Optimization of Operation and Maintenance in Thermal Power Plants using PI System

Presented by Hiroshi Kuwahara
Ryota Iseki
Agenda

- Overview of Kansai Electric Power
- Challenges in Thermal Power Generation
- Optimization of Operation and Maintenance in Thermal Power Plants with IoT, Big Data and AI
- Introduction of PI System to Thermal Power Plants
- Application Examples
- Expansion Plan
- Conclusion
Overview of Kansai Electric Power

- Established in 1951
- Electricity Sales: 127,516 GW
- Installed Plant Capacity: 46 GW

Capacity (2016)

- Fossil Fuel: 52%
- Fossil: 19%
- Nuclear: 21%
- Hydro: 29%
- Renewable energy etc.: 10%

Kansai Region

Tokyo

Osaka

Coal Plant
Gas Plant
GTCC Plant
Oil Plant

Fossil
Nuclear
Hydro
Renewable energy etc.

Coal
LNG
Oil

Kansai’s Overseas Projects

- Total Output: 2,159 MW
  - Fossil: 1,788 MW
  - Hydro: 371 MW

Empire Power Station
GTCC, 635 MW
Rensselaer, NY, US
Power System Deregulation in Japan

Before
- 9 Electricity Power Companies dominated and controlled the market.

After
- Full liberalization of the electricity market in 2016
- Opening a new market - 200 billion $ market scale
Challenges in Thermal Power Generation

Optimization of Operation & Maintenance

Minimizing Forced Outage
Optimizing Maintenance Plan
Enhancing Plant Efficiency

To address these challenges, we need to make the best use of enormous amount of plant operating data.
Challenges in Thermal Power Generation

Number of Forced Outage

Utilization rate (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Forced Outage</th>
<th>Utilization Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>79</td>
<td></td>
</tr>
</tbody>
</table>
Challenges in Thermal Power Generation

Downtime (hours)

Coal Fired Power Plant
2010 - 2014

Preventive

Predictive

Long Tail

Boiler Tube
High voltage motor
Desulfurization system
Coal pulverizer
Main system piping
Sub system piping
Boiler Casing
Circulation water pump
Ash handling system
Others
Optimization of O&M in Thermal Power Plants with IoT, BD & AI

Optimization of Operation & Maintenance

- Minimizing Forced Outage
- Optimizing Maintenance Plan
- Enhancing Plant Performance

BD Analytics with AI + IoT devices

Data Management Infrastructure - PI System

Expertise | Operating Data | Knowledge & Experience
Introduction of PI System to Thermal Power Plants

2015

- Oil Plant
- Coal Plant
- GTCC Plant

2016

- Condensate Water
- Forced Draft Fan
- Feed Water
- Steam Turbine

- Deployed to 3 Power Plants / Coal, Oil & GTCC Plants
- Create 200 + surveillance screens

- Build the system in two months.
Introduction of PI System to Thermal Power Plants

Existing System

DCS
- Plant A
- Plant B
- Plant C

OPC, Modbus are not used for DCS

PI System

DB Server

Data Transfer Program was Installed

PI UFL Interface was Installed

Data

Plant A

Plant B

Plant C

It took only 2 months to install PI System in our existing plants.
Ensuring Expertise Transfer

We have …
- Operation Data
- Knowledge
- Know-how and etc.

OSIsoft has …
- PI System
  - ProcessBook
  - DataLink
  - Coresight

Enhancing Condition Monitoring
Example - Condition Monitoring on Heat Exchangers

Condensate Water System Surveillance Display

Know-how & Instruction to cope with tube failure

細管漏れの有無 細管漏れ「疑い有」時の点検ポイント
第1給水加熱器細管漏れ 無し
第2給水加熱器細管漏れ 無し
第1給水加熱器と第2給水加熱器のドレン水位開度を比較して、大きい方が細管漏れの疑いあり。
※両方共に細管漏洩の可能性もあるため、正常時の開度と比較することが重要です。
※第1給水加熱器へはグランド蒸気ドレンも流入するためグランド蒸気切替弁の状態を確認すること。
Example – Condition Monitoring on Coal Mill

- Setting pre-alarm based on past failure data for earlier anomaly detection.
- Adding a single pre alarm to existing system costs US$ 10,000 / in PI System US$ 0 !

Coal Fired Boiler Surveillance Display

Display for Pre-Alarms

<table>
<thead>
<tr>
<th>Aミル</th>
<th>Bミル</th>
</tr>
</thead>
<tbody>
<tr>
<td>ミル差圧</td>
<td>0.057 kPa</td>
</tr>
<tr>
<td>ミル電流</td>
<td>0.1 A</td>
</tr>
<tr>
<td>ミル振動</td>
<td>13 μm</td>
</tr>
<tr>
<td>ローラを荷物</td>
<td>0.051 mm</td>
</tr>
<tr>
<td>ローラ加圧</td>
<td>0.04 MPa</td>
</tr>
</tbody>
</table>

Coal Mill
Life Estimation of Crucial Equipment

**TBM**: Maintenance Intervals recommended by Manufacturers.

Past

**TBM > CBM**
- Now in the process of transition to CBM...

Present

**TBM < CBM**: Optimize Maintenance Management
- Extend equipment lifetime based on real-time condition monitoring & inspection records.

