Applying Artificial Intelligence to Modern Building Controls

Michael J. Birchak, PE, CPE
Managing Principal
The Industrial Solutions Group
This presentation’s learning objectives are to:

1. Share a proven concept that enhances the usefulness of existing DDC and PLC-based controls
2. Provide an understanding of how intelligent, knowledge based controls system help ensure systems consistently operate at design conditions
3. Inform how payout results from improved performance and lower energy, maintenance and operating costs
Agenda

• An Opportunity for ‘Greener’ Control Systems
• Status of Hardware and Software Development
• Adding Intelligent Control
• What’s Required
• A Case Study
• Benefits
• Summary
Current Systems Aren’t ‘Green’ Enough
Some Problems are Obvious
Other Opportunities Aren’t as Obvious

- Fouled Coils
- Fouled Heat Exchangers
- Damaged Impellers
- Inadequate Air Flow
Why don’t systems work as they were designed, constructed and commissioned?
Owners Have Limited Resources

- Quantity
- Ability
The key to making commissioning systemic is to make it easier for Owners to do the right thing.
The Germination of an Idea
Why isn’t our chilled water system delivering 42°F?
Intelligent Control allows equipment to communicate when it’s got a problem.
Possible root causes:

• Setpoint Problems
• Cross-flow/warm water mixing with cold
• System design issues
• Fouled Evaporator
• Fouled Condenser
• Other?
Defining Intelligent Control
Gas Mileage Checks
Examples of Utility System
‘Gas Mileage’ Checks

• At the current loading and outside air conditions, is my chiller efficiency (kW/Ton) matching design?
• Are my pumps currently operating at design efficiency?
• Are the heat transfer coefficients of each of my coils meeting design parameters?
• Are the chiller’s evaporators and condensers meeting design?
Operational/Reliability Checks

- Are critical instruments properly calibrated?
- Are air dampers bringing in the right amount of outside air?
- Are the variable speed drives operating at the proper speed?
- Are pumps operating on their ‘curves’?
- Is this bypass valve or damper ‘leaking’?
Intelligence Costs Some Money –

But Ignorance Costs More
Process Utility System Case Study: Evaporator System

• Multiple pumps
• Several heat exchangers
• 700 HP compressor
**Pump Algorithm**

**Input Data**
1. Fluid Flow through the pump
2. Amperage
3. Suction Pressure
4. Discharge Pressure
5. 700 HP compressor

**Output Data Available after logic checks**
1. Actual brake horsepower
2. Actual differential head
3. Actual efficiency

**Intelligence Provided:**
Compare outputs vs. design. Alert operating Team when there is a discrepancy.
Heat Exchanger Algorithm

**Input Data**
1. Hot and cold fluid flows
2. Temperatures in and out
3. Pressures in and out

**Output Data**
1. Actual U values
2. Fouling Factor

**Formula:**

\[
Q = U \times A \times \Delta T_{LM}
\]

Where:
- \(Q\) is the total heat transferred, BTUH
- \(U\) is the Overall Heat Transfer Coefficient, BTU/(hr*ft\(^2\)*°F)
- \(A\) is the heat transfer area, ft\(^2\)
- \(\Delta T_{LM}\) is the Log Mean Temperature Difference (see Figure 2), °F

**Intelligence Provided:**
1. Heat exchanger is functioning properly
2. Instruments are properly calibrated
Input Data
1. Actual Pressures
2. Actual Flows
3. Actual Amperage

Output Data
1. Variances in Pressures
2. Variances in Flows
3. Variances in Amperage

Intelligence Provided:
Is the compressor operating at design?
Making it Happen
Hardware Requirements

- Field instrumentation
- HMI (Human Machine Interface)
- Electronic pressure and temperature indicating transmitters
- Electronic watt (or at least amp) meters on major motors
Software Requirements

- Supervisory Control and Data Acquisition (SCADA) software systems
- Custom software to translate the algorithms for each component to use on-line data
Case Study: System Integration with SCADA

- Multiple Programmable Logic Controllers (PLC’s)
- Remote I-O configuration to reduce field wiring
- Networked using manufacturer’s communication protocol
- Workstation that facilitates full system monitoring and control
- Allows for un-attended, “lights-out” operation
- Communicating via phone and Internet to off site operators
Data Management

- Relatively slow sampling rate (5 seconds)
- Process data is stored as part of the manufacturer’s standard package
- Data is available for historical trending
- Operators periodically save historic data to CD’s.
• Key equipment performance parameters are password protected
• Real time data is shown adjacent to the respective equipment icon
• Operators can call up and trend data
• ‘Alert’ limits are placed on intelligent equipment performance parameters
• Transparency – ‘intelligent’ data is just as easy to manipulate as regular data.
Holding Down Costs

- Set a priority list – there may not be an adequate payout on smaller equipment
- Use existing instruments
  - Packaged controls
  - Electronic versus gauges
- Don’t duplicate instrumentation
- Perform calculations on some ‘plug-in’ numbers (if necessary)
Intelligent Control Benefits

- Systems deliver better quality
  - Design flows
  - Temperatures
  - Pressures
- Systems operate more reliably
  - Fewer unplanned outages
  - Fewer incidents of costly breakdown maintenance
- Systems use less energy
Commissioned Buildings Stay Commissioned

System Owners that are empowered with system intelligence and knowledge reduce maintenance, energy and operating costs.
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Thank You Very Much for your Participating in Today’s Presentation

Michael J. Birchak, PE, CPE
The Industrial Solutions Group
635 W. 7th Street, Suite 406
Cincinnati, OH 45203
Ph: 800-850-0384 * 513-651-4414 Cell: 513-218-8541
Fax: 513-723-2242
Email: mbirchak@yoursolutionscompany.com
Website: www.yoursolutionscompany.com