THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICHAL ENGINEERING, ISSN 1224-5615
2011

THEORETICAL AND EXPERIMENTAL STUDIES FOR AUTO SUSTAINABLE DEVICE USING COANDĂ EFFECT

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ABSTRACT

The paper presents the stages involved in creating the experimental prototype of an auto sustainable device based on the Coandă effect as well as some simulations performed on the aerodynamic profile of the device using FLUENT software.

KEYWORDS: Coandă effect, auto sustainability, experimental study, simulation

1. DESIGNING THE EXPERIMENTAL MODEL OF THE DEVICE

To achieve an experimental prototype as close to optimal as possible, we first designed an experimental model of the auto sustainable device, which required some study [1, 2], for correct and optimal dimensions of the device’s outer shell, the propulsion system and the systems to ensure stability and maneuverability.

The theoretical and experimental trials performed on the designed models had different types of nozzles with variable diameters and the possibility to continuously adjust the circular exit slot of the air, to ensure analysis for the influence of Coandă effect over the forces required to lift and keep the device airborne. The study regarding the influence of the constructive and physic-mechanic parameters on the airflow is extremely important for the positioning of the guidance elements on the outer shell and allows for some prediction regarding the pressure forces on the device’s surface. The testing device, Figure 1, consists of a shell which incorporates the main body of the small scale experimental prototype, a central system (pipe + distributor) which performs the fueling with compressed air and a series of 6 profile disks which are mounted on the distributor, Figure 2.

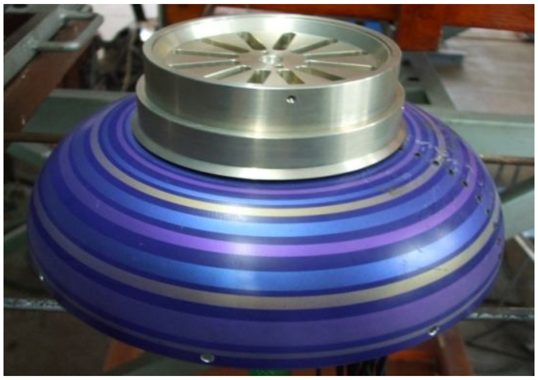

Figure 1. Experimental model

Figure 2. Profile disks

Corroborating data with the experimental data obtained on the practical model, which was subjected to testing in the aerodynamic tunnel has brought on some corrections which were taken into consideration to redo the theoretical modeling. These were dictated by the possibilities to ensure certain work flows and certain values for speed and pressure.

After all the theoretical and experimental studies [3,4] performed on the experimental model, we created a prototype for the device presented in Figure 3. The prototype contains the same main elements like any other air model: fuselage, wings, rudders and control surfaces. The radio control system, which for more complex models allows for similar behavior to real airplanes, was later attached, Figure 3b.

Any flight device, including the prototype, follows the same aerodynamic rules. The device is powered by the traction supplied by a 250 mm diameter propeller, driven by an electric motor [5].

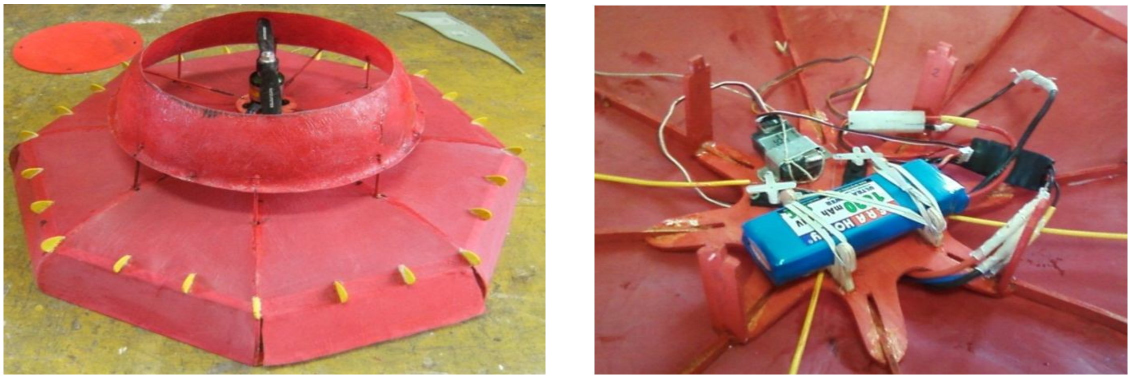
a. b.

