International Journal of Multidisciplinary Research and Modern Education (IJMRME)
ISSN (Online): 2454 - 6119
(www.rdmodernresearch.org) Volume II, Issue I, 2016

DESIGN AND FABRICATION OF AERIAL VEHICLE

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Abstract:

Aerial vehicle which is used for travel in road and also to fly in air. The purpose of aerial vehicle is used for emergency purpose. In this vehicle we have installed rack and pinion mechanism. The rack and pinion will extract the wing when it need for working and get reacted when it is in stable condition. The aluminum frame is used for this vehicle.

1. Introduction:

May be everyone would have imagined of an aerial vehicle at least once in a lifetime. Not only in movies but also in books, advertisements, games, etc. are paying attention on aerial vehicle. These days this kind of 'magical' aerial vehicle is being researched from many places and even several models of aerial vehicle are introduced. Lots of airplane, automobile related venture corporations are concentrating on R&D of aerial vehicle. As mentioned the future where aerial vehicle are flying around the sky is not far. If there are tons of vehicles in the air it will be lots of mess. So, we have to be prepared for the aerial vehicles. For example, the road system has to be a lot different from now. So in this project we are going to propose a road system model for the upcoming future and analyze the system using industrial engineering methods.

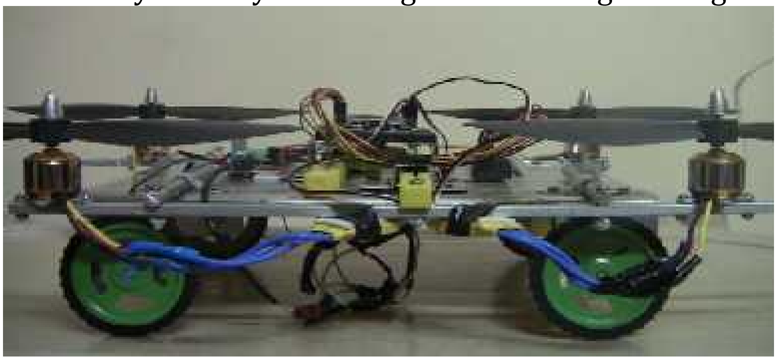


Figure 1: Aerial Vehicle

2. Purpose of the Aerial Vehicles:

Aerial vehicle which is mostly used for an emergency purpose. And it can also use for an army, for an emergency purpose. It can be used in very poor road condition. Our project can capable of flying the vehicles with whatever the maximum capability of the vehicles and also provides the security to the passengers. We use a composite material to the weight of vehicle with same or more than the factor of safety of the actual vehicle.

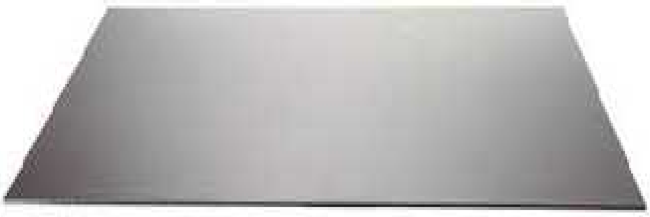
3. Components Used in Aerial Vehicles:

- ✓ Aluminum frame
- ✓ Rack and pinion
- ✓ Brushless high speed motor
- ✓ Propeller
- ✓ Flight control board
- ✓ Electronic speed controller
- ✓ Lithium polymer battery

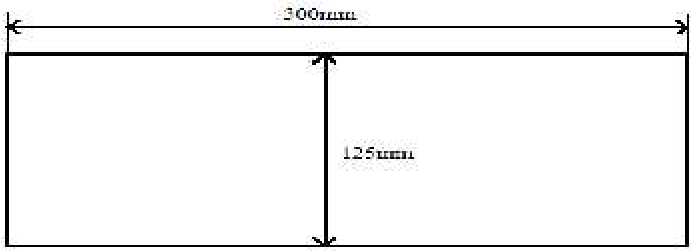
- ✓ Transmitter and receiver

3.1 Aluminum Frame:

Aluminum is used frame for aerial vehicle. Because has less weight and have high strength, if we use aluminum the weight of the aerial vehicle is much reduce. If the weight of the vehicle reduces the vehicle can be lifted easily without any problem. The aluminum has more stiffness if we more thrust mean also there will not be any bend occur in it. The whole setup is fitted in it so needed more stiffness and also less weight. The thickness of the sheet is 0.5mm.



