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Design and Analysis of Multipurpose Servo-Based Gimbal for Airborne Vehicle

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ABSTRACT: This paper presents the design and comparative material analysis for newly designed multipurpose servo-based gimbal system for airborne vehicles. The gimbal consists of servomotors instead of brushless dc motors. This single gimbal design can be used for enormous applications. This servo gimbal design can carry various objects such as camera, pesticide sprayer, water sprayer, foam sprayer, etc. And also attached objects can pan 360 degree and tilt as per need. Attached objects is controlled by servomotors with required electronic components. Methodology involved in this design, material analysis and their results are discussed.

KEYWORDS: Design, Analysis, Multipurpose gimbal, Servomotors.

I. INTRODUCTION

UAV's and drones play important role in airborne platform. Drones used for major applications such video recordings, aerial photography, mapping etc. gimbal are used for the purpose of stabilization of various movements towards multiple axes. [4] They are three types of gimbal based on the axes.

1. Single axis gimbal
2. Two axes gimbals
3. Three axis gimbals [1,2,3]

Brush less gimbal is majorly used. But brush less gimbal are more expensive and heavier than the servo-based gimbals. Brush less gimbal usually requires a specific control board. Those brush less gimbal are used only for specific image/video recording purposes.

In this project we have designed a multipurpose innovative servo-based gimbal where it can pan up to 360 degrees and tilt as per need. We can easily attach various objects of this gimbals such as camera, pesticide sprayer in agriculture fields, etc. Assembling and dismantle of various equipment attached to the gimbal is quite easy. So, this gimbal is designed to provide a new way for multipurpose drones.

Note: In this paper, Camera module is attached with newly designed servo-based gimbal for analysis purpose.

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II. PROPOSED METHODOLOGY

CONSTRUCTION

The construction of this design is very simple. It consists of hexagonal base plate, circular plate, three servo motors, two bottom pillars, servo holder and camera (other objects can also place instead). The hexagonal plate is the base plate where it may attach with bottom surface of the airborne vehicle. Servo motor 1 is fixed under the hexagonal base plate. Shaft of the servo motor 1 is fixed with circular plate. Two pillars like structure is attached under the circular plate. Servo motor 2 and 3 is fixed at the pillar like structure with servo holder. These servo holders help to bind the object and the servo motor 2 & 3.

The 3-d designs are shown below,

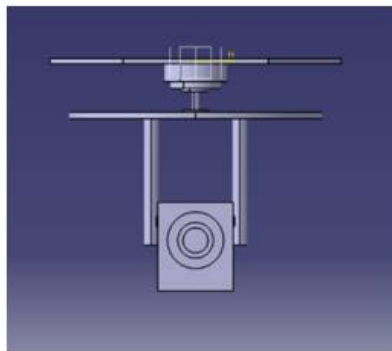


Fig 1. Front view

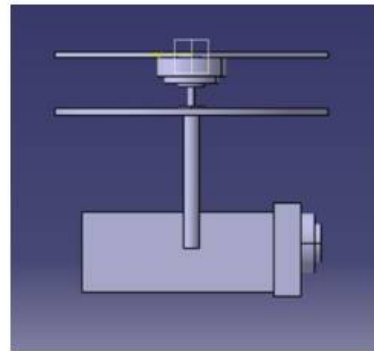


Fig 2. Side view

The fig 1 and 2 shows the front and the side view of the newly designed servo-based gimbal.

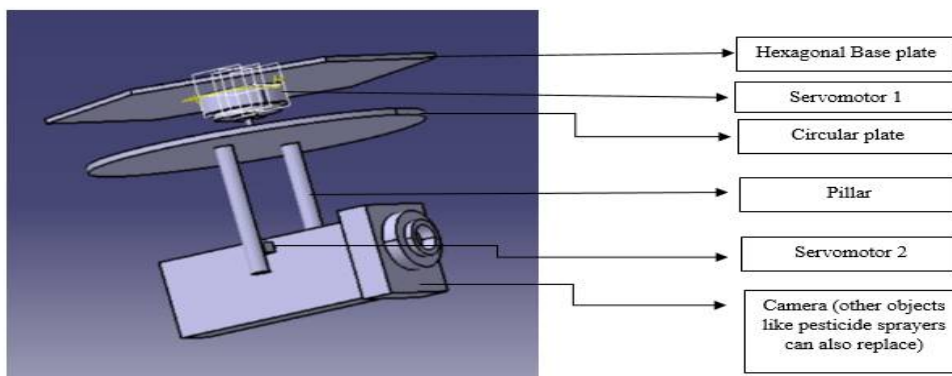


Fig 3. Isometric view

The fig 3 shows the isometric view of the design with respect to the parts of the servo gimbal.

