

The Trailing Edge

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A Near Tale of Woe, or “The Fracture Mechanic Strikes Again!”

There is a “not so well known” cliché in the aviation business. That is, “aviation is like a self-cleaning oven, it cleans up its own messes”. The point of this “tongue in cheek” saying is that despite the excellent safety record of the aviation business, it is very unforgiving of negligence, or downright unsafe behavior. Such behavior by either pilots or mechanics can easily start a chain to an accident unless someone breaks the chain. One of the other things about the aviation business is the willingness of aviators to share their “tales of woe” to save their fellow aviators from possibly befalling a similar fate.

This is actually a success story that almost ended up as one of those “tales of woe”. It’s the story about a maintenance problem that started a chain of failure events, like those described in “Stormy” Weathers poem, “The Fracture Mechanic”, available at <http://erbman.org/trailingedge/2303%20The%20Fracture%20Mechanic.pdf>. This story is based on a factual incident, but like many great “screen plays”, the author has embellished the story to make it easier to tell, and to teach the essential lessons. There was never an accident. Nobody was hurt, and no names, locations, or aircraft identities will be revealed to, as Obi Wan Kenobi said in the original Star Wars, “...avoid any imperial entanglement.”

The first link of the chain.

Long ago and in an airfield far far away, there lived a simple single engine aircraft, used by a flying club. It was a simple, sturdy aircraft. Easy to fly, and a “workhorse” for the club, and fly it they did, for years and years and years. In fact, it’s still happily carrying aviators into blue skies today. But the happy ending wasn’t always assured. Like every aviator and their machines, any simple error was capable of starting a chain of events that could have resulted in a serious if not fatal accident.

Like all “loved” airplanes, this one got lots of attention from its owners and users. A special paint job, regular oil changes, and a couple washings a year. Like all airplane (and motorcycle) owners know though, the high expense and difficulty of replacing aircraft parts and the desire to “get in the air” are competing activities. All of these activities are essential to the health of the aircraft. Unfortunately, the competition between the requirements of these actions are also conducive to “cutting corners”, and cutting corners is one of those “openings” described in the poem “The Fracture Mechanic”, which in this case would plant the first point of one of those “chains of events”.

Over a decade plus of successfully serving its club members, this airplane responded to the touch of lots of pilots, endured many missions, flew many takeoffs and landings on unimproved surfaces, and was worked on by many mechanics who endeavored to get her back into the hands of competent pilots as soon as possible. Anybody who’s ever operated on unimproved surfaces knows the propeller lives a tough life. It is prone to stains and strain from errant grass stalks and occasional sticks, nicks from occasional pieces of FOD, constant use as a “handle” to move the aircraft, and so on. Fixed pitch propellers also occasionally need to be rebalanced and sometimes repitched, even under good conditions. So, over the decade plus of successful service, both her propeller and engine had been removed and remounted several times. Because the bolts looked good, people were eager to fly again, and AN prop bolts ain’t the cheapest, the same bolts that came out got put back on again and retorqued. Funny thing about torques, too much is just as bad, if not worse, than too little. Add to the confusion, depending on what the bolt is used for, and what it’s attached to, it may even have different torque values. We talked to another A&P who was familiar with this specific model/type aircraft, and he told us that the maintenance manual for that “assembly” had two different torque values. Several of the parts associated with the engine mount vibration dampers were also either not “aviation standard” or missing.

Anyway, let’s consider a verse out of Scott “Stormy” Weather’s poem, “The Fracture Mechanic”:

*“So I look for places where the stress is high,
And I start by taking it slow.”*

*“I look for ragged edges,
Or an inside corner that’s tight.
That’s where I can get a crack to grow
With all the loads in flight.”*

Prop bolts are definitely in a “high stress” part of the engine. Every time a bolt is torqued, it “stretches” just a teeny bit, and the thinnest part of the bolt is in the threads which have sharp corners. This poor girl’s prop bolts had been torqued (maybe even overtorqued) multiple times, and over the decade plus period of this story, a crack started on one of them, and it continued to grow.

One day, one of the pilots noted a different sound. Talking with the other pilots, they started listening more, and several of them heard an occasional “buzz” at low RPM, kind of like a vibrating panel. They looked carefully and felt around, but nobody could find anything, but they stayed vigilant. A number of “flying days” later, a new pilot took the old girl out for her weekend workout, and when pushing her around to put her back in the hangar, he pulled on one of the prop blades and it “gave” a little. “That’s not right”, the pilot thought, so he grabbed a blade and gave it a good solid “back and forth” motion perpendicular to the plane of rotation, to discover her prop had “play” in that direction that was noticeable when compared to the spinner.



