Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 04, April-2016

Design Analysis and Fabrication of Delta Wing Amphibian UAV

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***Abstract*— This project reveals the design, analysis and fabrication of delta wing amphibian, Unmanned Aerial Vehicle (UAV). The UAV is capable of both vertical takeoff and landing (VTOL), and short takeoff and landing (STOL). This UAV can be used for both surveillance and medical emergency. Adding an advantage to this UAV camouflage image setup is used for the better surveillance in air and water. Delta wing is used for the serious aerobatic motions and control ability. Design and analysis result shows that delta wing is suitable for this quadcopter and gives the high lift coefficient and decrease in drag. The design is done by using CATIA V5 software and the flow and structure analysis is done with help of ANSYS software. The lightweight materials like aluminum, corrugated sheet and thermocol and card board sheet is used which reduces the weight and helps the quadcopter to float in water. Quadcopter is being used to have better fuel efficient and reduce in control channel. From the calculation and testing the range is obtained to be 7miles. The maximum speed is 30m/s and the endurance is to be 1hr 30 mints.**

Keywords—Amphibian quadcopter; Delta wing; flow analysis; structural analysis; flight testing

I. INTRODUCTION

Birds can fly in sky due to their inherent characteristics. They are the dominant in the sky. It is human characteristics to dominate or rule over other. So they tried their best to fly in sky from dawn of civilization. And they got it through the success of Wright brothers in 1903. Subsequently many modernization and invention had done through 19th century and now a day's fly without pilot is one of the most important topics of study worldwide for national, international, military purposes under the banner of Unmanned Aerial Vehicle (UAV).Unmanned-Aerial-Vehicle (UAV) development was inspired by the evaluation of piloted airplanes. Interest in the design and development of small UAVs began for more than 25 years ago. Although the definition of small UAVs is arbitrary, vehicles with length less than 6m and mass less than 25 kg are usually considered to be in this category. There are a wide variety of UAV shapes, sizes, configurations, and characteristics. Historically, UAVs were simple drones (remotely piloted aircraft),but autonomous control is increasingly being employed in UAVs. UAVs come in two varieties: some are controlled from a remote location (which may even be many thousands of kilometers away, on another continent), and others fly autonomously based on pre-programmed flight plans using more complex dynamic automation systems.

Small unmanned air vehicles (UAVs) can be deployed at the front lines of combat to provide situational awareness to small units of troops through real-time information about surrounding areas. The technical challenges for small rotary-wing UAV systems are numerous. High thrust-to-weight ratios are necessary for the propulsion system. An endurance long enough to perform a meaningful mission will also be important. A careful matching of batteries, electric motors, and rotors will be essential; and these will have to be sized to carry the necessary payload. Incorporating a reliable semi-autonomous control system in these small vehicles, so that the operator does not have to constantly monitor their performance or location,

II. CAD MODEL DESIGN

Solid modeling is the most complicated of the CAD technology, because it stimulates an object internally and externally. Solid models can be sectioned to reveal their internal features, and they can be stress tested as if they were physically entities in the real world.

A mathematical technique for representing solid objects. Unlike wireframe and surface, modeling systems ensure that all surfaces meet properly and that object is geometrically correct solid models allows for interference checking, which test to see if two or more objects occupy the same space. Primary use of solid modeling are for CAD, engineering analysis, computer graphics and animations, rapid prototyping, medical testing, product visualization and visualization of scientific research.

A numerical model describes some physical phenomenon which comprises equation relating the dependent and the independent variables and the relevant parameters typically, a numerical model consist of different equations that govern the behavior of the physical system, and the associated boundary conditions.

The model for the numerical method is constructed using the software CATIA V5

CATIA V5, which stands for Computer Aided Three-dimensional Interactive Application, is the most powerful and widely used CAD software of its kind in the world. CATIA V5 was created by Dassault System.

Using the CATIA V5 software, constructed a solid quadcopter and the isometric view and the dimension of the quadcopter used are given:

TABLE 1: DIMENSIONS OF THE QUADCOPTER

No. of aluminum rods	4
Arm length	450mm
Arm height	12mm
Arm breath	12mm
Arm thickness	2mm
Arm angle	90 deg
No. of base plate	2
Base plate	120mm x120mm
Box thickness	5mm
Arm cover length	350mm
Arm cover height	35mm
Arm cover breath	35mm
Arm cover thickness	5mm

BASE FRAME DESIGN OF THE QUADCOPTER:

The below mentioned figure 1 shows the base frame design of the quadcopter this designed is chosen for the structural analysis of the quadcopter.

