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Design and Analysis on Flex foil of Wing

Thota Markandeyulu[1], T Naganna[2], D Muppalla[3]

[1]PG Student, Department of Aerospace, Marri Laxman Reddy Institute of Technology & Management (MLRITM), Hyderabad-500043,Telangana, India.

[2,3]Associate Professor, Department of Aeronautical, MLR Inst of Tech and Management, Hyderabad, Telangana, India.

Abstract: **In this we will design a advanced flexible tailing-edge wing with a composite material, where flaps will be gapless, forming a seamless transition region with the wing while remaining attached at the forward edge and sides. The designed wing is known as flex foil. The flex foil can improve the aircraft aerodynamic efficiency and significantly reduce the airport area noise generation during take-off and landing.**

Keywords: **Aerodynamic efficiency, Aerofoil, Composite material, Conventional aerofoil, Flaps, Flex foil, Noise generation, Pressure profile, Seamless translation region, Velocity profile.**

1. INTRODUCTION

At present when conventional flaps are lowered, gaps exist between the forward edges, sides of the flaps and the wing surface. By this the efficiency of aircraft is reduce and there is noise generation during the take-off and landing.

Now we are going to reduce the gaps between the forward -edge and sides of the flaps. In this we will design a advanced flexible tailing-edge wing with a composite material, where flaps will be gapless, forming a seamless transition region with the wing while remaining attached at the forward edge and sides. The designed wing is known as flex foil.

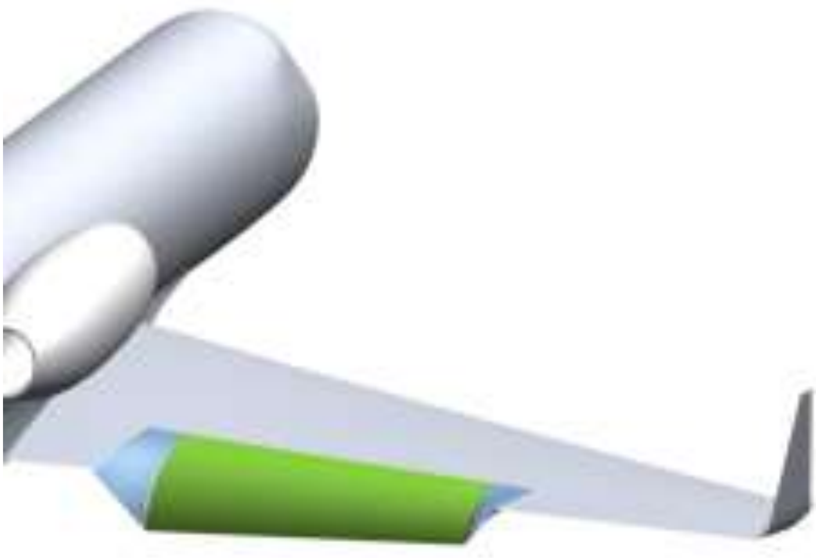

Fig. 1 flex foil of wing

If it will be success, The advanced shape-changing flaps that form continuous bendable surface. The flex foil can improve the aircraft aerodynamic efficiency and significantly reduce the airport-area noise generation during take-off and landing.

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2. BODY OF THE ARTICLE

The various terms related to airfoils are defined below:

1. The suction surface (a.k.a. upper surface) is generally associated with higher velocity and lower static pressure.

2. The pressure surface (a.k.a. lower surface) has a comparatively higher static pressure than the suction surface. The pressure gradient between these two surfaces contributes to the lift force generated for a given airfoil.

