

## Orange Crusher Evaluation

### PART 1: LAB EVALUATION ACTIVITY

#### Test the orange crusher:

- 1) Name of orange crusher you are using: Jerry
- 2) Observe the orange crusher design, and how it is similar/different from the representation in CAD. Provide any notes on design decisions that were made between the CAD model and the prototype you are looking at. Observe the fastener choices, extra parts (not-modelled or not shown in your models).

The orange crusher closely resembles the CAD model, with additional fasteners and small components added to ensure proper alignment. For instance, spring is wrapped around the highest axis (Point A) to keep the ABD arm centered.

The crush cap sliding on the backbone is connected to the backbone with a bearing to ensure smoother sliding.

Most 3d printed parts are connected together by screws, while the hollow cylindrical metal rails are connected with wires inside.

- 3) Measure the linkages and rods assembled on the orange crusher. Using the excel spreadsheet, what is the predicted output force for a 5kg applied force? For the 20lb maximum force specified in the design optimization assignment?

a = 3in

b = 3.5in

d= 4.5in

Theta = 103 degrees

h= 5in - 0.75in = 4.25in

H= 6.4in

Input = 5kg, Output = 53.59lb

Input = 20lb, Output = 97.25lb

4) Move the orange crusher through the full range of motion. List any usability concerns that you have based on this. Make sure to list at least one concern related to a failure/issue that you predict you will have when you try to crush an orange.

When the handle is pressed down, the reaction force pushes the top cap where the handle was pinned upward, resulting in less crushing force.

The linkage and crush cap are not moving strictly vertically, but have some deflections horizontally due to the loose screw connection among the cap and linkages, so the net vertical crushing force might be smaller than expected.

5) Using each crushing surface A & B, apply a ~2kg vertical load (hanging from the end hole of ABD) to one of the grapes-clementine (grapes were not provided in our lab section). Make sure to support the orange crusher while load is applied, and to apply the load slowly to avoid unnecessary strain on the orange crusher. What, if anything, occurs?

Crushing surface A: holes present on crushing surface

- The orange was barely squeezed
- Orange crusher began to flip over with the applied load
- The orange was squeezed, but minimal juice was produced. None of the juice landed in the cup and the clementine appears to not be fully crushed.

Crushing surface B: holes are not present on crushing surface

- Performed better than surface A could be because of the holes on the top or the difference in size.
- Slightly more juice came out

6) Now use the handle directly to crush clementine #2 (and/or clementine #1). You may apply an appropriate load but slowly increase load and observe changes (and don't break your orange crusher!). It is recommended to take videos in case you need to review, and have the same person apply load for consistency and to note what they observe.

Crushing surface A: holes present on crushing surface

- More juice came out with greater applied force
- The peel on the orange broke

### Crushing surface B: holes are not present on crushing surface

- The clementine was significantly more crushed and more juice was produced at a high applied load
- More orange juice came out as the applied force got larger
- Some juice landed in the cup, most of it was on the bottom surface

7) Repeat #6 but with your grape half. Note that the applied loads will be greater, use appropriate caution – don't forget these are prototypes!

Grapes were not offered in our lab section, but we suspect that grape has a softer shell than clementine so it would require less load to crush than clementine.

8) Adjust the clementine, and continue pressing down on the orange half until you believe you have extracted the maximum amount of juice. You may try any procedures you think are relevant. Record what you did, and what you observed, as well as the full weight of orange juice in the cups.

- We manually applied what we estimated to be "light," "medium," and "maximum" loads using our hands.
- However, much of the orange juice missed the cup and landed on the base plate, making the weight of the juice in the cups an unreliable measurement for our procedure.

9) For the other half of your orange, consider alternate ways to crush this that may result in more juice, or may be a better crushing process. If you choose not to crush this on the 3D printed surface, do not drink your orange juice!

- Use our hand to press the orange vertically down on the crushing surface
- Rotate the orange while squeezing it down on the crushing surface
- Use our hand to squeeze the orange directly



## PART 2: EVALUATION

The merit of this orange crusher would be the simplicity and low cost to build. As most of the parts are 3D printed, any user with a 3D printer could print and construct the orange crusher within a day, compared to the orange crusher in the market that cost about \$150-300. However, since the orange crusher is constructed from 3D printed parts, the connections between parts are mostly done by screws that make the structure a bit shaky. In comparison, other orange crushers in the market that have a steel+plastic structure look much more secure.

Therefore, one of the concerns I have is about the insecurity of the structure. From my observation, when the handle is pressed down, the reaction force could actually push the top cap upward; also, the connections of the linkages are shaky because the linkage plates are too thin and vacancies appear between the plates even when screws are on.

