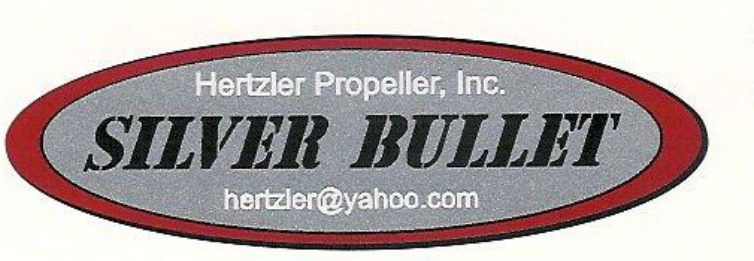
Silver Bullet Propeller



A little insight on how they are designed, manufactured and tested

Creation of Hertzler Propeller

- 30 years experience at Honeywell as turbine project and design manager
- Retired in mid 2000
- Started Hertzler Propeller December 2000 as a retirement “hobby” business
- Produced 30-40 props a year primarily for the canard pusher aircraft

Business Expansion

- Attempted to keep business small
- No formal advertising or internet site
- Word of mouth only kept me too busy
- Resorted to some outsourcing for several years to shorten delivery times

Silver Bullet Construction

- 5 laminations of clear straight grain hard maple
- Covered with unidirectional carbon and bi-directional fiberglass (45 degrees)
- MGS 285 or EPON 862 epoxy resin used – high Tg
- Hard Urethane rubber LE for FOD and rain erosion– Hapco Products
- Filled and painted per standard EZ painting techniques
- All PPG or Imron products used

Why Composite Prop Covering?

What went through these props?

Lower left quadrant of a Vari Eze cowl

13 inches of exhaust pipe

Why Composite Prop Covering?

What went through these props (continued)?

Fuel cap – Long-EZ. A plain wood propeller would have failed.

