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PROPOSED DESIGN OF SELF PROPELLED AERIAL VEHICLE

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Abstract— Day by day the usage of Unmanned Aerial Vehicle (UAV) increases. But advancements in the design field for UAV were very less. Our project outlines the design of an UAV/model aircraft which is. Our first goal is to achieve a design of UAV which satisfies functions such as seamless joint, most appropriate aerodynamic shape, enough internal space to contain all equipment into it. They are generally fulfilled by aeromodelling.

Keywords- Aeromodelling, design, UAV, model aircraft, seamless joint, aerodynamic

I. INTRODUCTION

In today's world UAVs have tremendous applications. From defense to surveillance and from attack to rescue operations they play major role. So many companies design their UAVs, but some of them do not have aerodynamic seamless shape, so it can be a hurdle when the UAV flies at higher speed, means it does have high drag. Anastasios P. Kovanis et al. [1] have researched on design of small scale UAV. So it has been a true guidance for us. Also data they have collected also helpful for us. Ertugrul Cetinsoy et al. [2] worked on Aerodynamic Design and Characterization of a Quad Tilt-Wing UAV via Wind Tunnel Tests which is very useful for us when the design stage was initiated.Junlan Li et al. [3] have done Shape Representation of the Nose Cone and also explained same by numerical example.Guowei Cai et al. [4] have done work oncomprehensive design methodology for constructing small-scale UAV.Elisa Capello et al. [5] have designed a quad rotor UAV.M. Belardo et al [6] have designed the UAV keeping structural and aeroelastic design of a joined wing UAV. Apart from these our project also focuses on aerodynamic modeling. It is concerned with the development of mathematical models to describe the aerodynamic forces and moments acting on the body [8]. Solid works 2013 is used for modeling.

II. PREVIOUS DESIGNS

Many companies made their designs of UAVs. Some of the designs are not optimized for aerodynamic performance in other words they have less aerodynamic characteristics. They may be production friendly but they are not much aerodynamic. Many of them already in production. Of which the company Barnard Microsystems is more important. Barnard Micro system has designed an UAV named as In View shown in the figure below.[7]

Fig 1: Barnard Microsystems In View UAV

III. DRAWBACKS OF PREVIOUS DESIGNS

Some of the current designs are optimized for easy way of production for their UAVs. So many of them are not as aerodynamic as they can be. One of them is shown in the Fig 1. There are some areas like the design of nose cone and the joint between nose cone and fuselage is not seamless. There is a clear visible line can be seen. So it reduces overall aerodynamic performance due to shape induced drag.

IV. PROPOSED DESIGN

Our design of UAV is focused on the parameters listed below.

- It should have minimum drag by selecting most appropriate shape
- Seamless joints
- Enough internal space/volume
- Design should provide a good balance between four forces acting on an aircraft[9]

Our design is subdivided into three parts as;

- Nose cone
- Fuselage
- Tail cone

Now designs of all components are explained in detail as below.

Nosecone:

It is the forward most component of an aircraft. It shaped to serve minimum aerodynamic resistance. It is designed by keeping the below parameters in mind.

- Shape, Equations and Procedure followed:

The shape of nosecone must be chosen for minimum drag so a solid of revolution is used that gives least resistance to motion. For our design it is chosen as “Elliptical” in shape. It is the most common shape used to make model aircraft because of its low drag characteristics. Refer Fig. 3 (A).
Our shape of nose cone is governed by the equation, shown below.

$$y = R\sqrt{1 - \frac{x^2}{L^2}}$$

Where, x & y = coordinates on axis X & Y respectively.
R = maximum distance in Y direction from the axis of curve to the periphery of the curve.

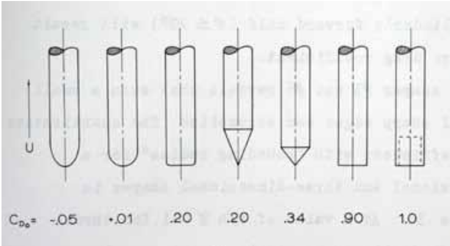


Fig. [2]

The fig. 2 shows various drag coefficients for various nose cone shapes. It shows that elliptical shape has lowest drag coefficient among all. Thus it is chosen for our design.

