REMOTE CONTROL PAPER PLANE

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Author Note

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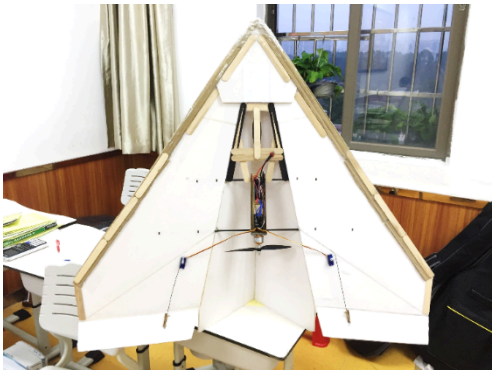
Abstract

Our Science Fair project is a remote-controlled paper plane which took us more than five weeks to complete building it, checking its function and improving it. After testing for more than twenty times, we finally made it hard enough and fast enough. We made this paper plane based on Newton's Laws and following the rules of fluid. We searched for mountains of information and the principles of the plane before we started. We learnt how the plane sets off and how it keeps balance in the air. How big the wings should be, how large the body should be and how fast the electrical machinery should rotate.

We made a paper plane before finishing making another finished product. The first paper plane crashed accidently because of our lack of Knowledge and experience. However, by using the first plane to practice controlling it and having an intimate knowledge of the plane's structure. This provided great support and base for our second plane.

Our paper plane is very hard to build although it has a simple structure, but we finished making it after all. This activity not only showed other people our great talent in self-making ability, but also improved our skills and confidence to face difficulties.

Fig1: Our handmade paper plane Fig2: Our group members and our





product

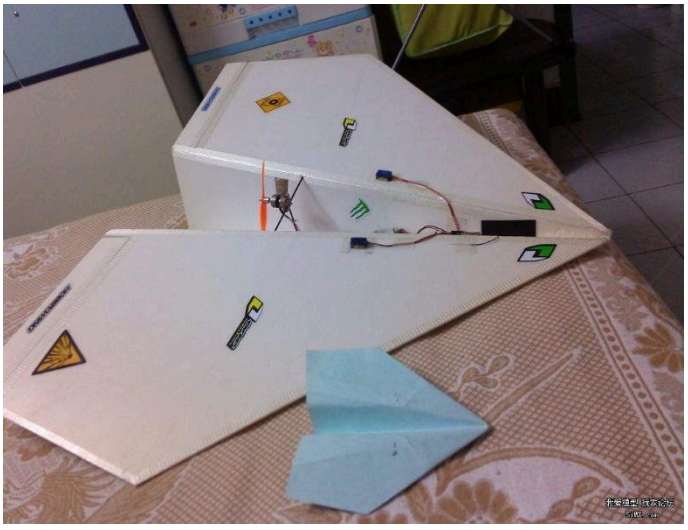
Background Research

In a real, lift-generating wing, the airflow always meets at the trailing edge; otherwise, there will be a point at the trailing edge where the airflow velocity is infinite. This condition is called the kutta condition, and it is only when this condition is met that the wing can generate lift. In the ideal gas or when the wings start moving, this condition is not satisfied, and the viscous boundary layer is not formed. In general, airfoil (wing cross section) has a longer distance from the top than the bottom. At the beginning, airflow velocity on the upper and lower surfaces is the same without circulation, which leads to that when the lower airflow reaches the trailing edge point, the upper airflow has not yet reached the trailing edge. The latter stagnation point is located at a point above the airfoil, and the lower airflow must bypass the sharp trailing edge and converge with the upper airflow. Due to the viscosity of the fluid (i.e., the conda effect), a low-pressure vortex will be formed when the lower air flows around the trailing edge, resulting in a large adverse pressure gradient at the trailing edge. Then, this vortex will be rushed away by the incoming flow, and this vortex is called the starting vortex. According to the law of conservation of helmholtz vortices, for ideal incompressible fluid under the action of forces, there will also be a vortex around the airfoil with the same intensity and opposite direction as the starting vortex, which is called circulation, or the amount around the airfoil ring. The circulation flows from the

