International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 12 Issue 3, March-2023, Impact Factor: 7.957

Chompix®- A Plastic Pre Recycler

(IP India - Full Patent Application No. 202341001923
US PTO: Provisional Patent Application No.63296506)

Neeraj Nagaraj

Research Scholars Program, Harvard Student Agencies, In collaboration with Learn with Leaders

ABSTRACT

Plastics are lightweight, inexpensive, and durable synthetic materials that can be molded, extruded, or pressed into solid objects of various shapes. This adaptability has led to its widespread use. The consequence of this was the increased production of plastics. A major portion of the plastic produced each year is used to make disposable items of packaging or other short-lived products that are discarded within a year of manufacture. This shows that the current use of plastics is not sustainable. In this paper, we propose a system for recycling Polyethylene Terephthalate (PET or PETE) bottles. We are designing a vertical standing system that cleans, dries, shreds and creates a block of plastic that can be further taken to the factory for reusing by employing additional manufacturing processes. This will be a fully automatic system that will be assisted by a timing circuit that controls the motor movements and activation of various parts of the system. There are similar systems available that crush the bottles and shred them. But it becomes difficult to transport this shredded plastic as they have to be packed in a separate bag manually. Our proposed solution tries to solve this issue by creating blocks of plastic that are easy to carry around.

Keywords: Recycling, Plastic, Shredding, Polymer.

Subject: Robotics Engineering

INTRODUCTION

Approximately 50 percent of plastics are used for single-use disposable applications, such as packaging, agricultural films, and disposable consumer items. Most types of plastics are not biodegradable. The majority of polymers manufactured today will persist for at least a decade and probably for a century. As a consequence, substantial quantities of plastics are accumulating in landfills and as debris in the natural environment, resulting in both waste-management issues and environmental damage. Due to its slow decomposition rate in natural ecosystems, plastic has caused widespread environmental problems. Recycling is one of the most important actions currently available to reduce these impacts and represents one of the most dynamic areas in the plastic industry today. Recycling plastics provides an opportunity to reduce the oil usage and carbon dioxide emissions associated with the manufacturing of plastics. Recycling plastics is one of the methods for reducing environmental impact and resource depletion. It can decrease energy and materials used per unit of the output and so yield improved eco-efficiency. In this paper, we are attempting to create an easy-to-use plastic recycling machine that will help to recycle the everyday used PET bottles by cleaning them, drying them, shredding them, and then compressing them into a rectangular mold of a plastic brick. This plastic brick can then be used for further applications like mixing it with other polymers and used in construction work, melting it completely, creating new PET bottles, etc.

Recycling plastics is the need of the hour but very few steps have been taken for the same. Even though the use of single-use plastics has been banned, there are still a lot of other plastics that create the bulk of the plastic wastes - PET bottles forming a major part of it. Here we are attempting to design a novel Plastic Recycler device that will help in recycling these PET bottles. A Plastic Recycler is an automatic machine that can be placed in any public place for people to use. The working of the Plastic Recycler can be explained using 4 main steps - Cleaning, Drying, Shredding, and then Shaping. The used PET bottles of packaged water or soft drinks are fed into the machine in the input area. These bottles will then be cleaned with soap and water, clearing any kind of leftovers inside them. Then it is dried using

hot air. These clean and dry bottles are then put into the shredder process, to shred. The shredded pieces of plastic are then shaped into a brick by compressing.

PROPOSED METHODOLOGY

Working

The design and working of the proposed Plastic Recycler will be described in this section. The construction of the Plastic Recycler is mainly done using sheet metal. The design of the recycler has been through various iterations of design modifications. Only the components used in the final design have been explained in detail in the below section. The main components used in the design are listed below.

