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DESIGN AND DEVELOPMENT OF SWASHPLATE-LESS HELICOPTER

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Abstract:

Helicopters are rotorcraft with horizontally rotating rotors that provide lift and thrust. The helicopter will take off and land vertically, hover, and fly forward, backward, and laterally as a result of this. These motions are created with the aid of a complex swash plate. This mechanical system has a lot of wear and tear, and the pumps are more expensive per unit. This needs to be replaced. Making a helicopter with the technical simplicity of a drone would be a fascinating way to reconcile the technically complex flying helicopter and the technological complex flying quad copter. This can be accomplished with just a programmed micro controller and no swash plate. This gives rise to the concept of a helicopter without a swash plate. By removing the complicated controls of a traditional helicopter swash plate or the dispersed propeller array of a quad rotor, this concept enables new inexpensive, durable, and light weight aircraft

***Keywords* - Engineering, Helicopter, Swashplate, Arduino, PLA, Matlab.**

I. INTRODUCTION

The main rotor of a helicopter is the most critical component of the aircraft. It provides lift for the helicopter to fly as well as power for the helicopter to travel laterally, turn, and adjust altitude. The rotor must first be extremely powerful in order to do all of these activities. For each revolution, it must also be able to change the angle of the rotor blades. The swash plate assembly is a mechanism used by the pilot to communicate these changes.

II. METHODOLOGY

A. Selection of motor and propeller blades:

The motor should be chosen so that it can generate the amount of thrust needed by the system and that it can operate at a higher efficiency under all conditions.

B. Design of main rotor system:

A combination of a traditional flap hinge and a distorted lag-pitch hinge will be used to cause blade lag-pitch coupling or lead-lag motion.

C. Programming:

The cyclic system's goal is to cause an elevated blade pitch as the blades move through a certain station on the rotor disc, and a depressed blade pitch as the blades pass through the opposite station. The positive and negative blades' geometry is complementary to one another, yielding opposite responses, and these positive and negative blades are 180 degrees out of alignment with one another. Both blades fall behind as the motor's speed increases.

D. Development of helicopter prototype:

The tail rotor will be assembled to counterbalance the torque of the main rotor, and other parts of the small helicopter will be picked from existing small helicopters. It's also necessary to calculate all of the losses.

E. Cost estimation:

The expense required to purchase and fabricate the selected and designed components is estimated.

III. MODELING

The design is carried out in CATIA V5 software. The dimensions of different parts are taken according the dimensions of electric component it carries. The designed model shown in Fig.1 and Fig.2 is then 3D printed with PLA material.

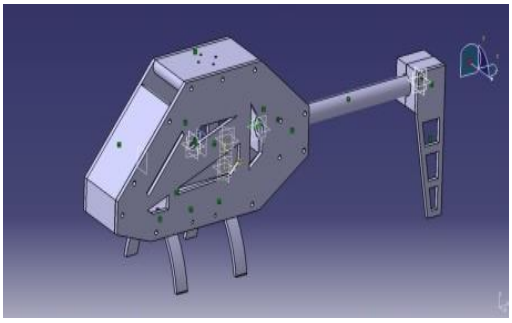

Fig.1:3D view of model.

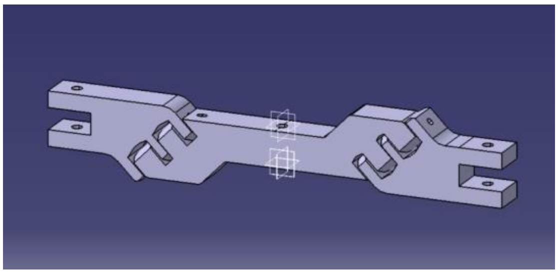

Fig.2:3D view of hinge part.

IV. PROGRAMMING

Sample programming to change the speed of the motor is done in Matlab.

The speed of the motor is kept constant for certain RPM called base RPM and sine wave is used to accelerate and decelerate the motor above and below the base RPM. Output from the Matlab can be shown in Fig.3

Trail.1- MATLAB Code:

```
clear all
close all
clc
a = linspace(0,360,361)
%angle from 0 to 360º
b = sind(a)
 %sine modulation
c = 200 + (100.*b)
 %200 is constant rotor speed
plot (c,'linew',3)
hold on
plot([0 400],[200 200],'color','k','linewidth',2)
grid on
```

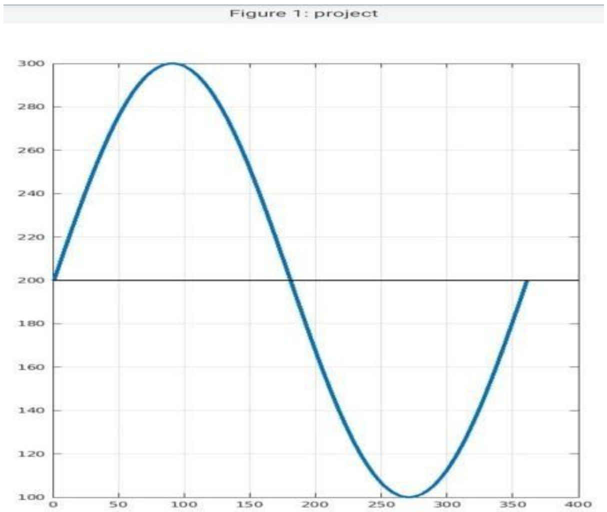

Fig.3: Output graph from Matlab.

