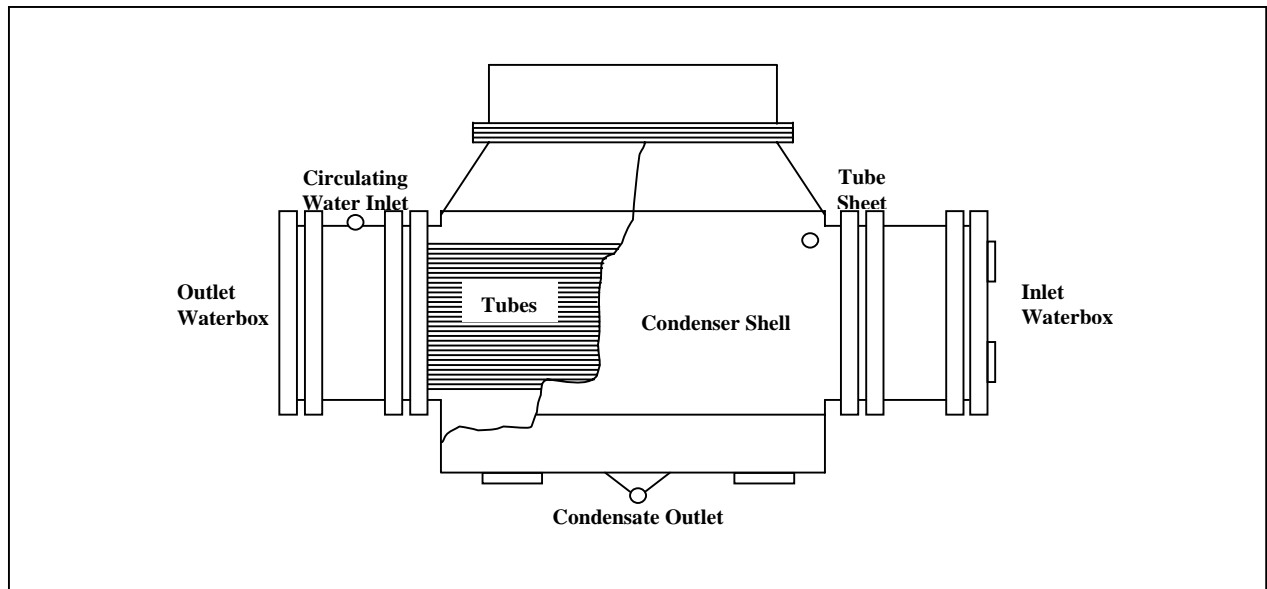


# HC900 Power Plant Condenser

Industry: Utility



## Problem

Cooling water for condensers is supplied via circulating water pumps at the intake structure. Water flows through an inlet pipe to the inlet waterbox, through the tube bundle into the outlet waterbox, and out through the discharge pipe. From outlet waterbox to discharge pipe, the flow experiences an abrupt contraction where flow separation and acceleration cause the static pressure of the fluid to decrease.

Because of high Reynolds numbers (i.e. turbulent flow), the pressure differential across the contraction is linearly proportional to the flowrate through the condenser. The constant of proportionality is dependent only on the geometry of the outlet waterbox contraction and the units chosen for flowrate and differential pressure. The relationship between flowrate and differential pressure is shown by equation 1:

$$Q = C \cdot \Delta H$$

Where:

Q is circulating water flowrate

C is flow coefficient (waterbox constant)

$\Delta H$  is pressure drop across outlet waterbox contraction

The pressure drop across the outlet waterbox can be measured using a differential transmitter. The flow coefficient is determined through a field calibration, whereby the circulating water flowrate is measured using the dye solution method and the result is plotted as a function of the square root of the observed  $\Delta H$ . A linear regression analysis is performed on the data points and the resulting slope is equal to the value of the flow coefficient.

Having determined the value of the flow coefficient, the circulating water flowrate may be continuously monitored by measuring the pressure drop across the outlet waterbox contraction only.

### FOULING MONITORING

A relationship between the circulating water flowrate and the pressure drop between the condenser inlet and outlet waterboxes exists that is similar to that of equation 1.

$$Q = C_T \cdot \Delta H_T$$

Where:

Q is circulating water flowrate

$C_T$  is head loss coefficient of tubesheet

$\Delta H_T$  is pressure drop across tubesheet

As the condenser tubes become hydraulically fouled, the head loss coefficient will decrease because it is a function of the cross sectional area of the tubes; a greater differential pressure across the tubesheet will be observed for the same flowrate.

