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Towards the Design and Fabrication of a Sheetpress Machine for Plastic Recycling

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ABSTRACT

A recycling machine is a device that transforms plastic materials into granules for use in the manufacture of new goods. An element of environmental engineering is recycling. Environmental engineering focuses on creating systems (machines) to manage wastes produced by public and private sectors of industry in order to find technically sound solutions to environmental issues. Since plastics are not biodegradable and require significant energy to manufacture from raw materials, their buildup after usage poses a threat to the environment. Our study lays the groundwork for future contributions to the technological advancement of recycling machine design and production in both rural and urban locations, resulting in job opportunities and sustainable waste management. The goals of our research are outlined in this publication.

Keywords: Recycling, Plasric, Designing, Building, Degradable Mterials, Accumulation.

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1. BACKGROUND OF THE STUDY

PLASTICS

Natural or artificial resins or compounds can be molded, extruded, cast, or used as films or coatings to create plastics. It can also be defined as an organic material that may be caused or flow under heat and pressure and can be moulded into desired shapes through some mechanical processes. Most plastics are organically composed of hydrogen, oxygen, carbon, and nitrogen (Adekunle Y, 2019).

Large, organic (carbon-containing) molecules make up plastics, which are materials that may be shaped into a wide range of goods. Long carbon chains make up the molecules that make up plastics, which are what give them many of their beneficial qualities. Polymers are often defined as substances consisting of lengthy, chain-like molecules. The terms plasticus (Latin for

"capable of molding") and plastikos (Greek for "to mold," or "fit for molding") are the origins of the word plastic. Plastics can be manufactured as strong as steel, translucent as glass, lightweight as wood, and elastic as rubber. They can even be created to be hard like stone. Plastics are also made in nearly every hue, are lightweight, waterproof, and chemical resistant. Plastics are in more than 50 families, and more are being developed all the time. Plastics are available in a range of grades, just like metals. For instance, nylons are plastics that differ from one another in terms of their characteristics, price points, and methods of production. Similar to how metals can be alloyed, some polymers can also be blended to combine their advantages. For instance, several types of heat- and impact-resistant plastics are created by combining other plastics. Moldable synthetic (chemically produced) materials, such as oil, coal, and natural gas, are the main sources of plastics. Other materials, like glass, metals, and clay, are likewise moldable in their basic forms. The primary distinction between these substances and plastics is that plastics have long molecules, which are responsible for many of its distinctive features, whereas glass, metals, and clay have short molecules. (Eltayef, 2003).

Thermoplastics

These linear chain polymers soften when heated with or without pressure, but chilling is necessary to form them. They can be repeatedly heated and cooled, but they should not be heated beyond the point of breakdown, primary and secondary shaping, shape stabilization, melt transfer, mixing and homogenization, and melting, and finish operations are crucial thermoplastics processes. Some commercial thermoplastics are polyethylene, polyvinyl chloride (PVC), polystyrene, polytetrafluoroethylene (PTEE), polypropylene (PP), and polystyrene (PS).
Thermoplastics can be used as toys, combs, bathroom supplies, film for cameras, hoses, electrical insulation, etc. (Adekunle Y., 2019).

Governments, institutions, and society in developing nations are very concerned about the generation of municipal solid waste (MSW); this solid waste is particularly concerning in Nigeria due to the country's burgeoning population and socioeconomic conditions. Solid wastes are unwanted and unusable goods that have been dumped by society members. Municipal solid waste, industrial solid waste, and agricultural solid waste are the three general categories that solid wastes fall under. In most African cities, solid waste management accounts for 20–50% of the environmental budget, but only 20–80% of the rubbish is collected. In addition, Nigeria's solid waste management standards are at an all-time low due to inadequate recording of trash generation rates, an ineffective storage and collection system, and underutilization of disposal facilities. Urban Nigerian cities are currently having difficulty removing mountains of solid trash from their surroundings.