1. Outer Drum
2. Inner Drum
3. Shredder
4. Conveyer belt assembly
5. Compressor

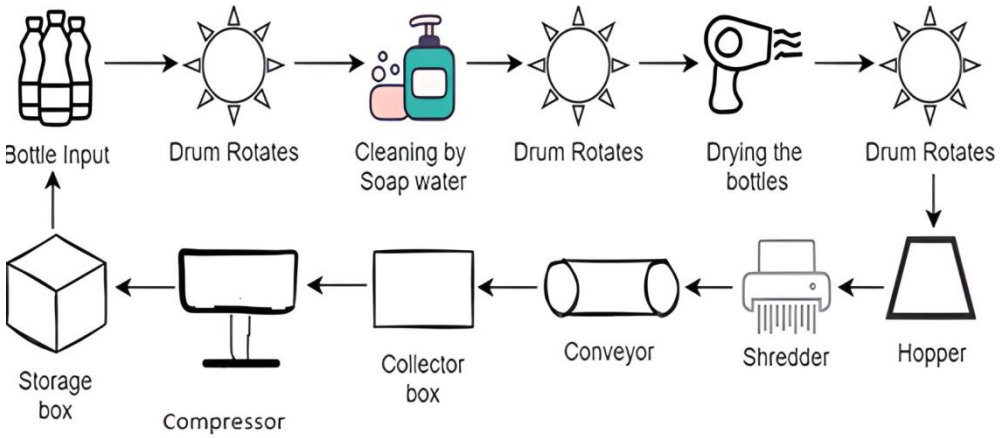

Figure 1: Workflow of the proposed system

Plastic PET bottles which we use in our everyday life like soft drink bottles can be recycled using this system. The proposed system has the shape of a vending machine. Its overall dimensions are 1.3m x 1m x 2m (L x B x H) including all the attachments. The machine has an input area where people can put the bottles for processing. The input area is covered by a transparent plastic door. The person can put the bottles on the rod by opening the door. After the bottles are placed, the person can activate the machine by pressing the start button. This will start the machine and the recycling process begins. The rods are part of the outer drum. This outer drum is rotated by a motor that is controlled by the timer circuit. This motor aligns the rods with the holes on the inner drum. After the holes are aligned with the rod, a pump is activated which is positioned inside the inner drum. This pump will spray water from the holes, through the rod, and into the bottles. The rods have holes at various locations and so will help clean the bottle. Slot holes have been made on the drums so that the water from the bottle drains back into the inner drum.

The raised portions around the rods will prevent any leakage. The pump will be on for a specific time, controlled by the timer circuit. After the cleaning, the motor rotates the outer drum to make the rods vertical. This will help in draining out all the water inside the water. At this position, another set of holes on the inner drum is aligned with the rods on the outer drum. This activates the hot air blowers. The hot air is blown through the rods to help dry the bottles completely. The rotation of the motors and activation of the hot air blowers is controlled using programmed circuits. After the bottles are dried, the outer drum rotates and goes back to its initial position in the input area. During this rotation, the bottles fall into the hopper of the shredder due to gravity. This activates the shredder motors. The cutting blades of the shredder pull the bottles in and shred them into tiny pieces. The activation of the shredder motors also activates the motor for the conveyor belt. The shredded pieces of plastic are collected by the conveyor belt and dropped into the collector box. The motor of the conveyor only stops a few seconds later, after the shredder motor stops. The collector box collects all the shredded plastic and when it's filled, the compressor which is powered compresses the plastic. After this using a sensor, the bottom of the receptacle is moved and the compressed block falls down. The compressed cube falls into the storage.

