Reliability of IGCC Power Plants

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Overview

- SPS’s ORAP database
- Project goals and methodology
- Some preliminary findings
- Project schedule
- Conclusions
SYNGAS CONSULTANTS LTD.

• Specialists in syngas production from gasification and steam reforming

• Activities
  – Process integration
  – Project consultancy
  – Training seminars
  – Plant audits
Who is SPS?  What is ORAP?

• An Information Technology & Reliability Engineering Company — Since 1987

• Support the Electric Power & Industrial Process markets...

• Recognized leader through ORAP… the Most Comprehensive Global Database in Our Industry … Unbiased & Accurate
  ▪ Monitors Gas & Steam Turbine Plants . . . ISO 9001 Certified
  ▪ Database in place since 1976
  ▪ Over 2,000 Units Worldwide, Over 20,000 unit years of operating information available . . .
  ▪ Strong Influence on Industry Standards . . . ISO 3977 Standard

• Provide “Knowledge Based” Engineering Services & Software Products focused on:
  ▪ Data analysis and evaluation… Availability & Reliability
  ▪ Knowledge transfer… Benchmarking & “Best Practices”
  ▪ Remote Monitoring… Real-Time Data for Maintenance & Life Planning

Reliable Data for Effective Decision Support through ORAP
ORAP – Forced and Scheduled Outage

Simple Cycle Plant Forced Outage Factor and Scheduled Outage Factor
2000 - 2005
ORAP Data

- Aerodervatives: Forced Outage Factor 2.3%, Scheduled Outage Factor 1.2%
- Mature Class: Forced Outage Factor 4.3%, Scheduled Outage Factor 1.2%
- F Class: Forced Outage Factor 2.2%, Scheduled Outage Factor 2.2%
ORAP – Availability & Service Factor

Simple Cycle Plant Availability & Service Factor
2000 - 2005
ORAP Data

Aeroderivatives: 51.9% Service Factor, 94.0% Availability
Mature Class: 38.8% Service Factor, 94.5% Availability
F Class: 57.5% Service Factor, 91.0% Availability

Service Factor
Availability
### A TOTAL PLANT APPROACH

<table>
<thead>
<tr>
<th>PLANT AND UNIT</th>
<th>COMBINED CYCLE MULTI-SHAFT</th>
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<tbody>
<tr>
<td>MAJOR SYSTEM</td>
<td>GAS TURBINE</td>
</tr>
<tr>
<td>SYSTEM</td>
<td>COMPRESSOR</td>
</tr>
<tr>
<td>COMPONENT GROUP</td>
<td>ROTOR GAS PATH</td>
</tr>
<tr>
<td>COMPONENT</td>
<td>BLADES</td>
</tr>
</tbody>
</table>

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**Diagram Description**

- **Fuel**
- **Combustor**
- **Air**
- **GT Generator**
- **Compressor**
- **Turbine**
- **Stack**
- **Cond/Feedw.**
- **Steam Turbine**
- **GT Generator**
Extending ORAP to IGCC

- Add codes for gas production and treating units
- Enter data from 150 public domain events to validate structure
ORAP Input Screen

Event Summary

- Event: ASU well failures
- Begin Date: 01/01/99
- End Date: 01/01/00
- Duration: 312.5 hrs
- Status: Estimated

Narrative:
ASU well failures - In July of the year, the ASU caused a 13-day outage when three gas headers within the main exchanger cold box failed at seal welded connections. The root cause of the failure was determined to be insufficient weld penetration. The repair required the removal of over 10,000 cubic feet of PTFE insulation from the cold box and a subsequent silica to remove moisture and organize the system prior to startup. Realizing the well repair, mechanical support was added to the header to ensure future reliability. (Event # 116 / HTA 1959)

Code Tree (All Codes):

- Electrical (E)
- Air (A)
- Compressor (C)
- Control (K)
- Cryogenic Cold Box (ACB)
- Direct Contact Coolers (DCC)
- Distillation columns (N)
- Distillation columns HP - Oxygen (ADH)
- Distillation columns LP - Oxygen (ADL)
- Intercooling System (AC)
- Turbine (A/T)
- Gas phases (G)
- Acid gas removal unit (AGAR)
- Cooling Water (C)
- Gasification System (G)
- Auxiliary Cooling Water System (ACWS)
- Auxiliary Pump (ACP)
- Controls (C)
- Cooling Water (G)
- Distribution Control System (DCS)
- Enclosures (EC)
- Oxygen Feed (OGF)
- Recycle Fuel Feed (RFF)
- Recycle Vapor (RVR)
- Syngas Cooler (S)
- Station Equipment (E)
- Auxiliary Cooling Water System (ACWS)
- Auxiliary Steam Supply (ASS)
- Circulating Chemical Feed (CF)
- Coal Fuel Delivery (CFD)
- Coal Drier (CD)
- Condensed Cycle Steam Supply (CCS)
- Cranes (CRS)
- Cycle Chemical Feed (CCF)
- Cycle Makeup Water Treatment (CMW)
Where is IGCC now?