The chaotic nature of neglected amounts of solid trash coming from society has now taken over strategic places of desirability in Nigeria. The illegal disposal of industrial and domestic solid trash, which is a blatant disregard of Nigeria's environmental sanitation rules and regulations and the Clean Air and Health Edicts, appears to go unaddressed by city officials. Polyethylene Terephthalate (PET) is a component of the solid waste stream, which includes plastic garbage. Plastic bottles and a number of other items are made from PET(E). The majority of PET bottles made are clear and used to package beverages like water and soda, etc.
They pose a threat to our soils, waterways, and drainage systems because they are not biodegradable and can last for up to 4500 years on Earth without changing. More than 20% of

Nigeria's municipal solid waste stream is made up of plastic garbage. Plastic trash is a problem that is not just present in Nigeria but is an international issue. The amount of plastic consumed annually by the world has expanded from 5 million tons in the 1950s to over 100 million tons now; as a result, twenty (20) times as much plastic is produced today as it was fifty (50) years ago. Simply said, more resources are being needed to provide the rising demand for plastic, which results in more plastic garbage being produced. The demand for bottled water is always growing in Nigeria due to the country's expanding population, the country's consistently hotter weather as a result of global warming, and the lack of accessible, safe drinking water in both rural and urban regions. Although there are public water systems in some places, it is not reliable that the water will be safe to drink. Private boreholes are common in Nigeria; however, the purifying system is sometimes substandard.

In Nigeria, where the population is projected to be one hundred and sixty-seven million (167,000,000), one hundred million (100,000,000) individuals drink bottled water every day, producing one hundred million (100,000,000) PET bottle wastes. PET bottle garbage is produced in public spaces including hotels, restaurants, offices, classrooms, marketplaces, parking lots, hospitals, events, etc. The majority of PET bottles produced in Nigeria are reportedly not collected and recycled by plastic manufacturers. However, new bottles are made every day, adding to the nation's trash problem rather than reducing the threat it poses. In contrast to other nations in the world, the country has a small number of recycling machines, if any at all, and is likely ignorant of recycling technology, which has prevented it from recycling the strewn trash PET bottles. In Europe (EU-27), 59.6% of plastics were collected and recycled in 2011, while 61.9 % of plastics were recycled in 2012 (David A. and Oluwayomi J., 2018).

In this line, we decided to design and fabricate a *sheetpress machine for recycling plastic* for plastic waste management in Nigeria.
The way that the molecules in a given thermoplastic are arranged allows for classification; stronger plastic is produced when highly aligned molecules assemble themselves more compactly.

For instance, nylon's closely aligned molecules give it its exceptional strength. The degree of molecular alignment also affects how transparent plastic is. Highly aligned thermoplastics scatter light, giving the impression that they are opaque. Most of these polymers seem translucent because semi-aligned thermoplastic molecules scatter some light. Thermoplastics with erratic (amorphous) molecular configurations are transparent and do not scatter light. The creation of optical lenses, windshields, and other transparent items uses amorphous thermoplastics (Eltayef, 2003).

Plastics That Are Commonly Recycled

- **PET (Polyethylene Terephthalate)** – They occasionally take on flavors and smells from the foods and beverages they store. This plastic is frequently recycled in products. Numerous everyday objects such as beverage bottles, medication jars, rope, apparel, and carpet fiber are made of PET(E) plastic (Goverment-UK, 2012)
- **HDPE (High-Density Polyethylene)** – These are extremely secure and are not known to introduce chemicals into beverages or food. Products made of HDPE are often recycled. Containers for milk, motor oil, shampoo and conditioner bottles, soap bottles,

detergents, and bleaches are among the products created from this plastic. If an HDPE bottle did not initially contain food or drink, it is NEVER safe to use it again as a container for food or drink (Goverment-UK, 2012).

Plastics That Are Sometimes Recycled

- **LDPE (Low-Density Polyethylene)** – These plastics tend to be both flexible and robust, making them highly healthful. LDPE is used to make products like cling film, sandwich bags, squeezable bottles, and plastic supermarket bags (Goverment-UK, 2012)
- **V or PVC (Polyvinyl Chloride)** – These are typically seen in plumbing pipes but are used for many types of pipes and tiles. Food shouldn't be in contact with this type of plastic because it can be dangerous to consume (Goverment-UK, 2012).

