

The Effect of Nozzle Size on the Static Force Produced by an Air-powered Rocket Car

Sayyid Abdullah

Freeport High School, Freeport, NY USA

Abstract. Compressurized air used as a power source for a zero emission car. In this experiment, various nozzle sizes were tested to find the optimum diameter that produced the most force. The stream of air from an electric air pump was directed onto a gram scale. The nozzle size was changed and the force was measured from each nozzle. There was an optimum nozzle size of 3.5 mm. For future experiments actually testing the pressurized cars I constructed a ramp. Using this ramp I will be able to measure the static force produced by the car. The ramp was used to measure the weight of a model car at different angles.

Keywords: mechanics, physics, engineering, air pressure.

INTRODUCTION

Can compressed air be used as a power source for a zero emission car? The car and the tank that the air is compressed in will be lightweight in order to be movable. The nozzle size will be adjustable by the operator of the car for the desired acceleration. For water jets, Johnson [3] found that the force increases with the nozzle diameter squared. I believe that I will get the same results for this experiment using air. Exploring different nozzle sizes will help me determine which one produces the most force.

METHODS

In the first set of experiments, a ramp was constructed using wood and a small weighted car, approximately 5 cm in length. The ramp's angle was changeable. By using a spring scale the car's mass was measured at different angles (0 degrees was horizontal) (as seen in Figure 3). For the second set of experiments. An air pump (GE Motors & Industrial Systems Mod 5KH33DN16JX) was used as a source of air. The air flow from the pump was directed from its nozzle perpendicular to a gram scale (Sargent-Welch Mod WLS 2648-10). Various nozzle sizes were used and the change in the air flow's pressure was measured (as seen in figure 4). The distance from the nozzle tip to the gram scale was fixed at about 2 centimeters.

Static Calibration Test

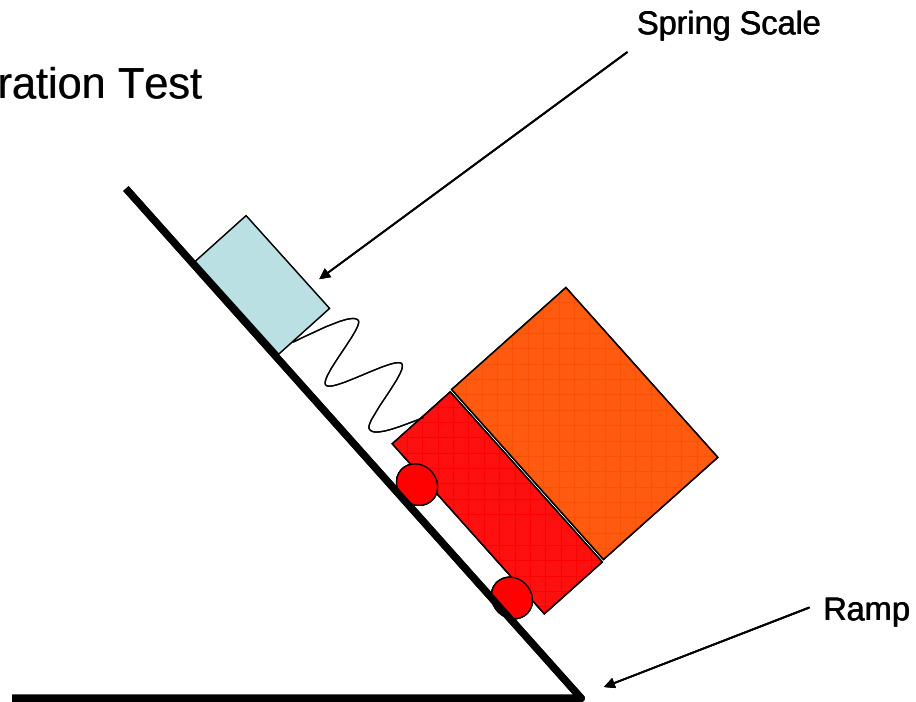


FIGURE 1. The spring scale was placed on the ramp. Next, the car was placed on the ramp and its weight at the angle it was measured. The ramp's angle was changeable. The car was measured at various angles. This shows that there is a direct relationship between the car's weight and the angle it was measured at.