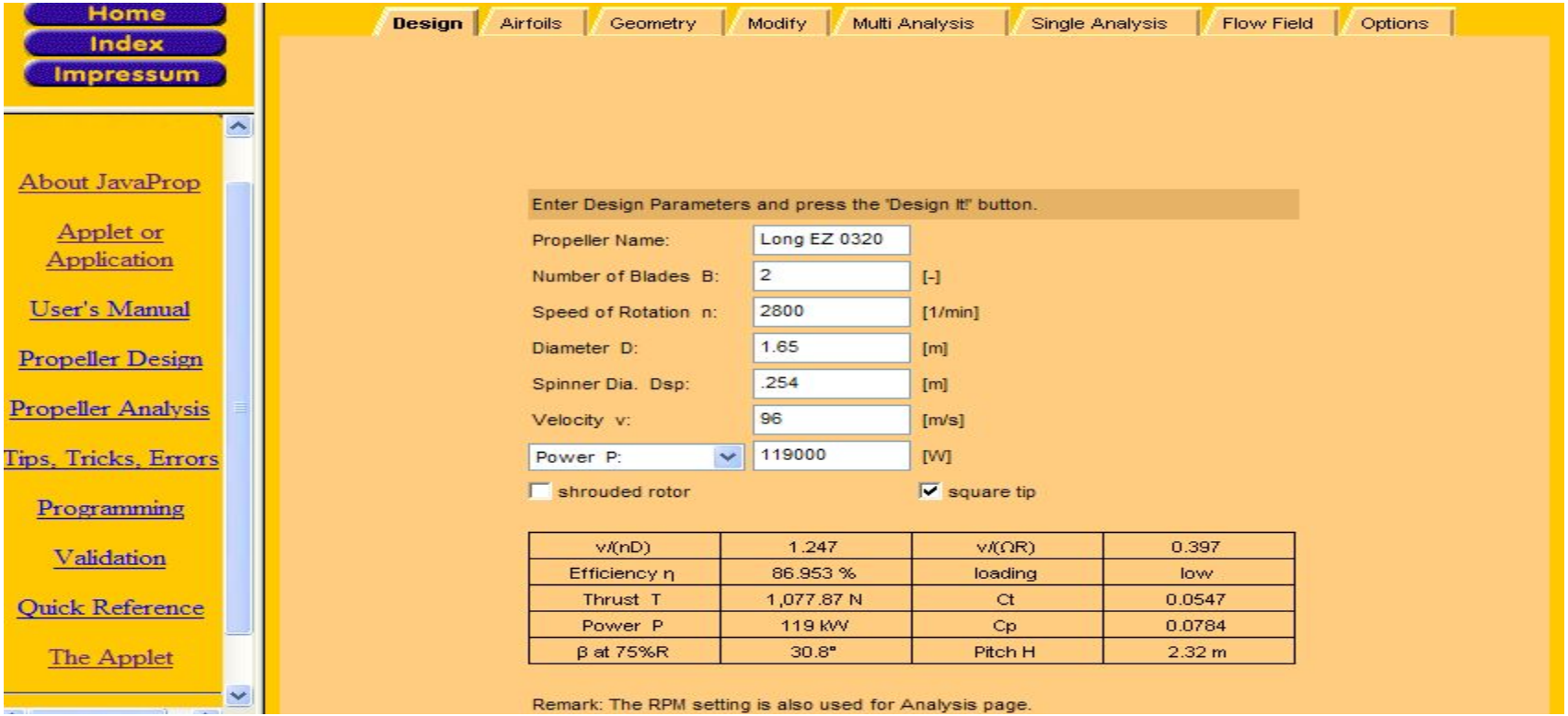
Propeller Design Programs

- Several design programs are available
  - Java Prop by Martin Hepperle
  - JC Propeller Design
    - http://www.jcpropellerdesign.com/
  - Prop Optimizer Pro
    - http://www.geocities.com/aeroopt/ppro.htm

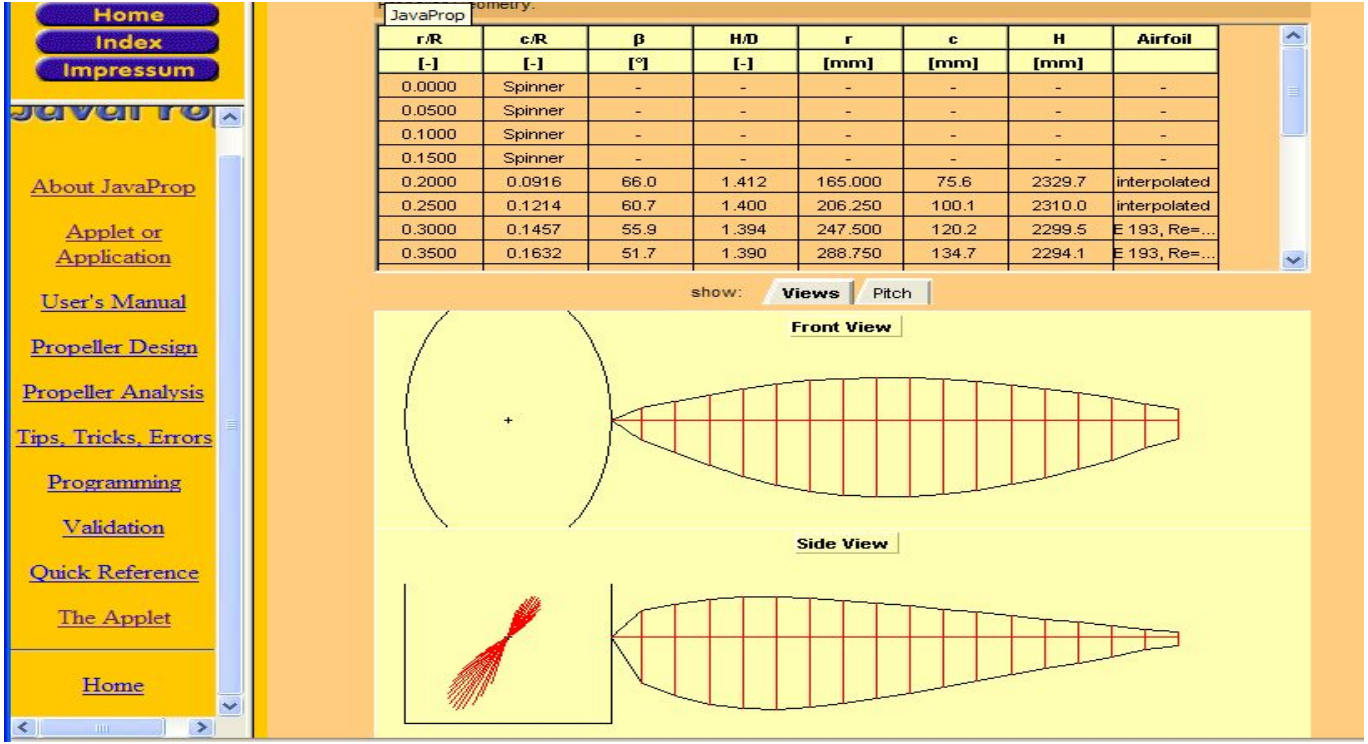
Propeller Design

- Input Parameters
  - Max S/L velocity
  - Engine rated horsepower and rpm
  - Propeller diameter
  - Propeller airfoil
  - Number of blades