Plastics That Are Occasionally Recycled

- **PP (Polypropylene)** – This is robust and typically tolerant of higher temperatures. Lunch boxes, margarine jars, yogurt pots, syrup bottles, and prescription bottles are all made with it. Polypropelene is frequently used to make plastic bottle caps (Goverment-UK, 2012)

Plastics That Are Difficult to Recycle

- **PC (Polycarbonate)** – This type of plastic is difficult to recycle and they are used to make baby bottles, big water jugs, medical storage discs, and compact disc (Goverment-UK, 2012)
- **PS (Polystyrene)** – Although it is challenging to perform, this is frequently recycled. PS is used to make products including plastic food containers, plastic cutlery, disposable coffee cups, and packing foam (Goverment-UK, 2012).

Plastics That Cannot Be Recycled

Any plastic that does not have a recycling number, such as dirty plastic bottles and bags, garbage bags, zip-lock bags, cereal box plastic, bubble wrap, clear plastic wrap, some department store bags, potato chip bags, single cheese wrappers, and 6-pack plastic bags.

Styrofoam: Despite being ranked as number 6 among plastics, Styrofoam is still not regarded as biodegradable due to no or insufficient left-over after being broken down to create new items (e.g. Foam tableware, To-Go boxes, cups, coolers, and packaging). They work best as insulating materials and as containers for breakables when packing items for storage. ("Non-Recyclable Material List," 2003)

Plastics Recycling

There are many advantages to recycling plastic, including reduced energy use and greenhouse gas emissions. In addition, it conserves nonrenewable resources like gas and oil. Additionally, recycling provides a means of subsistence for millions of individuals and families in underdeveloped nations, whether through formal employment or unofficial economic activity.
Although the consumption of plastics is also rising quickly in the developing world, particularly as a result of the rising demand for plastics in Asia, the per capita consumption of plastics in developing nations is significantly lower than in the virtualized nations.

However, because of a number of variables, recycling is far more prevalent in poorer nations:

- Decreased Labour costs.
- Reuse, recycling, and a method for gathering, sorting, cleaning, and reusing "trash" or worn objects are already cultural traditions in many countries.
- Lesser legislations govern the requirements for recyclable materials. (This is not to argue that standards can be low - the consumer will always demand a certain degree of quality).
- This is because hand or ox carts are frequently employed, transportation expenses are frequently lower.
- In the cutthroat manufacturing industry, inexpensive materials give an advantage.
- Creative processing of scrap machinery frequently results in cheap entry costs for manufacturing or processing.

As more plastic is consumed in developing nations, the potential for recycling plastic is expanding. Plastic garbage collection, sorting, and recycling are now realistic options (Milgrom, 1975)

Mould

The terms "mould" or "die" are frequently used to refer to the equipment used in molding plastic components. Molds were typically only utilized in mass production, where tens of thousands of pieces were being manufactured, due to the high cost of manufacturing them. Standard moulds are made of beryllium-copper alloy, hardened steel, pre-hardened steel, and/or aluminum.
The primary consideration for choosing a mold's construction material is cost; generally speaking, steel molds are more expensive to make, but their longer lifespan allows them to produce more components before wearing out, offsetting the higher initial cost.

Pre-hardened steel moulds, which typically range in hardness from 38 to 45 on the Rockwell-C scale (HRC), are less wear-resistant and utilized for larger components or smaller volume requirements. After machining, hardened steel molds are heat treated; these are significantly better in terms of wear resistance and lifespan. The typical HRC (Rockwell Hardness Scale) hardness varies from 50 to 60.
When developed and machined using contemporary computerized technology, aluminum molds can be produced economically for molding tens of thousands or even hundreds of thousands of parts. In parts of the mold where quick heat removal is necessary or where shear heat generation is greatest, beryllium copper is employed. Both electrical discharge machining and CNC machining, which uses computers to control machine tools, can be utilized to create the molds (Collier, 1974).

1.1. Problem Statement

The amount of plastic waste in the environment has continue to increase continuously, which can cause landfills, obstruct drains, pollute waterways, accelerate the loss of biodiversity, flooding and spread water-borne diseases. The device that recycles plastic into other materials can help minimize the amount of plastic waste in society.

1.2. Aim and Objectives

The main aim of this research is to fabricate a manually operated sheetpress plastic recycling machine. The Objectives are as follows:

i. To construct a machine that will recycle waste plastic and create new parts for use in Nigeria's rural and urban locations.
ii. To fabricate a manually operated sheetpress recycling machine that has a reduced weight and size
iii. The manually operated sheetpress recycling machine will be powered by electricity.
iv. The project will be environmentally friendly
v. The project should produce one plastic sheet in 1hour.

