2014 PSRU MODS, RV-9A N678RA

Egg 2.5L SOHC Subaru, MT Prop

Introduction

This document is an attempt to share the changes that have been made to the PSRU (Propeller Speed Reduction Unit) installed in Experimental Amateur Built airplane N678RA. I in no way claim this is the best way to accomplish the goal of increased PSRU spline coupling life or even a good way. Only the way I chose to move forward with this learning process.

The Issue

There have been a number of recent spline failures. Alignment and service/lubrication of the splines appears to be important. Honda Moly 60 paste seems to be highly recommended but as shown below it does have limitations in this application.

In 2013 at the annual condition inspection I liberally applied Honda Moly 60 to my male and female splines prior to reassembly after cleaning and inspection.

In 2014 my partners and I decided to do some avionics upgrades to our 2006 RV-9A so we decided to do the annual condition inspection at the same time. The airplane only had approximately 25 hours since last year's annual condition inspection. Disassembly started with the airframe and instrument panel in earnest. This left the engine, which has been running nicely since last annual, for later in the project.

When I removed the PSRU to inspect the spline I found radial streaks of gray on the end of the PSRU input shaft (Photo 1), but the female spline seemed to still be well lubed with Moly 60.

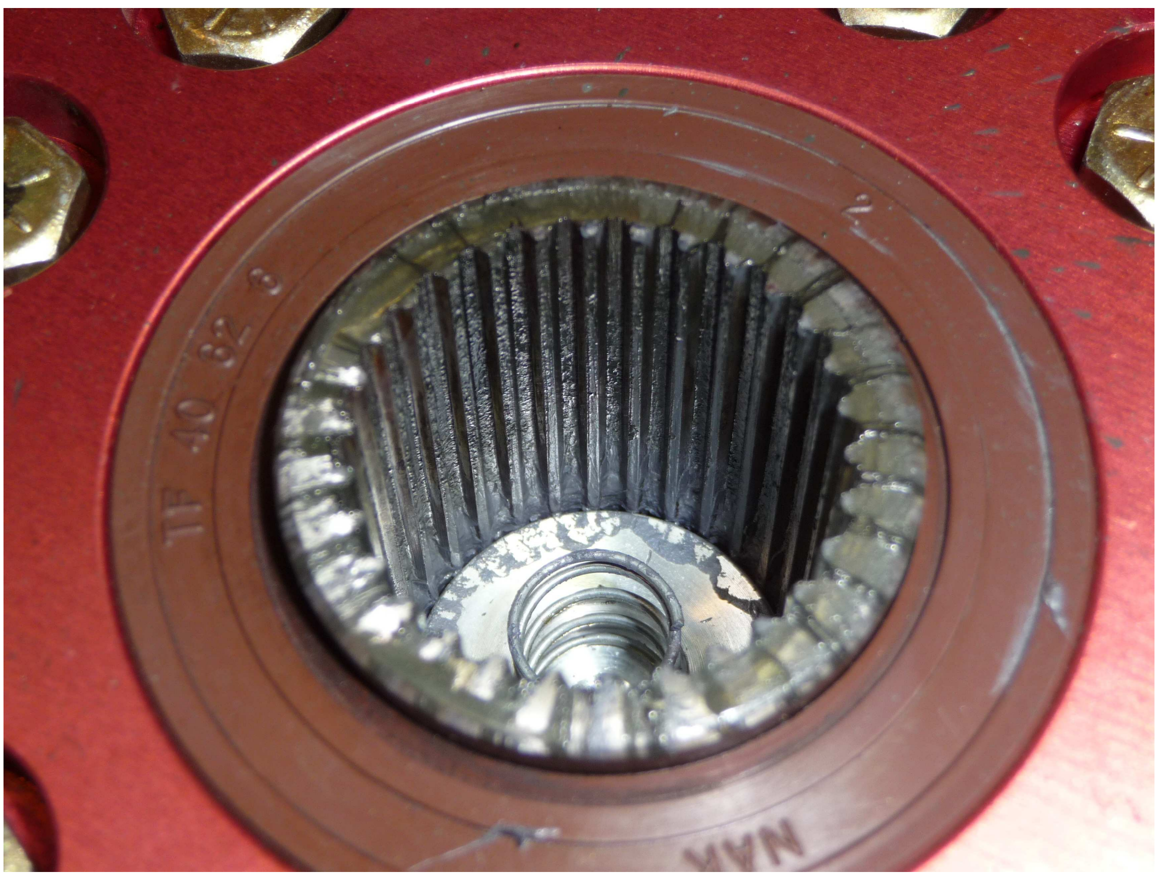


Photo 1

When I looked at the spline shaft still in the flywheel adapter, the male shaft also appeared to still be coated with the Moly 60, though not as much as I expected to see (Photo 2). If you look at the edges of the hole in the engine mounting plate you will see where all the Moly 60 went! That doesn't seem very good….

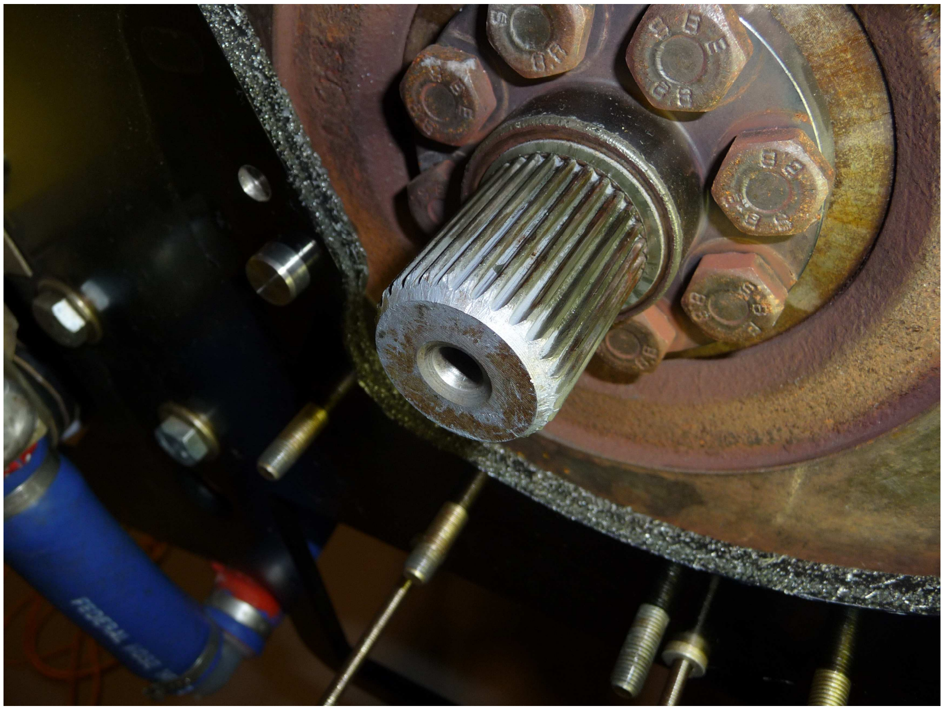


Photo 2

The next step was to remove the spline shaft and clean and inspect it. When I removed it from the flywheel adapter I was surprised to find most of the adapter to be dry with some iron oxide dust apparent, along with a very minor amount of Moly 60 residue (Photo 3). Notice the “ring” of Moly 60 around the perimeter of the flywheel adapter and all the Moly 60 around the edge of the adapter plate. This was NOT GOOD after only 25 hours of operation!