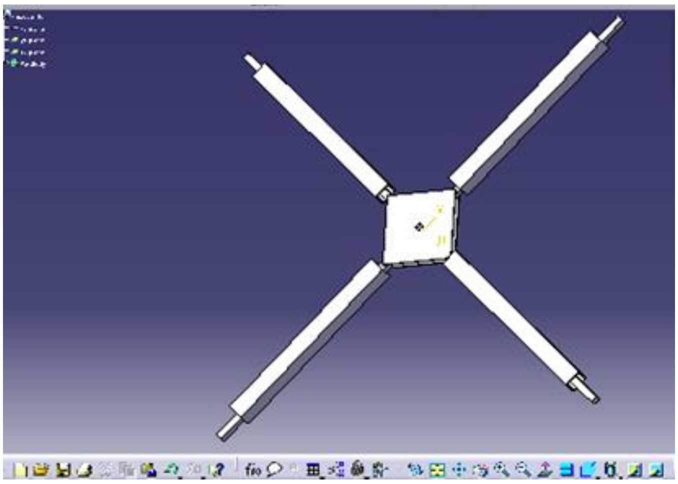

FIG 1: FRAME DESIGN OF THE QUADCOPTER

The above figure 1 shows the base frame design of the quadcopter in which the wing structure with boat shape and other electronics item will be attached to it.

Now the below figure 2 reveals the detail design of the entire quadcopter. Which was designed by using CATIA V5 and the tool used is generative sheet metal.

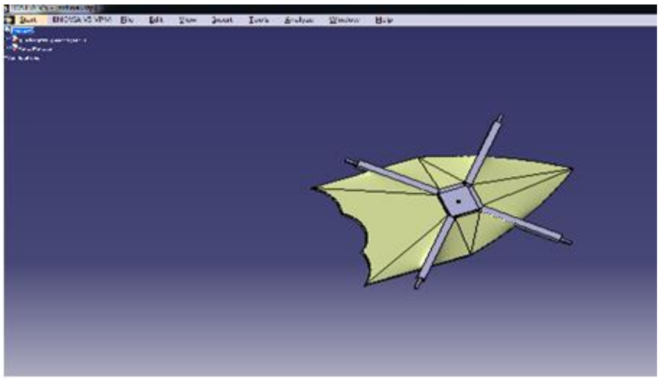

FIG 2: DETAIL DESIGN OF QUADCOPTER

III. FLOW ANALYSIS

After completing the design the next step is analysis. The process of analysis starts with the meshing. Meshing is the process of sub dividing a structure into a convenient number of smaller elements (mesh density)

A question that frequently arises in computational fluid analysis, how fines should the element mesh in order to obtain reasonably good result?" unfortunately, no one can give you a definite answer to this question; you must resolve this issue yourself.

IV. MESH OF QUADCOPTER SURFACE BODY

TABLE 2: MESH DETAILS

Mesh type	Triangular prism mesh
No. of nodes	32484
N0. Of elements	173574
No. of faces	321759
Mesh metric	Skewness(0.8575451)

A triangular prism mesh is used for this quadcopter to get the convenient values. Mesh view of the quadcopter is given below;

