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# Trash Compressor

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**Abstract** : The Trash Compressor permits a greater input of waste in a single plastic bag while preventing direct skin contact with the trash. The compressor adopts a manually operated system for simplicity using a handle and two holders to close the plastic and compress under on seamless motion, creating more room for additional discards after each compression. This operation allows consumers to restrict daily plastic usage which severs the constant flux of single-use plastic output where would eventually lead to plastic pollution in the long run. This project's main focal point is the study and fabrication of a functional prototype of a domestic trash compressor with the appropriate mechanism in order the meet its objectives. The report scrutinizes the current on-going problems faced by the community regarding plasticpollution and unsanitary landfills which inspires the idea of fabricating a working prototype that contributes against the root cause, single-use plastic consumption. The fabrication process as well the prototype performance test will also be discussed in this report. The aim of designing and fabricating this prototype is to weigh the merits and demerits of owning a domestic trash compressor through a performance analysis in terms of capacity ability and production cost.

**Keywords**: Trash Compressor, Mechanical Compression, Solid Waste, Fabrication

## 1. Introduction

A Trash Compressor effectively aids consumers' ordeal of compressing solid wastes by hand to clear up more space for additional discards which is unsanitary and inconvenient. Organic wastes lead

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Malaysia's plight with plastic, paper, and aluminium contributing significantly. Consumers are forced to tie up the superficially 'full' plastic bags and replace it even with ample room left in the former should they compress. Relative to the conventional trash bin, a mechanically operated trash compressor will prevent consumers from directly touching the trash while also being financially reserve.

In 2019, 28.1% out of 3,098.7 thousand of discarded solid waste was recycled [1] with SWCorps' aim to increase the recycling rate as high as 40% by 2025 from 30% in 2020 [2]. Organic wastes, especially food waste, contributes the highest to Malaysia's waste plight. Malaysians waste 15,000 tons of food daily, including 3,000 tons that are still edible [3]. The average Malaysian produces 1.64kg of solid waste a day, above the worldwide average of 1.2kg according to a World Bank report [4]. The wastes generated in Malaysia are sourced from household areas, wet and night markets which is a common weekly occurrence, and restaurants [5].

At present, the number of solid waste disposal sites is at 150 across the country with 74 or 49% of them are expected to reach their life span by the end of 2020 [6]. The numbers have dropped from 176 in 2010 [7] as an initiative by the Ministry Department to reduce landfills through operation cessation of which will convert the sanitary landfills to waste-to-energy (WTE) sites. One of the examples is the plan to transform Sungai Udang, a sanitary landfill, through the adoption of the WTE system including five other sites by 2021 [8].

## 2. Project Background

The general perceptions from the public regarding trash compactor is most likely unaware due to the lack of impact the idea of compacting wastes to reduce environmental damage is. Therefore, the majority settle for a more instinctive and intuitive approach which is manually compressing by means of a hand or a tool. Though this method proves to be effective in terms of compacting the trash, it also serves as a testament that trash compressing is easible without the aid of slightly advanced technologies.

### 2.1 Current Models

#### i. Whirlpool TU950QPXS

For household-friendly products, the Whirlpool TU950QPXS is one of the most common built-in trash compactors. The design offers a flush and seamless stainless steel look, as visually shown in **Figure 1,** in the kitchen while saving customer's time and energy by reducing trash volume and trips to the curb by up to 75%. Some of its features are (1) electronic touch controls, (2) automatic anti-jam which automatically reverse the compression ram in the case of the door opening to prevent jamming, and (3) "touch-toe" drawer opener bar. The Whirlpool has a height/width/depth of 33/15/24 inches or 84/38/61 cm with almost 40 litres of interior capacity and comes with an alert feature when the bin is filled entirely after a series of 4:1 ratio compression [9]. The main materials are stainless steel for the body and metal for the handler. However, the disadvantages lie with the large dimensions and the fact it is built-in. This contributed to the total price of $1299.00 or RM5410, based on the official website [9], which is considerably expensive for the average customer in Malaysia. The large size also eats a significant amount of space which is a concerning compromise for flat houses and small residential homes.

**Figure 1: Whirlpool TU950QPXS 15-Inch Built-In Trash Compactor**

### ii. Gladiator 15-inch Freestanding Trash Compactor

Another product is a wheeled and portable version of a trash compressor with a height/width/depth dimension similar to the previous Whirlpool brand, 34/15/24 inches. The Gladiator 15-inch Freestanding Trash Compactor showcases branded unique styling complete with casters (refer to **Figure 2**) for easy mobility. It also features an anti-jamming system where the compression ram reverses whenever the door is opened during operation to avoid jamming, with an addition 4-to-1 compression ratio, and a convenient toe-touch open drawer [10].

The Gladiator costs $829.99 or RM3457 [10] which is relatively cheaper than the Whirlpool branded compactor albeit expensive nevertheless, unsuitable for the common households of low-income and space-conscious.

**Figure 2: Gladiator 15-inch Freestanding Trash Compactor**

### iii. Titan 20L Trash Compactor

The final and to which our project closest resembles is a portable, conventional trash bin sized compactor. The Joseph Joseph Titan 20L Trash Compactor offers the most convenient service of the three and is the inspiration to our project with major tweaks and addition to the overall design to accommodate the lower-income households by adopting simple mechanical techniques. The Titan boasts it can hold up trash three times more that the amount relative to a similar-sized conventional trash bin and can hold up 20L holds up to 60 litres of waste due to its height/width/depth of 27/12/13 inches or 68/30/43 cm [11].

In terms of cost, it is the cheapest of the previous two with a sticker price of RM1120.00 [11]. The Titan can be considered as the most similar to our project as it prioritizes simple mechanical mechanisms as well as customer convenience due to the lack of maintenance and installation costs. **Figure 3** below showcases the similar resemblance of the product to the conventional trash bin. The red circle indicates the location of the odour filter as an additional feature of the product.

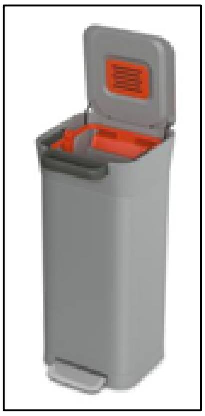


**Figure 3: Joseph Joseph Titan 20L Trash Compactor**

## 3. Methodology

Formulation is a phase for the prototype to be broken down into several parts from which, each should meet the objective and scope of the project in terms of functionality. In this case, the prototype should be able to compress and contain an amount of dry and wet wastes several times more than the conventional trash bin. Safety measures include non-sharp edges or points in the reach of small children as well any contraptions that could cause harm to users. Above all, the prototype design must be able to perform as intended as per the listed scope. The prototype should have a design in a way it could hold several more times than a regular trash bin.

In the concept design phase, the design will show the operation it undergoes to perform its task. From the formulation, this design is a result of raw ideas obtained from prior knowledge and inspirations from existing products. The existing products are evaluated to select specific ideas which can be adopted onto the prototype which later can meet the objective and scope of the project.

Configuration design is the next step where an on-paper illustration is translated into software where the final outline of the product is determined. The translated design must be able to interact with the plastic holders in such a way that the holders close the opening of the plastic as the handle is motioned downwards, compressing the wastes within the plastic, along the guide rails of the bin at its walls. SolidWorks is chosen as the software of operation in order to replicate the concept design with added animations to display the working mechanisms of the prototype. Animations are vital for this segment as it creates a 3D surround view of the prototype while operating the working mechanism simultaneously from which errors can be detected for further adjustments regarding the design. **Figure 4** showcases the final 3D model of the prototype using SolidWorks as mentioned.

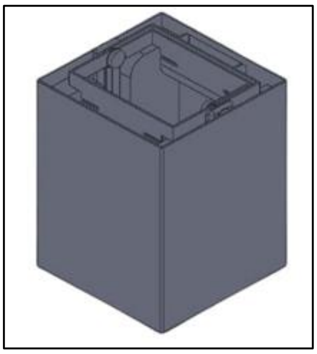


**Figure 4: Full 3D Model of Trash Compressor**

Parametric design is where every details of the prototype including measurements and materials are listed. It involves parametric values which must conform to and interact with the prototype's operating mechanism. Materials are vital for itemization of this project and must be determined using the software for a complete configuration design. With the context of our project of creating an affordable prototype, we have gone to choose polylactic acid (PLA) as our main material.

### 3.1 Final Model and Mini Fabrication

The fabrication mainly revolves around using the Creality Ender-3 V2 (refer to **Figure 5**) for each part, which are the handle and plastic holder, guide rails, tray, bin, as well as fasteners.

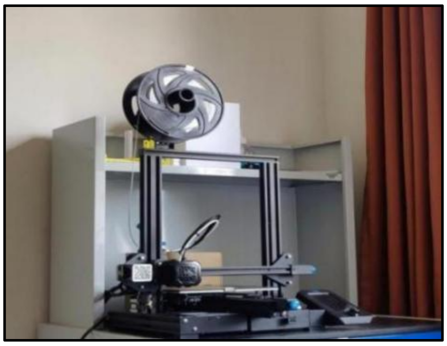


**Figure 5: Creality Ender-3 V2**

Following the printing operations, a functional mini model was fabricated which can be referenced for the full size prototype as shown in **Figure 6**.

(a)

(b)

**Figure 6: Mini Model Final Fabrication**

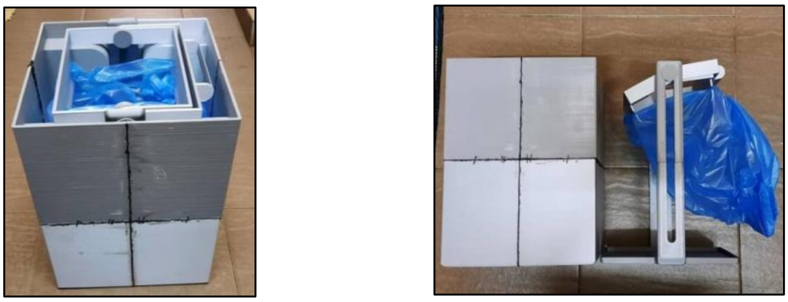
### 3.2 Performance Evaluation

To obtain value for the test, the result measured shall be in terms of the total mass of the trash able to fit in a single trash bag with a constant value. Firstly, a plastic bag is fitted into the bin. Then the bin is filled with trash until the bin can no longer hold the trash or until the bin overspills. This is to record the maximum amount of trash that can be filled in a plastic bag when the trash is not compressed. The plastic bag and its content were then placed on a digital scale to measure its mass in terms of gram. In order to obtain an accurate reading, the weight recorded is taken to 2 decimal places. After obtaining the mass of the trash without compression, a plastic bag with the same volume is then placed into the bin which is to be filled with trash to the maximum capacity. However, once the trash fills the bag to the brim, the compression mechanism is used to compress the trash. This is done until the trash can no longer be filled into the bin and it has truly reached its true maximum capacity.

To test for its efficiency, a specific amount of trash in terms of weight is used in this test. In this case, 1 kg of trash is used. The trash is then used to fill plastic bags of the same size and volume without compressing the trash using the trash compressor. The number of plastic bags used is recorded. Afterwards, the same mass of trash is then used to fill the trash plastic bags again, but this time the compressor is used to compress the trash into the plastic bag. The number of plastic bags used is then recorded. In order to find out the force needed to compress certain amounts of trash. The mass chosen for this study was 0.3, 0.6 and 0.9 kg. Trash with specified weight is compressed by the compressor with a digital scale on it to find the mass of the force applied. The mass of this force can then be calculated using these 2 formulas to find the mass and its unit mass needed to compress the trash.

## 4. Result and Discussion

From the design process of the prototype and development, a final design has been obtained in a form of a working prototype. **Figure 7** displays the result of fabrication of a full size trash compressor via 3D Printing.



(a) (b)

**Figure 7: (a) Trash Compressor (b) Bin, Handle, Frame and Tray**

### 4.1 Analysis of Product Costing

**Table 1: Cost Estimation**

| Component | Cost (RM0.10/g) | Time taken (hrs) |
|---|---|---|
| Bin | 144 | 192 |
| Tray | 21.50 | 32.25 |
| Handle | 3.50 | 5.25 |
| Front arm | 4.30 | 6.45 |
| Back arm | 4.20 | 6.3 |
| Total | 177.50 | 242.25 |

**Table 1** breaks down the costs required for each component of the prototype per gram and the time taken to fabricate. Prior to building the trash compactor, several attempts and trials have been done via 3D Printing to detect any defects and design flaws produced during the making process of both models. Factors of errors include software misconfiguration, where dimensions did not complement each other to form a coherent product, and filament selection, where prior choices came out as flimsy causing visible bends.

After several attempts of printing, improvements on the design such as minor configurations of dimensions of both left arm and right arm were made as they were not perfectly fitted thus operate properly. In addition, time estimation for the product to be completely produced has been recorded and calculated simultaneously.

### 4.2 Other Operation Costs

**Table 2: Other Operation Costs**

| Bill | Cost (RM) |
|---|---|
| 3D- Printing Machine | 1,300.00 |
| Energy consumption (RM0.02/kWh) | 38.76 |
| Sanding paper (15 pcs) | 20.00 |
| Super Glue | 6.00 |

| | |
|---|---|
| Total | 1364.76 |

The fabrication process is possible by a 3D Printing Machine. The machine the Creality Ender-3 V2 which costs around RM 999 based on the official website [12]. RM 1,300 based on **Table 2** is the summation of the machine and the prices of the filaments needed for fabrication. The usage of super glue is purposely chosen to connect the parts of each component due to size restriction from the machine which could only produce limited dimensions. Therefore, the main and the frame were required to be split into several parts from which assembly takes place. Super glue also enhances the rigidity of some fragile and thin parts such as the left arm and the right arm as Cyanoacrylate hardens well and bonds Polylactic Acid or PLA better than any conventional glue. Finally, sandpaper is used to smoothen the object surfaces from any residue during the process and to gain as a smooth surface finish as possible.

### 4.3 Analysis of Productivity and Efficiency

After conducting the performance test, it is found that the difference in mass of trash able to occupy a specific volume of a plastic trash bag is obvious. The plastic used has a specified volume of 4.8 $m^3$. By comparing the two masses obtain (refer to **Figure 8**) it is clear that the compressed trash weighed more than the uncompressed with a difference of mass of 0.348 kg. The mass compressed of trash able to fit in the same volume plastic bag is double compared to the uncompressed trash or specifically 1.956 times more.

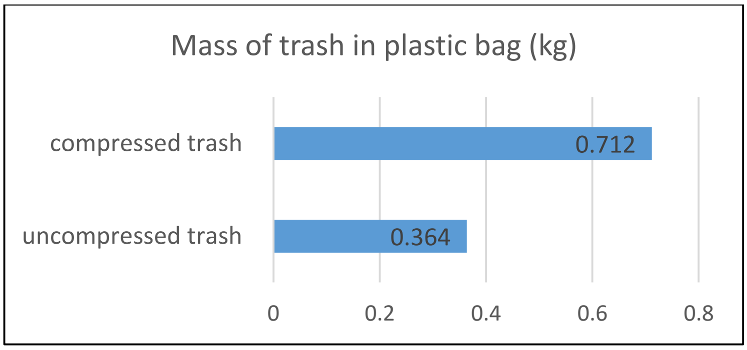



**Figure 8: Mass Comparison**

In the efficiency test, it is found that for one kg of trash, three plastic bags of the same volume specified at 4.8 $m^3$ is used. Precisely two bags full and a single bag one-third of the way full was the outcome. Meanwhile, by using the trash compressor, only half the amount of plastic bag is needed or specifically one bag full and another bag less than a halfway (40%) full. This means in terms of plastic bag usage the compressor makes it twice as efficient in utilizing the volume of plastic bags. **Figure 9** provides a visual testament to the prototype's efficacy.

(a) (b) (c)

**Figure 9: (a) Uncompressed Trash (b) Compressed Trash (c) Fixed Mass Measured**

The compression test procedures were conducted and the values were calculated by using Eq. 1 [13] and Eq. 2 [14].

$$Pressure\ (Nm^{-2} = \frac{Force\ Applied\ (N)}{Area\ (m^2)} \qquad \boldsymbol{Eq.1}$$

$$Force = Weight\ (N) = Mass\ (kg) \times Gravity\ (ms^{-2}) \qquad \boldsymbol{Eq.2}$$

**Table 3: Pressure Applied Value**

| Mass (kg) | Pressure Applied (Pa) |
|---|---|
| 0.3 | $P = \frac{F}{A} = \frac{(3.647)(9.81)}{0.0121}$ <br> $P = 2956.78\ \mathrm{N}m^{-2}$ |
| 0.6 | $P = \frac{F}{A} = \frac{(9.124)(9.81)}{0.0121}$ <br> $P = 7397.22\ \mathrm{N}m^{-2}$ |
| 0.9 | $P = \frac{F}{A} = \frac{(10.128)(9.81)}{0.0121}$ <br> $P = 8211.21\mathrm{N}m^{-2}$ |

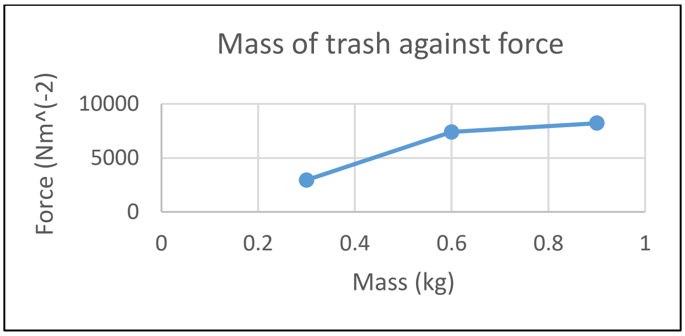



**Figure 10: Mass-Force Graph**

**Table 3** shows the amount of pressure applied based on each corresponding mass. The relationship between the two is seen as proportional based on the graph in **Figure 10**.

## 5. Conclusion

### 5.1 Key Findings from Result Analysis

From the analysis of the results of the test conducted, it is clear that the model is viable for its use in terms of its efficiency and its performance. From the performance test, it is clear that the compressor is able to perform as it is intended and achieve the goal of increasing trash capacity by 50 %. The compressor also proved its efficiency in terms of plastic bags, cutting its use by half and increase trash per plastic ratio by 1.25:2.33 which means its efficiency is 53 %. This was all done within the specified constant volume of the plastic bags used. Finally, in order to achieve the required efficiency and performance, the pressure produced from the compression can reach 8200 $Nm^{-2}$.

### 5.2 Project Limitation

Throughout this project, there are several limitations have been identified which disables the project's true expectations and capability. The first limitation is insufficient options for materials due to the 3D printing machine which is limited to only several thermoplastics. Since PLA is used for this project, the PLA can easily be deformed and warped by heat due to its low melting point (ie. 150-160°C) [15], albeit its hard and rigid condition. PLA also has a higher permeability than any other plastics as moisture and oxygen will go through it a lot easier which resulting in accelerating a faster food spoilage inside the component [15].

The second limitation is the restricted 3D-printing capability. We have successfully produced the sample model using the 3D printer but on a reduced scale. However, producing a full-scale production of the trash compactor is a true challenge for us as the machine only holds a printable volume of 220 mm x 220 mm x 250 mm [16]. The bin's height exceeds the printable table area with a total height of 295mm which shuts down the process of fabricating the bin component.

Due to cost reduction and using only mechanical mechanisms, this will lead to the final point for the limitations as the trash compactor can only be compressed when pushing downwards without any retraction mechanism.

### 5.3 Recommendations

Recommendations can be implemented to improve and overcome the previous limitations to achieve a better result. Using a plastic injection mold method will reduce the cost per unit time during manufacturing and can be produced on a large scale ~~of~~ quantity.

A final recommendation is to create a premium or high-end variant using stainless steel for the more durable operation of compacting and using a steel spring for a damp retraction to its initial position after compressing. A cylindrical dimension bin will look is recommended for a more premium design.

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