1.3. Economic Importance

This machine helps in promoting the economy whereby it:

a. Minimize the amount of plastic waste and hazards caused by waste plastics in the environment.
b. Recycle waste plastics into bi-products (chair, tables, etc.) that can still be used in homes, offices etc.

2. RELATED WORKS

Recycling plastic involves repurposing used plastic materials to create new goods. This can lessen the need for landfill space, conserve resources, and safeguard the environment from plastic pollution and greenhouse gas emissions when done properly. Even though recycling rates are rising, they still trail behind those of other recyclables including paper, glass, and aluminum. 6.3 billion tonnes of plastic garbage were produced globally between the start of plastic production in the 20th century and 2015; just 9% of this waste was recycled, and less than 1% of it was recycled more than once. In addition, 12% of it was burned, with the rest 79% being dumped in landfills or the environment, including the sea.
Since practically all plastic is non-biodegradable and accumulates in the environment, where it can be harmful, recycling is essential. For instance, each year, almost 8 million tons of waste plastic enter the world's oceans, harming the ecosystem and creating huge ocean garbage patches (Hdpe et al., 2015).

2.1. Origin of Recycling

Recycling by humans has a long history. Although the first instance of recycling is paper recycling; which was in Japan in 1031, earlier cultures frequently repurposed daily things because of a lack of resources and labor-intensive production procedures (Hire et al., n.d.)

Japan – 1031 – The earliest known instance of recycling paper

As workers gradually absorbed into common life amid the decline of the Japanese Imperial court during the Heian Period, paper production transitioned away from official control. Paper mills were built by private estate owners, who then hired these people to keep making paper. Reusing waste paper quickly expanded throughout society in an effort to conserve resources and boost productivity. (Hire et al., n.d.)

Philadelphia – 1690 – The Rittenhouse Mill
William Rittenhouse, a German immigrant who founded America's first paper mill, used worn clothing, cotton, and linen to create recycled paper for printing and publishing. The mill was owned by the Rittenhouse family for more than a century and ran until the middle of the 18th century (Hire et al., n.d.)

New York City – 1776 – Metal Recycling First
During the American Revolutionary War against the British, the first time metal was recycled to aid in the military effort was. Following the reading of the freshly prepared Declaration of Independence, a monument of King George III in New York City was destroyed, melted, and turned into bullets. The statue had 42,088 bullets, albeit there would have been more if the head had not been cut off and the crowd had not taken other pieces (Hire et al., n.d.)

Batley, West Yorkshire – 1813 – The Poor Process
The substandard method, which makes recycled wool from used clothing and rags, was created by Benjamin Law. He arranged the rags into a pile and ground them all up so that yarn could be spun from them again. By 1860, Batley was generating more than 7,000 tonnes of recycled wool products annually as the shoddy business quickly expanded. (Hire et al., n.d.)

London – 1891 – 'Darkest England' by William Booth
William Booth created the Darkest England program to assist the underprivileged in London after creating the Salvation Army in 1865. This included the notion of using low-wage, unskilled people to remove various abandoned things from homes. 'Our Household Salvage Brigade' was their name. Discarded things would be transported to a 'commodious wharf' near Battersea Bridge, which Booth had rented, and objects would then be sorted and reused whenever possible. (Hire et al., n.d.)

New York City – 1897 – Center for Material Recovery
The first materials recovery facility in New York City was established in response to a recycling order for city residents two years earlier. This made it possible to filter and categorize waste products, allowing recyclable commodities like metals, paper, fabrics, and more to be recovered and used again. (Hire et al., n.d.)

Chicago – 1904 – First Can Recycling Facilities Open in America
With the invention of the Hall-Héroult process, large-scale aluminum production in the United States started in 1886. The first recycling facilities for aluminum cans shortly followed, the first of which was based in Chicago, Illinois, in 1904.(Hire et al., n.d.)