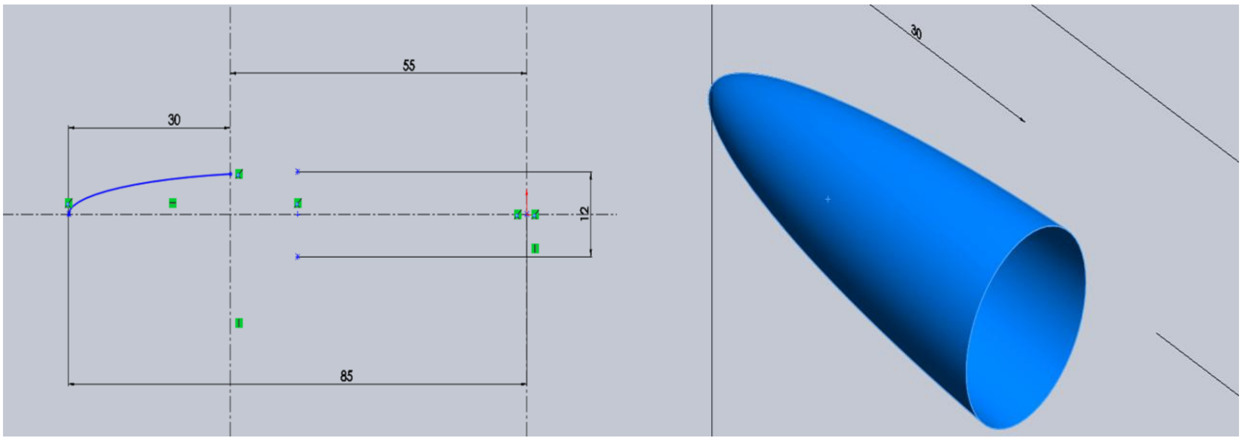
- Parameters for ellipse:

Length of major axis = 85 cm
Length of minor axis = 12 cm
Length:

The length of the nose cone kept as 30cm. Fig. 3 (A)

V. DESIGN PROCEDURE

Procedure followed is revolute of ellipse. Refer Fig. 3(B).



(A) (B)

Fig. 3 Steps followed for nose cone

Fuselage:

By definition it is an aircraft's main body which holds each and every component into their place. Our design has some requirements for it as follows.

- Seamless joint between nose cone and fuselage
- Enough internal space/volume to fit all components

To satisfy all above constraints our design of fuselage is done by these following steps.

- Procedure followed

Fuselage is made by using "Loft" of surface procedure. It contains two profiles at each end which are 55cm apart from each other. First profile made is at the end of nose cone which is circular in shape. And the other profile is of "Super ellipse" curve.

- Super ellipse curve

It is geometrically defined on a Cartesian plane as;

$$\left|\frac{x}{a}\right|^n + \left|\frac{y}{b}\right|^n = 1$$

Where n, a and b are positive numbers.

In Fig 4 the super ellipse is shown inside a square.

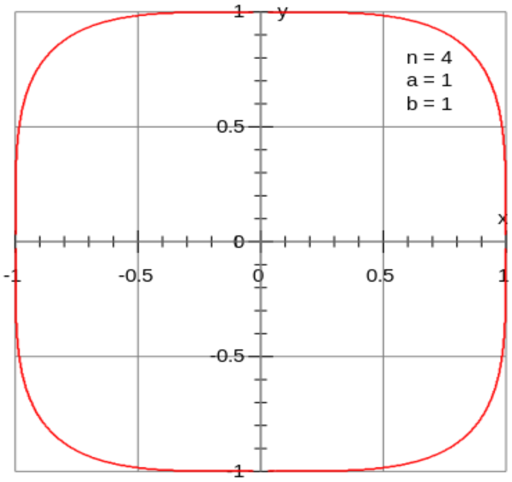
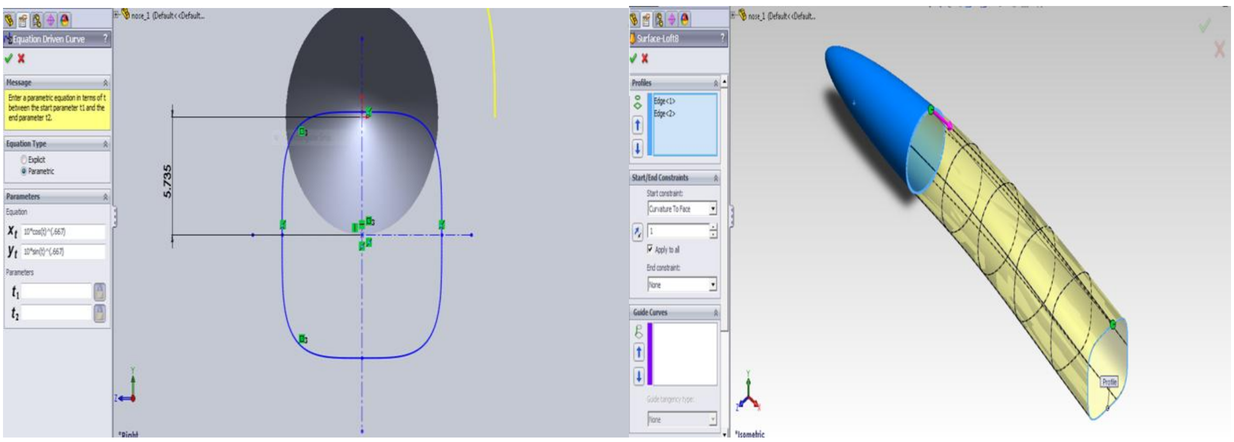


