Numerical and Experimental Investigation of Slot-Blowing Air Over a Cylinder

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The Coandǎ effect describes the tendency of a tangentially-blown fluid jet to adhere to a curved or angled surface[5], as a result of a transverse pressure distribution which pushes the jet towards the wall, deflecting its path[7].

This phenomenon has been studied since the early 1900's, and has been examined in numerous settings in science and engineering. Some of the best known aeronautical applications of the Coandǎ effect are in the tailboom of the NOTAR helicopter[4] for yaw control and antitorque production, and in circulation control over airfoils for high lift systems[6,8]. In these examples, a pressure source creates a jet through one or multiple linear slots, blown tangential to the adjacent surface. This slot-blown air creates a large area of attached flow, resulting in some desirable force on the body, such as increased lift.

A recent application where this type of circulation control is envisioned is the REDT helicopter concept (Fig.1). In this design, coaxial main rotors are directly driven by a turbine embedded in the rotor head[1,3]. Because this concept does not require antitorque, circulation control around the helicopter tail boom obtained via the Coandǎ effect appears to be a sensible choice to provide directional authority in hover and at low speeds (Fig.2). This avoids the use of a complex mechanical transmission system, which would otherwise be required to drive a tail rotor, and which has been found to drive helicopter cost and compromise safety[2].

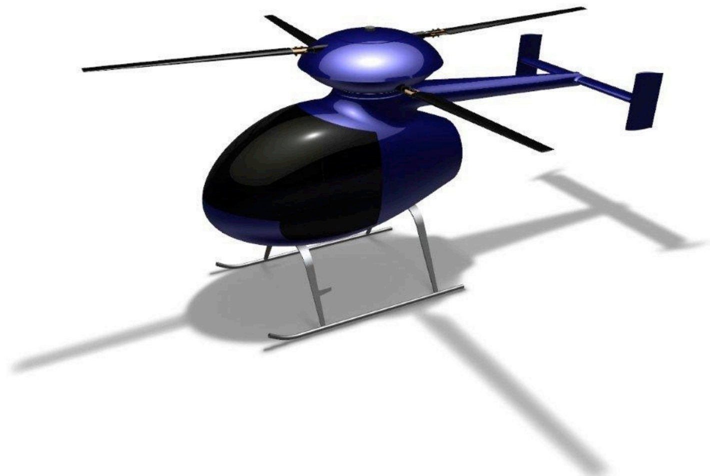

Fig. 1 : The REDT-helicopter concept.

At it's simplest, the directional control system amounts to a single slot on a cylinder, with an internal pressure source creating a blowing sheet that adheres to the exterior of the tail boom, while interacting with the main rotor downwash. Consequently, it creates the desired torque on the body of the helicopter, necessary for yaw control. Further study is needed, in order to refine this design.

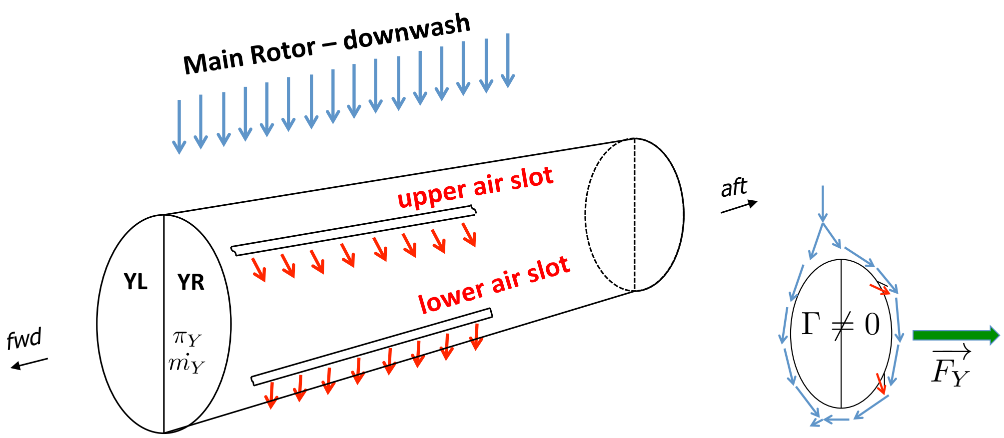

Fig. 2 : Directional control using the Coandă effect for circulation control

The project at hand is a numerical study, using Numeca's turbulent Navier-Stokes solver, supported by wind tunnel tests, to further examine the application of the Coandă effect to a cylinder. The study will focus initially on two-dimensional flow around a cylinder, with an emphasis on creating the greatest forces on the cylinder possible, using a minimum pressure ratio -defined as the ratio of pressures inside and outside the cylinder-, and to study the flow behavior for several flight conditions. This parametric study will examine the contribution of slot width, the number of slots, and the distribution of those slots around the cylinder. The cylinder will vary in diameter from 20 to 30 centimeters, and applied pressure ratios will range from 1.2 to 2.0. Full-scale wind tunnel tests are used to substantiate the results obtained via numerical analysis.

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