Extruder Machine Design as a Facility for Utilization of High Density Polyethylene Waste into Plastic Panels

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Abstract

Plastic waste is a persistent material that poses a serious environmental threat due to its resistance to natural decomposition. Indonesia generates approximately 27.3 million tons of waste annually, of which 19.8% is plastic, highlighting the urgent need for effective recycling strategies. This study aims to design and develop an extruder machine to recycle High-Density Polyethylene (HDPE) waste into value-added plastic panels. The research methodology comprised literature review, needs identification, concept design development using the Ulrich method, concept selection through the Analytical Hierarchy Process (AHP), fabrication, and machine performance testing. Concept 1 was selected as the best alternative among the three proposed design concepts, achieving the highest Alternative Weight Evaluation score of 35.14, compared to 34.65 for Concept 3. The fabricated machine measures 779.5 mm in length, 610 mm in width, and 689.3 mm in height, powered by a 1 HP electric motor and equipped with four 300 W heaters. Performance tests demonstrated that the machine successfully melted HDPE and produced plastic panels with uniform surfaces, good material density, and minimal voids, although the resulting color tended to be dark. The findings confirm that the developed extruder machine effectively supports HDPE recycling into functional products, contributing to waste reduction efforts and promoting sustainable plastic waste management technologies.

Keywords: Analytical Hierarchy Process, Extruder Machine, Finite Element Method, Ulrich.

1. Introduction

Waste is the residue of human and natural activities that are no longer used. In general, waste is divided into two types, namely organic and inorganic waste. Organic waste comes from the remains of living things such as food, leaves, agricultural waste, and animal waste. This type of waste is easily decomposed naturally by microorganisms so that it can be processed into compost which is beneficial for soil fertility. Inorganic waste, on the other hand, comes from artificial materials that are difficult to decompose, such as plastic, glass, and metal. Inorganic waste takes hundreds of years to degrade, so a management strategy is needed, especially through the recycling process, so as not to pollute the environment (Taufiq & Maulana, 2015).

The problem of waste, especially plastic waste, has become a crucial global issue. Indonesia is one of the countries with the largest contribution in producing plastic waste (Nirmalasari et al., 2021). Plastic is a petrochemical-based synthetic polymer that is resistant to natural degradation. Uncontrolled disposal of plastics, either through burning or landfilling, has the potential to produce toxic compounds that can pollute soil, water and air. Exposure to harmful compounds from plastic degradation can have serious impacts on the health of living things, such as hormonal disruption and organ damage (Isnawati, 2014). Therefore, the awareness and involvement of the public, industry, and government in reducing the use of single-use plastics and optimizing the recycling process is very important.

Data from the National Waste Management Information System (SIPSN) in 2024 shows that waste production in Indonesia reached 27.3 million tons per year or around 74,735 tons per day, with plastic waste accounting for 19.8% of the total waste. The high proportion shows the urgency of handling plastic waste systematically. Comprehensive and integrated management not only provides ecological benefits, but also contributes to public health and economic potential through the reutilization of plastic materials (Kurniawan & Santoso, 2021).

An approach that can be developed involves utilizing extruder machines to recycle plastic into value-added products. The extruder machine operates by melting plastic material through various temperature heating zones, subsequently conveying the material via the screw to the mould in accordance with the specified product design (Sibarani et al., 2018). The resulting products, including plastic panels, exhibit significant application potential in construction and interior design. Plastic panels can be fabricated from different polymers, including high-density polyethylene (HDPE), which is recognized for its favourable mechanical properties, durability, and ease of processing.

This research is titled "Extruder Machine Design as a Facility for Utilizing High-Density Polyethylene Waste into Plastic Panels." It focuses on the design and construction of an extruder machine capable of processing HDPE plastic waste into plastic panels. This technology is anticipated to enhance the efficiency and practicality of the recycling process, yielding value-added products and contributing to reducing plastic waste and promoting environmental sustainability.