leading edge of the upper surface of the wing to the leading edge of the lower surface, so the circulation plus the incoming flow leads to the rear stagnation point finally moving back to the trailing edge of the wing, thus satisfying the kutta condition. Produced by kutta condition around the wing circulation led to the wing surface flow backward acceleration, can be deduced from Bernoulli theorem pressure difference, and calculate the lift, the end of the circulation of the lift size can be calculated by dc - RuKeFu base equation: L (lift) = V Γ rho (gas density * ring velocity value) this equation can also calculate the aerodynamic magnus effect. According to Bernoulli's theorem, "the faster a fluid

travels, the lower its static pressure value (static pressure is the pressure generated when the fluid flows perpendicular to the direction of motion of the fluid)." So the pressure on the wing from the air on the upper surface F1 is less than the pressure on the lower surface F2. The net force of F1 and F2 is bound to go up, which produces lift. The principle of lift force is that the presence of circumferential vortices (attachment vortices) leads to different flow rates and pressures on the upper and lower surfaces of the wings.

Fig3: Remote controlled plane vs normal paper plane



The tail includes a horizontal tail (flat tail) and a vertical tail (vertical tail). The horizontal tail consists of a fixed horizontal stabilizer and a movable elevator (in some types of civil and military aircraft, the entire tail is a movable control surface and there is no special elevator). The vertical fin includes a fixed vertical stabilizer and a movable rudder. The main function of the tail wing (Sweden's aj-37, JAS39 and other aircraft are the first wing) is to control the pitch and deflection of the aircraft, as well as to ensure the smooth flight of the aircraft. When we talk about the power plant of an airplane, we have to talk about the thrust-weight ratio of the airplane. The thrust-to-weight ratio is the ratio of the thrust of an airplane to the force of gravity on the airplane. The thrust of a general civil aircraft is less than the gravity of the aircraft, because every increase in thrust of KN will increase the manufacturing cost of the aircraft. When the thrust of the aircraft is greater than

the gravity of the aircraft, the aircraft can achieve high-speed climbing or even vertical climbing. Many aircraft requiring high maneuverability, such as fighter jets, have a large thrust and a small gravity.

In addition, under the requirement of the same gravity, the greater the thrust of the aircraft, the smaller the wing area, the smaller the cruising resistance of the aircraft, the faster the speed, and the longer the glide distance. And vice versa. Power plant is mainly used to produce tension or thrust to make the aircraft forward. Secondly, it can also provide power for the

electric equipment on the aircraft and provide air source for the gas equipment. Steering gear is mainly composed of shell, circuit board, drive motor, reducer and position detection \

components. Its working principle is to send signals from the receiver to the steering gear, which is driven by IC on the circuit board to start rotating the coreless motor, which will move through the reduction gear. The force is transmitted to the swing arm and a signal is sent back by the position detector to determine whether the position has been reached. The position detector is actually a variable resistance. When the steering gear rotates, the resistance value will change accordingly. By detecting the resistance value, the rotation Angle can be known. General servo motor is the thin copper wire wound on the three-pole rotor, when the current flowing through the coil will produce a magnetic field, and the rotor outside the magnet has a repulsive effect, and then produces a rotating force. According to the principle of physics, the moment of inertia of an object is proportional to its mass, so the greater the mass, the greater the force required to rotate it. Steering gear for the speed of fast, small power consumption, so the thin copper wire wound into a very thin hollow cylinder, forming a very light weight of the non-polar hollow rotor, and the magnet placed in the cylinder, this is the hollow cup motor. This part consists of an inner ring of teeth and a matching gear or rotor. The inner gear ring and the housing can be fixed together, and the oil entering from the oil mouth pushes the rotor to revolve around a central point. This slow-rotating rotor drives the output through a spline shaft to become a

cycloidal hydraulic motor. After the advent of this original cycloidal motor, after

