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COMBINED CYCLE Journal
User Groups Gas Turbines HRSGs Controls

How to reduce the startup time of a legacy combined cycle

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Fast starting of combined cycles is a hot topic today because having that capability in certain markets enables power producers to maximize their revenue opportunities. The topic was on the 2012 and 2013 programs of the Combined Cycle Users Group and is on this year's agenda as well. It also was included in HRST Inc's workshop on heat-recovery steam generators (HRSG) at the 7F User Group's 2014 meeting last spring, and was on the 2014 Western Turbine program.

HRST's Ned Congdon, PE, incorporated fast starting into his Western Turbine presentation on flexible operation of HRSGs. Most of that material was repurposed by colleague Lester Stanley, PE, for the 7F workshop. Interestingly, Stanley presented the subject as "smart starts" rather than "fast starts," probably because the latter term depends on any given operator's definition of how fast "fast" really is, and the impact of the starting point—cold, warm, or hot condition. Plus, each plant's equipment/design/condition is unique and the time it takes to bring a combined cycle into service with acceptable life expenditure will vary from facility to facility.

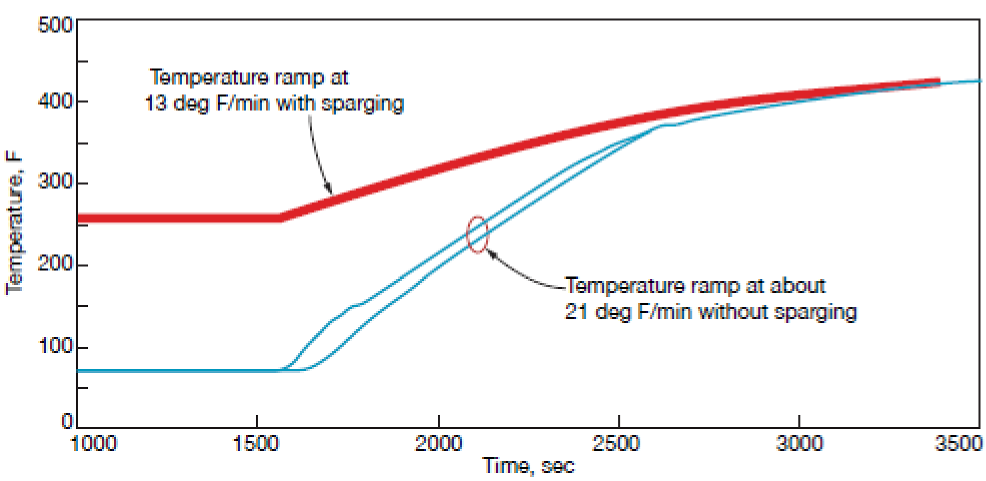
Congdon, who has been on the Western Turbine program for two years running, began his presentation by stating the goals of a fast-start program:

- Enable rapid loading of the gas turbines.
- Provide steam to the steam turbine at the proper flow rate and temperature.
- Avoid damage from thermal stress and overheating, and preserve reliability.
- Avoid corrosion.

Congdon then reviewed how legacy HRSGs in service may restrict or limit the plant startup rate and discussed possible upgrades to reduce the amount of time it takes to bring a combined cycle online. He discussed the damage that can be done by desuperheater overspray, the advantages of purging the gas side on shutdown rather than on startup, how to control steam drum level on startup, piping arrangements that match boiler HP steam temperature to turbine requirements, and how to reduce HP drum stress. This material is available in CCJ ONsite's coverage from the 7F meeting referenced above.

