Notes for the Subenews Yahoo! Group
ERA14LA130
RV-9A N19VC
Eggenfellner Engine installation
Accident Date: February 23, 2014

Introduction

The airplane had just flown 200 nm over open water and was approaching Sanford International Airport. The propeller stopped turning while the engine continued to run. The pilot executed an off-airport landing where the airplane nosed over and came to rest inverted. Safety Board investigators have found that the propeller stopped turning when the spline shaft uncoupled from the drive disk adapter. The two components are part of a system that transfers power from the engine to the propeller.

The experimental engine and propeller installation was designed by Eggenfellner Aircraft LLC which is now out of business. The installation utilizes a Subaru 2.5L automobile engine and a propeller speed reduction unit (PSRU) to deliver power to a propeller. The spline shaft and drive components transfer power from the engine to the PSRU.

This installation was originally put into service with a solid flywheel. According to a representative of Eggenfellner Aircraft, LLC the configuration that used a solid flywheel resulted in high load pulses being transmitted from the engine, through the spline drive components, the PSRU and propeller. The high transmitted loads led to accelerated wear and premature failures of the splined components and within the PSRU. Eggenfellner Aircraft developed a dual mass flywheel installation to better control high loads and wear.

The solid flywheel on this airplane had not been replaced with the dual mass design at the time of the accident. The drive disk adapter that mates with the solid flywheel was not hardened. The other spline drive components are hardened including the drive disk adapter that mates with the dual mass flywheel.

Subenews Yahoo! Group is a private website devoted to builders and owners of experimental airplanes that use the Eggenfellner Aircraft engine installations. The group has been extremely helpful in providing information, photographs and expertise regarding the Eggenfellner installation. The information related to previous failures and design modifications was particularly helpful. In some cases owners identified operational issues with the aircraft and discovered damage to the spline shaft and other components.

The service histories for the units in operation are not sufficiently mature to fully understand the nature of the wear and the failure modes. As a result, the Safety Board investigators are not in a position to provide recommendations or solutions to aircraft owners/operators. However, we can provide a summary of our findings that may help the individuals in the group decide the best way to move forward with their engine installations.

Findings to date:

The accident airplane was equipped with an Eggenfellner/Subaru Gen 3 V4 propeller speed reduction unit (PSRU) and solid flywheel, which had been installed by Eggenfellner Aircraft, LLC. prior to the aircraft's first flight. The spline shaft and associated components were not inspected or lubricated after installation of the PSRU.

This unit uncoupled at the interface between the spline shaft and the drive disk adapter (engine side) at 325 hours of operation. The spline shaft teeth and the walls of the grooves in the drive disk adapter were worn and damaged to the point that the spline shaft would spin inside the drive disk adapter.

Measurements show that the splines in the PSRU input spline were worn more than 40%. The splines on the PSRU-end of the spline shaft were worn more than 25%. There was excessive free play and wobble when the spline shaft was reinserted into the PSRU input spline.

The spline shaft and bearing exhibited discoloration consistent with thermal damage and oxidation. There was no grease in the bearing.

In effect, there was unacceptable wear on all four interfacing spline surfaces.

There was about a teaspoon of red dust in the cavity of the PSRU input spline. A Safety Board metallurgist confirmed that the red dust was consistent with ferrous fretting-wear debris.

Additional Information:

During installation of the PSRU, the manufacturer would place a small portion of nickel or copper anti-seize on the spline shaft. Deposits at the lip of the drive disk adapter were evaluated using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). The results were consistent with the presence of copper anti-seize.

Discussion:

Flywheel

It is not known why this installation, which included a solid flywheel, failed at 325 hours. There appears to be at least two major factors present: 1) high operating loads and 2) lack of inspection and lubrication. There was excessive wear on the four surfaces on the spline installation. Two of the surfaces wore to failure. The installation had not been inspected nor lubricated since its introduction into service.

It is unknown if there have been acceptable results using the solid flywheel with frequent inspection and lubrication of the spline components. Even if short term results are satisfactory, the long term effects of the higher operating loads are not known.

Eggenfellner Aircraft, LLC has recommended replacing the solid flywheel with a dual mass flywheel. However, the PSRU or spline components may incur wear or damage while being used in conjunction with the solid flywheel. Simply replacing the solid flywheel with the dual mass flywheel after the PSRU has been in service may not provide sufficient protection.

There are reports and photographs that show evidence of excessive wear in airplanes equipped with dual mass flywheels. However, it is likely that some of the units were not lubricated at frequent intervals, if at all. Reports from builders and owners also suggest that some have had success using the dual mass flywheel accompanied with frequent inspection and lubrication maintenance. Some reported using antiseize compounds with high solid content as the lubricant.

The dual mass flywheel installations have a limited service history; therefore, the service life of the dual mass flywheel is currently unknown. While the dual mass design may limit the loading and wear to the spline components and PSRU, the dual mass unit may be sustaining higher loads or cycles than intended by design. The failure mode of the dual mass flywheel and its failure risk during flight are currently not known.

Inspection and Lubrication

Repetitive inspections themselves can create problems. For example, multiple removal and reinstallation of components may alter critical alignments.

Proper lubrication is difficult to achieve in this type of application; however, the type of lubrication and lubrication intervals need to be defined to eliminate fretting corrosion.
In aircraft applications, the inspection interval may be set at 50% of the duty time to failure if the failure mechanism is well understood. If the failure mechanism or variables such as delayed

onset of wear or accelerating wear are not well understood, the inspection interval would need to be lowered to less than 33% or less than 25% of the known duty time to failure.

The wear in this unit was severe. A measure of 'acceptable wear' needs to be developed to better assure safe operation until the next inspection. Defined visual or measurable wear limits could aid when returning parts to service.

Frequent replacement of worn parts may be necessary if the wear rate is not well controlled. At this time, it is unknown how fast wear may progress once it becomes visible or easily measurable.

Simple preflight tests, if possible, could disclose the existence of developing wear. For example, there could be roughness when rotating the propeller or excessive free play between the propeller and the engine.

At this time, we are not aware of guidance that has been developed for the inspection and testing of this application to determine if it is airworthy or can be safely returned to service. There is a need to find effective methods to evaluate parts with subtle levels of wear.

Closing Remarks

There have been multiple cases of fretting corrosion in the spline hardware. There has been short term success controlling the fretting by using the dual mass flywheel with more frequent inspection and lubrication intervals and applying high performance anti-seize with high solid content. However, the combinations of factors such as flywheel configuration, type of anti-seize, lubrication interval, and engine power have made it difficult to assess the effects of each variable.

While controlling the fretting is essential, defining acceptable wear limits and perhaps time limits will become necessary as the service history matures.