(a)



(b)

Figure 2: (a) Aluminum frame and (b) its dimension

3.2 Rack and Pinion:

In aerial vehicle had installed rack and pinion mechanism. The rack and pinion is made up of PVC has high strength and more stiffness. The purpose of the mechanics is to extension of the wing. The rack get extended when it is in working condition and get retracted in it is in stable condition. When the vehicle is in working on road then the wings in get retracted by rack so wing will not been seen and when it need to fly for any emergency condition the rack is get extended so the wing will come out and start to work. The motor support is placed perpendicular to the pinion and also placed on the pinion end. The much power will be on the end of the pinion so the pinion should be high strength there should any bend in the pinion.

No of the teeth (N) = 25
Outer diameter (OD) = 40mm
Working depth (W) = 2.962mm
Tooth thickness (T) = 2.33mm
Face width = 13mm
Determination of the rack:
Assuming
No of the teeth (N) = 25
Outer diameter (OD) = 40mm
Diametrical pitch (P) = (N+2)/OD = (25+2)/40 = 0.675mm
Pitch diameter (PD) = N/P = 25/0.675 = 37.04mm
Circular pitch (PC) = 3.1416/p = 3.1416/0.675 = 4.65mm
Addendum (A) = 1/0.675 = 1.481mm
Whole depth (HW) = 2.2/ (P+0.002) = 2.2/0.675+0.002 = 3.25mm

Dedendum (D) = HW – A = 3.25 – 1.48 = 1.77
Working depth (W) = 2A = 2*1.48 = 2.962mm
Tooth thickness (T) = 1.5708/P = 1.5708/0.675 = 2.33mm
Face width = 13mm (assumption)
Based upon the rack pitch and the working condition the pinion is selected using the table which is provided
No of tooth = 63
Length of the rack = 330mm
Circulative pitch = 0.023mm
Width (B) = 14.5mm
Determination of torque motor for rack
Gross weight (GVW) = 1kg = 2.2lb
Weight on drive (WW) = 1kg = 2.2lb
Radius of the rack (Rr) = 40mm = 1.57in
Desired speed (Vm) = 10mm/sec
Acceleration time (Ta) = 1sec
Maximum inclined angle = 1degree
Working surface = plastic
Total tractive effort (TTE)
TTE = RR + GR + FA
RR = force required for rolling resistance
GR = force required for grade
FA = force required for final velocity
RR = GVW * Cπ
Cπ = surface friction
RR = 2.2*0.01 = 0.022lb
GR = GVW * sin (a) = 2.2*sin (1) 2.2*0.017 =0.0384
FA = (GVW*Vm)/ (32.2*ta) = (2.2*0.033)/ (32.2*1) = 0.0022
TTE = 0.022+0.0384+0.0022 = 0.0626lb
Determining the actual motor torque
Tw = TTE * Rw * Rf
Rf = resistance force
= 0.0626*1.57*1.1 = 0.108lb-in = 0.0122N-m
Reality checking
MTT = Ww*µ*Rw = 2.2*0.4*1.57 = 1.382lb-in = 0.156N-m

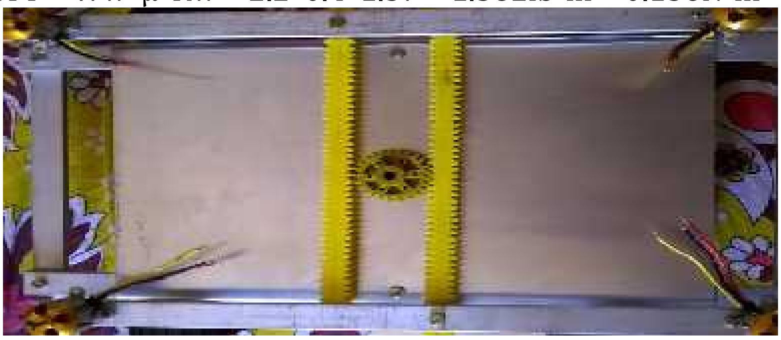


Figure 3: Rack and Pinion

3.3 Brushless High-Speed Motor:

As the name implies, BLDC (Brushless DC) motors do not use brushes for commutation. They are electronically commutated & better speed High efficiency with Noiseless operation & very high speed range with longer life. You need an

Electronic Speed Controller control the motor. As there are no brushes to wear out the life of BLDC motor is much longer. There is no sparking and much less electrical noise. The only disadvantage of a brushless motor is its higher initial cost. You need four nos. of BLDC Motors for the aerial vehicles.

