Propeller Testing Notes

Carl R. Denk (OH) - I have been flight testing propellers for Sensenich Wood Propeller Co. The following propellers are not necessarily the best performers for the situations, but the data was selected to illustrate a particular issue. I will draw conclusions from the data. I have heard that one particular propeller is a good or poor performer. This article will provide a standardized data collection method, covering most variables. Data collection is not as easy as one might think; issues and a few solutions follow:

1: Probably stable air is the most important item. My local terrain is flat, but surface color, i.e. a plowed or green field, parking lot or town causes thermals of more than 500 feet per minute. This will create a wide spread of climb data. In level flight speed data, when trying to maintain altitude, the airspeed can easily vary 10 knots. I ended up flying over Lake Erie for smooth air, but even there vertical air currents are possible if too near land.

2: I reduced climb data to something readily understood, but accurate enough to yield meaningful results and entered it in a MS Excel spreadsheet. After experimenting with various formulas, I settled on a straight line curve, which Excel fit to the data. Using data from 3000' to 8000' pressure altitude. Then 4 data points (only one for any one propeller) out of 54 data points were assumed faulty, and adjusted to make the curve fit better. The equation for each propeller's curve (straight line) was then used to calculate the rate of climb at 5000'. This is the key comparison number.

3: All testing used pressure altitude.

4: Aircraft fuel load and weight and balance was maintained closely.

5: Temperature: Most tests were with ground temperatures near freezing. I tested one propeller at warmer temperatures and will discuss it later. I have made no temperature adjustments to data.

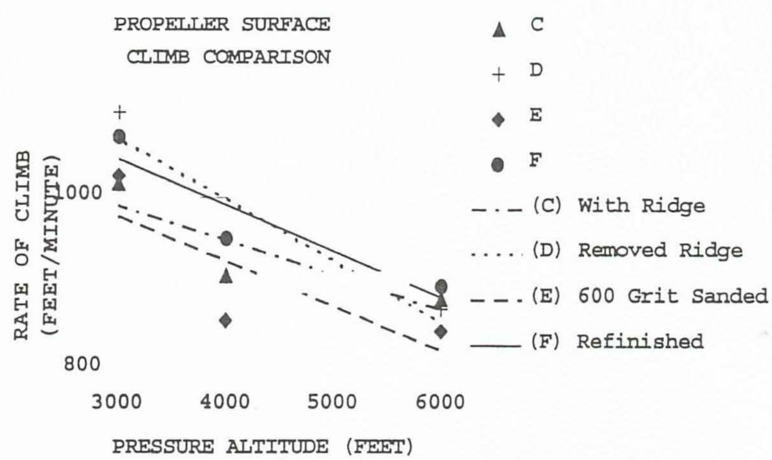
6: Humidity: No relative humidity correction was made.

7: Engine power output: The true indicator of propeller performance, is the ability to convert a given power output to speed and correctly dividing the speed by horsepower. This would be the ultimate comparison of propeller design and a better predictor of propeller performance at different power settings and altitudes. Designers are very interested in this factor, but I haven't touched it yet.

8: All fixed pitch propellers are compromises between takeoff distance, climb and cruise. There are propellers that give excellent cruise performance at certain altitudes. Cruise RPM, cruise power, cruise altitude, altitude of usual airport need to determined before the prop design can be completed.

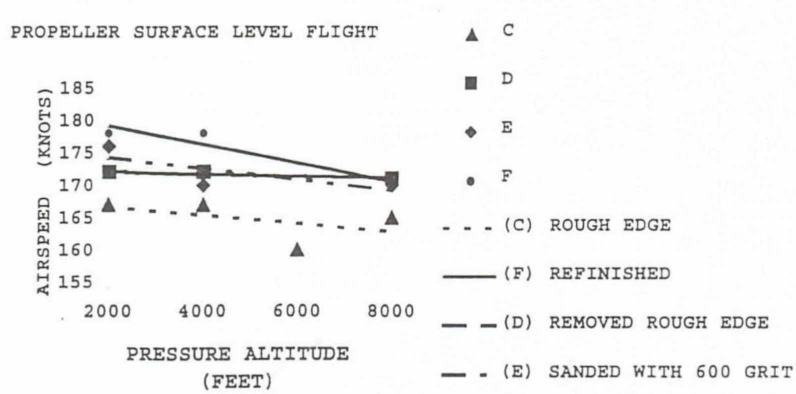
9: Pitch designation only has meaning within one manufacturer/family of propellers. Different manufacturers measure pitch at various distances from the center, on the flat or curved face, with or without a template and with airfoil differences.