2. Material and Method

2.1. Plastic Recycling

Plastic, a synthetic polymer, is characterized by its non-biodegradable nature, complicating its natural decomposition. These materials can persist in the environment for hundreds to thousands of years, potentially threatening the ecosystem (Wahyudi et al., 2018; Suminto, 2017). Common types of plastic include Polyethylene Terephthalate (PET), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low Density Polyethylene (LDPE), Polypropylene (PP), and Polystyrene (PS) (Hartulistiyoso et al., 2015). Among these types, HDPE and LDPE are predominant in everyday applications, such as milk bottles, cosmetic containers, plastic bags, folding chairs, pipes, and industrial containers. HDPE exhibits a high density (0.88-0.96 g/cm³), a relatively elevated melting point (115-135 °C), as well as notable chemical and impact resistance, making it a preferred material in the manufacturing sector (Nurminah, 2002). The significant consumption of HDPE positions it as a primary contributor to environmental plastic waste generation.

Plastic recycling is a strategic approach to mitigate pollution and facilitate the reuse of valuable materials. Recycling transforms plastic waste into new products, thereby minimizing waste volume, decreasing pollution, and promoting environmental sustainability (Hasibuan, 2023). Plastic recycling is categorized into four distinct processes. (1) Primary recycling processes clean plastic into new products that maintain quality comparable to the original; (2) secondary recycling produces similar products of lower quality; (3) tertiary recycling decomposes plastic into basic chemicals or fuel; and (4) quaternary recycling extracts energy from plastic waste (Kumar et al., 2011). HDPE's heat-resistant and reprocessable characteristics indicate its significant potential for processing via recycling technologies, including extruder machines, into value-added products like plastic panels.

2.2. Extruder Machine

The extruder machine is a machine that functions to print various kinds of needs, extruder machines not only process plastic products but can also process food ingredients and other products according to the extruder machine mechanism (Pambudi et al., 2024). For this plastic processing extruder machine has a working principle such as injection molding, it's just a slightly different system mechanism, for injection molding machines used to print one product at a time according to the mold where the mold is separate from the screw tube. Whereas the extruder machine has a continuous mechanism. Usually, extruder machines are used to recycle waste into new goods (Sibarani et al., 2018).

2.3. Extruder Machine Components

The extruder machine is a precision instrument, consisting of several main components that work in tandem to melt and form plastic. These components, including the hopper, screw, barrel, heater, motor, shaft, bearing, and mold, each have a specific function. The hopper acts as a container for supplying plastic material, which is then fed into the barrel. The screw, the core component, pushes the material through the heating zone, including the feed section, melt section, and metering section, to produce a homogeneous melt before it reaches the mould. The mold, the final part of the process, shapes the plastic melt into a panel product of a specific size and shape. The band heater, mounted on the barrel, is crucial in facilitating the material melting process. The amount of heat energy required can be calculated using Equation 1, highlighting the technical complexity and precision involved in the process.

$$Q = m \times c \times \Delta t \quad (1)$$

Where m is the mass of the barrel (kg), C is the specific heat of stainless steel. $\left(\frac{J}{kg°C}\right)$

The electric motor acts as the main drive of the screw through the pulley and belt transmission system. Motor power can be determined from the relationship between torque and rotational speed in Equation 2.

$$P = \frac{2.\pi.n.T}{60} \quad (2)$$

Where P is the motor power (watt), T is the torsional moment or torque (Nm), n is the engine speed (rpm).

Shafts and bearings function to distribute power while withstanding torsional and bending loads arising from transmission. The maximum shear stress on the shaft can be calculated using the following Equation 3.

$$\tau = \frac{5{,}1 \times T}{ds^3} \quad (3)$$

Where τ is the maximum shear stress (kg/mm2), ds is the shaft diameter (mm), M is the bending moment (kg.mm), T is the torsional moment (kg.mm).

The integration of these components enables the extruder machine to function efficiently, encompassing material input, melting, mixing, and moulding of plastic panels. The design of the heater, motor, and shaft is crucial for maintaining process stability and ensuring the quality of recycled products.

2.4. Finite Element Method

The Finite Element Method (FEM) is a numerical approach used to solve complex engineering and mathematical problems, such as stress, strain, vibration, and structural strength analysis. The main principle of FEM is to divide a model into small elements with certain mechanical properties, allowing for simpler yet accurate calculations. Compared to manual calculations, FEM is able to provide fast and precise analysis results, even on com-plex geometry shapes, non-homogeneous materials, and anisotropic properties (Akin, 2010).

In its application, Finite Element Analysis (FEA) is carried out through several main stages. First, determining the analysis study as needed, such as static, frequency, or thermal. This research uses static analysis because all machine components are assumed to be at rest. Second, the selection of materials tailored to the modeling specifications, either through software databases or manual data input. Third, the meshing process, which is the division of the model into discrete elements. The quality of the mesh greatly affects the accuracy of the analysis results, so smaller element sizes generally result in higher accuracy.

The next stage is the provision of boundary conditions and loading that represent real conditions. Boundary conditions are used to restrain certain parts from moving, while loading is applied according to the machine's operational scenario. After the numerical solution is obtained, the post-processing stage is carried out to display the stress distribution, deformation, and other visualization results. With this stage, FEM becomes an effective tool in evaluating the strength of the machine structure before the fabrication process, thus minimizing the risk of design failure and improving the reliability of the final product (Rizqi et al., 2025).

2.5. Ulrich Method

Product design and development is a systematic process that aims to produce solutions that meet user needs while being efficient in terms of costs and resources. Ulrich and Ep-pinger (2016) define product development as a series of activities that convert market needs input into output in the form of product designs that are ready for production. The success of product development is measured by the extent to which the design is able to meet consumer needs, remain economical, and provide profits for producers.

Ulrich's model divides the product development process into several main phases, including planning, concept development, system-level design, detailed design, testing and improvement, and product launch. These phases allow the development team to explore customer needs, organize a hierarchical list of requirements, and come up with alternative concepts. The developed concepts are then evaluated through systematic screening and assessment to determine the best design. Each stage is accompanied by documentation activities in the form of technical specifications, visual designs, and prototypes, which form the basis for ensuring product reliability. This process can be seen in more detail through the five-step concept development method shown in Figure 1.

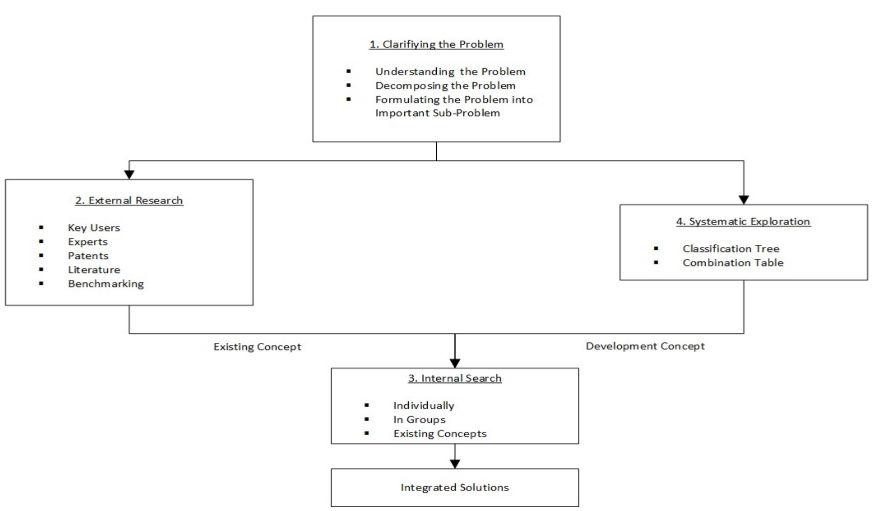

Figure 1. Five-Step Concept Development Method

Concept selection is a critical step because it determines the design that will be realized into the final product. Various methods are used at this stage, including a selection matrix and criteria weighting, to assess the relative merits of each concept compared to the reference product. Subsequently, the selected concepts are realized in the form of component designs, working mechanisms, and assembly technical details. This approach makes Ulrich's method relevant in this study, as it provides a structured framework for designing an extruder machine that meets the technical, economic, and functional needs of recycling HDPE plastic into plastic panels. In this case, the concept selection process is further strengthened by applying the Analytical Hierarchy Process (AHP), which allows a systematic breakdown of the decision-making problem into a hierarchy of criteria and sub-criteria. Through pairwise comparisons and consistency checks, AHP ensures that the weighting of each criterion is more objective and rational, thus improving the reliability of the final concept chosen.

2.6. Analytical Hierarchy Process (AHP)

AHP is a multicriteria decision-making method developed by Thomas L. Saaty in 1980. AHP is designed to solve complex problems that do not have enough statistical data by organizing them into a hierarchical structure consisting of main objectives, criteria, sub-criteria, and decision alternatives. With this approach, AHP is able to provide a systematic framework that is easier to understand and flexible in dealing with various technical and non-technical problems (Supriadi et al., 2018).

The main principles in AHP include problem decomposition, pairwise comparison, and priority synthesis. Decomposition is done by breaking down the problem into a hierarchical structure, ranging from objectives to alternatives. Pairwise comparisons use a scale of 1-9 to assess the relative importance between elements. The comparison results are then processed into priority weights, both local and global, which form the basis for selecting the best alternative. The validity of the assessment results is checked through the consistency ratio (CR), with values ≤0.1 considered consistent (Supriadi et al., 2018).

The main advantage of AHP lies in its ability to integrate qualitative and quantitative considerations in a structured manner, maintain logical consistency, and provide flexibility in evaluating alternatives. However, this method relies on the subjectivity of expert judgement so that potential bias can occur if the initial input is inaccurate. Nevertheless, AHP is widely used in technical research, including the selection of machine design concepts, as it facilitates transparent and systematic decision-making (Supriadi et al., 2018). The hierarchical structure in the AHP method can be seen in Figure 2, which illustrates the relationship between the goal, criteria, sub-criteria, and decision alternatives.

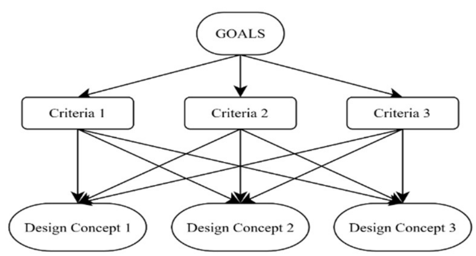

Figure 2. AHP Hierarchical Structure

2.7. Research Flow

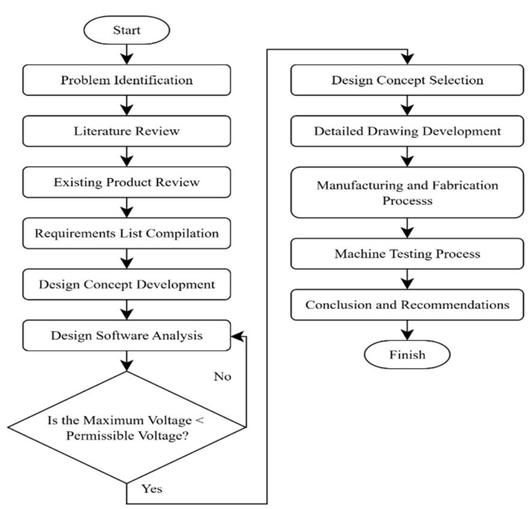

Figure 3. Research Flow Chart

2.8. Needs Identification and Design Concept Development

The initial stage of the research was carried out by identifying relevant problems and limitations, so as to obtain a formulation of the specific needs of the machine to be designed. The list of needs is compiled based on the results of observations, literature studies, and studies of existing products that have similar functions. This approach aims to find out the advantages and disadvantages of existing products, as well as a reference in developing new concepts.

Based on the list of requirements, several alternative design concepts were developed to meet the expected specifications. The design process was carried out with the support of Computer Aided Design (CAD) software to produce a three-dimensional representation of the machine and a detailed design of each component. This stage is important to ensure that the design meets the functional, technical and economic aspects.

2.9. Technical Analysis and Calculation

After the design concept was developed, a technical analysis was carried out with the help of Autodesk Fusion 360 software (Setiawan et al., 2023). The analysis focuses on the machine frame to determine the stress distribution, ensuring that the maximum stress at critical parts is less than the allowable stress. In addition, the power requirements of the motor, transmission system, and heating power were calculated so that the performance of the machine could meet the specifications. This analysis forms the basis for selecting a safe, reliable and energy efficient design.

2.10. Design Selection with AHP

From several design alternatives, the best design was selected using the Analytical Hierarchy Process (AHP) method. The assessment included the main criteria, namely structural strength, dimensions, weight, and cost budget plan. Each alternative was compared in pairs to obtain priority weights, and then a consistency test was conducted to ensure the validity of the results. The concept with the highest evaluation score was selected as the final design to be fabricated.

2.11. Machine Fabrication and Assembly

Machine fabrication is carried out based on the detailed drawings that have been prepared. The manufacturing process includes marking, cutting, drilling, welding, and machining of the main components such as the frame, hopper, barrel, screw, and nozzle. After all the components are completed, the next step is to assemble them into a single extruder machine. Finishing processes such as caulking, sanding, and painting are carried out to improve the quality of the final result.

2.12. Machine and Electrical Panel Testing

The final stage of the research is a machine trial to evaluate the performance and quality of the products produced. The test was conducted by melting HDPE waste using the extruder machine that had been made, then molding it into plastic panels. The evaluation focused on the quality of the panel surface, material density, and potential defects such as air voids. The trial results were used as the basis for assessing the success of the design as well as proving the effectiveness of the method used.

3. Results and Discussion

3.1. Description of the Proposed Design Concept

The existing product used is an extruder machine from Precious Plastic. This existing product is a comparison product that will be compared to the product plan that will be made. One of the shortcomings of this existing product is the relatively expensive price, as for the existing product specifications can be seen in Figure 4. and Table 1.

Figure 4. Existing Product

Table 1. Existing Product Specifications

Specification	Description
Extruder Type	Single screw
Capacity	5-10 kg/hour
Dimensions	85 x 50 x 120 cm
Weight	45 kg
Motor Power	1 HP
Heating Power	650 watt (3 x 150 watt + 200 watt)

A. Design Concept 1

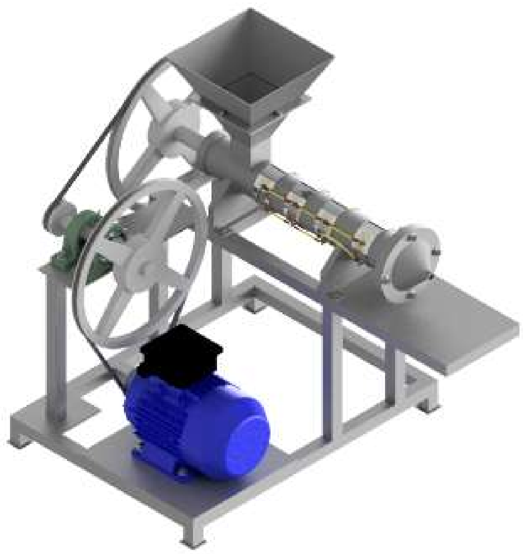

Figure 5. Design Concept 1

In design concept 1 the extruder machine has a total length of 749.5 mm, width of 617.3 mm and height of 689.3 mm. With compact dimensions it is expected that it does not take up much space for the placement of this machine. In concept design 1 has a transmission system using 2 shafts to get the required rpm. By using a two-shaft system it is expected to get a cheaper price. In this design concept 1 uses 4 heaters with each heater power of 300 watts. Details of concept 1 as shown in Figure 5.

B. Design Concept 2

Figure 6. Design Concept 2

In design concept 2 the extruder machine has a length of 824.5 mm, a width of 620 mm and a height of 720 mm. This second concept has larger dimensions compared to design concept 1 but remains smaller than the existing product. This second concept uses a reducer gearbox transmission with a ratio of 1: 40. The advantage of this design concept 2 is that the number of components used is less. Then the weakness in this design concept 2 has a relatively higher price because it uses a reducer gearbox. Details of the 2nd design concept as shown in Figure 6.

C. Design Concept 3

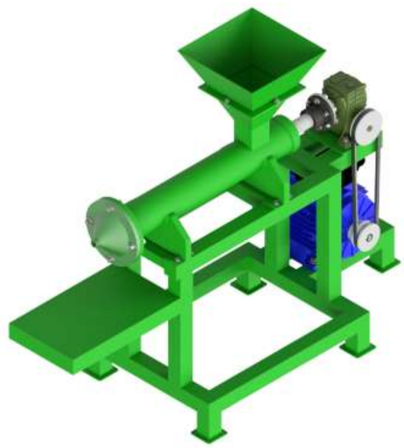

Figure 7. Design Concept 3

In design concept 3 the extruder machine has 1080 mm, 450 mm wide and 720 mm high. In this third concept using a couple to connect the rotation of the gearbox to the screw shaft. The advantage of this design concept 3 is the use of a couple as a power distributor so as to minimize the value of lost power. Then the weakness in this design concept 3 is that when there is misalignment between the gearbox shaft and the screw shaft, it takes more time for assembly. Details of concept 3 as shown in Figure 7.

3.2. Description of the Proposed Design Concept

The detailed calculations for each component and parameter underlying the analysis are systematically presented in Tables 2, 3, and 4, which provide the calculation outcomes for the respective design concepts. Building upon these results, the structural performance of design concepts 1 through 3 is comparatively illustrated in Table 5. Furthermore, to complement the technical evaluation, Table 6 summarizes the cost budget plan for each concept, thereby offering an integrated perspective that connects analytical, structural, and economic considerations.

Table 2. Calculation Results of Design Concept 1

Component/Parameter	Calculation Result	Description
Pulley D1 (motor → reducer)	315 mm (catalogue pulley, calculated result 323 mm)	Turns down from 1400 rpm → 266 rpm
Pulley D2 (reducer → screw)	315 mm (catalogue pulley, calculated result 319 mm)	Turns down from 266 rpm → 50 rpm
V-belt length (motor-reducer)	1145 mm (Z 45)	Calculation results 1160.75 mm → catalogue adjustment
Motor-reducer shaft distance (Cp1)	237 mm	Adjusted to catalogue belt length
Linear speed of belt (motor-reducer)	4.398 m/s	Using Dm = 60 mm, N = 1400 rpm
Contact angle (motor-reducer)	122,78°	Angle correction factor Ca = 0.84
Belt tension (motor-reducer)	169,3 N	Using belt weight 0.07 kg/m
V-belt length (reducer-screw)	1225 mm (Z 48)	Calculation results 1217.59 mm → catalogue adjustment
Shaft distance of reducer-screw (Cp2)	293 mm	Adjusted to catalogue belt length

Component/Parameter	Calculation Result	Description
Linear speed of belt (reducer-screw)	0.825 m/s	Using Dp = 315 mm, N = 50 rpm
Contact angle (reducer-screw)	130,39°	Angle correction factor Ca = 0.86
Belt tension (reducer-screw)	755,2 N	Using belt weight 0.07 kg/m
Maximum moment of transmission shaft	52,650 N-mm	Calculated from force distribution F1 = 758.5 N and F2 = 236.3 N
Maximum moment of screw shaft	36,450.5 N-mm	Calculated from force distribution F1 = 822.2 N and F2 = 43.2 N
Minimum diameter of transmission shaft	16.2 mm	Using ST 60 material (σ_b = 68 kg/mm²), 20 mm is used
Minimum diameter of screw shaft	22.53 mm	Using ST 60 material (σ_b = 68 kg/mm²), used 25 mm

Table 3. Calculation Results of Design Concept 2

Component/Parameter	Calculation Result	Description
Gearbox Output Round	35 rpm	Motor 1400 rpm, ratio 1:40
Pulley diameter Dp3	71 mm (from catalogue)	Pulley reducer to screw
V-belt length 1	728.4 mm ≈ 725 mm (Z 28 ½)	Motor - gearbox
Actual Shaft Distance 1	251 mm	Motor - gearbox
Linear Velocity of V-belt 1	4.398 m/s	Motor - gearbox
Belt Tension 1	128,86 N	With Ca=1Ca=1, M=0.07 M=0.07 kg/m
V-belt length 2	1119.74 mm ≈ 1120 mm (Z 44)	Gearbox - screw
Actual Shaft Distance 2	458 mm	Gearbox - screw
V-belt Linear Velocity 2	0.101 m/s	Gearbox - screw
Belt Tension 2	128,86 N	Gearbox - screw
Maximum Bending Moment	12,226.8 N-mm	At point B
Shaft Plan Power	0.75 kW	With fc=1f_c=1
Plan Moment (T)	24,350 kg-mm	Screw Shaft
Permit Shear Stress	5.67 kg/mm²	Material ST 60
Minimum Diameter of Shaft	27.99 mm	Using factors K_m=1, K_t=1K_m=1, K_t=1
Selected Shaft Diameter	30 mm	Standard and safe

Table 4. Calculation Results of Design Concept 3

Component/Parameter	Calculation Result	Description
Pulley (Transmission D1)	Dp1 = 71 mm	Pulley SPZ catalogue
Gearbox Output	n2 = 29.58 ≈ 30 rpm	As per screw requirement
V-belt length	L'p1 = 735.78 mm ≈ 735 mm	V-belt Z 29
Shaft Distance	C = 264.61 ≈ 265 mm	Valid
Linear Velocity of Belt	V = 4.398 m/s	-
Belt Contact Angle	γ = 177,63°	Ca = 1
Belt Weight	0.07 kg/m	From the characteristic table
Belt tension	Ts = 128.9 N	-
Shaft Bending Moment	M_{max} = 4864.8 Nm	At point C
Minimum Shaft Diameter	ds ≥ 13.7 mm	Selected 20 mm
Heater Power	Q = 1.04 kW = 1040 W	Selected 4 × 300 W band heater
Total Barrel Calorific Quantity	Q = 1,194,875 J	-
Heating Time	t = 995.7 s ≈ 16.6 min	-

Table 5. Structure Analysis Results

Parameter	Concept 1	Concept 2	Concept 3
Maximum von Mises stress	35.76 MPa	76.266 MPa	34.55 MPa
Maximum Displacement	0.135 mm	0.329 mm	0.087 mm
Frame material	ASTM A36 (σ_y = 250 MPa)	ASTM A36 (σ_y = 250 MPa)	ASTM A36 (σ_y = 250 MPa)
Safety factor (SF)	7,00	3,28	7,24
Design criteria	Safe, within load limits	Safe, close to minimum limit	Safe, tends to over design
Conclusion	The framework is able to withstand the load well	Framework able to withstand load, efficient	Framework is safe but too strong (over design)

Table 6. Summary of Cost Budget Plan Results

Parameter	Concept 1	Concept 2	Concept 3
Material Cost	Rp 4,406,911	Rp 4,955,938	Rp 4,598,622
Service Fee	Rp 414,250	Rp 386,550	Rp 494,600
Total Cost	Rp 4,821,161	Rp 5,342,488	Rp 5,093,222

3.3. Best Design Selection Results with AHP

The selection of the best design is based on the calculation of the comparison of weights between alternatives to the priority weight of the sub-criteria and criteria. Decision-making calculations are carried out by multiplying the weights between alternatives against the priority weight values of the sub-criteria and criteria. If there are no sub-criteria in the criteria, then simply multiply by the priority weight of the criteria. Calculation of decision making for the extruder machine design selection can be seen in Table 7.

