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DESIGN AND CONSTRUCTION OF AN UNMANNED AERIAL VEHICLE BASED ON COANDA EFFECT

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Abstract*- Unmanned Aerial Vehicles (UAVs) play a predominant role in the modern day warfare where emphasis on surveillance, intelligence-gathering and dissemination of information. Most of the UAVs accomplishing their specific missions are designed to have propulsion according to one of the following two schemes. First, some of them have a fixed wing design, which resemble the one of a traditional plane. They require a runway to take off and land. Others are employing rotors just as helicopter, thus achieving better result as far as hovering is concerned. This is important because the Vertical Take Off and Landing (VTOL) capability plays also a key part for UAV. Nevertheless, their autonomy is highly diminished, the vehicles being dependent on the fuel amount or the energy accumulators carried on board. Thus the above mentioned demands were analyzed for an efficient and inexpensive UAV. We may come to the idea of searching for a new design based on Coandă Effect (Coandă UAV). These have been evolved to generate lift and maneuverability force in a more efficient manner, which have rudder just as air plane, and also have two types of flap. It can Take-Off and Land just like helicopter but move faster than helicopter*.

Keywords: Coandă Effect, UAV, VTOL, Coandă UAV, Helicopter, Rudder, Flap.

1. INTRODUCTION

Unmanned Aerial Vehicles (UAVs), also known as remotely piloted aircraft are small aircraft that fly by remote control or autonomously, which air vehicle and associated equipment that do not carry human [1].

Most of the UAVs employ a fixed wing design like that a plane, but these design offer low maneuverability and payload capacity also required runway to take-off and Landing (VTOL) UAVs come around these problems, usually by using rotors like a helicopter [2].

Thus we analyzed for an efficient and inexpensive UAVs based on Coandă Effect having new propulsion and lifting system, which have rudder just like traditional plane and two types of flap that’s make it more maneuverability and suitable for adequate mission.

This paper will also discuss the limitations of currently marketed UAVs and explore the potential of using the Coanda Effect in building more capable and inexpensive system. The current main market for UAVs is in defence with 57% of UAVs being classed as military [3].

A VTOL UAV will often have the capability to carry significant things. This gives the opportunity for it to carry [4].

- Thermal imaging and infra-red cameras
- video cameras.
- Explosive equipment.
- Small delivery packages.
- Listening devices.
- Mine detectors.

With so many problem for a UAV during a mission just like Payload, Endurance, wind gusts, Communications, Maneuverability, Autonomy etc and many restrictions for the pilot of a UAV to consider, in the ideal word UAVs would operate without the requirement for human control , but there have few UAVs are fully autonomous. Autonomy is a very challenging solution from the developers perspective but it will ultimately lead to the most efficient UAV.

2. COANDA EFFECT

The Coandă Effect was discovered in 1930 by Henri-Marie Coandă. His patents state:

“If a sheet of gas at high velocity issues into an atmosphere of another gas of any kind, this will produce, at the point of discharge of the said sheet if gas, a suction effect, thus drawing forward the adjacent gas [5].

“If, at the outer of the fluid stream or sheet, there is set up an unbalancing effect on the flow of the surrounding fluid induced by said stream, the latter will move toward the side on which the flow of the surrounding fluid has been made more difficult” [5].

In simple terms, a steam of fluid at high velocity will attach to a curved surface rather than follow a straight line in its original direction. This stream of fluid will also entrain air from around it to increase the overall flow of the stream of air.

This phenomenon can be harnessed to produce lift in two ways. Firstly, it can be used to change the direction of airflow to point downwards, resulting in vertical thrust.

Secondly, it can be used to entrain air from above which causes a region of low pressure above the body, which results in lift [4].

Overview on the projects based on the Coandă effect :

In aeronautics, this effect is used today primarily in helicopters that’s have no tail rotors. The first design of a coandă UAV was created in 1932 [6], by the Romanian inventor Henri Coandă.

