Sensitive Payload Shock Absorber for Unmanned Aerial Vehicles

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Abstract

Today, many companies, specifically Lockheed Martin, design and develop unmanned aerial vehicles (UAV) as a part of their company focus. These UAV products experience high shock loads upon impact during landing. Therefore, it is necessary for these parts to be lightweight and durable in order to endure conditions that are apparent during the landing process. To compensate for the high shock, an additional part can be added to absorb shock loads from the tail and elevator. Designing this part can be complex, as the material must be lightweight but also very durable to resist corrosion and destruction during landing. In addition, this part can be used for different plane designs but our design will focus on the standard tail plane. Extensive research exists detailing the various benefits and downfalls of materials used, specifically the benefits of using aluminum alloys. Therefore, our approach will focus on the use of duralumin, an aluminum alloy that is often used for automobile and military aircraft body parts. In addition, it is lightweight and will ensure the effectiveness of this UAV part. The success of this product design will rely upon the durability of the product upon aircraft landing, as well as the lightweight nature of the product to ensure prolonged flying time. A 3D printed design of the model will be used to illustrate the structure.

Key Words: design, lightweight, durable, complex, 3D printed design.

1. Introduction

The process of creating an unmanned aerial vehicle that can sustain multiple uses after crash landing is an important task, as it can potentially save Lockheed Martin millions of dollars in repairs and new models. During the design process for this task, several key points were taken into consideration, including cost efficiency, durability of the product, and lightweightness of the product. Lockheed Martin is a military company, so it's important during the design process to remember that the UAV must be able to sustain shock from landing as well as harsh weather conditions and potential projectiles that may intercept and hit the drone while in the air from enemy fire. It is also essential to consider that the drone will be carrying loads, so the newly improved shock absorber can not be cumbersome and reduce the ability of the UAV to carry heavier loads. The purpose of this project and assignment ultimately is to develop a practical, durable solution to UAVs not getting much reusability after used.

2. Literature Review

There were two main concepts for the UAV shock absorbers already in place. The first of these involves a parachute that gets deployed when the UAV is ready to land. This concept is built around the idea of limiting the collision forces by slowing down the UAV using air force fighting against the parachute. While this isn't used much in a military sense, it can be slightly altered and optimized to face the heavy grind of militaristic use. At point of descent, the UAV deploys the parachute, which accelerates rapidly behind the drone catching the air, acting like a normal parachute on a human[1]. The second concept was focused on using magnetorheological landing gears, which uses hydraulic fluids to absorb shock in the similar method that cars use hydraulics to help go over bumps in the road without damaging the body of the car. This is much more suited for militaristic use, but its major downfall is the weight that it adds to the aircraft. Since the fluids weigh it down, it essentially cuts down the flight time by a large amount[2].

Typical UAV structure includes two parts, the front part and back tail part that separates upon collision. Shock is taken most at that point, because the weighted nature of the different parts cause the separation point to take most of the shock. The shock absorber is placed right at that point, and helps keep the rest of the UAV secure by preventing the shock from reaching them [3].

3. Design Process

Original instincts created the original design, which was modeled very closely to the parachute design. Slight alterations would have to be added to that design, such as making the parachute a stronger material in case the drone faces opposing forces such as harsh weather or enemy fire. After examining the pros and cons of that design, it was decided that while it would create a nice buffer from the shocks from impact, it would increase the weight of the UAV (especially considering the newly designed durable parachute will have to be heavier than current materials), which would limit the carrying capacity and length of flight for the drone.

The next concept was to follow the design of the hydraulic fuel. Unfortunately, this created the same problem of absorbing shocks, but at the cost of weight of the UAV. Although liquids are very good at absorbing shock and maintaining durability, the hydraulic fluid and pistons would weigh down the UAV to a point where it wouldn’t be able to fly nearly as far as it originally does. There is a possibility to reduce the amount of hydraulic fluid and distribute it differently, but that would adversely affect the shock absorption ability of the drone by a factor of the amount of liquid removed, not making optimal progress compared to the original design. More liquid removed would mean less weight, but also more of a risk of destruction of the UAV upon impact.

Keeping weight AND durability in mind, a third, original concept was created that used a durable material that could be compressed to absorb shock. The three different ideas were ranked. It was decided that the parachute and hydraulics weight were too much of a con to look over, and that the spring material was best suited for the task at hand. The best topic was decided and the next process was started, optimizing the selection of the durable, lightweight springs.

After deciding on a concept, materials next had to be considered to ensure the best design for the drone. Since current UAVs are made of alloys, it was decided to think of different alloys that could be used. Possible solutions included a steel-copper alloy, an aluminum-copper alloy, or a mixed metal alloy. The steel-copper alloy provided strength but added weight. The aluminum-copper alloy, duralumin, was strong and lightweight. The mixed metal alloy was too ambiguous and heavy to really determine, so it was scratched from the beginning of the metal selection process.

4. Design Result

The final design that was chosen involved the durable spring-like material. In order to make this innovative and an improvement to the original current designs, it was important to choose a lightweight material for this option. After studying several different materials, it was decided to choose duralumin, which is an aluminum-copper alloy that is extremely durable and lightweight. It is used to build large scale airplanes, so the material is available for immediate use in the development of UAV shock absorbers. The design involved a matrix-like design, where the base structure would be repeated in a staggered pattern in order to maximize surface area of the shock absorption portion of the design. In addition to the lightweight material, the specific design is not very dense, including many air gaps that are featured to give the spring-like objects an opportunity and area to compress.

5. Conclusion and Summary

Ultimately, the most important factors going into this design were durability and weight. It was necessary to pick a material that wouldn't burden the UAV's ability to fly far distances, but would also be strong enough to ensure that the UAV could sustain multiple uses without having to be replaced or repaired after every use. The current designs being used both by Lockheed Martin and other commercial companies don't fully utilize the correct materials to make these objects fly farther and safer. The parachute and hydraulic fuel designs are both extremely heavy in comparison to the duralumin, so the use of duralumin would actually enhance the flying capabilities of the UAV.

The duralumin spring shock absorber is a large improvement on the original design of the UAV. It provides more durability and longer flight time, both of which are extremely important to the success of a military drone used by Lockheed Martin. This is a concept that is original in design, and one that could essentially open a new area of drone flying capabilities, one where heavier loads could be attached to the drone and the drone could deliver it without fail to its destination, all while being returned safely by the receiver.

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