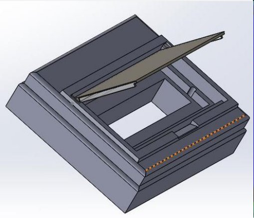
Project Portfolio

-Chathuni Fernando-



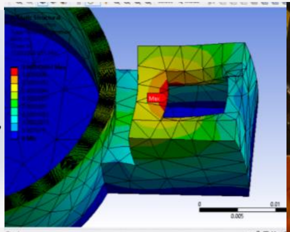


Table of contents

About Me

CHATHUNI FERNANDO

MECHANICAL ENGINEERING FINAL YEAR UNDERGRADUATE, UNIVERSITY OF PERADENIYA

Highly motivated and results-oriented Mechanical Design Engineering student with a strong foundation in model design, simulation, and design analysis. Eager to leverage my skills in leadership, coordination, and problem-solving to contribute to innovative product development, in a dynamic engineering environment. Possess a keen interest in automation and a growing knowledge base in this field too. This portfolio has included a thorough explanation about the projects I have done.

1. Optimizing A Bio-Mechanical Energy Harvesting Method For Hikers

SKILLS OBTAINED

Solidworks, ANSYS, Arduino Uno, R Studio

OBJECTIVE

to develop a conceptual mechanism to maximize power generation while minimizing the hiker's metabolic cost.

CONCEPTS OF THE OPTIMIZATION

CONCEPT I - Increasing rate of piezoelectric pulse generating within a stair gait cycle. (Refer Table 3.1)

CONCEPT II-Using a hybrid technology method (Piezo + Electromagnetic)

CONCEPT III- Selecting an optimized piezo plates configuration on heel area of the insole.

Figure 1.1: Piezoceramic discs attached on the insole of ball and heel areas

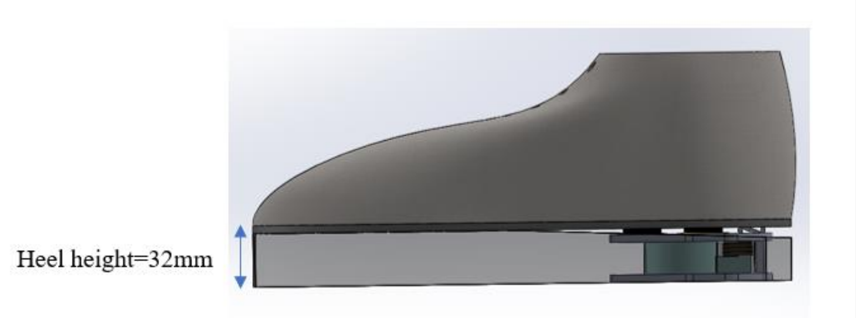
THE SUGGESTED DEVELOPMENTS IN CONCEPTUAL MECHANISM

Existing Method (Refer Figure 1.1)	The conceptual Method that developed
One voltage signal is generated during the stair gait cycle by the heel strike(when the stance phase is starting)	Two analog signals are generated. 1. By heel strike 2.By the beginning of the swinging phase using the developed mechanism.
No Hybrid Technology	Electromagnetism has been used to increase power generation

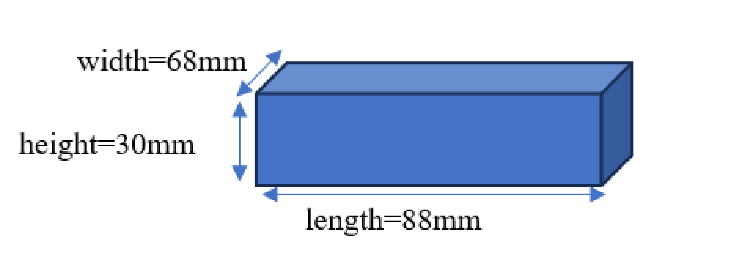
1. Optimizing A Bio-Mechanical Energy Harvesting Method For Hikers-CONCEPT I

