Proposal to Research Carbon Fiber Reinforced Polymer (CFRP) Drone Frame using CLIP Technology

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Brief explanation of Project and Objective

First invented and applied during WWII, unmanned aerial vehicles (UAV) nowadays have a wide range of military and civil applications. The applications range from agricultural surveillance, meteorological data acquisition, disaster monitoring to entertainment [1]. It is estimated that the number of UAV will increase dramatically within a few years, with their size and design depending on purpose [1]. Due to their future potential, our group chose to research unmanned aerial vehicles.

One common goal of UAV design is high endurance, which is achieved by aerodynamic parameter maximization and weight minimization[1]. Since additive manufacturing can produce drones with lighter weights without sacrificing strength, we see the potential of additive manufacturing for drone design. In addition, compared to equivalent traditional manufacturing, additive manufacturing has the capability of making high geometrical complex parts without additional cost[2]. With the advancement of additive manufacturing, drones can be created at a reduced cost with better capabilities.

In this project, a drone frame will be made with carbon fiber reinforced polymer (CFRP) using Continuous Liquid Interface Production (CLIP) technology. Through the project, our group aims to research the feasibility and effectiveness of using CFRP reinforced structure with CLIP technology. The drone will have the benefits of both detailed lattice structure and structural rigidity of carbon fiber.

Our project consists of two phases: drone frame design and drone manufacturing. During the design phase we will focus on design optimization, creation of lattice structures and mating with carbon fiber reinforcement in mind. During the manufacturing phase we will focus on optimizing the degrees of vacuum and temperature during carbon fiber and CLIP bounding.

Preliminary Designs and Manufacturing Consideration

Our preliminary drawing of the drone is shown in figure 1. We chose the common design of most drones. The tentative dimension is 300mm * 300mm.

