CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
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Project Number
S0310

Project Title
Safety or Savings? Washout Designs on an Airplane Wing Considering Induced Drag

Abstract

Objectives/Goals
The purpose of this project was to discover whether there was an optimum amount of washout that could be incorporated in an airplane wing, in which the stability and safety benefits are applicable while the accompanying induced drag is at a minimum value.

Methods/Materials
The effect of geometric twist (washout) was tested with regard to the point of flow separation along the wingspan and the coefficient of drag. 5 physical wings with +3, 0, -3, -6, and -9 degree washout were fashioned and tested individually in a water tunnel. Flow modeling was achieved using dye injection at the trailing edge of the wings, and aerial photos were taken of the wings at different angles of attack. Subsequently the computer program LinAir was employed to reproduce the modeled wings with geometric twist ranging from +16 degree washout to -16 degrees. For every wing the angle of attack at which the lift coefficient equaled 0.50 was used to calculate the corresponding drag coefficient for each wing.

Results
The implemented washout designs, as demonstrated by the flow visualization patterns in the wind tunnel, moved the point of flow separation inboard. However, the LinAir modeling showed that while the stall region move closer to the wing root, the coefficient of drag reached a minimum at -1 degrees of washout and began to steadily increase with both increased and decreased washout. The angle of attack at which each wing reached a lift coefficient of 0.50 increased as the amount of implemented washout increased.

Conclusions/Discussion
It may be beneficial to increase washout in order to gain the stability benefits since the amount increase in the coefficient of drag negligible. However, as demonstrated by the LinAir experimentation, with the addition of washout the wing begins to have a negative lift coefficient and effectively lifts downwards at small angles of attack, which slowly increases as the amount of washout is increased. In addition, the lift coefficient is significantly less for those wings with washout as opposed to those which twist in the opposite direction. Therefore, the question of whether to implement washout may simply be the choice between paying more for a safer, more stable airplane ride and paying less for a more efficient and faster ride.

Summary Statement
My project aimed to discover whether there was an optimum amount of washout that could be incorporated in a wing in which the wing is both stable and safe but the induced drag is at a minimum.

Help Received
NASA engineers provided computer program, assisted in creating wing models, operating water tunnel