LIMITATIONS

I. Shoe Heel Height



I. Exterior dimension limits for the conceptual mechanism



1. Optimizing A Bio-Mechanical Energy Harvesting Method For Hikers-CONCEPT I

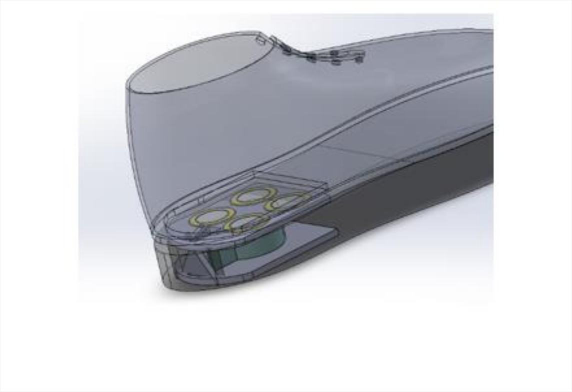


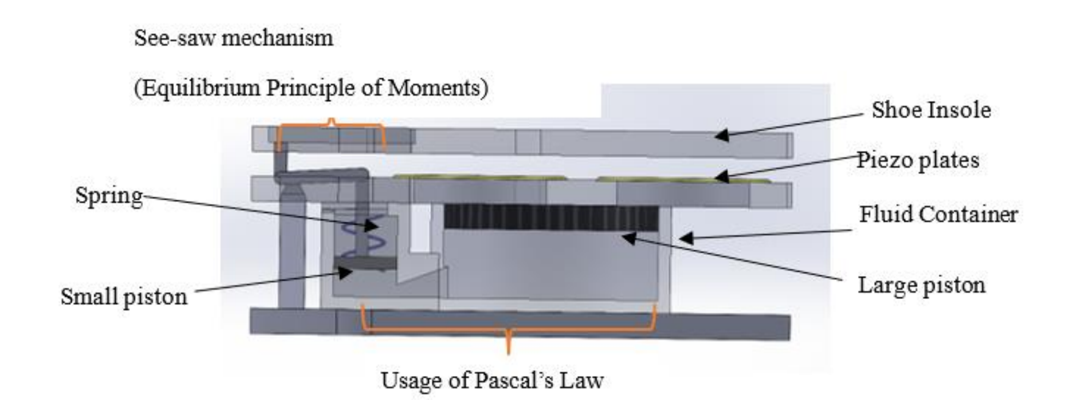
Figure 1.4: Model that has been implemented in shoe

