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Research Article

Hollow Roll Machine Design With VDI 2222 Method and Sample Additive Weighting (SAW)

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Abstract

PT. X is a company engaged in the construction of Exterior and Interior Signage. One of the products produced by this company is the Pylon Daeler Honda. This product is in the form of a signpost pole in which there is a curved hollow construction. The process of forming curves or rolling is currently still being carried out in the subcont. On average, every month the company places an order to the subcont for the process of rolling 201 hollow rods at a cost of Rp. 7,535,000/month or in a year of Rp. 90,420,000. The amount of the cost of the rolling process is the highest when compared to the cost of the laser process in the subcont of Rp. 2,042,000. /Month. This becomes a burden on the company in cost efficiency processes to subcont/suppliers. One alternative solution to reduce the cost of the rolling process at the subcont is to make your own hollow roll machine. The purpose of this research is to produce an effective and efficient hollow roll machine design and to choose the right machine component alternative using the VDI 2222 method (Verein Deutsche Ingenieuer / German Engineers Association) and Sample Additive Weighting (SAW). The stages of designing the VDI 2222 method include the stages of planning, conceptualizing, designing and finalizing, then selecting alternative functions for the machine. The selection of alternatives with SAW weighting obtained the best alternative from the function of this machine part with the highest weight on each component or function part, namely the drive system using an electric motor (0.77), the transmission system using a chain and sprocket (0.80), the forming system using a box groove roll (0.76).) and the frame system uses UNP iron (0.86). The total production cost of making a hollow roll machine is Rp. 11,599,497 with a yearly rolling process cost of Rp. 57,204,000, Rp.33,216,000 more efficient than processing costs in subcont or there will be savings of 36.7% of processing costs in subcont for a year. So, the company decided to make the roll machine.

Keywords
VDI 2222, Sample Additive Weighting, mesin roll hollow

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Introduction

With the existence of information technology that can be accessed easily by anyone, every company is required to advance technology in each of its production lines (Kurniawati, 2018). One of the technologies that can be used is automation with the aim of getting products with very high productivity. The process of producing a finished product that is ready for use by involving technology and has added value is called the manufacturing process (Wu, Sodell, Elmustafa, & Haile, 2021). The terms Quality, Cost, and Delivery (QCD) in manufacturing companies are very closely related in every production activity (Sarkar, Chaudhuri, & Moon, 2015)PT X is a company engaged in the construction of Exterior and Interior Signage. Signage products produced by this company include Signage products for Building, Automotive, Store and public facilities. The production system used by this company is a make to order production system. This study will discuss one of the products produced by PT X, namely Pylon Daeler Honda. This product is in the form of a signpost pole in which there is an iron construction. This pylon is placed in front of the dealer building or the official Honda motorcycle workshop. Inside the pylon construction, there is a curved hollow component. The process of forming the arch or rolling is carried out at the supplier/subcont. Hollow rolling results are sent to the company for welding and assembly with other components into a pylon construction. Based on observations made at PT X, especially in the production department and PPIC for the last two years, every month the company orders subconts for the hollow rolling process. In addition to rolling, other processes such as laser processing are also carried out in subcont. This is done because the company does not yet have a machine for the process. On average, every month the company places an order to the subcont for the process of rolling 201 hollow rods at a cost of Rp. 7,535,000/month or in a year of Rp. 90,420,000. The amount of the cost of the rolling process is the highest when compared to the cost of the laser process in the subcont of Rp. 2,042,000. /Month. This is a burden on the company in cost efficiency processes to subcont/supplier. PT X has three alternative solutions to overcome this problem, namely buying a hollow roll machine, renting a hollow roll machine, and making its own hollow roll machine. This choice will affect the development and profitability of the company, so it is necessary to compare the costs between the three options with the subcont costs each month

