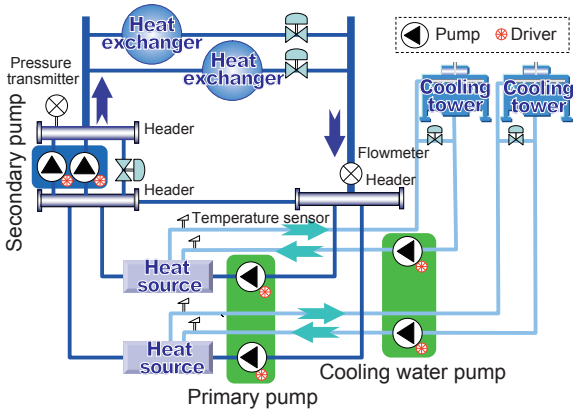

Figure 4 Secondary Pump System

The Econo-Pilot HSP is applicable to any type of heat sources, so it can provide optimal energy-saving solutions to various customers of such as factories, hospitals and general buildings. Although Econo-Pilot controls only secondary pumps, the Econo-Pilot HSP can provide energy-saving solutions to customers whose systems do not have a secondary pump.

Table 1 summarizes the control targets and control methods of Econo-Pilot HSP

Table 1 Control Targets and Control Methods of Econo-Pilot HSP

Water circulation system	Pump type	Control targets	Pipe friction predictive control	Heat source protection control	Optimal temperature control
Primary pump system	Primary pumps	✓	✓	✓	
	Cooling water pumps	✓		✓	✓
Secondary pump system	Primary pumps	✓		✓	
	Secondary pumps	Note	Note		
	Cooling water pumps	✓		✓	✓

Note: Control by Econo-Pilot

FEATURES OF ECONO-PILOT HSP

Since Econo-Pilot HSP is one of the Econo-Pilot series, it inherits well-established features of the series. In addition, it offers functions peculiar to controlling pumps around heat sources.

- High energy-saving effect
  Both the consumed electricity and CO_2 emissions can be greatly reduced by applying the control method considering required amount of water supply, which is based on the well-established pipe friction predictive control of Econo-Pilot.
- Simple installation
  Replacing existing equipment with advanced equipment to achieve energy-saving usually costs much and some downtime is inevitable. The Econo-Pilot HSP is configured to add energy-saving control units on existing equipment, so it can be installed with minimum downtime at low cost.
- Visualizing reduction results
  Econo-Pilot HSP saves both actual consumed electricity data during energy-saving operation and simulated data based on the actual operation for a long time. This enables to accurately identify the reduction of energy and CO_2 emissions. The reduction results can be easily recognized on general-purpose PCs over the network.
- Heat source protection function
  Unlike Econo-Pilot, controlling target devices are pumps around heat sources. When the flow of water drops below the required limit level, the heat source unit may stop or fail. To prevent this, it is necessary to set the minimum flow rate and limit the changing ratio of flow rate. The Econo-Pilot HSP is equipped with pump control functions to ensure stable operation of the heat source units, fulfilling these requirements.

ENERGY-SAVING PRINCIPLE AND CONTROL METHODS OF ECONO-PILOT HSP

This section describes the energy-saving principle of Econo-Pilot HSP and its control methods which are summarized in Table 1.

Energy-saving principle

The principle is that the electricity consumed by a pump is proportional to the cube of the number of revolutions of the motor. Since the number of revolutions is proportional to the flow rate, when the flow rate of water is 60% of the rating, the number of revolutions can be reduced to 60%. Thus, the power consumption is reduced to the cube of 60%, namely 21.6%; energy is saved by about 78%. The Econo-Pilot series makes full use of this principle to reduce the electricity consumed by the motor.

Pipe friction predictive control

Like Econo-Pilot, Econo-Pilot HSP applies pipe friction predictive control for the primary pump in a primary pump system.

Water flowing in a pipe suffers a pressure loss. This loss is proportional to the square of flow volume (flow rate). Efficient water circulation can be achieved by applying a slightly higher supply pressure than the pressure loss. The principle of pipe friction predictive control achieves energy-saving control by applying a slightly higher pressure than the pipe friction characteristic curve of pressure and flow rate which is determined by pump performance. Figure 5 shows comparison with conventional controls. The energy required for pumping water is represented by the area of a rectangle having a diagonal from the origin to an operating point (This value is equal to the product of the pressure, which is proportional to the square of the flow rate, and the flow rate, consequently proportional to the cube of the flow rate). Because the electricity consumed is proportional to the energy required, it is clear that this predictive control greatly saves electricity.