DESIGN OVERVIEW

I. Theories used in the mechanism

-Seesaw mechanism

-Pascal's Law

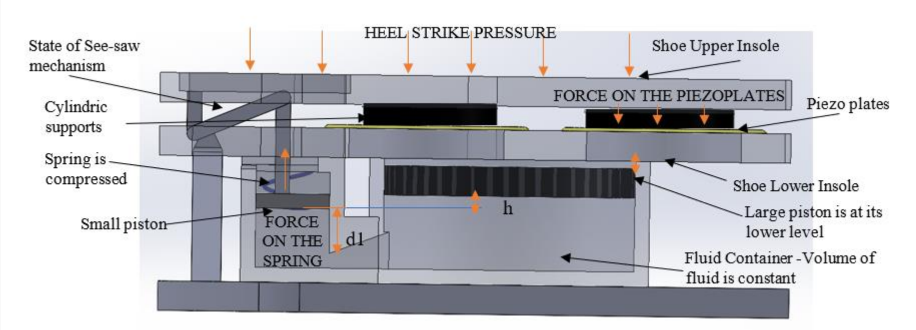


1. Optimizing A Bio-Mechanical Energy Harvesting Method For Hikers-CONCEPT I

MECHANISM

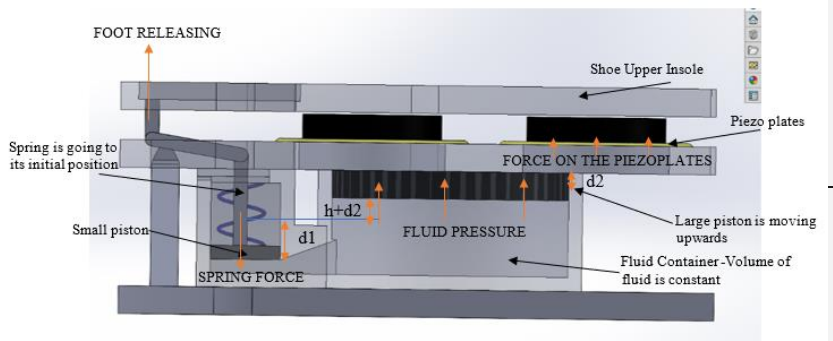
I. Heel Strike Phase

•**Piezo-Plates**: These plates generate energy when compressed by foot pressure. Compression occurs as the upper insole of the shoe presses against a cylindrical support connected to the plates.
•**See-Saw Mechanism**: This mechanism operates in a way that compresses a spring, storing energy. To maintain comfort and stability for the hiker, the upper and lower insoles are locked in place during this phase.



II. At the Beginning Of The Swing Phase

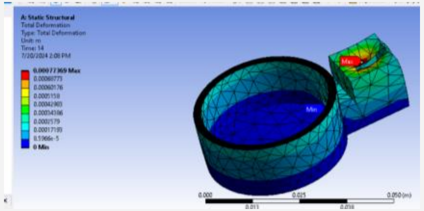
- In conventional energy harvesters, the stress on the piezo plates is released when the foot is lifted off the ground.
- However, with the newly implemented mechanism, the piezo plates undergo additional compression by a large piston.
- When the foot is lifted, the see-saw mechanism is activated, causing the spring to return to its original position.
- This process converts the stored spring energy into work, which involves moving the fluid. The work done on the fluid then compresses the piezo plates again.



1. Optimizing A Bio-Mechanical Energy Harvesting Method For Hikers- CONCEPT I

DESIGN EVOLUTION (Simulation –Fluid Container Mechanical Strength)

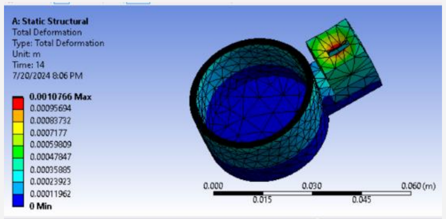
- Polycarbonate was selected as the material since the deformation is minimum



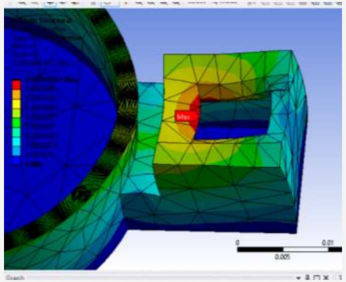
Results for Simulation of Fluid Container

	deformation/m	max stress/Pa
Polycarbonate	7.74E-04	7.72E+07
Polyurethane	2.68E-02	8.61E+07
PVC foam	2.53E-02	8.63E+07

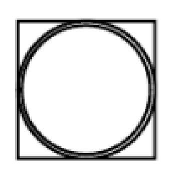
- Some design changes were done to minimize deformation more.



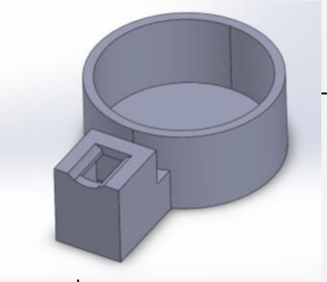
When increasing the surface area, the deformation is limited to a smaller area but the deformation has increased up to 1.08mm



The design has been developed by decreasing the contact area. The deformation decreased to 0.45mm.



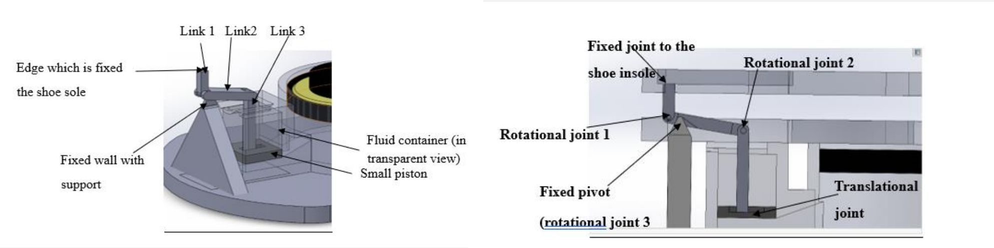
the circular steel strap was suggested to be fixed on the surface for more safety and to minimize this deformation by analyzing the methods in [(Matsagar Vasant A. Department of Civil Engineering, 2014)].