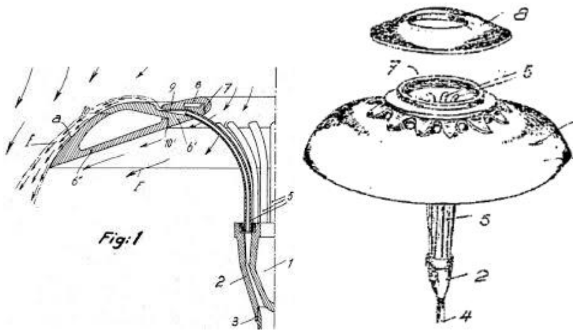

Fig.1: Coandă patent “ Perfectionnement aux propulseure” [6]

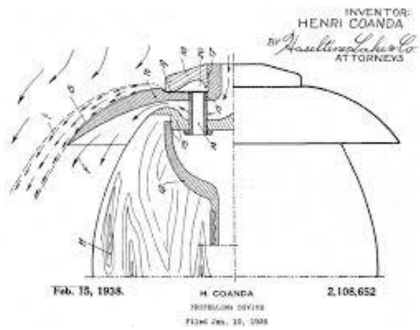

Fig.2: Henri Coandă’s original patent for a propelling device [7].

In his first patents related to Coandă Effect applications, in order to generate the jet of fluid over the upper surface of the fuselage, he was using mainly other means than a rotor, i.e. a burner or a combustion chamber. But in a patent he obtained in 1935, [8] he was enumerating the possibility to use also a centrifugal fan supplying the necessary air flow.
In UK 50 years later, Robert Collins valued Coanda Effect capabilities in one of his inventions, which obtained a GB patent no.2387158, granted in 2oo3. This new Coandă application was already presented in his paper “Coanda – A new Airspace Platform for UAVs” at the Bristol International UAV Conference, in April 2002 [9].

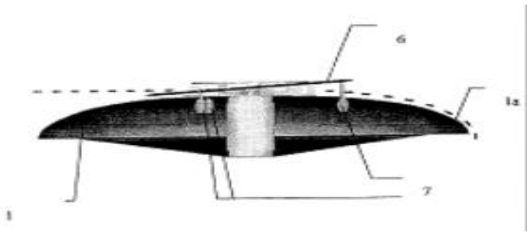

Fig.3: Robert Collins aerial Flying Device [9].

In that design of a Coandă UAV the rotor at the centre of the hollow fuselage canopy pulls air in form above the craft and blows it out radially, over the top of the curved body. Because of the Coandă Effect, the airsteam remains ‘stuck’to the canopy and follows the curved surface, leaving the body at its base. This, along with the downward thrust of the fan, pulls the air raft upwards.

Also in 90’s, another inventor from UK, Geoffrey Hutton, together with the GFS project team, promoted also an aerial Coandă Device, with a circular shape canopy.

Fig.4: Geoff Hatton and his flying saucer [10].

When GFS projects built their first model, the circular shape turned to be octagonal, with flat flaps on four opposite sides of the trailing edge [10].

In 2006, Jean-Louis Naudin made and tested his first UAV (GFS-UAV model N-01A). This one, propelled by an electric engine, was using the Coandă Effect to take off vertically, fly, hover and land vertically (VTOL).

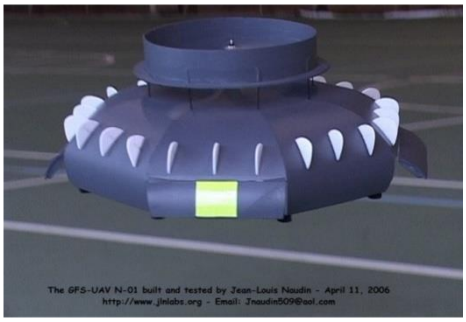

Fig.5: J.-L. Naudin’s first GFS-UAV (N-01A) [11].
The design of the GFS-UAV N-01 was based on the Geoff Hatton flying saucer from GFS Project limited. In

the next year, Jean-Louis Naudin Freely published the full plan of the GFS-UAV N-01A and a detailed tutorial to help UAV fans to repliate his GFS UAV [11].

