CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Sarah M. Balbi

Project Number

S0101

Project Title

Let's Get Wet: A Comparative Analysis of Competitive Freestyle Stroke Methods

Abstract

Objectives/Goals

The purpose of this experiment is to find the answer to a personal question: What is the fastest way to swim freestyle stroke? I want to compare two different strokes to see if there is any advantage of one stroke style over the other.

Methods/Materials

For five weeks twice a week I would alternate the two strokes starting with the stroke that I had not started with the previous day. I produced a method of swimming a warm-up of 1000 yard and the swimming a set of four 50-yard sprints. All times were timed by my swimming coach.

Results

The results show that there was not a significant difference between the two strokes, because I took the standard deviation and the standard deviation of the mean (SDM.) The plus or minus of the SDM turned out to be greater than the difference between the average times for the two strokes. However, the results show that whichever stroke was sprinted first was the faster was the faster sprint throughout the four 50's.

Conclusions/Discussion

In the 50-yard swim, it does not make a significant difference in time to swim the old way or the new way. What does make a difference is if the stroke is swam first or second. Each of my trials proved that whatever stroke type the day started out with is the fastest stroke of that trial. Therefore, with the data I have collected it appears that neither stroke is obviously faster.

Summary Statement

I compared two methods of swimming the competitive freestyle stroke.

Help Received

My coach Larry Countryman timed every one of my sprints during the experiment. My teacher Mr. Sweet gave me advice in what way to direct my experiment and corrected my spelling.

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Victor Guerrero; Rene Sorrosa

Project Number

S0102

Project Title

Floating on Air

Abstract

Objectives/Goals

To test the kinetic and static friction of a home-built hovercraft on five different surfaces.

Methods/Materials

We built a hovercraft using plywood, plastic, pipe fittings, and a vacuum cleaner motor. Then we used a Vernier LabPro force meter to measure the static and kinetic friction of the hovercraft on the different surfaces. We tested each surface five times. Then we calculated the coefficients of static and kinetic friction for the hovercraft on each of the surfaces.

Results

We found that the 4 mil plastic had the lowest static friction coefficient; the highest was a waxed wood floor. For the kinetic friction coefficient the waxed wood floor was lowest and carpet was highest.

Conclusions/Discussion

We were surprised with some of our results. We expected the waxed wood floor to have the lowest friction; it turned out to have a high static friction coefficient and a low kinetic friction coefficient. We expected carpet to have the highest friction; it turned out to have the second highest static friction coefficient and the highest kinetic friction coefficient.

If we were to continue this project next year we would like to see what effect two motors would have on the performance of the hovercraft.

Summary Statement

We made a hovercraft and tested its coefficient of static and kinetic friction of five different floor surfaces.

Help Received

Ms. McCorkell, our teacher, helped us with the idea, with troubleshooting the hovercraft, and with editing. She also taught us how to use a LabPro force meter and to calculate static and kinetic coefficients of friction.

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Keiko Imazumi; Nicole Parsels

Project Number

S0103

Project Title

Salinity, Buoyancy, and Drag

Abstract

Objectives/Goals

Our objective was the measure the effect the change in salinity has on the buoyancy and drag of the boat.

Methods/Materials

We constructed a modek boat and tank out of masonite and pine wood. Two pumps were used to maintain a constant flow of water through the tank. The boat was placed in the tank and a pully system and spring gauge were used to measure the drag of the boat. We added 1L of salt to the water, then measured the drag after the salt dissolved. Procedures were repeated with an increase of 1L of salt for each event.

Results

The first event of our enperiment, which has no salt measured a drag of .75 newtons. As we continued the events, adding 1 liter of salt each time, the results were, .65 newtons for 1L of salt, .55 newtons for 2L of salt, .55 newtons for 3L of salt, .45 newtons for 4L of salt, .45 newtons for 5L of salt, .40 newtons for 6L of salt, .35 newtons for 7L of salt, .30 newtons for 8L of salt, and .30 newtons for 9L of salt. These results showed that as the amount of salt increased, the drag decreased.

Conclusions/Discussion

Our conclusion was that the increase in salt causes the density of the water to increase, which reduces the volume of water displaced by the mass of the boat. It reduces the hull surface in contact with the water, which reduces the drag. For change in salinity of 9% we recorded a 40% reduction in drag.