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WORKING

The shaft of the servomotor 1 is attached with the circular plate which is responsible for the X-axis movement i.e., pan movement of the object. The servomotors 2 and 3 are responsible for the Y-axis movement i.e., tilt motion.

III. EXPERIMENTAL RESULTS

The gimbal design is gone through various analysis process and they are total deformation, equivalent elastic strain, equivalent stress, modal analysis with applied pressure of 100 N/m^2 . The comparative analysis of design with aluminium alloy and structural steel material are shown below

1. STATIC STRUCTURAL

Aluminium Alloy:

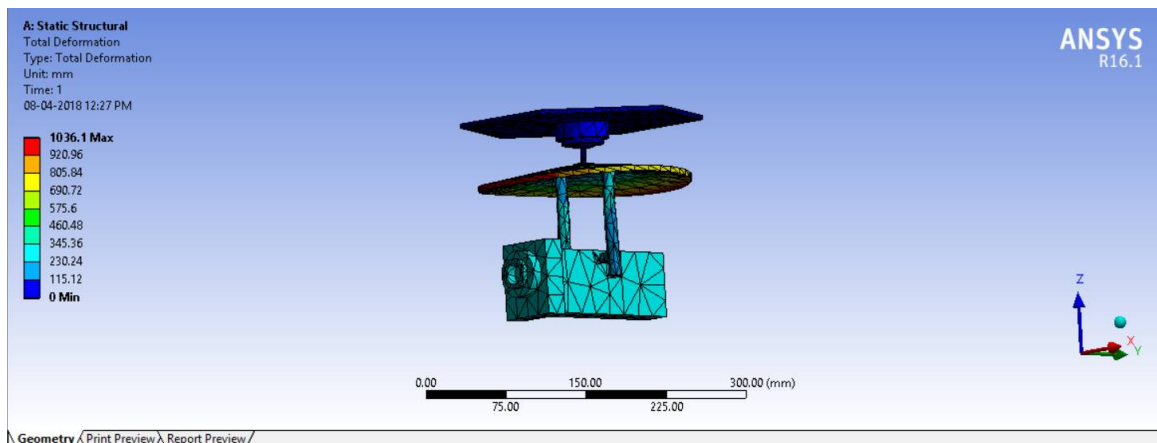


Fig 4. Static structural total deformation – Aluminium alloy

Structural Steel:

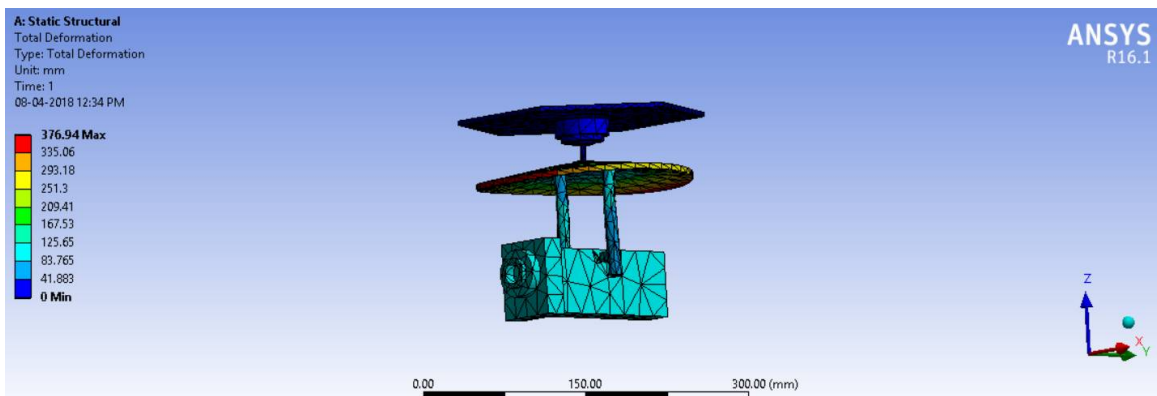


Fig 5. Static structural total deformation – Structural steel

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The fig 4 and 5 defines the static structural deformation of aluminium alloy and structural steel with the maximum and minimum limits.