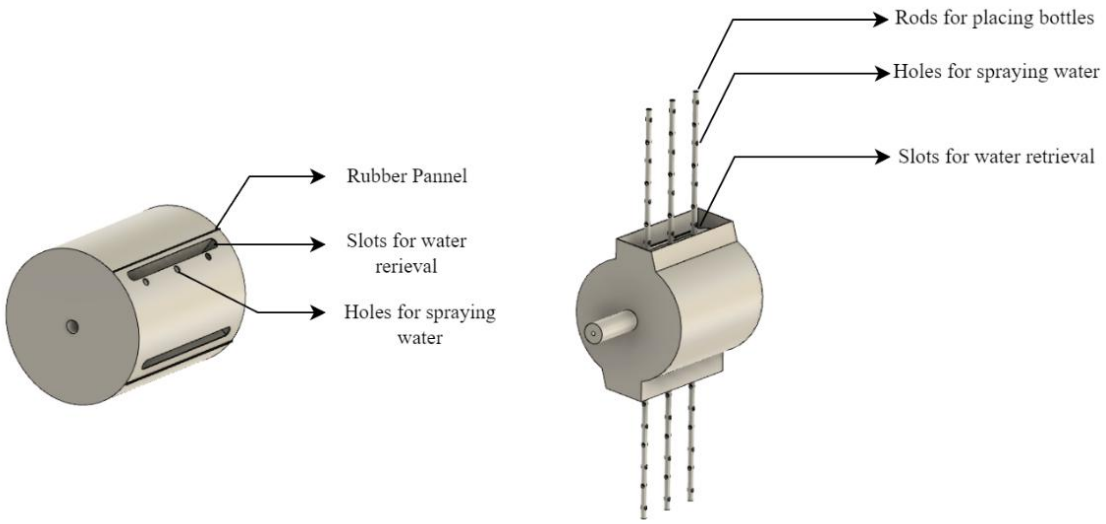

Figure 2: Inner and outer Drum description

The first process of recycling plastic is by cleaning it. For this, we have designed a rolling drum system. The rolling drum has 2 concentric drums - The inner drum and the outer drum. The inner drum is fixed while the outer drum rotates around it. The outer drum has 6 rods - a set of 3 rods each separated by 180 deg. At a given time, a set of 3 rods will be stationed at the input area. The input area is where people can put the bottles. 3 bottles can be put on the 3 rods. The rods have holes in them so that water can be sprayed through them for cleaning the bottles. The general dimensions for 2L PET bottles have a height that varies between 300-310mm, and a diameter of approximately 100-120mm. The length and spacing between the rods have been made considering these dimensions. At a time, 3 such bottles can be easily placed on the rods. There are two slots provided beside the rod so that the water that drains back from the bottle goes back to the partition with water, which is present inside the inner drum. The slots are surrounded by a raised portion that will prevent water from leaking into other places. This outer drum will be connected to a motor and controlled using the sensors. The inner drum is fixed to the enclosure walls. Inside the inner drum is a separate partition that has a pump for spraying water and a container for water. On the other partition, we have attached hair dryers that will blow hot air to dry the bottles. There are two slot holes to allow water to flow from the outer drum to the water container partition in the inner drum. There are rubber panels that will prevent water from leaking inside the inner drum.

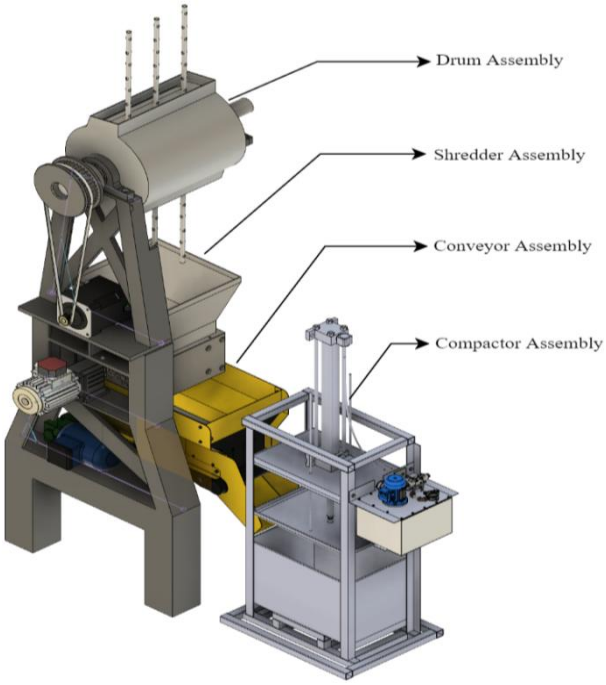

Figure 3: Unit Assembly

The next step after cleaning and drying is shredding the bottles. For this, we have created a shredder assembly that has a hopper to intake the bottles. Below the hopper are two sharp-edged circular cutting blades. They are controlled by a powerful motor thus enabling the shredding of the plastics. As per the arrangement of the drum assembly and the shredder assembly, there was a lot of space being left out. To occupy those spaces and make the final device as compact as possible, we are making use of the conveyor belt. The shredded plastic will be collected by the conveyor belt and dropped into the shaping box.

Electronics components

Once the Mechanical design aspect was completed the actuators required to drive this system were selected. Design considerations have been made before selecting a particular component. Adequate safety factor has been included while selecting components. The electrical components required to drive the entire system are listed below.

1. Water pump
2. Shredder motor
3. Motor For Outer Drum
4. Motor for conveyor belt

RESULTS

Calculation

Volume of the Collector box	9562.5 cm^3
Weight of an empty 2L PET bottle	54 gms (approx)
Density of PET	1.38 g/cm^3
Mass of PET that can be collected in the Collector box	13200 gms

Therefore, the number of bottles to be shredded to obtain this will be around 250 bottles.