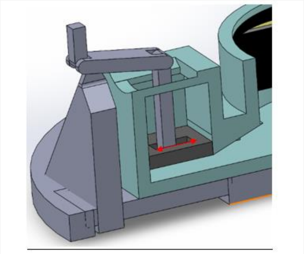
Final Design

1. Optimizing A Bio-Mechanical Energy Harvesting Method For Hikers- CONCEPT I

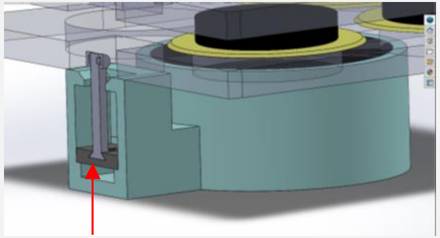
DESIGN EVOLUTION - See-saw Mechanism



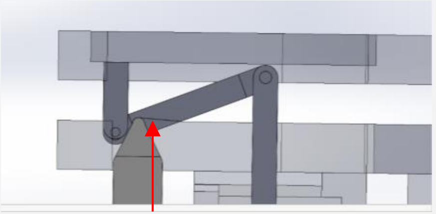
SPECIAL FEATURES



translational joint-to move smoothly link3 when small piston moves up and down



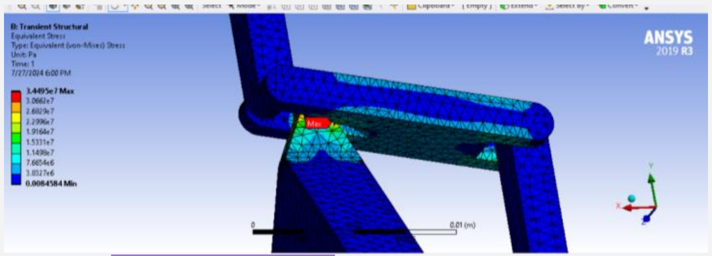
An undercut was designed to hang the small piston by the link 3

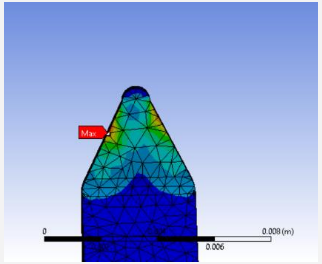


Special cut to prevent collapse between link 2 and fixed supportive bar

SIMULATION- See-saw Mechanism

Structural steel was selected since the max deformation (4.75e-5m) is negotiable





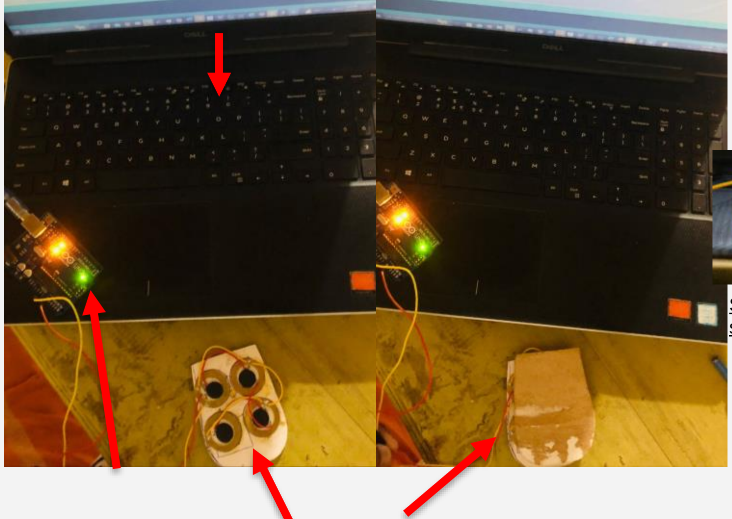
1. Optimizing A Bio-Mechanical Energy Harvesting Method For Hikers- CONCEPT II

Selecting the best configuration of piezo plates

Test was done by a 57.10kg person walking in a random frequency stepping.27D(27mm Diameter Piezo plates has used in parallel.)

