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Plastic Cutter

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ABSTRACT

One of the most important global challenges today is environmental pollution, mainly caused by single-use plastics like PET (polyethylene terephthalate). Due to its resistance, durability, and light weight, PET is widely used in the food industry, especially for the production of bottles and containers. However, these advantages become a threat to the environment, as PET takes approximately 500 years to decompose and releases harmful chemical substances that negatively affect human health, fauna, and agriculture. Recycling is one of the most effective solutions to this problem, as PET can be reused in new containers, construction materials, packaging, and textile fibers. This process promotes sustainability and the circular economy, in addition to reducing the volume of waste. However, significant challenges persist, such as inadequate waste segregation at the source, limited public awareness, and a lack of infrastructure. Recycling can only be successful if it combines environmental education, solid public policies, and technological innovation. A global approach is necessary to mitigate the impact of PET and move towards a cleaner and more sustainable future.

Keywords: PET; recycling; shredder; technological innovation; sustainability; environment

INTRODUCTION

In Mexico and the rest of the world, a serious environmental problem is faced: pollution. The number of inhabitants continues to increase, and with it, the ecological footprint becomes increasingly evident due to the large amount of waste generated daily. Disposable containers are one of the most common products we use daily. They can be made of various materials, but PET (polyethylene terephthalate) is the most common. This polymer is widely used in the food industry, especially for manufacturing bottles. PET is used for its resistance, durability, and lightness. However, PET is harmful to the environment, as it takes about 500 years to decompose and releases toxic substances that contaminate the soil and water, harming plants and animals.

To reduce the damage that PET causes to the environment, it is important to classify it, dispose of it properly, and recycle it. Recycling PET is a good option because it allows this material to be transformed into new products, such as textile fibers, containers, construction materials, and packaging. This practice benefits the environment, supports sustainability, and fosters the circular economy.

Challenges include inadequate infrastructure for collection and processing, insufficient public awareness, and inadequate segregation at the source. Furthermore, contaminants reduce the quality of PET waste and increase processing costs. If these problems are not resolved, large amounts of PET continue to accumulate in landfills and natural areas, resulting in long-term ecological damage.

The recycling of PET represents an essential strategy to reduce environmental pollution and promote a circular economy. Through the implementation of efficient recycling processes, such as the design of plastic bottle shredders, the volume of waste can be reduced and new products created from reused material. However, for recycling to be truly effective, it must be accompanied by social awareness, infrastructure development, and solid public policies. In conclusion, the combination of technological innovation, education, and sustainable practices is key to mitigating the environmental impact of PET and building a cleaner and healthier future.

Materials and Polymers

- PET: Polyethylene Terephthalate
- PE: Polyethylene
- PP: Polypropylene
- PVC: Polyvinyl Chloride
- PS: Polystyrene
- ABS: Acrylonitrile Butadiene Styrene
- HDPE: High-Density Polyethylene
- LDPE: Low-Density Polyethylene
- PET: Recycled PET

Equipment and Components of The Mill
- HP: Horse Power
- RPM: Revolutions per Minute
- MM: Millimeter
- kW: Kilowatts
- N-m: Newton-meter (torque)
- dB: Decibels (noise level)
- \Phi: Diameter
- kg/h: Kilograms per hour (grinding capacity)
- HMI: Human Machine Interface
- PLC: Programmable Logic Controller
- VFD: Variable Frequency Drive

Process an Operation
- PM: Preventive Maintenance (mantenimiento preventivo)
- CM: Corrective Maintenance (mantenimiento correctivo)
- TPM: Total Productive Maintenance
- OEE: Overall Equipment Effectiveness (eficiencia global del equipo)
- QA: Quality Assurance (aseguramiento de calidad)
- QC: Quality Control (control de calidad)
- SOP: Standard Operating Procedure (procedimiento operativo estándar)
- DOE: Design of Experiments (diseño de experimentos)