Recycling During Conflict
Due to the first and second World Wars, resource management had to be done in a novel way. Both the US and Great Britain asked the people for assistance as supplies ran out. The 1942 US marketing campaign "Salvage for Victory" urged people to be more considerate about what they tossed away and how they divided waste. For instance, individuals were told to deliver used cooking oil to the neighborhood butcher shop so that it could be converted into explosive fuel. (Hire et al., n.d.)

United States – 'Throwaway Living' debuted in 1955'.
The trend toward recycling has not always been positive. A substantial article titled "Throwaway Living" appeared in LIFE Magazine in 1955, supporting the notion that single-use objects were the norm and an essential component of contemporary life. The joyful but ominous piece encouraged a less responsible way of thinking about garbage, which resulted in widespread littering and a lack of conscience or consideration for the environment. (Hire et al., n.d.)

United States – The Recycling 'Mobius Loop' Logo from 1970
To come up with a new logo for recycled paper, the Container Corporation of America organized a competition. Gary Anderson, a 23-year-old engineering student, arrived with a straightforward logo made of interlocking arrows. He triumphed, gaining $2000, and ever since, the distinctive emblem has remained imprinted in people's minds. (Hire et al., n.d.)

Barnsley, South Yorkshire – The UK's first bottle bank debuted in 1977.
Stanley Race deposited an empty jar into the nation's first glass recycling bank on June 6, 1977. This initial deposit sparked the widespread establishment of bottle banks, where members of the public can drop off empty bottles and jars for recycling. Glass is a material that can be recycled indefinitely, and the development of bottle banks was a turning point that made glass recycling simple for everyone. (Hire et al., n.d.)

Canada – 1983 – System for Recycling in Blue Boxes
The introduction of the blue box recycling system in Kitchener, Ontario, allowed for the effective separation and collection of residential waste. The public may recycle plastic, paper, glass, aluminum, steel, and other commodities with ease thanks to the blue box system. The method was adopted and altered all around the world, and it is still in use today. (Hire et al., n.d.)

Switzerland – The First Electronic Recycling Program Debuted in 1991.
It wasn't until 1991 that recycling of electronics became a priority. Importers of IT and electronics came together in Switzerland to discuss the problem of disposing of electronic trash. Following discussions, the Swico recycling system was created, which would gather used electronics and recycle them without charging customers. Old refrigerators were the system's initial focus, but it later expanded to accommodate all electrical garbage. (Hire et al., n.d.)

The EU – THE WEEE DIRECTIVE, 2003
The Waste Electrical and Electronic Equipment Directive (WEEE) was established as European law by the European Union. The regulation established objectives for EU nations to raise the rate of electronic recycling. The directive has undergone numerous amendments over the years, and in 2006 the UK unveiled its own, extended version: "the waste electrical and electronic regulations." (Hire et al., n.d.)

England – Household Waste Recycling Act of 2003
Since the adoption of this recycling legislation, local governments in England are required to collect at least two different types of recyclable items from each household by the year 2010. (Hire et al., n.d.)

United States – Dell Creates a Free Recycling Program in 2006.

A greater emphasis is placed on the manufacturer's role in producing more environmentally friendly products and accepting responsibility for their disposal as computer manufacturer Dell becomes the first corporation to offer free recycling for its products. Since then, similar actions have been taken by other manufacturers like Sony and Apple. (Hire et al., n.d.)

England - 2015 Single-Use Plastic Bag Fee of 5p

For anyone who wants to use a plastic bag, there is now a five penny fee in all English stores as part of an effort to restrict the usage of plastic bags nationwide. In England, the use of plastic bags has decreased by about 80% since the charge was implemented (Hire et al., n.d.)

3. CONCLUDING REMARKS

Waste is now an international issue that needs to be resolved in order to address the global resource and energy issues. The machine was fabricated using the available raw materials and techniques, it is expected that upon the completion of the fabrication, our design will assist in decreasing the volume of plastic waste causing pollution in the environment with a sizable efficiency