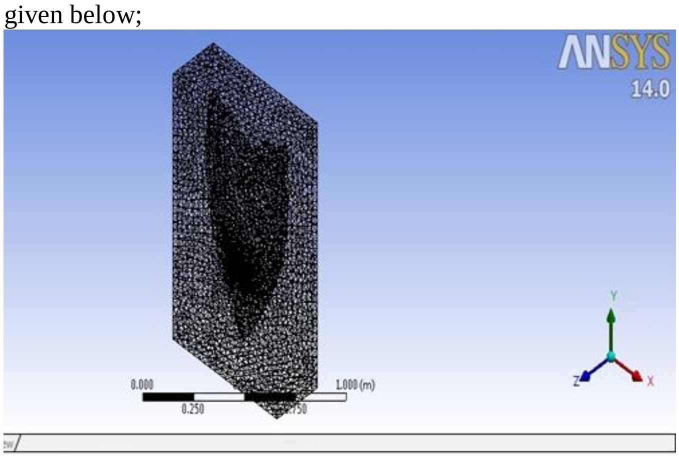

FIG 3: MESH VIEW OF QUADCOPTER SURFACE

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 04, April-2016

After completing the CAD modeling, the next step is the analysis of quadcopter. Before to start with fluent, it is necessary to know if the meshed geometry is correct, so is checked. To ensue with, we are to define the model, material, operating condition and boundary condition. Models are to be set in order to define the continuity, momentum, energy equations are dealt with our study, if the flow is viscous…etc. We have chosen coupled solver, 2d implicit, absolute velocity formulation, cell based gradient option, superficial velocity porous formulation. As our flow is dealt with continuity, momentum, energy equation so is necessary to check them up. The material is selected as air and the density as ideal gas to make the solution simpler. Under the solve command the control is initialization of value is compute from the inlet. It is also necessary to select the appropriate approximation required in the residual command under monitor and check in plot to visualize the progress of iteration. Once every parameter is described the iteration is performed till the value gets converged to required approximation. The figure can be plotted between position in x-axis and any other function in y-axis from plot command. In the velocity magnitude, velocity vector, static pressure, quadcopter surface velocity has been chosen. The three basic equations are:

Continuity Equation:

$$\partial\rho/\partial t+\blacktriangledown.(\rho V)=0$$

Momentum Equation:

- $\blacktriangledown.(\rho uV)=-\partial p/\partial x$
- $\blacktriangledown.(\rho vV)=-\partial p/\partial y$
- $\blacktriangledown.(\rho wV)=-\partial p/\partial z$

Energy Equations:

$$\blacktriangledown.\ [\rho(e+v\text{^}2/2)v]=-\blacktriangledown.(\rho v)$$

V. STRUCTURAL ANALYSIS

After completing the flow analysis using the ANSYS fluent software, now the structure analysis is also dose with same ANSYS (static structural). The structural analysis is nothing but it is about to analysis of the material characteristics. Such as stress, strain, load distribution and deformation of the structure.

In this structure analysis we calculated the following material properties for our quadcopter aluminum frame. The materials properties are:

- Total displacement
- Normal stress
- Normal strain

The following steps are carried out for our structural analysis:

- Applying the material property
- Meshing
- Load conditions
- Result by contour

VI. MESH OF QUADCOPTER BASE FRAME

TABLE 3: MESH DETAILS

Mesh type	Triangular prism mesh
No of nodes	4568
No of elements	17684
Smoothing	Fine
Mesh	Fine

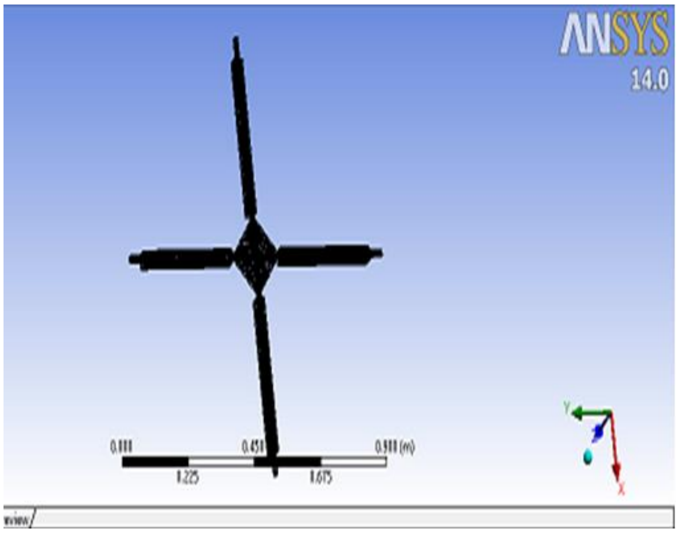

FIG 3: MESH VIEW OF QUADCOPTER BASE FRAME

VII. RESULT AND DISCUSSION

A. *Flow analysis*

From the analysis of this quadcopter, it is clearly visualized the pressure and velocity distribution during the flow. We have obtained the co-efficient of lift and drag values from the iterations.

TABLE 4: BOUNDARY CONDITIONS

PARAMETERS	Value
Inlet Velocity	30m/s
Hydraulic diameter	0.45m
Turbulence intensity	2.14 %
Inlet static pressure	1 bar

PRESSURE DISTRIBUTION OVER THE SURFACE.