KV (rpm/v): 1800
Max Power: 190W
Max Thrust: 920grams
Weight: 53grams
Shaft Diameter: 3.175mm
Shaft Length: 45mm
Battery: 2S-4SLi-Po
ESC (A): 30A
Thrust force = 29.42 N/motor
Power = 0.00986hp
Torque = 0.002397 N-m
Finding motor power:-
Assuming weight of vehicle =6kg
Thrust force:-
Thrust = (weight*2)/4
= (6*2)/4 = 3kg =3000g
Thrust force = 29.42 N/motor
Weight = 6kg
= 6/4 =1.5kg
Power = weight per motor *9.81*speed
Speed (v) = height/time = h/t = 0.5 m/s
Power = 1.5*9.81*0.5 = 7.35w 0.00735kw = 0.00986hp
Determining torque for this motor:
Power = 0.00986hp
RPM = 1800*12 = 21600
Torque = (hp*525.2)/rpm
= (0.00986*5252)/21600
= 0.002397 N-m

Figure 4: Brushless High Speed Motor

3.4 Propeller:

Propellers are used to generate the thrust for the quad copter hover or lift. These are in different variants which are classified based on their diameter and pitch by which they travel. To create maximum thrust we use to have two "standard rotation" and two "right hand rotation" propellers. We can see that a propeller will have to achieve approximately 412rad.s−1, which is equivalent to 3934 revolutions per minute, to provide the minimum 2.45N required for lift-off. The respective propeller power is

26W. After this short analysis we can state that the EPP1045 propellers are aerial vehicle design suitable for implementation in the aerial vehicle prototype, a statement that can be proved by experimental, showing that with the right motor we can produce the necessary thrust for Lift-Off.

Diameter of the propeller = 11inch
Angle of the propeller = 4.5inch

Figure 5: Propeller

3.5 Flight Control Board:

The flight controller is the "brain" of the aerial vehicle, and performs the necessary operations to keep the quadcopter stable and controllable. It accepts user control commands from the Rx, combines them with readings from the attitude sensor(s), and calculates the necessary motor output. For aerial vehicles, one would select a purpose-made flight controller board. These boards often have integrated attitude sensors, and provide well-tested flight control software. For our project however, we used an Arduino Pro Mini as the flight controller, as we intended to program the flight control software ourselves. The attitude sensor provides the flight controller with readings of the aerial vehicle's orientation in space. At minimum this requires a gyroscope, but most aerial vehicle also incorporates an accelerometer. For a self-stabilizing quadcopter (such as ours), an accelerometer is required. For an aerial vehicle application, a 4-axis inertial measurement unit (IMU) is desired, consisting of a gyroscope and accelerometer on the same board. We selected a Spark fun 9DOF Sensor Stick, seen in Figure 8. This board includes an ADXL345 accelerometer, an ITG-3200 gyroscope, and an HMC3885L magnetometer.

Figure 6: Flight Control Board

3.6 Electronic Speed Controller:

Electronic speed control convert the available 2phase battery current to the 3-phase power and also regulates the speed of brushless motor by taking the signal from the control board. The speed of a brushless motor is controlled by an Electronic Speed Controllers (or ESC). This hardware receives the power from the battery and drives it to the motor according to a PWM (Pulse Width Modulation) signal that is provided by the controller unit. It has a mass of 9g and is capable of providing up to 9A of current4 The ESC as used in radio controlled craft performs two primary functions. The first is to act as a Battery Elimination Circuit (BEC) allowing both the motors and the receiver to be powered by a single battery. The second (and primary) function is to take the receiver's and/or flight controller's signals and apply the right current to the motors. Each BLDC motor needs an ESC. ESCs do the perfect job of controlling BLDCs. The ESCs is simply a brushless motor controller board with battery input and a three phase output for the motors. For the control it is usually just a simple PPM signal (similar to PWM) that ranges from 1ms (min speed=turn off) to 2ms (max speed) in pulse width. The frequency of the signals does also vary a lot from controller to controller, but for aerial vehicles it is recommended to get a controller that supports at least 200Hz or even better 300Hz PPM signal, as it should be possible to change the motor speeds very quickly to adjust the aerial vehicles to the stable position. You should always choose an ESC with about 30A or more in sourcing current as what your motor will require. Computer-programmable speed controls generally have user-specified options which allow setting low voltage cut-off limits, timing, acceleration, braking and direction of rotation. Reversing the motor's direction may also be accomplished by switching any two of the three leads from the ESC to the motor.

