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A1_8 Chitty Bang Bang

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Abstract

The film *Chitty Chitty Bang Bang* tells the story of a man and his incredible car. One of the things his car was capable of is the ability to fly. This paper investigates the feasibility of such a vehicle based on the film specifications. In reality the car as it is seen in the film would not be able to fly but by increasing the wing area from $10m^2$ to $56.99m^2$ the car would be able to take-off within its normal performance parameters.

Introduction

Chitty Chitty Bang Bang is a 1968 British Musical based on a novel by Ian Fleming. Set in the 1910s the story follows a race car that crashes and then is subsequently bought and rebuilt by an eccentric inventor [1]. One of the design improvements is the way in which he builds the car with the ability to fly as if it was a normal aircraft. To investigate whether this vehicle would actually be capable of flying, certain assumptions need to be made. This paper is going to focus on the wing size and speed of take-off of the car. Therefore other issues with the design can be neglected, such as complex features of the cars aerodynamics relating to the shape of the car and wings. Furthermore, we will assume the wings of the car are aerofoils with an *m* value of *m=1.1*. *m* being the ratio between the speed of the air passing below and above the wing. We are going to investigate whether the car can take off with a wing size similar to that seen in the film and what speed that would require. Secondly, we will then see if the car can take off with a suitable top speed for the vehicle and what wing size that would require.

The film car was based on a series of cars christened "Chitty Bang Bang"[2] and built by Count Louis Zborowski. Chitty 1 (being the first of these cars) is considered to be the most similar vehicle to the film car and so we will be taking some of the specifications from it. Chitty 1, as a two seated sports car was able to reach a top speed of 120mph (53.64m/s)[2]. The weight of the car used in the production was 2 tonnes[3] so we shall assume a total take-off weight of 2150kg. This takes into account two adult passengers presuming the two children to be seen also flying in the car to add a negligible amount to the weight and considering the example car (Chitty 1) only had two seats[2]. Although the wings in the film aren't the correct shape for an aerofoil, we will assume they act like one. The wing Area can be approximated to be $6.71m^2$ from viewing the film. The wings come out as two triangles with one edge covering about half the cars length (2.59m). Therefore, taking the area of the square with a side length of 2.59m gives $6.71m^2$, plus some of the other parts of wing protruding from other areas gives an approximated total area of $10m^2$.

Theory

Starting with Bernoulli's equation and manipulating to find the velocity needed for an aircraft to take-off. Firstly, Bernoulli's equation,

$$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2. \quad (1)$$

Rearrange, considering that, $y_1 = y_2$ and that $\Delta P = P_1 - P_2$.

$$\Delta P = \frac{1}{2}\rho v_2^2 - \frac{1}{2}\rho v_1^2. \tag{2}$$

The ratio between the speed flowing below and above the aerofoil wing of the aircraft is

$$m = \frac{v_2}{v_1} \ or \ v_2 = mv_1. \tag{3}$$

Therefore substituting for v_2 in Equation (2) and rearranging whilst considering $\Delta P = \frac{Mg}{A}$,

$$v = \sqrt{\frac{2Mg}{(m^2-1)\rho A}}. \tag{4}$$

Where, throughout, v_1 is the speed of the air flowing across the lower surface of the wing, v_2 is the speed of air across the upper surface of the wing and m is a constant for a particular aerofoil. $P_1$is the pressure below the wing, $P_2$is the pressure above the wing and ΔP is the difference between the two. ρ is the density of the air (1.225kg/m^3) and g is the acceleration due to gravity (9.81m/s^2). y_1 and y_2 are height components and can be considered to be equal, therefore cancel each other out in Equation (2). When "$F = Mg$," and hence when "$\Delta P = \frac{Mg}{A}$," , the limit of the minimum force required for a takeoff is reached and the equations subbed into Equation (3) to make (4). F is force experienced on the wings and A is the area of the wings. M is the mass of the aircraft and g is the same as stated previously. The assumption is made that the car travels at $v = v_1$.

Discussion

First we will think about the speed needed for the car to take-off, using Equation (4). M = 2150kg, g=9.81 m/s^2, m=1.1, ρ = 1.225kg/m^3 and A can be assumed to be 10m^2. Plugging in these values gives the speed it would need to be travelling for a successful take-off to be v = 128m/s (286.32mph). This is an impossible speed for the car in question to be travelling, as of this year the fastest road car in production is the Bugatti Veyron sport, only capable of 268mph. Soon we may have a road car able to take-off with these specifications but as of now it is impossible for Chitty Chitty Bang Bang to fly. Now we will consider Chitty Bang Bang's actual top speed and the wing area needed for the car to take off at that speed. By rearranging Equation (4) for A we get

$$A = \frac{2Mg}{V^2(m^2-1)\rho}. \tag{5}$$

Now plugging in the known values, M = 2150kg, g=9.81 m/s^2, m=1.1, ρ = 1.225kg/m^3 and V=53.64m/s. We get a value for total area, A = 56.99m^2. This seems to be a reasonable area for the cars wings to have, with each wing being around 28.5m^2.

Conclusion

In conclusion, it would be impossible for the current specifications of Chitty Chitty Bang Bang to fly with a wing size of around 10m^2 due to the large take-off speed this would require. However by increasing the Area by a factor of around 5 to about 56.99m^2 the car would be able to take-off at the actual top speed that it can perform at.

References

[1] http://uk.imdb.com/title/tt0062803/- accessed 12/11/12.

[2]http://www.brooklands.org.uk/index.php?option=com_content&view=article&id=96:zborowski-and-the-chitty-bang-bangs&catid=52:cars&Itemid=50 - accessed 12/11/12.

[3] http://chittygen11.com/about_chitty.htm - accessed 12/11/12.

[4] http://www.guinnessworldrecords.com/records-1/fastest-production-car/ - accessed 12/11/12.