College of Engineering
UNIVERSITY OF GEORGIA

USDA Pecan Project Updates

USDA United States Department of Agriculture

NPSA National Pecan Shellers Association

I LOVE pecans

Equipment

Precision Universal Testing Machines

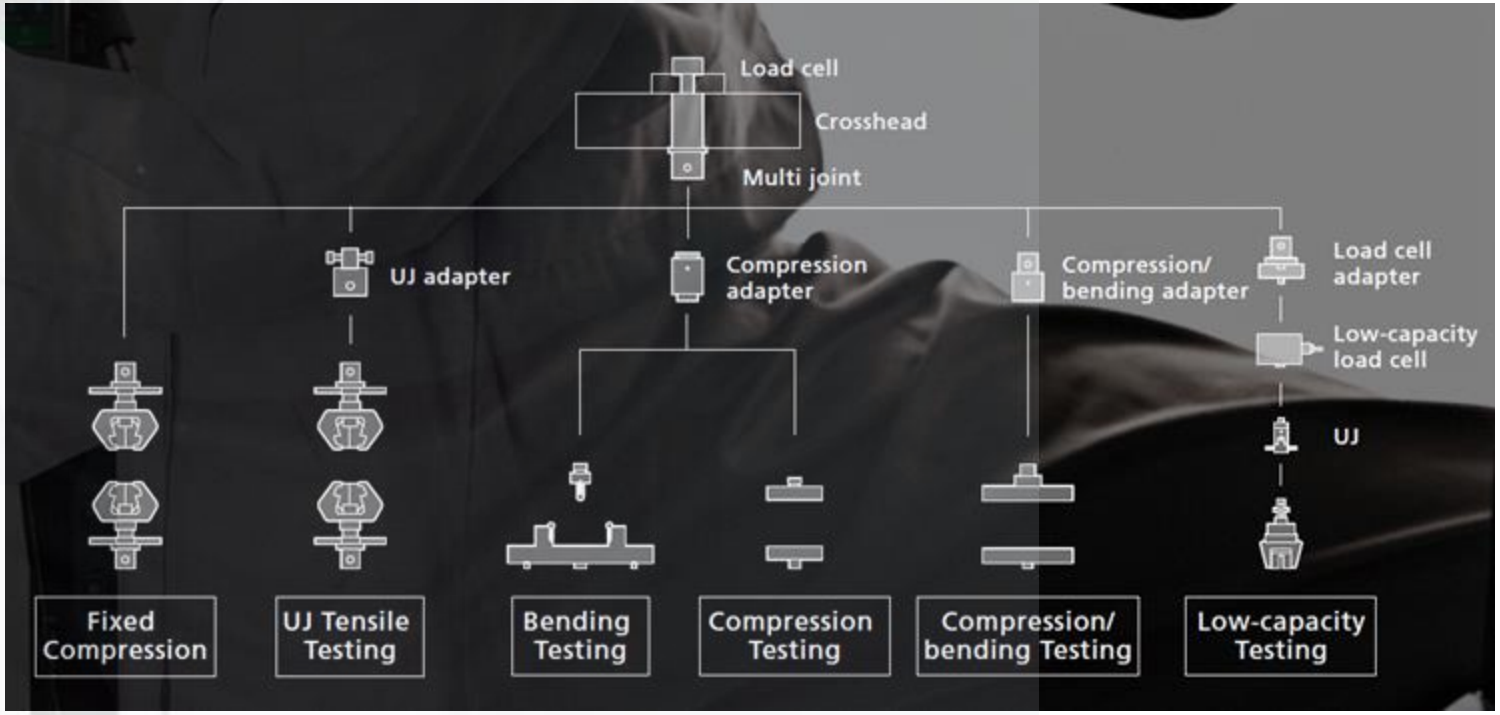
AUTOGRAPH AGX-V Series

It features a **high rigidity frame**; **multi processors**, **high-speed sampling** and **high-accuracy automatic control**; an **intelligent crosshead**; **stroke limit switches**; a high degree of safety; a smart controller equipped with a progressive user interface; and software that supports the creation of test conditions and data processing with intuitive operability.

