CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

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Project Number

33834

Project Title

High Performance Sail Design

Abstract

Objectives/Goals

This science fair project determined the best mainsail design for racing, cruising, and racer-cruiser sailboats. I experimented with three sail designs: the Marconi sail (shaped like a right triangle); the high roach mainsail (shaped like the Marconi sail, except the hypotenuse is curved aft, giving the sail more area high up); and the flat-head mainsail (shaped like a rectangle). My hypothesis is that the flat#head mainsail will produce too much sideways force to be effective, the Marconi sail will not be effective enough at the head or top, and the high-roach sail will produce the most effective force for racers and cruisers. By effective force I mean that the sail will produce the largest amount of forward thrust, and the sideways force will be less than or equal to the forward drive.

Methods/Materials

I designed a two-layer, non-friction force-testing device to measure the forces generated by the sails. Two layers of wood, separated by three marbles encaged in plastic rings, were used to support the boat and enable the measurement of sideways and forward force by two strain gauges. I designed a flat-head mainsail and a high-roach mainsail on a piece of graph paper, copied the designs onto sail cloth, cut out and stitched them (the Marconi came with the sailboat). I rigged one sail on the model boat, positioned it in the testing device, and used a fan to control for wind angle and speed. I released the top board, let it settle, and recorded the numbers shown on the strain gauges. I repeated the process 100 times for each sail, generating 300 data points.

Results

The flat-head mainsail preformed the best with an average forward thrust of .36 Newtons (N) and an average sideways force of .32N. The Marconi mainsail#s forward thrust average was .28N and the sideways force average was .28N, while the high roach had a forward thrust average of .26N and a sideways force average of .34N.

Conclusions/Discussion

The high roach mainsail performed the worst: the sideways thrust exceeded the forward drive, opposite of what I hypothesized. The Marconi sail performed second best as predicted. The flat-head mainsail was the most efficient; it has the optimal width from top to bottom, producing drive while minimizing drag. More sail area up high affects the amount of heeling less than I predicted. The flat-head is best for racers, but impractical for others due to the need for running backstays.

Summary Statement

This project determined which of three mainsail designs (high roach, flat-head, and Marconi) would work the best for racer, racer-cruiser, and cruiser sailboats.

Help Received

Peter Berry helped me with the design of the testing device and the application of battens on the sails; Mark Baker helped me build the testing device; Louise Berry instructed me on how to use the sewing machine; Kim Berry taught me Microsoft Publisher for designing the backboard.

Preliminary