GE Frame 5PA Upgrade Motivated by Forced Outage Also Works for 6B and 7B-EA

TTS Successfully Converts a Mark V Fuel Control to Electronic Valves

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A paper products plant in the Southeast was planning for a major spring 2017 inspection for their Frame 5 with preparations were well underway in October 2016 when suddenly, the unit tripped on high vibration, just as day shift arrived at the facility.

1. Two independent studies traced the root cause of the Row 2 bucket failure to stress corrosion cracking and fatigue

2. Collateral damage from the bucket liberation is in evidence at the trailing edges of the second-stage airfoils

An original Row 2 bucket failed, causing considerable downstream damage. Management decided to begin necessary repairs immediately and to conduct the machine's third major inspection at the same time.

The Frame 5 cogen unit had accumulated nearly 115,000 total fired hours and 1,500 starts since its commission in 1997. The 24.5-MW (on gas) MS5001PA engine was equipped with a DLN-1 combustion system and capable of dual-fuel firing. It was one of the most advanced Frame 5s in the fleet when it was first installed.

Since its commissioning, the 12 combustion, six hot-gas-path (HGP) and three major inspections typically revealed little beyond normal wear and tear. In fact, few significant modifications had been made to the basic engine in its two decades of service and plant personnel told the editors that the bucket failure was the first major issue suffered by the gas turbine in its lifetime.

Chris Mancini of Mechanical Dynamics & Analysis Ltd was informed of the unit trip and its likely damage shortly after it occurred. He and a superintendent were onsite within two days to assist in damage assessment.

Field service personnel arrived one day after Mancini and the following day, the day shift completed its site and safety orientation, organized tools and work areas and ran power and compressed-air lines as needed. The night shift received its site orientation, set up lighting and began disassembling the unit. The project proceeded at an aggressive pace from that point forward given the black-start cogen unit's importance to mill production.

MD&A was awarded a turnkey contract for repairs, the major inspections of the turbine and generator, as well as some additional projects including the removal of the liquid-fuel and trip-oil systems.

Because the mill never had success operating on liquid fuel, the most practical solution was to not burn liquid fuel. That decision, made years ago by plant management, was easy given the ready availability of quality gas.

However, oil infrastructure eventually ran afoul of the company's goal for continuous improvement. It took three shifts to remove liquid-fuel components to conduct a combustion inspection and three to reinstall it before engine restart.

The facility has been performing CIs at 8000-hr intervals so the cost, in terms of labor and outage schedule impact, added up quickly.

The plant engineer was guardedly optimistic about doubling that interval, as promised by the more robust coating applied by ACT Independent Turbo Services Inc, on hot-section parts in its Texan LaPorte shop during the outage. However, this doubling required approval by the facility's insurer and the coating's merit would need to be considered.

MD&A was credited with developing a plan to eliminate oil capability, including the fuel-nozzle mods, at less than half the cost estimated by an alternative supplier. It should also be noted that by eliminating the parasitic power associated with the liquid-fuel system, unit output increases by 280 kW.

Issues with fuel valves equipped with hydraulic actuators motivated the mill to replace that equipment with electrically actuated valves when the change to gas-only firing was made. With this upgrade, less gas is burned to produce a given amount of power than with hydraulic valves in the circuit.

Replacing the mechanical overspeed bolt and trip-oil system with an electronic overspeed trip enables operators to now verify trip functionality at 500 rpm without stressing the unit.

Converting from Dual Fuel to Gas-Only

The liquid fuel system (LFS) for this Frame 5 included the following subsystems: primary and secondary liquid fuel and purge, atomizing air, and water injection and purge. LFS decommissioning, a first step in the conversion of the unit to gas-only operation included deactivation or removal of all hardware associated with oil supply as well as of equipment in the subsystems noted.

During the forced outage, key components of the LFS were removed, but because of schedule constraints and the physical location of some hardware, it was not feasible to remove everything at that time. Others who have performed similar conversions told the editors it's important to disconnect/remove components that would consume power when inactive—such as the fuel pump and atomizing air compressor—and simply abandon in place piping that would have no adverse impact on gas-only operations.

The end covers and piping inside the turbine compartment were modified during the outage to reflect elimination of the LFS; Mark V controls software was reconfigured to accommodate the changes made.

Checklist of LFS Hardware Removed

- Accessory-gearbox oil-vapor educator; a desiccant breather cap was installed in its place.
- Atomizing-air booster compressor driven by the starting diesel, along with related piping and valves.
- Atomizing-air pre-cooler and its cooling-water supply piping. Source-air piping from the atomizing-air pre-cooler inside the turbine compartment also was removed.
- Extraction piping from the compressor to the atomizing- and purge-air subsystems.
- Gas-fuel purge system hardware.
- Primary liquid-fuel lines from the flow divider to the fuel nozzles.
- The accessory-gear-driven atomizing air compressor—together with its drive gear and associated bearings.
- The accessory-gear-driven fuel pump—together with the electric clutch, coupling, bypass valve, and gear and its bearings.
- Water-injection piping to the fuel nozzles.

