Introduction to Step Wing & Kline Fogleman Airfoil

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Abstract— This Paper is discussed with the study of the analysis of the concept of step wings with Kline-Fogleman airfoil. Here the study of analysis at different angle of attacks helps to conclude that the KF airfoil provides promising results against the stalling at higher angle of attack as well as in some configuration the lift generation is really appreciable. Here the entire KF and KFm family of airfoils are described along with their application. The concept of Kline Fogleman airfoil is associated with the step shaped geometry at the top and bottom surface of the airfoil. This airfoil was generated by the Richard Kline and Floyd Fogleman in 1960 for the paper planes. In this paper we will check the possibilities of its practical application.

Key words: Airfoil, Step wing, KF airfoil, Stall

I. INTRODUCTION

[2] In an aircraft the wing performance is mainly based upon the wing configuration and the type of selected airfoil, so it is must to know what is an airfoil. Before dealing about the airfoil it is mandatory to know that why we use only airfoil shapes in the generation of the lift.

When airflows over the airfoil then the stream line pattern on the upper surface is found to be close together then the area between the stream lines are reduced which causes the flow to accelerate, hence the pressure on the upper surface is reduced from the atmospheric pressure. While on bottom side the stream line patterns are far from each other, the area between them is more so velocity reduces and pressure increases slightly from the atmospheric value.

Low pressure on the upper side and high pressure at the bottom side creates a resultant force. The vertical component of the force from the direction of the flow is a ‘LIFT’ force and the horizontal component of the force along the flow direction is known as the ‘DRAG’ force. The lift force of the airplane is given by the formula

\[ L = C_L \times \left( \frac{pA}{2} \right) \]

Where, \( L \) = lift force
\( C_L \) = coefficient of lift
\( p \) = density of the fluid
\( A \) = U=

II. AIRFOIL

Cross section geometry of the aircraft wing is termed as “Airfoil”. The generation of lift force is mainly depends on the geometry of the airfoil. For the satisfactory performance of any lifting body the performance of the airfoil is very important.

When a fluid flows on a stationary body, then there is an exertion of force on the body by the fluid and the same thing happens when a body moves through the stationary fluid.

Fig. 1: Stream Line Pattern over an Airfoil

Airfoil, a streamline body may be symmetrical or unsymmetrical in the shape is characterized by the some parameters such as chord length “C”, angle of attack “\( \alpha \)”, and span “L”.

Fig. 2: CL VS A Graph for Clark Y Airfoil Ratio =6

Clark Y Airfoil at aspect ratio=6

Fig. 3: Nomenclature of Airfoil

Some important terminology of airfoil [5][6]
A. Suction Surface:
The upper surface of the airfoil is termed as suction surface; it is generally associated with the high velocity and low static pressure.

B. Pressure Surface:
The lower surface is known as the pressure surface, having high static pressure in comparison with the suction surface. The other terms for airfoil are:-

C. Leading Edge:
It is defined as the point in the front of the airfoil which has the maximum curvature or minimum radius.

D. Trailing Edge:
It is also defined as the point in the rear of the airfoil that has the maximum curvature.

E. Chord Line:
It is straight line connecting leading edge to trailing edge. It is denoted by “c”.

   The mean camber line is defined as the locus of the point at the midway of the upper and lower surface, and the shape of the camber line is decided by the thickness distribution along the chord.

![Fig. 4: Airfoil Showing Camber Line and Chord Line](image1)

![Single step airfoils - multistep airfoil](image2)

Fig. 5: Geometry of Kline Fogleman Airfoil

III. KLINE FOGLEMAN AIRFOIL

The Kline- Fogleman airfoil (fig. 5), also termed as the KF airfoil. It is a simple design airfoil with the steps along with the direction of the chord length. Steps can be single or multiple times. 50 years ago it was generated for the paper planes. KF airfoils with simplicity of construction in 21st century again found its interest between the builders of radio controlled aircraft. But still it is not applied yet for the big size aircraft which is used to carry substantial payloads or passengers.

![Fig. 6: Kline Fogleman Series of Airfoil](image3)

Fig. 6: Kline Fogleman Series of Airfoil

[3] The KFm airfoil is designed by the Richard Kline & Floyd Fogleman when he was experimenting about the high strength paper plane, with a nice glide and after so many experiments he was enables himself to achieve this goal. Richard and Floyd found that this step wing concept is able to resist the stalling then they decided to file a patent on stepped airfoil (fig. 6).

After some time the further development in KF airfoil lead to the new design airfoil which is known as KFm (Kline – Fogleman modified) airfoil. The step airfoil either at top (KFm2) or bottom (KFm1) surface or both side (KFm4) fall into this category. These steps can be use more than one time. For example; KFm3 [4] and KFm7 (fig. 7).

When the flow passes through the step airfoil then some displaces air falls into the pocket behind the step, here the air behaves as a trapped vortex and becomes the part of the airfoil, and further when air passes over the surface of the step airfoil, then flow will not going to separate from the surface (fig. 8).

![Fig. 7: Kline Fogleman Series of Airfoil](image4)

Fig. 7: Kline Fogleman Series of Airfoil
BBIT {Chief, aerodynamic division, pressure, taken from manometer using appropriate tunnel testing are 
that KFm variant with the step of reading of KF airfoil was taken from o to 700 pitch angle the airfoils at different manometer. The entire procedure is repeated with for both tunnel starts the reading from the reading is taken the polythene tubes and 1.2 mm steel tube. The data is body) to the limbs of the ethanol manometer is done with 
the KFm airfoil and reanalyze the above experimental data in separate below for both the airfoil.

**Table 1: lift & drag coefficients for NACA 23015**

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**Table 2: Lift & Drag Coefficients Forkfm2 Variant.**

**VI. CONCLUSION**

In this review paper, our approach is to study behavior of KFm airfoil and reanalyze the above experimental data in which NACA 23015 and its KFm variant is compared at different angle of attacks, in subsonic wind tunnel. In this entire procedure we found that KFm variant with the step of 50% chord length shows some promising lift characteristics. Another thing is that this airfoil can resist the stalling at very high angle of attacks about 450 and after this it levels down itself with a good L/D ratio. The accident arises from the free fall at the critical angle can be prevent by using this type of airfoil. In the primary characteristics of the airfoil we have seen that is has very high strength only because of its geometry so it can be also used in light weight aircraft.

**REFERENCE**

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