Java Prop by *Martin Hepperle*



Java Prop by *Martin Hepperle*



Propeller Design

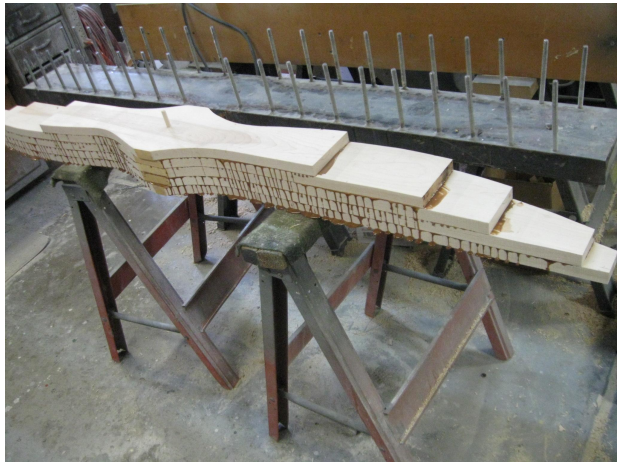
- Output Data
  - Airfoil coordinates
  - Full size templates at each 5% station

Creating a Master Blade

- Templates are glued to 1/8” masonite and mounted in a pressure side and suction side array

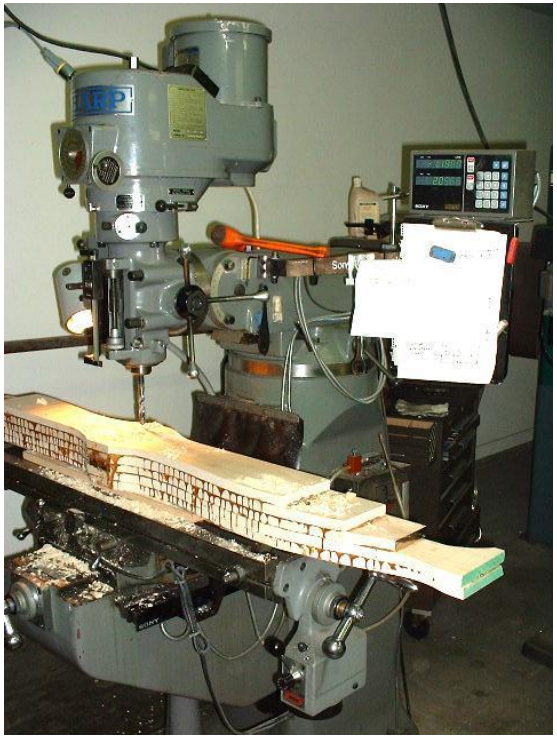
Creating a Master with a CNC Router

Gluing the Prop Blank



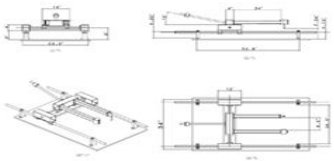
Drilling Prop Holes

- Precisely located with milling machine – not a drill jig
- The 6 prop bolt holes machined just prior to painting



Prop Duplicator

DYI or Purchased Duplicators



September 17 th, 2006

Drawings/Design: by Mark Grabowski, and Michael Duffy

Fabrication: Mark Grabowski, Michael Duffy, Shawn Schembri

Okay, we decided that it takes to long to hand carve a propeller, so we decided to design and build a propeller duplicator from scratch.

So from beginning to end I will take you through the long, and tedious process of manufacturing this thing. Cause designing it was the easy part.

Fabrication: Basically the design was based off of what we thought we could find in the scrap yard. If we could only find a round tube where a square one was suppose to go, then we used the round tube. Periodically there will be slight deviations from design because of this reason. Don't be alarmed, Mark knows everything.

