Self-Activated Moveable Flaps

David Rosenberg
Motivation

- “Pop-up feathers” on birds
- What are their function?
Objective

- Standardize data-taking method
- Evaluate self-activated moveable flaps at low Reynolds numbers
  - Size
  - Placement
Concept

- **Normal Flight conditions**
  - Pop up flaps not raised
  - Does not effect streamlines-
    Laminar flow

- **High Angle of Attack**
  - Separation produces low pressures
  - Flap raises to keep flow attached, increasing lift and delaying stall
Wind Tunnel Testing

- Tompkin’s wind tunnel
  - 14 in. by 12 in. test section.
  - NACA 2412 wing with 5 inch chord
- Force analysis with a force balance and LabView
- Testing at 4 inH₂O
- Testing of angles of attack from -2.5° to 17.5° in 2.5° increments.
The chart displays the tests performed with the flap size and flap position. Flaps were moved down the wing in increments of 1/10 of the chord.

In addition, tests were also performed with a 1 inch flap at the 60% x/c position, where the flap was cut to cover various amounts of the wing's width. The tests are listed below. Some of the tests had the end closest to the endplate taped down.

- 50% wingspan, endplate to middle, not taped
- 50% wingspan, middle to outer end, not taped
- 50% wingspan, middle to outer end, middle end taped
- 25% wingspan, middle to 3/4 wingspan, not taped
- 25% wingspan, middle to 3/4 wingspan, middle end taped
- 25% wingspan, 3/4 wingspan to outer edge, not taped
- 25% wingspan, 3/4 wingspan to outer edge, 3/4 end taped
- 50% wingspan, 1/2 wingspan to 3/4 wingspan, not taped

<table>
<thead>
<tr>
<th>Flap Position</th>
<th>1 in.</th>
<th>1.5 in.</th>
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</thead>
<tbody>
<tr>
<td>No Flap</td>
<td>X</td>
<td>X</td>
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<tr>
<td>0% x/c</td>
<td></td>
<td></td>
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<tr>
<td>10% x/c</td>
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<td>20% x/c</td>
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<tr>
<td>30% x/c</td>
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<tr>
<td>40% x/c</td>
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<td>50% x/c</td>
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<tr>
<td>60% x/c</td>
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<td>70% x/c</td>
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<td>80% x/c</td>
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<td>90% x/c</td>
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<tr>
<td>100% x/c</td>
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</tbody>
</table>
The Flaps

- The flaps used on the test were a flexible, clear plastic removed from common 3-ring binders.
- The flaps were rough on one side, and smooth on the other. For testing the smooth side was placed down, against the wing.
- The flaps were attached to the wing with electrical tape running along the width of the wing.
Smoke test

- Smoke seemed to separate at leading edge during stall.
**Results**

- **Dramatic improvement in lift at high angles for 40%, 50%, and 60% x/c**

While stall was delayed for flaps at 40%, 50%, and 60% x/c, stall never seemed to occur for a 1 inch flap at 10% x/c.
Results

- Dramatic improvements in Cd for a 1 inch flap at 10% x/c

All flaps had a dramatic increase in lift during stall between 12.5° and 15°, except a 1 inch flap at 10% x/c
Results

- **Dramatic improvements in Cl/Cd at high angles**

Stall was delayed by 22% for a 1 inch flap at 50% x/c, compared to no flap.
Results

- Flaps are effective only when they cover the entire width of the wing.
Conclusions

- Greatest improvements in delaying stall seem to happen at 50% or 60% x/c
- In smoke test, smoke seemed to separate at leading edge of wing
- In 1 inch flap tests, a flap at 10% x/c never seemed to stall.
Future Research

- Improved method of attaching flaps is needed.
- Test a flap at 0% x/c with improved method of attachment
- Improved flap material that will stand up to intense vibrations
- Professionally calibrated DAQ system
Contact Information

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