Fig.4 Super ellipse curve

The reason to choose the super ellipse curve over a standard curve is to keep balance between aerodynamic shape and internal volume. It can be explained furthermore, if the square shape was chosen then the internal volume/space can be increased marginally but due to the sharp cornered edges of square drag can be increased for side wind conditions as well as it cannot provide seamless or smooth shape in our case.

- Loft operation:

Our project generates a loft of surface for fuselage. To generate a surface loft two profiles are needed and they both are shown in fig and described in pervious sections. Fig 5 (A) & (B).



(A) (B)

Fig.5 lofting operation

- Seamless joint between nosecone and fuselage

Seamless curvature simply means the curvature of the one curve must equals to the curvature of other curve. In other words both curves share a common normal at the contact point, if they both are of seamless type. The reason behind to choose this seamless joint is to reduce the shape induced drag. Because if the curve is not seamless, at the point of transition the shape changes suddenly from one to another. This can cause very high drag on the surface of the UAV and also increases the load on it.

Tail cone:

Tail cone is the component of an aircraft which continues the shape of the fuselage and by continuing the shape; it reduces vortexes and thus drag of the overall aircraft. Also it can provide mounts for nozzle. The shape of the tail cone is kept in such a way that it provides continuity to the shape of fuselage. It is designed in following steps.

- Shape of profiles:

Front end of tail cone profile is made by the rear end of fuselage and thus the shape is super ellipse, and the other end has curve but with parameters modified.

- Method of generation:

The method here used is lofting operation between two planer profiles but with offset from their centers.

- Length

Length of tail cone = Total length – length of nose cone – length of fuselage = 110 – 30 – 55 = 25cm. Total length is assumed as 110cm when design was started.

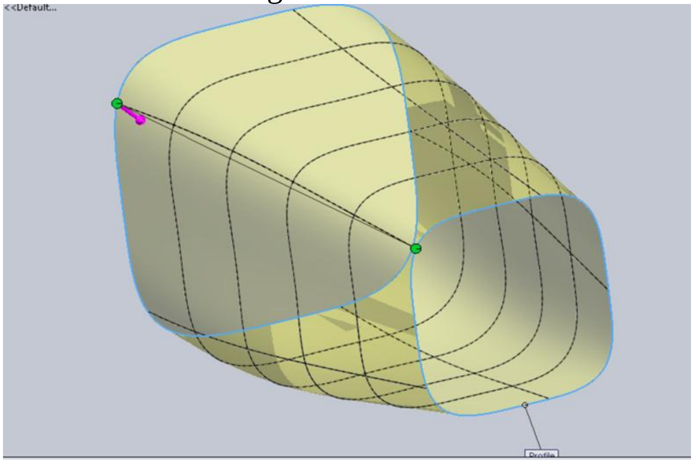


Fig. 6 Tail cone

VI. PROBLEM ENCOUNTERED

- Finding solution for seamless surface joint and maintaining throughout in Solid works 2013
- Selecting shape for other end of fuselage
- Selecting design from 7 alternatives
- Future development aspects

VII. SOLUTIONS

- The option of "Start constraints" in loft feature, Solid works 2013 is set to "Curvature to Face" with default value (tangent start length = 1). Thus seamless surface is made. The fig.7 shows a loft without any start and end constraints, while same fig. shows the same loft with start and end conditions kept as "Curvature to face".

