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Aerodynamics of forward swept wing.

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Aerodynamics of forward-sweptept wing

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***Abstract*—A forward-swept wing is an aircraft wing configuration in which the quarter-chord line of the wing has a forward sweep. Typically, the leading edge also sweeps forward. A Forward swept wing is proposed to enhance performance and controllability during high angle of attack perching maneuvers. Data manoeuvrested frare a series of XFLR5 analysis to quanalysese aerodynamic effect of forward-swept over a range of angles of attack from -25º to +75º. Various graphs were obtained during this analysis which indicates that the forward-swept the forward on figuration can achieve qualitatively different low-cost perching maneuvers.**

Keywords-forward swept wing,high angle of attack, perching maneuvers,canard wing,

I. INTRODUCTION

All the 5th generation jet fighters are using either variable swept wing or delta wing with a combination of swept forward and the normal wing. All the 5th generation fighters' characteristics include stealth, low-probability of-intercept radar (LPIR), agile airframes with super cruise performance, advanced avionics features, and highly integrated computer systems capable of networking with other elements within the battlespace for situation awareness and C3 (command, control and communications) capabilities. A few examples of 5th generation jet fighters are:

-The Lockheed Martin F-22 Raptor, which entered service with the United States Air Force (USAF) in December 2005

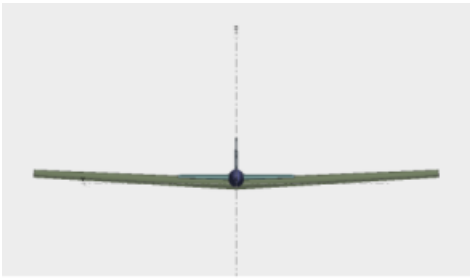
-The Chengdu J-20, which entered service with the People's Liberation Army Air Force (PLAAF) in September 2017

-The Sukhoi Su-57, which entered service with the Russian Air Force on 25 December 2020 The Sukhoi Su-57 was inspired by Sukhoi Su-47 Berkut which used a FORWARD SWEPT WING. This was not the first time an aircraft was made using a forward-sweptwing, the concept of forward-swept as first applied in World War II, independently in Germany, Russia, Japan, and the US. Type Style and Fonts

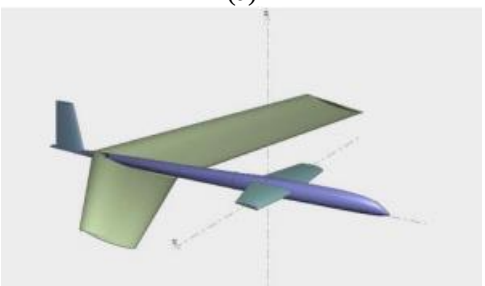
As forward-swept can be controllable at high angle of attack. we can use this to our advantage to enhance the perching maneuvers of small aircraft .This can reduce the distance required for take-off and landing of the aircraft, making it easy to launch and recover the UAV in a safe manner by just using the perching maneuver .Perching is difficult to because: 1. It involves flying at extremely high angle of attack which reduces lift and increases drag. 2. Perching involves flights in close proximity and even in contact with, obstacle that could cause damage. With the use of forward swept wing or forward swept variable wing this can be possible as they are suitable to fly at high angle of attack as in forward swept wing the stall first occurs in their aft most section leaving the ailerons functionable.

II. METHODS AND MATERIALS

A. Design



(a)



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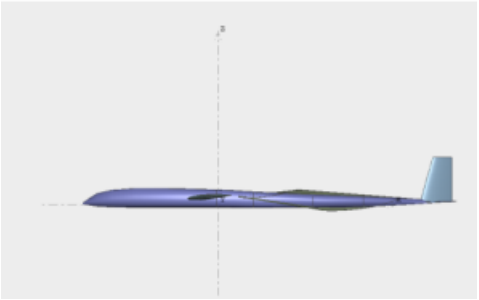


(c)

