

## Development of Plastic Film Shredding Machine for Material Recovery Facility

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**Abstract:** The study aims to design and implement a specialized plastic film shredding machine tailored for Material Recovery Facilities. The machine's development is geared towards optimizing material recovery processes within MRFs, emphasizing the efficient shredding of plastic films. The research highlights the importance of addressing the specific needs of Material Recovery Facilities in terms of material processing and recovery. Designing a dedicated shredding machine for plastic films aligns with the objectives of enhancing material recovery operations at MRFs. The primary goal of the project is to improve efficiency and recovery rates within Material Recovery Facilities through the utilization of an advanced plastic film shredding machine. By focusing on specialized equipment development, the study aims to streamline material recovery processes and maximize resource utilization in El Salvador City's Material Recovery Facilities.

**Keywords:** Plastic Film, Waste Recovery, Shredding Machine, Material Recovery

**Introduction:** Consumers in high-income countries generate more plastic waste per capita than those in middle- and low-income countries because they have more spending power and can buy a wider range of plastic-packaged goods. Mismanaged plastic waste in developed countries is beginning to decline, thanks to the introduction of plastic waste management systems. As a result of their poor or non-existent plastic waste management systems, middle and low-income countries have become the primary sources of global plastic pollution, with up to 90% of plastic waste properly disposed of [1]. Plastic bottles, bags, food containers, gloves, and cups that end up in landfills and the environment could linger for hundreds to thousands of years. Furthermore, the COVID-19 pandemic caused by the novel coronavirus (SARS-CoV-2) exacerbated global plastic pollution as the use of personal protective equipment (PPE i.e., gloves, and masks) became imperative to prevent the spread of this Plastic, which eventually degrades into micro and nanoscopic particles as a result of physical, chemical, or biological action in the environment, can enter the animal and human food webs. As a result, plastic management programs must become more robust, with a focus on preventing micro and nano plastics from entering the environment and food web [2]. Approximately 70% of waste is collected in urban areas, with the remaining 40% collected in rural

areas. In some cases, waste is collected by organized bands of eco-aides (for example, Linis Ganda in Metro Manila), who collect more waste than informal street collectors. They act as go-betweens for junkyards and waste consolidators. There are some conflicting waste regulations. While the Philippines encourages the assimilation of the informal sector into SWM, waste picking in dumpsites and segregation areas is prohibited unless permitted by the operator (often for a fee). Although waste separation at the source is required in the Philippines, it is rarely practiced [3]. Representatives of the #BreakFreeFromPlastic movement have renewed their call for the government to impose a blanket prohibition on single-use plastics, mandating businesses to phase out their use. Following the release of the Philippine version of the 2020 Brand Audit Report, which revealed that only three corporations are responsible for nearly half of the country's plastic waste, the call was made. According to the report, the top three corporate plastic polluters in 2020 were Universal Robina Corporation (URC), Nestle, and Colgate-Palmolive. URC, Nestle, and Colgate-Palmolive account for 46 percent of the total 38,580 plastic items collected, with URC accounting for 6,350, Nestle for 6,168, and Colgate-Palmolive for 5,580. Non-recyclables, such as sachets, that have no economic value to reward collection and cannot be handled sustainably, accounted for an alarming

91 percent of the total collected plastics, according to the report. According to the organizations, this figure demonstrates that recent efforts by FMCGs to increase their so-called recycling efforts have been completely ineffective in addressing plastic pollution in the Philippines [4].

Universal Robina Corporation's El Salvador Misamis Oriental plant (URC ESMO) responds to the Environment Management Bureau Region 10's (EMB X) call to recycle waste. On June 25, 2021, URC ESMO donated 30 kilograms of shredded plastic laminates in support of "Sachet Mo, Palitan Ko," an EMB X community pantry project that provides a food package consisting of basic goods/food in exchange for a kilo of sachet or plastic laminates. According to Reynaldo Digamo, Regional Director of EMB X, this paved the way for the success of the eco-bricks production.

