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Design of Plastic Shredding Machine with HSS Crusher Type

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ABSTRACT

Human commonly use plastic because it is easy to get, economical, heat-resistant, and lightweight. PET plastic is widely used for single-use bottles. This high usage of plastic leads to the accumulation of plastic waste which is difficult to decompose and damaging the environment. The solution is to recycle plastic using an HSS crusher-type plastic shredder. The design process of the HSS crusher-type plastic crusher machine includes: the data collection process, the design starting from the design concept, design embodiment, and design details using Solidworks 2021 Software in two- and three-dimensional forms then processed for design validation. Then, the supervision of the tool manufacturing was continued to determine the suitability of the tool with the created design, machine testing, and evaluation. The dimension of this HSS crusher-type plastic shredding machine design is 775 × 635 × 1553 mm with a machine weight of 200 kg. The machine components consist of AS blade, US blade, side blade lock, side blade, UCP 208, size sieve, US knife holder, machine frame, output, holder, US cover, top cover, pulley cover, pulley, output cover, input, hopper, and machine wheel. The engine frame is made by using UNP 50-60 iron. The engine drive is a a 1HP electric motor. The machine made by mild steel plate material which has 10 pcs of steel blades consisting of 6 pcs of steel blades and 4 pcs of sitting blades. The product from this shredded machine is in the form of PET plastic flakes which can be recycled further.

INTRODUCTION

Plastic is an item that humans commonly use as a material or tool daily because its benefit as easy to get, economical price, heat resistance, and lightweight. Plastic material is a type of polymer that has a permanent structure. In other words, the plastic refers to a specific type of polymer that includes a wide variety of polymer variations (Linda et al., 2016). Plastic seems to have become a necessity that must exist in society, although some people are unaware its bad impact on the environment when it is no longer used (Saila et al., 2024). The use of plastic in food packaging, beverage packaging, shopping bags, and other wrappers are some of the main sources of plastic waste generation today (Inggit Br Sitorus & Nanda, 2024).

The types of plastics include PET (*Polyethylene Terephthalate*), HDPE (High Density *Polyethylene*), PVC (*Polyvinyl Chloride*), PP (*Polypropylene*), and PS (*Polystyrene*) (Haryono, 2024). Of these several types of plastic, some plastics are often used by the community, namely PET plastic which is usually used in the manufacture of single-use plastic bottles. PET is a polymer produced from the dehydrated condensation of *Ethylene Terephthalate*, through the esterification process of terephthalic acid with *Ethylene Glycol* (Achidah et al., 2024). Because of its economical nature, the more plastic is used, the more plastic waste accumulates and is thrown carelessly, the plastic waste becomes difficult to decompose in the soil, causing environmental damage (Huzein & Hasballah, 2020). Waste and other pollutants that are disposed of carelessly can cause serious environmental pollution, endangering human health and ecosystems (Achmad et al., 2021).

According to the Indonesian Plastic Industry Association (INAPLAS) and the Central Statistics Agency (BPS) in 2022, the amount of plastic waste in Indonesia will reach 64 million tons per year (Nurhayani, 2024). In the last ten years, the amount of plastic waste in Indonesia increased by 6% to reach 11.6 million tons in 2021, which is equivalent to about 17% of the total national waste. This means that each Indonesian people produce is around 0.11 kilograms of plastic waste per day (Malihah et al., 2024). To overcome the accumulation of plastic waste that is increasing day by day, it can be overcome by recycling plastic waste. Recycling is the process of turning waste into new products while reducing the use of fresh raw materials, to produce more useful products (Rohima et al., 2024). Plastic waste recycling is included in one of the waste utilization programs, namely the 3R program which consists of Reduce, Reuse, and Recycle, this program is expected to reduce the environmental impact of waste management improvement (Hidayat et al., 2024).

One of the plastic waste recycling technologies that can be done is the use of plastic shredding machines which are intended to process plastic waste into processed products that have a higher use value and sell higher by carrying out the waste recycling process. A plastic shredder is a waste recycling technology, or a tool used to chop or crush plastic into smaller pieces. The chopped products then can be used as recycled materials for entrepreneurs (Habib Almukti et al., 2018).

