Implications of Removing Start and Peak Load Multipliers from CC/CT Cost Development Equations

Presentation to Cost Development Subcommittee
April 1, 2013
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Impacts of Maintenance Multipliers

• Issue for both CC and CT units
• Thermal stresses affect component life
  – Fast temperature changes during startup/shutdown
  – High temperature fatigue during peak firing
  – Documented by OEMs
  – Direct impact on maintenance cycles
• Proposal at CDS to remove maintenance multipliers from formulas for cost-based schedules
  – Potential for major impact on unit operations.
Maintenance Issues Associated With Turbine Overfiring - GE

**Firing Temperatures**
Significant operation at peak load, because of the higher operating temperatures, will require more frequent maintenance and replacement of hot-gas-path components. For an MS7001EA turbine, each hour of operation at peak load firing temperature (+100°F/56°C) is the same, from a bucket parts life standpoint, as six hours of operation at base load.
Equivalent Operating Hours

The wear sustained by hot gas path items is a function of both time and cyclical processes. Time-related wear effects include:

- internal creep damage to the material as a result of mechanical loadings at high metal temperatures during base load and peak load operation
- creep deformation of hot gas path items
- erosion due to fine dust particles which enter the hot gas path despite filtration of the air and fuel
- oxidation at high metal temperatures when using "clean" fuels
- additional corrosion-induced removal of material caused by slightly contaminated fuels or severely contaminated heavy fuels
- additional mechanical loadings at elevated metal temperature and the destabilization of oxide coatings caused by water injection
- vibrations which promote friction wear.
Siemens Conclusion

Equivalent and actual operating hours are accrued at the same rate (base load factor $b_1 = 1$) as long as the $\psi_{OTC}$ value associated with base load is not exceeded. Shortening of the service life must be anticipated at higher $\psi_{OTC}$ values, because the turbine inlet temperature and thus the metal temperatures of hot gas path items increase. Consequently the number of operating hours between base and peak load $t_2$ is multiplied by the peak load factor $b_2=4$. As the equivalent thus accrue more rapidly than the actual operating hours, the calendar intervals between inspections and major inspections are correspondingly shorter.
Cyclic (Startup) Impacts

• GE

“Operating conditions other than the standard startup and shutdown sequence can potentially reduce the cyclic life of the hot gas path components and rotors, and, if present, will require more frequent maintenance and parts refurbishment and/or replacement.”

• Siemens

Each start involving measured and registered gas temperatures which are clearly elevated, indicating ignition of the main flames, is designated as Start \( (n_1) \). Automatic registration (major inspection meter) counts a start when the switching speed above ignition speed is exceeded (approx. 1/3 rated speed). The associated weighting factor for starts is \( a_1 = 10 \) (start factor). Measurement of operating time is also based on this speed switching point.
Potential Impacts

- PJM could call for multiple starts each day based on low start cost.

- PJM could expect CC and CT units to load to peak energy output during many hours if the energy cost for the peaking increment is close to the base load energy cost.
Simulation of Impact on Operations of Removing Peak Load Maintenance Factor

Simulation of CC operating levels based on size of maintenance cost adder.

Simulation based on gas costs and LMPs for 2012.

<table>
<thead>
<tr>
<th>Maintenance Cost</th>
<th>Hours Run (by Mode)</th>
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<tbody>
<tr>
<td></td>
<td>Min-Base</td>
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<tr>
<td>0 $/hr</td>
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<tr>
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<td>6,028</td>
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<tr>
<td>400 $/hr</td>
<td>6,383</td>
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</table>
Maintenance Interval Impacts

• Assume major hot section maintenance every 33,000 equivalent service hours
  – Current interval is once every five years
  – Interval with zero incremental maintenance for peaking would be once every 8 months

• Turbine shafts have an assumed life of 200,000 equivalent service hours – lifetime of plant
  – This interval could drop to four years (!) if most plant operation was at peak load.
  – Unit availability and overall lifetime would both be affected in negative ways.
Solution Paths

• Administrative
  – Ensure parameter limits allow only one start per day
  – Confirm that peaking increments can be listed as available to load at Max Emergency only

• Market Based
  – Include true maintenance interval and cost impacts of startup and operation at peak are included in cost-based formulas