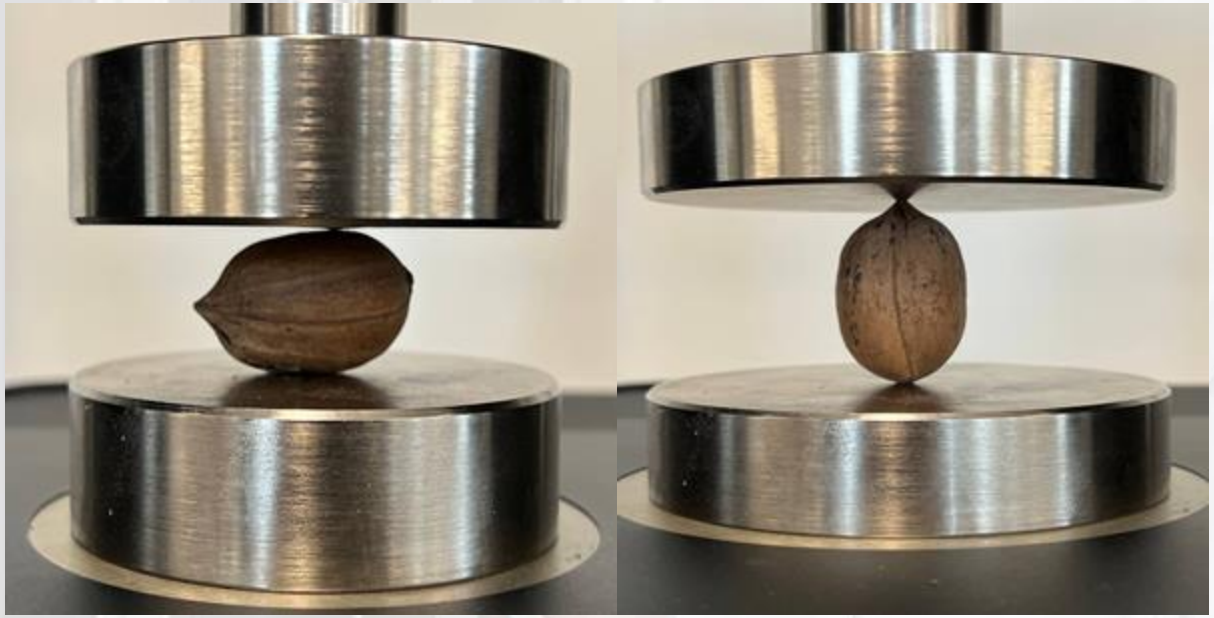
Experimental Variables

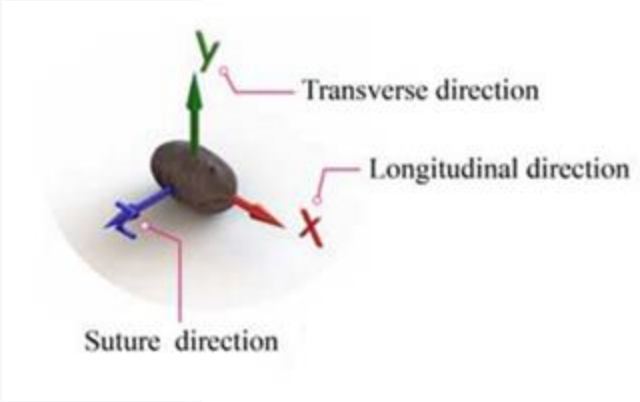
- ❑ Temperature
- ❑ Forces
- ❑ Direction
- ❑ Compression plate

The multi joint, which connects jigs to load cells, enables all jigs, including tensile, compression, and bending jigs, to be connected easily.



