CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)
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Project Number
S0106

Project Title
Which Angle of Attack Generates Maximum Lift for Cambered and Symmetrical Airfoils?

Abstract

Objectives/Goals
The project's purposes were 1) to determine the geometric and effective angles of attack that would generate maximum lift for the airfoils I tested and 2) to determine how an airfoil's camber affects the angle at which it generates maximum lift. Most commercial aircraft (with moderately cambered wings) stall between 15 and 20 degrees, immediately after generating maximum lift. Therefore, I hypothesized that a moderately cambered airfoil would generate maximum lift at a geometric angle between 15 and 20 degrees. I also hypothesized that increasing camber would increase the angle that generated maximum lift.

Methods/Materials
Three airfoils were constructed: one moderately cambered (A), one symmetrical (B, the control), and one highly cambered (C). In a wind tunnel, each was tested for lift at fifteen effective angles of attack from -30 to 40 degrees (at 5-degree intervals). Lift was calculated by finding the difference in each airfoil's weight before and during each test and converting this weight (grams) to lift (newtons). The cambered airfoils' lift patterns were compared to the symmetrical airfoil's. All other variables of lift (airfoil planform area, air velocity, and air density) were controlled.

Results
Both the moderately cambered airfoil (A) and symmetrical airfoil (B) generated maximum lift at an effective angle of attack between 25 and 30 degrees (a geometric angle between 16 and 21 degrees). The highly cambered airfoil generated maximum lift at an effective angle of 40 degrees (a geometric angle of 28 degrees).

Conclusions/Discussion
My original hypothesis was correct; the moderately cambered airfoil (A) (modeled after a Boeing 747-400 wing cross-section) generated maximum lift in this range. As Airfoil C demonstrated, camber in an airfoil increases not only the angle of attack that generates maximum lift but also the rate at which lift increases. The symmetrical airfoil (B) likely exhibited patterns similar to A's because the scale's shape may have generated additional lift.

Summary Statement
This project examines 1) the effective and geometric angles of attack that generate maximum lift for airfoils and 2) how camber affects these angles.

Help Received
Father helped construct airfoils.