DESIGN, FABRICATION AND FINITE ELEMENT ANALYSIS OF AUTONOMOUS TRICOPTER USING BIODEGRADABLE COMPOSITE MATERIAL

Project Reference No.: *45S_BE_4581*

College **:** *Vidyavardhaka College of Engineering, Mysuru*
Branch **:** *Department of Mechanical Engineering*
Guide(s) **:** *Prof. Praveenkumara B M*
Student(S) **:** *Mr. Vignesh Kumar R*
Mr. Syed Maaz Ahmed
Mr. Deepthi Rao
Mr. Madhan Kumar J

Keywords:

Bio-degradable, Silk-Jute composite, ANSYS, Solidworks, UAV, Tricopter

Introduction:

Composites consist of two or more phases with significantly different properties (Physical and chemistry). Together they form a material with different properties from individual components. Each phase remains separated within the completed structure. The components of a composite material can be classified based on their function as fillers. And matrix. The most commonly used matrix materials are polymers, metals and natural composites (jute, Wood, bamboo and silk) Ceramic and carbon, glass, carbon, aramid, fillers boron. Reinforcing materials come in several forms, including continuous fibers, staples, and particles. The main advantage of composites is the combination of high strength and rigidity. It has a lower density than bulk materials and can be made lighter Finished product.

In the coming years, the demand for Unmanned Aerial Vehicles (UAVs) will increase day by day, aircraft that operate aerodynamically to provide lift without the need for human control on board. In general, the drone can be controlled automatically or remotely, the drone is equipped with three coaxial propellers. Each motor of each coaxial rotor in this configuration rotates in the opposite direction of the other to suppress the tilting yaw generated by each motor in the coaxial rotor assembly, the tricopter has three single rotors with a single servo motor. for one rotor. The servo motor is used to change the lift angle of one of the three single rotors. Turning the engine clockwise or counter clockwise according to the control ring will change the tilt angle of the vehicle. In both configurations, the main objective is to stabilize the vehicle's yaw moment.

Combining all of this, we get an autonomous flying tricopter drone, whose frame is made of a biodegradable composite material consisting of jute and silk fibers bonded using epoxy. bio (Epicerol) and electronic components fastened to the frame with bolts, nuts, double face tape and epoxy all wires tied together with zip ties

Objectives:

1. To design and fabricate tricopter frame using bio-degradable composite material.
2. To do the finite element analysis to composite material and compare it to the existing tricopter material.
3. To design frame of the tricopter stronger in strength compared to traditional material.
4. To design a cost-effective of the drone frame.
5. To develop autonomous tricopter in order avoid human intervention in controlling activities.
6. To make drone flying with precision using GPS data and other telemetry data.

Methodology:

1. Components:

   Servo-Motor (MG 996R): A servo motor is a Dc motor device that works with the servo mechanism principle. Servo Motors are controlled by electrical pulse through the variation of width (PWM from the Arduino). Servo motor can turn a maximum of 180^0 angle of movement that is 90^0 in any direction. Dual axis uses Three servo motors for rotating the frame in X-axis and Y-axis with base.
   Battery: Uses the chemical energy stored in the battery to supply the power to the tricopter or the system.
   KK2.0 board: multi-Rotor controller is a flight control board for multi-rotor aircraft (Tricopter). Its purpose is to stabilize the aircraft during flight. To do this it takes the signal from the 6050MPU gyro/acc (roll, pitch and yaw) then passes the signal to the Atmega644PA IC. The Atmega644PA IC unit then processes these signals according the user's selected firmware and passes control signals to the installed Electronic Speed Controllers (ESCs).
   Electronic Speed Controllers (ESCs): These signals instruct the ESCs to make fine adjustments to the motors rotational speed which in turn stabilizes your multi-rotor craft. Once this information has been processed the IC will send varying signals to the ESCs which in turn adjust the rotational speed of each motor to induce controlled flight.
   Propeller: The primary purpose of a propeller is to convert rotary motion of an electric motor to axial thrust via torque transfer to the propeller. The rotating propeller produces thrust by capturing air and expelling out at the back. The more air it expels over time, it consumes more power and generate greater thrust. In order to push the air, the blades need to capture the air and hence they will be twisted so that they can propel into the air.
   Motor: three standard brushless out runner motors with standard aerodynamically designed propellers. The configuration of the Tricopter constructed is three arms spaced at 120 degrees separation to maintain continued stability even while hovering. Speed controllers are employed to control the speed of each motor. model No. A2212/10T having motor KV 1400 And a maximum efficiency of 78%.