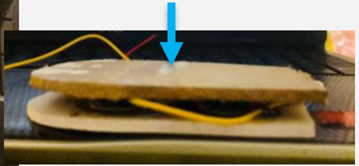
Testing Arrangement

PC



Prototype of shoe sole with piezoplates

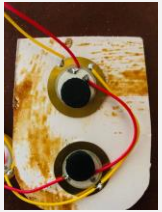
Foot pressure applied



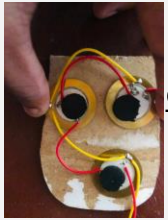
Side Elevation of prototype sole

Tested Configurations

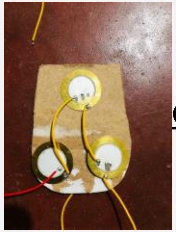
- A data set of 200 for output AC voltages was collected with 250ms time intervals for each configuration.
- Design was analyzed by doing tests by Rstudio.



Configuration A



Configuration B

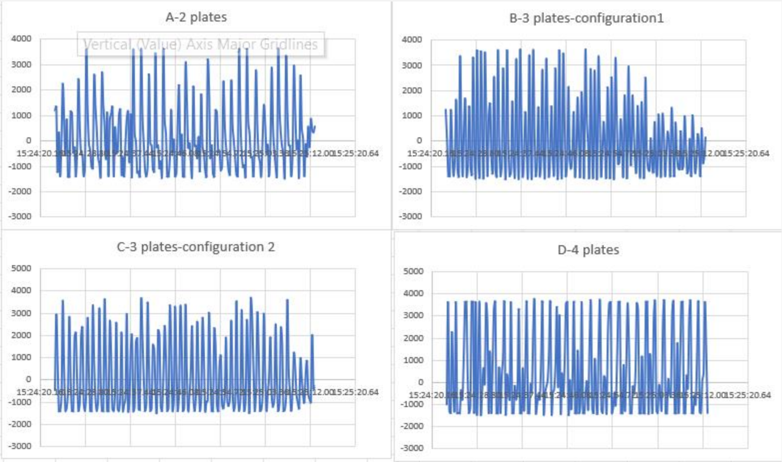


Configuration C

Configuration D

1. Optimizing A Bio-Mechanical Energy Harvesting Method For Hikers- CONCEPT II

Results



AC output voltage Vs Time for each configuration

Test	Results and Conclusions
anova	P value< 0.05 Therefore reject H0 at 5% significance level. There is **a significant effect of configurations of plates on voltage** at 5% significance level
pairwise comparisons	P-values between B and A,C & D is MORE than 0.05. Therefore cannot reject H0 at 5% significance level **B and A,C & D configuration have similar effect on voltage** C & A ,C & B, D &A,D&B have different effects on peak voltage.

Configuration	Effect of configuration	difference of effects		peak voltage mean
A	-368.6724	C & A	681.5924	1944.209
B	-282.5835	C & B	595.5035	2030.298
C	312.92	D & A	1106.719	2625.801
D	738.0461	D & B	1020.63	3050.927

Conclusions

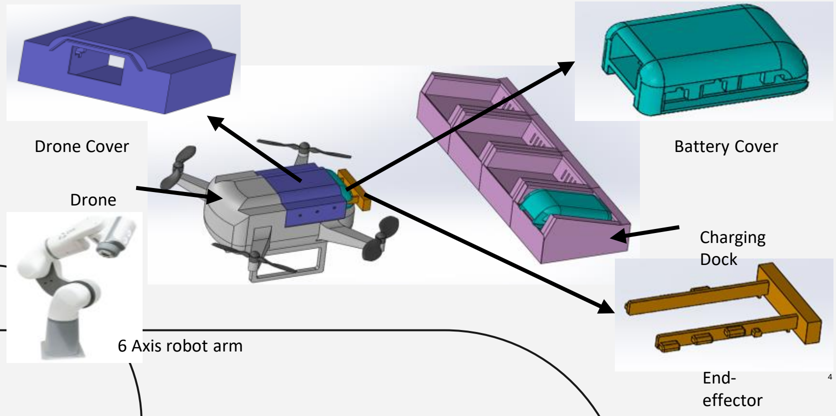
- 4 parallel piezo plates-configuration gives the highest treatment effect (Vm=3.05mV)
- The placement of piezo plates do matter when the no. of plates are constant in heel area. (comparing the different effects of B and C)
- But the effect of increasing the number of piezo plates is higher than changing the placement

