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Fanwing Aircraft- Scope as an Agricultural Aircraft

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Abstract: The objective of this paper is to apply the concept of fan wing to agricultural aircrafts which are conventionally fixed wings aircrafts or multi-rotor drones.

Fan wing is capable of producing good amount of lift at a sufficiently low speed without stalling, thus is apt for agricultural processes of irrigation, spraying pesticides, etc. Fan wing has a special ability that it doesn't stalls (for the practical range of AOA), making this spraying method reliable.

A fanwing aircraft is modelled using CATIA V5 and the flow visualizations for the same are performed on the ANSYS. This aircraft is then compared with three different existing agricultural aircrafts on different parameters, namely payload capacity, work efficiency and ease of operation. The comparison shows that such fanwing vehicle is a good substitute over the conventional fixed wings and multi-rotor drones.

Keywords: Fanwing, Agricultural aircraft, ANSYS, CFD

I. INTRODUCTION

A. Fan Wing

A fan wing aircraft has a cross flow fan located at the wing's leading edge, usually covering the whole span of the wing as shown in figure-1. This fan generates lift as well as provides the forward thrust. As the flow passes downstream of the fan over the later part of the airfoil, that section also generates some lift due to the pressure difference over this trailing wing.

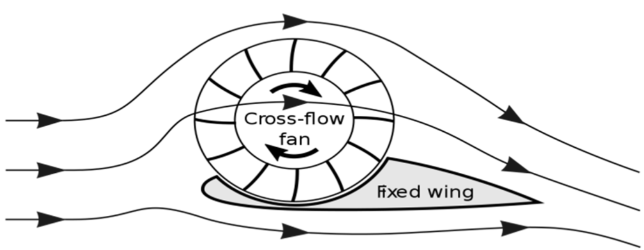


Figure-1

For our model the lift is further enhanced by attaching a ducted fan on the later part of airfoil as shown in figure-2. The longitudinal axis of the aircraft is along the x-axis from figure-2. Keeping the x-coordinate of the ducted fan sufficiently behind the Centre of pressure of the fanwing would enable to generate variable pitching moment via varying the ducted fan's thrust and thus achieving the longitudinal control. This feature rejects the need for the horizontal tail and thus saves a good amount of weight on the empennage.