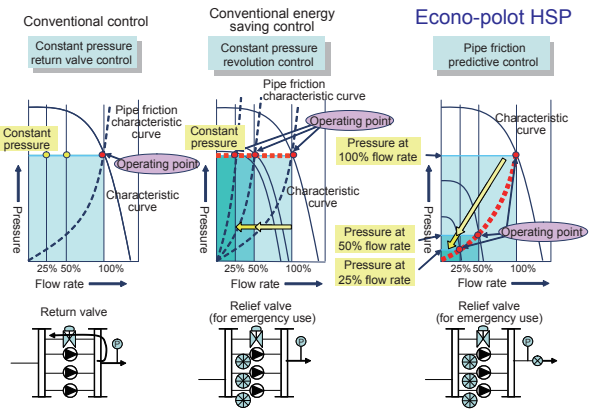

Figure 5 Comparison of Pipe Friction Predictive Control with Other Controls

For energy-saving around heat sources, control of the number of operating units has been conventionally applied. Preparing the required maximum number of heat sources and pumps, the number of units in operation is changed depending on the demand, which reduces the fuel cost for heat sources and the electricity cost for pumps. Figure 6 shows the power consumption under this control combined with other methods. The Econo-Pilot HSP applies this control, and reduces energy further and achieves more efficient energy conservation by combining the pump control.

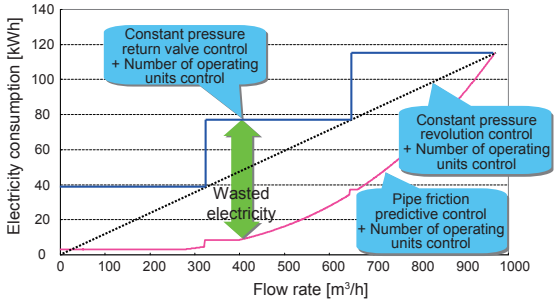

Figure 6 Electricity Consumption under Number of Operating Units Control and Other Methods

Cooling Water Pump Control

The cooling water pump is controlled to supply enough amount of water to the heat source for heat exchange with the warmed water. The Econo-Pilot HSP controls it with excellent responsiveness by considering not only the temperature of supply water but also the difference between that of supply water and return water so that the temperature of supply water from the heat source is kept constant.

Heat Source Protection Control

As described before, Econo-Pilot HSP performs control meeting with the minimum flow rate and the changing ratio restrictions for the heat source. In addition, it automatically switches the operating condition according to the water temperature. The Econo-Pilot HSP achieves more efficient energy conservation under the restrictions of the heat sources.

Even in operation, the control of pumps can be switched to the existing method by one switch operation without any suspension. The Econo-Pilot HSP is also equipped with a fail-safe function as standard which prevents any influence on the water circulation around the heat sources even if a problem arises with Econo-Pilot HSP itself.

ENERGY-SAVING EFFECT BY ECONO-PILOT HSP

Primary pumps and cooling water pumps, which are the targets to be controlled, must be operated above the minimum flow rate to protect the heat source. In most heat sources, the lower limit is ranging from 50% to 75%. Figure 7 shows the energy-saving effect in this case. When the pump is controlled at the lower limit of 50%, annual average flow rate will be about 60% considering actual operation. This means that electricity consumption is reduced by 78% theoretically.

Econo-Pilot HSP can achieve a significant energy-saving effect when the operating time is long. The longer the operating time is, the more amount of reduction (electricity and CO_2 emissions) is attained, increasing the investment effect. Similarly, the effect becomes larger as the electricity consumption of the pump increases.

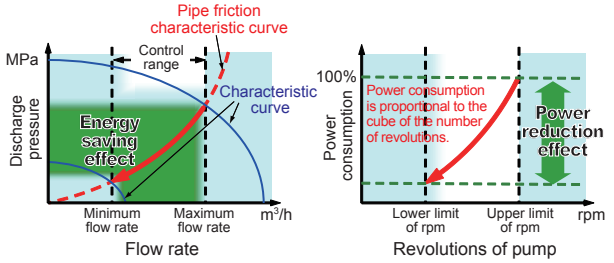

Figure 7 Energy-Saving Effect

SYSTEM CONFIGURATION AND FUNCTIONS OF ECONO-PILOT HSP

The field control node (FCN) of STARDOM is adopted as a core controller to perform the control described above. We have successfully developed it by utilizing the basic functions of STARDOM. Figure 8 shows the basic configuration of Econo-Pilot HSP and its connection with an upper system (CENTUM in this example). Figure 9 shows the signal connection.