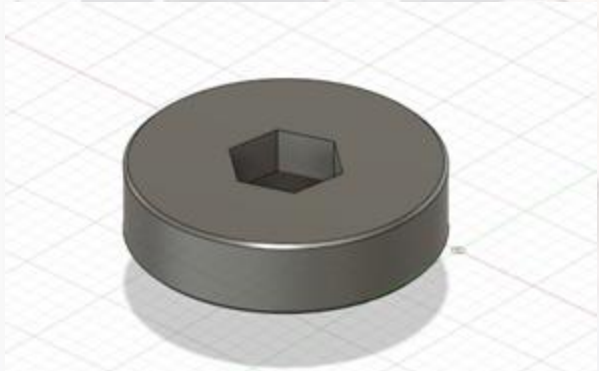
Experiments

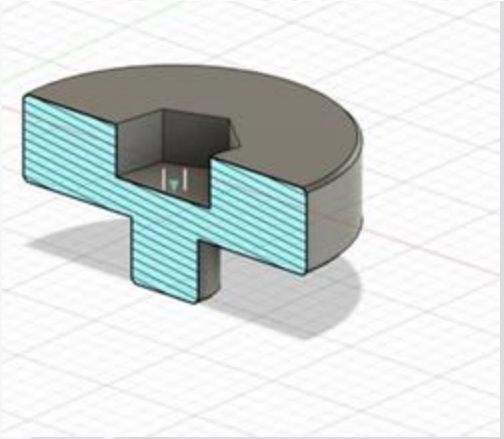


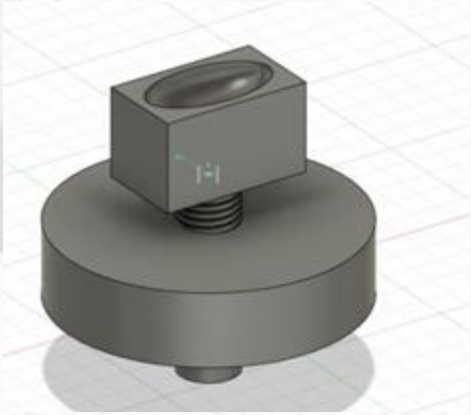


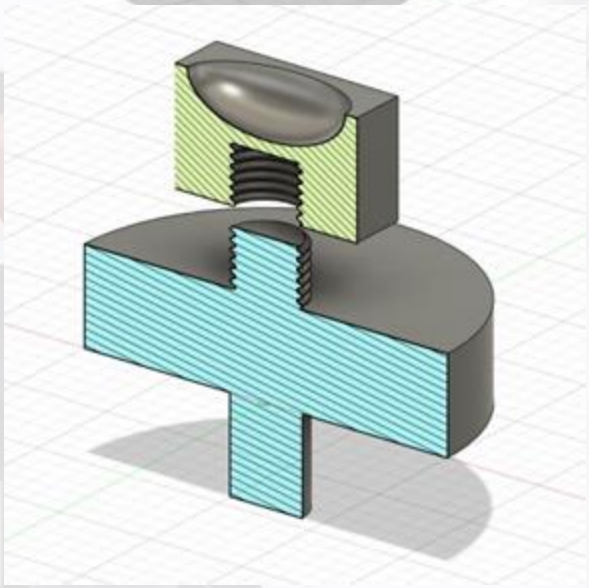
Determine some engineering properties such as geometric features, density, and friction coefficient, which might be considered as input parameters to define them in engineering simulation studies related to deformation analysis of the Pecan fruit components.

