Upgrading of Control of a Pump House with Ovation Discrete Control System

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ABSTRACT

This paper describes a method of upgradation of existing power plant water supply electrical control system with distributed control system (DCS) and controlling of a pump house with Ovation DCS OCR 400 CONTROLLER. By this upgradation we can improve a plant’s performance by making a better product with fewer resources and less waste. These pumps are generally controlled by relay logic or with Programmable Logic Control’s (PLC). As compared to relays and PLC’s, DCS is more advantageous in its operating and controlling applications. DCS plays a major role in process instrumentation. The big change in DCS over the past 20 years is its move from the hardware to the personal computer (PC) and standard local area network (LAN) technologies. With each advance in PC power, DCS have moved up in power. PC’s gave us speedy, responsive, multi-media, windowed operator interface (OPI), rational databases and spreadsheet software which enhance the ability of DCS to store and manipulate data. This paper also describes the controlling of raw water pump house with relays and DCS.

Keywords- Programmable Logic Control, Discrete Control System, Relay Logic, Ethernet.

INTRODUCTION

Generally in power plants, water cycle plays a major role. This water system is known as raw water system. Raw water system is separated in 3 ways, they are DM plant (de-mineralization plant), PT plant (portable water) and it is used for the condenser cooling and for ash disposal. DM plant water is used to generate steam and PT plant water is used as potable water i.e. for drinking and sanitary purposes. To control all these plants, pump houses are established like raw water pump house [1] system which is shown in the Fig1. To
control this pump houses early relay logic or PLC logics are used. When compared to these two logics, DCS is more advantageous. A communication is established between the two DCS systems which are located at control room and raw water pump house. The DCS used in raw water pump house system is Ovation OCR 400 controller.

**Fig. 1 Raw Water Pump House System**

### NECESSITY OF UPGRADING WITH DCS

The various potential benefits for upgrading existing plant electrical and control systems [2] are manpower savings, production cost savings and directly measurable operating and maintenance cost savings. The upgrading of power & drive systems, and control instrumentation systems are necessary as product quality can be easily increased. The other intangible benefits for upgrading a plant raw water supply electrical system are:

a. **To Improve Efficiency:**
   The efficiency improvement [3] can be done by replacing fixed speed drives or eddy current coupling drives with variable frequency drives.

b. **To Reduce Maintenance:**
   The maintenance can be reduced by installing new equipment with less moving parts and wear components. The other maintenance items can be replaced with static and standard systems. The relay systems can also be replaced with PLCs to avoid repair costs, system down time and spare part costs.

c. **To Increase Capacity to Accommodate Plant Changes:**
   Most up gradation in power plants increase the capacity of the electrical system [4] or the capability of the control system to accommodate new processes or new products.
d. Reduce Deviation from Set Point Using Advanced Controls:
One of the major benefits of advanced process controls is to reduce the variation of the process variable from the desired control set point. A stable process variable results in better product quality and cost reductions from better operation of steam and power utilities and process chemistry.

CONTROLLING RAW WATER PUMP HOUSE WITH DCS:
Ovation is a Distributed Control System (DCS) [5] whose modular design permits to configure the process management system exactly as needed. The small installation includes as many as 254 intelligent modules which are referred to as drops. Each drop is a separate module that can perform various functions. Ovation uses commercially available hardware platforms, operating systems and open network technology. The oervation is so flexible that configuration of the system can be done easily. The following elements should be considered when the system is configured with ovation:

a. Redundant high-speed network:
It uses Fast Ethernet standards to send input and output data to all the stations and controllers which are connected to the network.

b. Workstations:
Solaris-based or Windows-based computers receive and send data in order to perform any operation which is needed to run a process. These workstations are typically connected to a switch, which is, in turn, connected to the network.

c. Controller:
It executes modulating and sequential control strategies and also interfaces with input and output modules. The controller is a drop containing Input/output modules which are attached to sensors on the actual plant equipment. These sensors measure the point values and then broadcast into the ovation network.

d. Hardware:
The equipment such as cabinets, cables, and grounding equipment should be taken into consideration.

e. Input/Output (I/O) modules:
These modules are interfaced with field signals such as temperature and pressure from the actual plant processes to the controller. Then the controller sends the information over the network to the workstations. In turn, this information is sent from the workstations to the controller, so that adjustments can be made, as needed, by the controller.

f. Software packages:
The workstations which perform the tasks are needed to be configured on Ovation system.
COMPONENTS OF AN OVATION SYSTEM:

Ovation is the control industry’s most reliable and responsive real-time plant monitoring and process control system. It uses commercially available hardware platforms, operating systems and network technology. The Ovation system consists of different workstations that are linked to each other through a high speed network. These workstations perform different functions and communicate the results of these functions by sending data throughout the entire network. Therefore, each station on the network is able to collect data and also to send data out when requested by other stations.

