Moose Flutter Incident

Overview

On October, 4, 2011 there were four of us flying from Colorado to Hays, Kansas for a fly-in. It was a picture perfect day, with little wind and very little turbulence. Mid-way into the flight, all of us felt a brief—less than one second—"vibration." A friend in the right seat was flying, so I didn't feel the controls at the time. None of us thought much of the "vibration" as it was both brief and seemingly very slight (though odd).

When we landed, we saw—and were astounded by—the damage below.

Needless to say, I left the plane there, returning the following weekend with friends and a trailer. We took the plane apart and returned home to effect repairs.

Why did the incident happen? We had numerous experienced Moose builders as well as an engineering firm analyze the pictures of the damage. At the end of the day, I believe there were four elements that contributed to this event. More on each of these in a moment.

- Lack of balanced rudder
- Addition of curved rudder fiberglass top, most of which weight was aft of the rudder hinge point
- Addition of electric rudder trim; where the trim motor, tab and hinge are all aft of the rudder hinge point
- Loose tail structure overall caused by numerous tailwheel shimmy incidents over the years—looseness which I didn't know about as I was remiss in never having grasped the vertical fin and attempted to move it side-to-side during a preflight.

Need to balance aircraft controls

All of the literature and research on aircraft control flutter attributes flutter to having the control's center of gravity aft of the control hinge point. The universal method for avoiding the propensity for control flutter to ever occur involves adding weight forward of a control's hinge point—in other words "balancing controls."

One of the first NACA flutter research articles in the 1930's states, "Flutter can occur at any airspeed." The first recorded flutter incident was that of a Handley Page bomber in WW-I (probably flying at less than 80 mph). Darryl Murphy, of Murphy Aircraft, says, "Our planes do not fly fast enough to warrant the need to balance control surfaces."

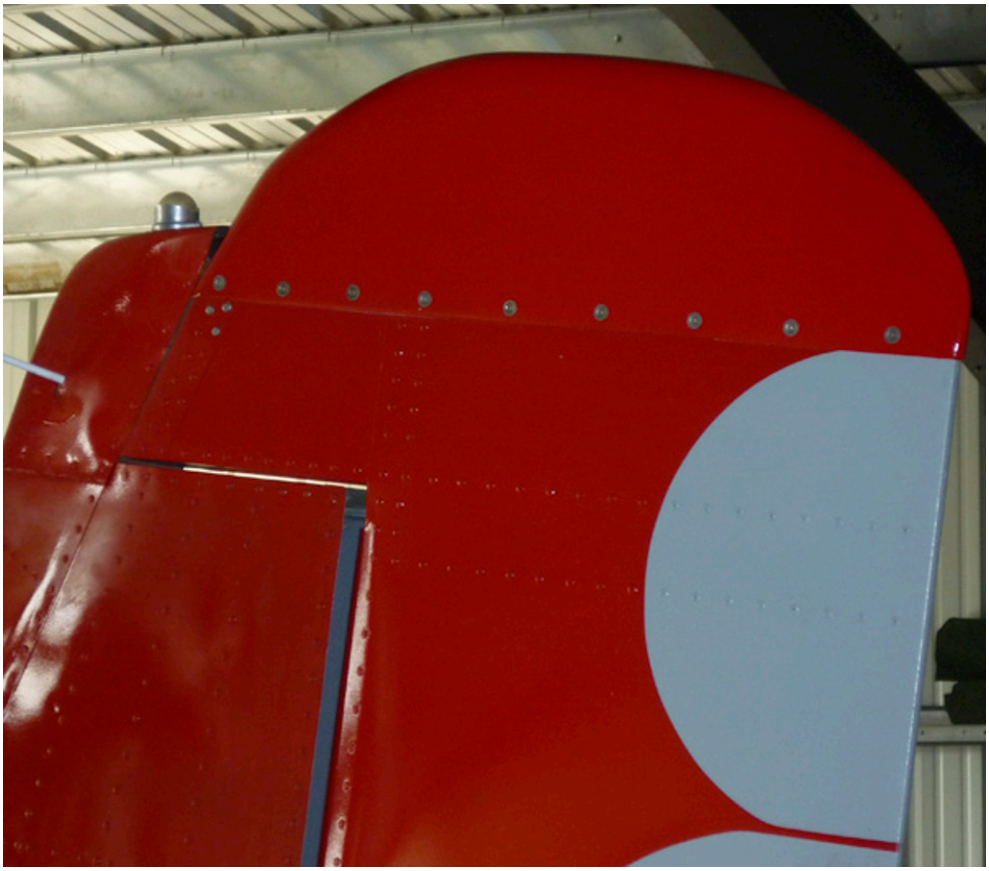
After my flutter incident I emailed 50+ Moose builders and Moose flyers. To my surprise, most that I contacted knew enough on their own—through whatever individual research—to know to balance their controls. In other words, many Moose builders/flyers already had taken it upon themselves to perform this critical step.

