Phys 381 Final project

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Abstract

In this Paper I synthesize the data of two papers using physics in in Python to code a program that would derive the Drag Coefficient from any Wind Tunnel data or Speed Vs Drag Force Graph Data points. This derivation in conjuction with another Python program that will model the theoretical Maximum Velocity of Motorcycle, in this case a Yamaha YZF-R1.

1 Introduction

In the world of automotive industry, vehicle performance is at the core of all their efforts. An important factor in the performance of a vehicle is their Maximum Velocity, which is largely determined by two factors that can be changed through engineering design. These factors being the Drag Coefficient (C_d) and the power produced by the engine.

The Drag Coefficient is a unit less number representing the effects of an object when a fluid, such as air, pushes past it. This effect creates an air resistance (F_d,) which is a force that acts in the opposite direction to the velocity, represented by the equation[2]:

$$F_D = \frac{\rho C_d A v^2}{2} \tag{1}$$

We can use this equation to determine the Drag Coefficient from Wind tunnel Data or Speed Vs Drag Force Graphs.

This is crucial to determine the Maximum Velocity (Top Speed) of a Vehicle as we know that the maximum velocity is achieved when the drag force is equal to the force produced by the engine power as modeled by the equation[2]:

$$P = \frac{\rho C_d A v^3}{2} \tag{2}$$

Using the drag coefficient from experimental data (such as a wind tunnel test or a speed vs. drag force graph), We can accurately predict the Top speed of the vehicle. This can provide valuable insight as to what can be changed to the design to optimize the vehicle speed or compare the performance of different vehicles. Thus, allowing designers to achieve the desired design goal by building from science.

2 Method

I was unable to locate any data files containing wind tunnel data for motorcycles, but the physics can be applied to any Speed Vs Drag Force graph. I was able to use an experiment on bicycles[1] as theoretical practice. The graph is shown below:

Using the shapes as data points, I was able to recreate the graph (Fig.1) within python. This allowed me to derive my own calculation for each bike's Drag Coefficient (C_d). I modified the Drag equation 1 to calculate the Drag Coefficient:

$$C_d = \frac{2F_d}{\rho A v^2}$$

. Using this formula I was able Create a Model that would calculate the Drag Coefficient from any Data that contained the Drag Force and the velocity of the air causing the drag force using the Curve fit function of Scipy.Optimize. Once

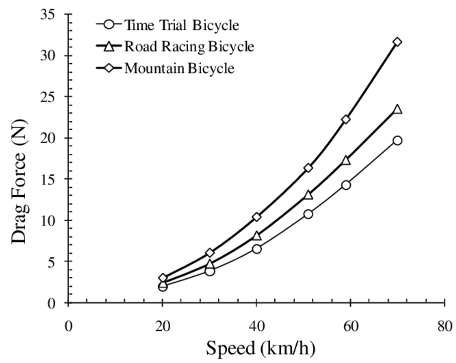

Figure 1: Drag force variation with speed for three different types bicycles [1]

I had my model and was able to calculate Drag Coefficient for each bike, I was able to generate a line of fit for each bike using the mathematical Model. This created a way to visually asses the accuracy of the Drag Coefficient, as well as a way to estimate the expected Drag Force for any given Speed. Then following the same method, I created a model in Python to using Equation 2. This model allowed me to use Data from a different paper [3] , and use their parameters to determine the Top Speed for a Yamaha YZF-R1 motorcycle with a Drag Coefficient of .5. I then created a graph using this model and Drag Coefficient for a range of Engine power of 5 to 200 HP.

3 Results

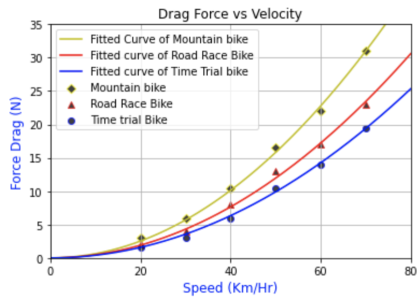

Figure 2: Linear fit of Drag Force using Data

Above we have the Bike data[1] along with our estimated line of fit using the Python program created. It is clearly visible that the model is sufficiently accurate.

The table contains all the calculated Drag Coefficients as well as the calculated

Bike Type	Drag Coefficient (C_d)	Calculated error
Mountain Bike	0.5738	$\pm$ 0.0073
Road Race Bike	0.4338	$\pm$ 0.0074
Time Trial Bike	0.3591	$\pm$ 0.0055

Table 1: Calculated C_d and error

error for each type of Bicycle in our data [1]. We can see just how much variation in Drag Coefficient is possible even in something as small as a bicycle.

The graph (Fig.3) shows that the increase in power yields diminishing returns

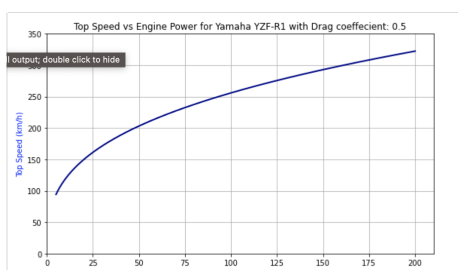

Figure 3: Top Speed of Yahama R1 for different Engine Powers

in the increase of Velocity, so at a certain power threshold it may be better to improve the aerodynamics of the machine than the power output.

4 Conclusion

In the End I was able to synthesize the data available with physics into a code in Python that would enable me to derive the Drag Coefficient from any Wind Tunnel data or Graph Data points. This allowed me to create my own Model to determine the Theoretical Top Speed for a motorcycle using a derived Drag Coefficient. Effectively creating a Program that can derive the Drag Coefficient from any dataset and calculate the theoretical Maximum Velocity of that exact Vehicle.

References

[1] Harun Chowdhury, Firoz Alam, and Iftekhar Khan. An experimental study of bicycle aerodynamics. *International Journal of Mechanical and Materials Engineering*, 6:269–274, 08 2011.

[2] Raghuveer Parthasarathy. Cars and kinetic energy — some simple physics with real-world relevance. *The Physics Teacher*, 50(7):395–397, 10 2012.

[3] Braulio Pimenta, Luís Moreira, Adriano Rosa, and Roberto Miserda. Aerodynamic influence over leading and pursuing motorcycles equipped with downforce-generation wings, 11 2024.