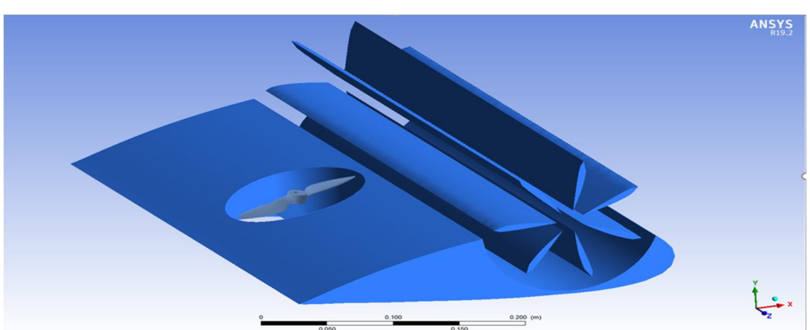


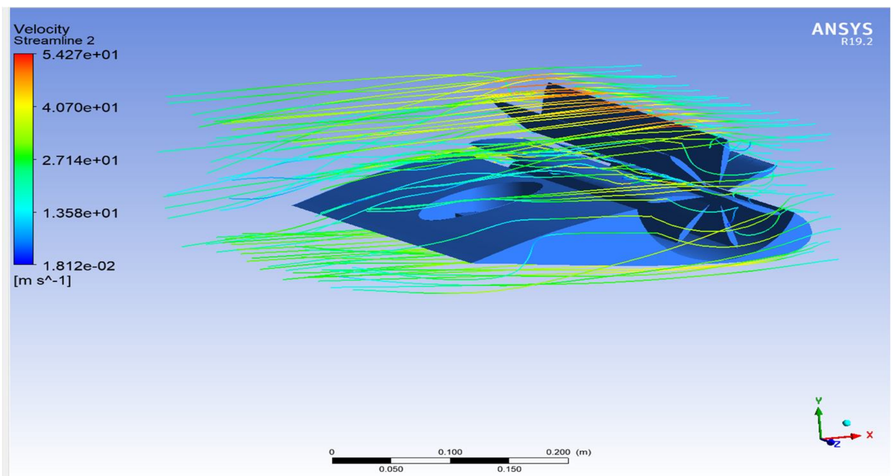
Figure-2

II. MODELLING

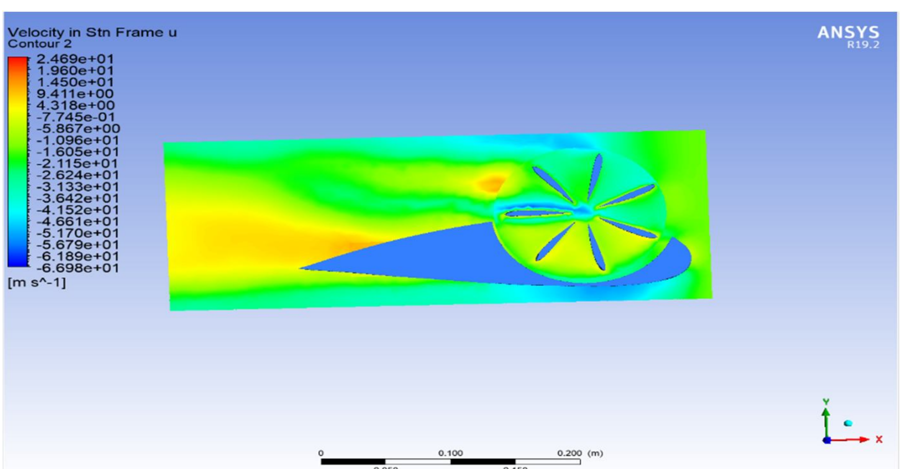
The model is created on CATIA V5. The wing is constructed of NACA2412 airfoil with 200% thickness. The thickness would enhance the volumetric storage of the wing and hence more volume for payload. The rotor fan blades consist of 7 blades each of NACA2412 profile. The trailing part of the airfoil consists of a circular opening for propeller to be attached inside, which act like ducted fan(figure-2).

III. CFD (FLUENT)

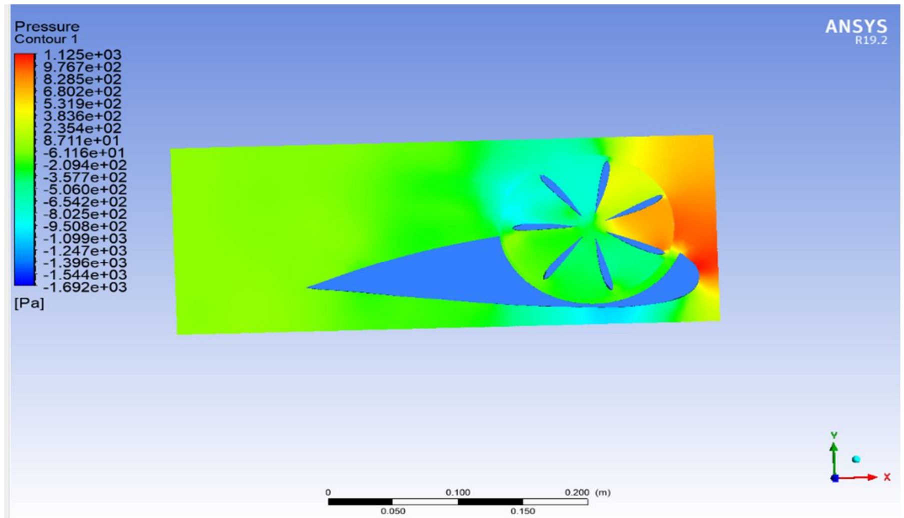
Above model is used in the geometry portion of the ANSYS FLUENT.
A rotating domain is set around the rotor with z-axis as the rotation axis and another rotating domain is set around the ducted fan along the y-axis. The whole model is enclosed in the cuboidal region of freestream flow domain.
Fine element meshing size of 0.005 m is taken for the overall body mesh whereas even refined sizing of .001m is taken for the face of rotor blades so as to analyze the flow more accurately over these regions.
Calculations are done assuming the K-Omega SST model, with the following inputs and assumptions
Incoming flow velocity of 15m/s
fan rotor speed of 2000rpm
ducted fan speed of 2000 rpm
Span of 1m and the chord length of 0.3m
The following results are obtained



