ME304
MACHINE DESIGN

Critical Design Review

Multi-Fruit Electric Juicer

TEAM MECHIES

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Introduction

- Our problem statement is based on a digital twin of a multi-fruit electric juicer that extracts juice from a variety of fruits.
- The major goal of this project is for the juicer to be able to extract juice even without peeling them manually.
- Implying that the peeler mechanism is incorporated within the juicer.
- The maximum size of the fruit can be 10x10x10 cm^3 to extract the juice.
- The fruit larger than the size can be manually cut and then the above procedure is processed.

Use of human machine interface

- Since, it is a multi fruit electric juicer, the human interface will be required to select the fruit which is to be processed.
- On the basis of selection, peeler will be commanded to exert required amount of force to hold the surface of the fruit.
- Also, the number of rounds of peeling operation to be performed will be decided.
- In case of juicer, the selection of fruit will decide the required angular velocity.

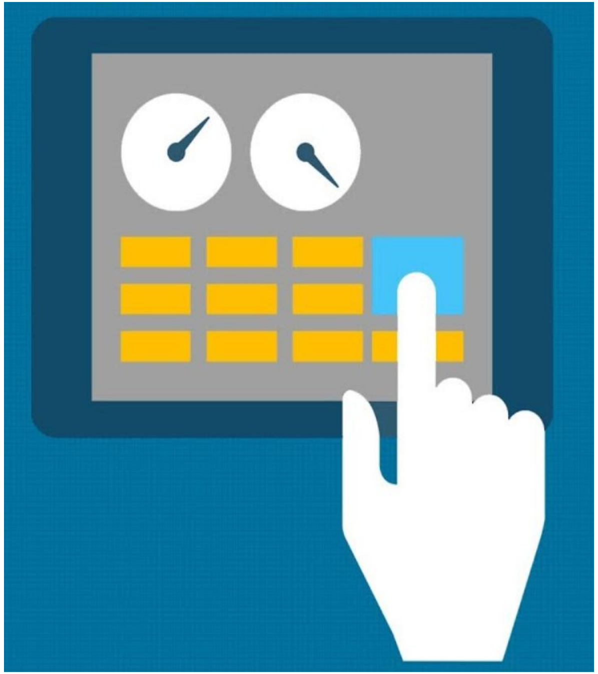


Figure 1: Illustration of interface

Overall Mechanism

- The electric juicer is divided into two segments - in- built peeler and juicer, both connected using a conveyor belt. When the raw fruit is put inside from the peeler end, the peeler detects if it is a hard fruit or a soft one and accordingly, the blade and abrasive are activated.
- When the peeling is finished, a gate which stops the fruit from falling while cutting now opens using a gear mechanism, detected by the finishing of the process.

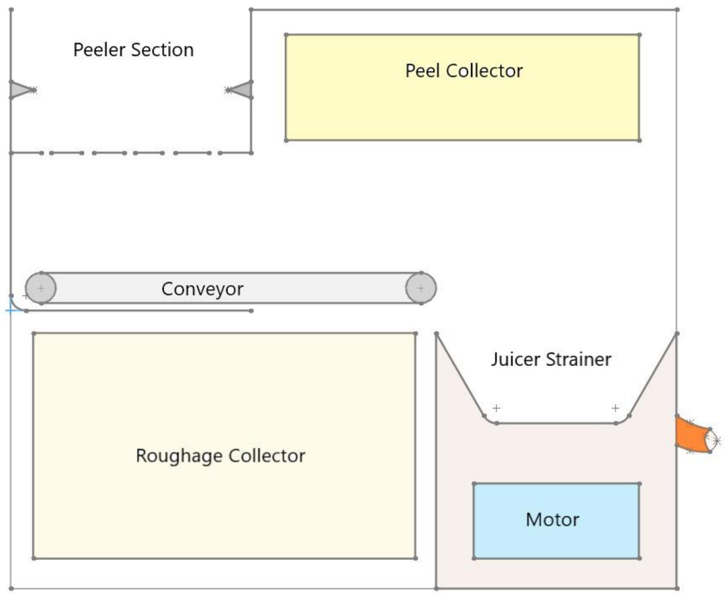


Figure 2: Rough schematic of juicer body and components

Overall Mechanism

- When it drops on the conveyor, the motor drives the conveyor belt. This belt takes the fruit from the peeler to the juicer end.
- The juicer then turns the fruit into juice and the extract is collected separately in another basket.
- A particular design without the conveyor belt was thought about but that will bring instability to the system.

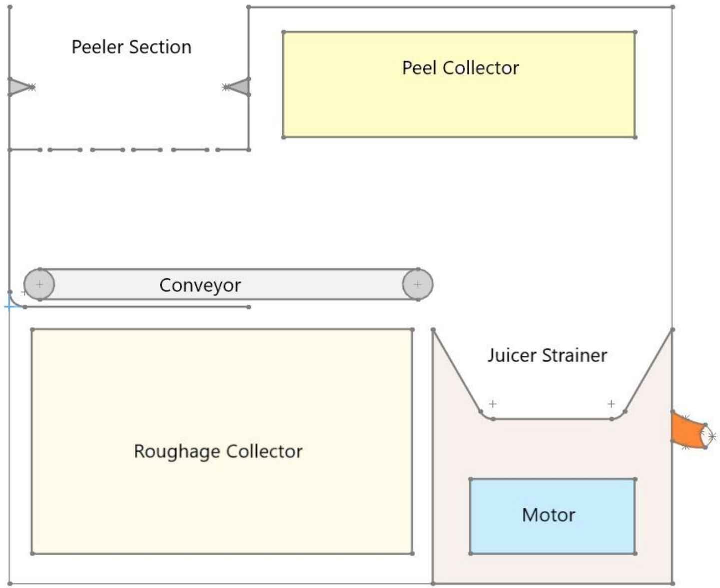
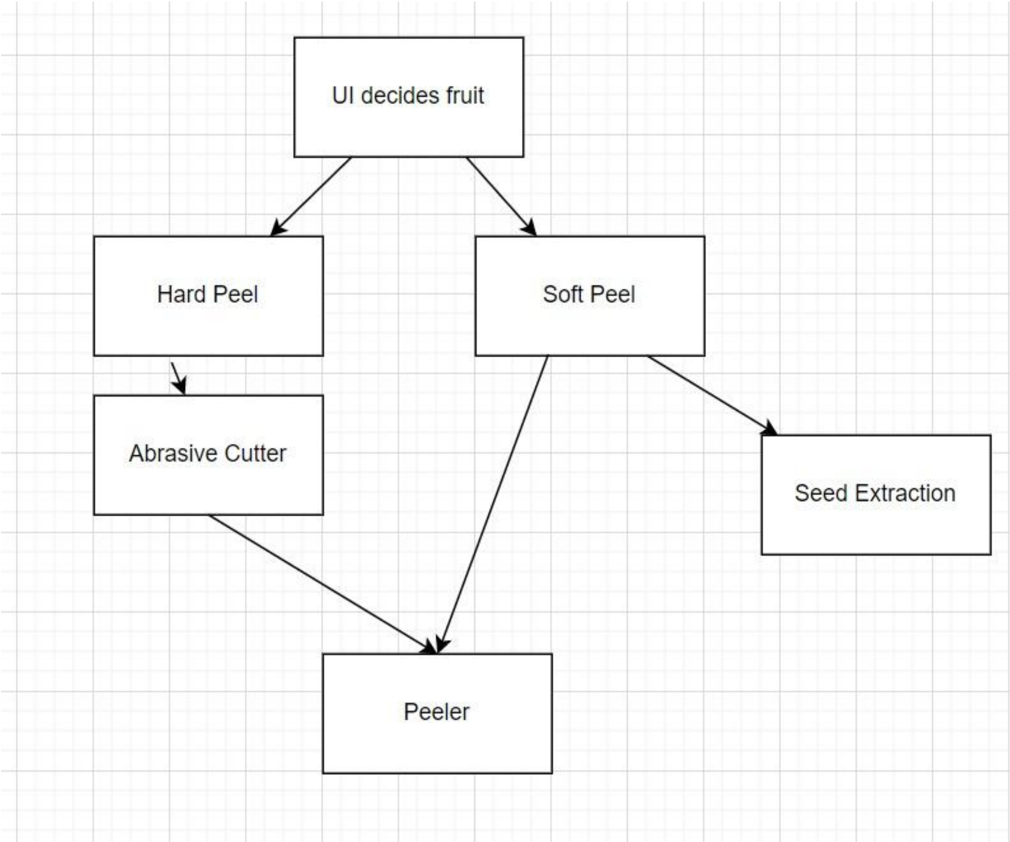


Figure 2: Rough schematic of juicer body and components

Overall Mechanism



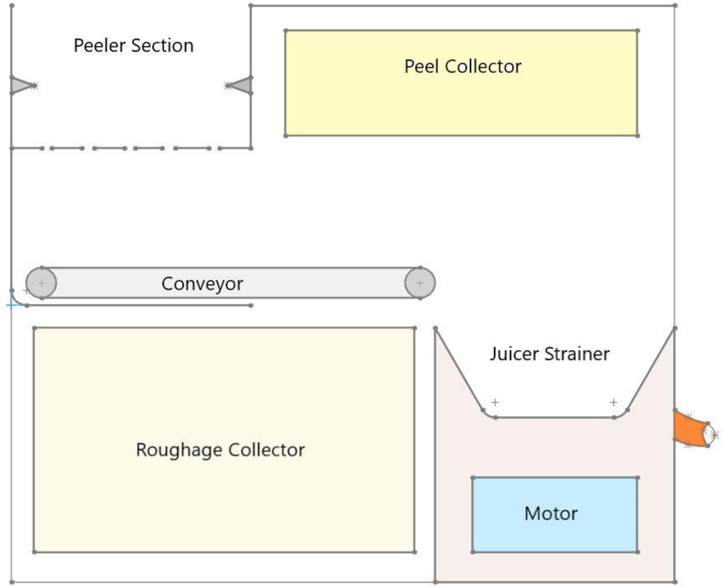


Figure 2: Rough schematic of juicer body and components

Peeler mechanism

- The peeler mechanism consists of a cutter and two pins.
- The cutter peels off the fruit in the linear direction (left/right).
- The two pins hold and rotate the fruit in it and the cutter peels of the fruit.
- For the fruits having a harder skin, they are first removed by using an abrasive and then a blade to cut the skin. For the fruits with a softer skin, the fruits are directly cut using a blade.

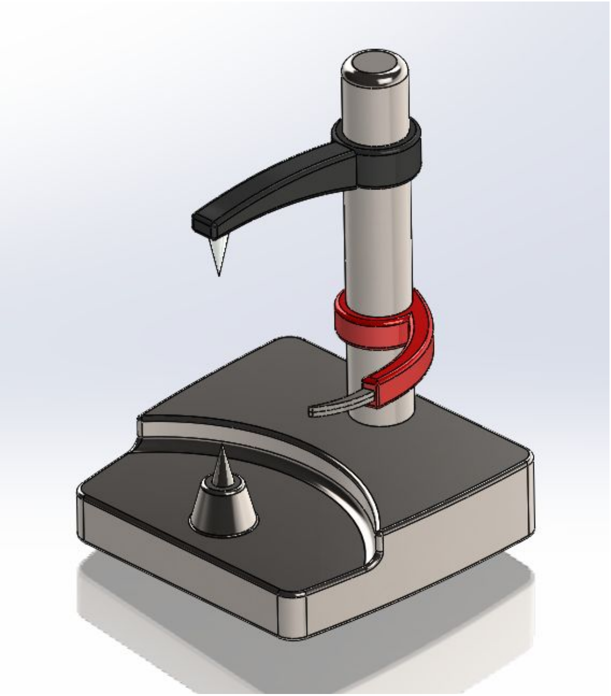


Figure 3: CAD model of peeler

Conveyor

- The conveyor belt serves as a link between the peeler and the juicer.
- The peeled fruit is transported to the juicer via conveyor belt.
- It is driven using an external motor which starts after the peeler retracts and the fruit falls on it. The conveyor is a two-way system to save time.

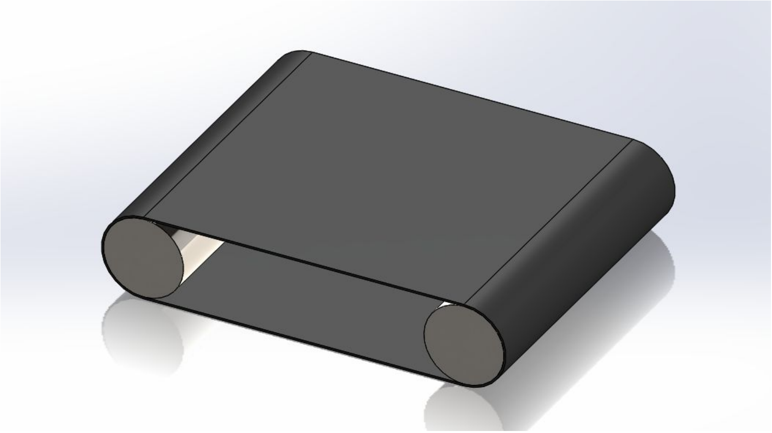


Figure 4: CAD model of Conveyor

Juicer mechanism

- The juicer contains a strainer vessel equipped with a disc blade at the centre.
- It is connected to a DC motor with the help of shaft.
- When fruit is inside the strainer, it is rotated at high angular velocity.
- The disc blade shreds the fruit into finer particles.
- Due to centrifugal force, these particles are pushed to the slant surface of the strainer vessel.
- There are a number of minute holes on the surface through which juice is extracted out and then filled in a container.

Figure 5: CAD model of juicer strainer

Material selection

The Performance Metric

P = f_1(F). f_2(G). f_3(M)

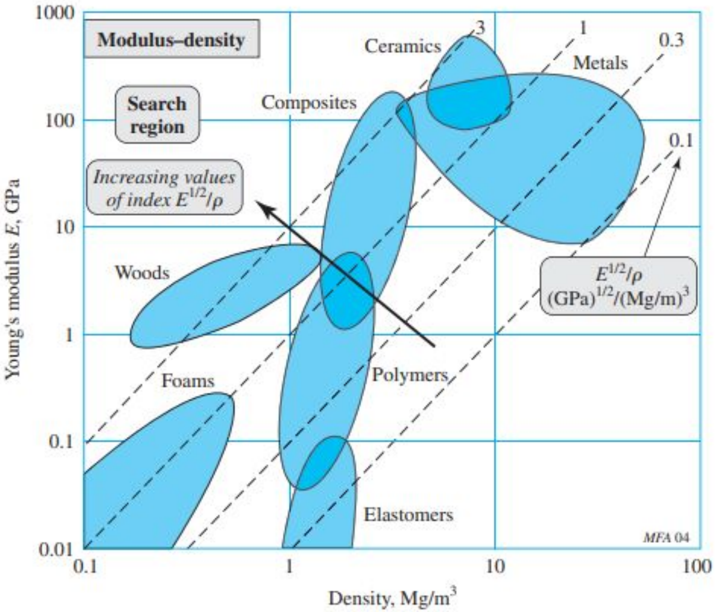
Where f_3(M) is material efficiency coefficient

For the components such as motor shaft, peeler blade or juicer strainer, most of the forces are torsional or bending in nature.

Hence, f_3(M) = $\frac{\rho}{E^{1/2}}$

$\frac{\rho}{E^{1/2}}$ should be minimised or $\frac{E^{1/2}}{\rho}$ should be maximised

to get a light but stiff component.



Ref: Machine design textbook
Figure 6: E versus ρ chart showing a grid of lines for various values the material index

M = $\frac{E^{1/2}}{\rho}$

Material selection

In this regard, metals possess a high value of $\frac{E^{1/2}}{\rho}$

Particularly, steel and its alloys make a suitable choice.

Motor Shaft - Carbon steel 40C8 ; to withstand high torsion

Peeler blade - Stainless steel

Juicer Strainer - Stainless steel

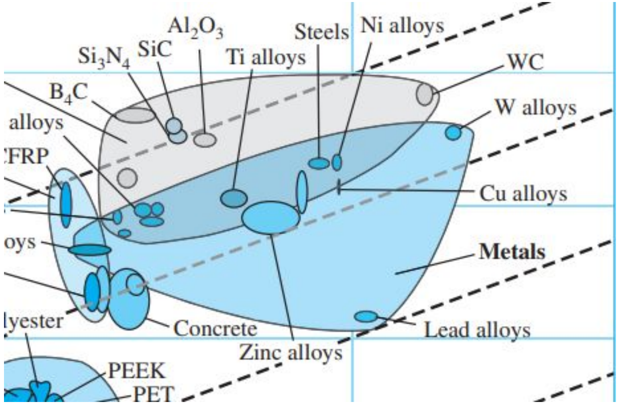


Figure 7: Magnified E versus ρ chart focussing on Metals

Juicer body and Containers

- The juicer body is required just to hold the weight of the assembly.
- In Modulus-Density and Strength-Density plot, plastics and polymers lie almost middle of the graph, which provide optimum strength to the body as well as are lightweight.
- Out of the group ABS (Acrylonitrile Butadiene Styrene) stands out for manufacturing of body because of its high heat resistance.
- PET is suitable for containers since it is stronger and more durable; hence, more rewashable.
- Also plastics are bad conductor of electricity which is preferable.

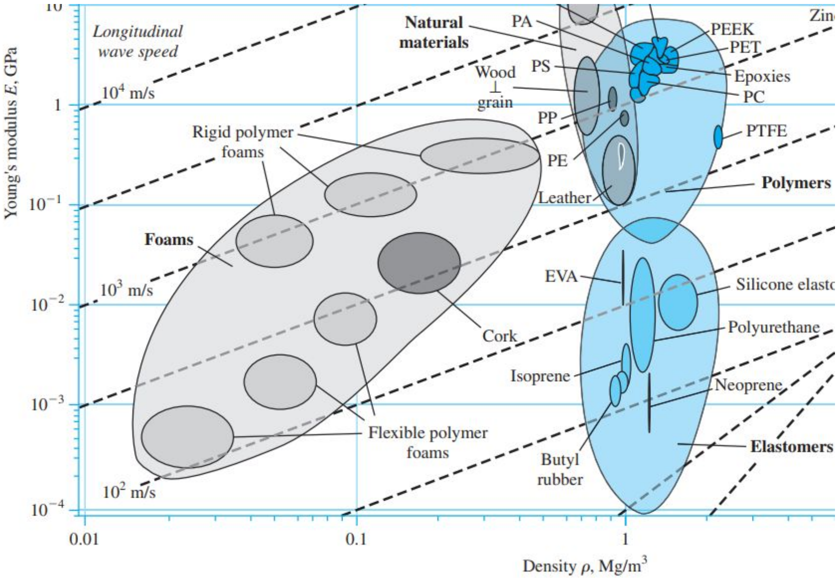


Figure 8: Magnified E versus ρ chart focussing on Plastics and Polymers

Critical Design Review:
Shaft Design and Fatigue analysis of Shaft:

Goodman Criteria:

$$d = \frac{16n}{\pi}\{\frac{1}{S_e}[4(K_f M_a)^2 + 3(K_f T_a)^2]^{1/2} + \frac{1}{S_{ut}}[4(K_f M_m)^2 + 3(K_{fs} T_m)^2]^{1/2}\}$$

Tm = 0.08; Ta= 0.04; Mm= 0.06; Ma = 0.03

S ut of carbon steel 40C8 = 665 MPa
S e = 0.5(S ut) if S ut < or = 1400 MPa
Therefore S ut = 335 MPa

Calculation of diameter(d) of motor shaft :

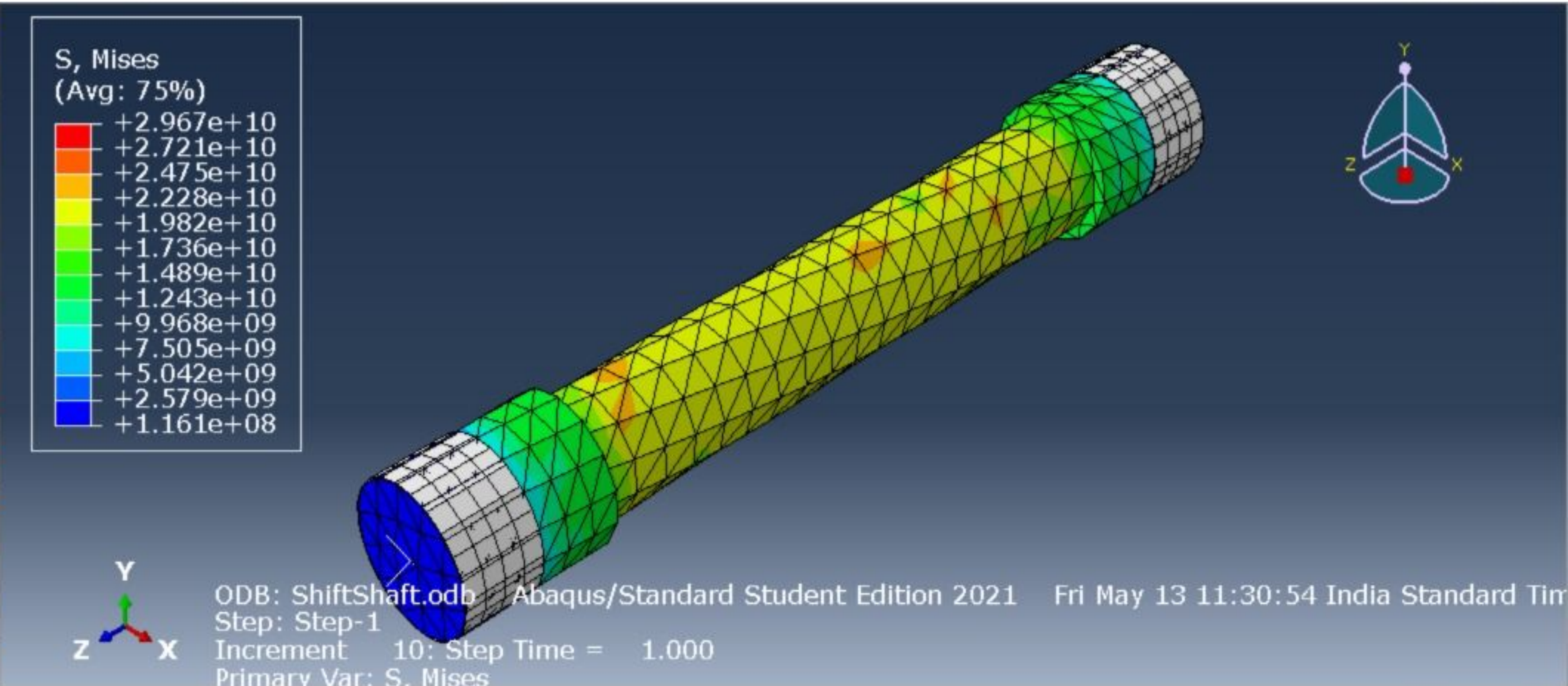
n = 1.5 (design factor)

$$d = \left[\frac{16 \times 1.5}{3.14} \left\{ \frac{1}{335} \left[4(1.24 \times 0.05)^2 + 3(1.22 \times 0.05)^2 \right]^{1/2} + \frac{1}{665} \left[4(1.24 \times 0.08)^2 + 3(1.32 \times 0.08)^2 \right]^{1/2} \right\} \right]^{1/3}$$

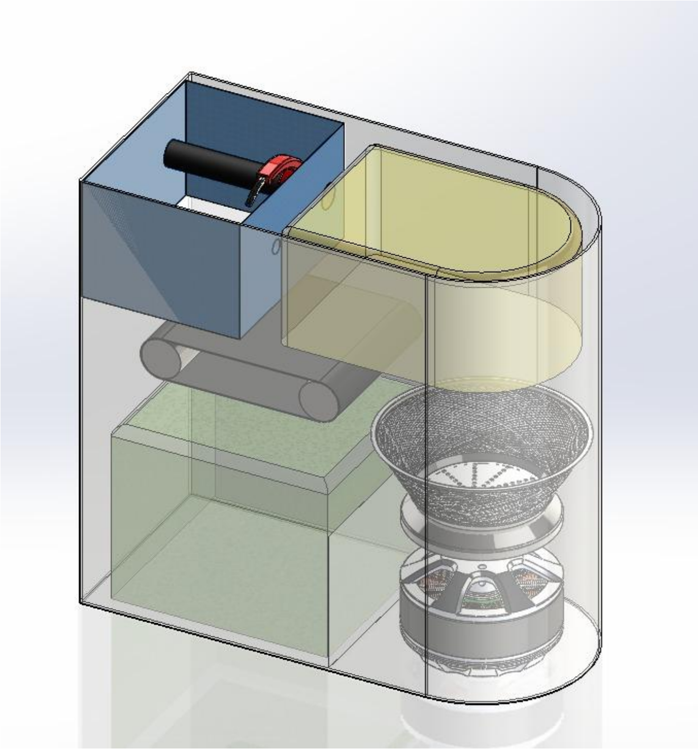
= 0.018m(approx)

= 18mm

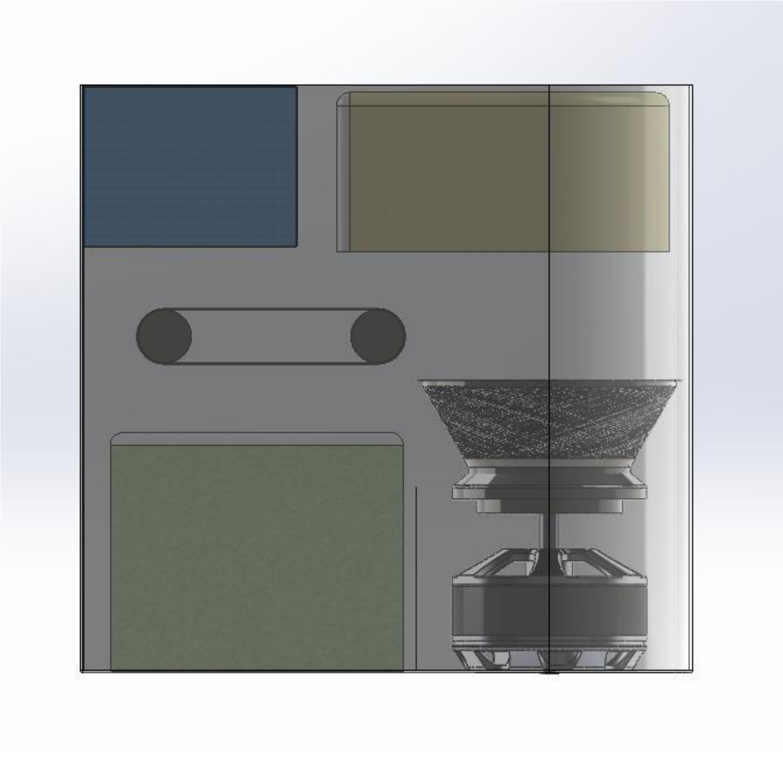
Torsional Analysis of Shaft



CAD Body Model of Juicer Mixer:



Mixer Body Assembly



Front view of Mixer

Cost Analysis:

Materials	Rupees/Quantity	Quantity	Amount (Rupees)
ABS	100/kg	0.7kg	70
Shaft Screw	50/piece	2 piece	100
Angle iron	30/kg	0.5 kg	15
Cutting disk(Aluminium)	85/piece	1	85
Faucet (Brass)	500/piece	1	500
Faucet Socket	10/piece	2	20

Materials	Rupees/Quantity	Quantity	Amount (Rupees)
Bearing	10/piece	50	500
Hinges	20/piece	10	200
Bolt and nut	20/piece (10mm)	20	400
Transportation	18/metric ton kilometer	-	-
Motor	400/piece	2	800
Mild steel	100/kg	3.2kg	320

Materials	Rupees/Quantity	Quantity	Amount (Rupees)
Stainless Steel Blade	30/piece	1	30
Workmanship			1500
Peeler	350/piece	1	350
+ 1% contingency			500
Total			Approx 5000

Product Specifications

Power to be delivered: 800W
Operating Voltage: 210V - 250V
Power efficiency: >95%
Max angular speed (juicer motor): 10000 RPM (Based on Motor specification)
Max angular (peeler motor): 4000 RPM (Based on Motor specification)
Operating temperature range: -5 ^{0}C to 105^{0}C
Noise: <90dB from 1 meter
Max continuous operation time: 40 minutes
Estimated Weight: 4800 grams
Manufacturing cost: < Rs 20000/-

Contribution

Aryan Anand (2019meb1244)	Juicer - motor mechanism, CAD, Overall Body CAD
Hrithik Gupta (2019meb1259)	Material Selection, conveyor CAD, FEM Analysis of Shaft
Harshpreet Singh (2019meb1260)	Peeler mechanism, CAD, FEM Analysis of Shaft
Tushar Raj (2019meb1302)	product specifications, CAD of Juicer
Yagesh Kumar (2019med1015)	Shaft diameter calculation, shaft material selection, cost analysis