“Uh George, is that supposed to move like that??”

After a couple seconds of “It ain’t supposed to do that, is it?” self-introspection, the pilot shot a quick movie with his phone, sent it to the appropriate operations folks, and said “this plane is grounded until somebody can look at it.” The club ops folks echoed the “grounded” verdict and contacted maintainers. Word spreads quickly in a small club, and all the pilots started sharing their thoughts. Suddenly, the occasional “buzz” at low RPM, like that of a vibrating panel, that several of them had noticed, but nobody had been able to find, made sense – the “accident chain” had just been broken by a pilot paying attention and noticing something different than it had been during preflight.

Exploratory surgery.

Another factor in the “old girl’s” favor in this case, was that the club members responsible for the operation of her and her “stable mates”, were experienced, seasoned aviators with good experience in maintenance operations. The senior operator immediately grounded her from ANY operation, and contacted experienced maintainers to come pull the prop assembly apart and see what was going on.

A propeller with ANY lateral “wobble” is concerning enough, but when the spinner was removed, this is what the mechanics immediately saw.



Spinner plate on front of the propeller hub

To anybody familiar with aviation maintenance procedures, this image will usually induce an immediate “oh s..t!” exclamation. You’ll notice that none of the safety wire is intact. From this photo, it appears the safety wire on the bolts at 2 and 6 o’clock are attached backwards and are applying loosening torque to their bolts. Two of the bolts appeared to be completely out of the threads and were essentially only still there because the spinner wouldn’t let them out all the way. One other bolt had backed out partially and was removed just using finger pressure, and the three final bolts were essentially the only ones holding the prop down to the flange. They suspect that the round scrape marks around the two broken bolts were where the safety wire scored the spinner front plate as the bolts spun. When the three loose bolts were removed, it was discovered that two of them had sheared completely.

This is what they looked like:



Fractured propeller bolts

These bolts didn't just "back out", they appeared to have failed in tension. The ends of these bolts showed signs of classic metal fatigue ending in complete failure and the crankshaft propeller hub bushings still had the ends of the bolts in them. Here's what the bushing/nuts at the front of the propeller hub looked like:



Front view of crankshaft propeller hub.

Notice the two bushings with bolts still in them in the above photo in the 6:30 and 10:30 position. The bolt at 8:30 had backed itself completely out of its bushing. The bolts at 12:30, 2:30, and 4:30 were the only ones holding the propeller on.

Here's a close up of one of the sheared bolts and it's "partner" nut/bushing:



Fractured bolt and companion bushing/nut.

As you could imagine, loose bolts are bad enough, but failed or disconnected bolts are really bad news as they no longer provide any support in the direction (tension in this case) they are supposed to support. This allowed vibration between metal components and assemblies of different hardness. Although all the bolts and bushing/nuts are steel, the propeller is aluminum, and aluminum is significantly softer than steel. THIS is what the back of the fixed pitch propeller looked like:



Damaged propeller hub

So the failure of these propeller bolts resulted in all kinds of additional motions by both the bolts and the prop, resulting in the destruction of the propeller hub (thus making the prop unusable).

The good news (Epilog)

With this much damage and vibration occurring on the front of a crankshaft, the next question is whether the crank or bearings are damaged. The basic test for this problem was to mount a dial indicator to measure the “roundness” of the hub and crank to see if it is in limits. In this case, the “old girl” received even more good news, as the “runout” of her hub and crankshaft were within limits.

As we said earlier, this actually was a SUCCESS story of a diligent pilot who “broke the chain” of an impending loss of the propeller, and possible loss of the aircraft and the next pilot. It was a CLOSE call. Although it’s difficult to predict when the final 3 bolts would have failed, it could have very easily been the next sortie.

As we also noted before, the “old girl” was complaining. A destroyed fixed pitch prop, bolts, and bushings easily costs several thousands of dollars of repair. Damaged journal bearings, or crankshaft damage is tens of thousands of dollars at a minimum. She’s still awaiting parts and the final surgery to put her back together, but due to the careful gaze of one pilot, and the love of her co-owners, the club is looking forward to having her fulfill her flying missions again.



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