decades of evolution, another concept of motor began to form. This type of motor is equipped with rollers in the built-in gear ring. The motor with rollers can provide higher starting and running torque. The rollers reduce friction and thus improve efficiency. By changing the direction of the input and output flow, the motor can be quickly reversed, and equal torque can be generated in both directions. Each series of motors has a wide range of displacement options to meet various speed and torque requirements. A Battery is a device that contains an electrolyte solution and metal electrodes to generate electricity in a cup, trough, or part of a container or composite that converts chemical energy into electrical energy. It has a positive

pole and a negative pole. With the development of science and technology, batteries generally refer to small devices that can generate electricity. Such as solar cells. The performance parameters of a battery mainly include electromotive force, capacity, specific energy, and resistance. Use battery as a power source, can get a stable voltage, stable current, stable power supply for a long time, influenced by the outside world is very small current, and the cells of simple structure, easy to carry, easy to charge and discharge operation, not affected by weather and temperature, stable and reliable performance, in all aspects of life in modern society play a large role. You can think of a propeller as a wing that rotates and goes forward.

The flow through each section of the blade is composed of the forward velocity along the rotation axis and the tangential velocity generated by rotation. In the propeller, the radius r1 and r2(r1<r2) each take a minimum section, discussing the airflow situation on the blade. V - axial velocity; N -- propeller speed; Phi - a flow Angle, that is, the flow and propeller rotation

plane Angle; Alpha - blade profile Angle of attack; Beta - blade Angle, that is, the Angle between the string line of the blade profile and the rotation plane. 16. Obviously, alpha + beta = phi.

Air flow through each small section blade aerodynamic, drag and lift Δ Δ D L, synthetic after total aerodynamic Δ R. Δ R component for tension along the

direction of flight Δ T, and screw propeller rotating in the opposite direction of force Δ P stop rotating propeller. The tension of each segment of the entire blade and the force preventing rotation are added to form the tension of the propeller and the torque preventing rotation of the propeller.

It is necessary to make all sections of the propeller work at the Angle of attack with relatively high lift resistance, to obtain greater tension and smaller resistance moment, i.e., higher efficiency. When the propeller is working. The axial velocity does not change with the radius, but the tangent velocity changes with the radius. Therefore, close to the tip of the propeller, the larger the radius is, the smaller the airflow Angle is, and the smaller the blade Angle should be. And close

to the root of the propeller, the radius of the smaller airflow Angle is larger, corresponding to the blade Angle should be larger. The blade Angle of the propeller should increase gradually from the tip to the root according to a certain law. So it's more accurate to say that the propeller is a twisted wing.

The flow Angle reflects the ratio of the forward velocity to the tangential velocity. For a certain section of a propeller, the Angle of attack varies with the ratio. As the Angle of attack changes, so do the tension and resistance

moments. The inlet moment ratio "J" is used to reflect the airflow Angle at the tip of the propeller, J=V/nD. Where, D-propeller diameter. Theoretical and experimental results show that the propeller tension (T), the power (P) and the efficiency required to overcome the propeller resistance moment, can be calculated using the following formulas: Ct/Cp eta = j. Where: ct-tension coefficient; Cp- power coefficient; Rho - air density; N - propeller speed; D-propeller diameter. Where Ct and Cp depend on the geometric parameters of the propeller, and the value of each propeller changes with J. The characteristic curves show that the propeller tension coefficient, power coefficient and efficiency vary with the forward ratio. It is one of the main bases for selecting propellers and calculating aircraft performance.

Data Analyze & Discussion

Battery of propeller

Battery	2200A		3800A	
Time(s)	velocity(m/s)	Dead?	velocity(m/s)	Dead?
10	6.7		4.7	
20	6.3		4.1	
30	6.5			yes
35	6.2			yes
40	6.4			yes
45	6.3			yes
50	6.1			yes
55		yes		yes
60		yes		yes

Fig4: Graph of velocity vs time of the paper plane for two kinds of batteries.