Measurement and Control
- T°C: Temperature in degrees Celsius
- A: Amperes
- V: Volts
- Hz: Hertz (frequency)
- CFM: Cubic Feet per Minute (air flow)
- PID: Proportional-Integral-Derivative (type of control)
- Standards and Norms
- ISO: International Organization for Standardization
- ASTM: American Society for Testing and Materials
- DIN: Deutsches Institut für Normung (German Institute for Standardization)
- CE: Conformité Européenne (European certification)
- UL: Underwriters Laboratories (electrical safety)
- NEMA: National Electrical Manufacturers Association

Recycling and Sustainability
- GMP: Good Manufacturing Practices
- LCA: Life Cycle Assessment
- CO_2: Carbon Dioxide
- CSR: Corporate Social Responsibility
- SDG: Sustainable Development Goals

GENERAL OBJECTIVE

The project aims to design and build a PET bottle shredder. This machine will reduce the volume of plastic waste generated by container consumption. Furthermore, it seeks to foster recycling and promote environmental care. The goal with this equipment is to utilize materials that can be reused. In this way, the amount of waste that reaches the environment is reduced. Thus, the project contributes to the care and sustainable development of the planet.

Specific Objectives

The specific objectives of this project focus on leveraging the available resources within the university community and generating a positive impact on the local environment.
- To implement a technological project that drives PET recycling within the institution, promoting the separation and use of plastic bottles.
- To facilitate the use of the shredder to process the PET waste collected. This waste comes from both the university and the nearby areas.
- To involve students and residents of the rural community in recycling activities. This way, the project contributes to reducing the volume of plastic waste, fostering environmental awareness, and promoting the responsible use of natural resources.
- To motivate the educational community to care for the environment, raise awareness among students and teachers about the importance of recycling. This strengthens the environmental commitment within the institution.
- To serve as a supporting tool to boost the sustainable development of the region.

DEVELOPMENT

Prototype design

The prototype design is based on a mechanical approach that integrates a feeding hopper, a shredding chamber with mobile and fixed blades, and a transmission system that connects the motor to the main shaft. Software like SolidWorks is used to model the parts, ensuring adequate tolerances and facilitating manufacturing. The design prioritizes ease of maintenance and operational safety, incorporating metal grids that control the size of the resulting particles. The structure uses steel, a common material in industrial applications for its resistance and low cost. The bearings (plummer blocks) are self-lubricating to reduce maintenance.

Construction or assembly process

Construction begins with the machining of the fixed and mobile blades, followed by assembly in the blade box. The main shaft is installed and supported by plummer blocks, and spur gears are coupled to transmit movement. Then, the support structure is fixed, and the single-phase electric motor is installed, connected by a transmission system that may include pulleys and belts or a speed reducer. Finally, a functional test is performed to verify the correct assembly and alignment of components.

Operation

The cutter operates by introducing PET bottles into the hopper, where they fall by gravity into the shredding chamber. An electric motor, typically 5 HP, transmits power to the shaft that moves the mobile blades at speeds between 76 rpm, depending on the design. The mobile blades, in contact with the fixed ones, cut and tear the plastic through a shearing effect, reducing it to particles of 10 to 12 mm in diameter. The shredded material passes through a grid and is collected in an output container.

Safety norms or measures

Safety measures include grounding the electrical equipment and adequate insulation of cables in steel pipes. It is prohibited to look inside the shredding chamber during operation or to make adjustments while the machine is running. The operator must use personal protective equipment (PPE), such as a mask and cap, and stay to the side of the hopper during feeding. Additionally, the absence of hard objects in the input material must be verified to prevent damage to the blades and accidents.

Materials used

The selected materials ensure durability and efficiency. The blades are manufactured from SAE 1045 carbon steel, known for its hardness and wear resistance. The main shaft and gears are also constructed of steel, specifically SAE 4140, to withstand high mechanical stresses. The support structure uses ASTM A36 steel.

Showing results achieved with the machine

The machine significantly reduced the volume of PET during testing, with a volume reduction of approximately 70% in a typical shredding process. Some high-capacity machines reach up to 80%, depending on the size and type of PET and operating conditions. Furthermore, the production capacity in some models reaches 1000~kg/h, demonstrating efficient performance in industrial environments.