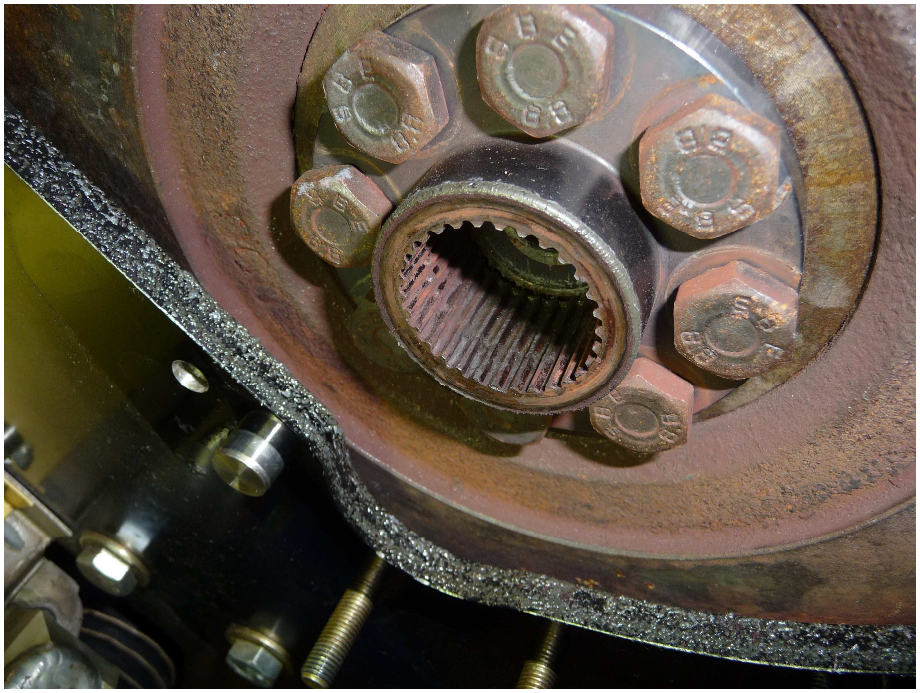


Photo 3

Here is a photo of the uncleaned spline shaft as removed from the flywheel adapter (Photo 4). You can see that the upper portion above the snap ring is quite dry compared to the lower portion. I decided that this needed to be fixed if I wasn't going to spend every third weekend lubricating the spline shaft.

