Replacement of damaged lower IGVs with rotor in place saves IMPA a million

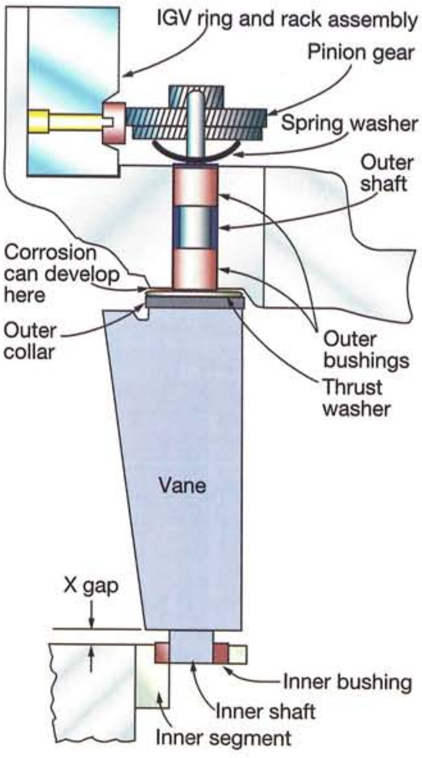
Proper operation of compressor inlet guide vanes (IGVs) is critical for reliable startups and for achieving maximum output from your gas turbine (GT). The importance of periodic inspection and operation cannot be overstated. Keep in mind that IGVs need occasional service: Any foreign material that gets by the trash screen can hit them; they can suffer ice-related damage under certain weather conditions, and water carryover into the bellmouth area from improperly located/designed air inlet louvers and/or poorly designed wet-type inlet-air cooling or wet-compression systems can attack critical parts.

The inexperienced plant operator may think that IGV maintenance is relatively easy. After all, if you crawl into the bellmouth you can touch all the vanes. But that's where "easy" ends. The upper-half IGVs are accessible once the inlet elbow and upper-half of the bellmouth are removed. However, the vanes in the lower half are difficult to service without removing the rotor—difficult, but not impossible for an experienced mechanical field service engineer.

There's plenty of incentive to accept the challenge of repairing or replacing vanes in the lower half of the row without removing the rotor. At least some experts say that step can add $250,000 to IGV work for a typical frame machine manufactured by GE Energy, Atlanta.

Scott Berry, plant manager for Indiana Municipal Power Agency's Anderson and Richmond peaking plants, confirmed this. He told attendees at the Frame 6 Users Group annual meeting last June that IMPA saved about $1-million on IGV overhauls for four Frame 6Bs (two at each plant) by keeping the rotors in the machines while the work was done. Berry is a member of the group's steering committee.

Berry said he and his staff—including Senior Operator Brian Markley—were preparing for the 2006 "peaking season" and while calibrating IGVs found that at least some vanes were not moving freely. Close inspection revealed that several vanes were hanging up at the top (inner ring) because the so-called "X gap" in Fig 1 had closed up; it should be about 9 mils. This condition was attributed to deterioration of the metal thrust washers installed in the IGVs when then engines were built 15 years ago. Specifically, rust pushed up the vane into the inner ring impairing its motion. The thrust washer is retained in a cup that can collect water from washing and fogging sprays thereby enabling the corrosion process.



1. Inlet guide vane simplified sketch shows corrosion is most likely where the thrust washer is located

2. Vanes 48 and 49 are in the 6 o'clock position and the ones most likely to have corroded thrust washers

Vanes 48 and 49 in each machine were replaced along with a few others (Fig 2) because of twisting damage sustained as the ring and rack assembly tried to turn blades wedged into the inner ring. Note that vanes 48 and 49 are in the 6 o'clock position and the ones most susceptible to water retention. Berry mentioned that he had difficulty finding a supplier willing to provide less than a full row of vanes. The old style metal thrust washers (Fig 3) were replaced by nonmetallic washers (Fig 4) on all vanes.

Bushings also were replaced. IMPA's machines did not have the old style steel bushings, which have a tendency to corrode and bind. But the better-performing Chemloy® bushings that were installed when the machines were built wear faster than steel and the utility decided to replace them while the IGVs were accessible.

Removing the IGVs

IMPA retained Pond and Lucier LLC (also known as PAL Engineering),

3. Metal thrust washers installed in older machines are likely to corrode over time

4. Nonmetallic replacement thrust washers help maintain the X gap dimension

Clifton Park, NY (www.pondlucier.com), to plan and provide technical advisory services for its IGV overhaul project. PAL had the experience to accomplish the work scope with the rotor in place. In a presentation before the 7EA User's Group in early October, Charlie Pond described the IMPA job. He said the first step was to remove the compressor inlet elbow and the upper half of the bellmouth.