To date, the city government of El Salvador has collected waste plastic from these industries for proper disposal via Materials Recovery Facilities. While other waste plastics were properly disposed of, the URC Company's plastic waste in the form of snack sachets posed a challenge. The existing plastic bottle shredding machine purchased by the city government appeared to be ineffective in cutting the snack food plastic film bags to the desired size for use as an additive material in the molding process in the brick-making of El Salvador City.

Given the above-stated problem, the researchers conducted the study through the Development of a Plastic film shredder machine for the Material Recovery Facility for El Salvador City. The proposed roject can help reduce the present stock of Plastic films from snack foods collected from URC company stored at the Material Recovery area of El Salvador City, thus maximizing the utilization of the space for other equally important government purposes.

**Objectives:** The main objective of the study is to come up with a plastic-film waste shredder that can produce output size for proper recycling and use in brick-making by the city of El Salvador. Thus the study aims to design, develop, and assess the Plastic Film Shredder machine via performance evaluation to attain the desired output.

Specifically, the study aims to:

1. Design a plastic film shredder machine to reduce the plastic waste size for brick-making additives.
2. Develop an effective Plastic Film Shredder machine for Material Recovery Facility for El Salvador City.
3. To assess of the Plastic Film Shredder machine via performance evaluation to attain the desired output.

The study's conceptual framework was described using the input-process-output (IPO) model. The relationship between the variables in the current study is depicted in Figure 1 This framework has had a significant impact on recent empirical research, with much of it explicitly or implicitly referencing the IPO model. Three dimensions comprise the conceptual framework: input, process, and output. Inputs result in processes, which result in outcomes.

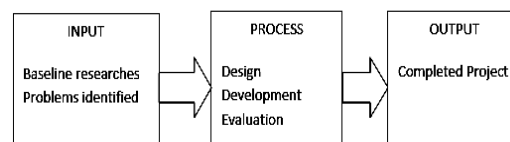


Figure 1. IPO Framework

## Methods:

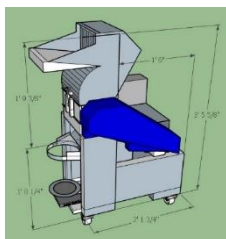
### Research Design

The study utilized quasi-experimental research interrupted time-series design to achieve the researcher's goal in terms of the predetermined outcome. It is the systematic process of designing, developing, and evaluating educational programs, processes, and products to meet internal consistency and effectiveness criteria. After the researcher has gathered all of the preliminary research findings, the next step is the design and development of the prototype, followed by an evaluation of the prototype.

### Design

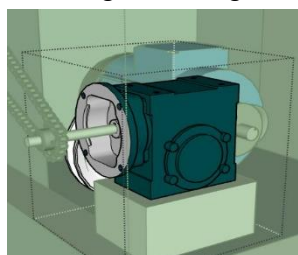
The external dimensions of the Aluminum Plastic Shredder are divided into two distinct systems: the shredding system and the weight limit system. The concept design of the study shows all of the components used in each system, including both electrical and mechanical components. The isometric view of the conceptual design shows the actual widths, lengths, and heights used in the prototype as depicted in Figure 2. It indicates the

overall size of the Integrated design of the shredding system.



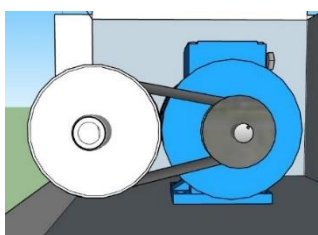
**Figure 2. Concept Design**

An exploded view of the Aluminum Plastic Shredder is shown in Figure 3. The aluminum plastics that are fed into the hopper and are shredded by the machine. There are several different types of components in the aluminum-plastic shredding machine; these include an electric motor, a gear reducer, a belt and pulley, a chain and sprocket, and a control box, among other things.