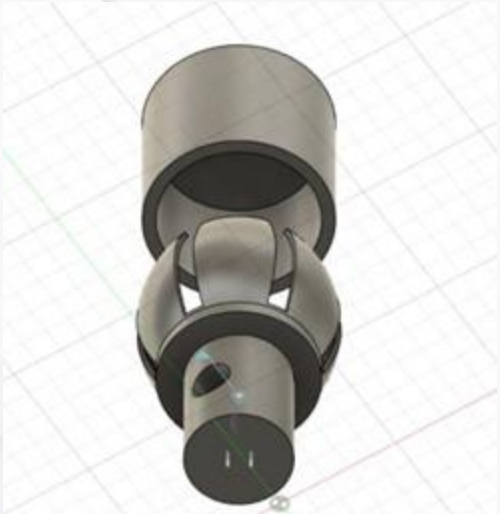
Attachment designs

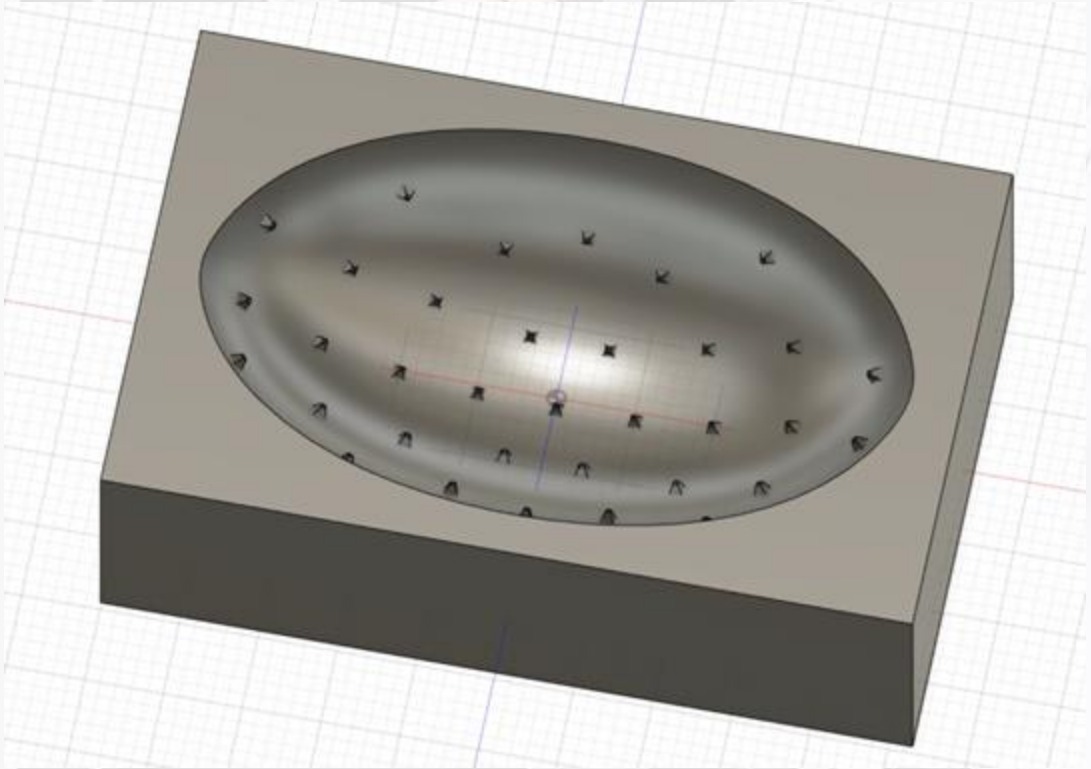


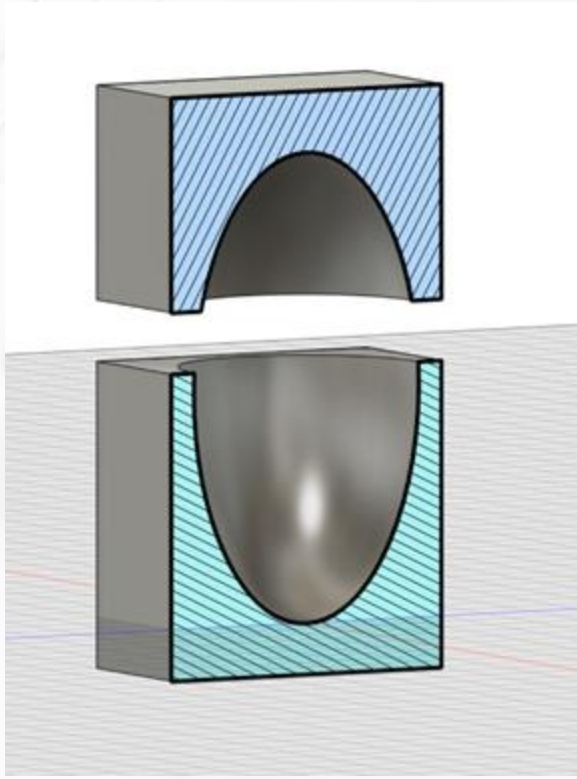










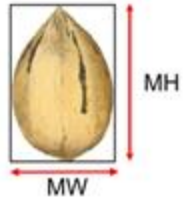


Next Steps

Crack Line measurements in order to predict the result before putting the nut into sheller

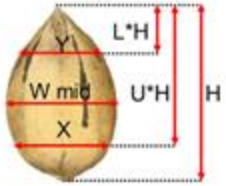
Maximum Height (**MH**)

Maximum Width (**MW**)



Fruit Shape Index External I (**FSIEI**)= $\frac{MH}{MW}$

Proximal Angle Macro (**ProAMa**)= ∠ABC
Distal Angle Macro (**DisAMa**)= ∠DEF

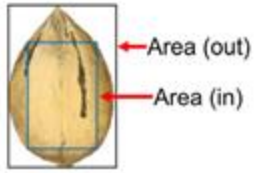


Proximal Fruit Blockiness (**PFB**)= $\frac{X}{W\ mid}$

The ratio of the width at the lower blockiness position (U) to Width Mid-height

Distal Fruit Blockiness (**DFB**) = $\frac{Y}{W\ mid}$

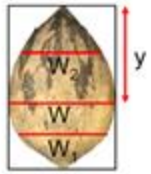
The ratio of the width at the upper blockiness position (L) to Width Mid-height