Table 7. Determination of Concept Rate Value

Attribute Weight	Attribute					Alternative Weight Eval.
	Max Stress	Deflection	Machine Dimension	Machine Weight	Cost Budget Plan	
	0.31	0.35	0.1	0.14	0.1	
Existing			22.36	26.13	17.33	
Concept 1	38.59	40.68	26.47	25.01	27.93	35.14
Concept 2	23.44	19.02	25.37	24.24	27.23	22.58
Concept 3	37.97	40.30	25.8	24.61	27.51	34.65

Calculation:

$$\text{Alt. Weight} = (23{,}44 \times 0{,}31) + (19{,}02 \times 0{,}35) + (25{,}37 \times 0{,}1) + (24{,}24 \times 0{,}14) + (27{,}23 \times 0{,}1) = 22{,}58$$

The calculation results of the best design decision making show that alternative concept 1 has the highest Alt. Weight Evaluation value is the highest among other alternative concepts. The value of Alt. Weight Evaluation value on concept 1 is 35.14. It can be concluded that design concept 1 is the best result of this research.

3.4. Machine Fabrication and Assembly Process

The fabrication of the extruder machine is done through the process of cutting, welding, and painting the frame made of hollow steel; making the hopper from black steel plate by CNC cutting; and making the nozzle made of alloy steel using a lathe. All components were then assembled into a single extruder machine according to the design, resulting in a prototype that is ready to be used to recycle HDPE into plastic panels. The overall assembly process of the components can be seen in Figure 8.

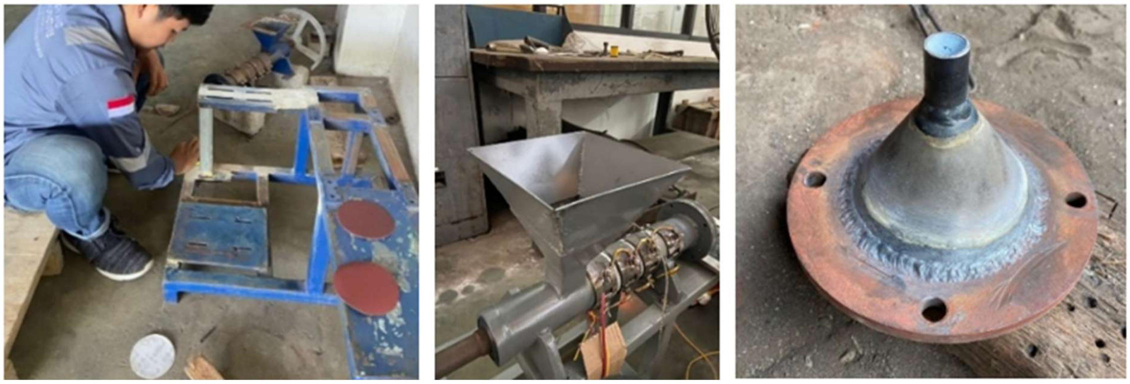

Figure 8. Machine Assembly Process

3.5. Machine Fabrication and Assembly Process

Figure 9. Test Results

Based on the tests that have been carried out by the author, testing this extruder machine using high density polyethylene plastic, this machine is able to melt plastic with a stable temperature of 270 °C and the maximum temperature that can be reached by the heater up to 280 °C read by the thermocouple. The test results can be seen more clearly in Figure 9.

4. Conclusion

This study successfully engineered an extruder machine to transform High-Density Polyethylene (HDPE) plastic waste into plastic panels. The Analytical Hierarchy Process (AHP) was used to methodically choose the best machine design based on structural strength, size, weight, and cost-effectiveness. The fabrication and assembly process resulted in an extruder machine capable of operating as designed and producing high-quality plastic panels with flat surface quality, good material density, and minimal structural defects. This finding shows that the selected design-based extruder machine effectively supports efforts to recycle HDPE plastic into value-added products. Thus, this research contributes to the development of a more efficient plastic waste processing technology that has the potential to support the reduction of environmental pollution and increase the reutilization of plastic materials.

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