Summary Statement

For our project, we measured the effect the change in salinity has on the buoyancy and drag of a boat.

Help Received

My father helped us in building the tank and the boat.

Name(s)

Kevin K. Kuramura

Project Number

S0104

Project Title

Airplane Maneuverability

Abstract

Objectives/Goals

My objective was to learn about what makes an airplane maneuverable.

Methods/Materials

I used paper airplanes with rudders and elevons. I threw them multiple times with different rudder and elevon positions to see what effect each has on the flight path.

Results

My results indicate that when the rudder is bent to the left, the plane turns to the left, and vice versa. It also shows that both elevons bent up make the plane's nose rise, and vice versa. When one elevon is bent up and the other is bent down, the airplane rolls.

Conclusions/Discussion

In conclusion, the rudder and elevons make an airplane maneuverable. The rudder controls yaw (side to side movement), and the elevons control pitch (up and down movement) and roll.

Summary Statement

My project is about learning what an airplane uses to maneuver.

Help Received

Mother took pictures and bought board;

Name(s)

Chris T. Lynch

Project Number

S0105

Project Title

Down With Drag, Part Deux: Further Investigation into the Mechanism of Decreased Hydrodynamic Drag in Swimsuit Design

Abstract

Objectives/Goals

A velvety fine layer of air bubbles was previously observed to form on the surface of newer "elite" racing swimsuit fabrics. The object of this study was to investigate further and determine if a surface emulating a "microbubble" layer would have reduced hydrodynamic drag compared to other surfaces. I propose that the improved hydrodynamic performance of these swimsuit fabrics is actually the result of forming this coating layer of minute air bubbles.

Methods/Materials

A thin flow chamber (Hele-Shaw cell) was constructed out of two parallel plexiglass sheets separated by polyvinyl plastic spacers, and sealed aginst leakage using vaseline and binder clips. Water was channelled across the edge of polyvinyl plastic templates loaded into the chamber, and the flow rate at constant pressure was measured. Five templates were designed to simulate flow surfaces, including a "sawtooth" pattern mimicking the surface contour of the elite fabrics, a plain control, a "sine wave" pattern, an "irregular" pattern, and a "bubble-top" surface emulating the presence of a microbubble coating layer. Ten trials were conducted for each surface, and the cumulative results were statistically compared using T-testing with a level of significance at $P<0.01$.

Results

Water flow was significantly improved with the bubble-top surface, by +7.52 % compared to the plain control surface (7.00 +/- 0.04 ml/s vs. 6.51 +/- 0.27 ml/s, $P<0.001$). The sawtooth pattern (6.50 +/- 0.43 ml/s) as well as the sine wave design (6.50 +/- 0.15 ml/s) did not differ from control. The irregular surface had a trend toward lower flow/higher drag (6.30 +/- 0.41 ml/s), but this did not achieve statistical significance ($P>0.1$).

Conclusions/Discussion

A surface emulating a microbubble coating had improved flow compared to a control surface and other contours. I had previously observed that modern "elite" swimsuits became covered with a layer of minute air bubbles during immersion. This study supports my new proposal that the improved hydrodynamic qualities of elite swimsuits is imparted by the induction of a coating with microscopic air bubbles.

Summary Statement

This project tests the hydrodynamics influencing drag in swimsuit fabrics, and suggests that the actual mechanism by which elite fabrics reduce drag is by forming a coating layer of minute air bubbles.

Help Received

My father helped hold the apparatus steady while I conducted the flow measurements.

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Amanda M. Marshall

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.

Name(s)
Brandon T. Miller

Project Number
S0107

Project Title
Windy Conditions

Abstract

Objectives/Goals
Which kind of blade will produce a greater force of wind?