In the manufacture of this hollow roll tool or machine, it is necessary to select the right materials and components, so that this machine is able to work optimally in terms of the strength and durability of the machine. In addition, the ease of machine operation and worker safety also need to be considered so that everyone can use the machine easily and safely. In order to achieve this, it is very necessary in the design accuracy and careful planning. So the VDI 2222 method was chosen (Verein Deutsche Ingenieuer/German Engineers Association). The VDI 2222 method is a product design consisting of 4 phases, namely planning and explanation, product concept design, product form design and detailed design (Pahl & Barrett, 2010). The application of the VDI 2222 method using CAD/CAE software has been carried out in the welding fixture design process for the chimney connection and the results are very suitable and can speed up the design process (Berselli, Bilancia, & Luzi, 2020). In the design stage, there is a link between processes, where the next design process depends on the results of the process assessment carried out from several alternative constructions. To determine the choice of alternative used, an assessment of each available alternative is carried out using the Simple Additive Weighting (SAW) method. The advantage of this method compared to other decision-making methods lies in its ability to make a more precise assessment because it is based on predetermined criteria and preference weights (Ramadhan & Zaky, 2020). In addition, SAW can also select the best alternative from a number of available alternatives because of the ranking process after determining the weight value for each criterion (Tian, Nie, & Wang, 2020). There are four criteria in determining the design of this machine, namely safety, reliability, cost and ease of production (manufacturability). These criteria will be considered in the selection of alternative roll machine construction. Based on this, the purpose of this research is to produce an effective and efficient hollow roll machine design and choose the right alternative machine components using the VDI 2222 method (Verein Deutsche Ingenieuer / German Engineers Association) and Sample Additive Weighting (SAW).

Literature Review

Hollow Iron

Hollow iron is iron in the form of a hollow box (square or rectangular). Hollow iron is also called square hollow, hollow box or iron holo. Hollow iron is usually made of galvanized iron, stainless or steel (Martinez, Ahmad, & Al-Hussein, 2019). Hollow iron is becoming quite popular nowadays because of its many and varied functions. Often used in building construction, especially in the construction of accessories such as fences, raillings, roof canopies and gates. Hollow iron can also be used to support ceiling installations between contributed human activities and the resulting output units. This work measurement relates to efforts to determine the standard time required to complete a job. This standard time is the time required by an operator who has an average level of ability to complete the job. In this case, it includes the slack time given by taking into account the situation and conditions of the work that must be completed. Thus, the standard time generated in this work measurement activity can be used as a tool to make a work scheduling plan that states how long an activity must be carried out and how much output is produced and how many workers are needed to complete the work.
(Petrosyan, Dunoyan, & Mkrtchyan, 2020)

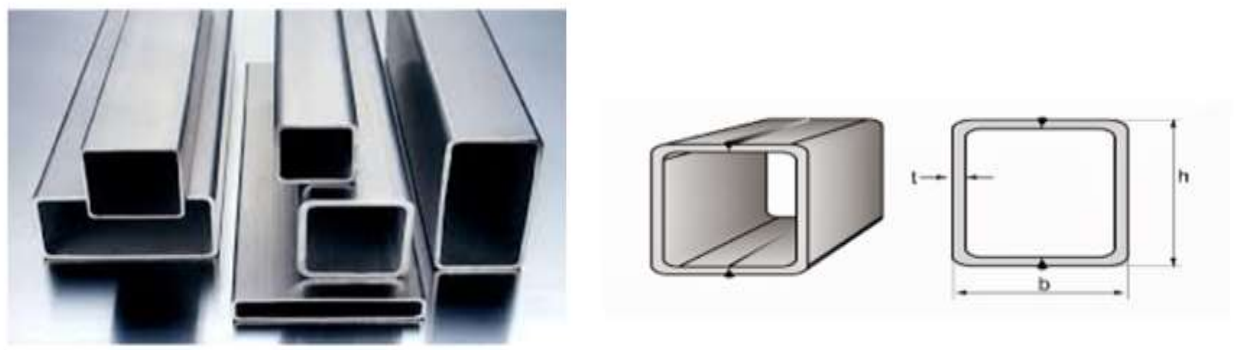

Figure 1. Hollow Iron

Design Method VDI 2222

Design Method VDI 2222 is a method of systematic approach to design to formulate and direct various design methods that are growing as a result of research activities. (Pahl & Barrett, 2010). This method is often used by German engineers to describe an idea they have to solve a problem. The elaboration of these ideas into a design that is needed in a problem and can produce a work that is real and can be scientifically justified. (Yang, Yuan, Chen, & Yu, 2020). The VDI 2221 method aims to make it easier for a designer to formulate and direct the various design variants that exist because in this method the existing ideas are arranged efficiently and systematically. Overall, the work steps contained in VDI 2221 consist of 7 (seven) stages, which are grouped into 4 phases, namely Clarification of Tasks, Conceptual Design, Embodoment Design and Detail Design (Deng, Qin, & Liuyi, 2020).