2. Hot Swapping Of A Battery In A Drone In A Box

SKILLS OBTAINED

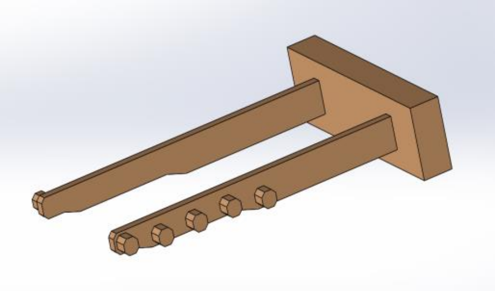
Solidworks, ANSYS

- In this project, the **main objectives** were to design the locking and holding mechanism for the end effector on the battery with one/two actuators, the locking mechanism of the battery when the drone was flying, and the fixing mechanism of the battery to the charging dock.
- The main considerations were the safety of the battery, adaptability to bad weather conditions(rains), reduction of battery heating, and minimizing the downtime of drones.
- **My role** was designing the initial **design of the end effector**, developing it up to the final design, its stress analysis simulation by Ansys and material selection (stainless steel), **design of the charging dock.**



2. Hot Swapping Of A Battery In A Drone In A Box

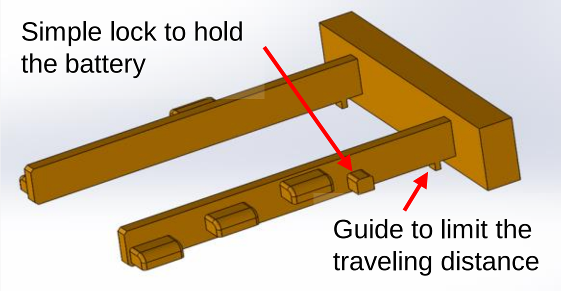
End Effector Design Evolution



Drawbacks

- Need one actuator to operate
- Complex shape

End-effector – Prevous design



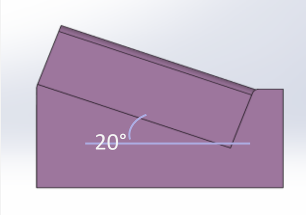
End-effector – Final design

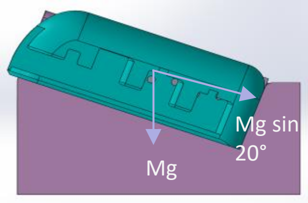
Specialty

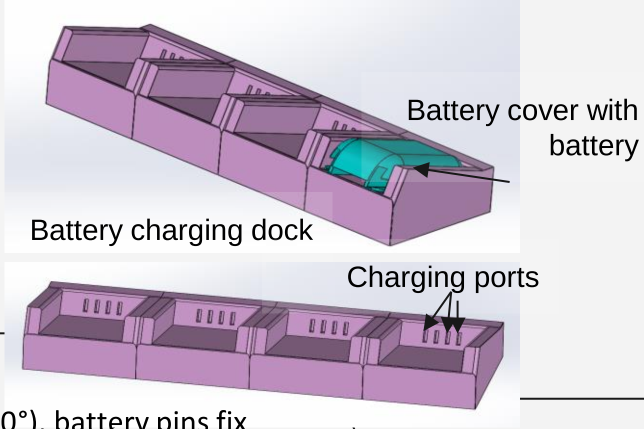
- Can operate without actuators
- Simple
- Easy to handle

Charging Dock Design Evolution

- Charging dock is designed with 20° angled surface







Main advantage:

- Due to the force along the angled surface (Mg sin 20°), battery pins fix properly to the charging ports. (Here, M≈3kg)