Since the flowrates expressed in equations 1 and 2 are identical, equation 3 also applies:

$$C^2 (C_T^2) = \Delta H_T / \Delta H$$

Where  $\Delta H_T / \Delta H$  is hydraulic fouling ratio

Equation 3 shows that the hydraulic fouling ratio is inversely proportional to the head loss coefficient and is independent of the flow rate through the condenser (provided that the Reynolds number remains high). Thus, the hydraulic fouling ratio is a reliable indicator of the degree of fouling in the condenser tubes.

# HC900 Power Plant Condenser

## The HC900 Solution

The HC900 Hybrid Controller offers an ideal solution for condenser performance monitoring.

Circulating flowrates can be successfully monitored using differential pressure measurements. A linear relationship exists, and generally holds true for normal pump operation, between the condenser flowrate and the pressure drop across the outlet waterbox contraction. Pump performance can be monitored at any time by generating a curve of total head vs. circulating water flow, derived from data collected by the HC900.

Differential pressure taps at the inlet and outlet waterboxes are used to measure pressure drop across the outlet waterbox contraction. The HC900 provides continuous monitoring of these differential pressures and offers an easy means of calculating circulating water flowrate and hydraulic fouling, providing a successful monitoring tool for evaluating condenser performance.

## Benefit Summary

Circulating water flowrate and tube fouling are important parameters affecting the performance of condensers in power plants. The effective monitoring of these two parameters is vital in establishing maintenance schedules and in keeping heat rate losses to a minimum.

Condenser tube fouling may be categorized as follows:

- Thermal fouling
- Hydraulic fouling

Thermal fouling is the buildup of organic film on the inside surface of the tube, causing a reduction in the convective heat transfer coefficient between the tube wall and the cooling water.

Hydraulic fouling is the accumulation of debris on the inside surface of a tube or on the tubesheet entrance, causing an increase in the resistance to cooling water flow through the condenser.

Typically, hydraulic fouling becomes a problem before thermal fouling. In either case, condenser tube fouling makes itself evident by increased condenser back-pressure, affecting both turbine efficiency and heat rate.

Continuous monitoring of flowrate and tube fouling can be useful in determining the effectiveness of anti-fouling coatings applied to the circulating water pits and pipes.

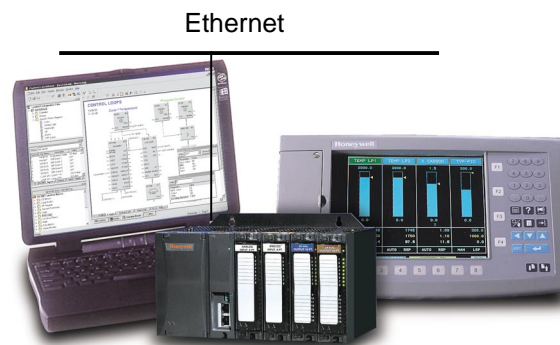
The HC900 provides the following benefits when used in condenser performance monitoring applications:

- Extensive set of advanced algorithms for maximum process performance

- Open Ethernet connectivity via Modbus/TCP protocol provides plant wide process access and data acquisition
- Extensive equipment diagnostic and monitoring to maximize process availability

## Implementation

**Overview** - The HC900 as shown in Figure 2 consists of a panel-mounted controller, available in 3 rack sizes along with remote I/O, connected to a dedicated Operator Interface (OI).



**Figure 2: HC900 Hybrid Controller, Model 1042 OI and Hybrid Control Designer Software**

All field signals terminate at the controller. The controller has universal analog inputs, analog outputs and a wide variety of digital input and output types. This controller will provide all the monitoring functions.

**Configuration** - The Hybrid Control Designer provides advanced configuration techniques allow a variety of strategies to be easily implemented. The run-mode configuration monitoring and editing capability allows these strategies to be tested and refined as process knowledge is gained.

**Monitoring** - The complete operation can be monitored and controlled from the easy to use, familiar displays of the Model 1042 OI.

**Data Storage** - The data storage feature of the OI can be used to log process information during the cycle to an integral floppy disk for a permanent record.

**Open Connectivity Over Ethernet** – Use popular HMI, data acquisition, OPC server, and HC900's HC Designer configuration software over an Ethernet LAN concurrently to access HC900 controllers.

**Peer to Peer Communications** - Any HC900 can support up to 8 peer controllers for exchange of analog or digital data over Ethernet.