Simple Additive Weighting Method

The SAW method is often also known as the weighted addition method. The basic concept of the SAW method is to find the weighted sum of the performance ratings on each alternative in all attributes (Gao, Li, & Zhong, 2020). Simple Additive Weighting (SAW) is one of the methods used to solve multi-attribute decision problems. The use of the basic concept of the SAW method is to find the number of weights performance rating for each alternative on all attributes (Pataropura, Riki, & Manu, 2019). The SAW method requires a process of normalizing the decision matrix (X) to a scale that can be compared with all available alternative ratings (Panjaitan, 2019).The steps of the SAW method are as follows: (Gulo & Riandari, 2020):

Determine Alternative A_i

The decision matrix for each alternative for each attribute is given as follows:

$$x = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \dots\dots\dots\dots\dots (1)$$

x_{ij} is an alternative performance rating -i against criterion j.

a) Determine the criteria that will be used as a reference in making decisions, namely C_j.

b) Make a table of suitability ratings for each alternative on each of the following criteria:

Table 1.
Match Rating

Alternative	Criteria			
	C_1	C_2	…	C_n
A_1	x_{11}	x_{12}	…	x_{1n}
A2	x_{12}	x_{22}	…	x_{2n}
…	…	…	…	…
Am	x_{m1}	x_{m2}	…	x_{mn}

c) Determine the weight of preference or level of importance (w) for each criterion, as in Equation (2). The weight values that indicate the relative importance of each criterion are given as follows:

$w = \{w_1, w_2, \dots\dots w_n\} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$

d) Create a decision matrix (x) which is formed based on the table of suitability ratings for each alternative (Ai) on each criterion (Cj), with i=1, 2,…, m and j=1,2,…, n, as in Equation (1).

e) Normalize the decision matrix by calculating the value of the normalized performance rating (p_{ij}) from the following alternative criteria.

$$p_{ij} = \begin{cases} \dfrac{x_{ij}}{\underset{i}{Max}} & \text{, if the profit criteria} \\ \dfrac{x_{ij}}{\underset{i}{Min}} & \text{, if the cost criteria} \end{cases} \dots\dots\dots (3)$$

With i=1,2,...,m; j = 1, 2, …, n

f) The results of the normalized performance rating value (pij) form a normalized matrix (P).

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ p_{m1} & p_{m2} & \cdots & p_{mn} \end{bmatrix} \text{......................} \mathbf{(4)}$$

g) The final result of the preference value (V_i) is obtained by adding up the multiplication of the normalized matrix row elements (P) with the preference weights (w) corresponding to the matrix column elements (w^T).

$$V_i = \sum_{j=1}^{n} w_j p_{ij} \text{ wih i = 1, 2........, m; j =1,2,.....,n}$$

The largest V_i value indicates that alternative A_i is the best alternative

Research Methodology

In the machine design process, a method is needed so that the designed machine can be made with a systematic process. The method used in designing this hollow roll bending machine is the VDI 2222 method which refers to the product design stage. This method was chosen because of the simplicity of the steps in making a solution to a problem without considering the initial concept design so that engineers can easily make repairs. At the planning stage of the row hollow machine, the most important thing is to identify the product in the design of the roll hollow machine obtained from observations of the product samples that are in production. The identification carried out on the hollow includes identification of the size, material and function of the product and then poured into the drawing

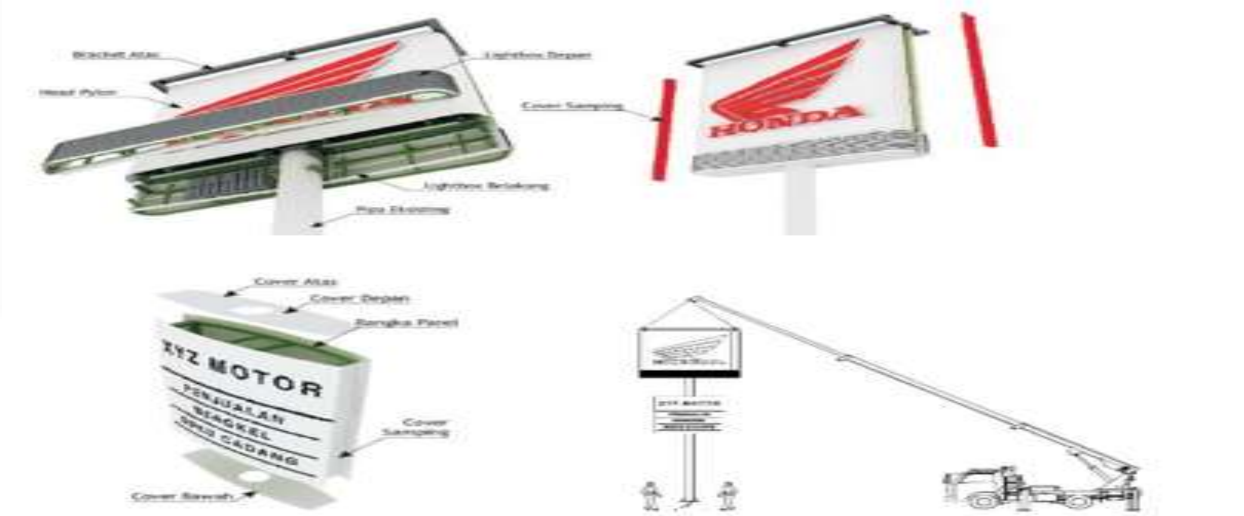

Figure 2. Frame Construction

In this study, there are 2 hollows that will be rolled out, namely hollow aluminum and hollow iron. Hollow Aluminum measuring 19x19x1 mm is an accessory component of the outer Light box, while hollow iron 20x20x1.2 is a component that forms the frame. These Hollows are processed in subcont with the average total quantity of both of them is 200 sticks. The next step is the product concept stage. The current process is the rolling process is carried out in the subcont because the company does not have a roll machine. The roll size of the subcont is also sometimes not always good. The price or fees charged are also quite expensive with an average cost of 7 million / month. Alternatives that you get, such as buying a new machine or renting a new machine, are still considered expensive. In this study, the problems faced by the company will be answered in the proposed design of the hollow roll machine.

At the design stage, the SAW (Simple Additive Weighting) method is calculated in the design of the hollow roll machine:

1. Determine the criteria for the alternative function parts
2. Give a weight value to each criterion
3. Create a matrix for normalization

The formula for the Normalization Matrix equation is as follows:

$$p_{ij} = \begin{cases} \dfrac{x_{ij}}{\underset{i}{Max}} & \text{, jika j kriteria keuntungan} \\ \dfrac{x_{ij}}{\underset{i}{Min}} & \text{jika j adalah biaya (cost)} \end{cases}$$

Determine the Preference value with the following equation:

$$V_i = \sum_{j=1}^{n} w_j p_{ij} \text{ withi = 1, 2……., m; j =1,2,…..,n}$$

The largest V_i value indicates that alternative A_i is the best alternative

Determination of the weight of the criteria in determining each alternative function of the part in the design of this hollow roll machine is obtained through a questionnaire conducted at the company, At the stage of completion and production using machine operating standards applicable in the company, this is necessary to maintain the method or working method of operating this machine so that the quality of the hollow rolling results remains good.
The detailed stages are as follows:

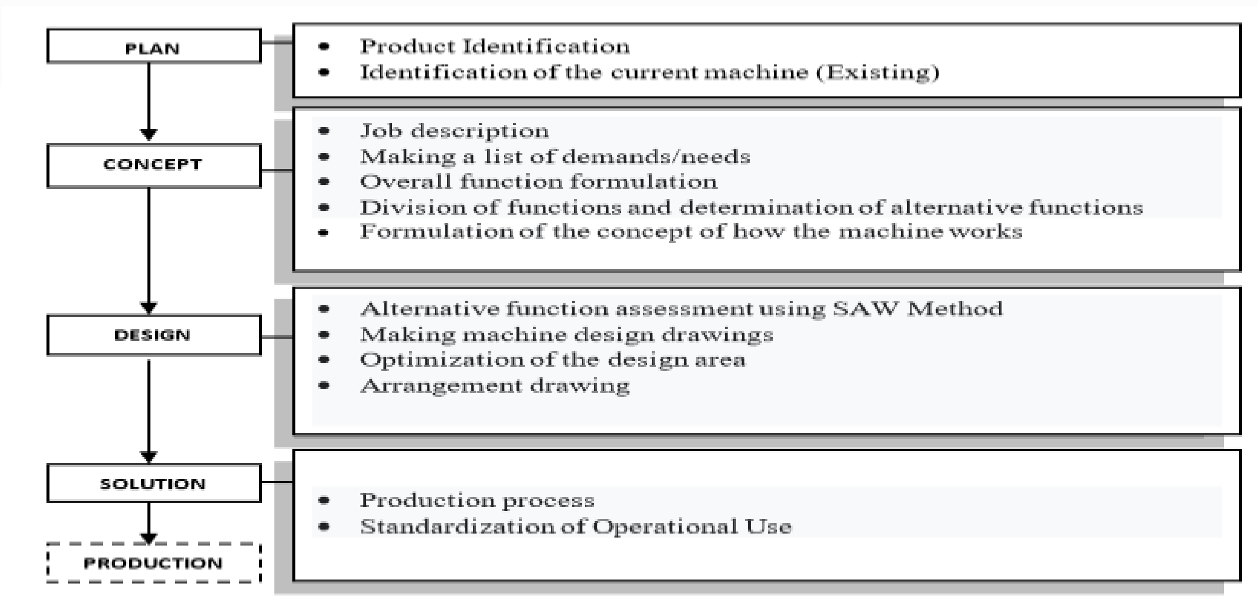

Figure 3. Data Processing Stage

Results And Discussion

There are 16 pcs of 25x25 aluminum hollow pylons installed, while 4 pcs of 40x40 iron hollow pylons are installed. The raw materials for these Hollows come from the factory and are cut to size in a bandsaw machine and then sent to the subcont for roll processing. Holoow that has been rolled is sent back to the factory for further processing. Based on observations in the field, some of the results of the hollow roll arches are not the same as other hollows, so they must be sent back to the subcont for repair

Figure 4. Light box Construction

The following is the production process of Honda's Pylon Light box at PT X, in which there are Hollow components that are rolled from raw materials to installation at the customer, which can be seen in the image below.

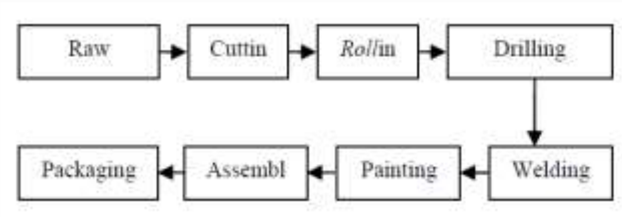

Figure 5. Pylon Light box Production Process

Based on the data and information obtained from the PPIC and purchasing departments at PT X, the number/quantity of the Roll Hollow Process orders carried out at the subcont in the last 1-year period is as follows:

Table 2.
Data on the Number of Orders for the Roll Hollow Process in the Subcont

No	Month	Item	Qty	Tot.Qty	Unit	Unit Price	Cost	Total Cost
1	January	*Iron Hollow* 40x40	56	278	stem	Rp 50,000	Rp 2,800,000	Rp 10,570,000
		Alumunium *Hollow* A 25x25	222		stem	Rp 35,000	Rp 7,770,000	
2	February	*Iron Hollow* 40x40x2	28	272	stem	Rp 50,000	Rp 1,400,000	Rp 9,940,000
		lumunium*Hollow* 25x25	244		stem	Rp 35,000	Rp 8,540,000	
3	March	*Iron Hollow* 40x40x2	0	28	stem	Rp 50,000	Rp -	Rp 980,000
		Alumunium *Hollow* 25x25	28		stem	Rp 35,000	Rp 980,000	
4	April	*Hollow* Besi 40x40x2	54	224	stem	Rp 50,000	Rp 2,700,000	Rp 8,650,000
		Alumunium*Hollow* 25x25	170		stem	Rp 35,000	Rp 5,950,000	
		Average qty		200.5			Average cost	Rp 7,535,000

After obtaining data on the number/quantity of Hollow Roll Process orders carried out in the subcont, it can be concluded that the average number of hollow processed rolls in the subcont is 201 btg/month, with an average cost of Rp. 7,535,000/month. The following is a table comparing the costs of the rolling process at the subcont, the purchase and rental costs that have been obtained for the hollow roll process of 201 sticks/month.

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Table 3.
Comparison of Roll Hollow/Month Process Costs

No	Cost Component	*Subcont*	Buy Machine (Rp. 35 jt)	Making Machine
1	Labor	Rp -	Rp 3,500,000	Rp 3,500,000
2	Operational	Rp 7,535,000	Rp 100,000	Rp 100,000
3	Maintenance	Rp -	Rp 200,000	Rp 200,000
4	Procurement Cost (12 month)	Rp -	Rp 2,917,000	Rp -
5	Biaya sewa	Rp -	Rp -	Rp 3,500,000
6				
	Total	Rp 7,535,000	Rp 6,717,000	Rp 7,300,000

Table 4.
Process Cost Simulation Per Year

Alternative	Jan	Feb	March	Apr	May	Jun
Subcont	Rp 7,535,000	Rp 7,535,000	Rp 7,535,000	Rp 7,535,000	Rp 7,535,000	Rp 7,535,000
Buy	Rp 6,717,000	Rp 6,717,000	Rp 6,717,000	Rp 6,717,000	Rp 6,717,000	Rp 6,717,000
Rent	Rp 7,300,000	Rp 7,300,000	Rp 7,300,000	Rp 7,300,000	Rp 7,300,000	Rp 7,300,000
Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Rp 7,535,000	Rp 7,535,000	Rp 7,535,000	Rp 7,535,000	Rp 7,535,000	Rp 7,535,000	Rp 90,420,000
Rp 6,717,000	Rp 6,717,000	Rp 6,717,000	Rp 6,717,000	Rp 6,717,000	Rp 6,717,000	Rp 80,604,000
Rp 7,300,000	Rp 7,300,000	Rp 7,300,000	Rp 7,300,000	Rp 7,300,000	Rp 7,300,000	Rp 87,600,000

In the simulation table the process cost alternative is the lowest machine purchase with a total cost in a year of Rp. 80,604,000, Rp.9,816,000 cheaper than the processing fee in subcont. This fee

is also lower than the total cost of renting the machine. However, companies need other alternatives such as buying machines so that costs are lower and company profits are more optimal. A careful design and calculation method is needed so that the cost of making a hollow roll machine can be the best alternative solution in reducing the cost of the hollow rolling process in this company. The results of the roll machine design method using the VDI 2222. method
The following is a description of the roll machine design method using the VDI 2222 method which includes four stages of planning, conceptualizing, designing, and completing.

Planning

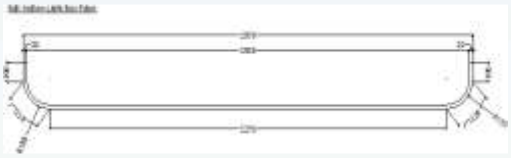

Figure 6. Identification of Roll Hollow Products

Concepting

The design of this hollow roll machine adapts to the current demands/needs of the company, so that the function/purpose of the machine is made to be achieved and not excessive. This rolling tool/machine has various demands that must be met, so that later this tool/machine can be accepted and meet all user needs. The following are the demands of the hollow roll tool/machine, namely:

Table 5.
List of Demands/Needs

No.	Parameter	Design Demand	Need Level
1	Energy Sources	a. Using motor power b. Can be replaced with other Mover	D W
2	Mechanism	a. The direction of rotation must be back and forth b. Easy and simple to operate c. Using the transmission system to gain mechanical advantage	D D D
3	Material	a. Easy to get and cheap. b. Has good mechanical properties. c. According to general standards d. Long service life. e. Good quality	D D D D W
4	Dimentions	a. Length ranges 1200 mm b. Width ranges 1000 mm c. Height ranges 750 mm	D D D
5	Syle	Has a downward pressure	D
6	Ergonomics	a. As needed b. No Noise c. Easy to operate	D D D
7	Security/Safety	a. Frame construction must be sturdy b. The dangerous part is closed c. No pollution	D D W
8	Production	a. Can be produced in a small workshop b. Spare parts are cheap and easy to get c. Relatively cheap production costs	D D W
9	Maintenance	a. Low maintenance cost b. Easy maintenance	D D
10	Transportation	a. Easy to move b. No need for special tools	D D

After the main problem is identified, then the overall function structure is made. The structure of this function is illustrated by a box diagram showing the relationship between input and output. Input and output in the form of energy flows, materials, systems and finished products. The function of this hollow roll machine is that it is used to change straight hollows into curved hollows with a compressive force

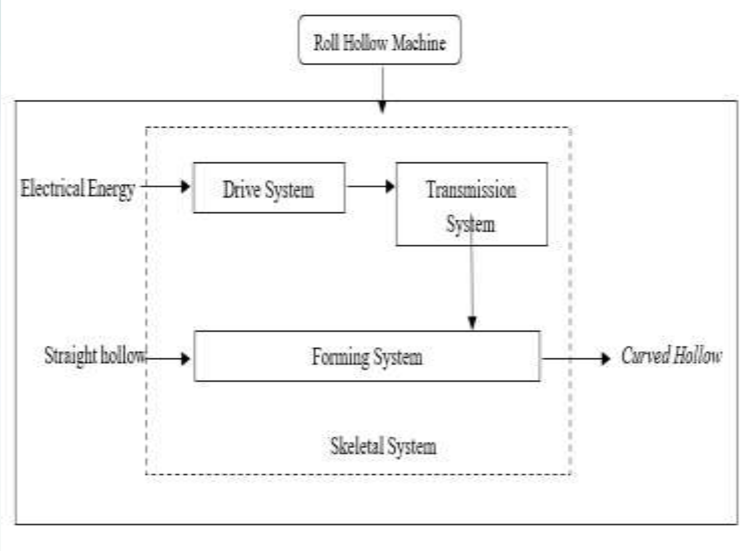

Figure 7. Overall Function Diagram

The function of the parts is formulated to clarify the interrelated functions of the whole. Furthermore, alternative functions of the part must be determined to select components that may be used to realize the machine design. If the alternative functions have been obtained, they need to be re-analyzed, in which alternative functions of the less useful parts can be eliminated or ignored with the aim that in the alternative selection stage there are not too many evaluations that must be done.

Table 6.
Alternative Function Parts

No	Function Parts	Alternative 1	Alternative 2	Alternative 3
1	Drive System	 Electric Motor	 Manual/mekanic	 Petrol Motorbike
2	Transmission System	 Chain & Sprocket	 Belt & Puley	 Gears
3	Shaping System	 Cast Iron Roll	 Book Groove Roll	
4	Skeletal System			

Designing

At the design stage, an Alternative Functional Assessment is carried out and calculations using the SAW (Simple Additive Weighting) method in machine design. Here are the results:

Table 7.
Preference Matrix Results (V) For Drive System

Preference Matrix					
Alternative	C1	C2	C3	C4	Amount
Electric Motor	0.45	0.10	0.15	0.07	0.77
Manual/Mekanic	0.30	0.06	0.06	0.10	0.52
Petrol Motorbike	0.15	0.30	0.09	0.03	0.57

From the results of the Preference calculation, an Electric Motor is obtained as the best alternative to the Drive System with the highest value (0.77).

Table 8.
Preference Matrix Results (V) For Transmission System

Preference Matrix					
Alternative	C1	C2	C3	C4	Amount
Chain & Sprocket	0.45	0.10	0.15	0.10	0.80
Belt & Puley	0.18	0.15	0.06	0.07	0.46
Roda Gigi	0.27	0.30	0.09	0.03	0.69

From the calculation results of Chain & Sprocket Preferences as the best alternative to the Transmission System with the highest value (0.80).

Table 9.
Preference Matrix Results (V) For Shaping System

Preference Matrix					
Alternative	C1	C2	C3	C4	Amount
Cast Iron Roll	0.27	0.30	0.10	0.04	0.71
Box groove Roll	0.45	0.06	0.15	0.10	0.76

From the results of the calculation of Preferences for the Shaping System, it is found that the Box Flow Roll as the best alternative with a value of 0.76.

Table 10.
Preference Matrix Results (V) For Skeletal System

Preference Matrix					
Alternative	C1	C2	C3	C4	Amount
UNP Iron	0.45	0.20	0.15	0.06	0.86
Hollow Iron	0.27	0.30	0.09	0.10	0.76
Elbow Iron	0.18	0.12	0.06	0.04	0.40

From the results of the Preference calculation, it was found that UNP Iron was the best alternative to the Frame System with the highest value (0.86).

Roll Machine Design Results

The alternative functions of the parts that have been selected are then carried out by making a design drawing of a hollow roll machine using Solidwork 2013 software.

