How to change Inlet Guide Vanes . . .

. . . WITH THE ROTOR IN PLACE

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On GE models 5000, 6000 and 7000, it is now possible to change the variable Inlet Guide Vanes (IGV) with the rotor in place. The variable IGVs (Figure 1) serve two purposes: They prevent compressor stalls during startup, and modulate airflow to maximize exhaust temperature on units with waste heat boilers.

There are four common reasons for changing IGVs:

- Frozen or worn bushings
- Broken IGV shaft
- Upgrade to a High Flow IGV to increase MW
- Cracked IGV

For the past 35 years the only way to change the Inlet Guide Vanes was to perform a major overhaul and remove the rotor. With new techniques and special tools this is no longer necessary, which saves you about $300,000.

IGV troubles

There are 64 IGVs mounted on the inlet bellmouth. Each vane has a pinion gear on the end rotated by a rack gear (Figure 2). The rack gear is mounted on a control ring which is actuated by a large hydraulic actuator. In a few rare cases, a limit-torque motor is used instead of a hydraulic actuator.

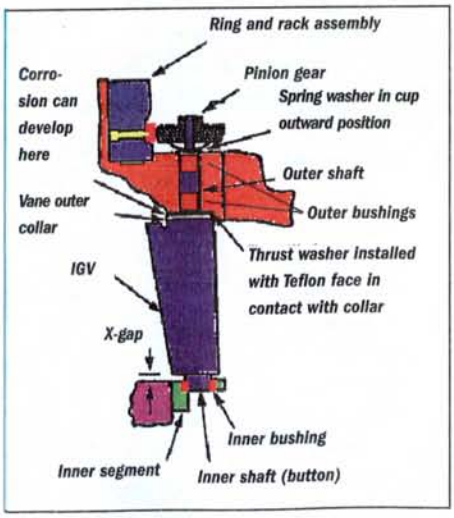
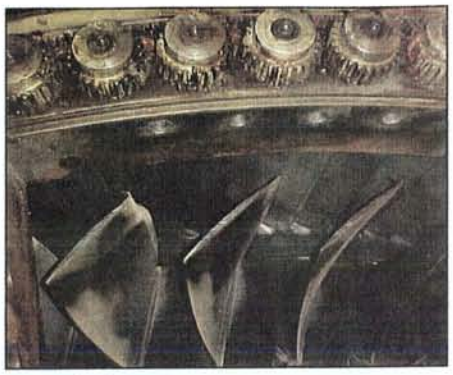
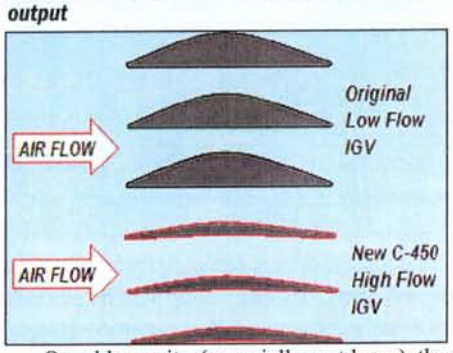
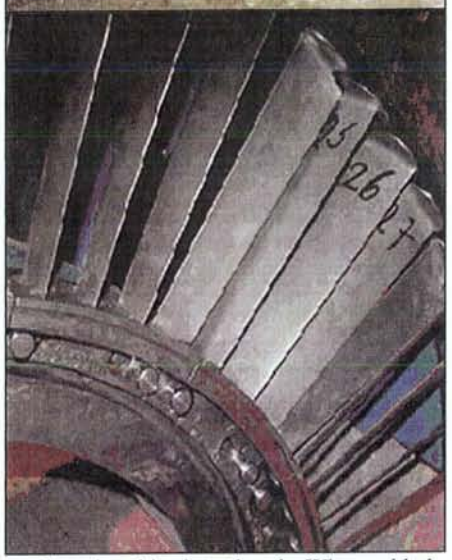


Figure 1: IGV construction sketch



Clockwise from top
Figure 2: IGVs, 1st stage blades and pinion gears engaging with rack
Figure 3: Rusted bushings and rack gears
Figure 4: Closed IGVs block air flow
Figure 5: C-450 IGVs can be made thinner, allowing more air flow and increasing power output





On older units (especially outdoors) the shaft can get seized in the bushing. Old-style bushings were steel and would corrode and bind to the shaft (Figure 3). New-style bushings are Teflon-coated. (Refer to GE Technical Information Letter #517 (TIL) for more information [1])

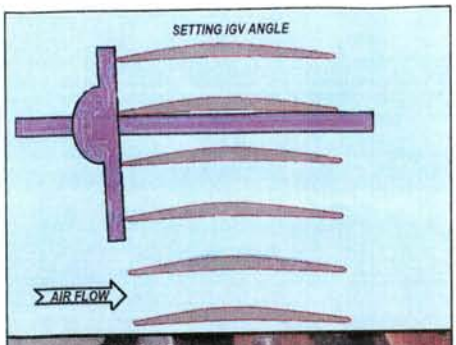
Bushings on the inner diameter are now made of Chemloy. With Chemloy — a material similar to Teflon — the IGV can never seize. However, Chemloy is very soft and wears rapidly (TIL #1068 instructs operators on how to check for excessive bushing wear).

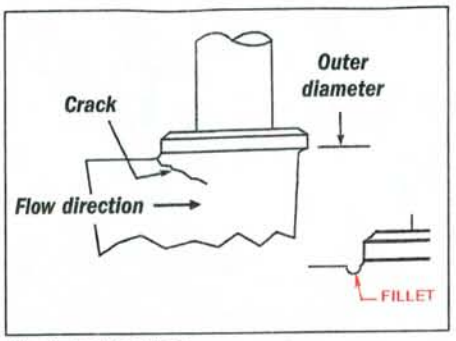
If shaft corrosion is severe, the IGV shaft will rust solidly to the case and no longer rotate. During the next startup the hydraulic actuator, which is extremely strong, can develop a pressure of 1,200 psi, which will break the shaft just below the pinion gear.