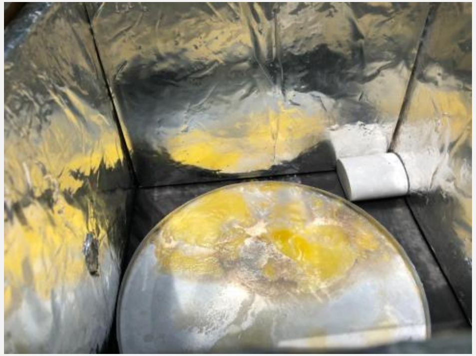
3. Solar Cooker Project (OREL Coporation)

SKILLS OBTAINED

Solidworks, Prototype making and testing

Introduction

- Assigned to design an efficient solar cooker
- Given a cardboard model with limited temperature capabilities



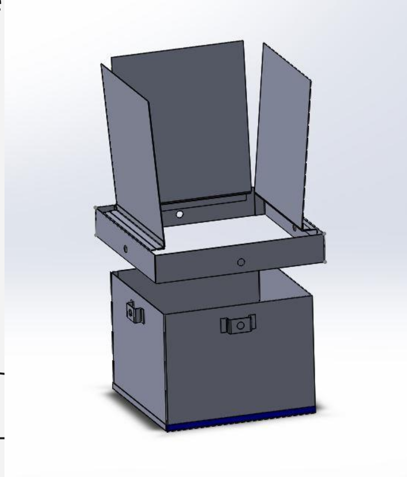
given solar cooker model

Problem Satetment

- Increase inside temperature of the cooker to egg boiling temperature
- Pressurize inner air and minimize existing model errors
  (leakage, inconsistent heat, glass crashing, humidity, light interference)

Proposed improvements to overcome existing model problems:

- Use black matte pot for increased heat absorption
- Implement sealing mechanisms and locking system
- Increase area of reflecting panel with adjustable angles
- Redesign casing for upper glass sheet cover
- Change box material to reduce heat loss
- Reduce radiation and convection through wall modifications
- Implement methods to reduce water vapor



Solid works Model of the Solar Cooker

3. Solar Cooker Project (OREL Corporation)

Design and Implementation

- Created a SolidWorks model with modifications based on proposed improvements
- Implemented prototype using Sheetmetal and powder coating
- Added sealing mechanisms, reflective materials, and a low-emissivity layer

Results

- Presented prototype of the Solar Cooker
- **Achieved desired temperature of 81°C**
- Challenges faced: air leakage, glass crashing, humidity, transparency
- Areas for improvement: Better sealing mechanism without compromising material strength
- Durable glass material to prevent crashing
- Improved ventilation system to reduce humidity
- Incorporating a fan or blower for better air pressure control

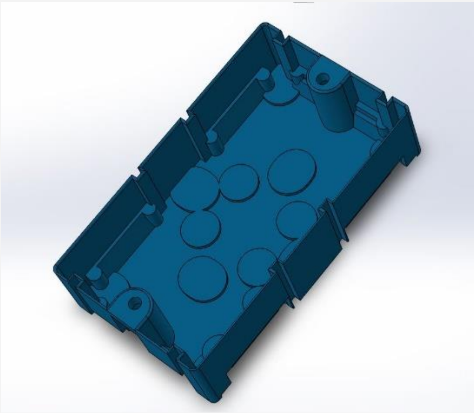
Prototype of The Solar Cooker

4. A Container For Face Recognition Terminal(OREL Corporation)

Objectives

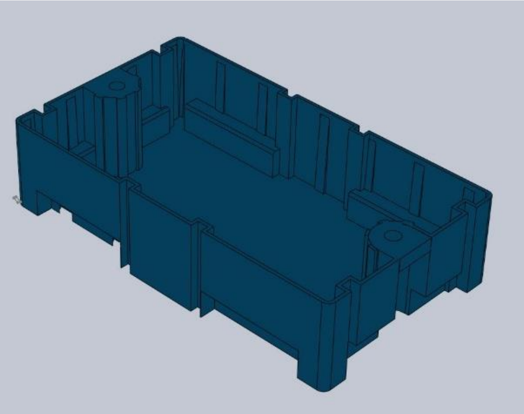
- Design a container for face recognition terminal
- Fit inside surface mounting box with precise arrangement of components

