A Review on Tilt Rotor Aerial Vehicles for Commercial Purpose

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Abstract:

A tilt rotor aircraft consists of one or two rotors that are mounted on the aircraft. The location of rotors is distinct and depends on the purpose of manufacturing. In general they are mounted on the top of the engine nacelle, fuselage and at the wingtips of an airplane. Tilt wing aircraft is the amalgamation of the conventional aircraft design and the helicopter design. This aircraft consist of fixed wing along with the rotors and this design helps in vertical take-off and landing (VTOL) of an aircraft. It has three modes, 1. Lifter, 2. Transition, and 3. Thruster. Lifting is carried out by the rotors on the aircraft where the helicopter vertical take-off principle is used. Transition is the phase of airplane where the mode of flying is converted is converted from helicopter to aircraft for forward movement. Thrusting is carried out by the propulsion unit for forward cruising of the flight. This design reduces the take-off distance and time. Runways can be eliminated and many aircrafts can land at that same instant in airport. This type of aircrafts can also possess the ability to hover. The comparative study of this design with the conventional designs is illustrated in this paper. The major advantages and drawbacks is also discussed below.

Introduction:

The evaluation of airplanes has been started from the beginning of 19th century with the Wright brothers. There are many developments and modifications are being carried out in the design and performance of aircraft. The design changes based on the criteria of requirement. There are basically two types of aerial vehicles- a fixed wing aircraft and a rotary wing aircraft. A fixed wing aircraft is driven by the jet engine or commonly called as gas turbine engines. It can fly at higher altitude with high cruising speeds and it also possess high range and endurance value. The rotary wing aircraft attains low altitude with less cruising speed and it also possess low range and endurance value. The amalgamation of both the type of aircrafts gives the concept of tilt rotor aerial vehicles. Partial wing is tilted rather than the complete wing. The tilting angle is adjustable based on the flight mode. During take-off the rotors are facing upward and it generates lift by helicopter principle. During transition mode, the rotors are at a particular angle of inclination and during the forward motion the rotors are in the direction of flight.

Use of twin tilted rotors in aircraft will add up an advantage to the flight performance and reduces the drag. The movement of the rotor produces the torque and leads to the generation of moments, by using two rotors each on aircraft wings will cancel out the effect. The successful model of tilt rotor aircraft was developed by Bell in 1955. The latest tilt-rotor aircraft is XV-15

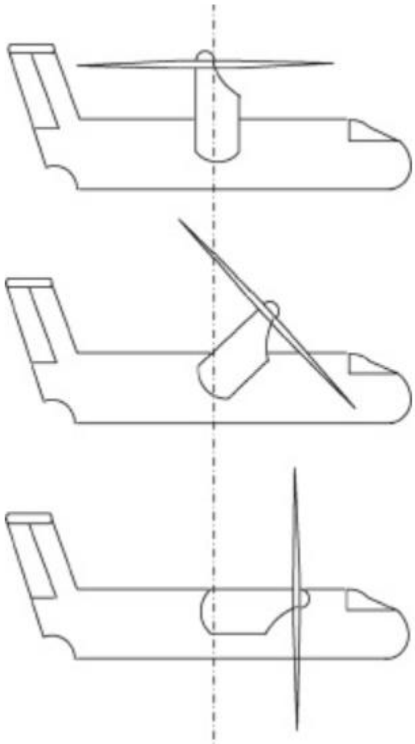

Fig 1: pictorial representation of three modes of flight.

Literature Review:

The rotor wing needs to be tilted during the transition mode of the aircraft. The transition is occurred from helicopter to forward movement of airplane. There exists the relation between the angles of tilt with the airspeed. If the tilt angle of rotor is high with the airspeed value low then there occurs the reduction in the altitude. This leads to crashes.

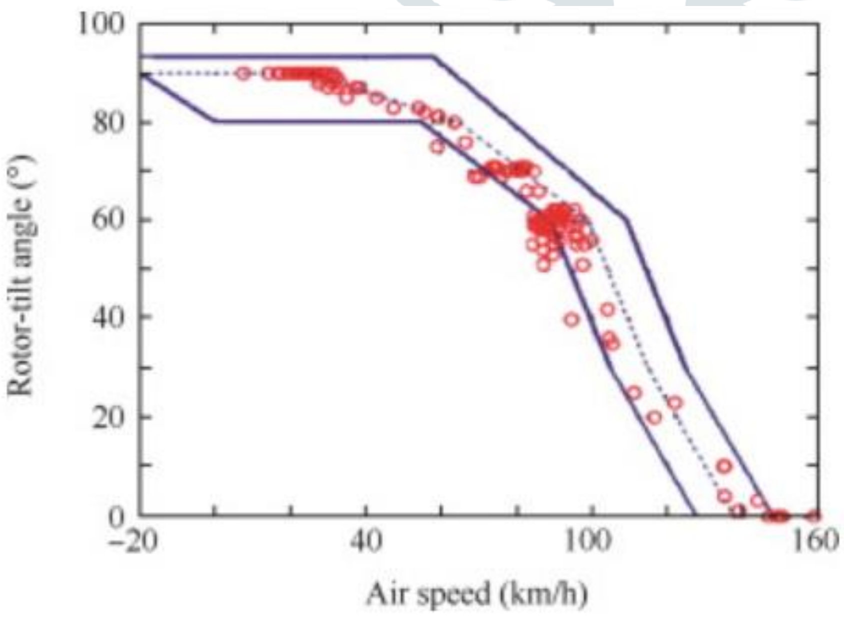

Fig 2: Rotor-tilt angle versus Airspeed

The hollow circles represents the range of angle of rotor tilt with the airspeed.