Actual Propeller Duplication

Video of Propeller Duplicator in Action!

Copycarver.com

Gemini Duplicator

Production

Post Curing the Epoxy

Urethane Rubber Leading Edge

Leading edge sanded to a point for superior contact surface

Liquid urethane rubber poured into a leading edge mold and clamped into position until cured

Ready For Final Finish

Finishing process

- Squeegee on micro when layups are partially cured (West System)
- Sand and check balance
- Spray 2-3 wet coats of urethane primer
- Sand and check balance
- Spray on 2-3 coats of PPG Concept or Imron
- Final balance

Final Product Ready to Ship

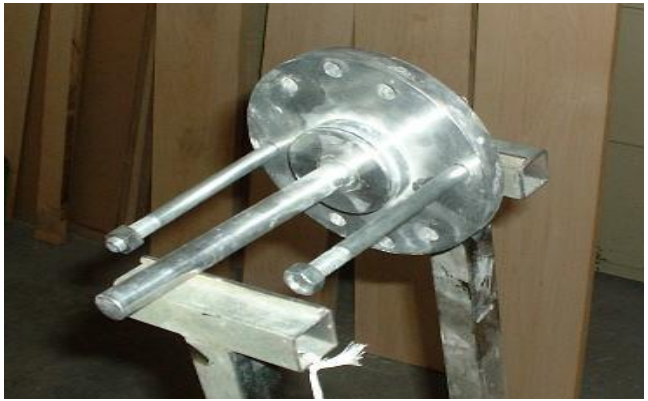
…and Tractors Too

Propeller Induced Vibration

- Static or single plane balance – mass center of each blade is in the same radial location
- Propeller track – mass center of each blade in same axial location
- Blade thrust – airfoil contour and planform control resulting in identical blade thrust

Static Balance

- The prop is balanced at each stage of manufacture
- Small weight as needed inserted and sealed in the prop hub at final balance