Observations from the tests performed

- The shredding blades must be kept sharp; wear affects the efficiency and quality of the shredded material.
- Energy consumption capacity varies according to the hardness of the PET and the equipment configuration, so it is recommended to adjust the operating parameters.
- Material accumulation was observed in the discharge tube in some cases, causing jams or downtime for cleaning.
- The size reduction in PET waste facilitates space management for storage and transport, allowing for a more efficient recycling process.
- Possible improvements or failures found
- Improvements in the equipment structure to reduce vibrations and noise, increasing the durability of the blades and components.
- Incorporation of screens with different sizes to adjust the granulometry of the final product, according to the required application.
- The frequency of preventive maintenance can be increased to prevent failures due to aging components, such as bearings and blades.
- Failures were detected in the obstruction of the discharge tube and in the wear of the hammer, which affects the continuity of the process.

RESULTS

TABLE 1: Operating parameters and performance results of the PET shredder prototype.

Parameter	Unit / Description	Value obtained	Comment / Observation
Motor speed	rpm (revolutions per minute)	1750 rpm	Stable speed during grinding
Power consumed	kW	2.3 kW	Moderate consumption, within the expected range
PET Shredder Models	mm	5 mm	Uniform size, ideal for later recycling.
Grinding capacity	kg/h	25 kg/h	Good productivity for semi-industrial use.
Engine temperature	°C	45 °C	Safe temperature, no overheating.
Noise level	dB	80dB	Requires hearing protection.
Equipment vibration	m/s^2	0.5 m/s^2	A low level indicates good rotor balance.
Type of PET processed	–	Transparent (bottles)	Dry and clean material
Grinding efficiency	%	92 %	Good use of the material was achieved.

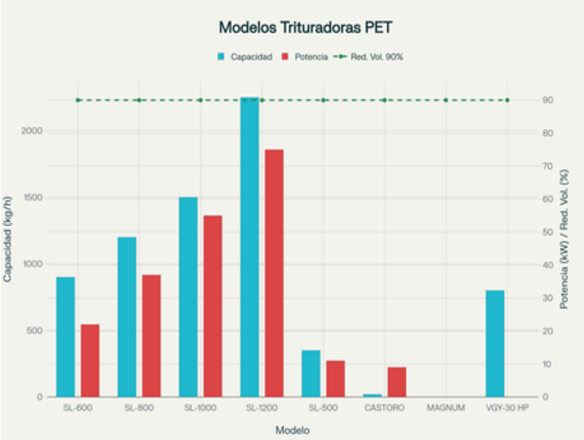

FIGURE 1: Comparison of PET shredder models based on grinding capacity, motor power consumption, and volume reduction efficiency.

Bar chart comparing different PET shredder models in terms of their capacity (kg/h), energy consumption (motor power in kW), and estimated volume reduction percentage (90%) for all models. Models included are SL-600, SL-800, SL-1000, SL-1200, SL-500, CASTORO, MAGNUM, and VGY-30 HP. Capacity and power vary according to each model, while volume reduction remains approximately at 90% for all of them. This chart allows for easy visualization of the differences in capacity and energy consumption among the most common models on the market. The development of the PET shredder project demonstrated the importance of applying technology for the benefit of the environment and the community. Through its design and construction, it was possible to use accessible materials and promote sustainable practices within the university. The operation of the prototype contributes to reducing the volume of plastic waste, which represents a direct benefit to the institution and the surrounding rural areas.

Furthermore, the project fosters environmental responsibility, teamwork, and student awareness of the impact of recycling on environmental preservation. Furthermore, community participation in these types of initiatives strengthens the link between education and sustainable development. This lays the groundwork for future projects that promote technological solutions to local environmental problems. In conclusion, the PET shredder represents a practical and educational alternative for the responsible management of plastic waste, promoting positive change in the university community and its surroundings.

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