Several studies have explained that plastic shredding machines have several types according to the cutting tools used, such as the shredder type which reel type of cutting tool that is usually used as a conventional lawn mower (Yudha Triadi et al., 2020) the scissor cutting type whose cutting tool has the smallest angle to facilitate chopping (Desi et al., 2018). Meanwhile, the design of this plastic shredder is an HSS crusher-type plastic shredder. This plastic shredding machine is a crusher-type machine or type used to damage the structure of the material and reduce its thickness so that it will be easier to chop. The results of the cutting were obtained in the form of small flakes (Nur, 2015).

The problem faced by the community is the management of plastic waste. People are still not aware of the importance of managing plastic waste which is difficult to decompose in the environment so if the waste is left alone, it can cause problems in the future. People's habit of throwing rubbish

anywhere, such as on roadsides, gardens, and rivers, pollutes the environment. In this process, the plastic shredder plays a crucial role. This machine cuts or shreds plastic into smaller sizes, making the recycling process, such as melting and reshaping into new products, more manageable.

However, most plastic shredders available today face various challenges. Some of these include high production costs, large energy consumption, limited capacity, and insufficient ability to shred different types of plastics effectively. Moreover, many machines are not designed with sustainability in mind, such as energy efficiency and ease of maintenance. Therefore, developing a more efficient, affordable, and environmentally friendly plastic shredder has become an urgent necessity. With an optimized plastic shredder, plastic waste management can be improved, helping to reduce environmental pollution while supporting a circular economy.

METHOD

This research went through several stages of completion starting from data collection, to supervision of the manufacture and testing of the plastic shredding machine, the design results can be seen in the following flow diagram.

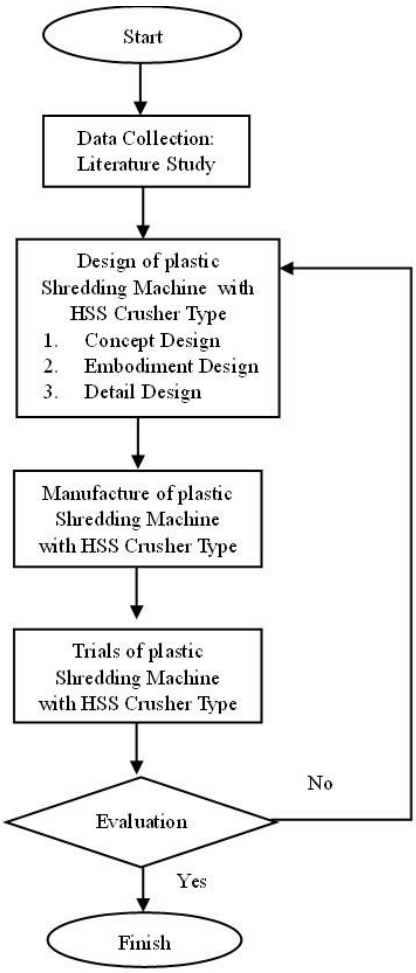


Figure 1. Flow Diagram

The research method carried out begins with the collection of qualitative data with a literature study on the current plastic waste problem. With this data, a design of a plastic shredder design concept

was made using Solidworks 2021 software. The design of the plastic waste shredder concept is made based on the data that has been collected. At this stage, the design concept that has been designed is then implemented in a more detailed three-dimensional form. This process results in a variety of components that, when combined, can form a complete and functional product. Furthermore, a design embodiment is made, which is a stage in the design process where the initial concept is realized in a more detailed or detailed form. At this stage, a complete drawing design along with the technical specifications of the tool will be produced.

Designs that have gone through various stages then validated for design. The purpose of this stage is to ensure that the tool drawings prepared in the design stage meet the predetermined standards. This validation includes the suitability of the working drawings and the ease of reading so that the design can be passed on to the tool manufacturing stage. If there is a discrepancy in the design, it will return to the design embodiment stage. After the manufacture of the tool, a trial of the tool and an evaluation stage were carried out.

RESULTS AND DISCUSSION

The design of an HSS crusher-type plastic shredder was utilizing data from the literature studies. The design concept was produced after considering various aspects, such as recycling needs, material availability, and estimated costs required. This conceptualized design is then broken down into several components. Once the machine concept is designed, the next stage is to create an embodiment using CAD software, such as SolidWorks 2021, which includes the creation of 2D sketches, 3D models, and assemblies. This stage ensures that every component of the machine is precisely designed before it is manufactured. After that, the design validation of the HSS crusher-type plastic shredder was carried out with the final design that has been validated as indicated by Table 1.