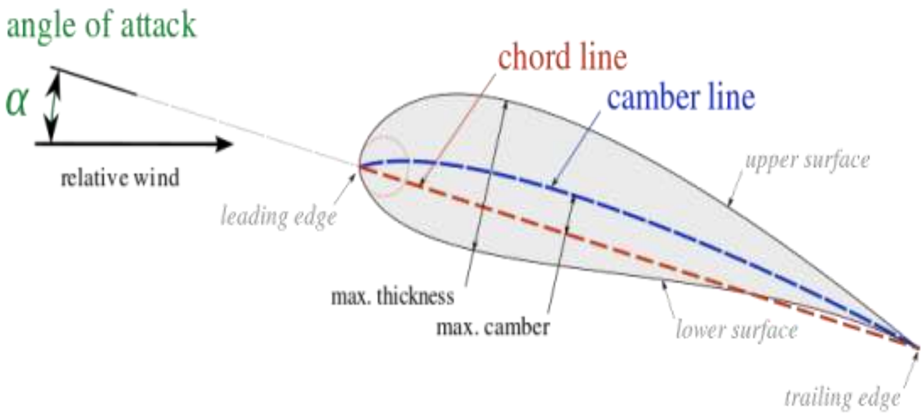

Fig. 2 Aerofoil geometry

Two key parameters to describe an airfoil's shape are its maximum thickness (expressed as a percentage of the chord), and the location of the maximum thickness point (also expressed as a percentage of the chord).

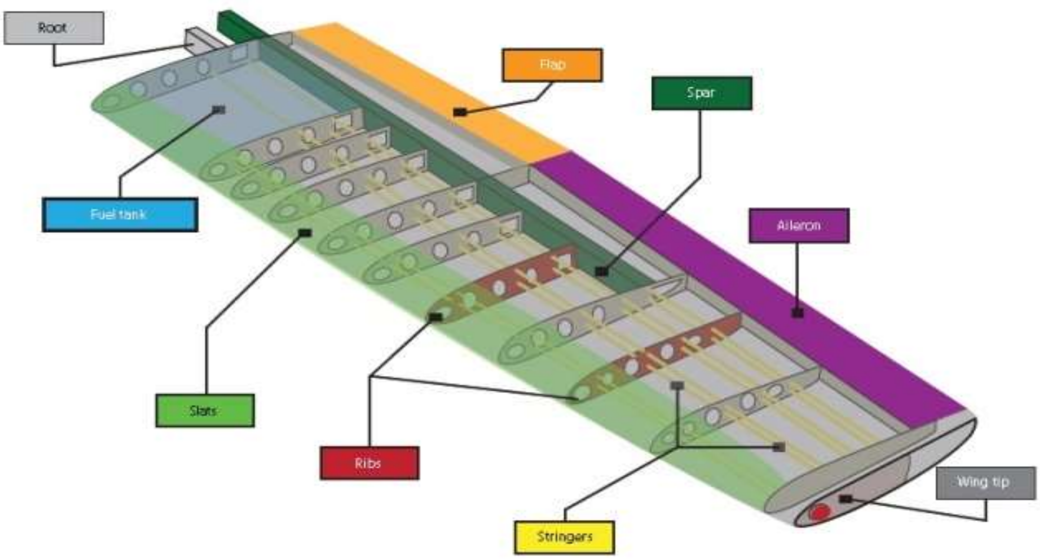

Fig. 3 parts of wing and wing construction

Finally, important concepts used to describe the airfoil's behavior when moving through a fluid are:

- The aerodynamic centre, which is the chord-wise length about which the pitching moment is independent of the lift coefficient and the angle of attack.
- The centre of pressure, which is the chord-wise location about which the pitching moment is zero.

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EXPERIMENTAL ANALYSIS:

Testing equipment: Low speed subsonic wind tunnel

Fig. 4 low speed wind tunnel used for testing

Fig. 5 Flex foil prototype used in wind tunnel testing.

Material used for building flexible flaps are silicon rubber and Polyurethane with the mechanical properties respectively as

TABLE: I

Young's modulus, E	5 Mpa	8 Mpa
Density, ρ	1250 kg/m^3	445kg/m^3
Poisson's ratio , µ	0.47	0.49

Location of pressure probes

TABLE: II

PROBE NO	**COORDINATES** (x_i, y_i)
1	(x_1, y_1)= (8,11)
2	(x_2, y_2) = (21,14)
3	(x_3, y_3)= (33,13)
4	(x_4, y_4) = (44,12)
5	(x_5, y_5) = (60,10)
6	(x_6, y_6) = (60,-4)
7	(x_7, y_7) = (44,-5)
8	(x_8, y_8) = (33,-6)
9	(x_9, y_9) = (21,-8)
10	(x_{10}, y_{10})= (8,-9)

ANALYSIS:

An 3D model of wing is modelled in Ansys and analysed in CFD module for flow analysis