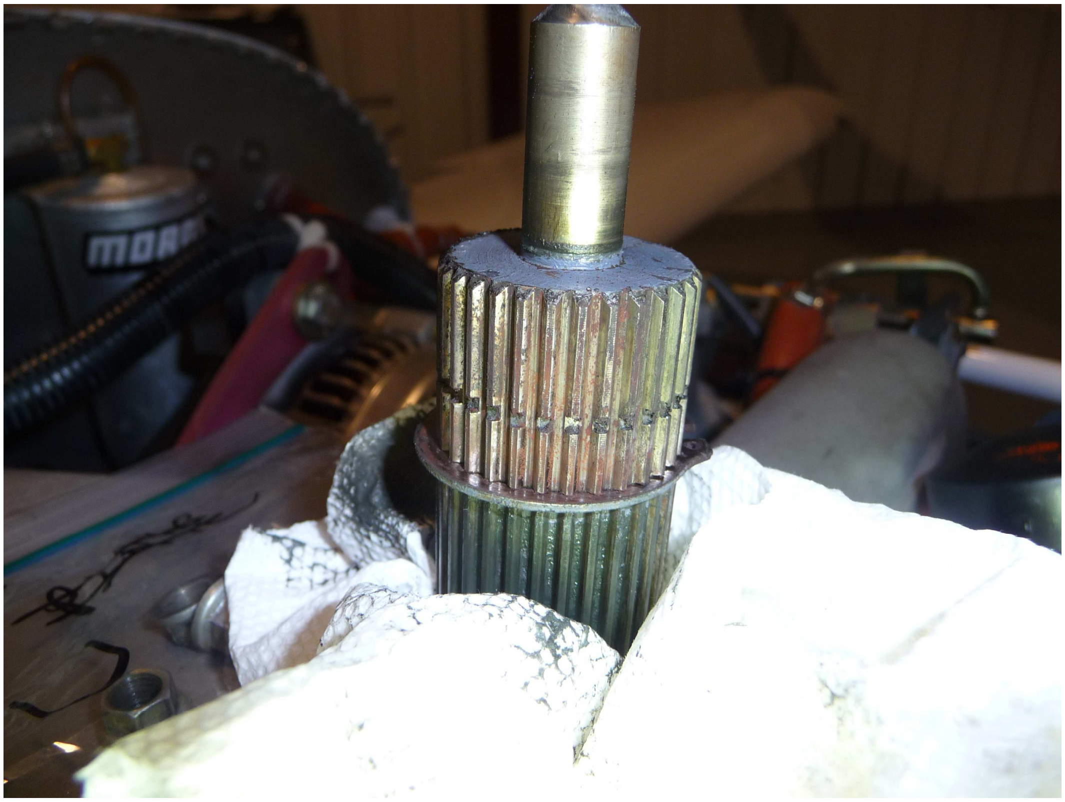


Photo 4

Spline Shaft Measurements

The next step I took was to clean up the male and female splines and measure the spline shaft for later reference. I had not done this in 2013 because I had no idea how to do it. In the interim I did some research and asked a machinist friend how to take measurements. The photo below (Photo 5) is how I accomplished this. I selected two brand new drill bits that measured the same diameter that fit between the teeth of the spline shaft but did not bottom out in the space between teeth. I measured the outside diameter including the drill bits placed 180 degrees apart. I recorded the measurements for a full 360 degrees or 30 measurements. I did this at each end of the shaft (first .025”) and in approximately the middle.

As the face of the teeth wear, the pins (drill bits) will drop down into the space between the teeth and exaggerate the amount of wear so it can be measured more easily.

Of course I will need to build a history of dimensions over time for comparison or compare to a new spline shaft.

I keep the drill bits and digital caliper together labeled as special tools only for the airplane. I also noted the diameter of the drill bits and the temperature the measurements were taken under for the sake of repeatability. Probably silly but I just don’t know how important this may be.

Here are the measurements taken. Note that my caliper is only good for an accuracy of plus or minus 0.001 inches.

1.3700	1.3700
1.3700	1.3705
1.3700	1.3705
1.3700	1.3700
1.3695	1.3695
1.3695	1.3700
1.3700	1.3700
1.3705	1.3705
1.3700	1.3705
1.3700	1.3705
1.3700	1.3695
1.3700	1.3710
1.3705	1.3705
1.3705	1.3705
1.3705	1.3700

2014
PSRU end

1.3720	1.3710
1.3715	1.3710
1.3705	1.3705
1.3700	1.3705
1.3705	1.3705
1.3705	1.3705
1.3705	1.3710
1.3705	1.3705
1.3705	1.3705
1.3705	1.3705
1.3710	1.3700
1.3705	1.3705
1.3710	1.3710
1.3705	1.3710
1.3710	1.3705

2014
flywheel end

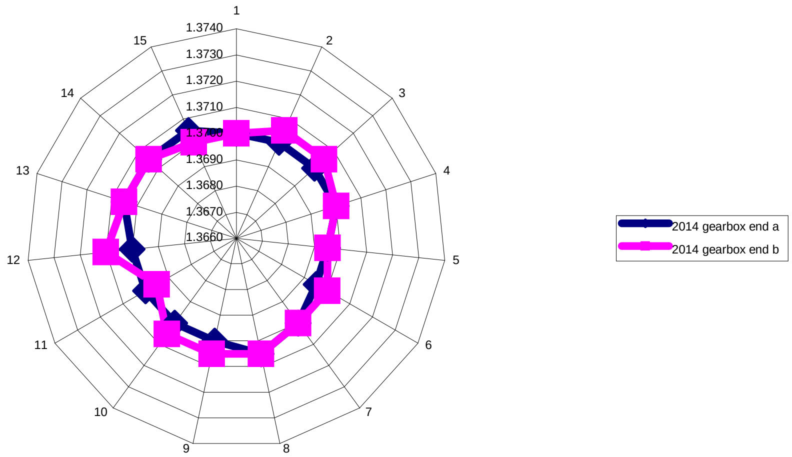
1.3730	1.3730
1.3730	1.3735
1.3735	1.3730
1.3730	1.3730
1.3730	1.3730
1.3730	1.3730
1.3730	1.3730
1.3730	1.3720
1.3730	1.3730
1.3730	1.3730
1.3730	1.3730
1.3730	1.3730
1.3725	1.3730
1.3730	1.3735
1.3725	1.3730