Figure 1. (a) Front view of the design; (b) Isometric view; (c) Side view

B. *Specifications*

The prototype was designed in XFLR.
Details of the design:
Wing span= 1.4 m
Wing area= 1.395m
Plane mass= 6.8 kg
Wing load= 19.503 kg/m2
Tail volume= -0.238
Root chord= 0.300 m
Aspect ratio = 5.600
Taper ratio = 0.667
Root-tip sweep = -21.448

During each test, servo commands were sent to sweep the model's angle of attack from −25° to +75° with a wind velocity of 40 meters per second. The aircraft was designed using a forward swept wing with swept angle of -21.448 degrees. A canard is used in the front inspired from the Grumman's x-29, the airfoil for canard is NACA 4412 and chord length at the root is 0.15m and chord length and end is 0.08m. Single vertical stabilizer is used and the airfoil used here is NACA 0012.

C. *Literature Study*

1) *Aerodynamic coefficients:*

Aerodynamic coefficients were then calculated from the standard definitions

$$C_L = \frac{2F_z}{\rho S v^2},$$

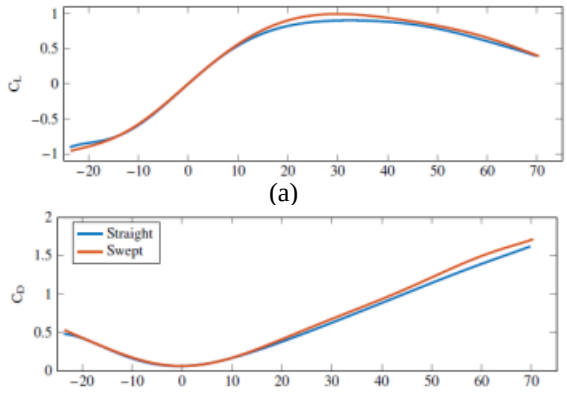
$$C_D = \frac{2F_x}{\rho S v^2},$$

$$C_M = \frac{2\tau_y}{\rho S c v^2},$$

Where ρ is the air density, S is the planform area of the model, c is the mean chord of the wing, and v is the wind velocity

2) *Graphs:*

Grumman's X-29 dealt with a lot of problems that arose with the forward-swept wing aircraft Composite materials were used to control the aero aero elasticrgent twisting experienced by forward-swept, and to reduce weight. The aerodynamic instability of the X-29's airframe required the use of computerized fly-by-wire control. Still is the most unstable fighter jet to ever fly, three computers where wagered to correct the flight paths with 40 error corrections per second. The researchers have said that if all the three computers failed together then the plane would break down for the pilot had a chance to eject. Since then there was no production of forward-swept jets other than Sukhoi the Su-47, both X-29 and Su-47 served as a technology demonstrator prototypes forseveralf advanced technologies later used in the 4.5 generation fighter. The instability is a very big problem faced by thitheseghter jets.



(a)

(b)

Figure 2. Lift and drag coefficients for the straight and forward-swept configurations of the model are plotted in Figure 2.

D. *Analysis*

The analysis of this forward-swept wing aircraft was done on XFLR5 at a different angle attack to study the flow field and aerodynamic coefficients. XFLR5 is an analysis tool for airfoils, wings and planes operating at low Reynolds Numbers. It includes:

- X Foil's Direct and Inverse analysis capabilities
- Wing design and analysis capabilities based on the Lifting Line Theory, on the Vortex Lattice Method, and a 3D Panel Method.

The specifications of the design are mentioned above.

III. RESULTS AND CALCULATION

This shows the potential of the forward-swept wing aircraft in enhancing the agility and performance of UAVs in future. Perching remains an extremely difficult challenge for autonomous aircraft and an area where birds can offer inspiration and, perhaps, some design guidance. As suggested by avian behavior, our preliminary modelling and control work indicates that a forward-swept wing may provide better performance than a straight wing in such maneuvers.