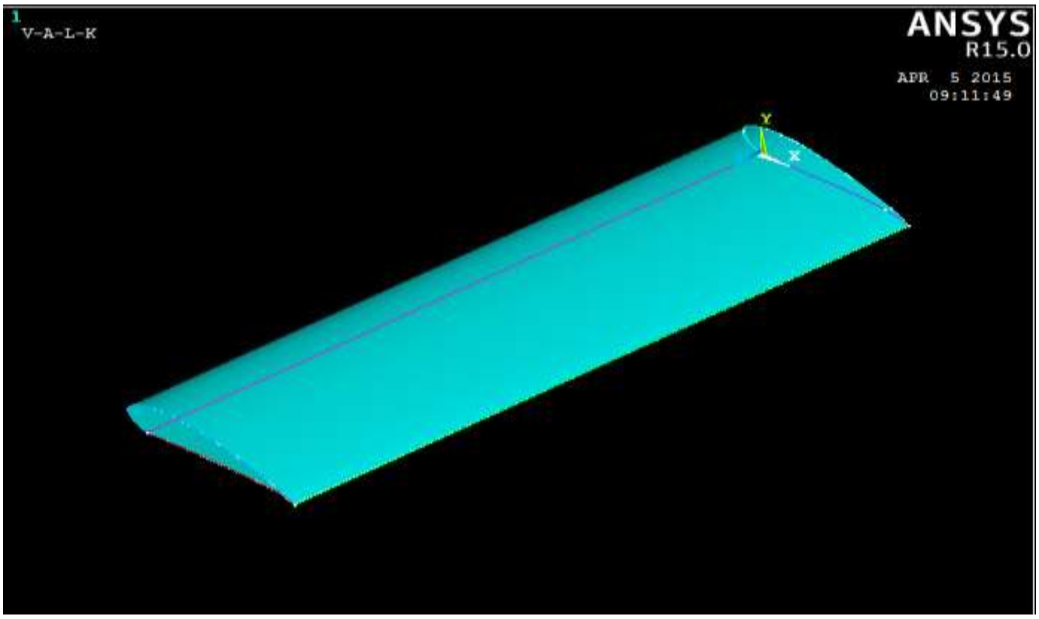

Fig. 6 3D Model of wing

Given initial values as pressure = 0, x-velocity = 150m/s, y-velocity = 0, z velocity = 0

The flow results in velocity profile and pressure profile are came out for flexfoil are:

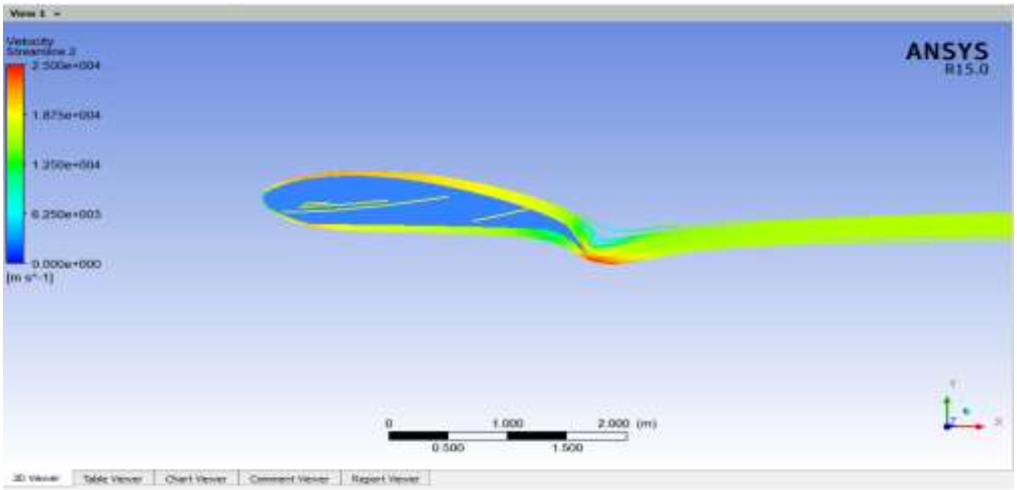

Fig. 7 Velocity profile for flexfoil

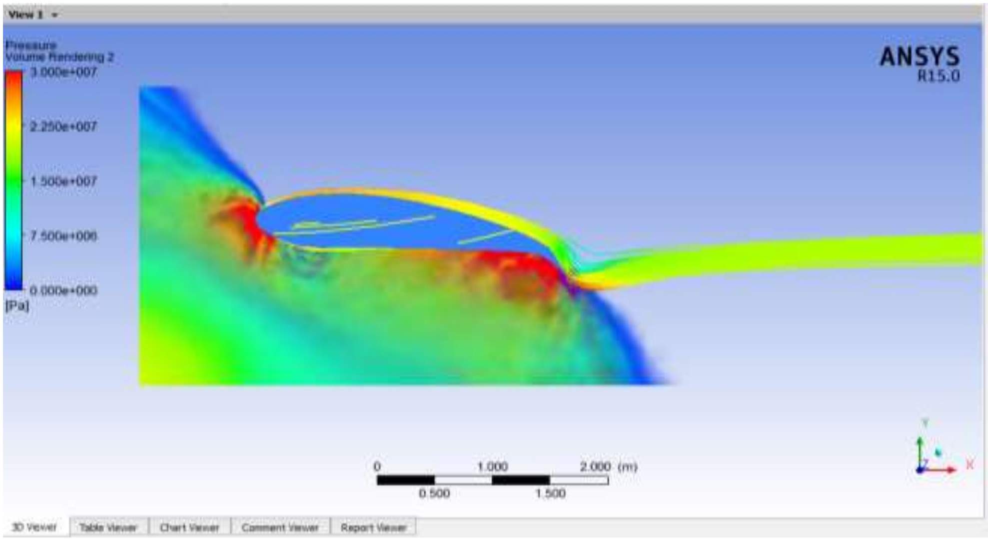

Fig. 8 Pressure profile for flexfoil

Flow analysis of conventional aerofoil are also done and velocity profile and pressure profile came out as

