GURNEY FLAPS AND RELATED AIRFOIL MYSTERIES

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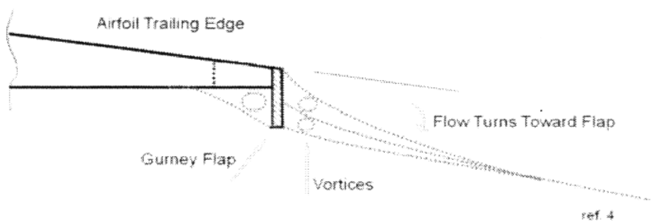
Airfoils are discussed when modelers are not actively building, flying, or making imaginary airplane sounds. Gurney flaps are one of these airfoil devices that consist of a small angle (.01- .02 chord) that dangles below the airfoil at the trailing edge of the wing. They are used to modify the airflow either to change wing lift overall or locally applied to adjust the trim of the airplane.

What they are and they work?

R. Liebeck developed a sophisticated low speed two element airfoil for application to Indianapolis racing cars using computer modeling (ref.1). The Li74 airfoil as designed had a very thin trailing edge. It vibrated at race speeds so the race car team reinforced the trailing edge with small angle iron. Both the lift and LID improved. This was a surprise to the race team, but would not have been to modelers such as Bill Gieskieng who described a similar trailing edge wedge back in the 1964-65 Zaic Yearbook (ref. 2). The thing that surprises me is that it was named for the race car driver instead of the forgotten car mechanic or named the "Zaparka Flap" after the aerodynamicist who patented something similar in 1935.

A Gurney flap is a small strake that is perpendicular to the bottom of the wing located at the lower trailing edge. It influences the airflow around the wing by causing the airflow to bend towards the flap increasing the wing downwash and thereby lift. They are commonly sized around .01 to .02 of the chord length (optimal size is below the thickness of the boundary layer at the lower trailing edge - ref. 3). More thickness of the flap further increases lift but can cause the drag to rise as well. Tests done by Liebeck (ref. 1) showed the device increased lift and decreased drag around two dimensional wind tunnel models. Because of the lower speeds and smaller size of our models the impact for them is untested. I've made a small sketch to show how the gurney flap deflects the air downward near the trailing edge. The local airflow separates from the wing both in front of and behind the wing. The dividing line between smooth air and separated air is shown as a dotted line. The separated air makes the wing behave as if it was wider and had more camber. The downward deflection of the air acts just like a physical deflected flap.



The entire airflow around the wing is affected so the flap also increases the way the flow approaches the leading edge and ever important forward upper surface where most of the lift is generated. The Gurney Flap would be expected to change the trim of the model.

Related to the Gurney flap is the use of a small triangle in the same spot to accomplish this task. The Brown study, ref. 3,indicates that a triangle does not have as great a impact as a similar sized Gurney flap. I prefer a triangle because they provide adequate surface area to allow easy gluing under the trailing edge.

Impact

While carefully done tests have shown some impact on improved lift compared to drag, I am immediately attracted to the capability to carry a heavier load from higher lift, and the stiffening effect of a perpendicular piece on a lightweight trailing edge.

I experiment with the amount of rubber that my models can manage. I built two dime scale models from the same plan at staggered times. One model for reasons that remain a mystery flew best on a modest rubber motor and would not tolerate my efforts to fly it with a heavier thicker motor. The second model readily accepts more power and motor weight leading to a longer higher powered flight (I leave it to you to consider which of the two thermaled better). The use of a Gurney flap to aid in producing lift could have an advantage in being able to shoulder more rubber weight for longer motor runs.

The addition of a Gurney flap adds to the structural depth of the trailing edge. The traditional trailing edge structure resists the pull of tissue forward but can deflect upward. The depth of the flap helps the upward bowing.

Because the effect from the flap is generated by the vorticies and flow surface behind the wing the impact of air gusts and turbulence in wind is untested. According to Brown, the vorticess that produce the additional lift are rather unsteady and have oscillatory characteristics at low speeds. His measurements are a view of the time average of resulting forces. In our real world, gust and turbulence playa role. In addition, nice tests on a two dimensional wind tunnel airfoil give no indication of three dimensional span wise flow. The vorticies behind a Gurney flap allow flow down the length of the wing. This might be important in highly tapered, swept wings, or in situations were one portion of the wing stalls locally. Airflow at one portion of the wing influences other positions. You'll just have to try something and see. Why should the aerodynamist and wind tunnel guys have all the fun.

Tried and True Testing

The modeler should be aware that there is not much research at the low size and low speed regime where our models fly. Other than those who dream of the flying-machine exploration of Mars or the increasing horde of drone designers, most research has been focused on full size and fast airplanes. While others may wait for advances in science, computers, and specialized wind tunnels, I'm for getting some air under your wings and fly. Here is a way to do some tests.

Trim a model to fly absolutely straight in a glide with propeller removed. Then make the experimental change to one side of the model. Repeat the trial and carefully observe the model. Does it lift one wing more than the other inducing a turn. Does the change induce a stall with the resulting dropping of a wing. Does one side seem to have more drag causing a turn. This testing takes repeated launches because the effects might be subtle and subject to differences in launching technique. Don Srull and I did this with an old timer model to try to tame an otherwise horrid airfoil. Some careful testing and application of turbulators helped the situation.

You might consider doing this type of tests with an older model that has past its Kanone-grabbing days. What better way to learn something than with a model with which you have some experience.

Trimming Aid

Stan Buddenbohm in his hand-launched and catapult-launched gliders has long advocated using wedges near the trailing edge to modify the models' trim. He argues that adding a short wedge makes for trim changes that are permanent, variable with a change in their length, and not subject to changes in humidity. I prefer thin edges that can be adjusted by breathing on them in my gliders but maybe it is just a case of old-dog-and-new-tricks. Jack Gore's superb rubber models frequently feature a short wedge (1 *3/4"* to *2 1/4"* long by *1/16"* to *3/32"* thick) under one wingtip to help lift that wingtip during a portion of the flight. Such wedges increase the local lift on that section of the wing. The overall effect on the flight can be quickly tested using a wedge stuck on with glue stick and more permanently attached later.

The strength of the trim wedge is changed by the location, length of the tab, and tab thickness. If it doesn't work right, just change it. In this application a wedge or Gurney flap replaces unsightly paper tabs or tedious steaming over a kettle. Wash-in can be added by using a flap without building in wash-in or warping it in. Any place where you want to tailor the spanwise lift distribution these flaps are useful.

Unleash your inner scientist and experiment

The most important contribution of trying Gurney flaps or wedges is to awaken your inner 12-year old and find a new way to experiment and have fun with your models. Trying new airfoils normally means building new wings but anyone can glue-stick on a Gurney flap to see what happens.

1. Liebeck, R.H., "On the Design of Subsonic Airfoils for High Lift," AIAA paper No. 76-406, July 1976.
2. Gieskieng, B., "Indoor H.L. Glider Section," Zaic Yearbook 1964-65, pg. 164.
3. Brown, L. and Filippone, A., "Airfoil at Low Speeds with Gurney Flaps," Dept. of Mechanical Aerospace, Manufacturing Engineering, UMIST.
4. Simpers, G., "Gurney Flaps", National Free Flight Symposium 1977.