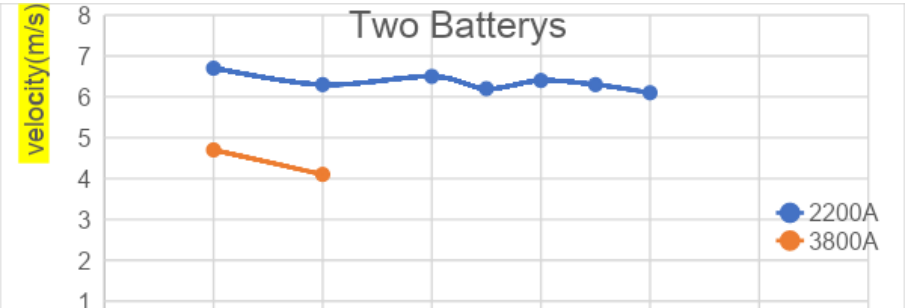


Fig5: Circuit boards & motors

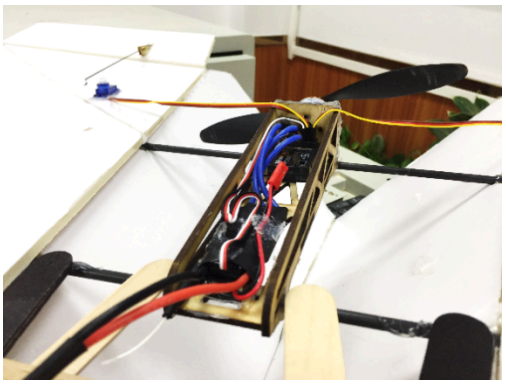


Fig6: Paper plane in air

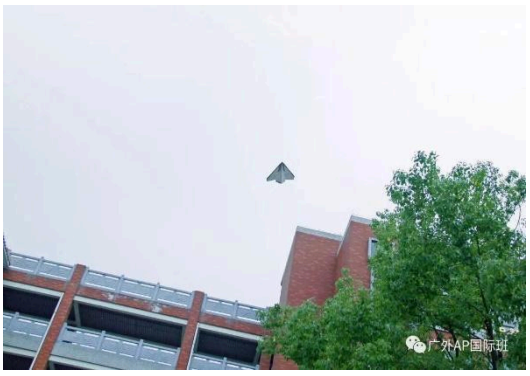
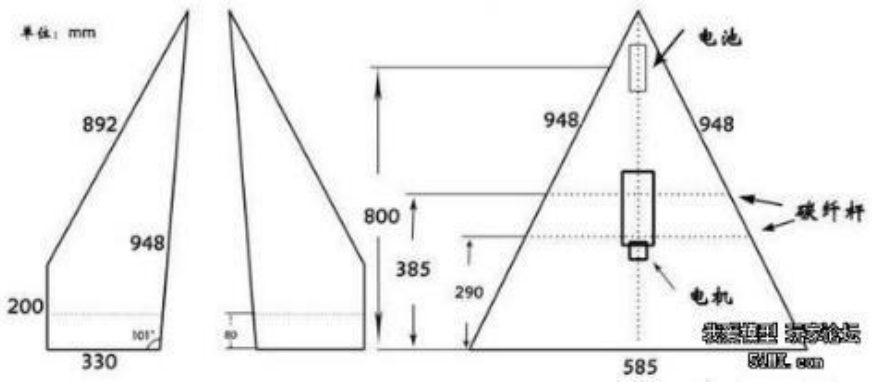


Fig7: Size of the Paper Plane:



Discussion

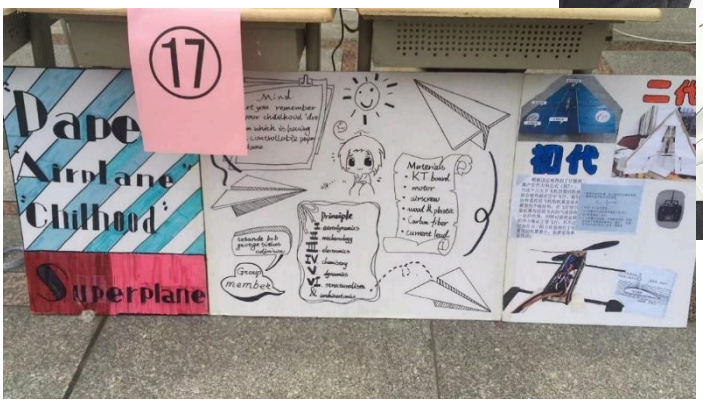
I'm sure you 've all been impressed by our group of remote-controlled paper aircraft, but we 've also been able to reform the previous generation of products, not only to enhance gameplay, to add control features to mobile