2014
mid shaft

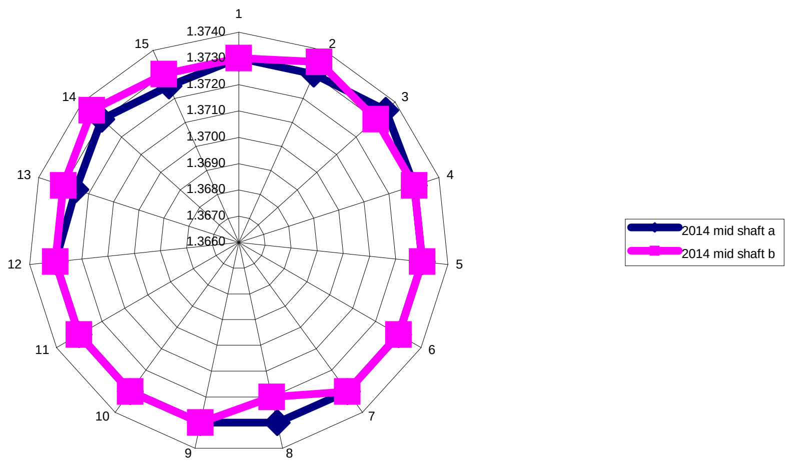
Photo 5

Spline Shaft with drill bits held in place with rubber bands.
The Digital caliper used is in the background.
Yes my wife was not happy I was doing this on the dining room table.

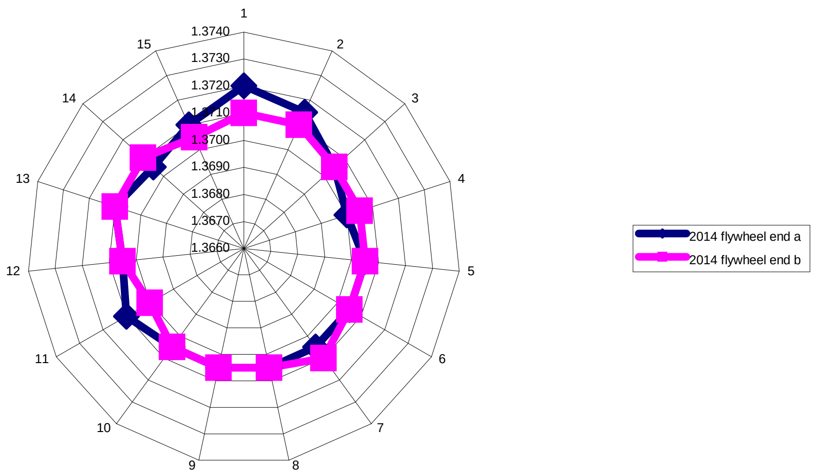
I entered the dimensions into an Excel spreadsheet and generated polar graphs for each column of numbers. As you can see from the numbers in the tables, and more easily from the graphs, I have tooth wear at the ends compared to the middle of the shaft. Each graph shows each number column as a different color to illustrate the limited resolution of the tools I am using and my own inconsistency taking measurements.