The normal startup procedure of the ESC is as follows:

Turn on the remote control and push the pull rod of throttle to the lowest position

→ Connect battery pack with the ESC, the ESC will give out two group sounds to present that the ESC enters working mode when the ESC is electrified for the first time.

→ The first group sound means that the number of battery in battery pack connected to the ESC (three beeps to three batteries, four beeps to four batteries.)

→ The second group sound means the situation of brake. (One beep to the open of brake, two beeps to the close of brake). The preparation of the ESC is completed.

Figure 7: Electronic Speed Controller

3.7 Lithium Polymer Battery:

Lithium Polymer batteries are a newer type of battery now used in many consumer electronics devices. They have been gaining in popularity in the radio control industry over the last few years, and are now the most popular choice for anyone looking for long run times and high power. LiPo batteries offer three main advantages over the common Nickel-Metal. LiPo batteries are much lighter weight, and can be made in almost any size or shape.

LiPo batteries offer much higher capacities, allowing them to hold much more power. LiPo batteries offer much higher discharge rates, meaning they pack more punch. But, just as a coin has two sides, there are some drawbacks to LiPo batteries as well. LiPo batteries have a shorter life span than NiMH/NiCd batteries. They average only 300 – 400 cycles if treated properly. The sensitive nature and chemistry of the batteries can lead to fire should the battery get punctured and vent into the air. LiPos need specialized care in the way they are charged, discharged, and stored.

Figure 8: Battery

3.7.1 Deans Connectors:

Deans Connectors are really the king of connectors. They've been around seemingly forever, and have been the top choice for the discerning R/C enthusiast for quite some time now. They are somewhat difficult to solder, especially for novice users. Deans connectors slide together smoothly, and are very well designed. Like almost every modern connector, they are polarity protected. Currently, they are neck-and-neck with connectors for the title of most popular connector has the edge in the R/C surface category, but Deans dominates in the air.

Figure 9: Dean Connector

3.8 Transmitter and Receiver:

The transmitter with used to operate the four motor by using the receiver which was wired by the four motor by the transmitter signal the receiver supply. So by using the transmitter the signal is supplied and makes the motor to rotate at proper and required through the electronic speed controller. The aerial vehicle is when it flies the required direction, height, speeds are controlled by the transmitter and the whole system is controlled by the transmitter.

The receiver get signal from the transmitter and based on it instruction it supply signal to motor through electronic speed controller. The remote control transmitter/receiver in a small package that requires no external dual-in-line package (DIP) switches on the system circuit board. The device can be easily set for one of many transmit/receive configurations using configuration codes along with the desired security code, both of which are user programmable. When used as a transmitter, the device encodes the stored security code, transmits it to the remote receiver using any transmission media such as direct wiring, infrared, or radio frequency. When configured as a receiver, the TMS3637 continuously monitors and decodes the transmitted security code (at speeds that can exceed 90 kHz) and activates the output of the device when a match with its internally stored code has been found. All programmed data is stored in nonvolatile EEPROM memory. With more than four million codes alterable only with a programming station, the TMS3637 is well suited for remote control system designs that require high security and accuracy. Schematics of the programming station and other suggested circuits are included in this data manual. In addition to the device configuration and security code capabilities, the TMS3637 includes several internal features that normally require additional circuitry in a system design. These include an amplifier/comparator for detection and shaping of input signals as low as several millivolts (typically used when an RF link is employed) and an internal oscillator (used to clock the transmitted or received security code). The TMS3637 is characterized for operation from –25°C to 85°C.

Figure 10: Transmitter and Receiver

3.9 Application:

Aerial vehicle can be used for emergency purpose like ambulance if any problem in driving on road condition can be used, so can be reached at proper time without delay. It can also use in army purpose so the improper condition way path it can be used, so less space is required for this vehicle. So there is no need of separate place is required for landing and takeoff.

4. References:

1. Conceptual Design and Simulation of a Small Hybrid-Electric Unmanned Aerial Vehicle by, Frederick G. Harmon, Volume 42, Issue 5, Page Number 1490-1498, 2006.
2. Unmanned aerial vehicle**:** A preliminary analysis of forensic challenges**, by** Graeme Horsman, Volume 16, Pages 1-11, March 2016
3. Beyond Line of Sight Control of Small unmanned aerial vehicle using a Synthetic Environment to Augment First Person Video by, onathan D. Stevenson, Siu O'Young, Luc Rolland, Volume 3, Issue 5, Page Number 960-967, 2015.