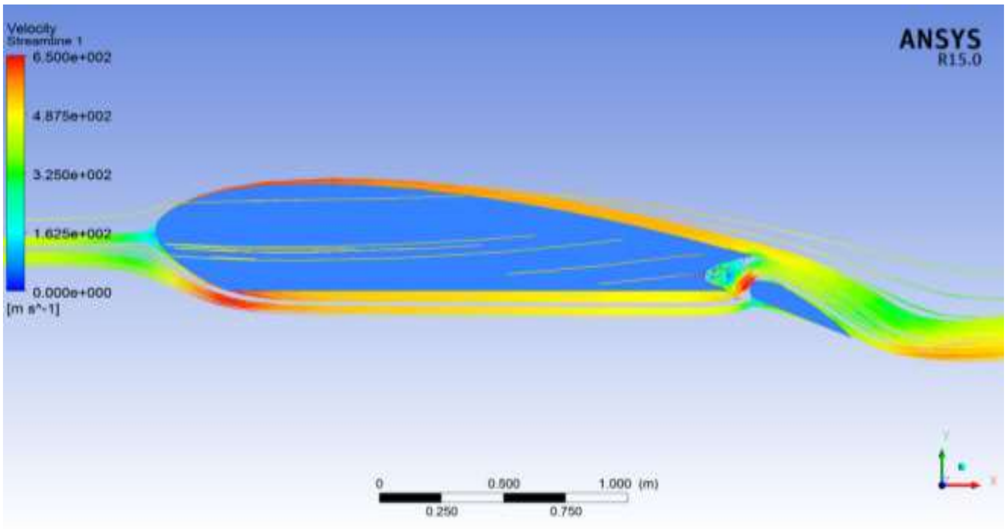

Fig. 9 Velocity profile for conventional aerofoil

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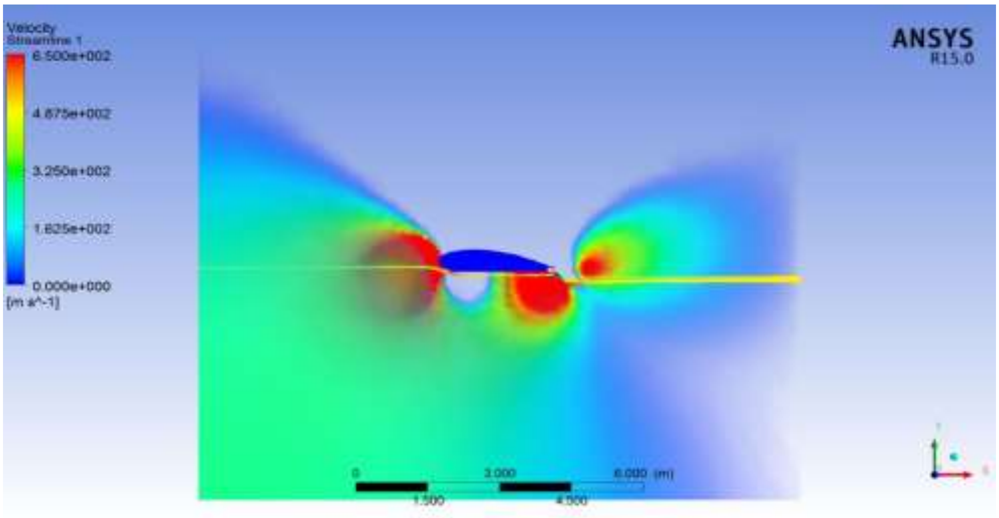

Fig. 10 Pressure profile for conventional Aerofoil

Theoretical calculations:

Theoretical calculations are done base on the profile and mathematical formulas given and results are compared with the experimental results for validation of testing of flexfoil

- $C_n = \frac{1}{c}\int_0^c (C_{p,l} - C_{p,u})\, dx$
- $C_a = \frac{1}{c}\int_0^c \left(C_{p,u}\frac{dy_u}{dx} - C_{p,l}\frac{dy_l}{dx}\right) dx$

$$C_m = \frac{1}{C^2}\left[\int_0^c (C_{p,u} - C_{p,l})\, xdx + \int_0^c \left(C_{p,u}\frac{dy_u}{dx}\right) y_u dx + \int_0^c \left(-C_{p,l}\frac{dy_l}{dx}\right) y_l dx\right]$$

- $C_l = c_n \cos\alpha - C_a \sin\alpha$
- $C_d = C_n \sin\alpha + C_a \cos\alpha$
- $C_l = \left[\frac{1}{c}\int_0^c (C_{p,l} - C_{p,u})\, dx\right]\cos\alpha - \left[\frac{1}{c}\int_0^c \left(C_{p,u}\frac{dy_u}{dx} - C_{p,l}\frac{dy_l}{dx}\right) dx\right]\sin\alpha$
- $C_d = \left[\frac{1}{c}\int_0^c (C_{p,l} - C_{p,u})\, dx\right]\sin\alpha + \left[\frac{1}{c}\int_0^c \left(C_{p,u}\frac{dy_u}{dx} - C_{p,l}\frac{dy_l}{dx}\right) dx\right]\cos\alpha$
- **L** $= C_l q_\infty S$
- **D** $= C_d q_\infty$ **S**
- **M** $= C_m q_\infty$ **S C**

TABLE III

	AOA	LIFT	DRAG	MOMENT
	α=0°			
Experimental		0.4	0.98	0.48
Theoretical		0.38	0.96	0.31
	α=10°			
Experimental		1.23	0.1	0.82
Theoretical		1.2	0.73	0.77
	α=20°			
Experimental		3.35	0.57	2.07
Theoretical		3.31	0.53	2.04

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Graphs:

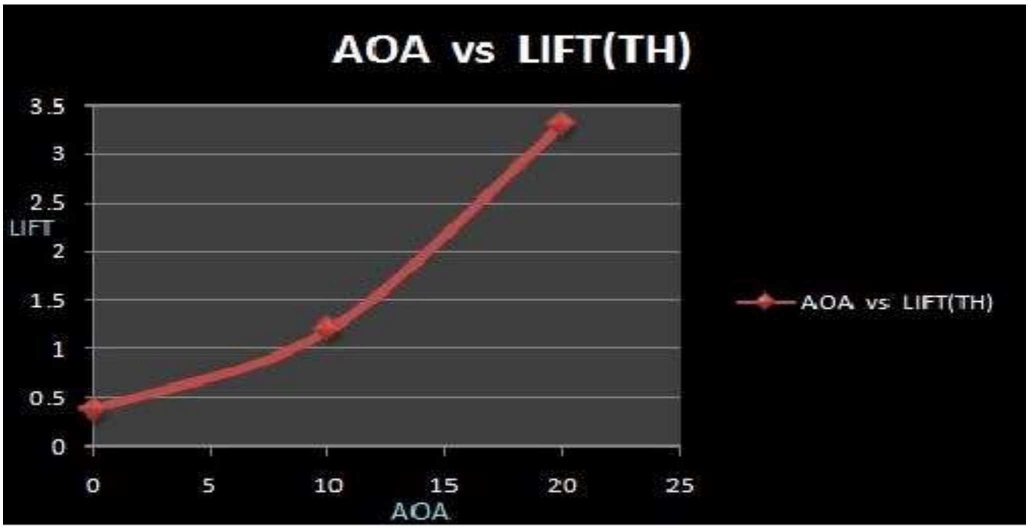

Fig. 11 Graph showing the variation of lift with respect to angle of attack based of theoretical results.