PSRU END OF SPLINE SHAFT



MIDDLE OF SPLINE SHAFT



FLYWHEEL END OF SPLINE SHAFT

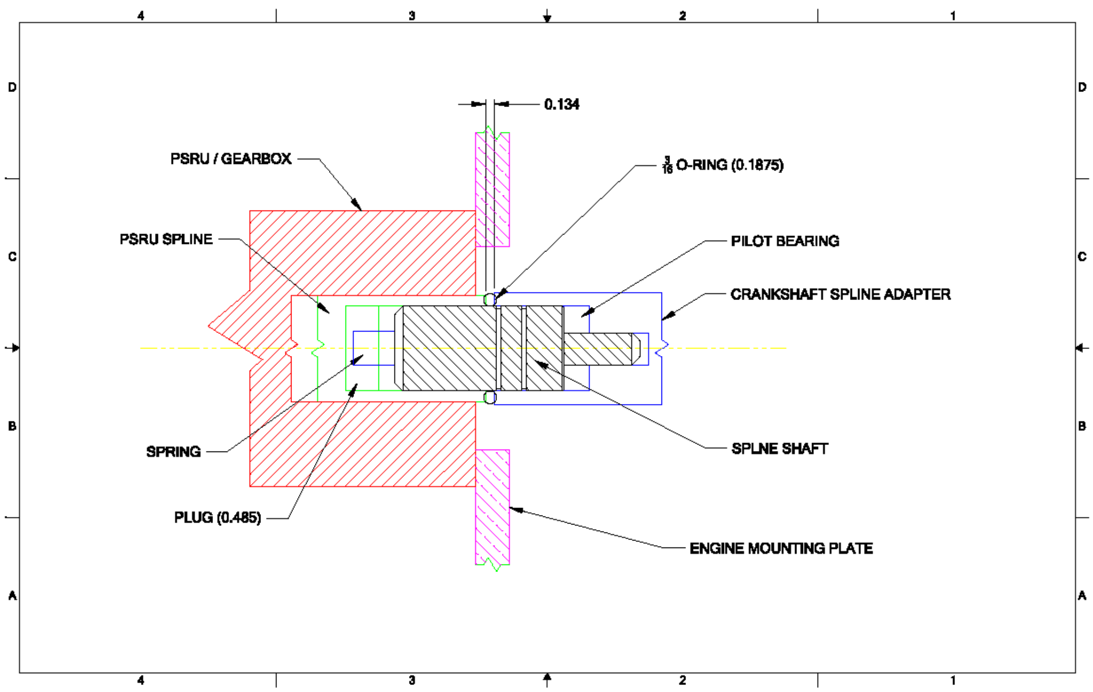
The outer ring of all three graphs is the same value (1.374) and the center of all three graphs is also the same value (1.366) so the graphs may be compared. Each increment outward from the center is 0.001 inches. Measuring using this technique appears to exaggerate the tooth wear by about a factor of four so I seem to have wear of about 0.0007 from the face of each tooth near each end.

I feel pretty good about the condition of my spline shaft but have begun looking for a source of a new one for reasons I will get to shortly.

I also feel OK about my engine to PSRU alignment but plan to fix it permanently after verifying it using the new tool so many people in Subenews helped me to obtain. (Thank You!)

Existing Installation

To retain the Moly 60 a seal was needed. So I took measurements and sketched a cross section showing the mounting plate, flywheel adapter, spline shaft and PSRU input shaft relationships. After doing this it was very obvious why the Moly 60 was all over the edge of the hole in the mounting plate. I also found that I only have a space between the flywheel adapter and PSRU input shaft of about 0.134 inches, which a simple Viton O-ring should be able to fill. See the diagram below. (Drawing 1)