Figure 3. Prototype for the auto sustainable device with Coandă effect
a. Top view; b. Electric accumulators fixed on the device

Following the forward motion of the model, air currents on the upper side of the shell produce an increase in carrying capacity. At a certain speed, the carrying capacity becomes higher than the weight of the device and the device becomes airborne. The rudders stabilize the device on its trajectory. The effect of locking the steering is that the model turns around its vertical axis, its regular trajectory being a horizontal circular arc. Locking the ailerons generates a rotation movement along the longitudinal axis. Locking the depth rudder changes the position of the device during flight compared to the transversal axis and generates descent or nose lift. The construction materials used to build the prototype are fiber glass, carbon fiber, balsa wood, thick synthetic fabric, light and resistant aviation plywood and extruded polystyrene. To increase the outer shell resistance, a special lacquer called emait was applied.

The electric propulsion system was selected due to easy usage. The modern electric motor together with the highly efficient accumulator was easily installed on the very light outer shell, with 8 supporting beams, Figure 4.

The necessary power was chosen based on the prototype construction, the weight of the additional devices which will be attached (video camera, audio, devices to measure the environment parameters), as well as based on the desired performance [6].

The unit load has to be kept at minimal value. The weakest upward currents can be valued only using a light device with minimal weight. The wings with efficient profiles and modern construction materials (balsa wood, emait, etc.) help the device perform in steep incline, with medium wind conditions and on flat terrain.


Figure 4. Prototype fuselage

2. ANALYSIS FOR FLOW AND STATIC PRESSURE ON THE OUTLINE OF THE SURFACE

Simulation of the flow for the constructive characteristics of the experimental model was performed using FLUENT 6.3.26 software, where a 1:1 virtual scale model was designed.

The relative speed was asserted to be 10 m/s, according to measurements taken on the experimental model.

Static pressure, dynamic pressure, speed on the aerodynamic profile and Reynolds number (fig. 6 – 9) were studied, by gathering data in four different points according to Figure 5.

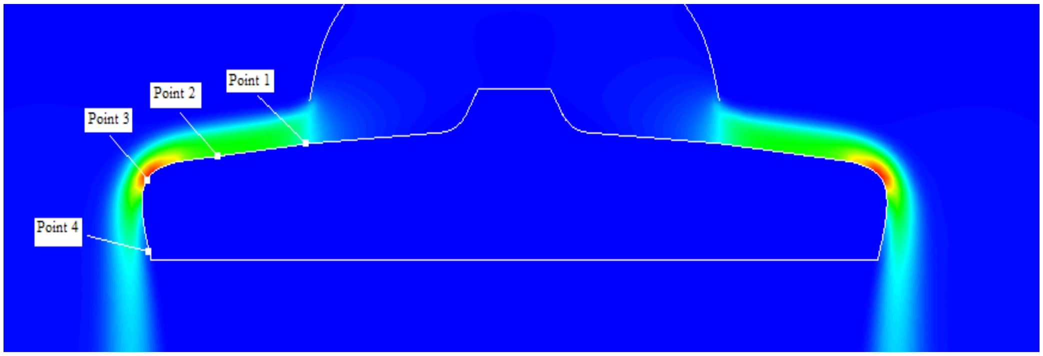

Figure 5. Diagram to gather experimental data

Figure 6. Static pressure for v=10m/s

$P_{S,}$ [N/m^2]: P1 – 1117,40; P2 – -61,27; P3 – -3125,82; P4 – -98,45.

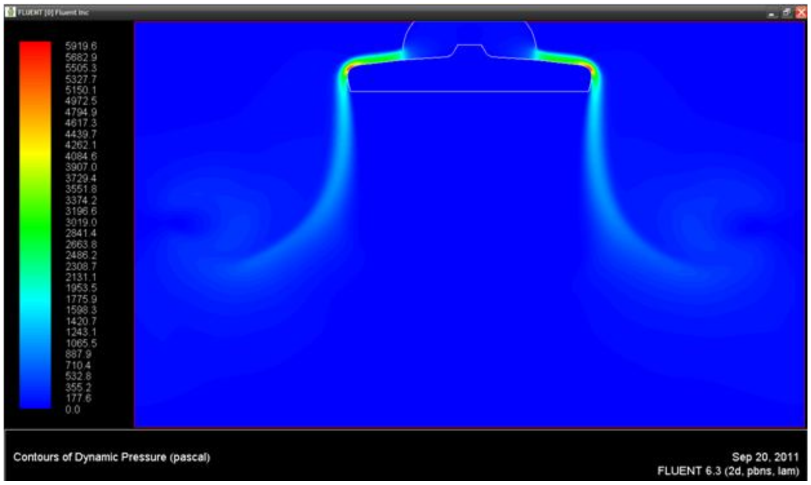

Figure 7. Dynamic pressure for v=10m/s

$P_{d,}$ [N/m^2]: P1 – 1953,48; P2 – 3019,02; P3 – 5327,48; P4 – 1243,12.