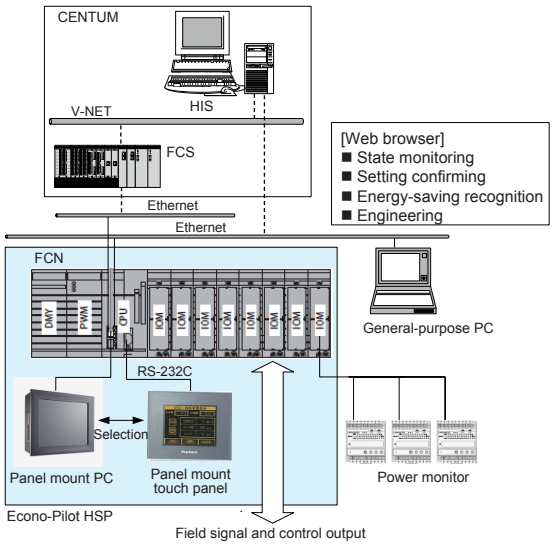

Figure 8 Basic Configuration of Econo-Pilot HSP and its Connection with an Upper System

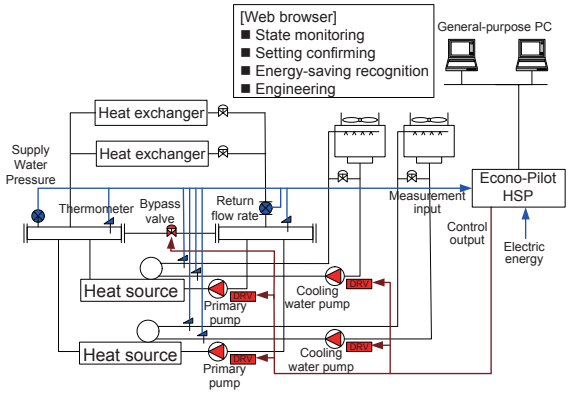

Figure 9 Signal Connection of Econo-Pilot HSP

1) Remote operation

The Web application function of STARDOM enables users to confirm the state, switch control methods, and recognize the reduced results via a web browser over the intranet, so they do not need to visit the site.

2) Reduced results collection

Various data collected by the logging function of STARDOM can be utilized to produce reports such as daily, monthly and annual reports. The reduced energy and CO_2 emission are simulated using the actual operating conditions. More accurate reduction values can be reported compared with the conventional estimation which is performed by comparing data before and after equipment upgrade and prone to be affected by the operating conditions.

3) On-site operation

Econo-Pilot HSP is equipped with a small touch panel as standard on the front surface of the cabinet, which enables on-site confirming conditions and operations and changing operations. A panel mounted PC is available for advanced operations.

4) Communication with upper systems

For communications with an upper system, Modbus communication protocol on the Ethernet is supported. This protocol allows control from the CENTUM and state/data communication with the CENTUM. Cooperation with the upper system allows advanced energy-saving control.

5) Installation

As shown in Figure 9, Econo-Pilot HSP acquires flow-rate, pressure and temperature information to control each pump. Installation can be performed easily by just adding the Econo-Pilot HSP, necessary devices and driver panels to the existing equipment.

CONCLUSION

Energy-saving helps achieve not only improving the management of a company by cost reduction but also solving environmental problems.

The Econo-Pilot HSP has enabled to offer customers total solutions for energy-saving in water circulation systems. We will continue to offer ways to reduce energy in factories for production as well as buildings by using the entire Econo-Pilot series including Econo-Pilot HSP and Econo-Pilot Comp, and hope to contribute customers to reduce costs and environmental burden.

REFERENCE

(1) The Energy Conservation Center, Japan, “Energy Saving in Office,” http://www.eccj.or.jp/office_bldg/index.html
(2) Tsuneji Sawai, Hiroshi Takahashi, Ken-ichi Inoue, “‘Econo-Pilot’ Energy-Saving System for Water Pumps,” Yokogawa Technical Report English Edition, No. 36, 2003, pp. 5-9
(3) Uichi Inoue, Air-conditioning Handbook, Maruzen Co., Ltd., 1994