Design and Analysis of Composite Micro Aerial Vehicle

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Abstract. Now a day getting materials which suit our requirement is very tough, so today almost all the industries are going to composite materials. Reinforced and matrix combination giving for new material which has high strength and reduction in weight ratio. These materials are called composites. This research work represents Aluminium matrix composite produced by stir casting techniques. Aluminium matrix composites have less weight, low cost and high stiffness. Composites are used in aerospace industries for reduction in weight. Aluminium matrix composites are tested under various mechanical tests and we’re carried out the characteristics. In this work micro aerial vehicle is designed by using CATIA. Structural and flow analysis were carried out by computational methods. Keywords: composite, LM5, Structural, MAV, Analysis

1. INTRODUCTION

From past 100 years’ growth of composite materials is tremendously increasing in aerospace field. For satisfying the need of light weight and strong material in aerospace industries two materials with different properties are reinforced with some techniques which gives a new material with very unique properties. This unique material is classified as composites material. The new material gives superior properties than the materials which have been combined. Due to its properties like less weight, high fatigue resistance and high impact strength application of composite materials is increasing rapidly in aerospace industries. Rather than aerospace industries these materials are also used invidious other industries such as automotive, construction, glasses, defence, nuclear etc. Designers, engineers have possibilities for bringing their ideas as it provides flexibility in design and it also has very unique material properties.

An Unmanned Aerial Vehicle (UAV) is the type of aircraft which is operated directly by flight control either by computer in the vehicle or by the remote control by the pilot from ground. Micro aerial vehicle is the type of UAV with very small size operating at very low speed and very low Reynolds number. Its Reynolds number is lower than 150,000.

Due to its small dimension it is widely used for Reconnaissance, intelligence, armed attacking and surveillance in military. Instead of military applications it is also used in urban application for monitoring the traffic and for surveillance of the area. MAVs can also tell about the weather condition with the help of their sensors and can also be used for biochemical sensing.

For the optimized use of MAV there has been a procedure for validating the material selection. The material selection will affect the performance, capabilities and endurance of the MAV. For achieving the property of light weight for an MAV, optimized procedure is being followed for selecting material. Composites seem to be better option for MAVs as it gives flexibility and better mechanical response.

2. MATERIAL SELECTION
In order to get better properties, we have to select our material in such a way that it should satisfy the need of the manufacturer. From past few years it has been observed that metal matrix composites are used more than grid composites because of their enhanced properties. During development of the MAV different types of structure were tested with different results. For this MAV LM5 and Fly ash has been reinforced together with stir casting technique. It has been tested with different methods in our laboratory and was found very light weight and strong as compared to other composite materials. We also found that its impact strength and fatigue resistance is also high as compared to other composite materials. Table 1 show different properties of the material which has been known from the test conducted in our laboratory.

### Table 1. Properties of Material

| S. No | Properties                        | Results |
|-------|-----------------------------------|---------|
| 1     | Density                           | 2.8     |
| 2     | Toughness                         | 71.2    |
| 3     | Hardness (HRA)                    | 78      |
| 4     | Ultimate tensile strength (MPa)   | 678     |

### 3. CONCEPTUAL DESIGN OF MAV

The conceptual design is the initial step which is being taken before manufacturing of the MAV. As there are numerous MAV’s present now a day there are plenty of MAV with common features. Based on that proper literature survey has been done on different MAV and then based on sweet spot taken from them a new MAV has been designed in CATIA V5. Table 2 shows some of the detailed parameters taken from the literature survey and fig1 Shows the conceptual design of MAV designed from the parameters in CATIA.

### Table 2. Dimensions of MAV

| S. No | Parameters(m)          | Value |
|-------|------------------------|-------|
| 1     | Maximum chord length   | 10    |
| 2     | Total length of fuselage| 16.5  |
| 3     | Wing span              | 21    |
| 4     | Wing area              | 138   |
| 5     | Aspect Ratio           | 1.23  |

**Figure 1. Conceptual Design of MAV**

Figure 2 shows the fuselage design in which flapping mechanism and motors are to be mounted on the bottom side and wings are attached in the upper side. Same material with same properties has been applied
in fuselage also in CATIA. Many slots and holes are made additionally in unwanted area to reduce the weight of the fuselage.

![Figure 2. Conceptual Design of Fuselage](image)

4. ANALYSIS

Basic analysis has been done on the fuselage part as well as on the whole MAV with the help of ANSYS. Finite Element Analysis has been done on the fuselage and Von-misses stress and strain has been found. Load has been applied on the upper part of the fuselage because of wing and lift produced. Figure 3 and Figure 4 shows the variation of stress and strain in the fuselage due to load applied.

![Figure 3. Stress Analysis on Fuselage](image)

![Figure 4. Strain Analysis on Fuselage](image)

Flow visualization has been also done in ANSYS fluent. Flow analysis has been done on outer body of the MAV. It is also designed in CATIA to protect the inner body and the whole mechanism. It has been meshed in hyper mesh software and 313101 nodes and 274492 elements has been generated by cut shell method.
SST K-w and energy equation has been used for visualizing the flow over the surface of MAV. It has been analysed at the velocity of 2m/s with gauge pressure at zero. COUPLED method has been used for analysing the flow. Coefficient of drag and L/D ratio has been also found out from the software. Fig5 and fig6 shows pressure and velocity contour acting over the body of the MAV.

![Figure 5. Pressure Contour over MAV](image)

![Figure 6. Velocity Contour over MAV](image)

5. GRAPHS

Various graphs have also been validated from the software. Fig7 shows the graph of mesh at X-coordinate with respect to its position. Different points tell the position of the mesh with respect to X-coordinates. Fig8 shows the value of static pressure with respect to its position over the body of the MAV. Value of turbulence kinetic energy has also been found out in the graph.

![Figure 7. Graph of Mesh at X-coordinate](image)
6. RESULT AND DISCUSSION

Whole model has been designed in CATIA with the dimensions taken from literature survey. The fuselage structure has been made separately for analysis. The fuselage structure has been analysed in FEA and it has been found out that both stress and strain are acting mainly at middle part of the fuselage because of the load of wing and lift produced. Maximum stress was found out to be $1.6 \times 10^7$ Pa at the middle section of the fuselage. Pressure contour has been seen more at the head, starting of the wing and at the end of the tail part. Similarly, it has been seen that flow visualization around body of the MAV was symmetric and smooth. Value of $c_d$ has been found from the analysis as 0.024 and L/D value has also been found out. It has been seen that the flow is smooth and symmetric while applying the material as LM5+fly ash. Highest pressure seen over the body is $1.724 \times 10^{-1}$ Pa which is at the starting of the head and velocity seems to be reduced at the upper body of the fuselage. Minimum velocity found on the body is $5.93 \times 10^{-2}$ ms$^{-1}$. Different graphs have also been validated and many outputs has been taken from that.

7. CONCLUSION

With a general analysis of MAV with aluminium metal matrix composite we concluded that material selection plays a major role in reduction of weight as well as for getting high strength. We have seen that as we increase weight percentage of fly ash strength and hardness of the material is also increasing. From analysis we have seen that flow over the whole body is uniform and symmetrical. Our material develops very low coefficient of drag and it also develops sufficient amount of Lift to drag ratio. Also our material can be used for manufacturing various aerodynamic body which need less weight and more strength.
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