Channel Wing airplane

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1 Introduction

Vertical take off and landing (VTOL) or short take off and landing airplanes (STOL) have been and are still a great challenge for engineers. Helicopters can land everywhere but they are slow and expensive to operate. Some VTOL aircrafts combine the advantages of airplanes and helicopters. But most of these hybrids between helicopters and airplanes bring also the drawbacks of the 2 technology in term of maintenance, performances or range. A possible short take off and landing configuration is called the Channel Wing. Developed in the 40s' by Willard Custer, the advantages of this powered lift concept have still a great potential for future airplane designs.

2 The concept

The channel wing in its original configuration consists of a pusher configuration with the propeller located at the trailing edge of the wing as shown in the figure 1.

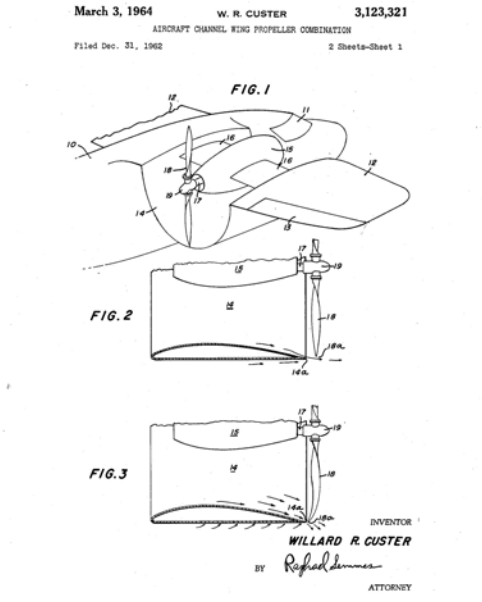
March 3, 1964 W. R. CUSTER 3,123,321
AIRCRAFT CHANNEL WING PROPELLER COMBINATION
Filed Dec. 31, 1962 2 Sheets-Sheet 1
FIG. 1
FIG. 2
FIG. 3
INVENTOR
WILLARD R. CUSTER
BY
ATTORNEY

Fig. 1 . From Willard Custer's patent: US3123321 A, published on: 3 mars 1964 [1]

The Wing is made in a half cylindrical shape in order to have the propeller tip very close to the wing trailing edge. This configuration is shown in the figure1 extracted from Willard Custer's patent.

When the propeller rotates, a relative airflow is generated at the upper surface of the airfoil in the channel. That permits to generate lift even if the airplane airspeed is 0. An other phenomena is added, the Coanda effect. It is the tendency for a flow to stay attached to a convex surface. Just after the propeller, a large downstream is generated. This added lift can only be achieved with a propeller. That's why the channel wing implies a propeller driven airplane configuration.

3 Performances

This wing configuration increases tremendously the lift created by the wing and the lift coefficient is around 5 while for a classic airplane it can reach only around 2. The major advantage of this technology is the possibility for taking off very shortly and with an low speed. In fact, the most advance airplane Willard Custer made is the Custer CCW-5. It was based on the Baumann B-290 Brigadier, a four seat twin engine pusher propeller airplane. It can take off and land in a very short distance at 20mph according to Custer. If the plane were immobilized, it might take off vertically if the engines are enough powerful. Moreover, thanks to the high lift on the wings, the plane can carry out important payload more than an equivalent classic airplane. This performances are desired by the Air force to shuffle payload in hostile areas where they do not have large runway and where they are only dirt track. This kind of performance are useful for humanitarian mission in some place in the world for the same reasons. Besides, we can see in the figure 2 that the lift coefficient increases when the attack angle increases too. That means that more the airplane is climbing more the lift works. So the airplane is able to stay in the air at a very high angle of attack of more than 20 degrees. In fact, it can reach around 60 degrees without stalling. That is useful for a short take off and if a plane has to climb fast to reach an altitude.

4 Limits

The limits that this wing geometry are firstly about the drag. There is a high lift so in the same time the drag is important, that induces that the max speed of the plane is low. In the same time to reach a high speed, the engine have to turn fast and so the lift induced by the propellers is higher that makes climbing the plane. Moreover, the airflow created is important and directly oriented in the horizontal tail that creates a huge pitch moment.