Streamlines



Velocity



Pressure

Similar analysis has also been done for tandem fan configurations[1] which suggests that a tandem fan is even more promising than a single fan wing, thereby strengthening the aerodynamic prospects of the fanwing aircrafts. There are a few variations of the list and thrust as the distance and orientation of the tandem fans. The drag coefficient comparison[2] of fan wing with the conventional wing also yields the same aerodynamic advantage of fanwing. Thus it is evident that fanwing aircraft is aerodynamically sound and now needs to be compared with existing aircrafts on parameters which are essential for an ideal agricultural aircraft.

IV. AGRICULTURE AIRCRAFTS CURRENTLY IN USE

Both fixed winged aircrafts and multi rotor drones are used for various applications like spraying and crop monitoring. In order to see whether the fan wing is a good substitute for the purpose we must compare them on some parameters. The parameters chosen in this paper are payload carrying capacity , work efficiency and ease of operation.

Payload carrying capacity would be measured simply as to what amount of fertilizer or water can be carried by the aircraft. Work efficiency would be compared by the amount of fuel energy (in case of piston engine) or electric energy(in case of battery powered) is consumed during the operation. While the ease of operation parameter would compare the aircrafts on features like: ease of filling the water/pesticide , stalling speed of the aircraft, runway length requirement for takeoff and landing, and the other specific advantages and disadvantages.

A. Our first aircraft is the Air Tractor AT-400 (figure 3-a)

Air tractor has a payload capacity of 1500 litres. It has one radial engine of 450KW. It cruises at a speed of 190–230 km/h. It has a wing span of 15 meters with the spraying span of about 10 metres.

a b c

figure-3

A boom structure is mounted under each wing which has spray nozzles attached to it spaced evenly along the span. The spray pump is fixed underneath of the aircraft and is driven by the wind. It has a tailwheel orientation with a non-retractable undercarriage, which would increase the parasite drag during flight. The fuel tank is located in each wing. Non-pressure refueling is done via fuel cap available on each wing.

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In order to operate the air tractor, pilot must have: Commercial pilots' licence along with low level flying experience, Turbine engine experience and Tail wheel aircraft experience. Thus, it requires long training and skill to operate it. Airtractor stalls at a speed of around 98kmph(27m/s). It requires a takeoff distance of about 700 metres.

B. Second aircraft is the Cessna 188ag (figure 3-b)

Cessna 188 ag has a capacity of 1100 litres. It has one radial engine of 220KW. It cruises at a speed of 182 km/h. It has a wing span of 12.7 meters with a spraying span of about 10 metres. The wing braces, unique to any Cessna design, are there to absorb the dramatic forces that a crop duster can be subject to.

Ventilation is provided at the top of the canopy to minimize ingress of spray from previous passes, and the cockpit has two doors. The airframe is triple corrosion-proofed, cables are corrosion resistant and removable panels allow operators to hose down the entire airplane-this exercise is necessary to prevent corrosion from chemical residue.

Stalling speed of air tractor is 92kmph or 25.5m/s. It requires a proper takeoff and landing strip pf about 500m.

C. Third aircraft is the AGRAS t20 dji drone (figure 3-c)

Agras has a capacity of 20 litres. It has a howering power consumption of 6200 W ,with a takeoff weight of 47.5 kg. Its Standard Takeoff Weight is 42.6 kg. Its operating speed is 7 m/s.