2. Mechanical Design:
   On the basis of availability of motor thrust producing capacity and dimensions. Then with the help of calculations and literature review, the triangular shape frame was fabricated using hand-layup process where 3 layers of jute and 2 layers of silk were combined with epoxy and let it dry for about 14 hours in room temperature and further fitting of motor stared, two motors were mounter permanently without any special mechanism another was fitted with thrust vectoring mechanism MG996R servo motors are taken for two axis rotation. As the MG996R motor have a torque value of 1.373 N-m (6V), 1.471 N-m (7.2V). As it will be difficult to have intensity difference of light in resistor due to small area.
3. Electrical Design:
   Under electrical section design includes the connection of ESC, Motors, KK2.0 Board, Propellers and Servo motor together in the board. Beside this an additional connection to the battery, the receiver circuit diagram is shown in the figure (4). And connecting motors through the ECS and a hub to the battery to supply power.

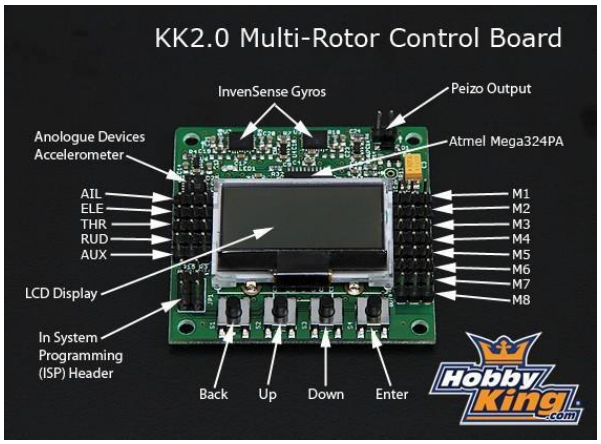

Figure 1: Hobby king KK2.0 board

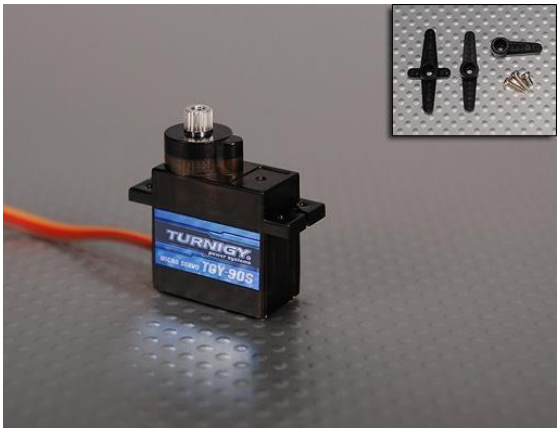

Figure 2: Servo-Motor (MG 996R)

Figure 3: Electronic Speed Controller

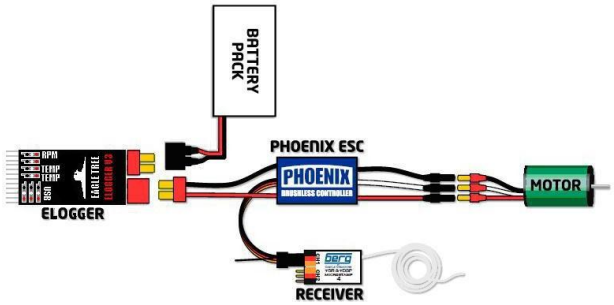

Figure 4: Electronic Speed Controllers – Motor – Receiver Wiring, Castle Inc.