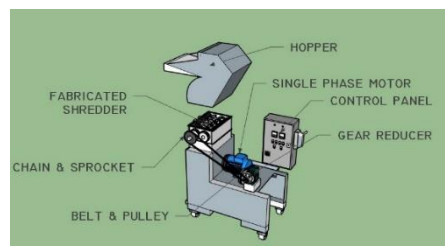
**Figure 3. Exploded View**

The belt and pulley showed in Figure 4 transfer energy from the motor having a rating of 1790 RPM; the belt is a circular rubber utilized to connect the pulley on the gear reducer and the electric motor. The size of the belt is dependent on the size of the pulley on both the electric motor and gear reducer. The computational data shows the design specifications of the first stage of the power transmission. The most important of the belt drive system in transmitting power is the angled contact at the smaller sheave because the higher the angle of contact of the belt, the greater the friction it can be made. The greater the friction develops in the sheave and belt, the greater they hold to each other and it can prevent the belt to slip from the sheave.



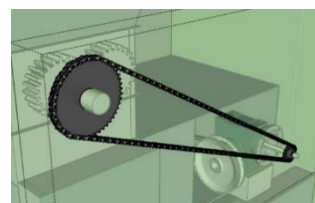
**Figure 4 The Belt and Pulley**

In Figure 5 shows the gear reducer connecting to the chain and sprocket from the belt and pulley. A mechanical component to convert a high speed into a lower speed depends on its ratio, the gear reducer is used in the prototype to increase the power of the shredder to cut Aluminum plastic. In this stage, the gearbox speed reducer with a speed ratio of ,this speed have a greater speed reduction. On the other hand, speed reducer used in the system not just to have a high-speed reduction but also to lessen the space occupied by transmission in the system



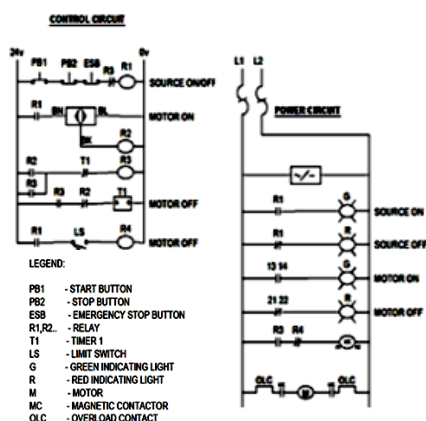
**Figure 5 The Gear Reducer**

In Figure 6 shows the chain and sprocket connected to the shredder blades. Chain and sprocket use in the machine to have more power regarding the shredding process. In the final stage, the designer used chain and sprocket because chain drive is very suitable speed transmission drive in terms of preventing slippage in the system. The output RPM needed is approximately 60 RPM to shred the plastic 1 revolution of the blade per second.



**Figure 6 The Chain and Sprocket**

The electrical circuit design used in the system undergoes systematic computations to distinguish the required parameters for the electric motor, gears, belt, chain, and gear reducer utilized in the study. Figure 7 shows the motor control and power circuit diagram used in the system.



**Figure 7 Motor Control and Power Circuit Diagram**

**Sampling Procedure**

The shredded Film plastic waste materials were used to evaluate the performance of the machine after its development. The MTC (Machine Throughput Capacity) of the machine was determined by observing the shredding time using a stop watch for various input masses starting from 5kg to 100kg with 5kg increment with a total of Twenty (20) sample data.

**Statistical Technique**

For the purposes of data analysis and interpretation, the collected data was statistically treated and quantitatively described. The time-series study designs, rates are collected at several periods, allowing the variations in the mass of plastic waste per unit of time to be empirically estimated and compared with the mean value.

**Results:** This presents the empirical outcomes of the investigations and providing a comprehensive analysis of its implications. In this section, the researchers meticulously examine the data garnered from experimental endeavors, exploring the patterns, trends, and relationships that emerged. The ensuing discourse delves into the significance of these findings within the context of the research objectives, elucidating their alignment with existing theories, and ultimately culminating in a nuanced understanding of the subject under investigation. The prototype design is derived from the foundational research completed on existing shredder machines, with the aim of improving the efficiency, mobility, and usefulness of the prototype. The accompanying photographs depict a

visual representation of the contrasting design and component arrangements observed throughout the initial stages of the prototype. Figure 8 below depicts the view the design with the physical manifestation of the design prototype.