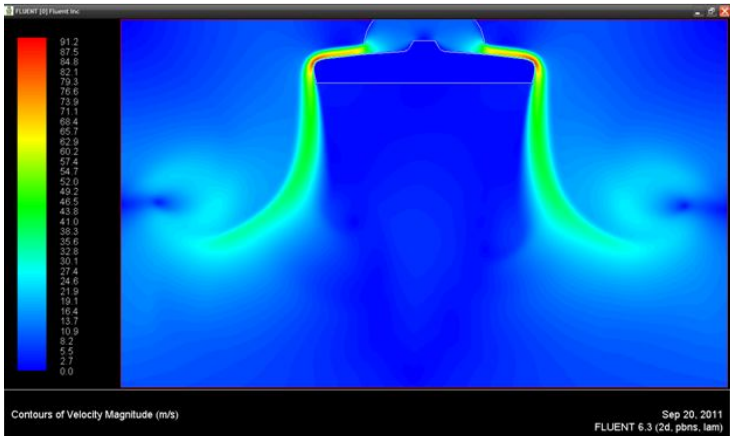

Figure 8. Speed chart on the aerodynamic profile
v, [m/s]: P1 – 51,97; P2 – 71,12; P3 – 84,80; P4 – 41,03.

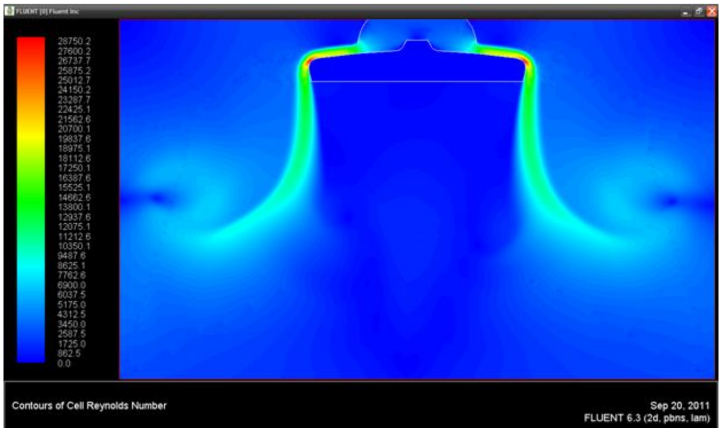

Figure 9. Reynolds number for v=10 m/s
Re: P1 – 12937,58; P2 – 18975,13; P3 – 27600,18; P4 – 10350,07.

CONCLUSIONS

1. The built device represents a first work form for later trials using specialized equipment to acquire data or different parameters, for video and audio surveillance.

2. Modeling the flow on the outer surface of the built device shows a decrease in static pressure once the device radius drops, which implies a decrease in carrying capacity and a decrease in the force created by the propeller.

3. The results of the simulation, presented in Figures 6, 7, 8 and 9 were achieved for relatively slow speeds, the proposed motors having the possibility to achieve higher flow speeds. Based on the engines, the simulations can be redone for higher values.

4. The values for pressure or speed on the outer shell of the device can be assessed according to the grid on the left side of the figures. The values can present small variations, based on the device’s radius. At higher speeds we can predict that the difference will increase.

REFERENCES

[1] **Florescu, I., Florescu, D., Nedelcu, D.-I.** *Study regarding the air flow of the propulsion system of an auto sustaintable vehicle*,Buletinul Institutului Politehnic Iaşi, tom LIV (LVIII), fasciculul 1, 2008, p. 51-58.

[2] **Zha, G.-C., Caroll, B., Paxton, C., Conley, A., Wells, A.** *High Performance Airfoil with Co-Flow Control*, AIAA Paper 2005-1260, Jan. 2005.

[3] **Florescu, D., Florescu, I., Nedelcuţ, F., Nedelcu, D.-I.** *Fuselage Airstream Simulation for a Coanda UAV*”, Review of the „Henri Coandă” Air Force Academy, No. 2 (17)/2010, Braşov, p. 83-87, ISSN 1842-9238.

[4] **Olivotto, C.** *Fluidic Elements based on Coanda Effect*, Anniversary Session “Celebrating 100 year of the first jet aircraft invented by Henri Coanda” organized by INCAS, COMOTI and Henri Coanda Association, 14 December 2010, Bucharest, Romania.

[5] www.siera.ro

[6] **Nedelcuţ, F., Bălan, G., Ciobanu, B., Florescu, I.** *Specifications for an UAV for scientific research in the field of monotoring environmental parameters*, AIRTEC – International Aerospace Supply Fair, November, 2009, Frankfurt/Main, Germany.