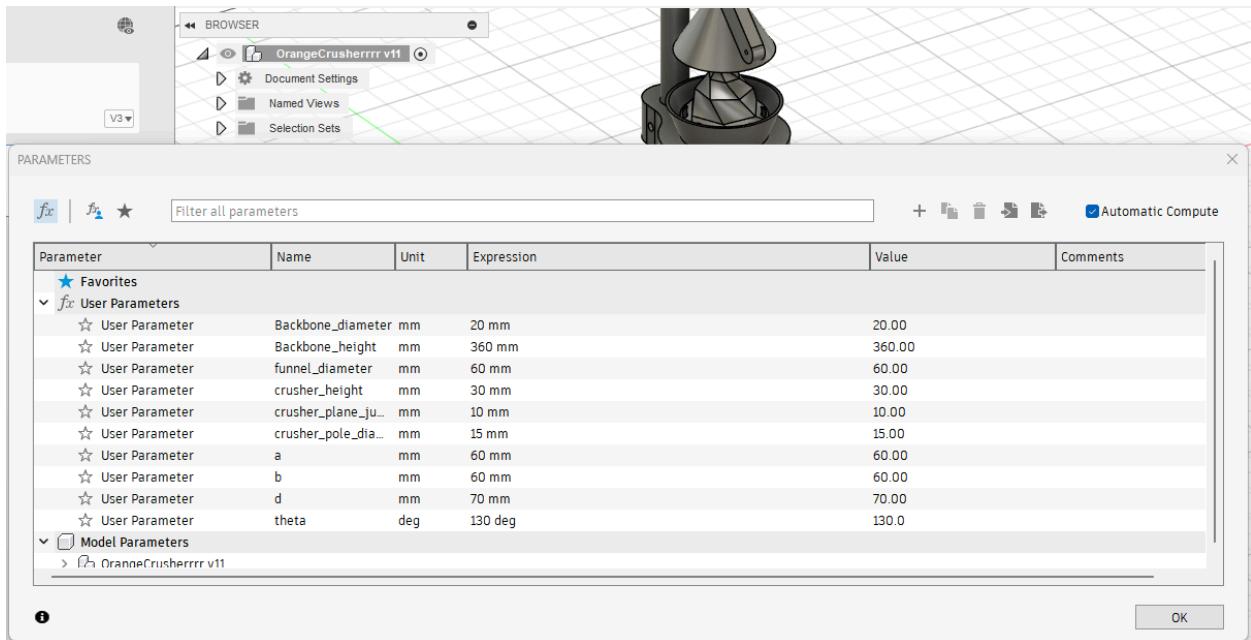
For the future students, I will recommend this project as it's a good way to practice linkages, but for them to have more sense of accomplishments by being able to squeeze out more orange juice, here's several suggestions:

- Make axial blades on the crush cap. Right now the face is just too flat with the shallow rib that could not cause much pressure.
- Make the linkage plates align better in terms of their thickness, so the assembled linkage could be less shaky.

## PART3: Design an Orange Crusher

### 1) CAD Design

#### a. Equations of Linkage: a b d theta



#### b. CAD & Assembly

Notes for grader: I chose to CAD my own orange crusher, with all the parts newly designed. The parts are all designed in one file “Raa’sOrangeCrusher” but as new components/bodies, because I consider it more convenient to keep the parameters consistent this way. The assembly is in the other file “Assembly”, with joints added to all parts.

### 2) Crush force testing

#### a. Experiment Procedures

1. Cut an orange in half to conduct two trials for more precise results.
2. Place the orange piece in a plastic bag (prevent orange juice from leaking) and put it on an electronic scale.
3. Press down on the orange with a ceramic plate until the juice comes out.
4. Film the readings on the scale while pressing downward and record the highest reading from each trial.

- Convert the weight reading to force and average them to obtain the orange crushing force that we want.

### b. Test Results and Conclusions

#### Data from Experiment:

| Trial Number | Scale reading [kg] | Force [N] |
|--------------|--------------------|-----------|
| 1            | 22.14              | 217.19    |
| 2            | 15.92              | 156.18    |

Therefore, the averaged orange crushing force would be **186.68N**

#### Confidence in setup:

The test setup is considered to be relatively simple and repeatable: the use of a plastic bag minimized juice loss, and recording the scale allowed for accurate capture of peak values. However, there are still some uncertainties that may affect the overall measured crushing force.

#### The reasons, improvements, and hypothesis:

- Flat surface v.s. Crush receiver: For the testing setup here, the orange is placed on the flat surface of the scale; while in the orange crusher, the orange will be squeezed on a raised angular hexagonal block, which in theory would increase the pressure exerted onto the orange. Therefore, I would expect the actual crushing force to be smaller on the actual orange crusher than it was here in the test.
- Pressing speed and angle: Since the orange is crushed by a plate that's controlled by human, it is very possible that the angle of the plate would not be perfectly vertical, and the speed of pressing would also not be consistent.
- Orange ripeness: the ripeness of orange may also affect the force required to crush an amount of juice out, as it is usually considered that a more mature orange would be softer and easier to squeeze out the juice.