Loyola Marymount University
Due Date: 1A 09/19, 1B 10/03
Fall 2024

MECH 598/698 – Thermal Fluid Design
Project #1(A & B)

Project 1 Specifications

A bottle water rocket (a partially filled water bottle with pressurized air) is an excellent example of a thermodynamic system that can be effectively designed and analyzed using thermodynamic laws.

In this type of rocket, a percentage of the volume is initially filled with water at room temperature. The air inside the bottle is then pressurized. At time=0, the bottle cap is opened, allowing the air/water to be ejected and thus thrusting the bottle.

Part A- Analysis

A1. Set your design specifications and assumptions, e.g., bottle size (diameters and length), initial T and P conditions, initial volumes of air and water, etc.

A2. Consider a frame of reference on the rocket (to avoid having different velocities for the rocket and for the ejected water/air), use the 1st law and the conservation of mass for appropriate control volume(s) and the ideal gas equations, combine and reduce your equations, and derive a differential equation for the instantaneous volume of the compressed air (in terms of time and air volume as the only two variables and other given/known parameters).

A3. Solve your derived eq. in part A1 numerically using MATLAB or any other professional programming.

A4. Determine how long it takes for the water to eject completely.

A5. Use your solution and plot the following with respect to time from the moment the valve is opened (t=0) till all the water is ejected (t= answer to part A4)

1. Air volume
2. The relative exit velocity of the water
3. The inside pressure of the bottle

A6. Determine the final mass and temperature of the air inside the bottle (when the thrust generation period is over) and discuss the temperature. *Hint: think about what will happen once all water is ejected*

A7. Approximately determine the altitude this bottle rocket could reach.

A8. Explain whether you think you are under or over-estimating the performance of your bottle rocket based on this analysis.

A9. Explain how you would incorporate any possible heat transfer and the drag force into your 1st law and how they would affect your final equation, e.g., what variables they will be a function of, or if variable(s) will be added to the analysis which would require additional equation to close the solution. You do not need to solve this part.

Part B- Experimental design

1. Design a test stand to test a bottle rocket safely. PVC pipes, wood, and other supplies will be provided. Load cells will be available to measure the thrust force. Some funding will be available to purchase other supplies if needed.

Report- Part A:

Your written report should include:

- Cover sheet
- A list of all your specifications and assumptions with justification, you need to refer to your assumptions during your analysis.
- Clear and complete analysis (all steps and all equations) based on conservation of mass and energy laws with schematics of CVs and names of your variables, answers to parts (A2) to (A7) with plots, and discussion of the results. You may scan your clean, neat, legible handwritten analysis.
- Your numerical code in an appendix with comments for names of the variables and units.

Report- Part B:

- Cover sheet
- Schematics or drawings and pictures of the design test stand.
- The plot of measured Thrust force vs time.
- Comparison of the experimental and the analytical data.

Submit your reports (each as a single pdf) + your code file for part A (e.g., .m file) to Brightspace.