Effect Of Propeller Surface Roughness: One propeller was intentionally finished with the urethane leading edge masked, while a urethane clear finish was applied to the prop. A rough ridge resulted on both sides of the leading edge where the flowing air had to step up. The 2nd flight was made with the ridge block sanded off back an inch with 600 grit. The 3rd flight had the entire blade area was roughened with 600 grit. The 4th flight was made with the entire prop refinished with Deltron, sanded with 1500 grit and buffed to a high gloss.

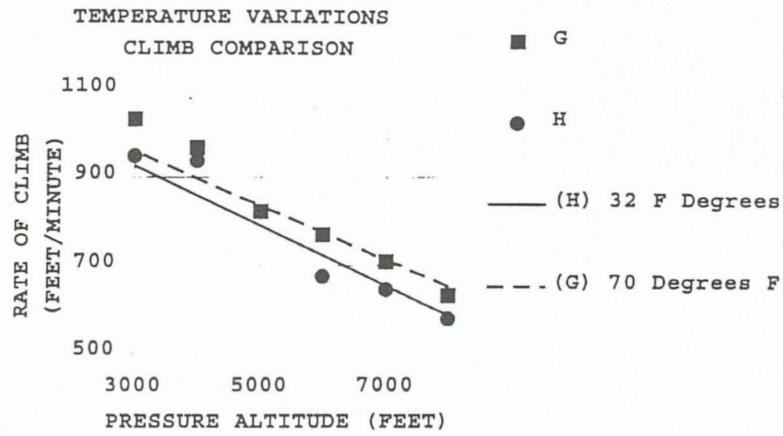


The above graph shows the stepped rough leading edge increased ROC (Rate of Climb) by 33 FPM. After sanding the whole blade with 600 grit paper, 60 FPM was lost. Finishing the prop to a high gloss, gained 70 FPM. The refinished prop produced about 5 knots extra at all altitudes. One may conclude a prop should be kept in high gloss condition for best performance.

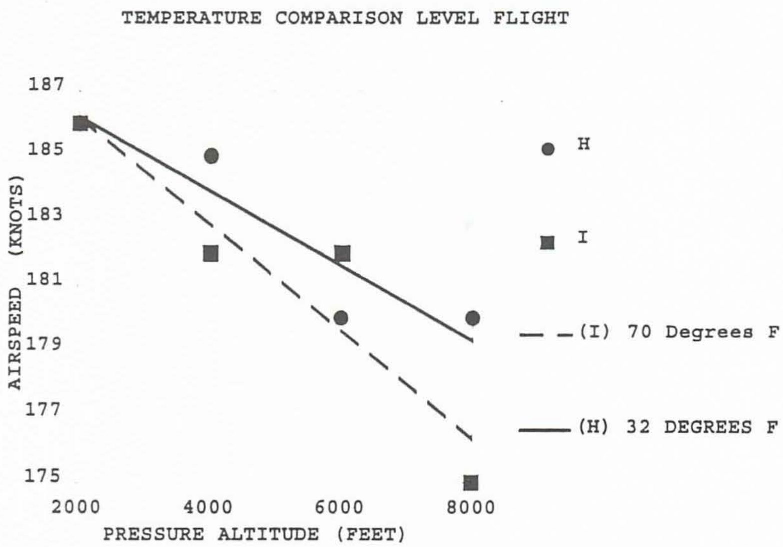
Cruise: The following chart is for the same props and displays the effects of surface roughness in cruise. All cruise data are with IO-320, 160 Hp., 2700 RPM or 25.5" Manifold Pressure, which ever is a lower power setting. The same trends are shown in cruise as in climb.



Temperature Effects: I haven't conducted much testing at different temperatures. I was able to test one prop at ground starting temperatures of 32 and 70° F. The adjacent chart shows a 42° F rise in temperature resulted in 54 FPM decrease in ROC. I think the rule of thumb could be 1 FPM decrease for 1° F increase, or the same ROC will occur 1000' lower for 40° F temperature rise.



As you can see, the level flight data points don't appear to be very good, but they show the issues involved. Possibly there was a thermal at lower altitudes that allowed the airspeed to be higher, while maintaining altitude.