After this incident, and during the rebuild, I fully balanced all of the controls. This of course is the rudder balance process:

Curved fiberglass rudder top

The Moose looks a bit like a small de Havilland Beaver. One of the engineers on the Beaver contributed to the start of the Moose design, which likely explains the similarity. I thought it would make the Moose look even more like a Beaver with the addition of a curved top on the rudder.

Seemed like a good idea. But at the time I didn't know I was adding a lot of weight aft of the control hinge point, making the propensity to flutter all that much greater.



Pictures show that during the rebuild I of course removed the top and reverted to the standard Murphy flat top rudder design.

Electric Rudder Trim

Most Moose builders I know added electric rudder trim. Again, weight with the trim motor and such behind the rudder hinge point.

Interestingly enough, I found that I never needed electric rudder trim. Once rudder trim was set, one never needed to adjust it. I'd play with it on long cross-country flights (out of boredom). Inevitably, I'd land and find the trim tab in the same relative position as I had it to start with.

During the rebuild I went to a standard bent rudder trim tab. Minimal weight added aft of the hinge line. Not to mention that this trim tab weight was accounted for when I balanced the rudder.

Loose Tail Structure

Over the years, with the standard Murphy tailwheel, I had off and on had a lot of tail wheel shimmy. Apparently, unbeknownst to me, this loosed the front spar of the vertical fin. Hence the whole vertical fin was able to move side-to-side to some degree. Again, I didn't know this (though I should have discovered such in pre-flight checks).

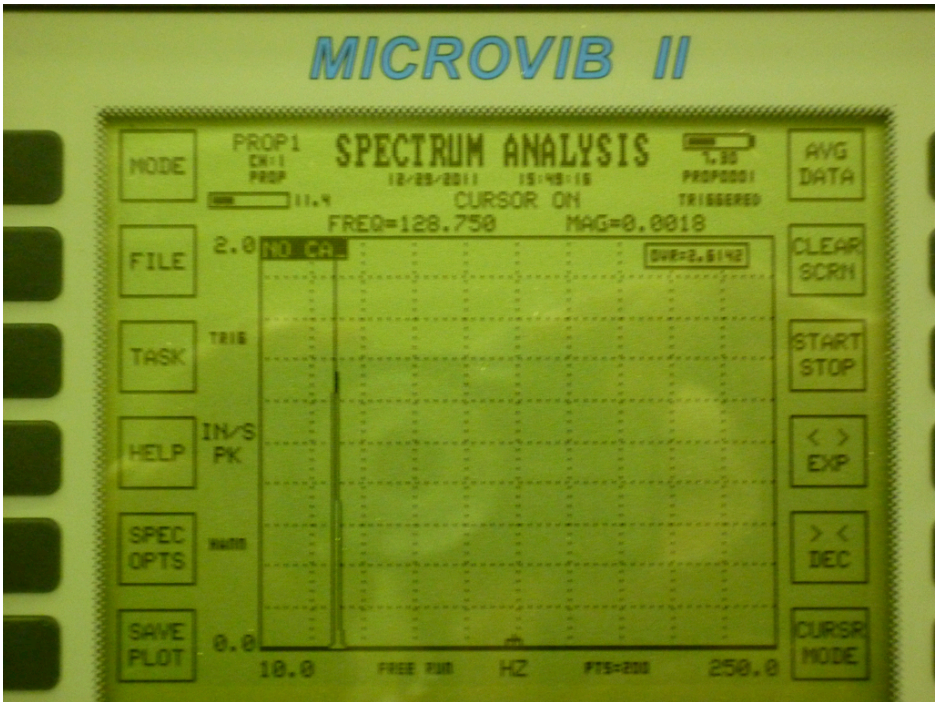
A very experienced engineer friend, who also has an outstanding Moose that he built, did some horizontal stabilizer vibration analysis with some telemetry equipment that he had available (during another project). Long story short, he fabricated parts and built horizontal stabilizer braces—as seen on many types of aircraft. He built me a set of the same parts and which I installed as seem below:

While the addition of the braces seen above was, and still is, likely a good idea, I believe this had the effect noted in the following paragraph. Others agree that the below summation is the best-guess rationale to the flutter incident itself.

