Back to Main Menu

Breakfast Minutes September 27, 2002

Technical Update

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GII/III/IV (ATA 49): Best Practices for APU Operation

Numerous questions have been received pertaining to improving the installed life of the GTCP36-100(G) APU used on the Gulfstream II/III/IV aircraft. This article offers recommendations to improve the installed life of the APU to gain maximum availability. Honeywell has provided below several different topics that may be of benefit on the causes of hot section damage.

General

The hot section life of the GTCP36-100(G) is mainly affected by damage to the turbine rotor and turbine nozzle. This type of damage is typically referred to as "Hot End Distress" or "Thermal Distress." Thermal deterioration or distress can also affect the interstage (labyrinth) seal plate. Typically, thermal distress, hot gas corrosion, and particle erosion are the causes for “Hot End Distress.” A number of material and component improvement programs have introduced better designs to the GTCP36-100(G) to increase the durability of the turbine area. These improvements were offered via Honeywell Service Bulletins. In addition to the available bulletins, there are a number of operational procedures that may improve the APU's installed life.

Thermal Distress

The APU’s hot section life depends on APU utilization. An APU that operates at maximum Exhaust Gas Temperature (EGT) will have a shorter life than one that operates at a part-load, lower EGT condition. Similarly, the number of thermal cycles has a direct bearing on the life of the turbine. Thermal cycles include starts and stops of the unit, as well as mode selections that result in step changes to the EGT.

Actually, high EGT is not the true cause for APU turbine distress. Turbine Inlet Temperature (T4) is the real parameter of interest. EGT is what the APU Electronic Control Unit (ECU) uses to maintain proper operation. However, ambient conditions will affect T4, but not necessarily EGT. For example, at maximum bleed load with the EGT at its upper limit of 1230ºF / 665ºC, the T4 temperature will be HIGHER on cold days than on warm days, due to the effect of air density on the APU's performance. Therefore, cold day operation of the APU can be potentially more detrimental than warm day operation.

Any operational procedural change that minimizes either the maximum EGT or the number of thermal cycles can be expected to help extend the hot section life. Ways of reducing the maximum EGT include the following:

- Cabin temperature management:
  - Single air conditioning pack operation instead of dual-pack
  - Operating ACM in "Auto" mode instead of "Manual"
  - Commanding slow cabin temperature adjustment rates, either "pull-down" or "pull-up"
- Minimizing bleed air system duct leakage.

In particularly hot or humid climates, it is recommended that the cabin door be closed to reduce the demand for air conditioning and APU operating time. All of these measures reduce the amount of APU bleed air delivery, which, in turn, causes the EGT to be lower.

Bleed duct integrity (although not part of the APU operation) is crucial to improving APU installed life. Bleed air leaks increase flow demand on the APU, resulting in a higher EGT. Regular bleed manifold checks are recommended to find and correct bleed air system leaks.

Back to Main Menu

Thermal Cycles

The best way to avoid excessive thermal cycling is to plan APU usage in advance. It is better to run the APU in an “unneeded" idle state than to shut it down for a short period and restart it.

Sudden load changes cause high EGT spikes that result from the APU control system's response times. For example, if an APU is operating at steady-state with one air conditioning pack operating and then the second pack is added, the APU speed drops off because additional energy is being taken away by the increased bleed flow. This causes the APU speed to momentarily drop, which the ECU senses. When the speed drops below 100% governed speed, the ECU compensates by adding fuel to return the APU to full-speed operation. The addition of fuel increases the EGT, often resulting in a brief spike that exceeds the steady-state temperature. These spikes are not seen on cockpit gauges, but cause high overtemperature conditions for very brief times. These spikes in T4 may exceed the melting point of the turbine nozzle material.

Repetitive temperature overshoots will lead to erosion of the turbine nozzle vanes, which, in turn, damages the turbine rotor. Having either bleed switch on along with the APU Air switch can induce these same surges. In this condition, when the power levers are advanced and retarded, the APU will be commanded off and on, respectively. Gulfstream has published in the GIV Maintenance Manual, Chapter 36, recommendations on single bleed air source operations that will prevent these specific thermal cycles.

Cockpit procedures may be recommended to reduce the amount and degree of APU load changes that would include gradual cabin temperature selection changes, using one or two air conditioning packs throughout an APU cycle (not switching back and forth) and maintaining "Auto" mode ACM operation. "Manual" mode should be used only for troubleshooting procedures. In addition, Gulfstream has released GIV Aircraft Service Change (ASC) 390 Part 3 and production standard from aircraft 1310, which installs a bleed air limiting venturi in the ducting. This venturi reduces the degree of EGT overshoots that result from load transients. Additionally, Gulfstream has published in the GIV Maintenance Manual, Chapter 21, recommendations for single pack operation that will keep thermal cycles reduced.

Another APU air use that should be avoided is to warm up the aircraft wings or engine cowl. This operation puts the maximum load on the APU and is not recommended. It should be the last method of choice to de-ice wing leading edges or the cowl area when no air supply carts or hot air blowers are available to ready the aircraft for flight.

APU Surge

APU compressor surges will damage the turbine section. When a surge occurs, there is a very high spike in EGT, similar to the spikes described above. Surging can result from a number of conditions, including the following:

- Hard carbon formation in the combustor that blocks turbine nozzle air passages
- Combustor cap shield too close to the outer wall of the combustor
- Inlet blockage or flow distortion entering the compressor
- Foreign Object Damage to the impeller or diffuser
- Excessive shaft load during very cold days or very hot days
- Bleed air management procedures (refer to Honeywell Service Information Letter SIL APU-54)

If APU surges are encountered, the cause must be determined and corrected prior to continued service.