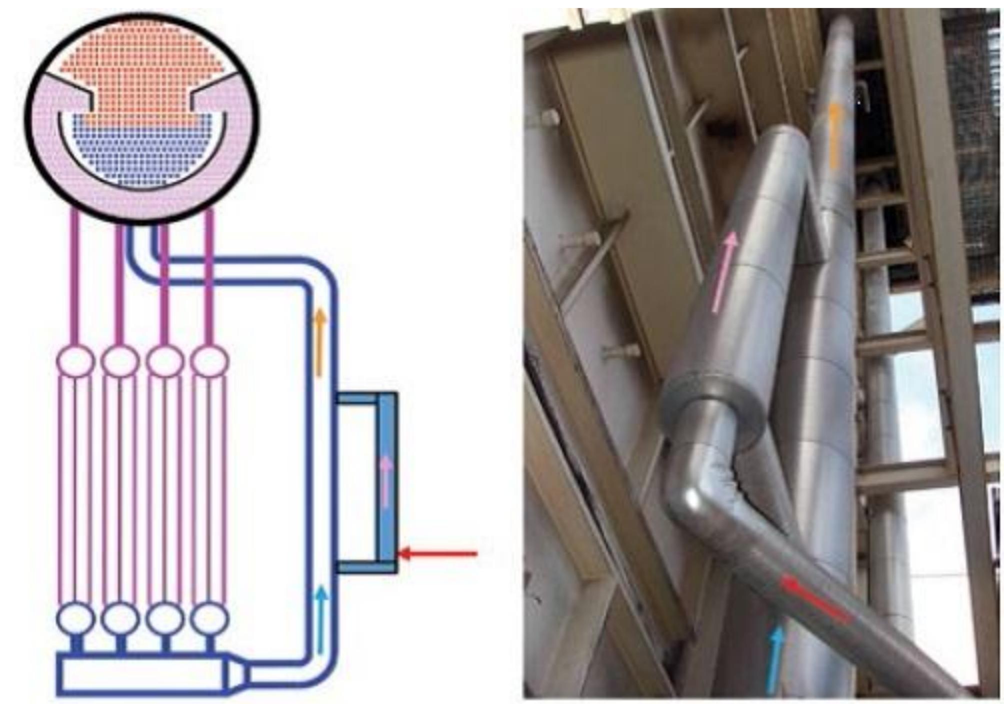
The Western Turbine presentation added information of value to users on the following three topics: steam sparging, HP-drum temperature ramp rate, and layup considerations. Here's a summary of what Congdon said:

- **Steam sparging.** One of the simplest ways to minimize the risk of drum cracking is by carefully controlling startup and shutdown temperature ramps with OEM guidelines. Cold starts can be particularly stressful, but steam sparging can mitigate those effects by keeping the drum warm and pressurized while the unit is offline (Fig 1). Congdon recommended that sparge steam be injected into a flowing fluid to prevent water hammer and suggested a downcomer location to promote reverse flow in that circuit. Some HRSG designs have a simple welded connection for this purpose, but HRST uses the arrangement shown in Fig 2 to better control the steam/water interface. Congdon advised against injecting sparge steam into the lower manifold or lower headers because the temperature of the water flowing to all tubes would not be the same (Fig 3). The result could be damaging thermal stresses.