The second important limit of the technology is about engine failure. In fact, if one engine knows a failure, the lift created by it will be null. So, the lift distribution over the wings will be unbalanced. Usually to deal with this kind of problem, just by increasing the engine power the plane can reach a airport to land but in our case, the pilot has to reduce the power of it to reduce the asymmetry that can be jeopardizing to reach a airfield.

5 Concept improvements and future designs

The original concept of channel wing can be improved in many ways. The original drawbacks, mainly a high drag in cruise mode can be minimized using different solutions. One of them is the control of the propeller position. The best position depends on the flight configuration and the channel best performance is not with the propeller at the trailing edge according to *Pneumatic channel wing powered-lift advanced super STOL aircraft* from[2]. In this publication, many tests have been conducted showing the real potential of the channel wing to create high lift coefficient. An example is shown in the figure2 from the same document.

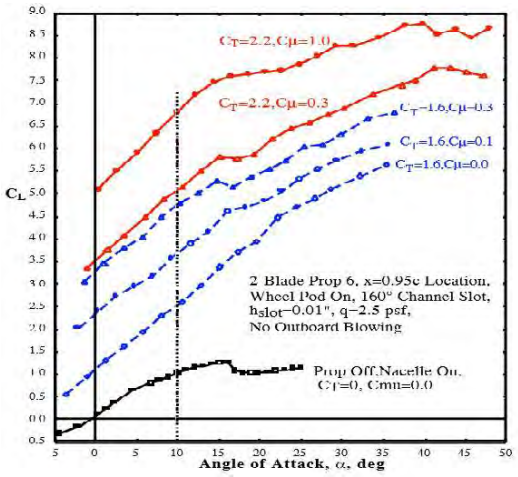

Fig. 2 . Lift coefficient achieved during the tests conducted in the publication [2] We can clearly see the impact when the propeller is on (CT = thrust coeff of the prop)

6 Conclusions

The Channel wing is a compromise as many aircraft technical solutions. Contrarily to other unusual STOL planes, as the XC-142 which goal was to create more lift by turning the plane propeller into a kind of helicopter rotor, there are no special moving parts for the channel Wing. It just adds a half-cylinder shape which can be a bit more complex to build. Anyway, it still ensues less maintenance than for a helicopter rotor. Very good super STOL performances can be achieved but with an increase of drag at high speed. A transportation cargo aircraft needs to have a high payload and so a high lift, speed is less important. Military cargo applications are offering good perspectives too with the need to land on short unprepared runways. Here is a view of a potential transportation airplane that was the object of the publication [2].

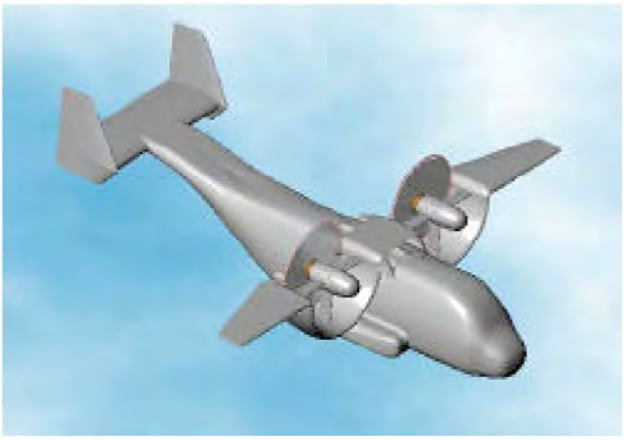

Fig. 3 . From publication [2] "Conceptual Pneumatic Channel Wing Super STOL Transport Configuration"

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REFERENCES

[1] Willard R Custer. *Aircraft channel wing propeller combination , patent US 3123321 A*. 1964.

[2] Robert JEnglar ; Bryan ACampbell. *Pneumatic channel wing powered-lift advanced super STOL aircraft*. 2002.