3. DESIGN AND CONSTRUCTION OF COANDA UAV

3.1 Design Parameter

A number of design parameters affect the capacity of a Coandă-effect screen structure. Some of these parameters are primarily related to the structure [12]:

- Drop height from upstream pool to start of screen (or from upstream weir crest to start of screen)
- Screen slope
- Curvature (arc radius) of screen
- Length of screen

Others are properties of the screen material:

- Slot width
- Wire width
- Wire tilt angle

3.2 Modeling

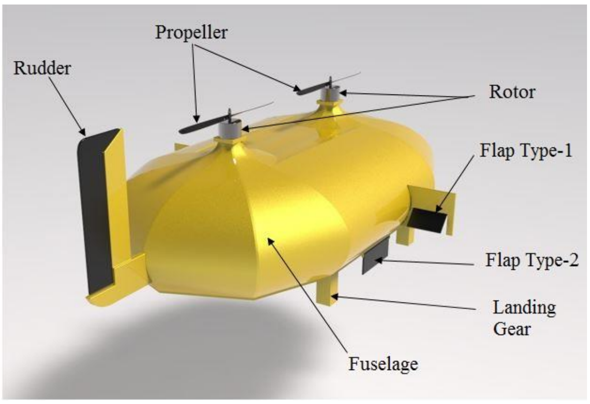

Fig.6: Model of The Coandă UAV.

In the design of the Coandă UAV the two rotor at the top and same distance from the two sides of the fuselage pulls air in from above the craft and bolws it out radially, over the top of the curved body. Because of the Coandă Effect, the airsteam remain attach to the fuselage and follows over the curved surface, leaving the body at its base. This, along with the downward thrust of the propeller, which help the fuselage of the aircraft upwards. The Rudder change the direction of the Coandă UAV at the time of flying forwards. The Flap Type-1 helps the Coandă UAV to move fast in forwards at the nunning fly and Flap Type-2 helps the UAV to move in right or left at an aerial platform.

3.3 Aerodynamic Properties of Design Model

The airstream flow over screen according to the design model as shown Fig 7

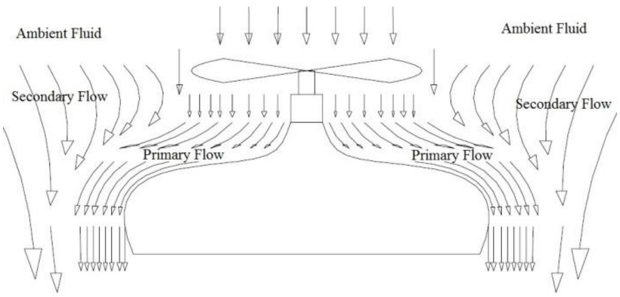

Fig.7: Jet flow over Coandă surface.

The rotor at the top of the fuselage pulls air in from above the UAV and blows it at down, according to the coandă effect the direction of the airstream change and remain attached to the fuselage. There two types of flow shown in figure, one primary flow another secondary flow. The primary flow produce by propeller and secondary flow is cause of coandă effect. The velocity of the primary flow gradually decrease due to produce of secondary flow.

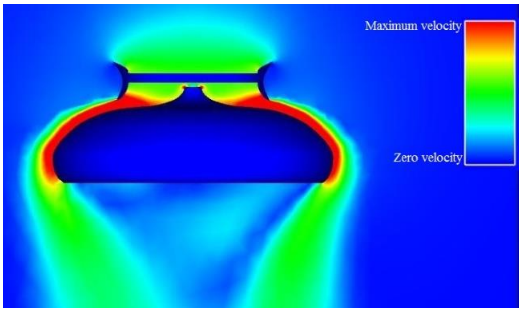

Fig.8: CFD simulation of coandă effect UAV

This phenomenon can be harnessed to produce lift in two ways. Firstly, it can be used to change the direction of airflow to point downwards, resulting in vertical thrust. Secondly, it can be used to entrain air from above which causes a region of low pressure above the body, which results in lift. This is as shown in figure. 8.