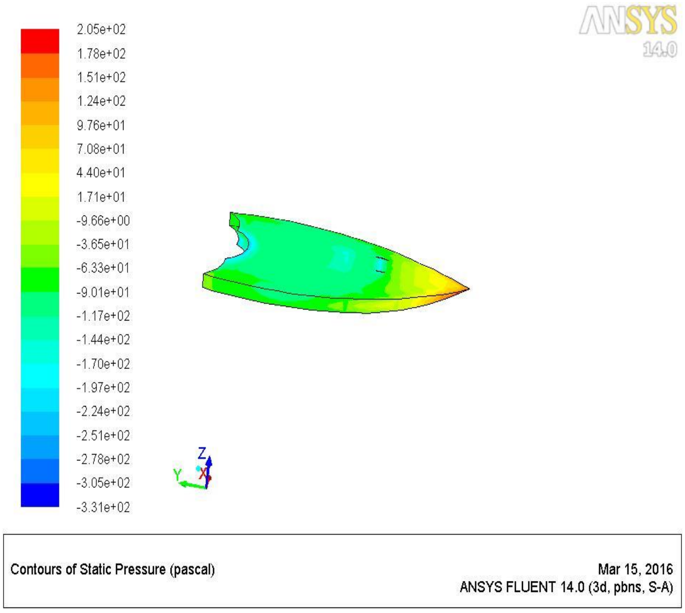

FIG 4: STATIC PRESSURE CONTOUR PLOTS

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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Firstly, we have done the flow analysis with zero degree of angle of attack. Since our delta wing, which we have used here is static one.

The pressure distribution over the surface. The inlet pressure is given as the atmospheric pressure over the surface and the pressure flow is evenlly distributed over the surface. From the contour plots we can understand that the pressure starts to decrease from the leading edge of the surface, it also indicates that the increase in velocity.

VELOCITY DISTRIBUTION OVER THE SURFACE

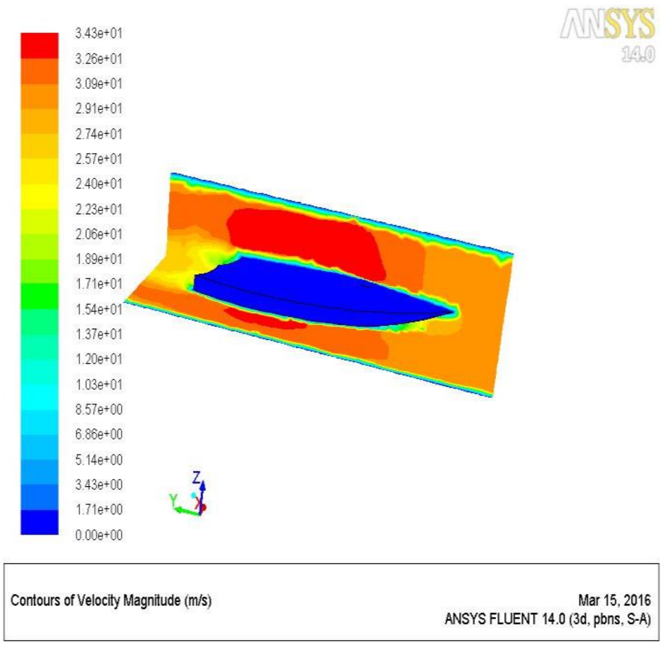

FIG 5: VELOCITY CONTOURS OVER THE SURFACE

The velocity contour over the surface from the, figure it reveals that the velocity is maintained constant over the surface. And the velocity is slightly increased over the mid surface of the wing. Since the velocity is increased over the surface this model can be used for flying.

TABLE 5: RESULT FOR FLOW ANALYSIS

PARAMETERS	VALUE
Static Pressure over the surface	101323 Pa
Maximum Velocity	3.09e+01m/s
Co-efficient of lift	1.4510e-02
Co-efficient of drag	6.0698e-03

B *Structural analysis*

After meshing the loading conditions are given to the selected frames. The loads are given in opposite to X direction at each ends points and the load is given as the thrust load. The load value is given as -1.5 which will give the total displacement of the structure and also the normal stress and strain.

The following equation is solved for the structural analysis for the structure. And the total load distribution, normal stress and strain for the given loading conditions. The Finite element method is used for solving the structural problems.

$$F=ku$$

The results are solved from the above equations and the results are taken as the contour plots.