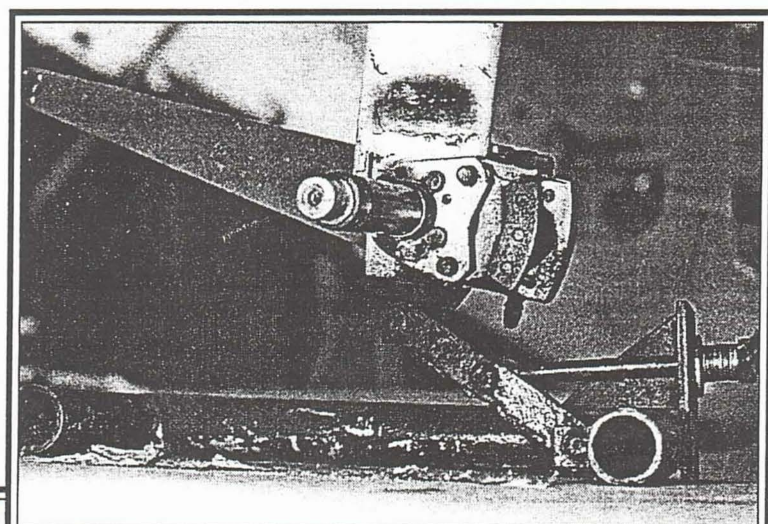


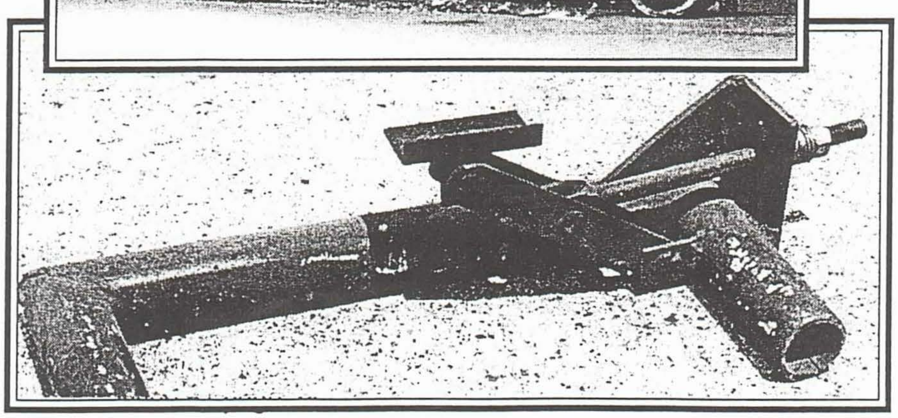
In the next newsletter, I'll compare the various props in climb and cruise configuration at various power settings. I have a conventional wood .3" lamination prop, and a composite prop now, with another conventional prop coming this week. This has been quite a learning experience.

Jack em Up

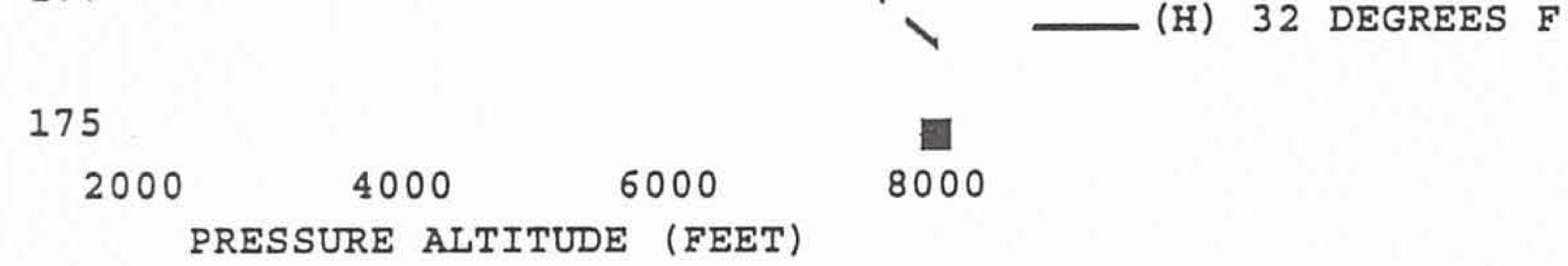
Sooner or later, one has to jack his airplane up to perform maintenance. Many methods will work and several have been published in this newsletter over the years. I have tried them all but have been unhappy with the lack of security I've felt while the airplane was off the ground or have found the hardware to be difficult to store in a limited area.

The jack I made is cheap and, being the size of a shoe box, takes little space. The frame is made of 1-1/4" water pipe while the remaining is fabricated of scrap steel pieced together. A length of all thread rod makes up the tensioning member and can be adjusted by adding washers to get the lifting range needed.





The lifting pad on top should move freely to match the angle of the main gear strut. Be sure the pad does not hit the brake disc or you will not be able to rotate the wheel when the strut is jacked up. The frame opening should be big enough to clear the tire when it is on the ground but other dimensions are not important.



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