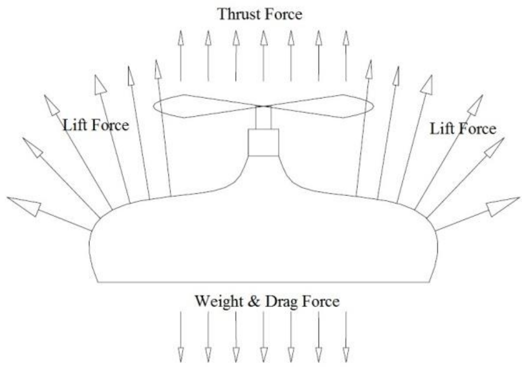

Fig.9: Aerodynamic force distribution on design Model.

The thrust force which produce by propeller and lift force which produce because of coandă effect act vertically upward. And the weight and drag force act vertically downward, which as shown in figure. 9.

3.4 Circuit Diagram of Coandă UAV

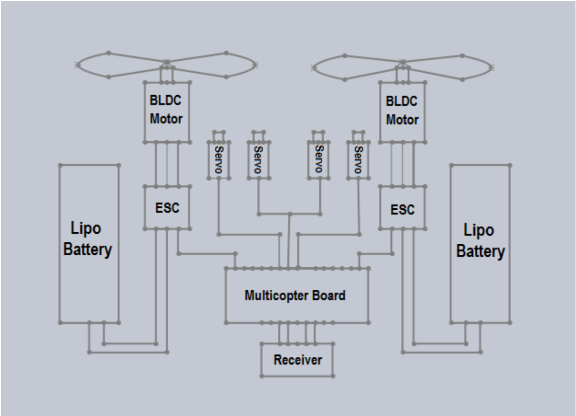

Fig.10: Circuit Diagram of the Coandă UAV.

3.5 Constructed Model of Coandă UAV

Fig.11: Construction Model of Coandă UAV.

A prototype model of Coandă UAV's fuselage and other parts(Rudder and Flaps) has been constructed by using foam board(5-milimeter theckness) and two BLDC motor(EMAX-KV 920) was used as rotor. Servo motor (TowerPro SG91R- Micro Servo) was used to control the control surface of the Coandă UAV .

4. DISCUSSION

These VTOL Coamdă UAV is using the Coandă Effect in ordar to generated lift and an excellent stability in their motion as a surveillance platform.
Missions that a Coandă UAV will be capable to accomplish will diversify in the time to come, both in civil and in the military field.

- First, as the Coandă UAV have no critical pats so, it is simple in design and the two rotor, by which the Coandă UAV comes stable position easily.
- The Coandă UAV it is not as vulnerable to impacts against walls, ceilings etc., as a more conventional unmanned plane, so it may bump into horizontal or virtical walls, or other kind of obstacles, without losing altitude.
- The Coandă UAV have two type of flaps and rudder just as traditional plane which, make it more maneuverability.
- Coandă Effect amplifies and even multiplies the lift forces due the increased air volume entrained.
- The payload is not located directly in the stream of air responsible for creating lift forces.
- The airflow necessary to create lift forces is not as dependent of the aititude or angle of attack as fixed-wing UAVs are, so the UAV is more stable during the flight.

The test the performance of flight of the Coandă UAV was performed which, showed excellent stability in it's motion as a surveillance platform.

5. CONCLUSION

After the design and fabrication of the UAV in this project, followings should be concluded.

- Coandă UAVs, a recent application of 100 years old discovery, are in a position of winning terrain in front of other light UAVs.
- UAVs represent a very interesting and exiting area of aerial robotics, involving very dynamic platforms. It seems highly probably the will continue to see ned applications, beginning with those that happen in relatively unpopulated areas and relatively high altitudes.
- The current applications of UAVs are research/education, surveying and data transmission in the field of military or civilian.
- In this paper, design and construction on an unmanned aerial vehicle, based on Coandă Effect was presented and discussed.

6. ACKOWLEDGEMENT

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