Methods/Materials
Make two holes in the front of the box, another in the back, opposite of the first holes. Put the holes two inches from the top and bottom. Make two holes in the jar lid using the nail. Make one hole in the middle of the lid and the other near the edge. Using the tack, attach a cork to the jar lid. This the handle of your fan Attach the handle to the box with the paper fastener. Push the fastener through the second hole in the box. The handle should turn easily. Cut four evenly spoced slits in another cork. Cut four long strips for the blades using the different blade materials. Make them as wide as the slits as wide as the cork. Push the blades into the slits, and push the stick in to the cork. Push the stick throw the other two holes in the box. The stick should poke out of the back of the box. Push the third cork onto the end of the stick; loop the rubber band around this cork and the handle. Your fan is ready now. Turn the handle of the fan. The blades spin rapidly and blow forward.

Jar lid; Thin wooden stick; Hammer; Knife; Three corks; Nail; Paper fastener; Tack; Rubber band; Milk carton; Scissors; Blades; Stiff plastic; Cardboard; Paper; Foam

Results
The results showed the 4-inch foam blades worked the best and the 4-inch paper blades were the worst. The foam blades produced the most air to move the test strip an average of 10 inches. The 4-inch cardboard was second. The 4-inch paper blades were the worst, with an average of 1.67 inches.
The results of the experiment using the 3-inch blades showed that the paper blades worked the best and the foam blades were the worst. The results of the 3-inch blade experiment were the complete opposite of the experiment using the 4-inch blades.
The stiff plastic blades did not do as well as predicted. The foam blades doing the best were a surprise and I did predict the paper blades would not do as well as the other types of blades.

Conclusions/Discussion
My hypothesis that the stiff plastic blades would work the best was wrong. The blades that worked the best were the foam blades. The data shows that the foam blades produced the most force.
The blades producing the most amount of wind determined the greatest amount of force. The 4-inch foam blades, according to the results, were the blades producing the greatest amount of force.

Summary Statement
Test different types of blades to discover which one would produce the greatest force of wind.

Help Received
Mother editted report and helped transport board around to competitions.

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Karis M. Miyake

Project Number

S0108

Project Title

Flight, the Fulfillment of an Ancient Dream: The Effects of Wing Design on Lift

Abstract

Objectives/Goals

What kind of wing design will prove to have the most effective flight, under a constant wind velocity? How will the changes in the angle of attack, weight to area ratio, and velocity affect the lift of the wing?

Methods/Materials

In order to carry out my experiment, I first collected all my necessary materials. Then, I constructed my wind tunnel and connected it with a fan. Afterwards, I tested the lift of each wing using a dual-range force sensor that was hooked up to a computer program that read the results. Based on my results for the first round of the experimentation, I then took 5 wings and made duplicates with different angles of attack: 5 degrees, 10 degrees 15 degrees; I also tested each one for its lift.

Results

I discovered that the wings that had the smoothest, most linear shape proved to produce the most lift. However, the weight to area ratio also was a major factor in determining the results. I also learned that the more the angle of attack was raised, the lift increased as well. The wings that were at an angle of 15 degrees had the most lift.

Conclusions/Discussion

I conclude that the most effective wing design is a standard, tapered airfoil, but the weight to area ratio and the velocity are important factors that need to be considered along with the design of the wing. Also, the best angle of attack is about 15 degrees.

Summary Statement

To investigate the different factors (e.g. shape, weight to area ratio, etc.) in wing design that affect its performance in flight.

Help Received

Father helped to build the wind tunnel

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Sarah M. Penicks

Project Number

S0109

Project Title

Flight of Discovery

Abstract

Objectives/Goals

I believe that the rocket that I have built will fly 350 # 1500 feet into the atmosphere with a type G engine.

Methods/Materials

Estes rocket g-force kit ; Recovery system (Parachute and Shroud lines); Launch lug; Recovery wadding; Fins; Engine mount; Nose cone; Body tube; Igniter & Plug; Ezacto hobby knife kit; 12 hour 2 set epoxy glue; Pad of steel wool; Sheet of fine sandpaper; Type #G# engine ; Rocket Launch pad kit; Roll of scotch tape; Pencil.

Results

I assembled and launched the rocket and my hypothesis was correct. However, my rocket blew up upon impact because the motor casing caught fire in mid-flight and burned through to the shock cord and parachute shroud and all the way through the body tube thereby destroying the rocket. However, the flight was a success in that it reached its estimated altitude. Had the recovery system worked properly, it would have been a good flight. Therefore, after building and launching the rocket, I must conclude that the experiment was a success although the rocket was lost. I learned volumes about the dynamics of an object in flight. I now understand what the four forces that act upon an aircraft in flight are. I learned that aircraft must have a center of gravity in order to remain straight and level during flight. I learned how to reduce the drag on my rocket so it would accelerate faster. Overall, the project was a success.

