August 2021

Self-Tilting Wing for VTOL and CTOL

Colin Hilton

Self-Tilting Wing for VTOL and CTOL

Colin S. Hilton

Abstract

‘Free’ wings deflected by a combination of free-stream airflow and servo-tab deflection date back to the 1940s, but may be applied with especial relevance in combination with tilt-wing forms of electrical vertical take-off and landing (eVTOL). An advantage of the means described is that forward impetus alone initiates the transition from a vertical-oriented airfoil to forward-oriented. Although this might use a separate power means, the device allows for a simple quadcopter to take off or land vertically as well as induce forward flight, purely by conventional quadcopter control.

Background

During the recent evolution of the technology there has been a trend toward those types which benefit from the lift generated by aerofoils, and away from those using rotary-wing means such as ‘multicopters’. This generally involves fixed-wing configurations augmented by multicopter means for the purpose of take-off and landing alone, or else means of tilting either the motor-units and propellers or else the wings to which they are attached, or a portion thereof.

Nonetheless, there has long since existed a device known as a ‘free’ wing whose incidence can be varied independently of the fuselage on a voluntary basis by artifice or involuntary in response to the external airflow. The latter propensity for the angle of incidence is of particular use with respect to tilting-wing types of eVTOL, in so far as it means that the transition to forward flight is effected by way of a simple response to the altered condition of airflow stemming therefrom.

Description

The disclosure presents a means by which a simple quadcopter for example might furnish its motors and propellers with an airfoil, so that manipulating their thrust alone induces forward flight following hover, and thereby adjusts the airfoils to free-stream airflow by no separate artifice; and which process reversed might return the air vehicle to the hover. In order to do so the airfoil freely ‘weather-cocks’ and is hinged about an axis lying ahead of the nominal centres of lift and gravity. It therefore hangs more or less vertically prior to activation as herein described. The airfoil may be constrained to rotate between fixed arcs of rotation in order for example for the quadcopter to tilt the airframe fore or back.

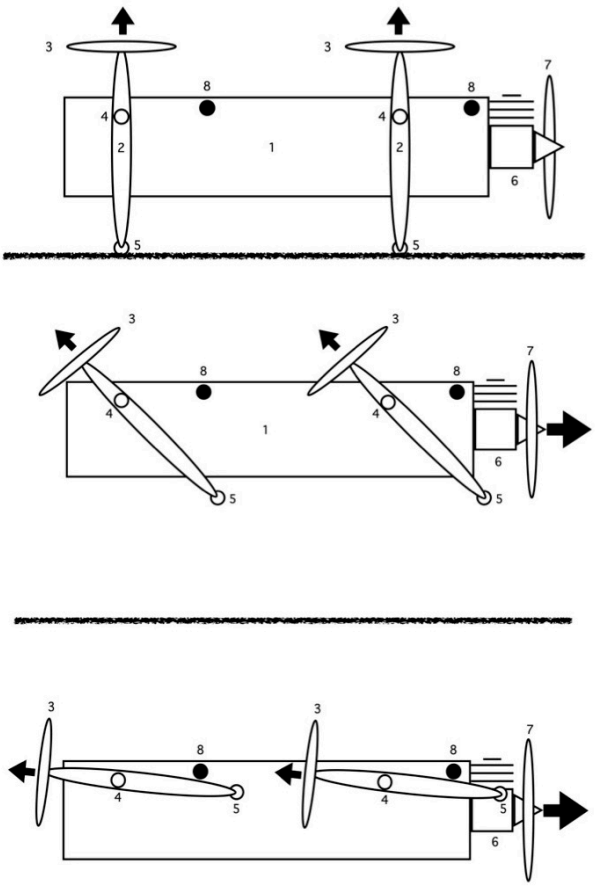

Fig 1 Transition from take-off through hover and cruise

The process is shown in an example that nonetheless uses separate means of propulsion, including a profile view of an airframe at rest, in transition and in forward flight.

Looking at the first of these, a stylised airframe comprises a fuselage (1) with a pair of aerofoils (2) either side in a 'quad' layout, for example, to which motorised propellers (3) are affixed at the leading edges. The aerofoils (2) are fixed on axles (4) to allow them to rotate more or less freely toward different degrees whilst also appending castors (5) for ground support. The fuselage (1) also appends a conventional power-unit (6) to which a pusher-propeller (7) is attached.

Take-off is performed by quadcopter logic, wherein the aerofoils (2) might be locked in a vertical or steeply-canted position so as to prevent collapse whilst previously grounded; a means of achieving this in the absence of locking mechanisms is by using an over-centre condition such that the aerofoils (2) are arranged like trestles.

Following take-off Fig 2 illustrates a forward-flight transition in which the aerofoils (2) are free to weather-cock in response to the airflow as the rear power-unit (6 & 7) accelerates the aircraft. Note that during this transition the quadcopter control logic remains in force so as to trim the craft beside applying directional thrust-vectors, yawing moments or lift.

In Fig 3 the aircraft has achieved a cruise condition, with the aerofoils (2) arrested either by physical stops (8) or for those with a camber, a stable angle of incidence where lift is nonetheless still being generated in support of the gross weight.

Note that the landing phase is merely a reversal of the take-off, wherein a reversion of the rear power-unit and propeller (6 & 7) to an idle condition will automatically return the motorised propellers (3) to a vectored state able to accommodate a steep approach and touchdown or else a vertical descent.

All of this is in contrast to conventional means of transition from forward flight wherein cognitive means are required to power up the vertical means of lift whilst powering down the forward, or reconfiguring the motors and/or wings to address the same procedures. At the same time the invention would also benefit from say eight motor instead of four, beside conventional control surfaces with which to meet degraded operational conditions.

Note that even in the absence of an additional power-plant the principals of the invention obtain, in so far as once the aircraft is underway by addressing the electrical motors using conventional logic the aerofoils adapt their position to suit forward flight while reversing that logic to decelerate the aircraft returns the propellers to the upright.

The method also applies to surface-effect, where the normalising effect of airflow on the aerofoils by gust-response has a stabilising effect absent from those of a fixed incidence.

Finally, whereas the prior art such as that for instance disclosed in European specification EP0629164B1 features a conventional pair of wings connected together in common upon a single axle, those aerofoils (2) and axles (4) described here may be wholly independent.

Conclusion

The disclosure provides a means of equipping conventional multicopters with airfoils to reduce the energy requirements during cruising flight, without unduly compromising that in the hover. The method adapts itself to conventional control of quadcopter types, for example, without the complication of control tabs or surfaces, servo-mechanisms or indeed further means of onward propulsion.