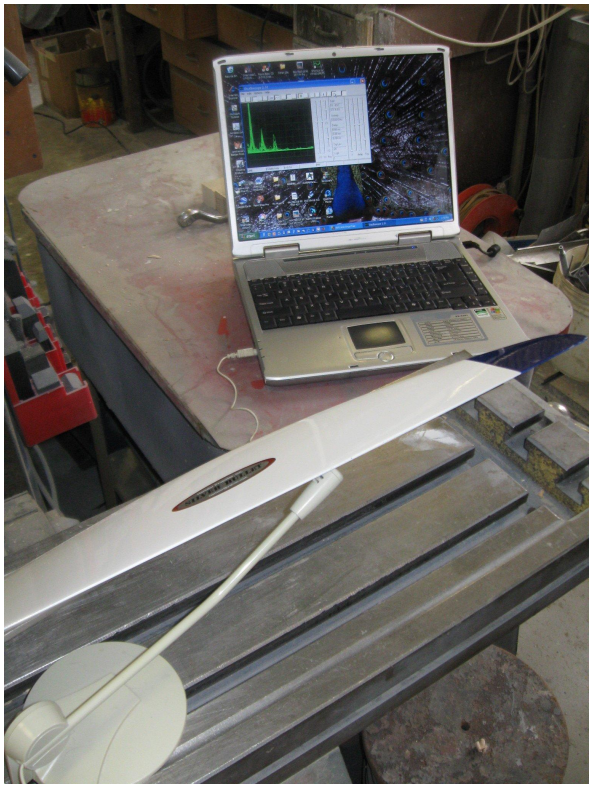


Propeller Blade Vibration

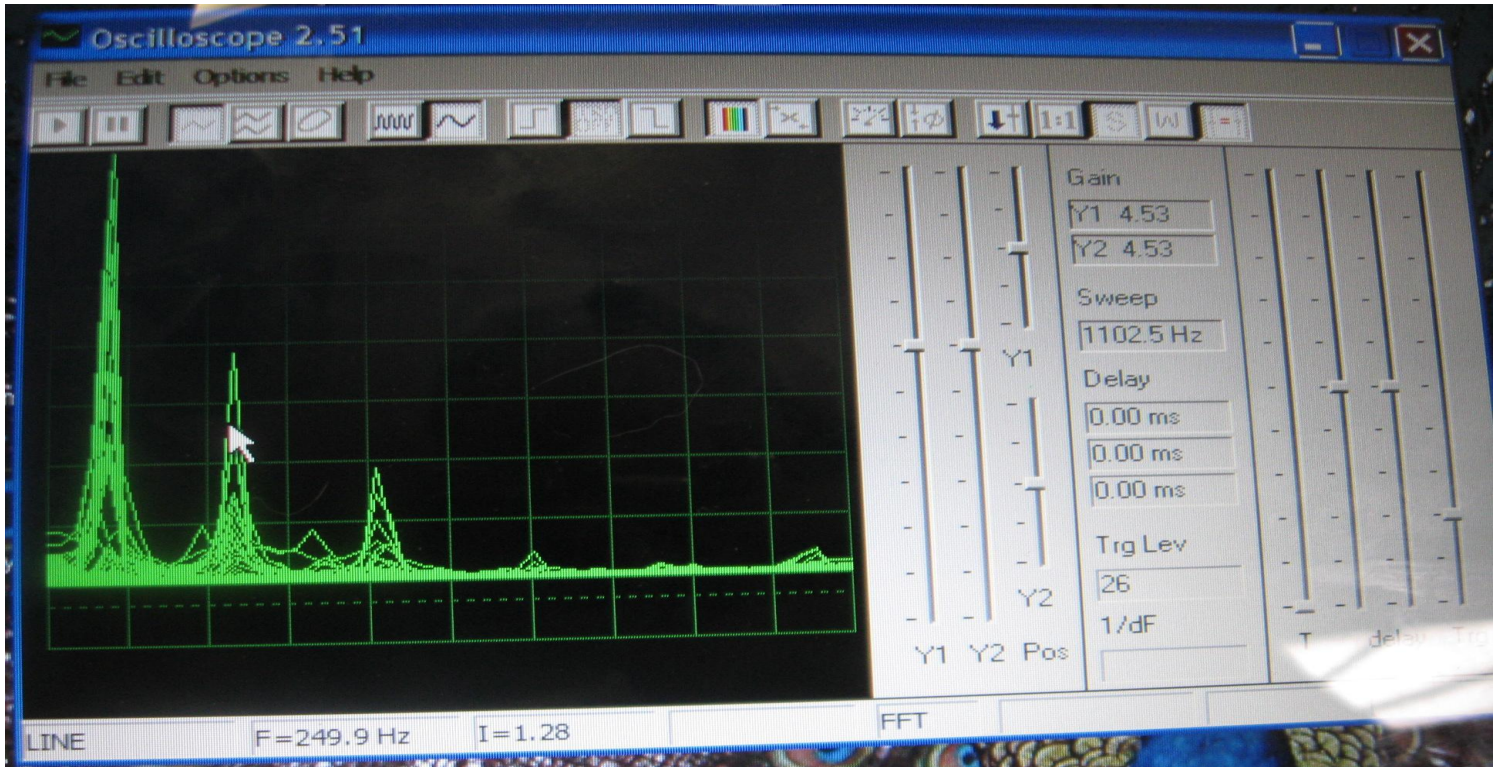
- Blade vibration induced by a combination of aerodynamics and engine torque pulses
- Wood/composite propellers are resistant to vibration induced failures
  - Internal damping
  - Crack growth properties

Blade Vibration Testing

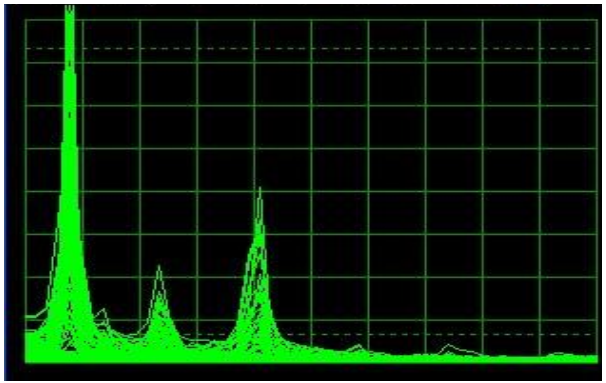
- Propeller mounted at hub
- Microphone pickup
- Winscope (shareware) installed on laptop
- Opposite blade tapped to induce vibration



