Public Summary

Title : Re-design of a drone for weight reduction and increased durability through Additive Manufacturing

A drone, also known as an unmanned aerial vehicle (UAV) is an aircraft without a human pilot inside. Drones have multiple functions and uses ranging from their initial use of military surveillance to photography, medical transport, high-rise firefighting, crop monitoring and spraying and much more in modern society. The aim of this research was to design a drone for indoor use within a greenhouse. The drone frame would be designed for safety by designing it to be approximately 250g for lower impact force in the case of a crash. The drone would also be designed to withstand a fall from 2.5 metres and still be useable. The research also explored the possible effects of the drone frame design to the flight time of the drone. A literature study was performed and found critical information on optimal materials for a drone body with high strength to weight ratio allowing the drone to be strong and light weight. Designing the drone to be light weight also creates better performance in manoeuvrability, flight endurance and agility. Additionally, materials with good impact resistance per an additive manufacturing process called multi jet fusion (MJF).

Additive manufacturing can be described as converting a 3D model into a real object with a layer-by-layer approach to fabricate a part either by, “melting a filament, curing the photo resin and melting the powder bed.” Light-weight complex structures are difficult to fabricate via conventional manufacturing methods such as injection moulding, machining, joining, etc. Additive manufacturing techniques offer the “ability to surpass the limitations of traditional production systems,” [13] allowing designers to create complex structures pushing the glass ceiling of innovation which used to be set by the more restrictive conventional methods. Improvements in the structural and aerodynamic performance of UAVs can be realised through AM. Additive manufacturing does not require, “moulding and tooling,” and depending on production volume can “(save) time, cost and effort”[10] and reduce material waste. Despite the clear advantages of AM, limitations arise depending on the chosen method. Common disadvantages include build size limitation, anisotropic properties, slower load recovery rate, material porosity and higher material costs. However, not all AM processes are equal but the production of a drone frame via Multi Jet Fusion has shown in theory to provide similar material properties to that of injection moulding and its behaviour to be predictable.

The utilisation of multi jet fusion’s (MJF’s) design freedom could then be utilised to create complex lattice structures for the absorption of impacts. The possible benefits of the use of lattice structures reaching upwards to 78.2% increase in impact resistance according to one study. Along with this is the potential use of shape memory polymers (SMPs) for the use in sacrificial parts. According to literature, they possess the ability to return to 100% of their original shape after permanent deformation through a thermally induced shape memory effect (heating the material to its glass transition temperature).

A design was created using knowledge gained from academic sources, market research and via simulations. Simulations were used to gain an understanding of the possible behaviour of the drone arms in normal use and in the case of a crash. The drone was designed to have detachable propeller guards that if broken/deformed can be removed ad replaced. The propeller guards were designed to be

made from a SMP, utilising its shape memory effects to create propeller guards that can be used again and again even after a crash. The result of which was a drone that has an increased flight time from approximately 17 minutes to an estimated 29 minutes. It also has the potential to successfully withstand a crash from 2.5 metres despite it being overweight by 18.05 grams. The drone body could not be tested but provides potentially useful insights into designing for impact resistance through the additive manufacturing.

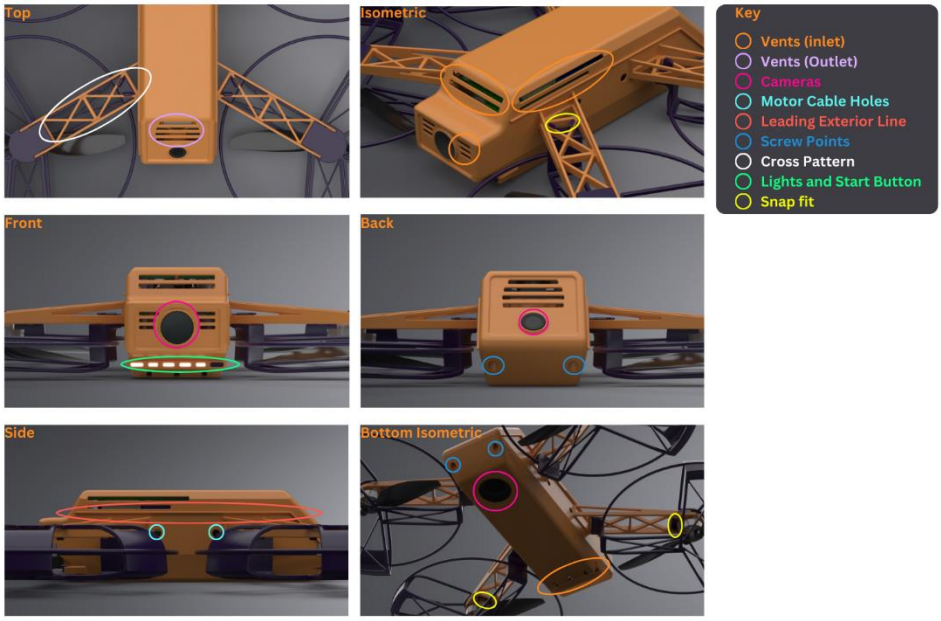

Fig.1 Design features of the drone frame

A pusher configuration (motors and propellers orientated downwards) according to literature, was 15% more thrust efficient than the traditional tractor (motors and propellers orientated upwards). This increase in efficiency was confirmed through a set of thrust tests which showcased a 17.55% increase in efficiency and a 2.69% increase in thrust. The use of lattices in the design has the potential to have large improvements in impact resistance and weight reduction. The success and distribution of load across a lattice structure is highly dependent on the design and the direction of force. The incorporation of diagonal cross-members in the drone arms proved to have significant effects in the absorption of a loading force.

From the research, additive manufacturing (AM) can be viewed as a viable solution for the low-batch production of drone body parts and proved to be a more affordable option compared to injection moulding for a batch size of approximately 10,000 parts. A cost estimation was done of the drone body which further showcased the cost effectiveness of additive manufacturing in small-scale batch production. AM also provides additional design freedom allowing for more complex and lightweight structures when compared to conventional manufacturing methods.

References