REFERENCES

1. Adekunle, Yekinni (2019): Properties of Materials: Lagos: Sol-fad Prints.
2. Chaturvedi, S. (2015). Unit - 1 Introduction to Machine Tools & Machines. April. https://doi.org/10.13140/RG.2.1.1419.7285
3. David A. and Oluwayomi J. (2018): “Design and Construction of a Plastic Shredder Machine for Recycling and Management of Plastic Wastes”, Internal journal of Scientific and Engineering Research, Vol. 5 No. 5 Pages 1-2
4. Digamber, G. M., Akbar, S. M., Govind, D. D., Ashokrao, S., Angadrao, B. M., & Rajkumar, D. A. (2019). PLASTIC INJECTION MOULDING MACHINE. 8220–8224.
5. Dinte, E., & Sylvester, B. (2018). Adhesives: Applications and Recent Advances. Applied Adhesive Bonding in Science and Technology. https://doi.org/10.5772/intechopen.71854
6. Erich Lawson (July 27th, 2018) (Sustainability in the Workplace: 5 Major Benefits of Plastic Recycling) Retrieved from blog.impactplastics.co
7. Fu, H., Xu, H., Liu, Y., Yang, Z., Kormakov, S., Wu, D., & Sun, J. (2020). Overview of Injection Molding Technology for Processing Polymers and Their Composites. 3–23.
    a. Gregersen, E. (n.d.). thermocouple. 1–2.
8. Goverment-UK. (2012). Different Plastic Polymer Types. Ryedale District Council 2020, http://www.ryedale.gov.uk/attachments/article/690/Different_plastic_polymer_types.pdf
9. Hdpe, R., Env, D. G., Act, R. R., & Beautiful, K. A. (2015). Plastic recycling. April 1973, 1–17.
10. Herrmann, H., & Bucksch, H. (2014). Hydraulic Jack. Dictionary Geotechnical Engineering/Wörterbuch GeoTechnik, 697–697. https://doi.org/10.1007/978-3-642-41714-6_81774

11. Hire, S., Collection, W., Hire, G., Clearance, J., Facilities, R., Covered, A., Centre, R., Us, C., Hire, S., Skips, D., Skips, C., Sizes, S., Skips, T., Skips, B., Hire, M. S., Hire, M. S., Skips, M., Service, L. S., Calculator, S. S., … Centre, R. (n.d.). 0208 684 0401. 1–11.
12. Jignesh Sabhadiya (January 30, 2021) (What Is Steel? - Properties, uses | Types of Steels) Retrieved from www.engineeringchoice.com
13. Jignesh Sabhadiya (May 16, 2022) (What Is Aluminum? - Properties, Uses & How It's Made) Retrieved from www.engineeringchoice.com
14. Milgrom, J. (1975). Recycling Plastics. 44(871954). https://doi.org/10.1007/978-1-4615 1615-6_5
15. Nuclear Power (2016) Heat transfer & Heat losses – Polyurethane Foam. Retrieved from https://nuclear-power.com
16. Rajput R.K. (2006) Non Engineering Materials and Metallurgy, Third Edition, S. Chand, India, Pp 111-114, 123-124, 157.
17. Responsibilities, N. D. (2015). 1 1 4). 1–8.
18. Soedira, D. M., Lintanghati, D. K., Koestoer, R. A., & Dhelika, R. (2020). Development of a low-cost prototype of an extruder for plastic waste. AIP Conference Proceedings, 2227(May). https://doi.org/10.1063/5.0000936
19. SSAB. (2019). Structural Hollow Section, Dimensions and Cross-Sectional Properties. www.ssab.com
20. Tempco (2021-2022), Electric-Heaters-and-Elements/Infrared-Heaters/Ceramic-E-Mitters. Retrieved from https://tempco.com
21. Ugoamadi and Ihesiulor, 2011. (2011). Optimization of the Development of a Plastic Recycling Machine | Nigerian Journal of Technology. Ajol. Info, 30(3). https://www.ajol.info/index.php/njt/article/view/123545
22. Vaggar, G. B., Sameer, M., Chitragar, M., Sharif, M. R., & Kareem, A. (2022). Plastic Extrusion Machine: A Review. 11(06), 357–360.
23. Variya, L. B., Bhavik, M., Harshil, P., Jenish, P., & Hardik, G. (2018). Plastic Extruder Machine. V (02), 53–54.
24. Yamashita, Y., Miyahara, R, & Sakamoto, K "Emulsion and Emulsification Technology in Cosmetics Science and Technology (Japan: Choshi, Yokohana and Chiba, 2017), Pp. 489-506