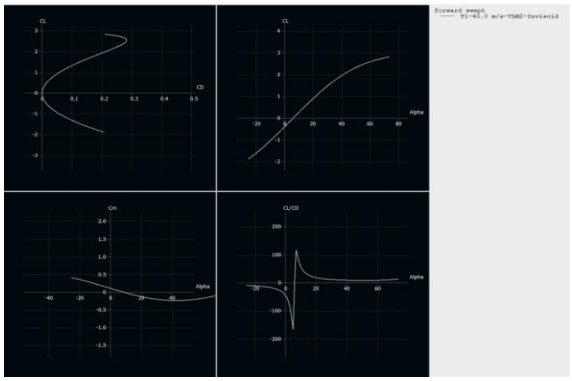


Figure 3: represents the graphs obtained after the analysis was run wa ith wind speed of 40m/s

The first block of the figure represents Cl vs Cd graph Second block of the figure represents the Cl vs Cd graph where you can observe the coefficient of lift at high Angle of attack,

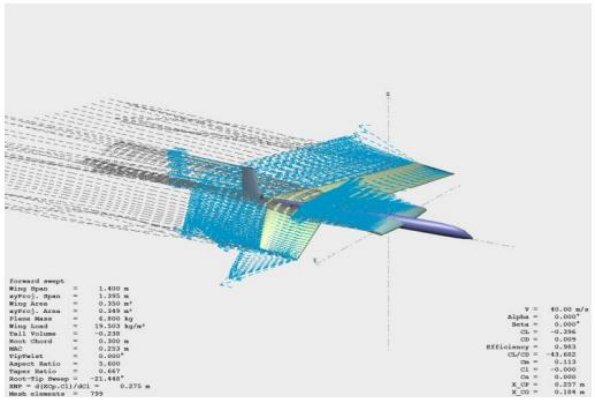


Figure 4: Aerodynamics of aircraft at 0º angle of attack

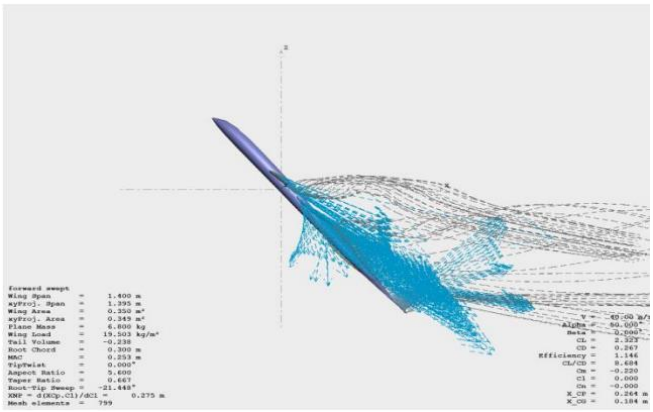


Figure 5: Aerodynamics of the aircraft at 50º angle of attack

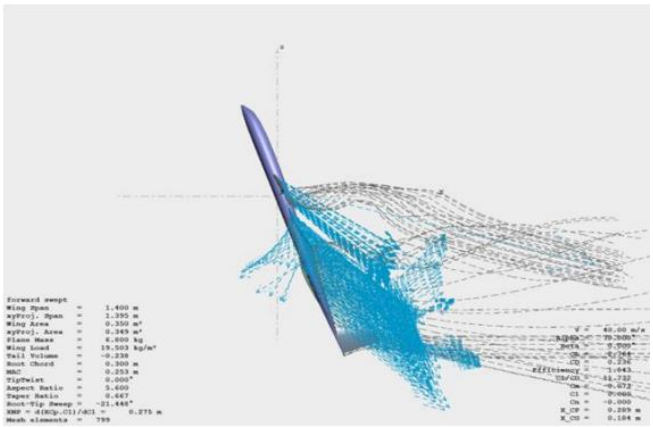


Figure 6: Aerodynamics of the aircraft at 70º angle of attack

IV. CONCLUSION

- The forward-sweep wing concept in this research shows potential for enhancing the agility and performance of micro aerial vehicles, how even at a high angle of attack it generates lift has good post-stall characteristics.
- It can be used to enhance perching maneuver in the UAVs to reduce the landing and takeoff distance
- Still it requires proper computer control and quick response to the CS.

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