2.EQUIVALENT ELASTIC STRAIN

Aluminium Alloy:

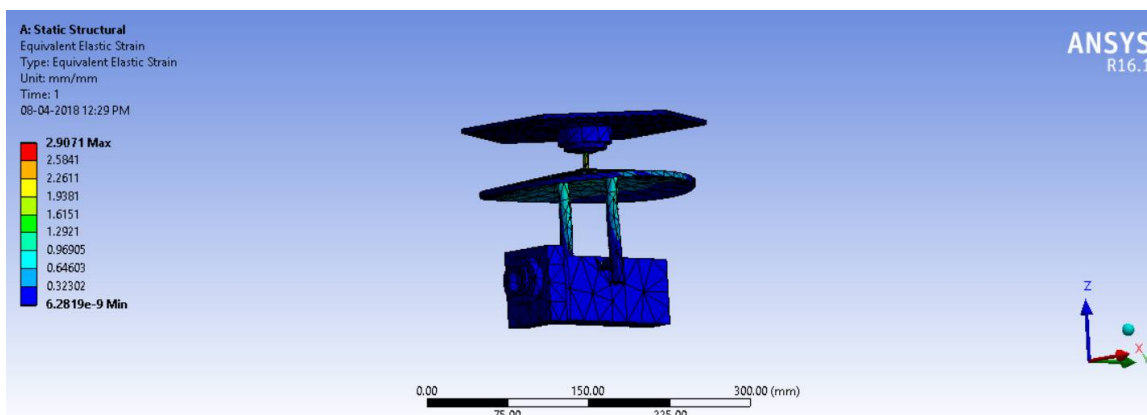


Fig 6. Equivalent elastic strain – Aluminium alloy

Structural Steel:

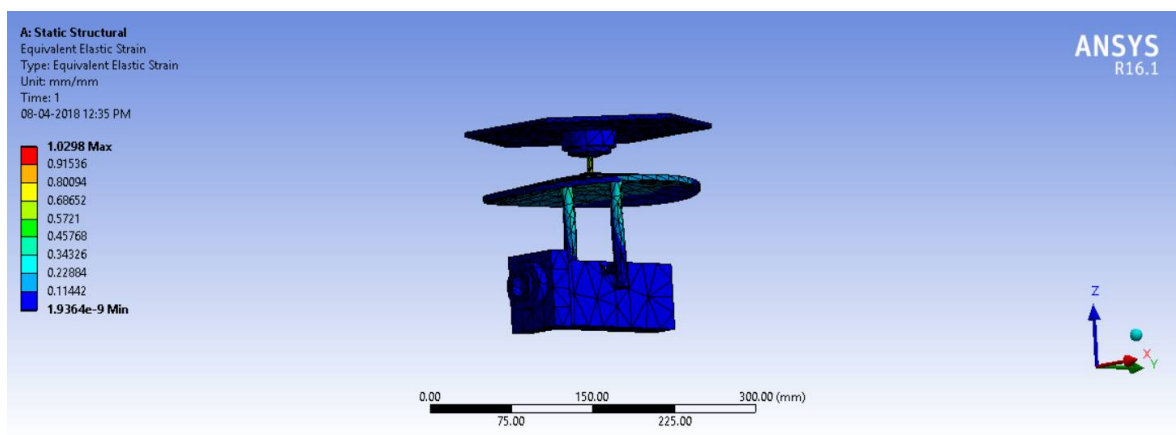


Fig 7. Equivalent elastic strain – Structural steel

The fig 6 and 7 displays that the amount of equivalent elastic strain with respect to the aluminium alloy and structural steel.