- Superior environmental performance
- Higher efficiency
- Installed cost
- Reliability
Current Reliability Performance

Plant A

- On stream: 75%
- Not required/despatched: 20%
- Planned outage: 5%
- Unplanned outage: 13%

Plant B

- On stream: 98.1%
- Not required/despatched: 1.1%
- Planned outage: 0.8%
- Unplanned outage: 0.0%

Legend:
- Green: On stream
- Orange: Not required/despatched
- Yellow: Planned outage
- Brown: Unplanned outage
Reliability - BP, Gelsenkirchen

Source: Laege, 2002
<table>
<thead>
<tr>
<th></th>
<th>Service Factor (%)</th>
<th>Capacity Factor (%)</th>
<th>Availability Factor (%)</th>
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<tr>
<td>Gas-fired boilers</td>
<td>40.0</td>
<td>23.1</td>
<td>87.5</td>
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<tr>
<td>Oil-fired boilers</td>
<td>41.1</td>
<td>27.5</td>
<td>86.5</td>
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<tr>
<td>Coal-fired boilers</td>
<td>83.2</td>
<td>71.9</td>
<td>87.6</td>
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<tr>
<td>Aero-derivatives</td>
<td>5.1</td>
<td>3.7</td>
<td>93.0</td>
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<td>Single Cycle GTs</td>
<td>4.3</td>
<td>3.8</td>
<td>93.1</td>
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<tr>
<td>Combined Cycle GTs</td>
<td>Not available</td>
<td>Not available</td>
<td>Not available</td>
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Source: DellaVilla, 2004
<table>
<thead>
<tr>
<th></th>
<th>Service Factor (%)</th>
<th>Availability (%)</th>
<th>Reliability (%)</th>
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<tbody>
<tr>
<td>Aeroderivative Utility</td>
<td>34.7</td>
<td>92.1</td>
<td>96.5</td>
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<tr>
<td>Non-Utility</td>
<td>55.3</td>
<td>94.3</td>
<td>97.9</td>
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<tr>
<td>E-Class Utility</td>
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<td>94.1</td>
<td>98.8</td>
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<tr>
<td>Non-Utility</td>
<td>62.0</td>
<td>95.0</td>
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<tr>
<td>F-Class Utility</td>
<td>60.6</td>
<td>90.1</td>
<td>97.6</td>
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<tr>
<td>Non-Utility</td>
<td>55.2</td>
<td>91.7</td>
<td>98.1</td>
</tr>
</tbody>
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Source: DellaVilla, 2004
Public domain literature
Project Goals

• Establish reliable, evidence-based expectation for IGCC availability
  – Using public domain reliability data
  – Using actual plant data
  – Using common definitions

• Update prediction models with “best-of-class” plant data

• Identify strengths and weaknesses
  – Inside/outside core gasifier unit
Potential Participating Plants

• 14 IGCCs
  – 8 solid feedstock
  – 6 liquid feedstock

• 11 chemical and refinery plants
  – 3 solid feedstock
  – 8 liquid feedstock
Include some chemical plants

- Increases sample for improved validation
- Provides representative data on
  - Oxygen supply
  - Gasification
  - Gas treatment
- Ammonia plants will supply data on CO₂ capture (and compression where integrated urea plant)
Project Schedule

- Data base structure and codes  July 2005
- Evaluate public domain data  End Aug 2005
- Preliminary findings  Oct 2005
  - Plant interviews  End Dec 2005
  - Detail evaluation & prediction model  June 2006
Some preliminary findings

- Air Separation Units
- Gasification Units
- Acid Gas Removal/ Sulfur Recovery Units
- Combined Cycle Units
- Overall Picture
Unplanned outages

Puertollano
Buggenum
Polk
Wabash
Negishi

% Planned + Unplanned outages

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Acid Gas Removal

Average of Four Plants

% Unplanned outages

- Sulfur Recovery Unit
- Acid Gas Removal
- COS Hydrolysis

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Power Block: Public Domain Data

Note: Wabash data estimated from “Syngas not required”
Data for some plants/years incomplete
Overall Outage Data
Average of four plants

% Unplanned outage

2001 2002 2003

CCU
AGR-SRU
Gasifier
ASU
Intermediate Conclusions

- IGCC availability is more than just a gasifier issue
- Attention to detail in “standard” auxiliary units can contribute substantially to IGCC reliability
- The introduction of advanced technology anywhere in the system has its attendant risks
- ORAP RAM tracking can help identify the areas for improvement
- The continued systematic evaluation of existing experience will contribute to that improvement
Thank you

Any questions?