However, because the bellmouths had never been removed previously on the utility's engines, each still had the hook fit provided by the OEM to properly align casings during initial factory assembly. This was ground out by mechanics so the upper half of the bellmouth could be lifted without picking the compressor case as well.

The upper half of the bellmouth was set down on cribbing arranged so mechanics had easy access to the IGVs. By contrast, access to IGVs installed in the the lower half of the bellmouth was through a space only about 2 in. wide. Pond said PAL has done such projects on the MS-7000 (very difficult), MS-6000 (extremely difficult), and MS-5000 (almost impossible).

To better illustrate the challenges of the job, Pond presented photos of the lower bellmouth from another project where the rotor had been removed (Fig 5). Each segment (arrow in photo) retains four IGVs. The closeup (Fig 6) shows there are two dowels, each staked in four places during assembly, and two screws holding a segment in place. Note that the dowels have a center threaded hole.

The project begins in earnest with removal of the rub ring to gain access to the dowel pins. They often are rusted in place and a generous soaking with PB Blaster helps. After carefully grinding away the staking marks, a jacking bolt assembly is installed on the pin closest to the horizontal joint on one side of the compressor and it is extracted.

Caution: Dowel pins must be pulled straight out to prevent the jacking bolt from breaking off. Should a bolt break, the rotor must be removed—a very costly consequence. Fig 7 shows the relative position of key parts.

Pins are removed working from the horizontal joints on each side toward the bottom centerline until all 16 dowels are extracted. After that, cap screws can be removed using an Allen wrench and companion cheater bar. Millwrights then should be able to slide the inner segments out of the compressor casing.

The dowel removal tool was fabricated onsite, but a local machine shop was needed to make the tool used to remove the bushings. Berry said that both tools were made under PAL's supervision. The two PAL technical advisors assigned to the IMPA project were Carlos Sanoja and Sal Paolucci; both were highly praised by Berry for their hands-on effort.

Reassembly of the IGVs may be different for the top half of the bellmouth than for the bottom half. To facilitate IGV removal in the future with rotor in place, so-called T-pin dowels are used in the bottom half of the bellmouth in place of the headless dowels originally installed. T pins look somewhat like golf tees (Fig 8) and are relatively easy to remove with a pry-bar type tool. However, to accommodate the protruding pins, a groove must be machined out of the lower-half rub ring (Figs 9, 10).

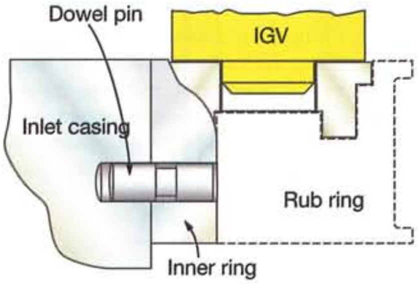
The dowel pins removed from the top half of the bellmouth can be reused, if desired. If all dowels are replaced with T pins, both halves of the rub ring must be machined to allow the space.

IGV refurbishment was done at both of IMPA's Anderson and Richmond facilities simultaneously because it was close to the time when peaking power would be required. Two mechanical contractors were hired to do the work. Millwright crews of five were required at each plant most days—including the PAL technical advisor and the labor foreman. Plant personnel also were involved when needed.

Berry budgeted 12 days to complete the work on each engine, from teardown through reassembly and testing. Teams worked six 10-hr days per week. The Richmond team came in right on estimate; the Anderson crew was ahead of schedule probably because the millwrights there had turbine experience. CCJ OH

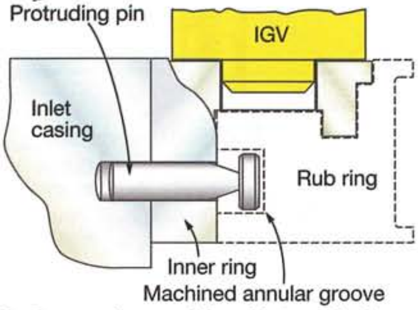
5. Inner ring segments are in evidence on lower half of bellmouth from unit where the shaft was removed

6. Each ring segment is retained by two staked dowels and two cap screws



7. IGV inner ring assembly illustrates position of components

8. T pins replace original dowels in the lower half of the bellmouth to facilitate access to guide vanes in future outages



9. Groove is machined into rub ring to accommodate the T pins

10. Rub-ring groove runs around the lower half of the bellmouth from horizontal joint to horizontal joint