**Figure 8. Actual Picture Prototype**

The belt and pulley which transfers energy from the motor to the shredding blades (shown in Figure 9) have a rating of 1790 RPM; the belt is a circular rubber utilized to connect the pulley on the gear reducer and the electric motor as shown in Figure 10.



**Figure 9. Shredding Machine**



**Figure 10. Electric Motor**

Figures 11 and 12 below shows the Panel Board enclosure to protect the connections that controls the shredder machine; as well as Circuit Breakers, Light Indicators and Push buttons for electric motor control operation



**Figure 11. Control Panel**



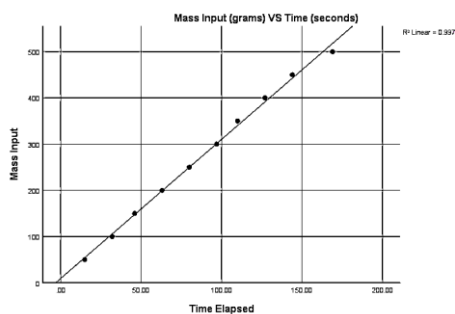
**Figure 12.**

**Control Panel Connections**

Table 1 shows the MTC (Machine Throughput Capacity) and efficiency of the machine for various masses tested during the performance evaluation. While the data on the efficiency of the machine was plotted against variations shown in Figure 13 in the mass of plastic waste introduced into the machine for shredding.

**Table 1. Performance evaluation of the Plastic Film Shredder Machine**

Mass Input (g)	Mass Output Shredded (g)	Time (sec)	MTC (Machine Throughput Capacity) (g/s)	Efficiency (Output/Input)
50 g	49 g	15	3.33	98%
100 g	98 g	32	3.13	98%
150 g	148 g	46	3.26	98.67%
200 g	198 g	63	3.17	99 %
250 g	246 g	80	3.13	98.4%
300 g	295 g	97	3.09	98.33%
350 g	347 g	110	3.18	99.14%
400 g	394 g	127	3.15	98.5%
450 g	448 g	144	3.13	99.55%
500 g	495 g	169	2.96	99%



**Figure 13 Efficiency of the Machine**

**Conclusions:** Based on the performance evaluation conducted through MTC (Machine Throughput Capacity), it is clear that the machine's efficiency is influenced significantly by the mass of plastic waste being shredded. Analyzing the data on efficiency concerning variations in mass reveals several key insights. Initially, as the mass of plastic waste increases, the machine's efficiency improves due to optimized processes and resource usage. However, beyond a certain point, diminishing returns set in,

where adding more mass does not proportionally increase efficiency. Factors like mechanical constraints, heat generation, or material handling challenges could contribute to this phenomenon. There appears to be an optimal mass range where the machine operates most effectively. Within this range, the machine efficiently shreds plastic waste while maintaining high efficiency levels. Operating within this range maximizes performance and minimizes resource consumption. Below a specific threshold mass, the machine's efficiency may decrease significantly due to inefficient resource utilization or inadequate processing conditions. Identifying this threshold is crucial to ensure the machine operates within its intended capacity. When contemplating scaling up operations or adjusting the machine for different capacities, understanding the relationship between mass and efficiency is vital. Scaling may necessitate modifications to the machine's design or operational parameters to uphold or enhance efficiency across various mass ranges. Efficiency can vary not only with mass but also with factors like material composition, feed rate, and operating conditions. Continuous monitoring and optimization are essential to maintain consistent and efficient machine operation.

The efficiency of shredding plastic waste is closely tied to the mass of material processed. Understanding this connection enables the optimization of machine performance, resource utilization, and operational efficiency, fostering more sustainable waste management practices not only applicable to El Salvador City but to the entire nation.

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