Rectangularity (**rect**) = $\frac{Area\ (in)}{Area\ (out)}$

Circularity (**cir**)

1 - (The ratio of the error resulting from a best-fit circle to the area of the fruit. Smaller values indicate that the fruit is more circular)



Ovoid (**ovo**)

$= \frac{1}{2} * scale\_ov(y) * (1 - \frac{w2}{W} + \frac{w1}{W})$

High Impact Cracker Experimental Setup

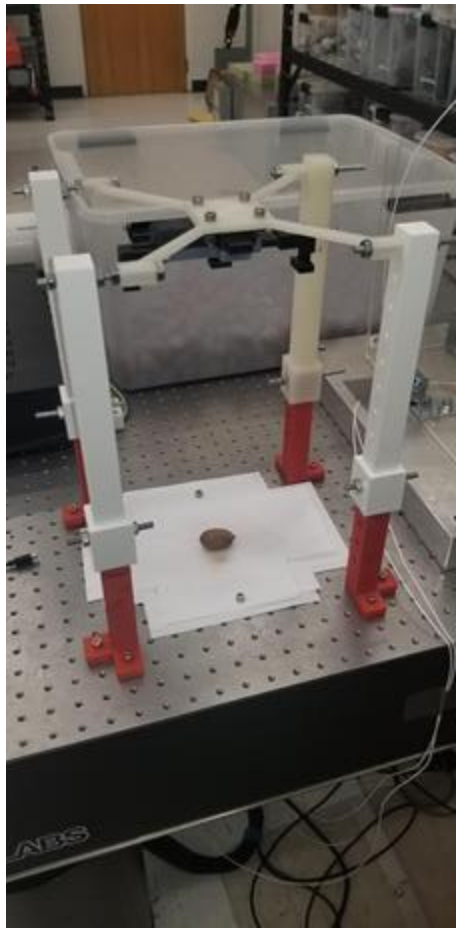
Drop Weight Rig (DWR)

- Impactor dropped to impact pecan in holder
- Drop height measured from rope which supports impactor
- Forces measured at holder base

Data Collection

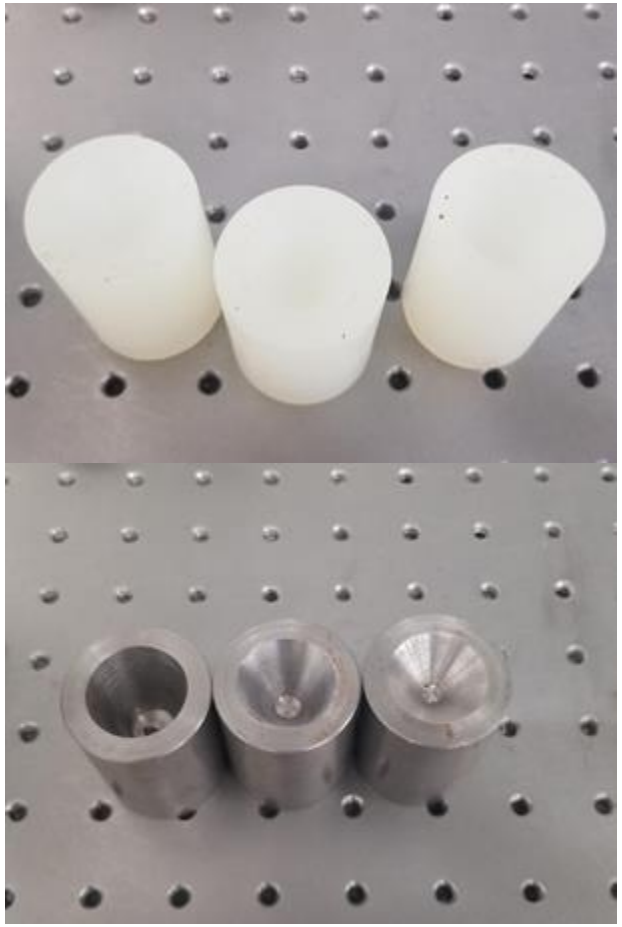
Imaging Test Stand (ITS)