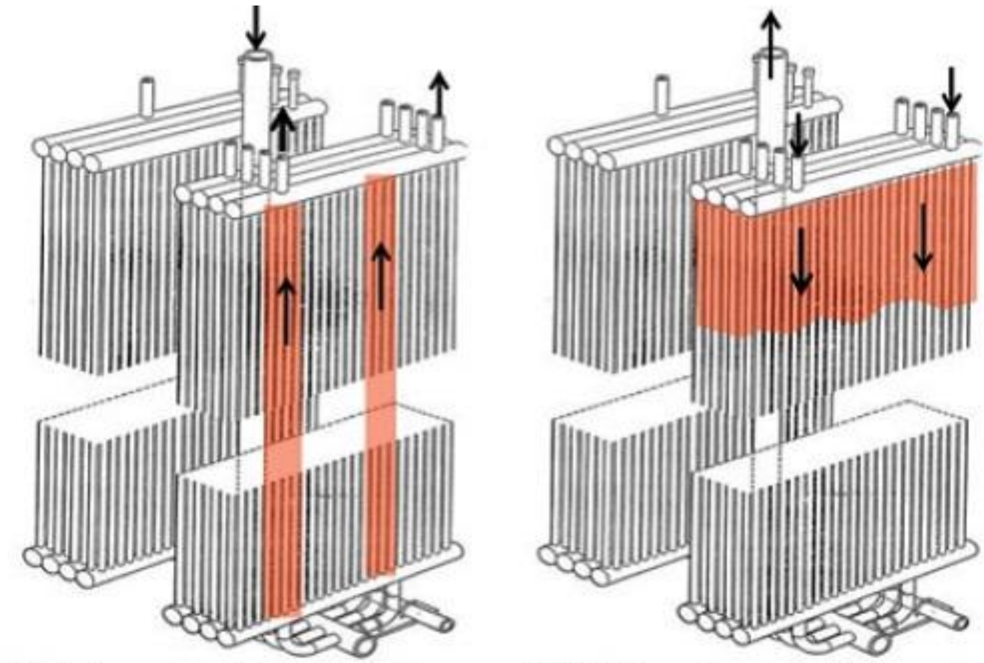
1. Sparge steam reduces thermal stress of thick-wall drum components by allowing a "softer" start

- **Control the HP-drum temperature ramp** rate independently of the gas-turbine startup rate by venting steam. In some cases this may be easier said than done, because additional vent and/or bypass capacity might be required. Recall that the volume flow of relatively low-pressure startup steam is greater than the volume rate of flow at design steam conditions. Thus physical changes to condenser and/or sky vent arrangements based on design steam conditions may be necessary. It is important to review condenser thermal performance and capacity for startup flows; vent valves as well, recognizing that most vents are designed for short-term full-load reject.



2. HRST Inc recommends injecting sparge steam into the downcomer. Its piping arrangement for this purpose is said to offer a controlled steam/water interface

- **Lay-up best practices.** Prior to shutdown, Congdon told the group, to (1) conduct several short intermittent blowdowns to eliminate solids; (2) raise the drum level to minimize nitrogen consumption; (3) eliminate leakage from vents, drains, and block valves to the degree possible; (4) maintain operating water chemistry—AVT-O, for example—during shutdown; (5) inject nitrogen near 0 psig. For prolonged wet lay-ups, provide the capability to circulate water to sample and maintain the desired chemistry.



3. Injecting sparge steam into the lower manifold (left) is not recommended because it can create non-uniform heating with resultant tube stress. Putting sparge steam into the downcomer is conducive to uniform tube-bank heating (right)

The boiler expert offered the following advice for minimizing the rate of cooling of pressure parts during short-term lay-ups:

- Install a stack damper, in particular, and insulate the breech/stack. They are your best defenses against heat loss. Keep in mind that low-emissivity stack paint, although a less-effective alternative than insulation, is much less expensive.
- Drums reach 0 psig at different times and, therefore, may require nitrogen additions at different times. A system that automatically injects nitrogen based on a drum pressure signal might be a worthwhile investment.

Long-term layups benefit from steam sparging. Keeping the HP drum warm reduces the thermal stress of thick components (such as the drum wall) as well as the time it takes for a cold start. Steam sparging also heats the gas side, lowers relative humidity, and helps avoid freeze-up. The potential risks of steam sparging are water hammer, diluted cycle chemistry, and thermal stresses if done incorrectly.

Proper gas-side layup is important because HRGSs can deteriorate more rapidly out of service than when they are operating. Take steps to avoid corrosion of gas-side components when the unit is shut down, thereby reducing the stack rust plume during the next startup and minimizing the increase in gas-turbine backpressure from tube fin fouling. Preventive steps include keeping rainwater and humidity out of the HRSG with good roof seals, installing a stack damper, and considering addition of a gas-side dehumidifier. During inspections, pay particular attention to material wear and tear near roof and floor pipe penetrations and tube fins.