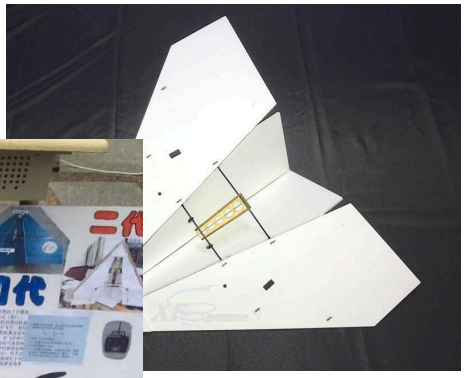
devices, but also to improve battery performance. To help paper planes soar better in the sky. The intelligent control paper aircraft kit is designed to allow users to re-experience the fun of childhood paper aircraft in a new high-tech form and to operate it more freely. The new 2.0 intelligent control paper aircraft kit is very light and easy to carry and fly. The built-in intelligent modular framework is made of percussion-proof carbon fiber, which can effectively resist the impact of a crash, making it more durable.

Fig8: SUPER paper plane

In addition, the self-controlled thrust design can help the aircraft to fly when tilted or rotating, and the precise control design makes it easier to fly. Behind it is a small propeller and a vertical tail design that is responsible for controlling the direction. By connecting Bluetooth 4.0 to the mobile phone, users can easily achieve remote control, and the remote-controlling distance can reach 55 meters.

Fig9: Our display board at Science Fair day:





It is powered by a built-in 1000 mA rechargeable lithium polymer battery, which is charged via a miniature USB cable and can maintain the aircraft for 10 minutes after full power. It can also be used in conjunction with applications on smartphones via Bluetooth. The 2.0 version of the smart control paper aircraft suite's supporting mobile phone application provides a large amount of flight data for users to manipulate. The biggest feature of the 2.0 intelligent control paper aircraft suite is that it can transform any home-made aircraft that is folded out of paper into an electric aircraft toy that is remotely controlled by a smart

phone. It has great flexibility. This remote-controlled paper aircraft production process is very simple, and it is not too high for the paper aircraft material, ordinary copy paper. Users simply stack a paper airplane with a strong enough piece of paper, then fix the 2.0 intelligent control paper aircraft suite to

the paper aircraft, and then pair the mobile phone application with the built-in smart module of the 2.0 intelligent control paper aircraft suite. Finally, just throw the plane out and remotely control it. Through this 2. 0 version of the intelligent control paper aircraft kit, users can customize their favorite aircraft color and aircraft shape, to achieve the diversity of aircraft types and replacement at any time, very convenient and practical.

In addition, the 2.0 version of the supporting App is also very practical. The interface includes a virtual throttle joystick, a magnetic control compass, a battery status indicator, a charging status indicator, a distance indicator, an engine rated thrust indicator, a simulated level meter, and an ATC system. Through the virtual throttle joystick, users can easily control the aircraft's rise and fall movement; By controlling the compass by magnetic force, the user can control the direction of the aircraft by tilting the phone to the left and right. At the same time, users can also have a very clear and intuitive understanding of the aircraft's power situation to charge in time.

Conclusions

After doing this Science Fair project together, we all learnt a lot from it. We also got a lot of fun. By building our own remote-controlled paper aircraft, we experienced the fun of childhood again, we had a better understanding of the flight principles of the aircraft in the course of constant attempts and improvements. we also improved our hands-on ability and the interest in physics, and we also gained a better understanding of aerodynamics. This activity also has certain help to our physics study in the future.

Bibliography

After having the Science Fair activity, we want to thank Guangzhou Foreign Language School for giving us this opportunity to improve our imagination, creativity, and hands-on ability and giving us a chance to show our talents. We also want to thank our tutor, Miss. Tammy, who has been giving us great support and encouragement for our project. Finally, we want to thank the teachers who voted for us during the Science Fair and thank you for your approval of our project.