Table 1. Components of Plastic Shredding Machine HSS Crusher Type

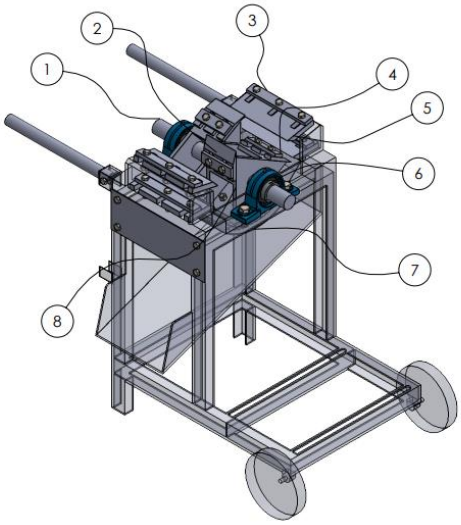
No	Components	Dimension (mm)	Design
1	AS Knife	450 x 40	
2	US Knife	100 x 90 x 15	
3	Side Blade Locks	200 x 30 x 10	
4	US Knife Locks	100 x 30 x 10	
5	Side Blades	195 x 90 x 15	
6	UCP 208	184 x 54 x 98	
7	Size Strainer	310 x 220	
8	US Knife Stand	200 x 200 x 200 (equilateral triangle)	

Figure 2. Inner Sub 1 Plastic Shredding Machine HSS Crusher Type

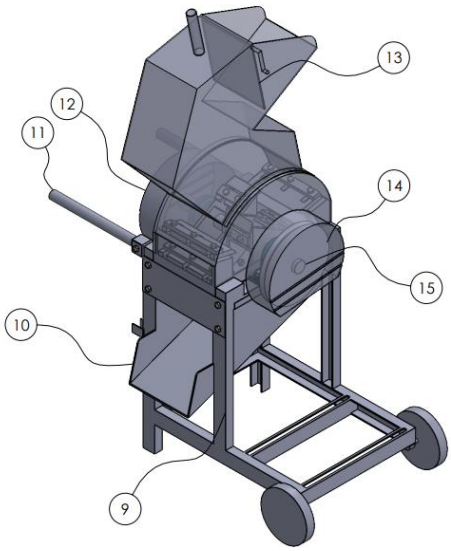
9	Engine frame	600 x 685 x 450	
10	Output	560 x 235 x 430	
11	Holder	350 x 40	
12	US Cover	295 x 80	
13	Top Cover	200 x 250	
14	Pulley Cover	295 x 80	
15	Pulley	250	

Figure 3. Inner Sub 2 Plastic Shredding Machine HSS Crusher Type

16	Output Cover	330 x 120
17	Input	200 x 640 x 555
18	Hopper	450 x 270 x 240
19	Wheel	160

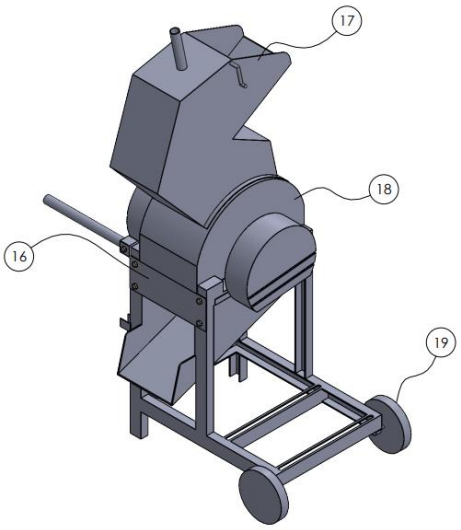


Figure 4. Plastic Shredding Machine
HSS Crusher Type

Manufacturing of Plastic Shredding Machine HSS Crusher Type

The result of the design and manufacture of this HSS crusher-type plastic shredding machine is that it has dimensions of 775 x 635 x 1553 mm with a machine weight of 200 kg. The machine components consist of AS blade, US blade, side blade lock, side blade, UCP 208, size sieve, US knife holder, machine frame, output, holder, US cover, top cover, pulley cover, pulley, output cover, input, hopper, and machine wheel. The engine frame is made using UNP 50-60 iron. The drive of this engine comes from a 1HP electric motor. The machine comes from mild steel plate material which has 10 pcs of steel blades consisting of 6 pcs of steel blades and 4 pcs of sitting blades.