- Used to capture photos of pecan for image processing
- Picture taken of pre-cracked pecan for kernel estimation
- Two post cracked pictures taken (one per kernel)



Experimental Variables

- Impactor Geometry
  - 15, 30, and 45 degrees
- Impactor Material
  - Durable resin and steel
- Mass of impactor
  - Screw on weights added to impactor
- Drop height of impactor

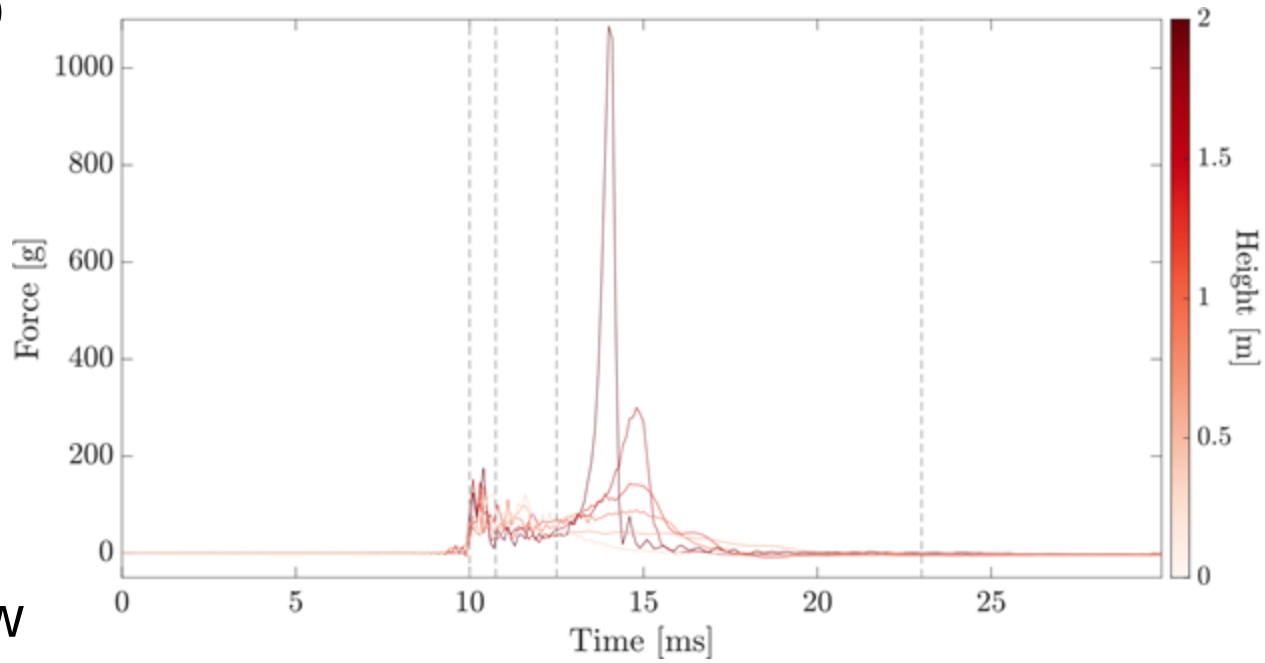


Data Analysis

- 100% kernel area is estimated from pre-cracked pecan
- Kernel area estimated by two key parameters:
  - Eccentricity of a best fit ellipse to pre-cracked image
  - Ratio between pre-crack pecan area and area of box bounding pre-cracked pecan
- Estimated areas validated by statistical analysis of experimental data
- Area of post cracked kernels computed through image processing techniques
- Experimental parameters defined as Pecan Integrity and Pecan Shellability optimized with respect to input parameters

Data Analysis

- Force data was collected from various drop heights
- Pecan crack is characterized into three phases:
  - Initial crack
  - Crack propagation
  - Pecan meat compression
- Largest force in phase one observed for low drop heights
- Largest force in phase three observed for higher drop heights



