Design and Shape Optimisation of 3-D Printed landing gear for Unmanned aerial vehicle applications

Madhavaram Sai Krishna
Mechanical Engineering
PES Institute of Technology
Bangalore, India
madhavaram.saikrishna@gmail.com

Kishore.M.N
Mechanical Engineering
PES Institute of Technology
Bangalore, India
kishoremn11@gmail.com

Dr.Suresh Nagesh
Mechanical Engineering
PES Institute of Technology
Bangalore, India
suresh.nagesh@pes.edu

***Abstract*—**Unmanned Aerial Vehicles (UAV) technologies have emerged as a crucial part of research in the aerospace sector because of their varied humanitarian applications like agriculture monitoring, disaster management, and resources mapping. However, it is also important to incorporate green technologies in the manufacturing of such UAVs. One such concept is to use 3D printing using the recyclable plastic material to make such UAV's environmentally friendly, lighter and hence consume less power for higher endurance. Being a prime emerging technology, 3D printing has evolved rapidly over the past decade and is predicted to evolve into a 30 billion dollar industry by 2019. In this paper, the attempt made with respect to design, develop and build 3D printable landing gear is presented for a Fixed wing type UAV lying in the weight class of 20-25 kilograms and using tricycle landing gear configuration. This design is unique due to its placement of damping elements within the primary struts of the landing gears. Smart connections have been provided to enable ease of assembly and disassembly of the landing gear.

Since the design is suited for 3-D printing, the manufacturing time is reduced drastically. Modular nature of the Landing gear allows for ease of maintenance and diverse functionality. Validation is carried out using numerical methods and 3D printing followed by operational testing on a functioning UAV.

Optimization Results For Main Landing Gear			
	Solid Model	Optimized Model 1	Optimized Model 2
Mass (kgs)	1.328	1.126	0.94
Percentage reduction from initial Model (%)		15.21	29.21

Table 1: Optimization Results of Main Landing Gear Design

Optimization Results for Nose Landing Gear		
	Solid Model	Optimized Model 1
Mass (kgs)	0.412	0.332
Percentage reduction (%)		19.41

Table 2: Optimization Results of Nose Landing Gear Design

Topological Optimization of the landing gear structure allows us to significantly reduce the weight of the landing gear and make the structure more efficient. This optimization is performed by providing limiting values on parameters like deformation or stress while the objective function is the minimization of mass. Optimization performed on the components yielded a weight reduction of the main landing gear by 29.2% and the nose landing gear by 19.4%.

The clever placement of damper and steering controls within the nose landing gear structure itself saves a large amount of space within the fuselage of the UAV. Aside from improving the payload capacity of the plane, by simple dynamics, it is shown that there is a minimal loss in transmission of torque from servo motor to the wheel. Such a feature is unique to this arrangement, as the loss of torque is a common phenomenon observed in other UAV landing gear designs.

The main landing gear, suitable for a tricycle configuration incorporates off the shelf dampers which are capable of handling impact loads of upto 3g. The dimensions of the current model have been chosen to accommodate the Penguin-B UAV. Penguin-B is one of the most reliable surveillance fixed-wing UAV.

This technology used with Glass fiber reinforced thermoplastic materials (GFRP) for 3-D printing allows for recyclability of the landing gear. After completing the 3-D printing of the landing gear, the prototype is currently under testing with a UAV of suitable weight class. This is being done to validate the reliability and sustainability of the design and subsequent 3-D printing.

A functioning prototype of the design has been generated using 3-D printing within a short duration of 2 days. Simplicity in design allows us to vary the dimensions at any point of time to suit specific requirements, like wheelbase and height. With an efficient design and simple concept, the landing gear thus designed is modular in nature, sturdy and also adaptable. This design incorporates off-the-shelf dampers to give a smooth landing for the tactical unmanned aerial vehicle.

Keywords – Unmanned Aerial Vehicle; 3D printing; Landing Gear; Weight Optimization; Design for assembly and disassembly.

Appendix :

Figure 1: 3-D printed Main Landing gear

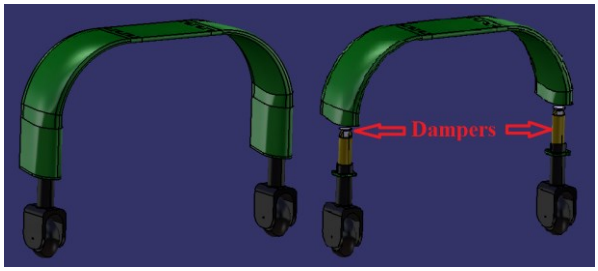

Figure 2: Incorporation of Dampers for Main Landing Gear

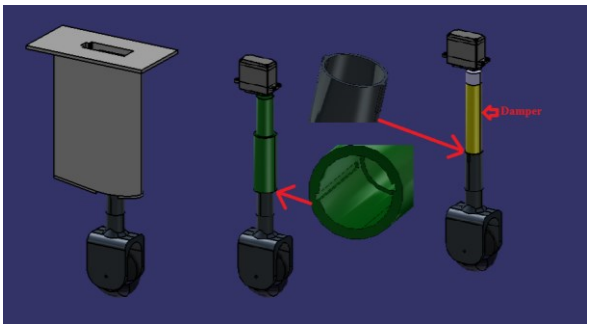

Figure 3: Incorporation of Dampers for Nose Landing Gear

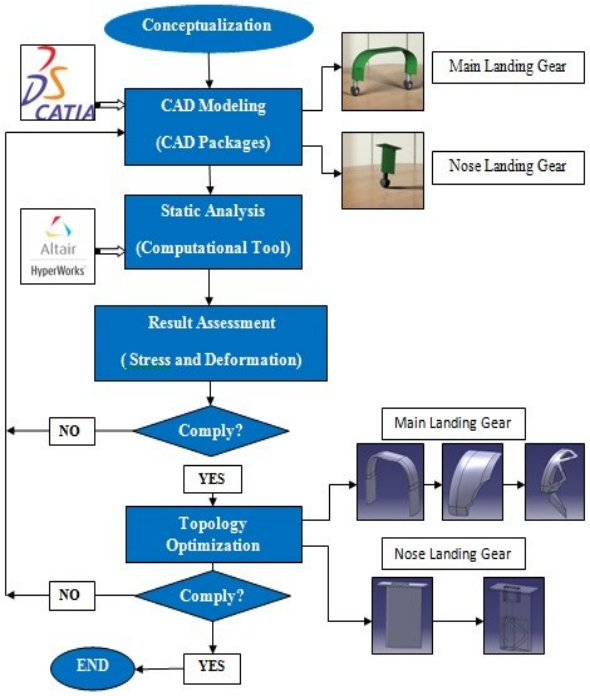

Figure 4: Process chart followed for the design of landing gear.