When the electric motor is turned on, the small pulley on the electric motor will rotate forward to the large pulley on the engine by using a V-Belt with an outer diameter of 16 mm and an inner diameter of 11 mm, this transmission movement will rotate the AS connected to the chopping blade so that movement occurs. The PET plastic that is inserted through the shredder hole will directly enter the shredder which is secured by the filter component so that the plastic bottles that are inserted do not scatter. When the process has been carried out, the result is in the form of pieces of shredded PET plastic bottles that come out through the filter and then continue through the exit hole.

Figure 5. Results of Plastic Shredding Machine Manufacturing HSS Crusher Type

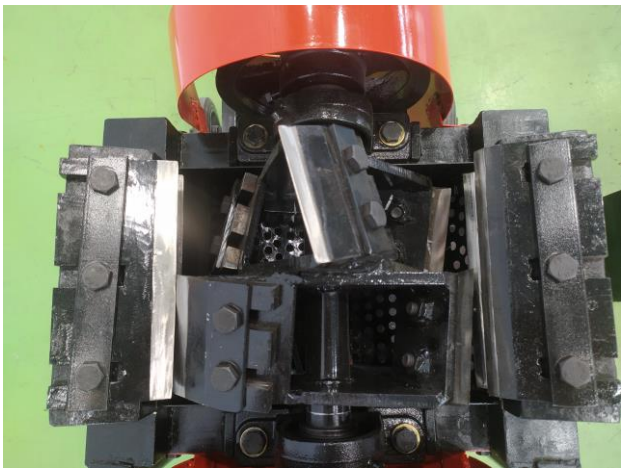


Figure 6. Knife Shredding of Plastic Shredder Machine HSS Crusher Type

Machine Trials and Evaluation

After the machine is manufactured, the machine performance test process is then carried out to determine the condition and operation of the machine before use. This test was carried out directly with test materials in the form of plastic bottles that are included in the type of PET plastic.

Figure 6. Performance Trial Process of Plastic Shredding Machine HSS Crusher Type

Figure 7. Results of Shredding Plastic Bottles Plastic with Shredding Machine HSS Crusher Type

The results of the shredding process of the HSS crusher-type plastic shredding machine have cutting results in the form of flakes from PET plastic bottles with almost uniform size. These flakes can then be sold for industrial recycling, offering an effective solution to deal with the buildup of PET plastic waste.

CONCLUSION

The design process of the type of plastic shredder is made based on literature study on the type of plastic that can be a solution to the problem of tracking plastic. The design is made using Solidworks 2021. This HSS-type plastic crusher machine is made with a crusher that can chop the plastic waste into small fragments that can be reprocessed into functional products in the plastic waste recycling process, especially PET-type plastics. The results of this shredded plastic waste can help the community process plastic waste that is difficult to decompose. The plastic shredder designed in this study demonstrates optimal performance in supporting the plastic waste management process. This machine is capable of shredding various types of plastic with consistent and high-quality results. The average size of the shredded plastic ranges between 5-10 mm, meeting the standards for further recycling processes, such as melting and reshaping. In terms of performance, this machine demonstrates good efficiency with an average shredding capacity of 75 kg/hour. Its energy consumption is relatively low, supporting sustainability aspects. Moreover, the shredded output exhibits a uniform texture with minimal residual fragments, thereby reducing additional waste during the recycling process.

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REFERENCES

Achidah, F., Indriani, A. M., & Utomo, G. (2024). PENGARUH PENAMBAHAN CACAHAN PLASTIK PET (POLYTETHYLENE TEREPHTHALATE) PADA BETON MENGGUNAKAN AGREGAT KASAR BATU PETANGIS TERHADAP KUAT TEKAN. *Open Journal Systems*, *18*(6).