Combustor Abnormalities

Aberrations in the fuel delivery system or combustion chamber can adversely affect turbine section life. Factors such as a streaking fuel atomizer, air leaks at the combustor cap flange, atomizer gasket, igniter or drain fitting bosses, poor combustor-to-torus fit, or distortion/erosion of the combustor cooling skirts can all contribute to uneven flame distributions. Heavy carbon buildup in the combustor is an indicator of poor fuel atomization and may lead to APU surges. Any of the above conditions can result in a "hot streak" impinging on the turbine nozzle, which can exceed the melting point of the material. Compliance with Honeywell's scheduled combustor/atomizer inspections is required and will help prevent these conditions from causing turbine section damage.

Torching Starts

Torching starts result from excessive fuel in the engine at light-off, which occurs typically following an unsuccessful start attempt. Conditions such as these will result in very high internal temperatures until the excess fuel is burned off.

If torching starts occur, there is accelerated turbine distress due to the high gas temperatures during APU acceleration. If torching starts are encountered, the cause must be determined and corrected prior to continued service. Torching can be minimized, following an unsuccessful start, by waiting for the excess fuel to drain overboard before attempting a subsequent start,

APU Shutdown Procedures

The APU shutdown procedure has been the subject of much confusion since introduction of the GTCP36-100 Series APUs into service. Previous APU models, especially those that use an aft bearing ("hot-end bearing") behind the turbine rotor, required a "cool-down" period to allow the aft bearing to be cooled prior to the oil supply's termination. Shutting down such an APU without cool-down would cause coking of the aft bearing.

The GTCP36-100 Series APUs do not use an aft bearing and, therefore, do not require the cool-down period. More importantly, a cool-down period is damaging to the GTCP36-100 Series APUs.

The correct shutdown procedure used on the GTCP36-100(G) APU is to command a shutdown from the existing operating condition and an existing APU load (either bleed or shaft) is NOT to be removed prior to commanding shutdown. The preferred method of shutting down the APU is to use the Overspeed Test switch. This procedure reduces the number of damaging thermal cycles and concurrently performs a test of the ECU's overspeed protection circuit

De-Icing Fluid Ingestion

This subject is covered in depth in the Honeywell GTCP36-100(G) APU Maintenance Manual (49-21-89), the Gulfstream Maintenance Manual, Chapter 12, and the applicable Airplane Flight Manual Cold Weather Operations section. APU ingestion of de-icing fluids or aircraft wash solutions that contain corrosive agents is to be avoided at all times. Rapid hot corrosion of the turbine can result, as well as unprotected overspeeds, leading to very costly repairs. In addition, washing agents that contain chlorine will attack the titanium compressor impeller and possibly lead to its failure during operation.

Main Engine Starting

Main engine starts that are slow should be avoided, as the longer the APU must be at maximum temperature, the more damage that will occur to the turbine section. Regular monitoring of the start cycle time is recommended in order to identify when the start time is getting lengthy, which will allow a quick correction to the situation.

Technical Assistance

Gulfstream and Honeywell maintain worldwide technical support. Whenever there is a question about a particular aspect of APU operation or if on-site technical assistance is required, contact your local Gulfstream Field Service Representative or Honeywell Field Service Engineer (FSE). Additional assistance can be obtained from Gulfstream Technical

Back to Main Menu

Operations (800-810-4853 or 912-965-4178) or Honeywell's 24-hour Customer Information Center (800-421-2133 or 602-365-2180).

Summary

This article presents many different causes and suggested corrective actions for hot section distress on the GTCP36-100(G) APU. Since individual operators will have widely differing conditions, Honeywell strongly recommends that questions relating to the APU or its operation be directed to a Field Service Engineer.

In short, APU turbine section life may be optimized by the following:

- Reducing APU operation at maximum EGT
- Correcting bleed air system leaks
- Reducing the number and degree of thermal cycles
- Following recommended Gulfstream operating procedures
- Correcting conditions that cause APU surging
- Compliance with required inspections of the combustor and fuel system
- Avoiding torching starts
- Shutting down the APU in whatever condition it was operating in and without a "cool-down" period
- Preventing ingestion of de-icing or washing solutions
- Monitoring main engine start times
- Contacting your local Honeywell or Gulfstream for additional assistance

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Current Events

Compiled by Chris Corbin, Technical Operations

ALL (ATA 25): Reregistration Required for 406 MHz Emergency Locator Transmitters

Submitted by Roy Chambliss, Technical Operations Avionics/Electrical Group

Gulfstream Technical Operations has recently been advised of a notice from the National Oceanic and Atmospheric Administration (NOAA) for operators of aircraft with a 406 MHz Emergency Locator Transmitter (ELT). The notice states that the registration is valid for two years only, and operators are required to reregister the beacon every two years so that NOAA can maintain up-to-date contact information records.

NOAA has an automated system that mails reregistration cards to operators to fill out and return every two years to keep their information current. Heavy pressure by the U.S. Coast Guard was applied to ensure beacon registration and timely updates, in order to reduce the huge workload on response centers. It was determined it is more cost effective to place a phone or radio call and find out that the beacon was accidentally activated instead of launching a boat or plane.

The National Search and Rescue Committee (NSARC) mandates this policy and is comprised of the following agencies: