RPMME

Design of Reverse Vending Machine Body and Storage System

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Abstract: Recycling behavior among civil society is unsatisfactory. It is because lack of center waste management that can also source be the reason that general public does not want to recycle in Malaysia. Research have been done to collect data of Reverse Vending Machine can be center waste of management. Reverse vending machine are popular at overseas to maintaining the behavior of recycling. To overcome this problem, Reverse vending machine have been designed to become center waste management in Malaysia. This project used George E Dieter design process to design this machine. The design process consists of eight phase which are Define problem, Gather information, Concept generation, Concept evaluation, Product architecture, Configuration design, Parametric design and Detail Design. The existing patent and available machine were referred to generate idea for reverse vending machine body and storage system. The selected idea and concept are used to modelled using Solidwork Software. Calculation and analysis also have been done to get the result of system. Based on analysis and calculation, the result of product can store about up to 15,000 sheets of paper, 2,488 bottle shredded, 6000 can shredded and 238 glass. The overall dimension of product 1690mm x 1250mm x 1800mm.

Keywords: Reverse Vending Machine (RVM), Waste Management

1. Introduction

Rate of waste production increased and this problem needs to be controlled by planning management of waste products and how to overcome these problems. Eventually reaching 32.8 million in 2021, the population will produce a massive quantity of solid garbage, which is projected to amount to 38,427 metric tons per day in 2021 (1.17 kg per capital per day). Institutes are the big part of the young generation to create awareness of 50 years forward on our country [1].

A reverse vending machine is a system that collects waste material and converts it for a user into money. Once the storage is full, all recyclables are ready for disposal. Storage is the main reason for

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downtime for the reverse vending machine and preventing the user from recycling. The employee is

handled manually to stop the activity and the recycle bin to continue the system of this machine. To overcome this problem, the storage system needs to be upgraded to reduce the downtime of reverse vending machines to allow the user and motivate them to recycle and increase the recycling rate of the country. Combining four different types of recycle waste material into one single machine, and an enhanced storage box system, will help users to use to choose paper, plastic, carton, and glass to dispose of without worrying about whether the storage box is full or not [2].

The adoption of Act 672 by the states that make up the Wilayah Persekutuan of Kuala Lumpur, Putrajaya, Pahang, Johor, Melaka, Negeri Sembilan, Perlis, and Kedah is required for the implementation of the system that separates garbage at the household level. The recycling campaign was initiated in 1993, but it has not been successful in meeting its objectives since there has been a lower level of commitment from the community and a lower level of serious knowledge about the programmed that has been done [3].

Based on the amount of household garbage produced throughout the states from 2014 to 2018, the cost of waste management is as follows. One of the states that spends the most money on waste management is Johor, with an annual cost of 30 million USD for landfilling practices. This is followed by Kuala Lumpur, which spends 22 million USD per year, and Kedah, which spends 13 million USD per year. Putrajaya had the lowest annual expenditures, which amounted to around 1.03 million USD. The nation's annual expenditure on waste management came to a total of 97.57 million US dollars [4].

2. Review of literatures

A The literature review is the method of collecting information on all relevant subjects or requirements of the project. It is carried out by collecting data through patent analysis, books, journals and current products that would be comparable and used for product design.

2.1 Study of Reverse Vending Machine

Reverse vending machine is a machine that allows individuals to return empty beverage containers for recycling, such as cans and bottles, is known as a reverse vending machine. The machine will often return a deposit or refund amount to the person who ultimately uses it. This is what distinguishes it as a "reverse" vending machine rather of the user putting in money and receiving out a product, the customer puts a product in and receives out a monetary value in exchange for that commodity [5].

2.2 Study of Reverse Vending Machine Process

This reverse vending machine is made up of several sensors that are used to receive cans into the system and in the checking system. The checking system includes a weight sensor (load cell) and an infrared sensor. Conveyor set, lid controller set for incoming can control lid, can pressing set using 350-watt DC motor, lid controller set for outgoing can classifying box, and hinge set for can classifying to classifying box are all functioning at the same time [6].

2.3 Study on Existing Product

Available products are products that exist and are sold in the market. Ready products are important because they can provide a lot of information about the features and specifications that can be seen from the product. The details and information are useful to generate idea in designing new product of reverse vending machine. The table below shows comparison of a few existing reverse

vending machine that available in market [7].

Table 1: Existing Product Comparison

PRODUCTS	1	2	3	4	5
	KEGOO	TOMRA T70	K3/7500	ECOVEND RVM100	RECYCLECELVER AM1
PRICE STORAGE CAPACITY	RM 20808.00 700 bottles	RM 30000 1100 PET bottles (compacted),3200 cans (compacted), and 300 glass containers.	RM 35000 2500-3000 bottles/cans	RM26200 250 PET bottles and 300 cans.	RM 29800 500 units
ACCEPTANCE ITEMS	plastic bottles (PET)	bottles, cans, , and glass bottles	plastic, aluminium, and glass	bottles and aluminium cans	(PET) bottles and aluminium cans
OPERATING POWER	100 volts	208 volts	380 volts	220/230 volts	240 volts
DIMENSION (L x W x H)	1090mm x 800mm x 1250mm	813 mm x 1040 mm x 1690 mm	1410mm x 1250mm x 2000mm	1850 mm x 650 mm x 950 mm	950mm x 650mm x 1850mm

2.4   Methodology

This project must be conducted using a design process model from George E. Dieter. According to George E. Dieter, a design project process consists of three phases and eight steps. Conceptual design is the first step of the process, second is embodiment design and lastly is detail design. The steps that are included to design this reverse vending machine and storage system are defining the problem, gathering information, developing concepts, and evaluating the concepts. The steps come out for embodiment design include product architecture, configuration design, and parametric design. Detail design is the last steps for design a product where all the specification are details and material of the body parts. The steps need to follow and referred to ensure the process of designing can make an innovative of the previous design or enhancement of product while maintaining the capability of the product. It is also to make sure author not missed an important steps or process along process for this project, and it also to make sure the product can fulfill customer requirement to make this product available on market [8].
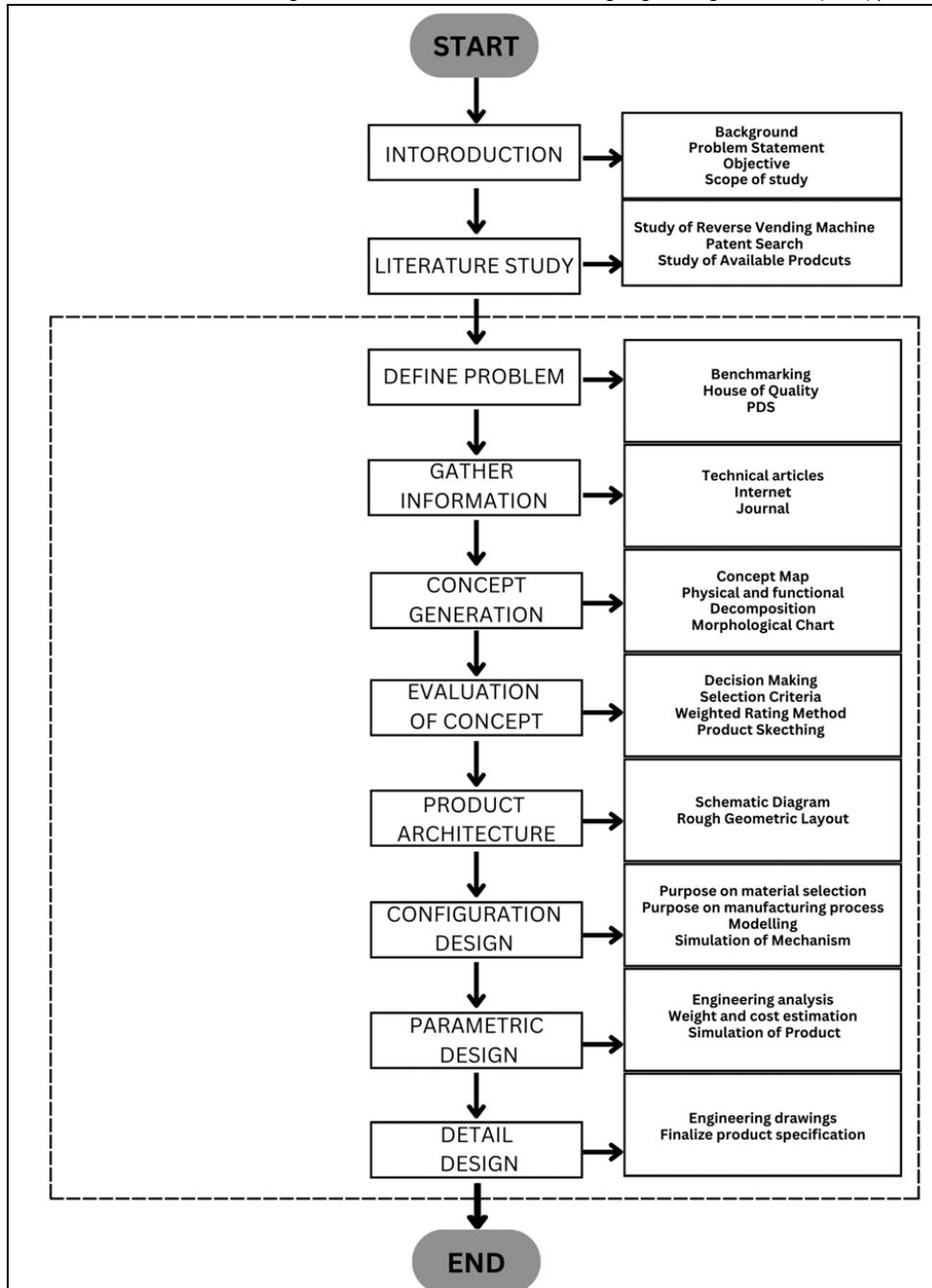
Figure 1: Project Flow Chart

3. Design Process

Methodology is essentially the process of using the research to build a project. By using techniques like flowcharts and implementation rules, the methodology employs the project design process.

3.1 Product Design Specification

In BDP I, it starts with a background study stage, where the results should be presented in a sequential order to highlight developments in the subject and gaps that must be filled. The background should be written as an explanatory description of past research and the aim of the investigation. The main source of literature review is the study of the Excel software itself where it helps in understanding a system and the method of developing a software using Microsoft Excel. This project planning was drafted as discipline that addresses how to accomplish a project within a specific timeline, typically with defined stages and resources.
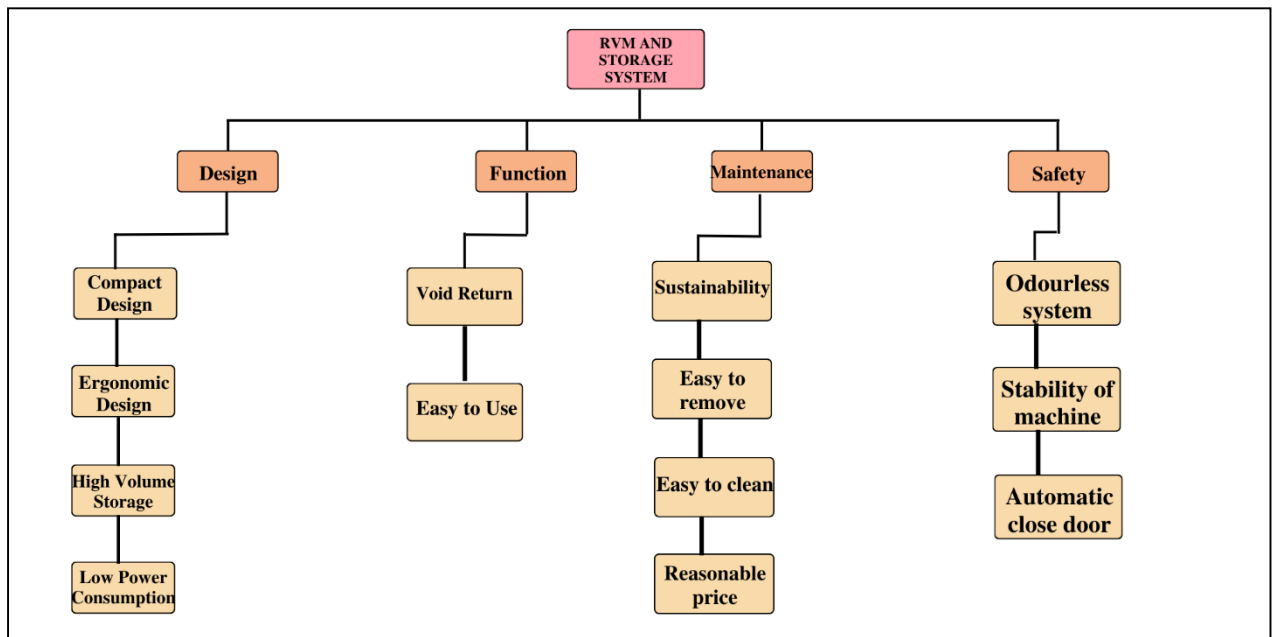
Figure 2: Objective Tree of Reverse Vending Machine

Title	Reverse Vending Machine and Storage System
Design Problem	Design a RVM that can receive multiple waste and compact storage
Intended purpose	Center of waste recycles
Special features	Odorless Storage System
Functional Performance	- Machine must be compact - Machine must be light in weight - Consume less amount of energy - Machine must have safety door
Maintenance	- Easy to perform maintenance - Maintain ability at a cheap cost - Does not require to do monthly
Design	- Machine should have ergonomic position for inlet waste - The design must look futuristic and safe - Machine must be compact
Safety	Automatic door to prevent from user to throw rubbish inside the machine

3.2 Concept Generation

The design concept for this project can be developed by following a few simple steps. The designer must now evaluate the concept considering the desires and requirements of the target audience. The steps that need to be followed to develop concept generation such as mapping concept, functional and physical decomposition, function structure and morphological chart. Figure 3 shows the function structure of Reverse Vending Machine and Storage system.
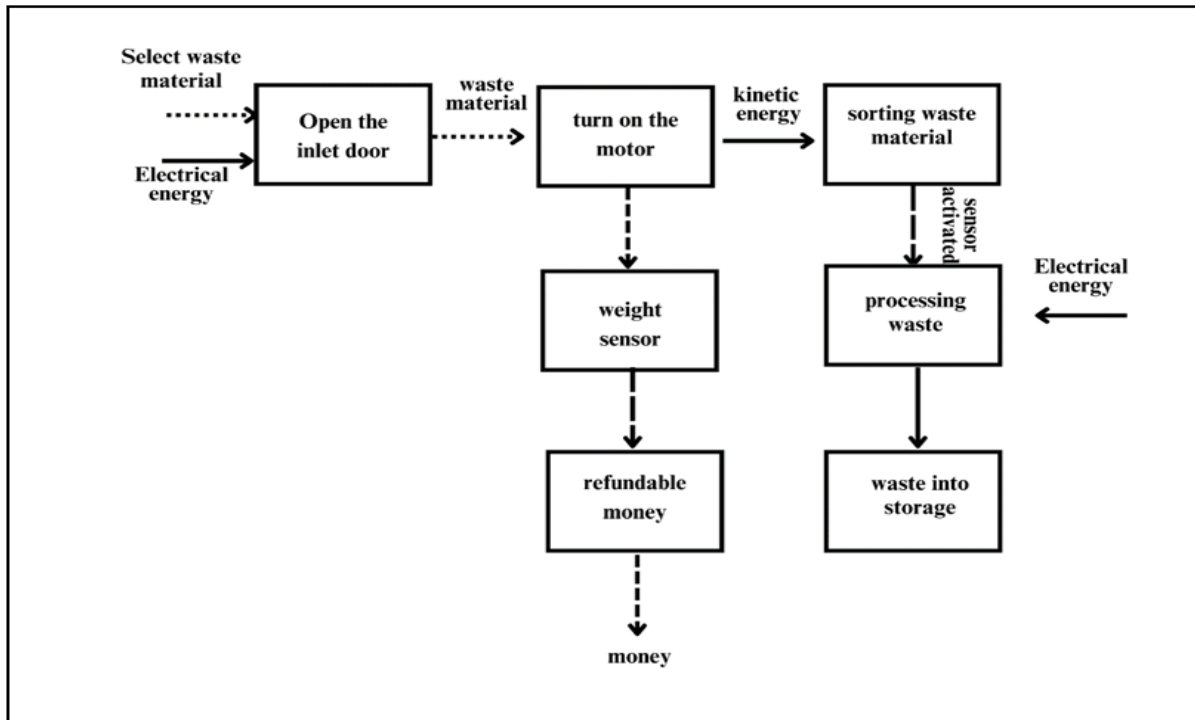
Figure 3: Function Structure

3.3 Concept Evaluation and Concept Selection

The weighted decision matrix is used to identify and assess numerous ideas with ranking criteria and factors derived from the objective tree. This is done by using the morphological chart as a starting point. With the help of this process, the author will be able to identify the most viable concept for satisfying the essential requirements posed by the client.

Table 2: Concept Selection of the reverse vending machine

No	Function	Specification
1	Open and close the door	Actuator door
2	Store the waste	Single storage bin
3	Move the storage	Single wheel
4	Seal the storage	Silicon rubber
5	Record movement of customers	Infrared camera
6	Lock the lower door	Double lever lock

3.4 Modelling

The design of the reverse vending machine was drawn by using SolidWorks Software. All component that are drawn will be assembled to form overall structure of reverse vending machine. Figure 4 shows the full assembly of reverse vending machine
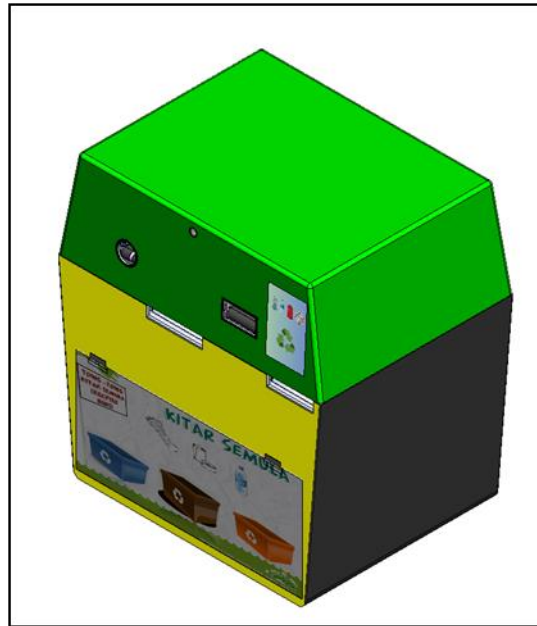
Figure 4: Full Assembly of Reverse Vending Machine

3.5 Machine Process Flow

Reverse vending machine have automatic door for safety. The user must choose what material want to recycle or to put in the reverse vending machine system. After material had been chosen, the automatic door will open to let waste material go through.

Figure 5: Movement of Automatic Door

The waste recycle then will process through the conveyer and will be shredded and keep into the storage system follows the categories. If machine detect unwanted material, the waste will be push out to the rejection system.
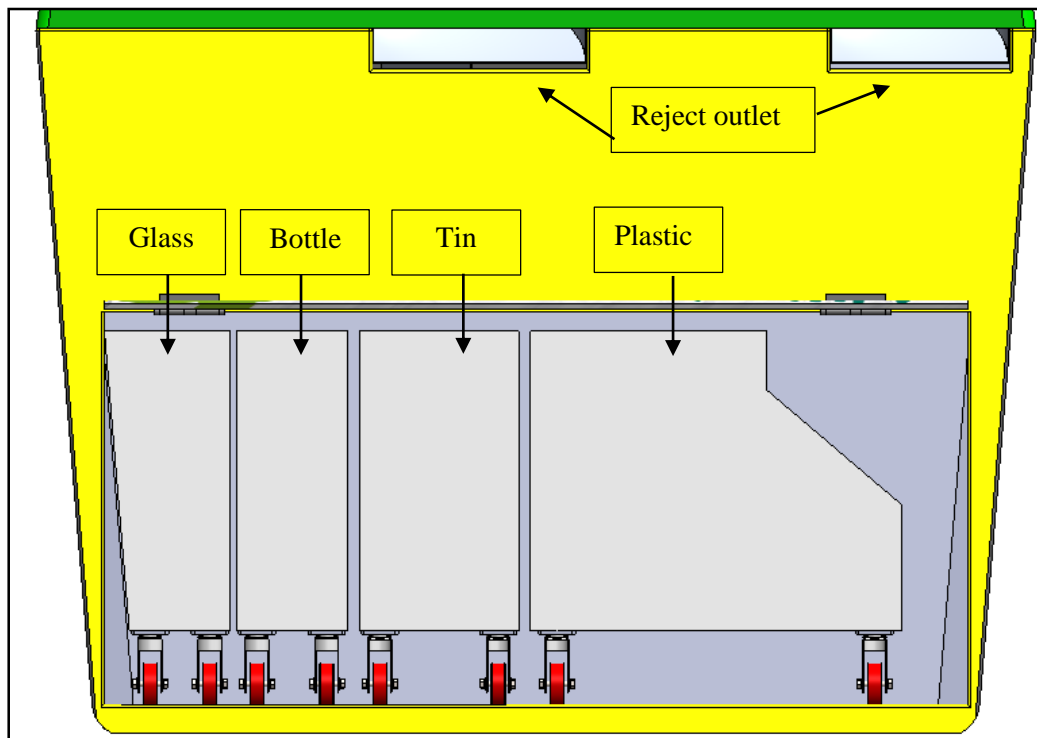

Figure 6: Rejection and Storage Reverse Vending Machine

3.6 Engineering Analysis

In this analysis, calculation of the related parameters such as weight, dimension and storage capacity are calculated. Based on calculation, it helps to design and choose material that is suitable for this project, and to prevent failure. From the analysis, the final product specification can be obtained. Table shows the Final Product Desing Specification for customer information.

Table 3: Final Product Design Specification

Product Specification	Description
Weight	499.11 kg
Size	1690mm x 1250mm x 1800mm
Maximum Storage	15,000 sheets of
	paper2488 bottle (shredded)6000 can (shredded)238 glass
Acceptance items	Glass, Bottle, Can, Paper

3.7 Body Structure Analysis

There are three important analyses has been done to the lower body frame of this machine. It was stress analysis, displacement analysis and strain analysis. The maximum displacement of this analysis is a $7.294e^{-04}$ mm and the minimum displacement of this analysis is a $1.000e^{-30}$ mm. Figure 7 shows the result of displacement analysis.
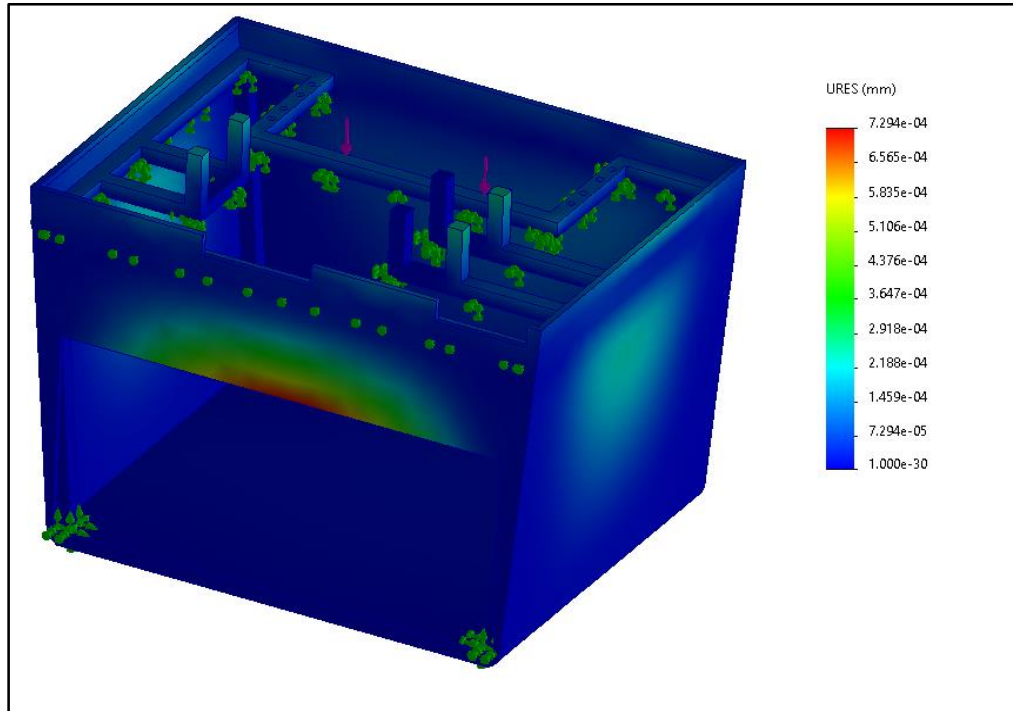
Figure 7: Result of Displacement Analysis

Then, the maximum of stress of this analysis has a magnitude of $6.573e^{+03}$ MPa and the minimum of the stress of this analysis is a $1.588e^{-01}$ MPa. Figure 8 shows the stress analysis of the body.
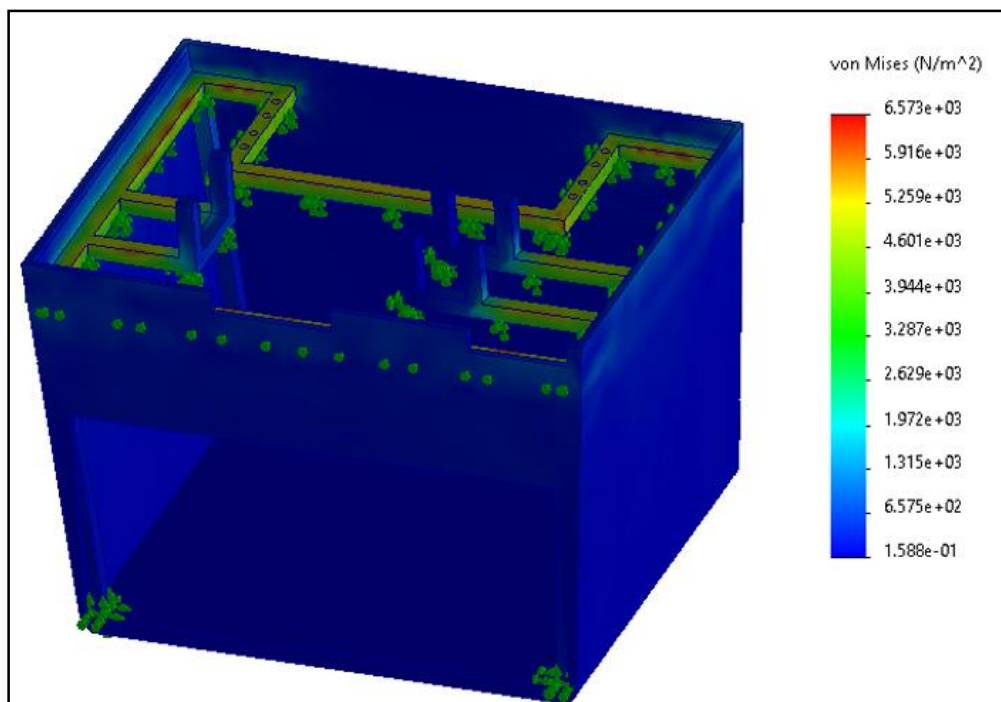

Figure 8: Result of Stress Analysis

Lastly, figure 9 shows the result of strain analysis of body frame which has maximum strain $2.71e^{-06}$ mm and minimum strain is $4.074e^{-11}$ mm.
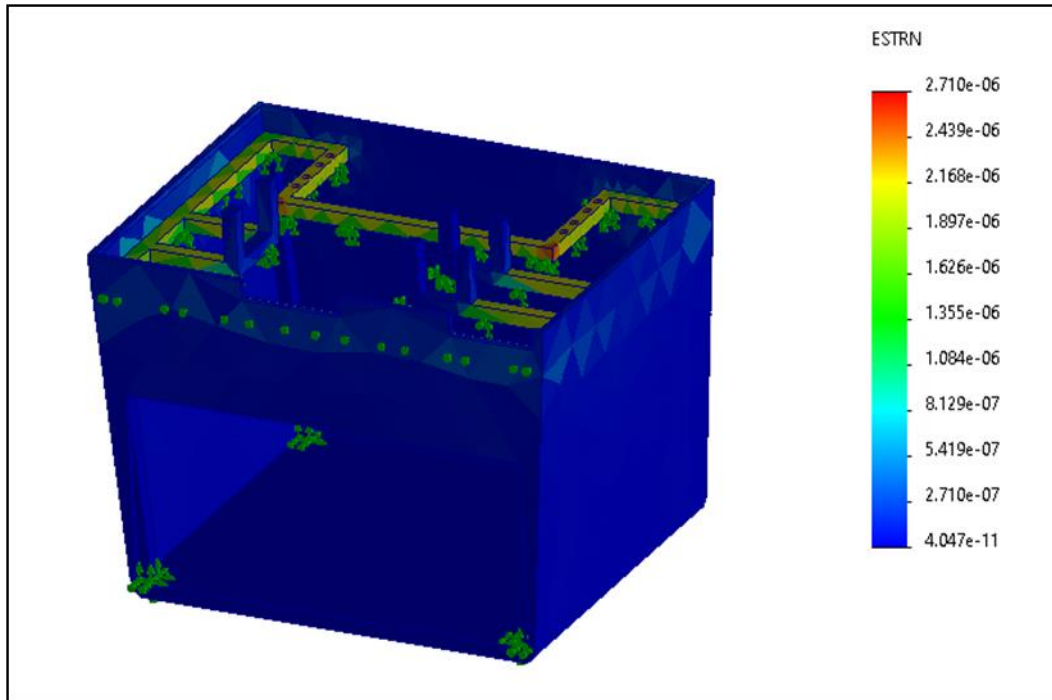
Figure 9: Result of Stress Analysis

4. Conclusion

The design of reverse vending machine has completed through steps and guidance. As a result, the machine has been successful and achieved the objectives by customer requirement. With the theoretical calculation and experimental result on the design, the machine can sustain about 400 kg of equipment and the storage can fill up to 15,000 sheets of paper, 2488 bottles (shredded), 6000 can (shredded) and 238 glass. Since the machine have been upgraded the capacity of the storage, the dimension of reverse vending machine is about 1.69m length x 1.25m width and 1.8m height. The machine expected to sell in range of below RM 30,585.97. Therefore, with this reverse vending machine, it will help Malaysia will increase recycling behavior in our country.

Acknowledgement

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