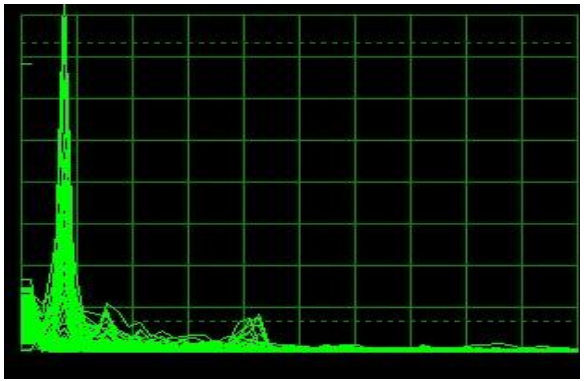
Vibration Signature



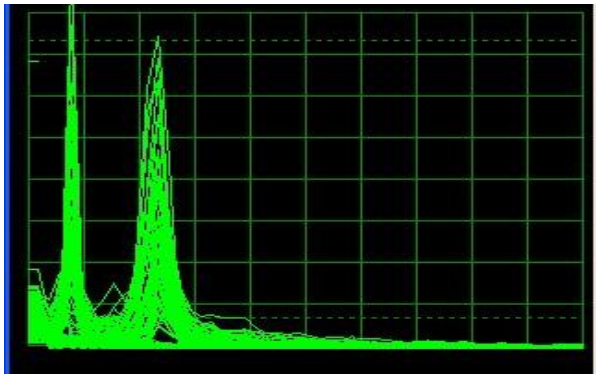
Node Point Location



12” from tip



6.5” from tip



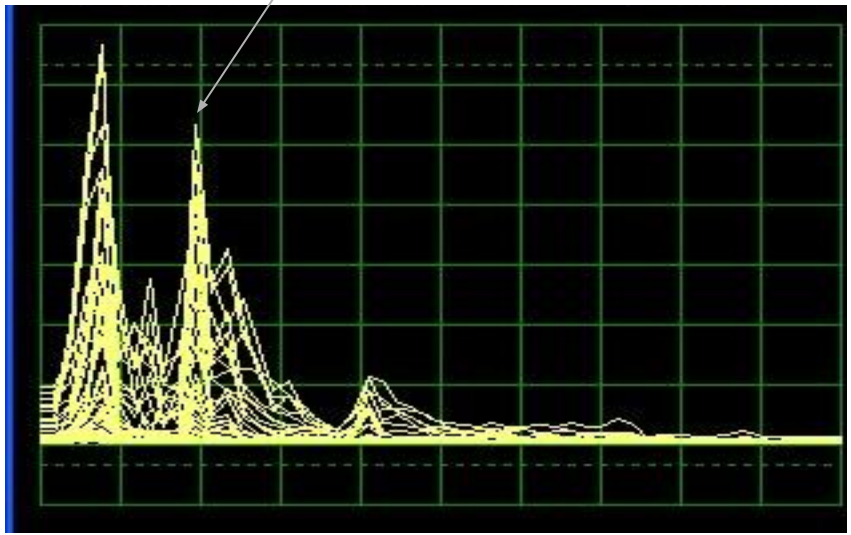
1” from tip

Increasing First Flex Frequency

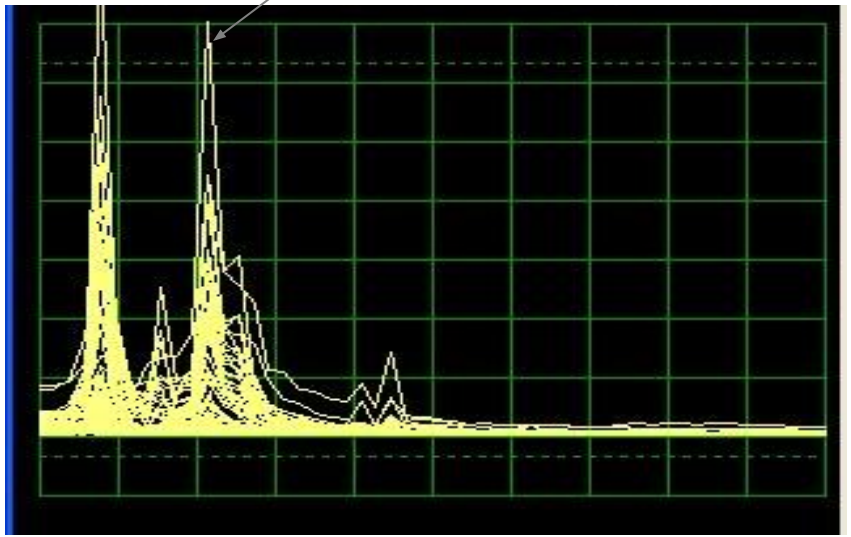
- Stiffen the blade
- Cut off the tip
- Remove mass from the tip