Conclusions/Discussion

The intense heat of the launch burned a hole through both the cardboard engine casing and the body tube of the rocket causing it to lose the aerodynamic quality that is necessary for controlled flight. The rocket did successfully reach the estimated apogee that was supposed in the hypothesis for the experiment of the rocket. However, the recovery system failed to deploy at the returning of the rocket to the landing. Therefore, rocket was damaged on the fins, body tube, and nose cone, which destroyed the rocket completely. In repeating this rocket experiment, I would check the recovery system more carefully to ensure a better flight and, as well as achieving a successful landing, use the recovery system so it would not damage the rocket and bring the rocket down to a successful landing.

Summary Statement

My project is about the flight of a model rocket.

Help Received

1st Lt. John Binder, C/Capt. Brysen Davis, Shannon Penicks

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)
Alex D. Provda

Project Number
S0110

Project Title
Optimal Windmill Blades for Power Generation

Abstract

Objectives/Goals
The goal of the experiement was to determine the most effective shape, and its relative angle to the direction of the wind for power genoration. In the experiment another goal was to examine the merits of lift, and drag and two determine which one is more important for windmills.

Methods/Materials
The minerature windmill stand was created out of a tool set, consiting of interlinking mettle bars. The windmill blades were each cut from balsa wood, by a power saw and then sanded with a power sander until they reached there desired shape. The blades were then hooked on to a motor, that had been turned to spin backwards, and then connected by wire to a miliamper reader. The source of the wind was a hair dryer bolted down to a stand approximetaly four feet away. To conduct the tests all you have to do iis turn the blades to the desired angle, turn the hair dryer on high and wait till the milamper readers needle is steady.

Results
The results showed the the most effective blade shape was a rectangualar blade with curved edges thick side forward turned to an angle of 30 degrees. In general the results showed that winged shaped blades were general less effective for power genoration than rectangular shaped blades.

Conclusions/Discussion
It can be concluded from the reuslts that having curved edges on a rectangual shaped blade will always increase the amount of power generated. It can also be concluded that rectangular shaped blades are better for power genoration. While looking at the performances by all of the different blades, it can be seen that the blades that combine lift and drag are the most effective for power genoration.

Summary Statement
My project is all about testing different shapes of windmill blades turned to different angles for maximum power genoration.

Help Received
My father helped me come up with the idea for the project, and the crafting of the windmill blades.

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Matthew R. Scanlan

Project Number

S0111

Project Title

Second Skin: Testing the Drag Coefficient of Swim Suit Materials

Abstract

Objectives/Goals

Many new materials for swimsuits are being created constantly that are less resistant than human skin or faster than normal material. This led me to my problem; do the fancy new materials cause just as much drag as the old polyester suits? I plan to test the drag from each material and to see if the manufacturers are truly being honest.

Methods/Materials

In order to test the amounts of drag each material has in water, I made a plastic cylinder and filled it with water to drop my dummy (a pot) down. I placed different suit materials on the same pot and dropped them 175cms down a guide rod. I measured the time it took to reach the bottom and compared. The four different suit materials were the powerflow, aquapel, normal polyester, and the drag suit. As the constant I used the pot without any material.

Results

The aquapel was the fastest with an average time of 4.142s followed closely by the powerflow (4.155s), no suit (4.207s), the normal suit (4.675s), and the slowest was the drag suit with 5.727s.

Conclusions/Discussion

The use of the new material suits stretched over the pot made the system more streamline thus eliminating drag from the angles of the pot, similar to a suit smoothing out the flow surface over a human body. The fastest material was the aquapel by about one hundredth of a second to the powerflow. They were the least resistant materials and went the fastest even though they weighed less than the slower suits and had less gravitational pull. The aquapel also weighs slightly more than the powerflow. If the two materials had weighed the same there is a possibility that the powerflow would have beaten the other. As I said, the weight of the suits may have changed the outcome, but it is all relative to the materials on the human body. I also based the timing system off of humans. If I could do it differently I would use some type of electronic timing system which involved touch pad so that the human error factor would be eliminated.