Fig10: Our Science Fair group members:



Reference

Figure3: Remote controlled plane vs normal paper plane from *https://image.baidu.com/search/detail?ct=503316480&z=0&ipn=d&word=%E9%81%A5%E6%8E%A7%E7%BA%B8%E9%A3%9E%E6%9C%BA&step_word=&hs=0&pn=119&spn=0&di=201050477320&pi=0&rn=1&tn=baiduimagedetail&is=0%2C0&istype=0&ie=utf-8&oe=utf-8&in=&cl=2&lm=-1&st=undefined&cs=3648855423%2C4127071476&os=3791561511%2C1729499423&simid=4224799037%2C527168051&adpicid=0&lpn=0&ln=809&fr=&fmq=1544682783335_R&fm=&ic=undefined&s=undefined&hd=undefined&latest=undefined&copyright=undefined&se=&sme=&tab=0&width=undefined&height=undefined&face=undefined&ist=&jit=&cg=&bdtype=0&oriquery=&objurl=http%3A%2F%2Fphoto.5imxbbs.com%2Fforum%2F201402%2F03%2F125938c236esin44ru8s4n.jpg&fromurl=ippr_z2C%24qAzdH3FAzdH3Fooo_z%26e3Bct4x_z%26e3Bv54AzdH3Fu5674_z%26e3Brir%3F451%3Detjopi6jw1%26pt1%3Dbld8nc&gsm=3c&rpstart=0&rpnum=0&islist=&querylist=&selected_tags=0*

Figure 7: Size of the paper plane from *https://image.baidu.com/search/detail?ct=503316480&z=0&ipn=d&word=%E9%81%A5%E6%8E%A7%E7%BA%B8%E9%A3%9E%E6%9C%BA&step_word=&hs=0&pn=138&spn=0&di=153213909530&pi=0&rn=1&tn=baiduimagedetail&is=0%2C0&istype=0&ie=utf8&oe=utf8&in=&cl=2&lm=1&st=undefined&cs=326825310%2C2357127271&os=264163409%2C2772633941&simid=0%2C0&adpicid=0&lpn=0&ln=809&fr=&fmq=1544682783335_R&fm=&ic=undefined&s=undefined&hd=undefined&latest=undefined&copyright=undefined&se=&sme=&tab=0&width=undefined&height=undefined&face=undefined&ist=&jit=&cg=&bdtype=0&oriquery=&objurl=http%3A%2F%2Fphoto.5imx.com%2Fforum*

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Figure 8: SUPER paper plane from *https://image.baidu.com/search/detail?ct=503316480&z=0&ipn=d&word=%E9%81%A5%E6%8E%A7%E7%BA%B8%E9%A3%9E%E6%9C%BA&step_word=&hs=0&pn=34&spn=0&di=124628783950&pi=0&rn=1&tn=baiduimagedetail&is=0%2C0&istype=0&ie=utf-8&oe=utf-8&in=&cl=2&lm=-1&st=undefined&cs=1917529603%2C965323419&os=3099197267%2C3510510831&simid=0%2C0&adpicid=0&lpn=0&ln=809&fr=&fmq=1544682783335_R&fm=&ic=undefined&s=undefined&hd=undefined&latest=undefined&copyright=undefined&se=&sme=&tab=0&width=undefined&height=undefined&face=undefined&ist=&jit=&cg=&bdtype=0&oriquery=&objurl=http%3A%2F%2Fimage.suning.cn%2Fuimg%2Fsop%2Fcommodity%2F527415138651062209407500_x.jpg&fromurl=ippr_z2C%24qAzdH3FAzdH3Fr6517vp_z%26e3Bf7gtg2_z%26e3Bv54AzdH3Faa0ad8lmcmAzdH3F8acm908aldm_z%26e3Bip4s&gsm=0&rpstart=0&rpnum=0&islist=&querylist=&selected_tags=0*