LITERATURE REVIEW & DISCUSSION

Goodship (2007) in her review paper discusses the issue related to recycling of plastic and plastic disposal. The paper gives an insight into the feedstock requirement in different phases of plastic recycling. Shen and Worrell (2014) in their book talk about how recycling is a challenge. They also talk about the quality of recycled plastic. Since in most cases the quality of the recycled plastic is low causing them to be not utilized properly after the recycling process. On average, only 25% of the total plastic waste is recycled in the EU. Miliosa et al. (2018) mentions how supply-demand-related issues cause barriers in Plastic waste recycling. They attribute the above issue to the fragmented market of the secondary material. Focus has been put on increasing the capital investment for research and innovation related to plastic recycling. Nkwachukwu et al. (2013) discuss various ways in which plastic decomposition can happen naturally. Discussion about unauthorized dumping sites due to lack of proper official channels is highlighted. Also, the effect of unauthorized dumping on the plastic recycling process is pointed out. Satapathy (2017) conducted a study on different plastic recycling methodologies currently being used in India. Barriers faced in each methodology are highlighted based on the cluster. The main issues include the lack of proper awareness, no proper government policies, and very low demand for recycled products. Ugoamadi and Ihesiulor (2011) have proposed a plastic recycling machine that gives 97% recyclability and a thorough output capacity of 265Kg/hr. The machine just requires 2 people to operate with a very low power requirement. Eriksen et. al. (2018) discusses the effect of metal contamination in the plastic which is being recycled. Metal is added during the manufacturing phase of the product to enhance certain properties of the product itself. However, during the recycling phase, these can cause issues. It was found that the level of Mn was above the acceptable limit.

CONCLUSION

Recycling plastic is the most important step that can be taken for the betterment of our planet. Even though there are industrial procedures in place, they should start with the common people. Our proposed system will help in recycling PET bottles which form a major part of our everyday plastic waste. Our proposed system can be placed in public places like gardens, railway stations, and other places of public gathering. The bottles will be cleaned, dried, shredded, and compressed into blocks. This plastic block can then be used for industrial applications like construction work, chemical additions to create new products, etc. This system will run on a single-phase 240V supply and so can be connected to any normal power source. It can process any PET bottle without any restriction of size. As per our calculation, at least

250 2L bottles will be needed to create 1 plastic block. There are provisions for changing the water for cleaning and removing the plastic blocks from the storage box. This proposed solution will be a starting step toward plastic recycling at the grassroots level. We will be working on improving this system by reducing its overall dimensions, including all kinds of plastic material for recycling, increasing the storage capacity of plastic blocks, etc.

FUTURE SCOPE

The proposed system uses PET bottles, cleans, shreds, and converts them to bricks. The system can be expanded so that other forms of plastic can be introduced into the system in the same way. Additional layers of process can be introduced so that different types of plastic can be converted into bricks with different compositions. A sensor array can be integrated into the conveyor belt system so that plastic waste with different sizes and compositions can be segregated before the brick creation process is started. As of now, the system is not autonomous as the bricks get filled into a tray which needs to be replaced when it is full. A conveyor belt system with a segregation mechanism can be introduced so that different types of bricks get sorted and placed on the respective conveyor belts.

REFERENCES

[1]. Goodship,V. (2007). Plastic recycling. *Science Progress, 90(4),* 245–268.
[2]. Shen, L., & Worrell, E.(2014). Handbook of recycling, Chapter 13. *State-of-the-art for Practitioners, Analysts, and Scientists*, 179-190.
[3]. Christensen, C., Christensen, L.H., Eriksen, M.H., McKinnon, D., Miliosa,L., & Rasch, M.K. (2018, June). Plastic recycling in the nordics: A value chain market analysis. *Waste Management Volume 76*, 180-189.
[4]. Albert,L., Chima, C.H., Ikenna,A.O., & Nkwachukwu, O.I. (2013). Focus on potential environmental issues on plastic world towards a sustainable plastic recycling in developing countries. *International Journal of Industrial Chemistry Volume 4*, Article No.34.
[5]. Satapathy,S. (2017). An analysis of barriers for plastic recycling in the Indian plastic industry. *Benchmarking: An International Journal.*
[6]. Ihesiulor,O.K., & Ugoamadi, C.C. (2011). Optimization of the development of a plastic recycling machine. *Nigerian Journal of Technology.* Vol. 30 No.3.
[7]. Astrup.T.F., Eriksen, M.K., Olsson, M.E., & Pivnenko, K. (2018, September). Contamination in plastic recycling: Influence of metals on the quality of reprocessed plastic. *Waste Management Volume 79*, 595-606.