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Abstract

In this paper, we determined that the Lady Penelope's car, named FAB 1 from the Thunderbirds 2004 film, has a weight of 32000 N (including passengers). With a takeoff lift of 32700 N, and an attack angle of around 17°, the car could indeed fly, when ignoring drag. However, at a constant altitude with a 0° attack angle, along with a lower air density, FAB 1 had a lift of only 6340 N, resulting in the car being unable to keep a steady altitude.

Introduction

In the live action Thunderbirds film (2004), Lady Penelope (a family friend) picks up the protagonists from school in her FAB 1 to take home. However, their home is an island, so the car on the road sprouts a large jet engine, wings and takes flight [1]. This paper investigates the possibility of the car being able to take off whilst ignoring drag.

Method

The FAB 1 is a six-wheeled, highly modified, pink Rolls-Royce driven by the chauffeur Parker. The car has a mass of 3000 kg and a top land speed of 134 ms^{-1} [2]. With four passengers, one small adult male (70 kg), two male teenagers (combined mass of 130 kg) and Lady Penelope (cannot possibly ask a lady's mass), the combined mass of the car including passengers is approximately 3260 kg. There are 4 fundamental forces when considering an aeroplane; lift, drag, weight and thrust. Although drag is an important factor, to facilitate the paper, it has been ignored. For an aeroplane to take off, the lift has to be greater than its weight. This means that lift needs to be in excess of 32000 N (taking acceleration due to gravity as 9.81 ms^{-2}).

To find lift, we use Equation 1, which is stated as follows [3]:

$$L = Cl\frac{\rho v^2}{2}A \tag{1}$$

Where Cl is the lift coefficient, ρ is the density of air, v is the velocity of the aircraft and A is the wing area.

The two teenagers are at an undisclosed boarding school in America. So taking the average sea level in America to be roughly 750 m [4], the air density is approximately 0.91 kgm^{-3} at take off altitude [5]. The car has a length of 6.40 m [2], so when analysing the film clip we can scale the car's length and thus determine the wing dimensions. We have found a scale of 1 cm : 0.244 m and therefore, modelling the wings as trapeziums, the total wing area to be approximately 2.50 m^2.

The last variable to determine is the lift coefficient. It is dimensionless and a number used to model the object's shape, inclination and some flow conditions [3]. It is usually measured in a

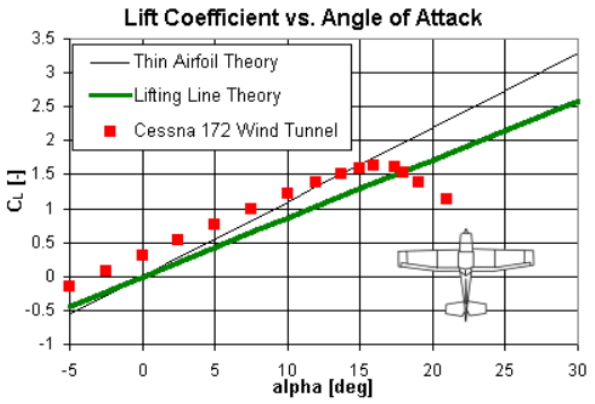

Figure 1: Shows how the lift coefficient varies with the angle of attack [6]

wind tunnel during the testing of the airfoil design. We have modelled the FAB 1 after Cessna's 172 aerodynamics due to having the same seat capacity and similar size. With reference to Figure 1, the Cessna 172 wind tunnel line cuts off past 20° as at that angle, the plane will start stalling. Parker is an excellent pilot therefore he would be able to lift off at the critical angle of attack - the difference between where a wing is pointing and where it is going (usually around 17°) [7]. At this angle, the maximum coefficient of lift will be 1.60. With a lift coefficient, we can determine the lift using Equation 1 to be 32700 N. This is when FAB first takes off (0.91 kgm^{-3} air density) at maximum speed (134 ms^{-1}) and assuming it is able to take off with the critical attack angle, corresponding to a lift coefficient of 1.60. However, the density of air will start to drop as altitude increases. Small planes typically fly between 600 - 3000 m [8]. By keeping all other variables constant, we calculate the minimum density of air to be 0.89 kgm^{-3}, which corresponds to a height of roughly 3000 m above sea level which coincides with the approximate small plane altitude. However, Parker cannot keep this angle of attack as it will exceed the minimum air density needed to keep flying. Therefore, the FAB 1 will have to eventually stay at a constant altitude and attack angle will be 0°, meaning a lift coefficient of 0.30 (Figure 1). We can assume Parker stops his angle of attack at 2000 m, with the density of air at approximately 0.94 kgm^{-3} [5]. This would result in a lift of only 6340 N, meaning FAB 1 will not be able to sustain this constant altitude. To be able to stay at this altitude, the wings would need to be 12.60 m^2. Over 5 times FAB's current wing area.

Conclusion

We have found that even though FAB 1 is able to take off, Parker would not be able to keep a constant altitude, which is far from ideal. One important force, drag, has been ignored. Cars are clearly not built for aerodynamic flight and the drag would most likely cause the 3 tonne car to stay on the ground. So at FAB's current wing area and velocity, it is very unlikely that Lady Penelope would be flying to Tracy island.

References

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