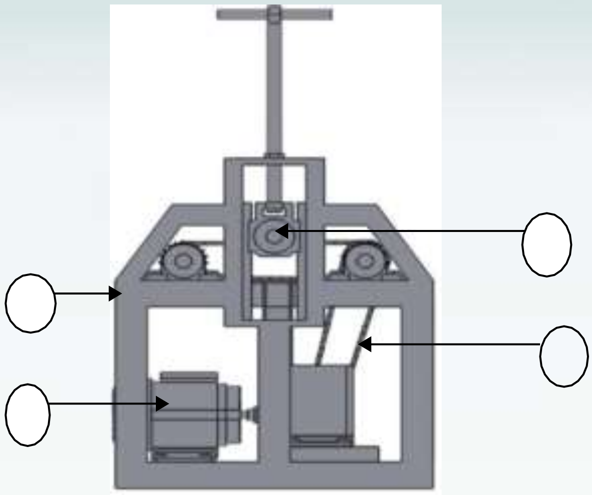

Figure 8. Roll Hollow Machine Design Drawing

The function of the part in the design drawing of the hollow roll machine that has been determined in this study is as follows:

1. Frame/Body System: The material used is UNP iron measuring 45x80 mm. This section serves as a frame or housing for all components
2. Drive System: The drive uses a new 2 hp electric motor/dynamo. The motor will be equipped with a gearbox/reducer which functions to reduce the motor speed from 1400 rpm to 20 rpm.
3. Transmission System: The rotational transmission system from the motor and gearbox is transmitted to the forming part by using a chain and sprocket. This system will make the shaper spin powerful and not slip.
4. Forming System: The material used is as an iron bar which is carried out by a lathe process to form a box groove. The width of the groove is adjusted to the size of the hollow to be formed

Solution

In the manufacture of this hollow roll machine, it is necessary to prepare a production process plan. The entire manufacture of this machine is carried out at PT X

Machine Manufacturing Cost Analysis

In determining the cost of making a hollow roll machine in this company, the researcher will use a method commonly used in this industry where production costs are the sum of material costs and process costs. The calculation results obtained the total cost of making the machine Rp. 11,599,497

Table 11.
Comparison of Machine Manufacturing Costs/Month

No	Cost Component	*Subcont*	Buy Machine (Rp. 35 jt)	Machine Rental	Making Machine (Rp. 11.6 jt)
1	Labor	Rp -	Rp 3,500,000	Rp 3,500,000	Rp 3,500,000
2	Operational	Rp 7,535,000	Rp 100,000	Rp 100,000	Rp 100,000
3	Maintenance	Rp -	Rp 200,000	Rp 200,000	Rp 200,000
4	Procurement Cost (12 month)	Rp -	Rp 2,917,000	Rp -	Rp 967,000
5	Rental Costs	Rp -	Rp -	Rp 3,500,000	Rp -
6			Rp -		Rp -
	Total	Rp 7,535,000	Rp 6,717,000	Rp 7,300,000	Rp 4,767,000

Comparative Analysis of Machine Manufacturing Costs

In the simulation table of process costs in a year, the alternative for making machines is the lowest with a total cost in a year of Rp. 57,204,000, Rp. 33,216,000 cheaper than the subcont process fee. There will be savings of 36.7% of processing costs in subcont for a year. So the design method and decision calculation system chosen have made the cost of making the hollow roll machine the best alternative solution in reducing the cost of the hollow rolling process in this company.

Conclusion

Based on the results of the research that has been done, it can be concluded several things as follows:

1. The design of this hollow roll machine is an innovation from the existing pipe/hollow roller tool/machine. The dimensions of this machine are 1200x750x1200 mm with a 2 hp electric motor connected to a 1:60 gear box/reducer with a final rotation speed of 20 rpm.
2. The design of the hollow roll machine produced is in accordance with the company's needs. The function of each part of this hollow roll machine is the best alternative from the selection process using the SAW (Simple Additive Weighting) method. The drive system uses an electric motor (0.77), the transmission system uses a chain and sprocket (0.80), the forming system uses a box groove roll (0.76) and the frame system uses UNP iron (0.86).
3. The production cost of the hollow roll machine as a result of this design is Rp. 11,599,497. So the cost of the rolling process for a year if the company uses this design machine is Rp. 57,204,000, Rp.33,216,000 cheaper than processing costs in subcont or there will be savings of 36.7% of processing costs in subcont for a year

Suggestion

Some suggestions for companies when realizing this tool/machine are:
1. To produce good and perfect rolling, this tool/machine requires additional components, namely a tool capable of measuring the straightness of the circle during the rolling process such as a jig or mall.
2. For the basic material of the axle must be considered, because the components of the axle always rub against other materials Maintenance of tools/machines must be carried out regularly
3. In order to obtain an effective and efficient design, the components or functions of the selected machine parts should be reproduced.
4. Planning a machine, we should look for the data needed first, such as data on all components of the tool to be used, calculation data for planning tools, and tables of safety factors that have become the standard planning tables used

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