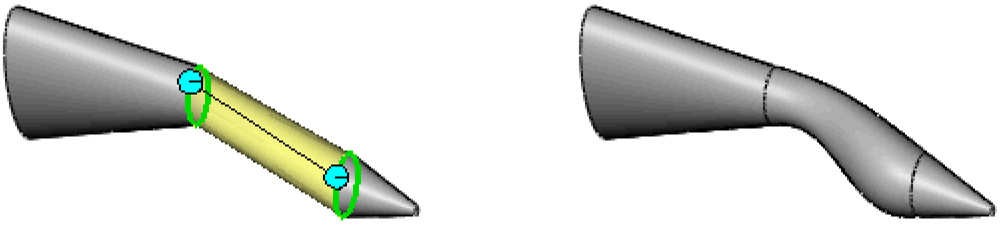


Fig.7 Seamless joint

- It was mentioned earlier, that super ellipse curve is chosen over square or any other curve due to its greater aerodynamic characteristics.
- When the design step was initiated, 7 alternatives were there. The mentioned design is chosen on the basis of Relative Aerodynamics Performance, Internal Space etc. One of the design alternatives is shown below in Fig 8. It does not have very well aerodynamic characteristics due to its non-gradual transformation of the area.

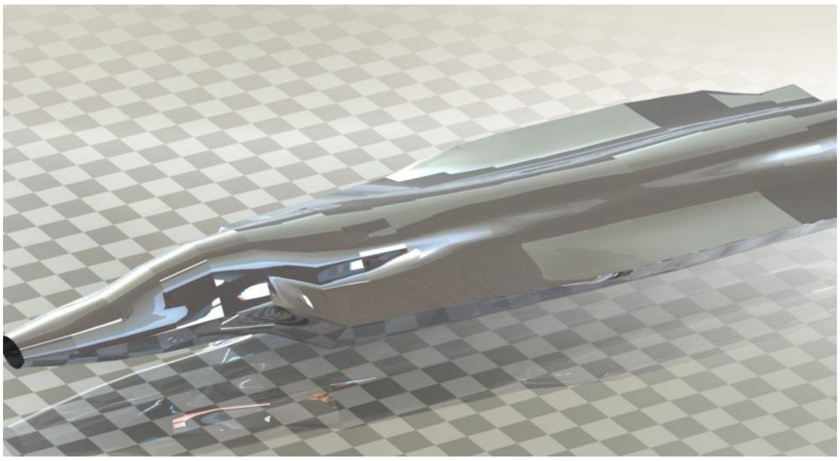


Fig. 8 Design alternative

- The UAV is designed in such a way that it can be developed for various fields and applications. Such as for intake and outlet duct openings, they can be cut from various places like nose cone, underbelly of aircraft etc.

VIII. CONCLUSION

It is concluded that aircraft and its components (Nose cone, Fuselage, Tail cone) are designed according the requirements and it is ready to be developed furthermore or adopted for specific usage. Fig. 9 shows rendering of the proposed design.

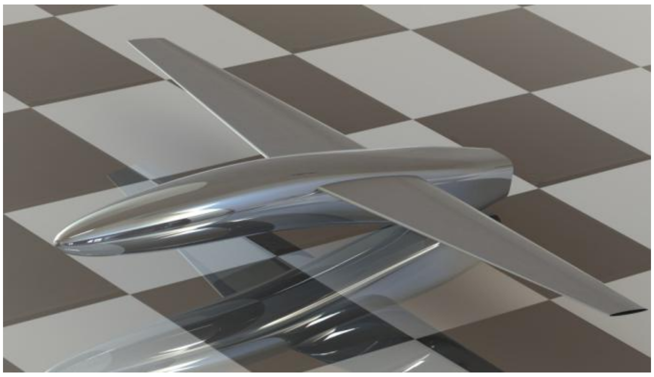


Fig.9 Rendering of the proposed design

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