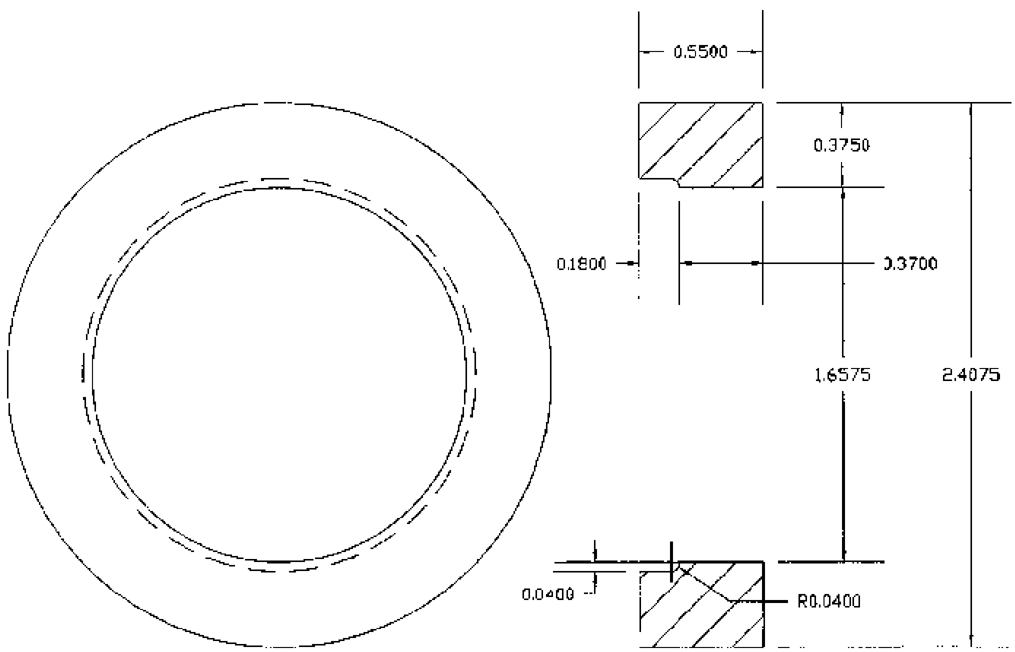
Drawing 1

Modification

The installation of the O-ring required the removal of the existing snap ring on the spline shaft. So an alternate means of locating the spline shaft to keep both ends fully engaged was needed. A plug and spring arrangement was used to allow some movement (0.250 inches) but maintain engagement (Drawing 1).

I also felt that I needed a retainer to create a cavity for the O-ring while preventing excessive expansion radially due to centripetal force during high rpm operation.

I designed one to hold the O-ring in place, allow deformation of the O-ring being compressed between the ends of the female spline shafts, and use the O-ring itself to keep the retainer in position (Drawing 2). The relationship was designed to keep the retainer about 0.100 inches away from the PSRU input shaft seal. The retainer was fabricated from Delron plastic.



Drawing 2

Here is the plug and spring (Photo 6). The plug was sized to be a sliding fit inside the female spline and leave a 0.250 inches space between the plug and spline shaft. The spring used was the larger of the two shown. This spring applies approximately 5 lbs of force to the spline shaft when compressed to the in-service size. The side of the plug touching the freeze plug inside the PSRU female spline shaft has Teflon tape applied to prevent chafing of the freeze plug. Additionally, the plug is fabricated from aluminum while the freeze plug appears to be steel. This should prevent wear through of the freeze plug. Time will tell.

Photo 6

Below are all the spline shaft installation parts together in order of installation (Photo 7). From left to right they are (1) Plug, (2) Spring, (3) Spline Shaft, (4) O-ring, (5) Retainer. At installation the PSRU would be to the left and the flywheel adapter to the right. Note that there is no snap ring and the Honda Moly 60 has not been applied.

Photo 7

Here is the retainer slid onto the flywheel adapter (Photo 8). Things were cleaned up further prior to final assembly.

Photo 8

Here is the spline shaft in the PSRU all greased up with Moly 60 and the O-ring in place (Photo 9). The plug and spring are pushing the shaft out of the PSRU to this position. Note the two snap ring grooves in the spline shaft.