Initial Design



- Focus on specific components and their arrangement
- Drawbacks-Complexity and thin walls

Final Design



- Stronger walls with improved structural integrity

5. Masking Plate For 13A Twin Socket(OREL Corporation)

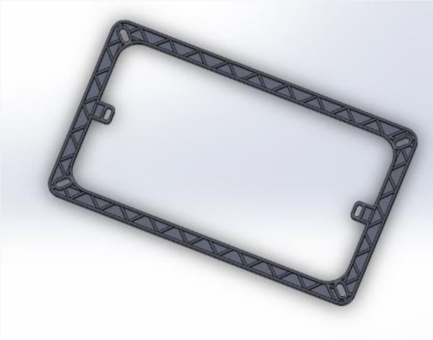
Objectives

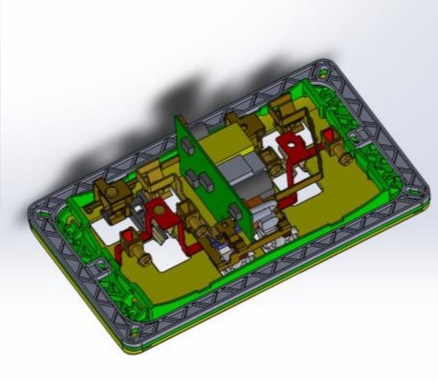
- Designing a prototype of a masking plate for 13A twin 2 gang sockets
- Purpose: Fixing the socket grid tightly to the wall, regardless of wall roughness

Design Process

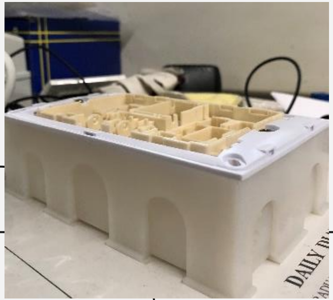
- Used SolidWorks to design the masking plate
- Added drafts to thinner walls to prevent molding issues
- Prototype printed using a 3D printer

SolidWorks Design





Prototype Design




Undercuts and Drafts in order

6. Mounting Distribution Box(OREL Corporation)

Objectives

- Designing a prototype of a mounting distribution box
- Do modification was to enlarge the terminal holes up to 6mm maintaining the existing length of the terminal.

Design Process

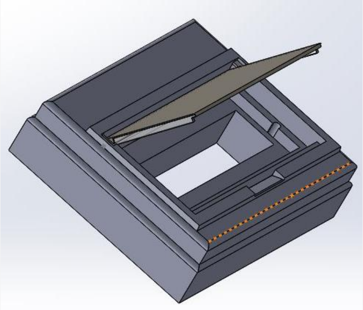
- Used SolidWorks to design the 3D model considering the scale of the existing product in the department
- Do modifications to model of Singapore distribution box comparing the Sri Lankan distribution box

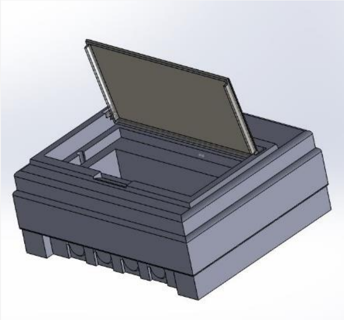
Results

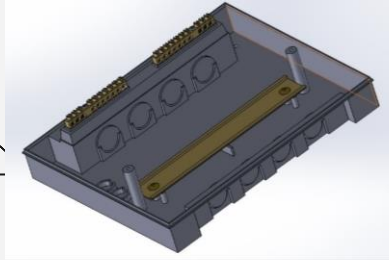
Terminal holes couldn't be enlarged up to 6mm as the horizontal length was not long enough to have large holes. Therefore, the needed requirements could not be achieved while maintaining the existing length.

Existing Distribution box at the department

SolidWorks Design







Thank You for Your Time!

CONTACT DETAILS:

Chathuni Fernando
chathuni111@gmail.com
+94705511066