TOTAL DISPLACEMENT OF BASE FRAME

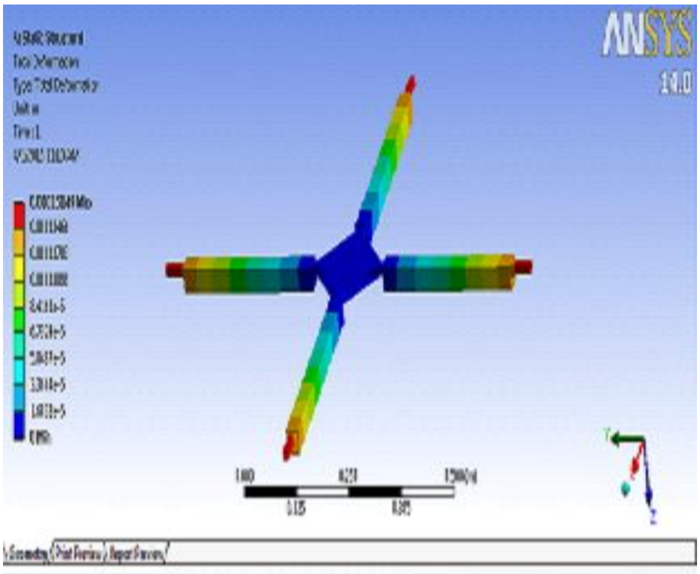

FIG 6: TOTAL LOAD DISTRIBUTION FOR STATIC STRUCTURE

The maximum total load distribution over the surface at each end points of the frame. This picture also reveals the selected load is suitable for the designed frame and the load is acting very low at the fixed point. So this frame is suitable for the selected thrust.

ELASTIC STRAIN OVER THE FRAME

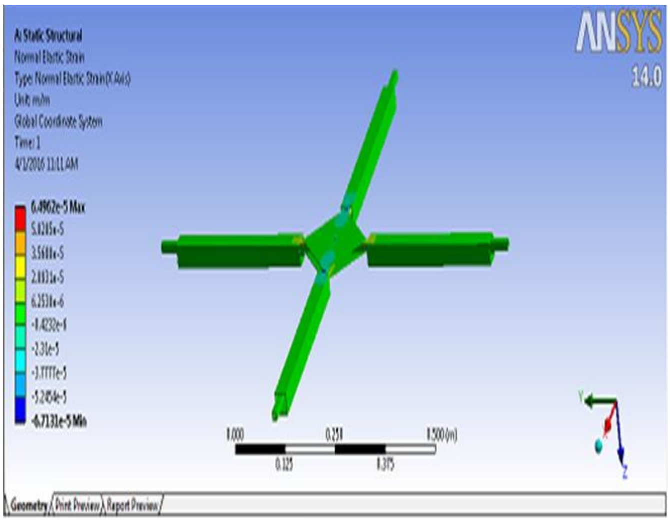

FIG 7: NORMAL ELASTIC STRAIN OVER THE FRAME

International Journal of Engineering Research & Technology (IJERT)
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ELASTIC STRESS OVER THE FRAME

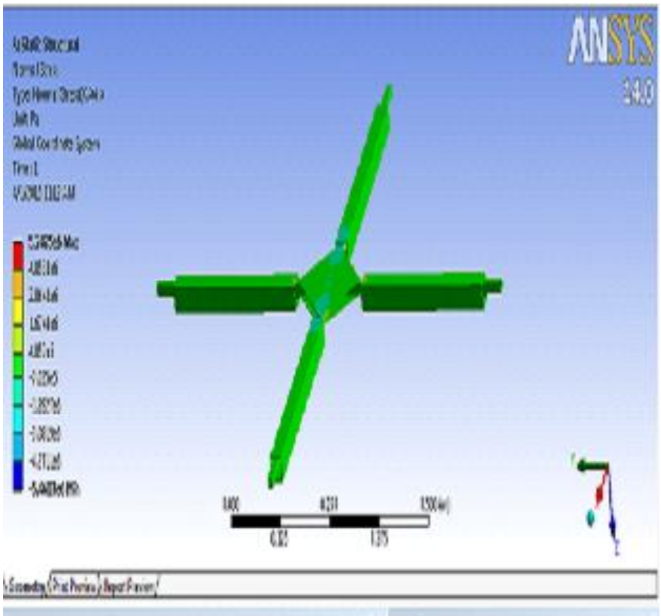

FIG 8: ELASTIC STRESS OVER THE SURFACE

From the figures 7 and 8 it shoe the normal elastic stress and strain for the given loading conditions. From the above obtained result we can find that the designed structure is suitable for the loading conditions.