Figure 6: proposed sketch

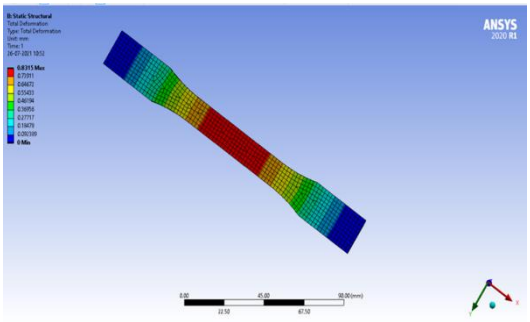

Figure 7: testing of ASTM specimen D638-1 Composite material jute and silk

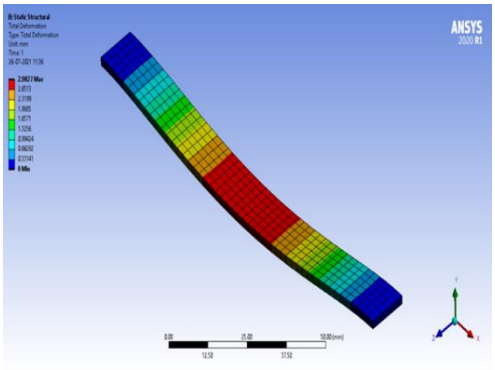

Figure 8: ASTM fluxture testing specimen D-790

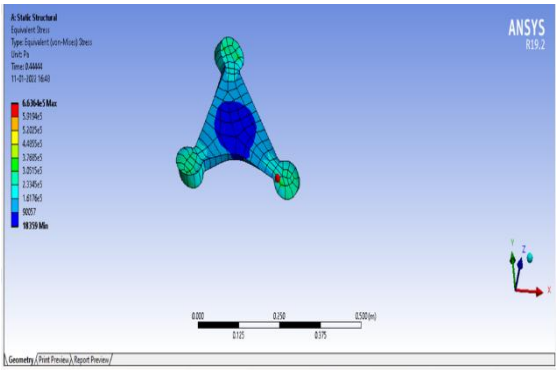

Figure 9: Static Structural Analysis- Equivalent stress

Figure 10: hand-layup process fabrication

Figure 11: composite drone frame

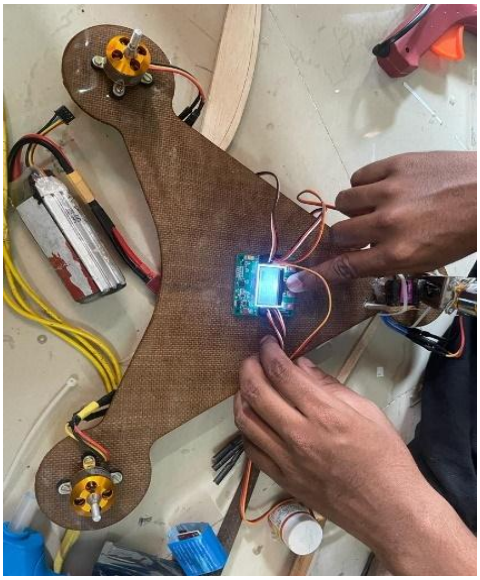

Figure 12: finished top view

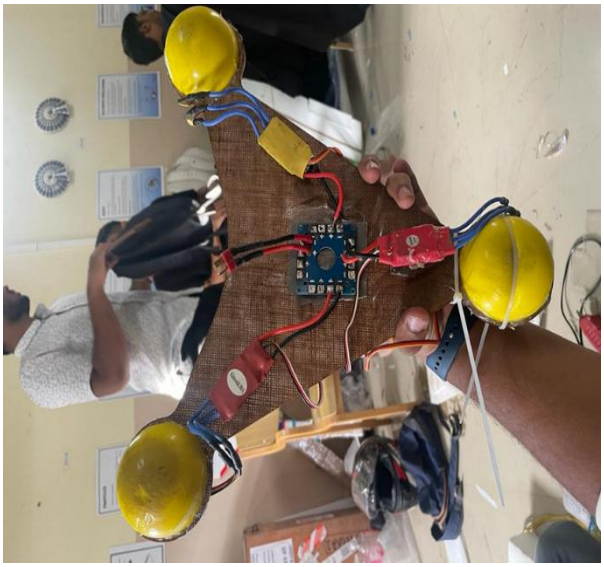

Figure 13: finished bottom view

Conclusion:

We successfully studied all about what is UAVs or drone, different parts of drone, how it work, how types of exist ,use of application of drone ,for who it is applicable ,why drone need in this days, future scope of drone , what are the different types of forces act on drone and different concept applied in making it, Nature of load acting on drone ,what are the advantage and disadvantage from this in day today life ,what are the facing drone users ,what are the various feasible manufacturing material can be used for drone manufacturing and which material will be the best one and which is usually used yet, which type of improvement need in current drone ,how to make drone for performing well in different operation which is impossible or not properly to do by human being or dangerous like data collection from remote places and other navigation and control purposes, what are the innovation required for drone.

As I think rocket propulsion can be a very efficient concept for making drone faster as our technology is growing very fast so in this age faster drone may be very beneficial for mainly for military purpose and by far drone we can make observation in less by collecting data from drone. I found different feasible material which can be used for drone and how to make more strength material by using the composite material concept. Which tests were accomplished by finite element test (ANSYS) software,I have analysed for different shape and different materials. Out of them I found some composite material which are most feasible for drone manufacturing. Like composite of jute fiber and silk for that data analysis are also included in this paper. On results of analysis of different composite materials and various pure materials it can conclude that this time composite material of jute fibres will be the most feasible and efficient manufacturing material for UAVs.

As composite of jute and silk fibre have high bending and torsional as compare to other material, also it has high corrosive resistance, easily mould in different shape and size. Design constraints to build a tricopter using composite material is designed and analysed using the ansys software. The forces acting on the plate are calculated by software and applied numerically to understand how the plate behaves under load conditions.

Scope for future work:

1. In future this autonomous bio-degradable tricopter frame doesn't cause any harm to as traditional drone frame does.
2. We can make the scouting work very easy with the help of tricopter.
3. The product is so portable, so that we could carry it anywhere.
4. the device will be implemented in electrical power station for surveying the electrical lines.
5. Make the device more compact by reduce its size and it make easier to work.
6. It helps villages to scout of agricultural land for fertilization, scaring animals from the framing land.
7. To get the samples or the data from the sky for weather forecast.
8. To perform cloud seeding in low rain fall areas.
9. To provide the drone for reasonable price while comparing traditional drone.

Reference:

1. Castillo, P., Lozano, R. and Dzul, A.E. (2004) Modelling and Control of Mini-Flying Machines, Springer, USA.
2. Chiou, J-S., Tran, H-K. and Peng, S-T. (2013) 'Attitude control of a single tilt trirotor UAV system dynamic modelling and each channel's nonlinear controllers design', Mathematical Problems in Engineering, Article ID 275905, 6pp.
3. Dorf, R.C. and Bishop, R.H. (2010) Modern Control Systems, 12th ed., Prentice Hall.
4. Escareo, J. et al. (2008) 'Triple tilting rotor mini-UAV: modeling and embedded control of the attitude', American Control Conference, IEEE.
5. Kataoka, Y., Sekiguchi, K. and Sampei, M. (2011) 'Nonlinear control and model analysis of trirotor UAV model', 18th IFAC World Congress.
6. Kulhare, A., Chowdhury, A.B. and Raina, G. (2012) 'A back-stepping control strategy for the trirotor UAV', Control and Decision Conference (CCDC), 24th Chinese, IEEE.
7. Mohamed, M.K. and Lanzon, A. (2012) 'Design and control of novel tri-rotor UAV', Control (CONTROL), UKACC International Conference on, IEEE