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P4_13 Hover Cars

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Abstract

Two methods of making cars hover are investigated. It is found that a wheel based propeller system, while allowed by the simple theory, would be practically impossible, and that a wheel based electromagnet coupled with a metal road seems a far more viable method.

Introduction

This paper aims to investigate two methods of levitating a car off the ground by applying a downwards force to counteract the effect of gravity. The two methods will be propellers and electromagnets, both employed via the wheels of the car. Both the methods we will look at work with the wheels rotated 90° under the car and we will assume that there exists a mechanism to do this in order to swap between driving and hovering. The car we will be using throughout these discussions is the second generation Ford Focus which has a mass of 1248kg [1] or 1528kg with four 70kg passengers, and for the wheels we have a total radius of 0.31m and a tyre thickness of 0.12m [2].

Propellers

We will first investigate whether it is possible to raise a car off the ground using turbines. We will outfit each wheel with propellers in place of the hub caps and angle them down to provide lift. We can model each
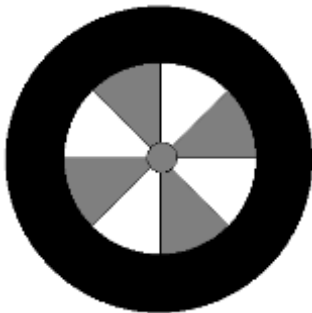

Figure 1. The grey segments are the aerofoil blades and the black rim is the tyre (not to scale).

of the propeller blades as a separate wing and work out the force using [3]

$$F = \tfrac{1}{2}\rho v^2 A(N^2 - 1), \qquad (1)$$

where v is the velocity of the blades through the air, ρ is the density of air, 1.29kg·m^{-3} [4a], A is the surface area of the blade and N is the ratio of path lengths over and under the blade. To work out the area we will model the hub of the wheel as being divided into 8 sections, 4 of which will be propeller blades, as shown in Fig. 1. If we equate the force produced from each of the 4 blades on the 4 wheels to the downwards force due to the mass of the car we can solve for N

$$N = \sqrt{\frac{Mg}{16\tfrac{1}{2}\rho v^2\left(\tfrac{1}{2}\pi r_r^2\right)} + 1}. \qquad (2)$$

where M is the mass of the car and passengers and r_r is radius of the wheel rims. In order to calculate v we assume the wheels are rotating at 23.2 revolutions per second (equivalent to a ground speed of 100mph), which for the tyre specifications outlined in the introduction gives a rotational period of 0.043 seconds. If we divided the maximum circumference by this value we will get a maximum speed for the blades of 27.8 m·s^{-1}. Putting all these values into Eqn. 2 we find that the path length over the blades has to be roughly 5.8 times longer than underneath.

Electromagnets

The second method we will investigate is using electromagnets to overcome the gravitational force on the car. Again we will assume the wheels are folded underneath the car only this time instead of propellers in place of the hub caps we will use 2mm radius

copper wire wound around the hub caps inside the tyre to generate a magnetic field that can be used to lift the car off a metal surface, which in this model will be a 10cm thick sheet of iron. We will approximate the force, *F*, between the electromagnet in the wheel and an iron road as the force between two magnetic moments, m_1 and m_2, which is given by [5]

$$F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{R^2}, \qquad (3)$$

where *R* is the distance between them and μ_0 is the permeability of free space. To calculate the magnetic moment of the road we will calculate the number of atoms in a wheel sized volume and multiply by the magnetic moment of an iron atom. For an atom, the magnetic moment can be calculated using [6]

$$|m| = \left[\frac{3}{2} + \frac{S(S+1)-L(L+1)}{2J(J+1)}\right]\frac{Je\hbar}{2m_e} \qquad (4)$$

where, *S*, *L* and *J* are the spin, orbital and total angular momenta of the atom and *e* and m_e are the charge and mass of the electron. For iron *J*=4, *S*=2 and *L*=2 [6].For the current loops inside the wheels the magnetic moment can be found using [4b]

$$m = NIA, \qquad (5)$$

where *N* is the number of turns of the loop, *I* is the current through the loop and *A* is the area enclosed by the loop. We can estimate how many turns would fit into the tyre by dividing the cross sectional area of the tyre by the area of the wire giving N~1862. This is a crude estimate and one that in practise may not be feasible whilst retaining the necessary properties of the tyre. Combining Eqns. 3, 4 and 5 and equating to the force on the car due to gravity we get

$$Mg = 4\frac{\mu_0}{4\pi}\frac{(NIA)}{R^2}\left(\left[\frac{3}{2} + \frac{S(S+1)-L(L+1)}{2J(J+1)}\right]\frac{Je\hbar Z}{2m_e}\right), \quad (6)$$

where *Z* is the number of atoms which we will estimate as the number of atoms directly under the wheel i.e. in a volume of $\pi r_w^2 d$ where r_w is the radius of the wheel and *d* is the thickness of the iron sheet. Using the density of iron, 7874kg·m^{-3} [7], we can work out that this volume would contain 2.55×10^{27} atoms. Solving Eqn. 6 for *I* gives 3086.4A. Using the resistivity of copper, 1.7×10^{-8}Ω·m [8], and the dimensions of the wire (the length was estimated by taking an average circumference of the tyre, 1.57m, and multiplying by the number of turns) we can work out the total resistance which comes out at 10.6Ω. From this we can use *V=IR* to work out what voltage would be required for each tyre which turns out to be 3.3×10^4 V.

Conclusion

As shown, using wheel based propellers to lift a car off the ground is completely unfeasible. The path length over the propeller blades required to generate lift is so extreme that they would cease to function as blades. Using electromagnets seems a far more viable solution however the simplifications made in this model, relating to the interaction between the magnetic fields and omission of any paramagnetic effects induced in the iron, would need to be refined and experimentally verified before any solid conclusions can be drawn.

References
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