Summary Statement

I tested the drag of different suit materials by timing how long they took to travel a fixed distance through a column of water.

Help Received

Father dropped pots during experiment.

Name(s)

Erik R. Van Esselstyn

Project Number

S0112

Project Title

Fastest in the Fleet: What Is the Most Effective Keel Design?

Abstract

Objectives/Goals

This project is an insight into what aspects of a keel#s design will make it effective on a planing hull. It tests six different keel designs, each representing a different time period, style, and aspect of keel design, on a proportionally downsized planing Laser hull.

Methods/Materials

The hull was constructed out of pine shelf board and the keels were constructed out of Lucite Extruded Acrylic, each with the same surface area. The keel designs can be named by their uses: Laser keel, tanker bow keel, old fashioned rounded keel, shallow draft keel, oceangoing racing keel, and catamaran dagger keel. Using information from research, which told about what aspects of a keel are the major factors in its performance, it was hypothesized that the keel that would provide the least amount of drag was the tanker bow keel, because it carries the water up along its curved edge and splits it at the top. To test this hypothesis, experimentation was done by towing the test hull, with attached keels, from a dinghy attached to a Cal 28 sailboat under power at three different speeds, which were proportional to the hull#s length of three feet. Drag was measured by a scale attached to the dinghy with a line running to the bow of the test hull, and the measurements were read off into a recorder.

Results

The results from the testing yielded that the Laser keel had provided the least amount of drag overall, because of its matching design to the hull and its good use of length versus width.

Conclusions/Discussion

The hypothesis, then, was incorrect, because the tanker bow keel did not have enough speed to fulfill its function.

Summary Statement

This project is an insight into what aspects of a keel#s design will make it effective on a planing hull.

Help Received

Mother steered Cal 28; Father helped with power tools and construction; Laser employee provided building diagrams.

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)
Jennifer J. Wan

Project Number
S0113

Project Title
Gone with the Wind

Abstract

Objectives/Goals
My goal in this experiment was to determine the effects of blade size, angle of positioning, and direction of wind on a windmill. In this experiment I believed that the propeller with a large blade, placed at 45 degrees would be the most efficient - efficient in the sense that it was able to complete the most amount of turns within the given time and that it pulled up the constant weight in the shortest amount of time.

Methods/Materials
In this experiment I first drew a template which I kept proportionally the same for all three blade sizes - large, medium, and small. I then created different angles in which the blades were inserted in the propeller - at either 30, 45, or 60 degree placements. I created a shaft and base in which the propeller went into. The testing required the fan to be placed 15 inches away and at level height with the propeller. I first counted the number of revolutions completed within 10 seconds. Then I moved it farther at 33 inches to see the effects then. The third portion of the experiment was where I timed to see how long it took for each propeller to pull up a specified wieght. Then finally I altered the angle at which the wind source was directed at the propeller - to be either headlong or at a 45 degree angle.

Results
From my experiment, I found that the propeller with the small blade, placed at a 30 degree angle, overall performed the best. Althought it did not indivdually work the best for each section of the experiment, it did constantly perform at a high rate for each test. The large blades continuously performed the slowest out of all three blade sizes. When the direction of the wind was position directly in front of the propeller, the propeller worked better - as apposed to being directed from an angle.

Conclusions/Discussion
Thus from the experiment, I have found that the smaller blade worked the best as well as the smaller angle. My hypothesis was wrong, but could have been so from a number of reasons. The large blades could have been affected by friction and resistance, or it the weight could have been a factor. The smaller blades most likely were the fastest most likely because of its lighter weight. Also, from this experiment it is determined that wind should be direct with the propeller, thus the need for windmills to be able to freely move with the wind, to be the most efficient.

Summary Statement
This project is about the effects of the size of a blade, the angle of positioning of the blade, and the direction of wind source on a windmill.

Help Received
Dad helped cut wood and nail together and saw.