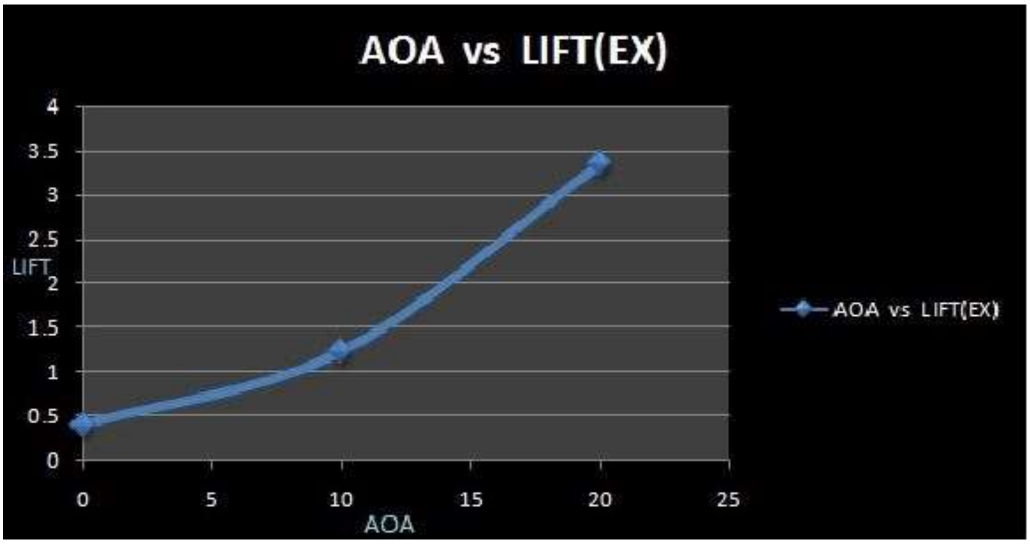

Fig. 12 Graph showing the variation of lift with respect to angle of attack based of experimental results.

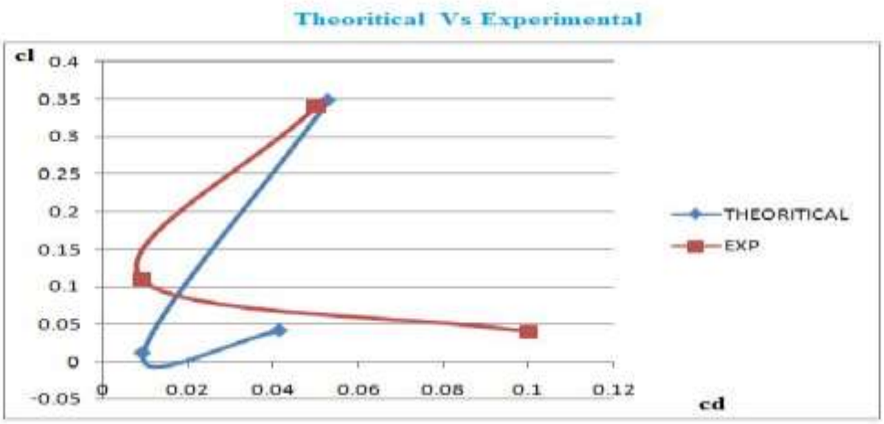

Fig. 13 Graph showing the variation in between theoretical and experimental values

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3. CONCLUSION

From this Flex foil can increase the Lift by reducing the Drag and it can also reduce Noise Generation. It reduces the weight of aircraft and increases efficiency.

Flex foil make airline industry more reliable and stream less to control the control surfaces in manner. It will improve efficiency of aircraft and also flex foil reduce the noise reduction during takeoff and landing.

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