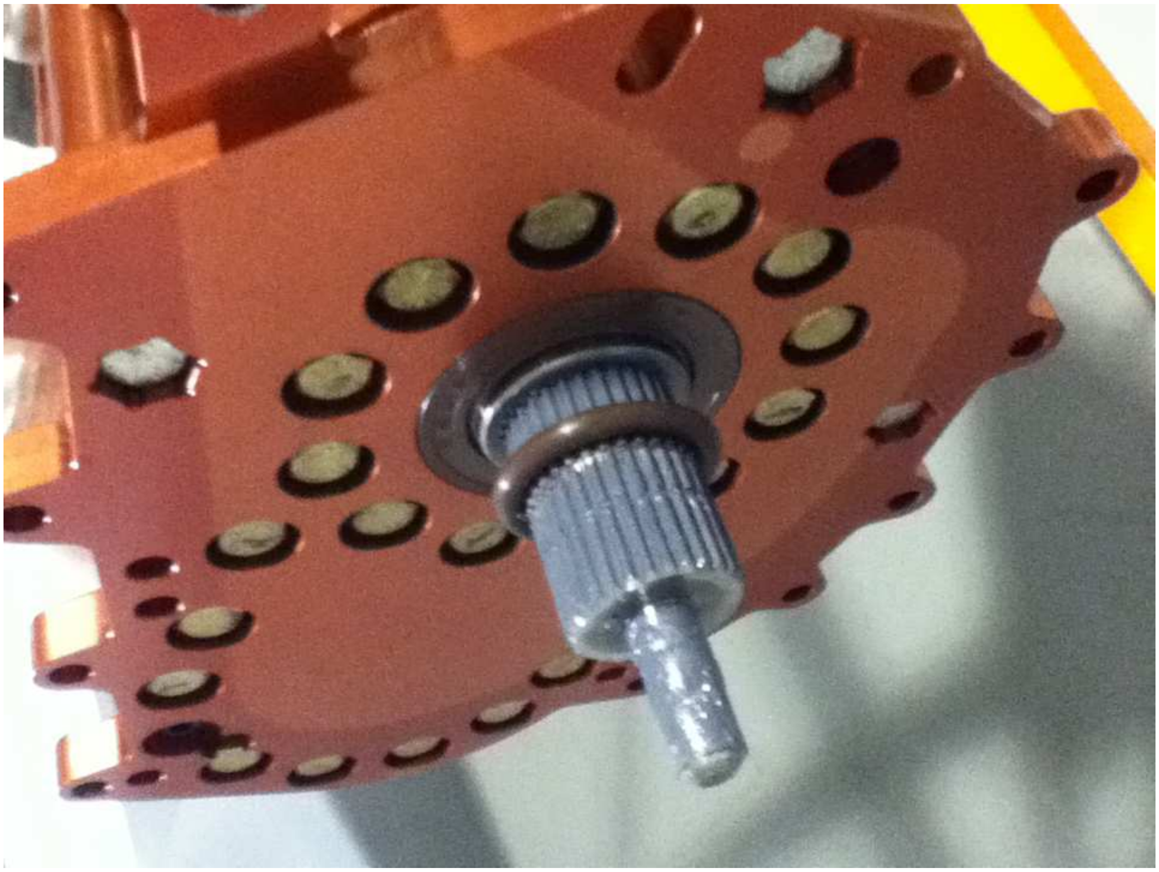


Photo 9

Finally, here is a photo taken by a low-resolution borescope showing the retainer and the space that exists between the retainer (white thing) and PSRU input shaft seal on the right (Photo 10). At the time the photo was taken we had almost 10 hours on the installation and there was no Moly 60 anywhere in sight.

Once this mod has some time in service I hope it shows no further spline shaft wear and does not cause any unanticipated problems.

If this comes to pass I plan to install a new spline shaft with no snap ring grooves to protect the O-Ring used as a seal from being chewed up by any longitudinal motion of the shaft.

Photo 10

This installation modification is truly experimental and is only my idea for use on our airplane. It may prove to create a hazard I have not anticipated. I offer this information only as an example of what I chose to do on our airplane.

My thanks to Pete Krok and everyone on Subenews for the tremendous amount of information, education and help provided to me to keep my airplane flying safely.

My thanks also to Col Jacob (Buddy) Smith III (Ret) for review of content, grammar and punctuation. To Pete Krok for his review and to Mike Talmadge for his review and comments on the next page.

Best Regards,
Tom Henry

September 9, 2014

Hi All,
This is pretty nice work!. As it stands, it ought to work well. But, being the next guy to look at anything mechanical, I can't help but offer a couple of thoughts. First, I'd keep a close eye on the Delrin. It's subject to quite a bit of heat and force. Second, maybe instead of using a new splined shaft with no snap ring, could you machine the splines off of the shaft where the O ring lives? maybe a quarter inch or so would let the O ring move axially and the I D of the O ring could ride on a nice smooth surface.

On a final note, what is the condition of the pilot bearing? This seems to be the telling factor in looking at PSRU/engine alignment. If its in excellent condition, alignment is probably good.

By the way, if anybody with a dual-mass flywheel wants to do this, a little thought needs to be given to axial positioning. The solid flywheel that Tom has is a bit different from the dual mass in this regard.

Nice Work Tom,

Mike T.