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Garrett L. Weekly

Project Number

S0114

Project Title

Ancient Polygonum Reveals Secret to Correct Ball's Erratic Flight Path

Abstract

Objectives/Goals

Determine why a ball of given mass, diameter and smoothness does not fly accurately and precisely. Manufacture two experimental ball groups with surface patterns ('Fully Dimpled' group and 'Equator Dimpled' group) that will increase range, accuracy and precision, and then compare those results with the control group. Success is defined as the pattern which is more accurate, more precise, and yields the most range or distance.

Methods/Materials

Smooth foam balls of 11/16ths-inch diameter are used as the control group and are propelled by precisely controlled air pressure at a target placed exactly 60 feet away with results recorded and measured. The control group ball's surface is then modified with 2 specific geometric patterns of dimples, re-fired and measured against the control group for range, accuracy and precision. Statistical information is used to compare results.

Materials are foam balls, propellant device with air tank, mount and regulators, target, and measuring devices. A butane gas powered soldering iron was used to impress the nearly 2,400 dimples into 60 balls. All tests were performed in an environmentally isolated outdoor area 60 X 150 feet.

Results

The smooth control group exhibited a nearly uniform normal distribution of results in range, accuracy and precision. The two test patterns differed wildly from the control group. The 'Fully Dimpled' pattern, which was expected to be the most successful, was not. The 'Equator Pattern' was unexpectedly highly successful.

Conclusions/Discussion

Owing to a physics principle known as the 'barbell effect', the 'Equator Dimpled' pattern was surprisingly successful in accuracy and precision. The 'Fully Dimpled' group was disappointingly inaccurate and imprecise, although expectedly, yielded the most range. Because each of the 60 balls of the two experimental groups was handmade, some degree of manufacturing imperfection was responsible for variances in results.

Summary Statement

Unusual geometric dimple patterns applied to the surface of a smooth skinned ball yields surprising effects on accuracy, precision and range.

Help Received

I would like to thank my Father for help with mechanical setups and statistics, Mother because she let me keep the organized mess together without cleaning up until the project was finished, Mr. Kangus for his help with the statistics and Mr Patzold for his overall guidance.

CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Ian R. Whittinghill

Project Number

S0115

Project Title

The Effect of Mass Flux on the C* Efficiency of Aluminized Grains in an N(2)O-Fed Hybrid Rocket Motor

Abstract

Objectives/Goals

The objective was to determine if the combustion efficiency of a N2O-fed, aluminized hybrid rocket motor is dependant on the propellant mass flux inside the motor ports.

Methods/Materials

After a substantial amount of research, a 300 lb thrust, 3.5 inch diameter, 2-port hybrid rocket motor was designed, machined, cast with fuel, assembled, safety tested, fired, and then analyzed. The operating parameters of the motor were designed to start at a high mass flux (1.0 lb/sec/in^2) and end at a low mass flux (0.15) in a single test. The motor was instrumented for N2O tank weight and pressure, motor thrust, and chamber pressure. Data was collected during the burn and analyzed afterwards.

All of the motor components were scratch-built from aluminum tube and plate, stainless steel, and graphite bar stock. The fuel was cast with a rubber binder and (10% by weight) 3-micron aluminum powder. The stand was welded steel, and the feed system was assembled from a stainless tank, purchased valves and fittings, and salvaged high-pressure hose.

Results

Motor performance exceeded my expectations and ran smoothly over the whole range of mass flux. The injector flowed more N2O than anticipated, resulting in a higher thrust (360 lbf) and higher than planned, initial mass flux (1.3). Nevertheless, my combustion, or C* efficiency, averaged about 84% over the whole burn, despite having an injector starting to burn through at 1.5 seconds. The injector did not completely fail, and the motor continued to burn well until the end of the 4-second burn.

Conclusions/Discussion

From the post-test analyses, I can conclude that C* efficiency, good motor stability, and high performance is more a function of proper motor and injector design than mass flux.

Summary Statement

My project showed that hybrid rocket motors can be operated at high propellant mass flux, delivering high fuel burn rate, high performance (C* efficiency), and stable motor chamber pressure, provided the injector and motor are well designed

Help Received

My father answered my questions and helped me anchor the thrust stand into the concrete pad at the test site. My mother helped me design the display board.