It has a hovering time of 15 min for a takeoff weight of 27.5 kg with a 18000 mAh battery, while of 10 min with a takeoff weight of 42.6 kg with a 18000 mAh battery.

It can resist a maximum wind resistance of 8 m/s. It has 8 spray nozzles attached at every end of its 8 arms with a spray width of about 4-7 metres.

V. ADVANTAGES AND DISADVANTAGES OF AVAILABLE AIRCRAFTS

The first two aircrafts are fixed wing aircrafts which have sufficiently good amount of payload capacity and high speeds which help in covering large stretches of land in less time. Thus, very useful for large fields. Whereas the multirotor drone has a comparatively much less payload capacity and a very short endurance, hence becomes a bit more time consuming. Such drones can be a preferred choice for small fields or a specific region which requires special attention.

The multi rotor drone can be operated easily by any person after a simple few hours training. This drone doesn't require runway for takeoff or landing, also the maintenance cost is also minimal. Whereas the two fixed wing aircrafts require licensed pilots to be operated, they require proper runway space for takeoff and landing, also their maintenance cost is pretty high.

Sometimes the chemicals that are used are very toxic and thus an unmanned drone which can be operated from a distance is comparatively safe than the manned aircrafts which have to pass again and again through that mist of toxic spray.

A. Advantages of the Fanwing

The Fan wing allows to use the specific advantages of both these fixed wing and multirotor aircrafts simultaneously. Having the capacity to carry large amount of payload in the wing section; taking off at very low speeds, therefore less runway length requirement; no stalling thereby making it easy to control and operate.

Alongside having less drag than conventional aircrafts wings[2] thus indicating a more efficient operation.

Taking into consideration the dangers of the toxic gases coming from the chemical spray, fanwing is advantageous as it can be controlled via radio fight control system[3] from a safe distance. The paper[3] provides for a radio controlled flight control system for a fanwing uav.

VI. CONCLUSION

A fanwing aircraft has been modelled and analysed via CFD . The aerodynamic results have been visualized via streamlines and pressure and velocity contours. The certain features essential for an agricultural aircraft have been used as the parameters to compare the fanwing with the existing aircrafts. Fanwing has been found to include the combined advantages of both the fixed wing aircrafts and multirotor drone vis-à-vis availability of remote control away from the toxic spray, good amount of payload capacity available, aerodynamically efficient(less drag coefficient). Thus it can be concluded that a fanwing has a good scope to be optimized and enter into the agriculture sector as a better substitute to the present aircrafts.

REFERENCES

[1] Du Siliang and Tang Zhengfei , "The Aerodynamic Behavioral Study of Tandem Fan Wing Configuration", Hindawi International Journal of Aerospace Engineering Volume 2018, Article ID 1594570, 14 pages

[2] S. Selva Jeba Darling, Janany Shri Pon, C. Sridevi, "Design and Analysis of Fanwing Concept in Conventional Wing Aircraft", Journal of Basic and Applied Engineering Research Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 1, Number 3; October, 2014 pp. 68-72

[3] Du Siliang Tang Zhengfei, "The Flight Control System of FanWing Uav Design and Simulation", The 2nd Asian/Australian Rotorcraft Forum and The 4th International Basic Research Conference on Rotorcraft Technology Tianjin, China, September 08-11, 2013

[4] Du Siliang , Zhao Qijun , and Wang Bo, "Research on Distributed Jet Blowing Wing Based on the Principle of Fan-Wing Vortex-Induced Lift and Thrust", Hindawi International Journal of Aerospace Engineering Volume 2019, Article ID 7561856, 11 pages

[5] Guide to Air Tractor Aircraft for Asian & Pacific Region Customers, by FIELD AIR

[6] https://en.wikipedia.org/wiki/Cessna_188

[7] https://www.dji.com/t20

[8] https://en.wikipedia.org/wiki/Air_Tractor_AT-400

[9] https://en.wikipedia.org/wiki/FanWing