Rolling Containers Lab

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Summer 2017

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Steps:

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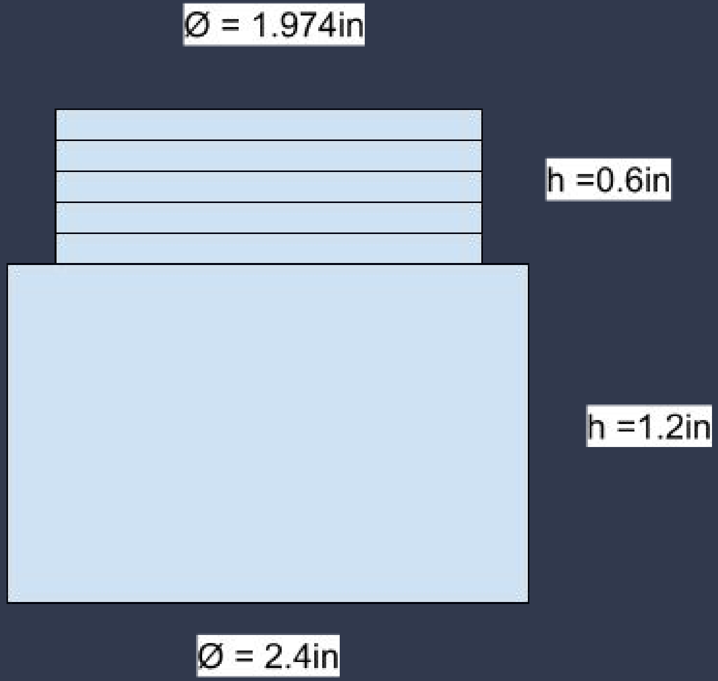
- Design a base model container and cap with thread design
- Design a second container with equal exterior dimensions but with an alternate interior setup
- Solve for volume and density proportions to achieve an equal weight for both containers
- Conduct trials
- Conclude with results

The Process and Basic Considerations

Firstly, a base prototype of a container had to be designed using AutoCAD. While designing the container, considerations towards the wall thickness, printing material, and time were used to design the model. After designing a basic shape, the model was fine tuned in respect to wall thickness, structural integrity while printing, and threads.

Base Model

The resulting model is as shown. From here, the interior volume can be defined using Inventor’s iProperties tool. This interior volume resulted as 7.625 in.^3. Next, the weight of the water for the above volume was solved for, which yielded 119.05 grams (not including the weight of the container itself).



Container Properties and Considerations

Besides the mass of the water, the weight of the container had to be determined. Within the 3D printing software I used, Cura, I was able to open up the previous file which contained the same customized settings I used to print the container and the cap. This sum turned out to be 46 grams, a value which later would be considered. Next is the process of determining the amount of honey required to satisfy the weight of the water. Due to the density of water at room temperature being 1.00 g/cm^3, and honey being 1.42 g/cm^3, the second container would have to compensate for this difference. The second container retained similar exterior features as the original, however, the interior contained a chamber which would reduce the accessible volume for the honey. Determining at what point this chamber was to be placed included the bulk of the calculations.

Determining Mass of Honey

I started the process by working from 119.052 grams, the mass I wanted to achieve with a certain volume. By using an online convertor, I was able to find that 119.052 grams of honey with the density of 1.42 g/cm^3 would take up 0.5116 in^3 of volume.

Now, the new volume must be compared with the proportions of the original container. The total volume of the container, as previously stated, is 7.265in^3, however, the container's volume may be split into two sections. The first section is the volume of the portion just inside the threads of the container. This section containers a diameter of 1.974 inches, with a height of 0.6 inches.

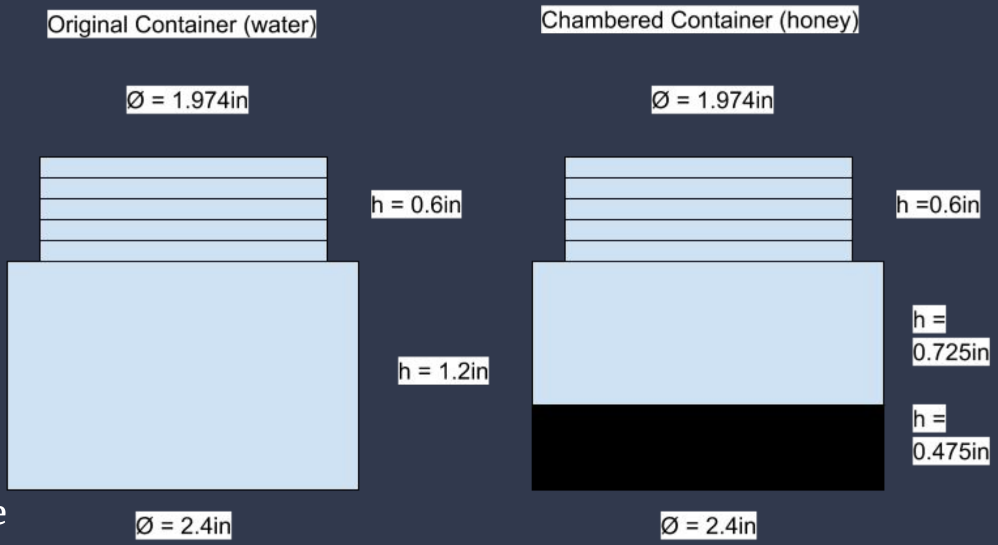
Using V=r2h, the volume can be solved as 1.836 in^3. And subtracting this from the total volume, 7.265in^3, we get 5.429in^3 for the volume of the second section, the larger part of the container.

Final Container Models

Now, if the total accessible volume of the new container is to be considered as 5.116in^3, and the the first portion (v1) is to remain constant at 1.836in^3, then the second portion, (the portion to be chambered), would be the only portion which would change. By subtracting the total volume from the volume of the first portion, the resulting volume is 3.28 in^3.

With this figure, we can solve for the height at which this volume would be achieved with the radius of the original container.
V=r2h > 3.28=(1.22)h > h=0.725in

Now by subtracting this value from the original height of 1.2in, a value of 0.475in^3 can be deemed as necessary amount of height in the second section to be chambered off.



Trial 1: Honey and Water No.1

Trial 2: Honey and Water No.2

Trial & Conclusion

A wooden plank with an even surface was used to act as the platform the containers would roll down. The container with the honey was labeled with a yellow piece of tape. Both containers were manually held at the top of the ramp and released simultaneously. All trials were shot in slow motion, which although had lower resolution, were shot at 120FPS to allow for better viewing.

For both trials, both containers started from the same height relative to the ground, which means both had the same potential energy to begin with. The potential energy is split into two forms of kinetic energy: rotational and translational. The honey container reached the bottom of the ramp in trials one and two most likely due to the viscosity of the honey. This property of honey would have had more of an effect than the water when considering rotational kinetic energy. Due to the rotational kinetic energy being higher for the honey container, the translational energy and therefore the linear speed of the container will be less in order to conserve total energy.

A small amount of the energy of the honey container could also in a sense been have been lost. This could be due to any miniscule movement of the honey within the container that could have resulted in the loss of energy in due to heat, also something that would be caused by viscosity.