TABLE 6: RESULT FOR STRUCTURAL ANALYSIS

PARAMETERS	VALUES
Maximum total deformation due to the effect of the lift	0.00001519 m
Maximum Normal elastic stress	6.4965e-05m/m
Maximum Normal elastic strain	5.24259e-05m/m

VIII. FABRICATION PROCESS

Fabrication work started with the metal frame construction and mathematical analysis. All the electronic controls and the wing construction will be attached to the metal frame. For the construction of metal frame the material is selected according to the estimated weight and total size of the model.

Material used:

1. Aluminum rod (frame)
2. Aluminum sheet (base frame)
3. Coharated sheet (wing section)
4. Cardboard sheet (base plate)

FIG 9: PRE-FINAL ASSEMBLY

The metal frame construction with all the electronics components attached to it.

FINAL ASSEMBLY

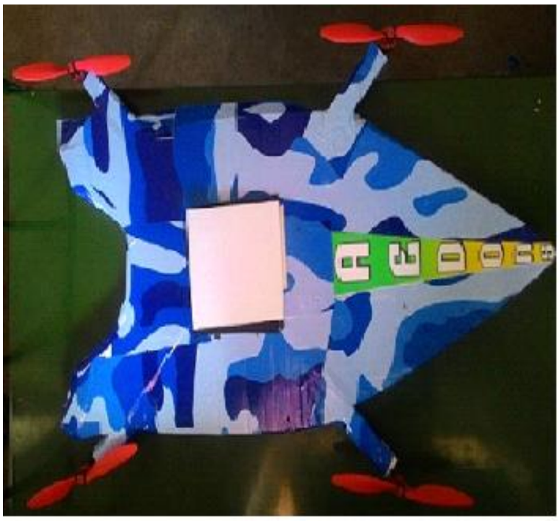

FIG 10: FINAL ASSEMBLY WITH CAMOUFLAUGE SETUP.

IX. CONCLUSION

By performance analysis from the both the software analysis of the designed model and the test flight from the fabricated model the results are obtained and the performance results are calculated both by numerically and analytically the results obtained are showing the positive for the use of the fabricated model. The flow analysis result shows the increase in velocity and decrease in velocity and also the proper value of lift and drag. On the other hand we also done the structure analysis for the frame here we obtained the values of structural properties of the frame such as maximum total load displacement, normal elastic stress and normal elastic strain are calculated. Then the fabricated model is tested both on the air and water the altitude is maintained above 1000m and efficiency for the flight time is about 1hr: 30 mints and the total speed of the model in air is 30m/s and in the water is 1m/s. these are results which we obtained from the software analysis and the experimental work. From this we conclude that this can implemented as an real one for both the defense and the social as an surveillance and medical emergency.

ACKNOWLEDGEMENT

The authors acknowledge the valuable suggestion from the faculty of aeronautical engg.., Sri Shakthi Institute of Engineering and Technology.

REFERENCE

[1] DoD. Unmanned Systems Integrated Roadmap - FY 2009-2034, April 2008.
[2] Vargas-Clara A, Redkar S. Dynamics and Control of a Stop Rotor Unmanned Aerial Vehicle, International Journal of Electrical and Computer Engineering (IJECE), 2013; 2(5): 597-608.
[3] Yanhui G, Qiangui X, Shousong H, Xiao J. Flight Control System Simulation Platform for UAV Based on Integrating Simulink With State flow, TELKOMNIKA Indonesian Journal of Electrical Engineering, 2012; 10(5): 985-999.
[4] Frederick-RecascinoC.New Uses for UAVs, Strata – Report on Research, Embry-Riddle Aeronautical University, 2006.
[5] Watts AC, Ambrosia VG, Hinkley EA. Unmanned Aircraft Systems in Remote Sensing and Scientific Research: Classification and Considerations of Use, Remote Sensing,2012; 4: 1671-1692.
[6] Cox TH, Nagy CJ, Skoog MA, Somers MA. Civil UAV Capability Assessment, NASA Report, Dec 2004.
[7] Wise J. Civilian UAVs: No Pilot, No Problem, Popular Mechanics, Oct 2009.
[8] Rango A et al. Using Unmanned Vehicles for Rangelands: Current Applications and Future Potentials," Environmental Practice, 2006; 8: 159-169.
[9] Wyllie D. Police UAVs – Nearly Limitless Potential, Police One, May 2012.
[10] McKay J. Sacramento Police Unmanned Aerial Vehicle Program Gaining Altitude, Government Technology Magazine, Sept 2007.