There is a positive speed stability in some cases of flight mode where as there is a negative speed stability in the flight mode gets converted from helicopter mode to the airplane mode.

Comparison of hovering performance:

Due to the rotor present on the wing, half portion of the wing is tilted whereas the other half is rigid. In general it is believed that the thrust and weight of aircraft is same but for a helicopter the power required need to be more due to the downwash by the fuselage.

In this design the power required is further more than the helicopter due to the presence of long wings along with fuselage. This effect can be minimized by applying a tilt of the wing.

Vehicle Configuration	Power Required in Hover
No Tiltwing	2245 kW
Half Tiltwing	1546 kW
Full Tiltwing	1165 kW

Table1: Power required in hover for variable configurations of tilt wing.

By using a numerical differentiation method, the dynamic stability of the tilt rotor aircraft is observed. The outcome of this technique is that there exists an effect by the flight speed and the tilt wing angle.

Relation of collective pitch and flight speed

An experiment has been done in order to test the XV-15 tilt-rotor model by using a nonlinear flight dynamics mathematical modelling method. In this study it also gives the relation of collective pitch with the aircraft speed. In forward motion of the aircraft, the flow through rotors is axial and collective pitch is more than compared with the helicopter mode. The graph between collective pitch and flight speed is a nearly straight line. In case of airplane mode, the for a pitch altitude, for the increase in flight speed, angle of attack has to be low.Downwash which is created by the rotor reduces the actual wing angle. Distribution of pressure over the wing at different tilt angles of rotor at different free stream velocities is illustrated in fig 3.

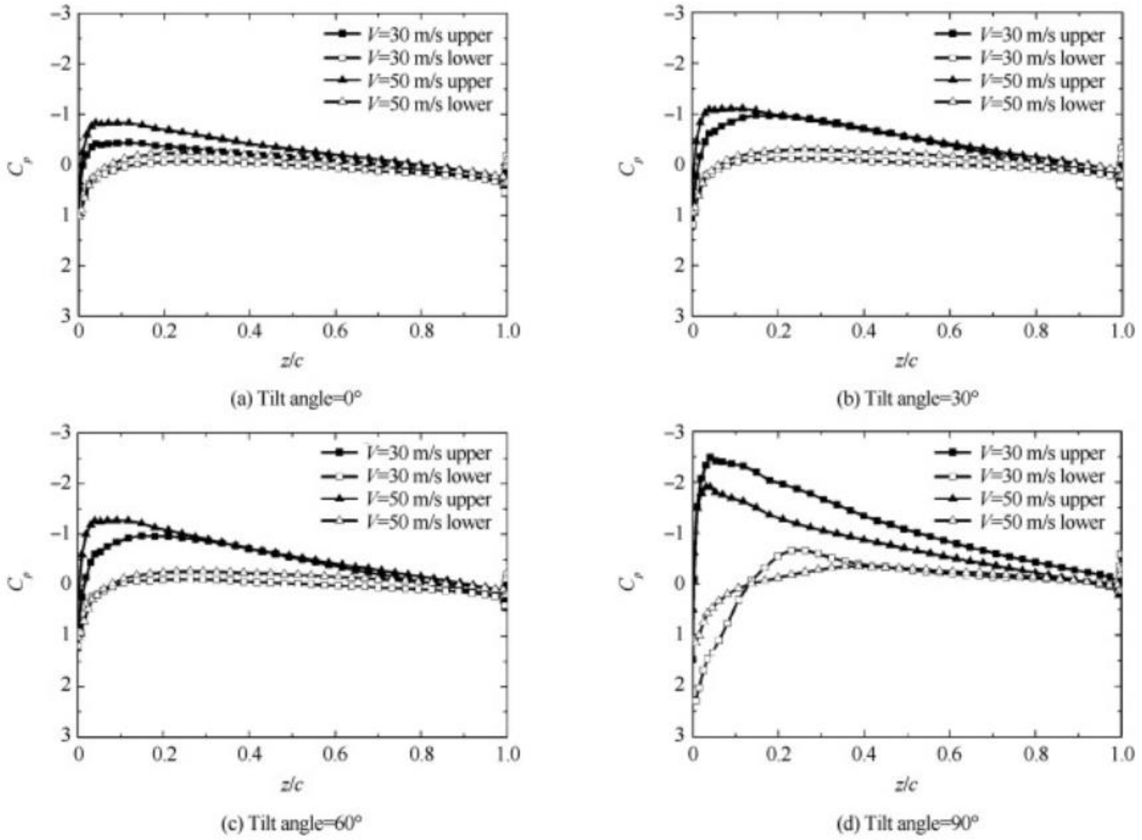

Fig 3: coefficient of pressure with the free stream velocity at different rotor tilt angles.

At a particular rotor tilt angle, the positive pressure at the bottom of the wing and negative pressure at the top of the wing surface gets decreases with the increase in free stream velocity. The change is more on upper surface which in turn responsible for lift generation. But this not the case when the rotor is perpendicular to free stream. The lift would decrease in this case.

Conclusion:

This design provides the elimination of runways and the precise use of airport space for landing and take-off of an airplane. It has the ability of vertical take-off and landing and at attain the higher cruise speed. This design also helps in engine failure condition where the rotors are used to land the aircraft. Though it has complex manufacturing design it ensures the safety during flight.

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