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3.EQUIVALENT STRESS

Aluminium Alloy:

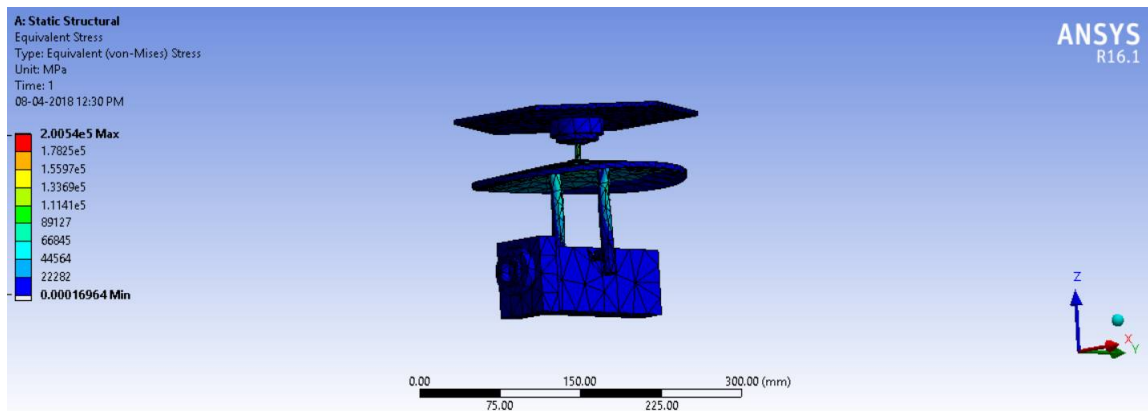


Fig 8. Equivalent stress – Aluminium alloy

Structural Steel:

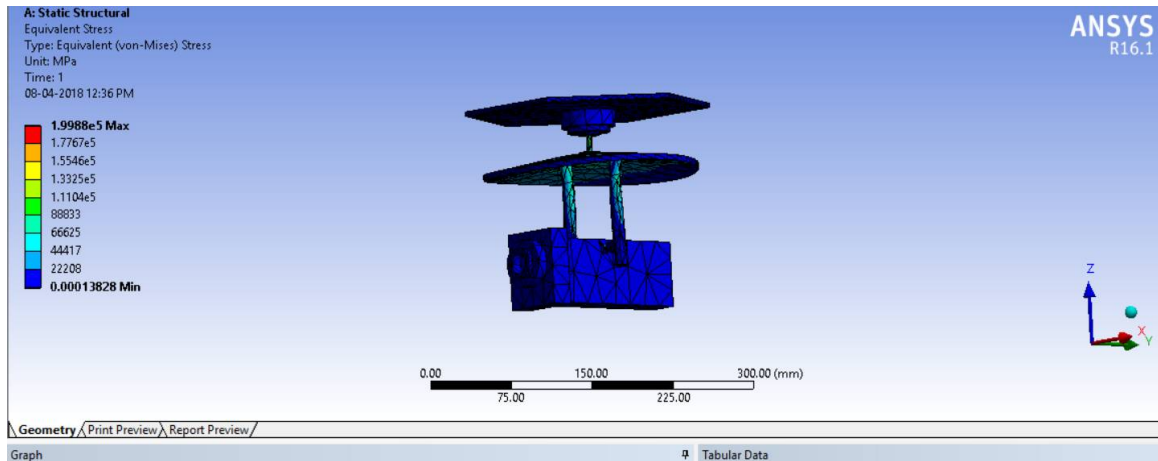


Fig 9. Equivalent stress – Structural steel

The fig 8 and 9 clearly shows the equivalent stress acts over the aluminium alloy and the structural steel material.

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4. MODAL ANALYSIS

Aluminium Alloy:

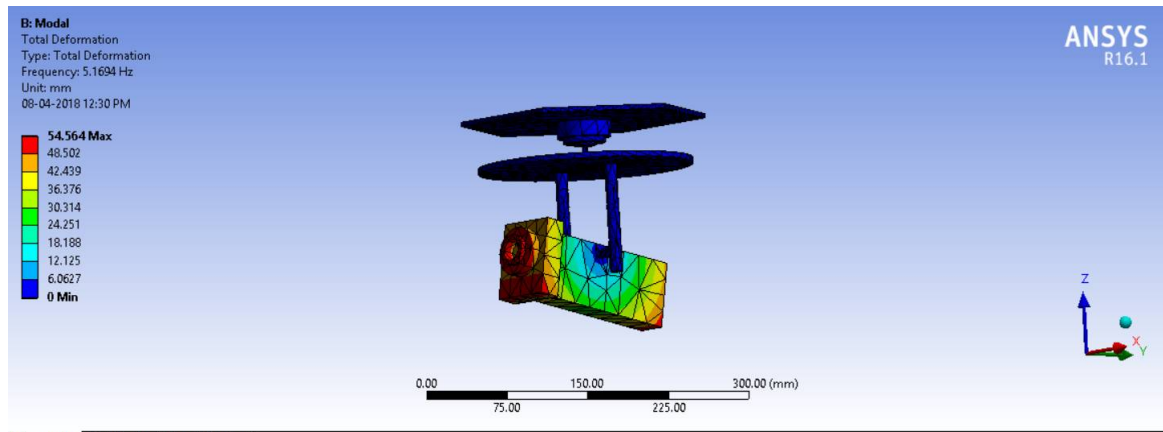


Fig 10. Modal analysis – Aluminium alloy

Structural Steel:

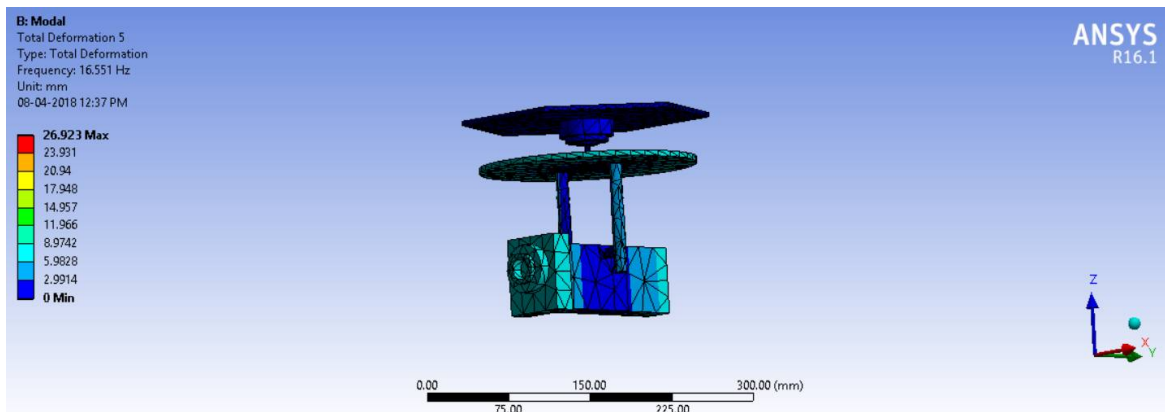


Fig 11. Modal analysis -Structural steel

The fig 10 and 11 explains the maximum and minimum limits of modal analysis with respect to the aluminium alloy and structural steel.

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TABULATION:

ANALYSIS	STRUCTURAL STEEL		ALUMINIUM ALLOY	
	Min	Max	Min	Max
Static structural- Total deformation (mm)	0	376.94	0	1036.1
Equivalent elastic strain (mm/mm)	$1.936e^{-4}$	1.0298	$6.2819e^{-9}$	2.9071
Equivalent stress (MPa)	0.000138	$1.9988e^5$	0.00016	$2.0054e^5$
Modal analysis (Hz)	0	45.295	0	54.564

From the above figures, the maximum and minimum limits of structural steel and aluminium alloy with respect to the various analysis using ANSYS has been tabulated.

IV. CONCLUSION

As a summary, a multipurpose servo-based gimbal is designed and analysed for various applications. This design can be used to handle different objects. In addition to that, attached object can pan up to 360 degrees and can tilt easily. The selected materials were tested and validate that the design was capable of withstanding the design loads for small applications. From the analysis result tabulation, it clearly shows that the aluminium alloy material perfectly suited for this project. Finally, we created a new design for multipurpose servo gimbal thereby paved way for multipurpose drone. Our project will replace use of different drones for different application. Single drone with this newly designed gimbal enough for various applications. Further research and development must be done to increase the efficiency.

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