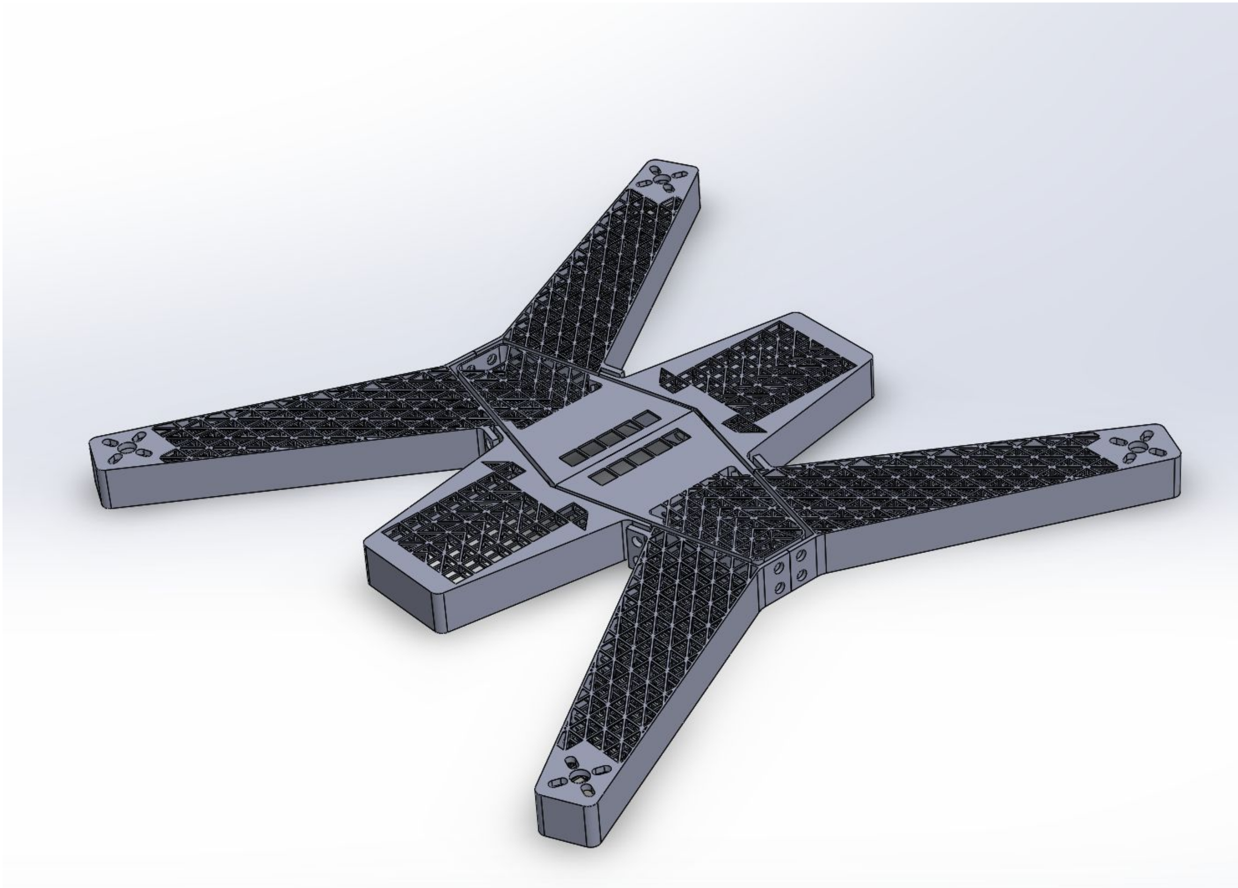

Figure 1. Preliminary Design

The material we will use in our project will be carbon fiber reinforced polymer(CFRP), in which carbon fiber binds with other thermoset resin. A light and strong drone is expected to be produced. As a result, the material should be low in density and high in stiffness so that our drone can minimize the damage due to a gust of wind or lifting heavy weight. Carbon fiber, a polymer with graphite form, was chosen for its strongness, stiffness and high stiffness-to-weight ratio[3]. To maximize its strength and minimize its weight, carbon fiber is usually combined with other thermosetting material. Because it is strong and lightweight and because of its resistance to corrosion and fatigue, CFRP is popular in space and car industry[4]. Our CFRP has been pre-impregnated into a resin system, so that we can have a repeatable and uniform material.

The additive manufacturing process is Continuous Liquid Interface Production (CLIP) technology. Tradition 3D printing technology, such as FFF used in the Makerspace, would cause trouble in the loading test since some mechanical characteristics would be different in horizontal and vertical direction[5]. Compared with other additive manufacturing processes, Continuous Liquid Interface Technology (CLIP) held its advantage in speed, quality, and range of material chosen. CLIP is approximately 25-100 times faster than traditional 3D printer[6]. For a relatively large part such as our quadrotor, using CLIP will be much efficient. In addition, since CLIP is a continuous process, the mechanical layer-by-layer property will be eliminated so that our part will have uniform property across all axises[5].

It should be noticed that the detail of our drawing is subjected to change. While CFRP and CLIP might not be available at the university, we are able to find these required materials and machine. As a result, the material or the machine will not be our constraints.

Proposed First Print Trial and Experiment

We have sent the design of print trial to the University of North Carolina. The test piece, which is the end of the drone arm, is shown in figure 2. The post processing involves adding carbon fiber, followed by using oven to achieve fully cure of the resin. After carbon fiber adding at the outside of the drone, the workpiece will be vacuumed and heated. There is a chance that the arm will deform during vacuum or during heating. The trail print will explore the behavior of the CLIP resin in high pressure and high heat. In addition, the test piece will also serve as a dimension check to determine if the motor can be mated onto the arm. The test piece can also explore whether weather support are needed.

The finished drone involves multiple parts, including four arms, four wing sections, and a electronics bay. Most of the parts were designed with carbon fiber laying up in mind and these parts require adding carbon fiber and eventually to be cured in an oven. After the fibers was layed and cured, holes on each end of the arms will be drilled as theses holes serve to join the parts together.

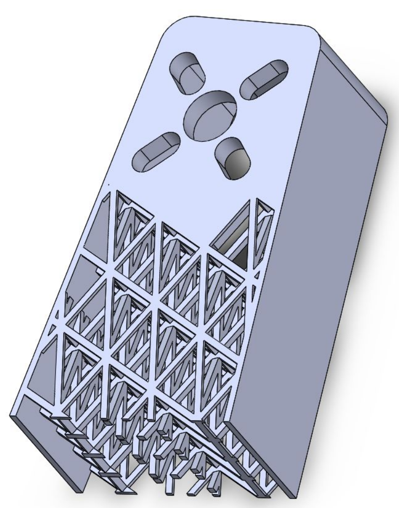

Figure 2. Geometry of Test Trail Part

Deliverable

A drone frame will be made with carbon fiber reinforced polymer (CFRP) using Continuous Liquid Interface Production (CLIP) technology. Our design file will be delivered upon request to proposal readers.

Schedule

Since drone project(for Polymer Engineering Center) started earlier than this project, a relatively comprehensive drone design has been drafted. Detailed schedule is listed below.

	Date								
	-3/3	3/4-3/10	3/11-3/17	3/18-3/24	3/25-3/31	4/1-4/7	4/8 - 4/14	4/15 - 4/21	4/22 -4/26
Research									
Preliminary design	■								
First print trial and experiment	■								
Revise design		■	■	■	■	■			
Print trial and experiments executions				■	■				
Print part							■		
Evaulate real life application							■	■	
Report									
Project Proposal	■								
First Project Update					■				
Second Project Update						■	■		
Drafted Project Report								■	
Finalized Project Report									■

Qualification

As students in Engineering at the University of Wisconsin-Madison, our group is qualified for this research. Our degree in Engineering help us to explore a variety of different courses, which have familiarized us with engineering drawing, manufacturing process, fluid mechanics and polymer properties. This comprehensive knowledge allows us to design and manufacture a part with thorough consideration while minimizing the possibility of defects. In addition, two members in our group work in the Polymer Engineering Center, so we have first hand experience with polymer analysis and additive manufacturing. With ample knowledge and research experience, our group is qualified to design an desired quadrotor frame within a timely manner.

Conclusion

In conclusion, our group proposes to design and manufacture a quadrotor frame made of carbon fiber reinforced polymer(CFRP) using Continuous Liquid Interface Production (CLIP) technology. Currently we have created the geometric design. By the end of the semester, we will submit a report to summarize the project proposal, trials and results. Developing a drone in our proposed material and technology has the potential to reduce cost of drone production, which will enlarge the market of quadrotor frames. With your permission, our group would like to begin our research soon.

Reference

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