Ovation offers unique features to its users: They are

- Transmits real-time data
- Detects, reports, or bypasses system faults
- Provides redundancy for all critical functions

Ovation provides redundancy for the most important system element i.e. control. So, the flow of data throughout the system is not interrupted by any single component, cable or device failure. This redundancy helps to prevent possible work stoppage. The basic drops or functions used in an Ovation system are listed below and described briefly.

**a. Ovation network**

The ovation network connects the components of the ovation system so that all components can communicate quickly and easily with each other. The ovation network is based on the standard fast Ethernet protocol and it is implemented in a robust, fail-safe, open design. This design provides easy and direct connection of third-party devices such as printers, wide area networks, local area networks, Allen Bradley PLC’s and other similar equipment that use Ethernet communications.

**b. Ovation database**

The ovation database consists of a master database that uses the relational database software package i.e. oracle. This database contains system configuration, control algorithm information, and the process point database. The ovation database provides the capability to integrate and organize the massive amounts of raw data in the system to create meaningful and valuable information. All programming tools and user interfaces store their data in the ovation database, and that information is transmitted to the control system. Application software and the control system can be easily accessed via third party i.e. through SQL (structured query language) tools. This means the ovation process control system data is open and accessible to all components of the ovation network that have permission to access the database data.

**c. Ovation input/output modules**

Ovation Input and Output (I/O) modules consist of modular, plug-in components that offer built-in fault tolerance and system diagnostics. Ovation I/O modules convert input signals and create output signals, which perform a multitude functions. Specialized I/O modules are also available for loop interfacing, serial linking, and pulse accumulating functions. These modules are typically located in ovation controller...
cabinets, but they can also be installed in remote cabinets that are up to 2,000 meters away from the controller.

d. Ovation Controller

The Ovation Controller is a process controller that is based on a commercially available operating system. The Controller executes modulating and sequential control strategies and supports the following functions:
- Originates and receives process points
- Adds, deletes, and modifies points online
- Provides alarming and command word processing for originated points
- Reads I/O modules and converts data to process points
- Reads process points and writes data into I/O modules
- Executes control algorithms
- Adds, deletes, and modifies control online

e. Ovation Operator Station

The ovation operator station drop provides communication with plant processes through the ovation network and it also monitors normal and abnormal plant conditions. A distributed database supports the operator station. This database is a subset of the information found in the master database and contains only those data items necessary to support operator station.

f. Developer Studio (Windows) or Engineering Station

The engineering drop provides tools that are used for the development, configuration, and maintenance of application and system software. These tools are known as ovation power tools. These power tools perform the following functions:
- It will define and configure the ovation system
- It will Create, modify, and delete points
- Defines the I/O modules used in an ovation system
- Stores the values from algorithms (typically, for special functions and ladder applications).
- It loads the control and originating point information into drops in an ovation system and also links the master database with other drops in the system.
- Creates point groups used in trends or graphics.
- It will create, modify, and delete security objects and definitions.
- It will track the changes made to the database.
- It will compare the external database with master database.
- Creates control logic which runs on the ovation controller.
- It will create and edit system process diagrams that display on the operator station.
Mainly in power plants Ovation OCR 400 Controller is used to control the raw water pumps. The controller in the plant contains cabinets which in turn contain input and output modules which are connected to field devices by wires. These modules monitor the changes in the device's condition. The ovation controller communicates with both the I/O’s. When detecting a change (input), the controller reads the change and tells the device (output) to perform an appropriate action as determined by the controller. This action is programmed into the controller by control sheets (also known as functional drawings) that are created in the ovation control builder. The control builder sheet consists of building blocks (algorithms) arranged in a logical pattern which defines what action to take place when certain events occur in a device. These algorithms are linked by signals; represent a simple two-step process or a complex process made up of many algorithms contained in the sheets. The ovation controller is based on the Intel Pentium processor and runs on a commercially available operating system. The controller uses an off-the-shelf interface to connect it to the ovation network. The controller executes modulating and sequential control strategies and supports the following functions:

- Originates and receives process points
- Adds, deletes, and modifies points on-line
- Provides alarming and command word processing for originated points
- Reads I/O modules and converts data to process points
- Reads process points and writes data to I/O modules
- Executes control algorithms
- Adds, deletes, and modifies control on-line

### The OCR400 Controller I/O Interface:

The ovation controller provides various types of interfaces to communicate with the system and other devices. These interfaces include:

- Ovation network
- Dedicated backup
- I/O devices

The Controller's processor module provides four network interface ports which are labelled as N1, N2, N3, and N4. These ports are located at the top of the module housing. Port N2 is typically used for single attached networking to the ovation network. Port N3 provides an additional Ethernet interface for dual attached networking. N4 is the default Ethernet interface for dedicated control synchronization. Port N1 is an additional Ethernet interface for other uses.
RESULTS:
The main logic involved in pump control is shown in the Fig 2. The input commands are start command and stop command, so whenever start command is given the pump opens and when stop command is released pump stops. If any internal trips are occurred then the alarm gives the signal to the system.

![Fig. 2 DCS Logic Diagram](image)

The below Table 1 shows the pump house cut sets of existing electrical system like loss of switchgear possibility, loss of main & standby transformers and loss of travelling screen motor after up gradation with OVATION DCS. By up gradation with DCS the annual failure percentage can be reduced with respect to the critical demand period.

Table-1: Pump house cut-sets of existing electrical system

<table>
<thead>
<tr>
<th>Cut Set</th>
<th>( \lambda )</th>
<th>Critical Demand period</th>
<th>Adjusted ( \lambda )</th>
<th>Annual Probability of Failure F1</th>
<th>30-year Probability of Failure F30</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Loss of switchgear PDP#401-1</td>
<td>0.01428</td>
<td>6</td>
<td>0.00714</td>
<td>1:140</td>
<td>1:5.2</td>
</tr>
<tr>
<td>2. Loss of main and standby transformers</td>
<td>2.0 E-6</td>
<td>6</td>
<td>1.0 E-6</td>
<td>1:1.0 E+6</td>
<td>1:33,333</td>
</tr>
<tr>
<td>3. Loss of traveling screen motor</td>
<td>0.0824</td>
<td>1</td>
<td>0.00687</td>
<td>1:146</td>
<td>1:5.4</td>
</tr>
</tbody>
</table>

Pumphouse Totals | 0.014 | 1:72 | 1:2.9
With OVATION DCS the annual risk of cost is reduced when compared to conventional system which is shown in below Table 2.

**Table-2:** Annual risk cost summary for pump house switch gear

<table>
<thead>
<tr>
<th>Description</th>
<th>Annual Probability of Failure</th>
<th>Single Loss Cost</th>
<th>Annual Risk Cost ARC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing installation</td>
<td>1:140</td>
<td>$100 million</td>
<td>$714,000</td>
</tr>
<tr>
<td>Upgrade Option #1</td>
<td>1:1.25 E+6</td>
<td>$100 million</td>
<td>$80</td>
</tr>
<tr>
<td>Upgrade Option #2</td>
<td>1:1470</td>
<td>$100 million</td>
<td>$68,000</td>
</tr>
</tbody>
</table>

**CONCLUSION:**

There are many positive results of the up gradation of pump house with DCS. They are:

a. The plant operation before the up gradation is “emergency response mode” and it changes to “anticipation and problem prevention mode” after the up gradation. The operators and process engineers will have a much better understanding of the process because they are different tools to explore the ways to improve the plant production.

b. After up gradation of the plant with DCS, operators no longer have to remember interlocking sequences when process starts as these are programmed in, and overall plant production also increases.

So, the raw water pump house control with OVATION DCS OCR 400 CONTROLLER is more advantageous as discussed above. So, the plant up gradation with DCS is beneficial in plant’s operations.

**REFERENCES**