Future
Example - Life Estimation of Gas Turbine Inlet Air Filters

Gas Turbine Output

ST 输出
121.00 MW

GT 输出
225.00 MW

Intake Air Temp

Intake Air Filters

Filter Differential Press

Example - Life Estimation of Gas Turbine Inlet Air Filters

Gas Turbine Output

ST 输出
121.00 MW

GT 输出
225.00 MW

Intake Air Temp

Intake Air Filters

Filter Differential Press
### Example - Life Estimation on Components of Crucial Equipment

<table>
<thead>
<tr>
<th>Component</th>
<th>Monitoring Parameter</th>
<th>Remaining Lifetime</th>
<th>Overhaul Schedule</th>
<th>Lifetime Consumption Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing</td>
<td>Operating Time</td>
<td>3,600 h</td>
<td>Jul.2020</td>
<td>0% 50% 100%</td>
</tr>
<tr>
<td>Solenoid Valve Stem Nut</td>
<td>Number of Open &amp; Close</td>
<td>7,200 h</td>
<td>Jul.2020</td>
<td>0% 50% 100%</td>
</tr>
</tbody>
</table>

Optimize overhaul schedule of crucial equipment based on monitoring deteriorating condition of the mechanical weak point of them.
Further Projects

Performance Optimization

Anomaly Detection Tools

PI System Tools

PI System / Collect • Store • Visualize

Plant Computers

Process Instruments

IoT devices
Use of high-tech sensor devices
- Multi-Point sensor for Boiler Super Heater tubes

- Thermocouple
- Single-Point Measurement

- Multi-Point sensor
- Multi-Point Measurement enables
  - More accurate lifetime estimation
  - Earlier anomaly detection
Use of high-tech sensor devices
- Multi-Point sensor for Boiler Super Heater tubes

Boiler Tubes

Multi-Point Sensor

Temperature of Boiler Tube Panel Surface

Boiler Tube Panel Location
Further Projects

- Performance Optimization
- PI System Tools
- Anomaly Detection Tools

PI System / Collect • Store • Visualize

Plant Computers

Process Instruments

IoT devices
# Big Data Analytics for Anomaly Detection

<table>
<thead>
<tr>
<th>Technique</th>
<th>Schematic Diagram</th>
<th>Method / Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td><img src="image" alt="Classification Diagram" /></td>
<td>Clustering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adaptive Resonance Theory Theory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pattern Recognition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deep Learning</td>
</tr>
<tr>
<td>Regression</td>
<td><img src="image" alt="Regression Diagram" /></td>
<td>Multiple-regression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Invariant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self-regression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mahalanobis - Taguchi</td>
</tr>
</tbody>
</table>
With BD analytics tools, the anomaly was detected 6 days earlier than operators actually had noticed it.
Further Trial

To verify whether or not the tools can detect anomaly even while plant load changes or plant is in start-up & shut-down operation.
Further Projects

Performance Optimization

PI System Tools

Anomaly Detection Tools

PI System / Collect • Store • Visualize

Plant Computers

Process Instruments

IoT devices

© Copyright 2017 OSIsoft, LLC

OSIsoft USERS CONFERENCE 2017
Plant Operation Optimization System

- Reduction of excess air rate
- Combustion optimization with image recognition technology
- Steam temp optimization
- Soot blowers optimization

Efficiency Improvement >>> 0.1% abs. UP
Expansion Plan - PI System

<table>
<thead>
<tr>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Trial and Evaluation</td>
<td>Deployment to all PPs</td>
</tr>
<tr>
<td>Headquarters</td>
<td>Maizuru</td>
<td>Himeji No.2</td>
</tr>
<tr>
<td>Sakaikou</td>
<td>Nanko</td>
<td>Himeji No.1</td>
</tr>
<tr>
<td>Akoh</td>
<td>Gobo</td>
<td></td>
</tr>
</tbody>
</table>
Summary

COMPANY and GOAL
1) Kansai Electric Power
2) To be the foremost Power Company in Japan. Competing successfully in the power market.

CHALLENGE
To maximize optimization of O & M at our thermal power plants.

- Minimizing forced outages
- Optimizing maintenance plan and time,
- Making plant operations more efficient.

SOLUTION
To merge our knowledge and expertise in O & M with recent remarkable developments in digital technology.

- PI System
- IoT devices
- Big Data Analytics tools

RESULTS
We confirmed that it is possible to reduce O & M costs by using the PI System and its high compatibility with sensor devices and Big Data Analytics tools.

- Strengthening condition monitoring
- Switching from TBM to CBM
- Conducted the verification of Multi-point sensor, anomaly detection tools and operational improvement software.
Conclusion

✓ Optimize our Operations and Maintenance in an ongoing fashion and stay competitive with PI System.

✓ PI System is a crucial “bridge” that links large process data with our expertise, collective knowledge and digital technology.
Contact Information

Hiroshi Kuwahara
kuwahara.hiroshi@c2.kepco.co.jp
Thermal Power Division
The Kansai Electric Power Co., Inc.

Ryota Iseki
iseki.ryota@b5.kepco.co.jp
Thermal Power Division
The Kansai Electric Power Co., Inc.
Questions

Please wait for the **microphone** before asking your questions.

State your **name & company**

Please remember to...

Complete the Online Survey for this session

**Download the Conference App for OSIsoft Users Conference 2017**

- View the latest agenda and create your own
- Meet and connect with other attendees

search **OSISOFT** in the app store

Thank You

감사합니다

谢谢

Danke

Merci

Gracias

Spasibo

Obrigado

ありがとうございます