Optimum Nozzle Size

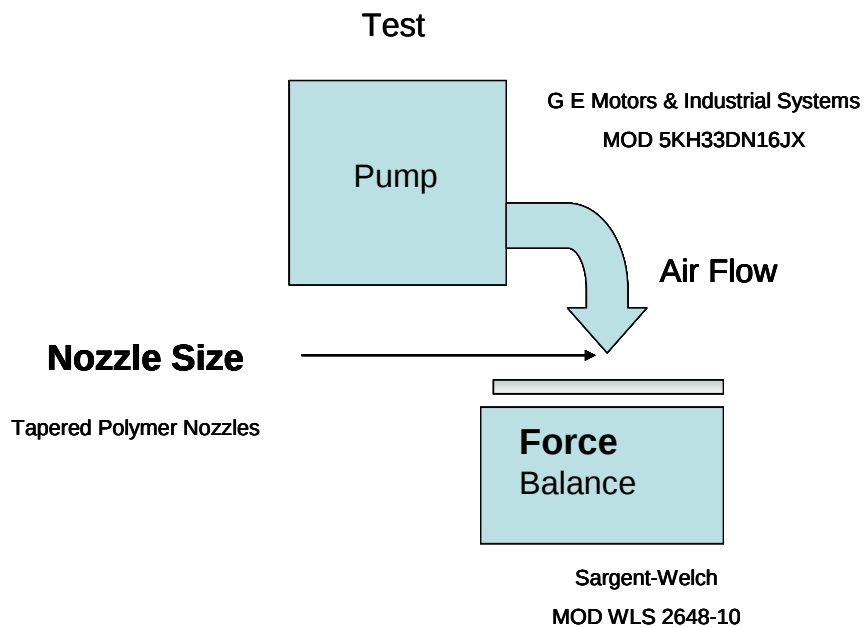


FIGURE 2. This is an apparatus for determining the optimum nozzle size. Nozzles of various sizes were attached to an outlet hose on an electric air pump. The air flow was directed onto a force balance. I recorded the most constant number on the force balance. Then I changed the nozzle size and repeated this process.

RESULTS

Figure 4 shows a sine curve ($F = w \sin \theta - \mu \cos \theta$) for the car on ramp weight measurements. The lighter gray line shows the curve without any friction. The black line shows the sine curve with some friction. The points without a line connecting them are the data points I got when I weighed the car at different angles. Figure 3 shows the force of the air exerted vs. the nozzle diameter. This graph shows that there is an optimum nozzle size of 3.5 mm.

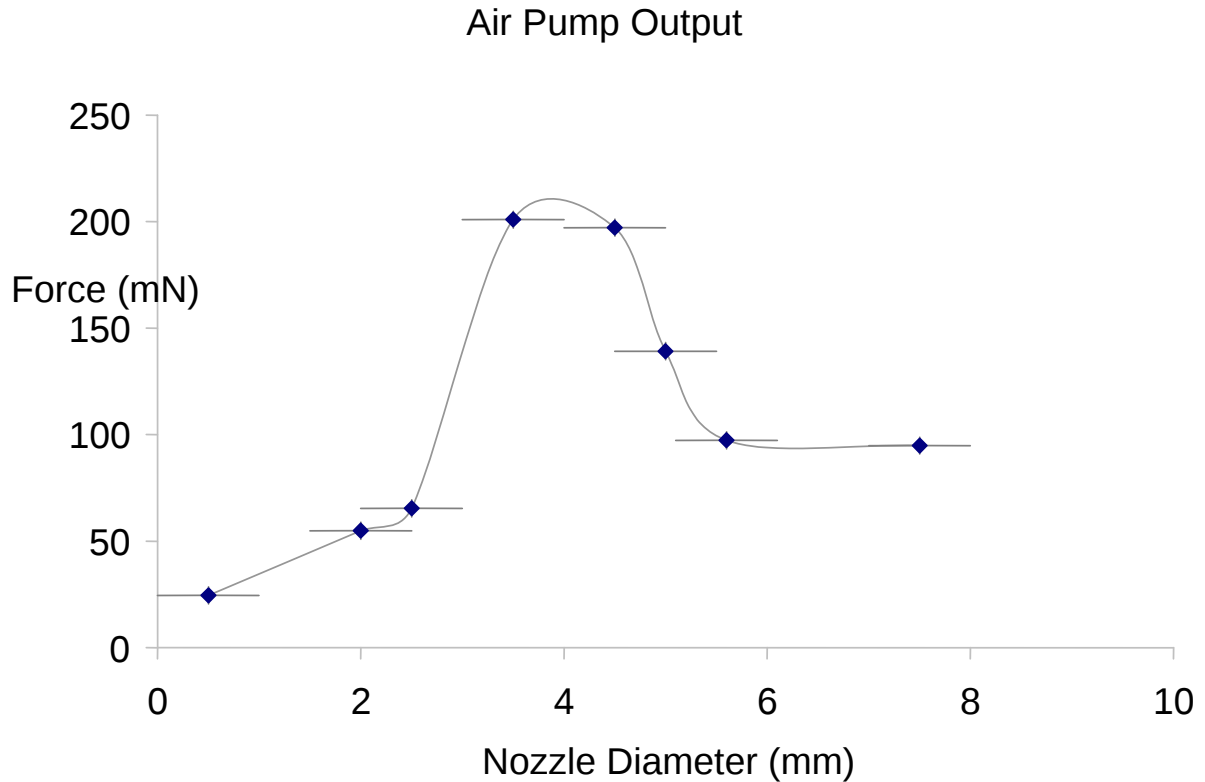


Figure 3. The y-axis is the force of the air exerted from the air pump (G E Motors & Industrial Systems MOD 5KH33DN16JX) and the x-axis is the restricted nozzle size. I restricted the nozzle size by using nozzles ranging from 0.5 mm to 5.6 mm. Then the air flow was directed from the nozzle onto a gram scale (Sargent-Welch Mod WLS 2648-10).