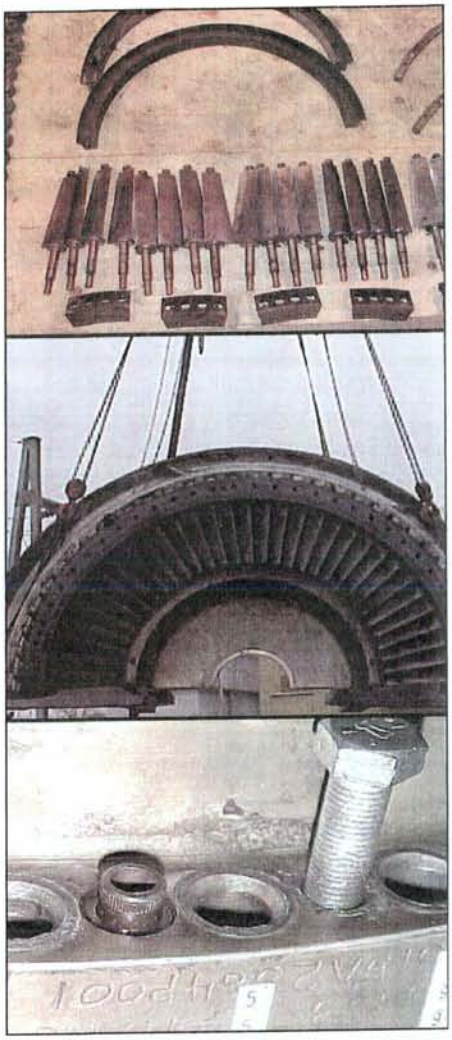
This is a hazardous situation because one IGV will be in the closed position during operation and will set up high cycle fatigue in the 1st stage rotor blade. When the 1st stage rotor blades are sucking in air they flex forward as they bite into the air. When a blade encounters a closed IGV, it relaxes for an instant because the incoming air is blocked (Figure 4). The high cycle fatigue (60 hz) will lead to a rotor blade failure at the blade root. Once the blade liberates, it causes catastrophic damage downstream.

The old-style IGVs were made of 403 or 316 Stainless Steel. The new-style ones are made of C-450. C-450 is a much stronger material and consequently can be made thinner, which in turn allows more airflow into the compressor (Figure 5). You will gain a 2% increase in flow. This translates to 2% more power output and is therefore an excellent upgrade for the money.

Older IGVs were susceptible to cracking where the airfoil met the shaft. This was a serious concern (TILs 511, 515, 522, 532). The crack can lead to a catastrophic IGV failure. Failures occurred at about 25,000-30,000 hours of operation. Crack inspection needs to be performed at 4,000-hour intervals. New-style IGVs incorporate a small fillet (Figure 6)







Clockwise from top
Figure 6: New-style IGVs have a small fillet that prevents crack formation
Figure 7: Parts in IGV assembly
Figure 8: Inlet bellmouth and IGVs
Figure 9: Jacking bolt modification added to bellmouth
Figure 10: IGVs and support blocks
Figure 11: Support block bolted to inlet bellmouth
Figure 12: Removing the lower half IGVs is difficult because the working space is only 2 inches
Figure 13: Proctractor used to set vane angle

to prevent crack formation.

Changing the IGVs is a difficult and repetitive task. The parts are numerous. There are 64 IGVs, 192 bushings, 192 washers, 64 pinion gears, 64 locking pins, 64 set screws, 16 support blocks, 4 rack gears, 2 pinion covers and 4 pointer parts. A total of 666 parts (Figure 7). No wonder it is a devil of a job.

To change the IGVs, you must first remove the inlet elbow, upper-half inlet plenum and the upper-half inlet bellmouth (Figure 8). The inlet bellmouth does not have jacking bolts. Therefore you will need to use wedges to split the horizontal joint. This is a good time to add jacking bolt holes (Figure 9).

After the inlet bellmouth is removed, the upper half IGVs can be changed. This is performed by removing the pinion gear and spring washer at the outer diameter.

Working in small space

The support block needs to be removed on the inner diameter (Figure 10). Each support block has two cap screws and two dowel pins that are staked (Figure 11).

Removing all of this hardware from the upper half is not too difficult. Performing this in the lower half with the rotor in place is extremely difficult because the work space is only 2 inches wide (Figure 12). Removing the cap screws and pulling out the staked dowel pins are difficult jobs.

An allen wrench with a cheater bar is used to remove the cap screws. To remove the dowel pins you must first grind away the staking with a small Dremmel grinder. A custom-made dowel puller is used to remove the dowel pins. After the dowels and cap screws are removed the support block slides off the end of the IGVs.

Once all of the hardware is removed, reassembly is easier. On units with a rub ring the dowel pins can be replaced with Tee-headed pins for easier removal in the future. This is also an excellent time to inspect the #1 bearing, correct oil leaks and fix any 1st stage rotor blades that are damaged.

After all of the hardware is reassembled, the IGV vane angle needs to be set (Figure 13). Increasing the Full Open position to 87° versus 83° will increase airflow and add up to 2 MW. Due to the complexity of the operation it is not advisable to try this without an expert. [2]

Footnotes

[1] Technical Information Letters should be on file at the power plant. GE mails these to power plant managers. Pond And Lucier (www.pondlucier.com) can also supply copies.

[2] PAL Engineering has performed this procedure on more than half a dozen units of all sizes.

Authors

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