Achmad, C. R., Faqih, I., & Pratiwi, T. A. A. (2021). *Identifikasi Kelimpahan Mikroplastik Air Kawasan Kanal Mangetan, Anak Sungai Brantas Kabupaten Sidoarjo*. https://ecotonjournal.id/index.php/epj

Desi, N., Dan, A., & Latief, A. E. (2018). *Rancang Bangun Mesin Pencacah Plastik Tipe Gunting*. *2*(2).

Habib Almukti, L., Purkuncoro, A. E., & Mt, S. T. (2018). Spark: Jurnal Mahasiswa PERANCANGAN KONSTRUKSI MESIN PENCACAH LIMBAH PLASTIK. In *Teknik Mesin ITN Malang* (Vol. 01, Issue 01).

Haryono, S. (2024). Perancangan Mesin Pencacah Sampah Botol Plastik Kapasitas 40 Kg/Jam. *JURNAL APTEK*, *16*(2). https://doi.org/10.30606/aptek.v16i2.2347

Hidayat, H. R., Devintasari, M., & Haryati, S. (2024). *Transformasi Sampah Plastik Menjadi Produk Unggulan sebagai Upaya Pelestarian Lingkungan: Pakaian Daur Ulang oleh Kelompok Tani Mekar Bersemi, Desa Dengkeng, Kabupaten Klaten*. *1*. https://ejournal.jurnalpengabdiansosial.com/index.php/jps

Huzein, R., & Hasballah, T. (2020). RANCANG BANGUN MESIN PENCACAH PLASTIK JENIS PET (POLYETHLENE TEREPHTALATE) KAPASITAS 50 KG/JAM. In *December* (Vol. 1, Issue 1).

Inggit Br Sitorus, N. E., & Nanda, M. (2024). *PENGETAHUAN MAHASISWA TENTANG PENGELOLAAN SAMPAH DAN PEMANFAATAN SAMPAH PLASTIK MELALUI ECOBRICK*. *5*(3).

Linda, R., Ekonomi, F., Uin, S., Syarif, S., & Riau -Pekanbaru, K. (2016). PEMBERDAYAAN EKONOMI KREATIF MELALUI DAUR ULANG SAMPAH PLASTIK (STUDI KASUS BANK SAMPAH BERLIAN KELURAHAN TANGKERANG LABUAI). In *Jurnal Al-Iqtishad, Edisi* (Vol. 12). http://kbbi.web.id/sampah

Malihah, L., Nazairin, A., & Martapura Kalimantan Selatan, D. (2024). YUME : Journal of Management Sampah Plastik Sachet Dalam Perspektif Pembangunan Berkelanjutan. In *YUME : Journal of Management* (Vol. 7, Issue 1).

Nur, I. (2015). *Pengembangan Mesin Pencacah Sampah/Limbah Plastik Dengan Sistem Crusher dan Silinder Pemotong Tipe Reel Engine Development Enumerator Garbage / Waste Plastic with Cutting System Crusher and Cylinder Type Reel* (Vol. 10, Issue 2). http://repository.ipb.ac.id

Nurhayani, N. (2024). PREDIKSI JUMLAH LIMBAH LINGKUNGAN SAMPAH PLASTIK MASYARAKAT DI KABUPATEN SIMALUNGUN MENGGUNAKAN METODE WEIGHTED MOVING AVERAGE. *Doctoral Dissertation, Universitas Malikussaleh*.

Rohima, S., Mardalena, & Widyanata, F. (2024). Pelatihan Daur Ulang Sampah Plastik Air Mineral Bernilai Ekonomis bagi Remaja Putri dan Ibu Rumah Tangga. *Sricommerce: Journal of Sriwijaya Community Services*, *5*(1), 85–94. https://doi.org/10.29259/jscs.v5i1.180

Saila, N., Hasanah, U., & Misdiyanto, M. (2024). SOSIALISASI PENTINGNYA PENGURANGAN SAMPAH PLASTIK DAN BAHAYA PLASTIK. *SUBSERVE: Community Service and Empowerment Journal*, *2*(1), 2024.

Yudha Triadi, N., Martana, B., Pradana, S., Raya Limo, J., Limo, K., & Depok, K. (2020). Perancangan Mesin Pencacah Plastik Tipe Shredder dan Alat Pemotong Tipe Reel. In *Jurnal Rekayasa Mesin* (Vol. 15, Issue 2). https://jurnal.polines.ac.id/index.php/rekayasa