Trail.2- Arduino coding

To vary the speed of the motor, to accelerate and decelerate motor in single rotation, microcontrollers are used. Arduino coding is formulated for this control.

The code employed in the Arduino that is used to accelerate and decelerate the motor is shown below.

The resulting variation in the speed of motor that drives the propeller leads to the production of lift that varies at two points separated by 180^0.

The below code is common internal loop use for various conditions involving the different motion of helicopter viz. Forwards, backwards, left and right.

Code:

```
#include<Servo.h>        //Including Servo Library
Servo ESC;               //Creating ESC class
float y;                 //Initiating float values
float Throttle;
void setup() {
// put your setup code here, to run once:
  ESC.attach(9);           //Attaching to pin number 9
  ESC.writeMicroseconds(1000);
  Serial.begin(9600);          //Serial communication
with Speed 9600 bit/sec
}
void loop() {
  // put your main code here, to run repeatedly
  int throttleValue = analogRead(A0);
 //Reads analog values of potentiometer from 0 to
1023
  intThrottle= map(throttleValue,0,1023,1000,2000);
//Maps analog values to motor speed between 1000
to 2000
//For loop to calculate all the degree values from 0
to 360
//Arduino code takes Radian value as default
//Conversion from Radian to degrees is done
  for (int x = 0; x<=63; x++){
  float y = float(x)/10;
  float n = (sin(y)*Throttle + 1000);
  delay(20);                    //Delaying code for 20
microseconds.. 1000 ms = 1 second.
  Serial.println(n);                  //Prints all values
to serial monitor
   ESC.writeMicroseconds(n);       //Sends all these
values to motor.
  }
}
```

V. DEVELOPMENT

The designed hinges are fabricated with 3D printing technology using PLA Material .PLA known as polylactic acid or polylactide is a thermoplastic material. Due to its more ecological origins this material has become popular within the 3D printing industry.

The Fig.4 shows input of the parts given to the 3D printer machine and the figure shown below is the standard settings in the 3D printer machine for printing the parts with PLA filament and the output from the 3D printer machine which is the final fabricated model. The Fig.5 shows the final 3D printed parts of the model.

The components are listed in table.1. To obtain the software, Arduino is connected to the laptop. The uploaded programme will run on the Arduino, which is powered by the battery through three jumper wires. The motor is linked to an ESC, which regulates the motor's speed. The battery is attached to the ESC. As a result, the Arduino software will use battery power and an ESC to drive the motor.

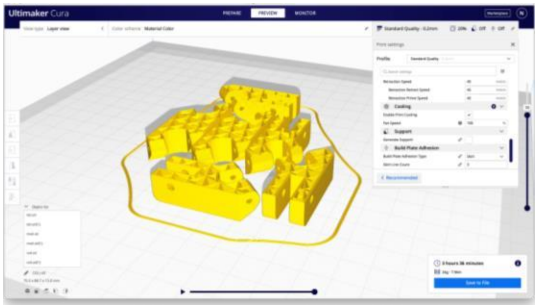

Fig.4: Standard settings in the 3D printer

Fig.5: 3D Printed parts using PLA Material.

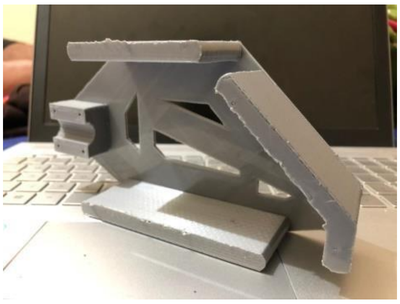

Fig.6: 3D printed part.

The following Table.1shows the Components used for the development of the model

Table.1: Components used

Main motor	Emax mt2216 810kv brushless dc motor
Tail motor	Avionic pro m1818 kv4500 micro brushless motor
Micro controller	Teensy 3.5
Electronic speed controller	EMAX 30A ESC.
Flight control	Omnibus f4 pro v4
Magnetic encoder	As5600 absolute encoder
Material	PLA
Battery	3S 11.1 Volt 1500mah LiPo battery

The below Fig.7 shows the assembly of helicopter prototype made from the parts displayed in the table.1. The assembly involves the main rotor head with hinges holding the propeller blades which are driven by the motor programmed with teensy board and is powered by motor residing in the front of prototype. The assembly reduces the mechanical complexity of swashplate and also involves less number of motors than the Quad copter. Hence it has ability to reduces both mechanical and electrical complexities and also easy to operate.

Fig.7: Assembly of the Helicopter prototype Side view.

Fig.8: Assembly of the Helicopter prototype.

VI. CONCLUSIONS

By replacing the mechanical swash plate assembly there is several advantages

a) Gross weight associated with swash plate system can be reduced.

b) Assembly complexities of the swash plate can be replaced.

c) As it is a simplified mechanism it can easily operate.

d) This system is less prone to wear and tear of components and it is robust.

e) Maintenance issues are comparatively less.

f) Hinge losses due to friction are the parameter that needs to be focused and it should be reduced.

ACKNOWLEDGMENT

What if the drawbacks of both the helicopter and quad copter could be eliminated? Making a helicopter with the technical simplicity of a drone would be a fascinating way to reconcile the technically complex flying helicopter and the technological complex flying quad copter. This can be accomplished with only two counter-rotating propellers and no swash plate. This gives rise to the concept of a helicopter without a swash plate. By removing the intricate ancillary controls of a traditional helicopter swash plate or the dispersed propeller array of a quad rotor, this concept enables new inexpensive, durable, and light weight aircraft.

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