Over time, in flight, the loose vertical fin—the whole tail structure—was able to find its own sweet spot. Everything was free to move—however slight—in all axis. The addition of the horizontal stabilizer braces restricted any tail movement to a single axis. For whatever reason—minor turbulence, a wind gust, control shift—flutter began. Thankfully, as described above, it only lasted a brief fraction of a second until the tail again found its new sweet spot.

Research

Myself and my above mentioned engineering friend/fellow Moose builder/pilot read every article we could find on flutter. We talked to an engineering firm. We then embarked on a detailed analysis of the Moose itself, using my friend's Moose, to see if there were any discoverable resonant frequency issues between the Moose fuselage, wings or controls. At the recommendation of an engineering firm, we suspended his plane on big rubber doughnuts, and used a spectrum analysis meter while we generated huge volume, large amplitude sound waves.



After several days of thorough analysis, we didn’t find any issue whatsoever.

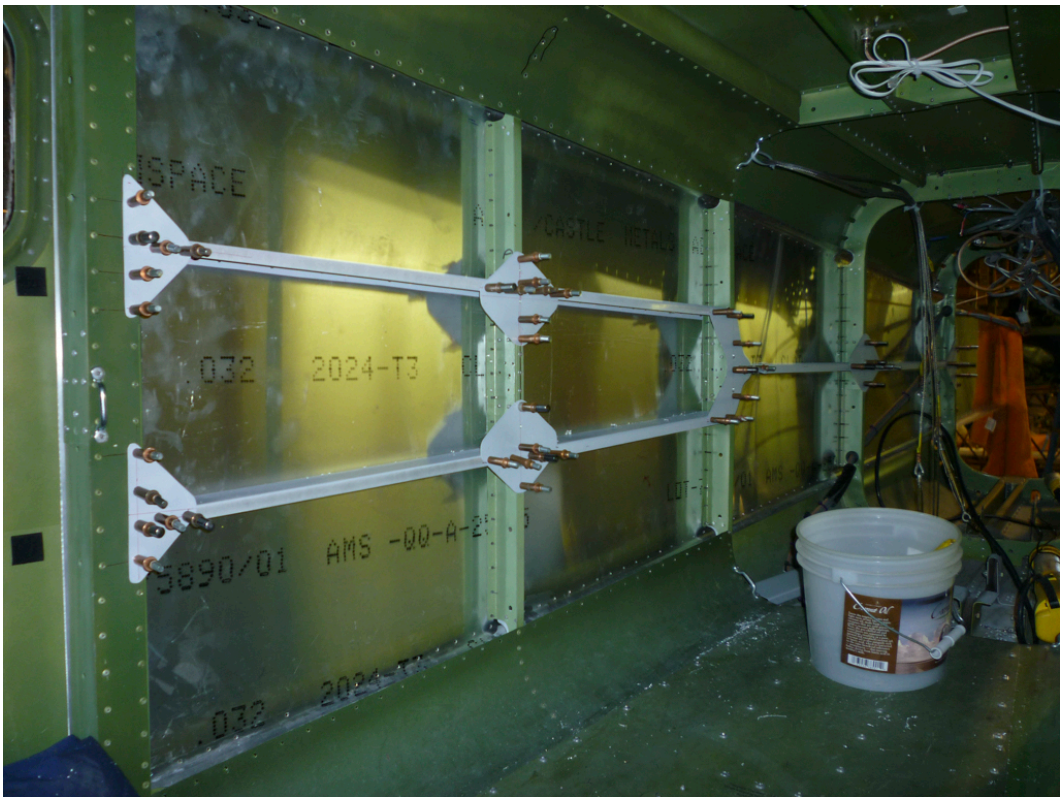
Rebuilding My Moose

Though I could have rebuilt only a few bulkheads, the project quickly became one of doing a much better build on the entire aft fuselage. I rebuilt everything aft of the baggage compartment. I employed much stronger (50% stronger) 2024 T3 rather than the standard 6061 T6 aluminum. I added channels and gussets to insure all structures were linked together into one stout aft fuselage.

I also swapped out the Murphy tailwheel with an Alaska Bushwheel tailwheel. Furthermore, I added a tailwheel lock as seen on many larger aircraft, including the Beaver.

As noted previously, I've flown the Moose well over 275+ hours since the flutter incident. I have had no problems whatsoever. No tailwheel shimmy either. I flew the Moose to Alaska and on many other cross-country flights in the West and to Oshkosh. Again, no issues at all. Problem solved—Solved correctly with balanced controls and a properly built aft fuselage!

There you have it! Additional pictures of the rebuild below.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