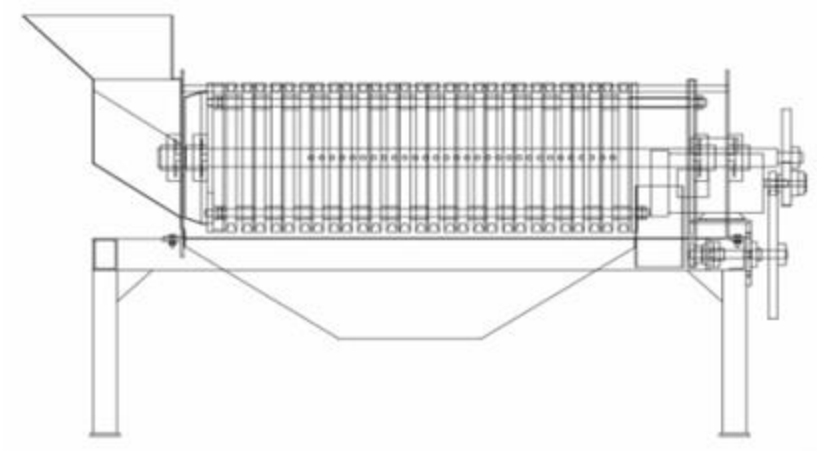
Preliminary Results

- Optimization of Pecan Integrity and Pecan Shellability show advantages toward durable resin material type with an internal angle of 30 degrees
- Further experimental validation needed to confirm results
- Future study will be conducted to determine optimal velocity and mass of impactor

Shelling Equipment Acquired

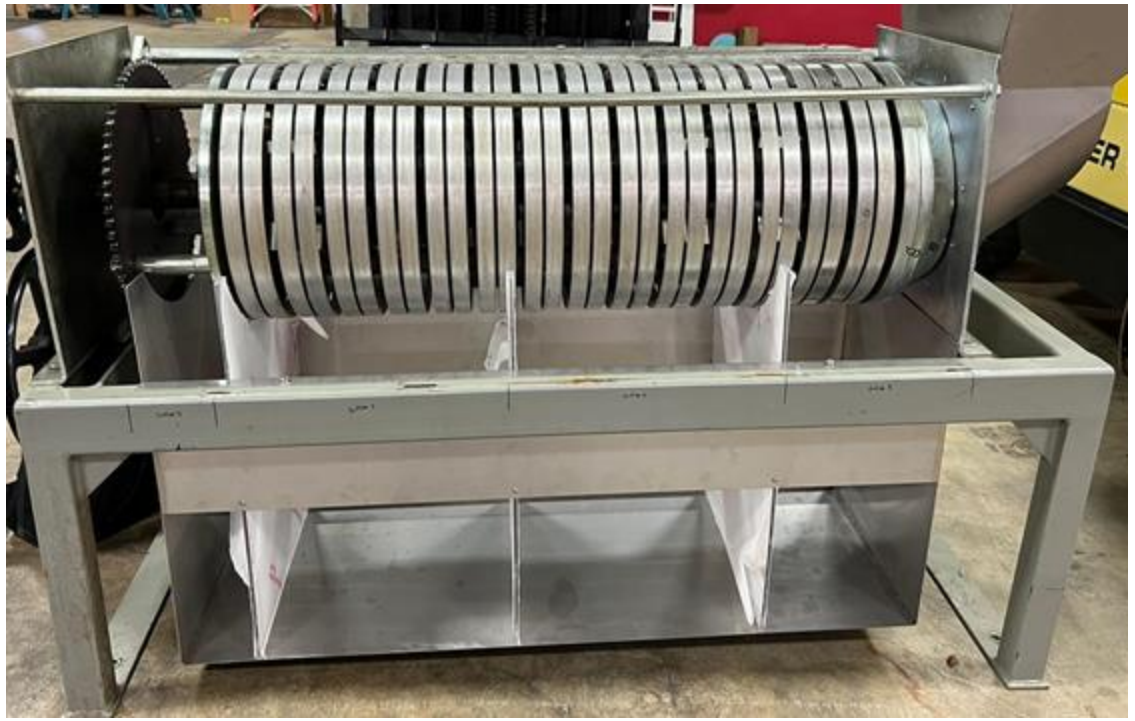
14” Sheller

- ❑ Obtained from ME&E
- ❑ Modified for research purposes



Sheller Modifications

- Added Lexan panels around sheller for better visibility
- Added dividers to sheller output based on paddle shaft pins
- Added ability to change machine tilt angle
- In the process of adding two motors to independently control drum and paddle shaft rpm



Relevant Information for Design of Experiments

- Paddle shaft originally has frequency range of 400-1100 rpm
  - Optimal range of 400-600 rpm
- Drum runs at 30 rpm
  - Equivalent to 0.2 g of force on the pecans
- Both drum and paddle shaft rotate in same direction
- Pins currently made from 1140 cold rolled steel
- Independent variables in design of experiments (DoE)
- Ring gap of drums
  - 3 variations, avg. pecan width +0, +1/32, +1/16 in.
- Paddle shaft rpm
  - 3 variations: 400, 600, 800 rpm
- Pecan feed rate
  - 3 variations, 300, 400, 500 lbs/hr