Fuel Valve Upgrades

The mill's Frame 5 was equipped with a combined, hydraulically actuated gas stop speed/ratio (SRV) and control valve (GCV) and gas fuel splitter valve. Recall that the SRV and GCV are independent valves. Gas flows through the SRV to the GCV, which regulates the amount of fuel flowing to the ring manifold serving the 10 combustion chambers. The splitter valve serving on DLN machines divides gas flow between the primary and secondary fuel systems.

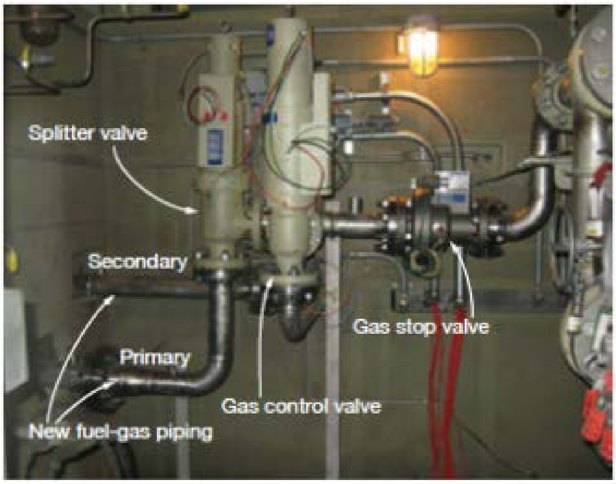
Turbine Technology Services Corp was retained to remove the liquid fuel system, as described above, and to replace the existing hydraulically actuated, 3-in. SRV/GCV and splitter valves with new electronic valves from Young & Franklin Inc. Existing gas supply strainers and valves were retained inside the compartment. A 3-in. stop valve was required in addition to electronic primary- and secondary-fuel control valves.

he company's Dave Simmons told the editors TTS has deep experience in this work, having removed liquid-fuel capability on about 50 GE Frame 5s through EAs over the years and retrofitted electronic valves from different suppliers on perhaps 20 machines.

Simmons said elimination of liquid-fuel capability on a non-DLN gas turbine is relatively easy, but experience counts when a DLN engine is involved. This project was unique: It was the first time that a Mark V-equipped DLN-1 machine was converted to electronic valves for fuel control—and it took only four weeks from initial request to startup.

TTS proved it could satisfy project goals by running tests on its reconfigured Mark V simulator. No empirical testing was involved. There were no surprises, Simmons said. The Y&F valves performed the way the company said they would.

He added that an increasing number of plants are investigating conversion to electronic valves and most projects can be justified based on opportunity costs. One of the first things to do, Simmons



3. A stop valve was required in addition to electronic primary- and secondary-fuel control valves

continued, is to determine the availability of physical space to accommodate the new equipment. This shouldn't be challenging for non-DLN machines, he said.

Some demolition and installation of the new valves and electrical conduit and wiring are key elements of the physical project. The editors were told that most wiring generally can be reused, excepting old non-DLN units. Otherwise, shielded cable is strongly recommended for use with electronic valves.

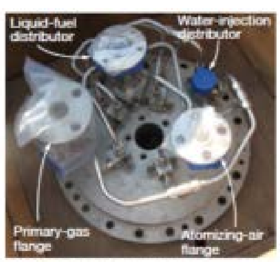
Finally, if considering electronic fuel valves for your plant, don't forget to audit the control system logic file to see if it can accommodate the switch from hydraulics to electric. There was no such issue on this project because of all the liquid-fuel infrastructure removed.

TTS modified the gas control software in the Mark V panel and HMI operator screens and then performed functional and operational tests of the new gas control system.

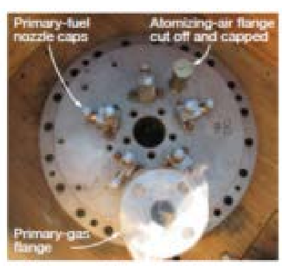
Other Activities Required to Complete the Project

- Disable piping to the gas control valve for the existing hydraulic- and trip-oil systems. Note that the mechanical overspeed trip was disabled when trip-oil supply to the gas control valve was terminated.
- Install an emergency-stop pushbutton inside the accessory compartment.
- Install two magnetic speed pickups and independently connect to the Mark V overspeed "hardware" trip.

4. Business side of an end cover showing the location of primary- and secondary-fuel nozzles



5. Original end cover with dual-fuel capability. Note that the secondary-fuel nozzle is not yet installed in the center hole



6. End cover after modification to gas fuel only. Here again the secondary-fuel nozzle is not yet installed in the center hole. Note, too, that only the primary-fuel flange remains

To convert the dual-fuel end covers to gas only, the liquid-fuel and water-injection distributors were removed. The tubing runs connecting the distributors to the corresponding five primary-fuel nozzles on each end cover also were removed and caps installed in their place at the openings created. Secondary-fuel nozzles attach to the center of each end cover—their liquid-fuel and water-injection connections were also removed and capped.

To learn more about TTS' dual fuel experience and capabilities for fuel conversions or upgrades, visit TurbineTech.com.