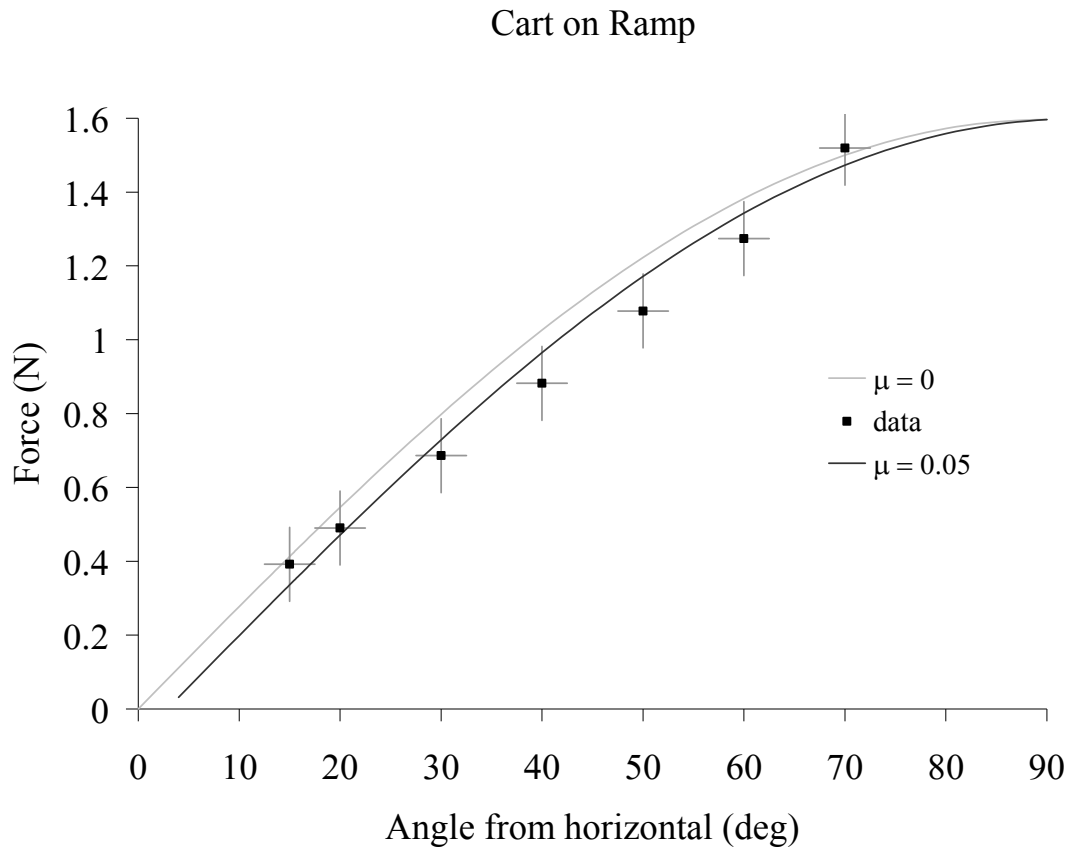


Figure 4. The y-axis the equation $F = W \sin(\theta) - \mu W \cos(\theta)$ ($\mu = 0.005$) best fit the graph. W is the weight of the car at different angles. μ is the coefficient of friction.

DISCUSSION

There is an optimum nozzle size for cars powered by air pumps. I predicted that the largest nozzle size would exert the most force. The optimum nozzle size was half the unrestricted nozzle. If a model size car was constructed its static forced can be tested on the ramp.

CONCLUSION

There is a direct relationship between the weight of the car and the angle of the ramp at which the measurement. The ramp can be used to measure motive force. There is an optimum nozzle size for cars powered by air pumps.

ACKNOWLEDGMENTS

The author of this project gratefully acknowledge the contribution of Dr. Robert Muratore for guiding me through this project and providing the necessary equipment for this project, Mr. Kyle Dawson for helping me with my experiment by assisting me set up for my tests, and Ms. Sandhu for some of the equipment used in this project like the ring stand.

REFERENCES

1. Conceptual Physics Fifth Edition Hewitt P.G pages 206-211 Published by Little Brown and Company in Boston Toronto

2. <http://eprints.nwisrl.ars.usda.gov/659/1/905.pdf> 4/29/09 SPRAYDROP KINETIC ENERGY FROM IRRIGATION SPRINKLERS Author: D. C. Kincaid Transactions of the ASAE VOL. 39(3):847-853 1996 American Society of Agricultural Engineers pg.847-853
3. Johnson, M.W., 'Water Powered Rockets - Propelling Students to Greater Height', EE2006, Liverpool, July 2006 <http://www.liv.ac.uk/~em22/papers/EE2006.pdf>