Stiffened Blade Results

213 Hz



235 Hz



Belleville Spring Washers

- Marc Zeitlin's excellent work on use of Belleville springs
- Propeller clamp load dependent on hub stability
- Shrinkage of hub can cause loss of clamp load
- Belleville spring washers provide added clamp load margin

Performance Testing

- Calm day with little up and down drafts
- GPS
- Stopwatch
- Voice recorder

Test Matrix

Aircraft :		Engine/HP:		Date:		
N#:		Fuel on board:				
Pilot:						
Prop						
Set altimeter at 29.92	Climb at a constant 120 knots IAS					
Begin timing at start of TO roll.						
	TIME	OAT	RPM	MP		
TO initiated	0					
Break ground						
2000ft						
3000 ft						
4000 ft						
5000 ft						
6000 ft						
7000 ft						
AT 8200 Ft Den Alt	IAS	MP	Fuel Flow	Indicated Alt:		
2200 RPM				OAT:		
2400 RPM						
2600 RPM						
2800 RPM						
Full Power _____RPM						
Compass heading	GPS Ground Speed	Indicated Alt:		Instrument Error		ITAS - indicated TAS
90 Degrees		OAT:		CTAS - ITAS:		CTAS - Calibrated TAS
180 Degrees		IAS:				
270 Degrees		ITAS:				
		CTAS:				
Fly at the same IAS for all three headings. Calculate CTAS from http://reacomp.com/true_airspeed/index.html						

Persson Propellers LLC

Established March, 2021. Assumed responsibility for Silver Bullet product line on January 1, 2022

Joe's Background

- 34 years experience at Boeing – Seattle
  - Retrofit Engineering (Structures, Mech. Systems, Propulsion, Cargo Fire Systems)
  - Certification Engineer and FAA ODA Project Administrator (FAA Appointee)
- Retired mid-2021 (sooner than originally planned, in order to spool up on propeller-making)

Transition from Hertzler to Persson

- Proposal made to Joe during Kanab, 2017
- Committed at Kanab 2018 to take over production
- First “training camp” with Gary in April, 2019
- Two more “training camps” followed

Transition from Hertzler to Persson

- First Persson propeller (to external customer) delivered in November, 2021
- Gary became a subcontractor on January 1, 2022
- This transition allowed the ramp-down (Gary) and ramp-up (Joe) over most of 2022.
- Gary produced 16 complete propellers in 2022 for Persson

Business Objectives

- Keep the business small – a “one-Person shop.”
- No formal advertising or internet site - word of mouth only
- Plan for 24 props per year (baseline):
  - Leave time to take care of incoming prop repair & refinishing
  - Leave time for “AOG” prop orders to best of ability

Business Objectives

- Limit repair/refinish work & technical support for propellers made only by Hertzler or Persson
- No near-term plans to develop new propeller models (this is a future objective)
- Primary product focus is propellers for the canard airplane designs

Product Changes

- Implemented small trailing edge skin-to-skin bond (with flox along wood) in outer blade section for improved TE closeout at the already thin TE
- Machine a relief outboard of the hub faces so composite skins are not “proud” of the planes of the hub faces – eliminates possible interference with spinner bulkhead

Product Changes

- Persson Propeller ID scheme:
  - Prop model example: 66P75, where “P” designates, “Pusher” (“T” for, “Tractor)
  - Each Persson prop has a serial number (“LMxxx”) where “xxx” is three digits
  - SAE hub type stamped in center bore beginning at S/N LM045
  - Carbon fiber ply count per blade surface stamped in center bore, done to ensure single-ply CF props are not used on higher HP engines

Product Changes

- Expanded Propeller Installation and Maintenance data:
  - Addresses propeller ID schemes for Hertzler and Persson propellers
  - Extra emphasis on best-practice propeller storage
  - Extra emphasis on using correctly-sized prop extension/crush plate combination
- Expansion of data done primarily assist the growing population of non-builder EAB operators

Questions and Contact Info

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