Delta Wings

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Delta wings are a specific shape of wings, which are recognisable by their characteristic triangle or delta shape. The initial concept was developed in 1867 and they are now primarily used by many supersonic aircrafts (Pevitt & Alam 2014, p. 156). Their notable features include having low aspect ratios, being highly tapered and highly swept (Zheng, Ahmed & Zhang 2014, p. 32).

Delta wings can be separated into two categories, slender and non-slender wings. Non-slender wing have a sweep angle of roughly less than 55°; and slender wings have a sweep angle of more than 55° (Gursul, Gordnier & Visbal 2005, p. 516). Additionally, within these two categories there are many different variations of the delta wings, including the lambda delta and cropped delta wing (Pevitt & Alam 2014, p. 156). Further variations can be seen below (Fig.1).

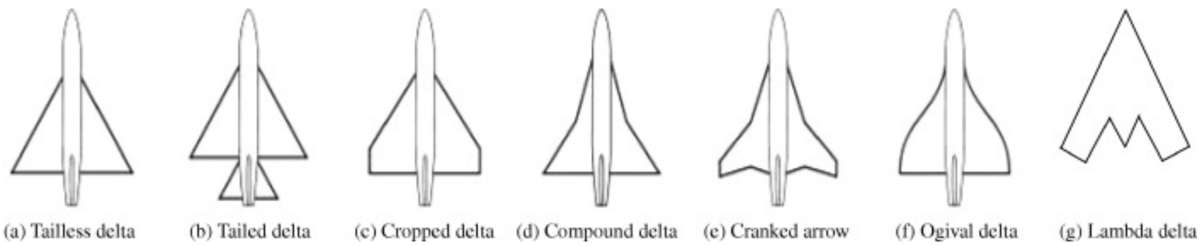

Figure 1: Delta Wing configurations (Pevitt & Alam 2014, p. 157)

Traditionally, delta wings have been used for aircraft travelling at subsonic, transonic or supersonic speeds (Zheng, Ahmed & Zhang 2014, p. 32). The swept shape of the delta wing allows it to minimise the effect of the shock wave generated by the nose of the aircraft at supersonic speeds (Zheng, Ahmed & Zhang 2014, p. 32). This is due to the wings leading edge being behind the shock wave cone. This enables the plane to travel at increased speeds, which would be more difficult to achieve with conventional shaped wings. Additionally, at high angles of attack the delta wings have vortex dominated flows (Gursul, Gordnier & Visbal 2005, p. 516). The resulting additional lift allows the aircraft to have a very high stall angle.

However, the delta wing shape does have its disadvantages. At low angles of attack**,** it has very poor lift generation compared to more conventional wings (Zheng, Ahmed & Zhang 2014, p. 31). Additionally, delta wings have a large amount of induced drag, due to its shape and large surface area. This causes it to have poor aerodynamic efficiency and a higher fuel burn. This becomes an issue when traveling at subsonic speeds, for example during take off and landing (Zheng, Ahmed & Zhang 2014, p. 33). Delta winged planes are currently attempting to resolve this issue by taking off and landing at high speeds or by using high angles of attack (Zheng, Ahmed & Zhang 2014, p. 33). These approaches, however, have safety issues for the aircraft and aircrafts following it and require longer runways in order to reach a higher speed.

With recent advances in technology, there has been an amplified demand for Unmanned Combat Aerial Vehicles (UCAVs) (Pevitt & Alam 2014, p. 155) . These UCAVs are required to be highly flexible and be able to perform extreme manoeuvres at high speeds (Gursul, Gordnier & Visbal 2005, p. 516). The lambda delta wing (Fig. 2), with rounded and sharp leading edge geometry was designed especially for UAVs, as they are able to fulfil the necessary requirements (Pevitt & Alam 2014, p. 156).

Figure 2 : Examples of UCAVs with Lambda Delta Wings (Gursul, Gordnier & Visbal 2005, p. 517)

Additionally, there has been an growing desire for increasing the speed and manoeuvrability of aircrafts (Pevitt & Alam 2014, p. 156). As already outlined, the advantages of delta wings include the ability to travel at high speeds, increased manoeuvrability and a high stall angle. However, the disadvantages still need to be fully addressed before it becomes a commercially feasible option.

Areas of research include: finding a new approach to improve the lift generation of delta wings at low speeds and angles of attack (Zheng, Ahmed & Zhang 2014, p. 31); finding a reliable method to predict with confidence the static flow characteristics in combat aircraft development (Pevitt & Alam 2014, p. 155); furthering the understanding of flows over non-slender delta wings (Gursul, Gordnier & Visbal 2005, p. 515).

As discussed, poor lift generation results in a large fuel burn due to the increase in speed needed during take-off and landing. With growing environmental concerns and the need for cost effect energy efficient products, there has been a need to re-examine the fuel burn needed for delta wings at subsonic speeds and low angles of attack. Flow modification and control can be used to improve the situation. However, this is met with certain complications, as the flow is more complex than for conventional wings (Zheng, Ahmed & Zhang 2014, p. 33). One proposed solution is to include upward deflected flaps which in turn increase the lift for low angles of attack resulting in less fuel burn (Zheng, Ahmed & Zhang 2014, p. 48).

Furthermore, many UAVs with lambda delta wings have stability and control issues. Using CFD modelling and the TAU computational model it is possible to get a more accurate prediction of the unsteady air flows (Pevitt & Alam 2014, p. 163). The knowledge gained from research into flow behaviours of high swept delta wings should enable the design of better flight control systems (Pevitt & Alam 2014, p. 156).

Finally, there has been extensive studies on flow over slender wings, in order to improve the design of delta wings. However, additional research is still needed in order to fully understand vortical flow over non-slender low swept wings (Gursul, Gordnier & Visbal 2005, p. 544).

In conclusion, the unique characteristics of delta wings enable them to perform well at supersonic speeds. With the prevalent use of UCAVs, interest in delta wings has increased in recent years. As a result, research has been undertaken in order to address its perceived drawbacks. Knowledge gained from the research undertaken is hoped to improve the design of delta wings to allow them to be more commercially viable.

Bibliography

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