Shelling Sample DoE

Pattern	Gap between Rings (in.)	Paddle Shaft Rotational Velocity (RPM)	Pecan Feeding Rate (lbs/hr)	Intact Halves (%)	Output Location 1 (lb)	Output Location 2 (lb)	Output Location 3 (lb)
001	Kernel Dia.	400	400	--	--	--	--
011	Kernel Dia.	600	400	--	--	--	--
021	Kernel Dia.	600	400	--	--	--	--
101	Kernel Dia. + 1/16	400	400	--	--	--	--
111	Kernel Dia. + 1/16	600	400	--	--	--	--
121	Kernel Dia. + 1/16	800	400	--	--	--	--
201	Kernel Dia. + 1/32	400	400	--	--	--	--
211	Kernel Dia. + 1/32	600	400	--	--	--	--
221	Kernel Dia. + 1/32	600	400	--	--	--	--

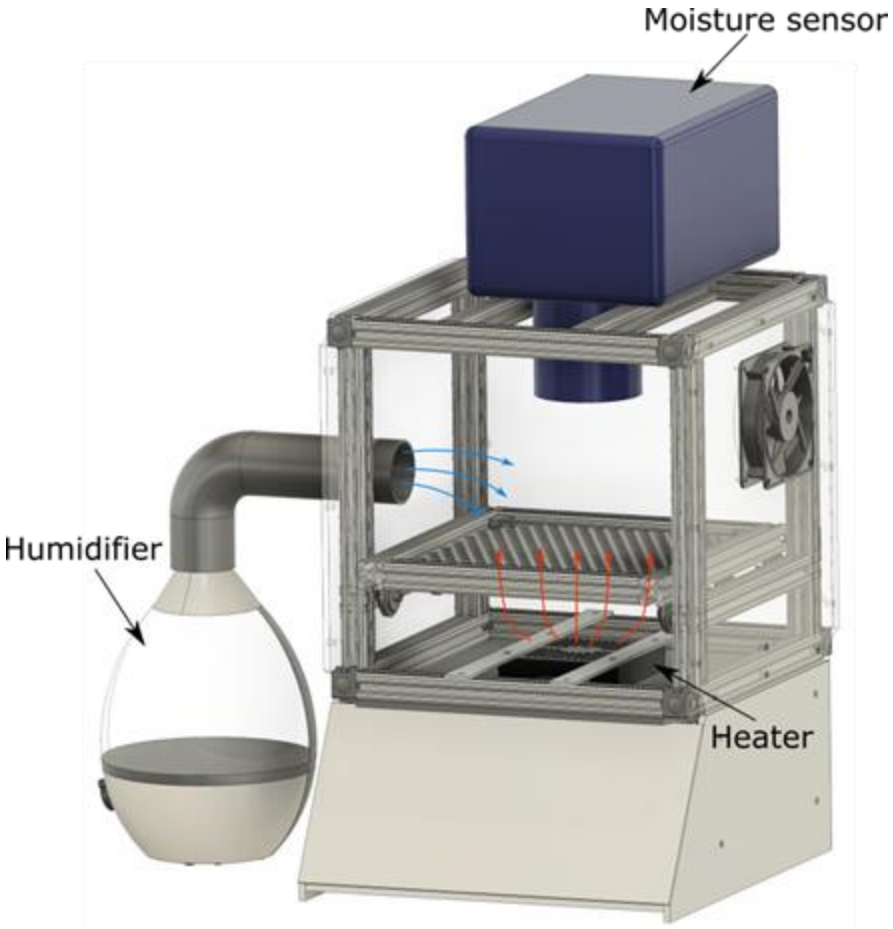
Phase 2 of DoE

- Add 3 more independent variables
  - Drum rpm, sheller tilt angle, and pin material

- Increase number of experiments to include more possible scenarios
  - Every possible scenario (full factorial) would be 486 experiments

Moisture Control

- A moisture sensor to measure the moisture content of the pecan samples
- A humidifier to increase the moisture
- A heater to decrease the moisture
- Samples are placed in the enclosed chamber.



Q&A