An investigation into material optimization for lightweight drones.

Abstract— Over the past five years, the commercial drone market has experienced a significant growth rate of 20% CAGR. Despite this high growth rate, there has been little development in the materials commonly used in the construction of these commercial, lightweight drones. This paper investigates the use of Trifilon's biocomposites into an existing drone structure and compares it with conventional materials in regards to weight and theoretical flight time. The results of this analysis show that a drone constructed with Trifilon's AP21 or AP23 biocomposite can achieve a 20% weight savings, which results in an increased theoretical flight time of 25%.

1 Introduction

Drones and other autonomous aircraft are currently going through a period of rapid development. Each week, new design reiterations and constructions are being launched to the commercial and military drone markets. While most of these drones include in a variety of configurations, the most important criteria for multi-rotor drones are the quality and length of video footage. Currently, most configurations achieve a relatively short flight time of approximately 15 minutes. While this is accepted by the majority of consumers, it is often considered too short for recording most sporting activities or capturing scenic video content. As such, the demand for energy efficient drone configurations and alternative, lightweight materials is growing. At the present time, there is a widespread misconception that achieving a significant improvement in flight time would require the use of prohibitively expensive materials and specialized manufacturing processes. This analysis of injectable thermoplastic compounds will endeavour to test whether or not longer flight times can be achieved in a cost effective manner.

Fig. 1. Illustration of a quadcopter drone frame.

2 New technology - new materials

The majority of today's commercial drones are built using either a laminate structure or with components that have been injection moulded. As the complexity of drone designs evolve, the demand for adaptable and effective construction processes has increased. While thermoset laminate structures offer superior mechanical properties to most injection moulded drone structures, they are far more costly and therefore only applicable for the premium commercial segments. For this reason, injection moulded constructions are the preferred option for the majority of the drone market. The existing injection moulded solutions employ mainly polyamide, also known as nylon or PA6. This high strength polymer is often reinforced with fiber glass to improve its mechanical properties. There are however a few drawbacks when using PA6. As an unmodified polymer, it is very sensitive to humidity and can lose up to 60% of its maximum strength when it absorbs moisture. Additionally, unreinforced PA6 has a relatively low impact strength compared to other widely used polymers. Considering this, it is obvious that given the typical crash impacts and moist conditions that most drones operate under, other lightweight materials would be better suited to drone structures.

3 Assessment Criteria

The materials investigated in this comparative analysis included polyamide (PA6), Trifilon's AP21 and AP23 biocomposites and low fraction glass reinforced PA6. These materials were chosen as they are all relatively low in density, are adapted to conventional injection moulding processes and satisfy the impact performance requirements for drone applications. The mechanical properties and the production cycle times were compared for these four materials. Additionally, stress and deflection simulations, as well as injection moulding simulations of the four materials were conducted.

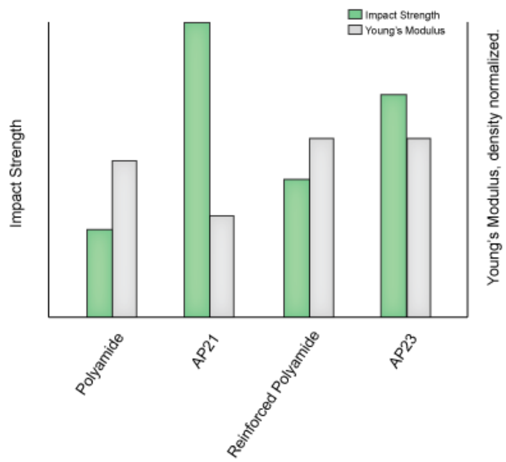

Fig. 2. Comparison of material properties.

4 Materials Investigated

Polyamide is a rugged thermoplastic polymer used in a wide variety of applications from packaging to automotive components. Trifilon's lightweight biocomposites AP21 and AP23 are specially designed PP based compounds that incorporate optimized hemp fibres for reinforcement. By integrating natural fibres that have a high specific strength and very low density (1.2 g/m^3), these injectable composites allow for a lighter structure and more freedom when designing complex drone components. Both AP21 and AP23 are designed for conventional injection moulding machinery and have superior melt flow capabilities allowing for lower injection temperatures (190°C). These lower injection temperatures allow parts to cool faster, leading to improved cycle times and lowered energy consumption during the production process as compared to polyamide (280°C injection temperature). In additional, unlike glass fiber reinforced PA6, AP21 and AP23 are not abrasive and do not cause wear on expensive tooling.

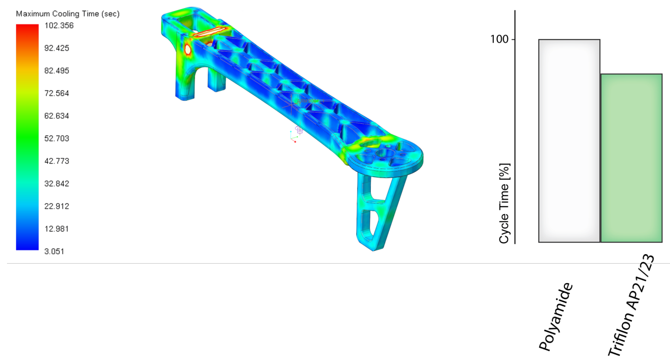

Fig. 3. Comparison of cooling temperature - cycle time. AP21 and AP23 achieves 17% reduced cooling time compared to the polyamide.

5 Conclusion

The key differentiator between the four tested materials was weight savings. Both Trifilon AP21 and AP23 are approximately 20% lighter than conventional PA6 and the reinforced polyamide. This 20% weight savings allows drones to fly further or carry a heavier, more sophisticated camera. It is this extended flight time that is the main benefit when evaluating the four materials.

The crash simulations demonstrated that Trifilon's AP21 and Trifilon AP23 produced comparable stress and deflections to both the PA6 and the reinforced PA6. Trifilon's biocomposites additional have significantly better impact absorption capacities and are not as brittle. These results prove that a biocomposite can compete with conventional materials.

Lastly, the simulated cooling time of the drone structure was compared. This analysis showed that Trifilon's AP23 achieved a significant 17% reduction versus conventional polyamide. A reduced cooling time is important for high volume producers where short cycle times are critical to profitability.

As depicted in Figure 4, there is only a slight difference between the two materials. Both materials are nearly equal in regards to overall stress and achieve deflections rates that are below the yield stress. While PA6 is deflecting slightly less, it is much heavier than either AP21 or AP23.

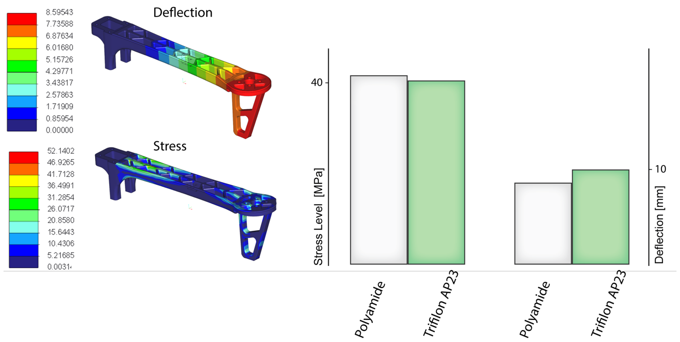

Fig. 4. Deflection and stress comparison between polyamide and Trifilon AP23, with a load case of a simulated crash from a 10 meter height.

5.1 WIDER APPLICATIONS OF LIGHTWEIGHT BIOCOMPOSITES

While the commercial drone industry is expected to grow from today's 1 billion USD to 4 billion USD by 2020, there are numerous other industries where weight saving composites are gaining traction. By using cutting-edge biocomposites in place of conventional polymers, not only can performance be improved, products can also be made more environmentally friendly. From longer flying drones, to more fuel efficient cars, to higher performing sporting goods, biocomposites are opening a new era for smarter, greener materials.

6 CONTACT INFORMATION

Trifilon's AP21 and AP23 are specifically designed for high performance applications where the requirements for strong yet lightweight materials is essential. Both AP21 and AP23 are fully recyclable. If you are interested to know more about Trifilon's AP21 or AP23, please do not hesitate to contact us.

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