The Implementation of Eco-Design Through Group Tool Design for Reinf-FR Towing Pipe Products

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Keywords: Green Manufacturing, Eco-Design, Group Tool, Press Tool, Reinf-FR Towing Pipe.

Abstract: Green manufacturing is a process or system that does not have a negative impact on the environment. However, in Indonesia, four-wheeled vehicles are still the most popular mode of transportation. With high demand, car production and the number of components are also increasing. Improving the efficiency of the tools and machines is necessary for the stamping process. One vehicle component with several process stages during stamping processes is the Reinf-FR Towing Pipe. Four stages of the process are required to manufacture the Reinf-FR Towing Pipe components. Eco-design can help to reduce or eliminate the negative effects of manufacturing on the environment. To implement green manufacturing, a group tool has been designed using VDI 2222 methods and ISO 14006:2011. By grouping multiple processes into one tool, only one machine is required.

1 INTRODUCTION

Four-wheeled vehicles are still the most popular mode of transportation in Indonesia. This can be seen in Indonesia, which became Southeast Asia's country with the highest car sales throughout 2021. Sales reached 887,202 units, an increase of 66.8% compared to 2020 (Kurniawan, 2022). In addition, the issue of the Abolition of Luxury Goods Sales Tax (PPnBM) is also one of the triggers for people to buy new cars (Doni, 2021). With high demand, car production is also increasing. Total car production in Indonesia during 2021 was 1,121,967 units, an increase of 62.6% from the previous year (Kurniawan, 2022).

Each car unit consists of many constituent components. The number of components in the vehicle causes the need for many tools to produce a car. Several stages of the process need to be done to make one vehicle component so that the number of tools required to make one component can be more than one. The more tools used, the more machines required. One vehicle component with several process stages during manufacture is the Reinf-FR Towing Pipe.

Figure 1: Reinf-FR Towing Pipe Component.

Figure 1 shows the Reinf-FR Towing Pipe component. This component is one part of the bumper beam. The bumper beam itself has a function as a protector of vehicle components such as engine parts and oil tanks in the event of a major collision due to accident. Four stages of the process are required to manufacture the Reinf-FR Towing Pipe components.

Figure 2 shows the stages of the manufacturing process for the Reinf-FR Towing Pipe component. The four stages of the process carried out in the manufacture of Reinf-FR Towing Pipe components are blanking & piercing, bending, bending & embossing, and piercing. The four processes are carried out using four different single tools, so four machines will be used for each tool.

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Budiarto, H., Erlangga, Y., Permana, S. and Wardhana, G.
The Implementation of Eco-Design Through Group Tool Design for Reinf-FR Towing Pipe Products.
DOI: 10.5220/0011966400003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 942-946
ISBN: 978-989-758-619-4; ISSN: 2975-8246

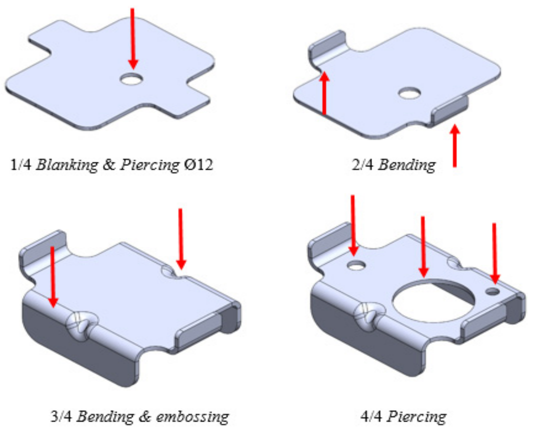


Figure 2: Stages of the process of making the Reinf-FR Towing Pipe component.

Figure 3 shows a graph of the contribution of various sectors to the amount of CO_2 emissions from fuel combustion in Indonesia. The industrial sector is in the top three positions, contributing the most CO_2 emissions, 27%. This is related to the large number of machines used in the industry. To overcome this, the concept of green manufacturing is needed.

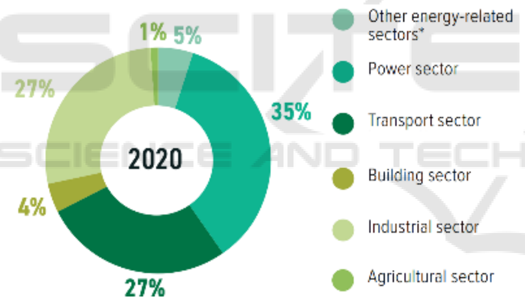


Figure 3: CO2 emissions from fuel combustion by sector in Indonesia (Climate Transparency, 2021).

Green manufacturing is a process or system that does not have a negative impact on the environment (Dornfeld, 2013). To reduce or eliminate the negative effects of the manufacturing process, lean manufacturing can be done. Lean manufacturing is streamlining the production process by considering all resource expenditures to produce products with economic value without waste (Sundar et al., 2014). It is considered to be the most influential in manufacturing as empirical evidence that enhances organisational competitiveness (Ikatrinasari et al., 2018). Eight things cause production wastage: transport, inventory, motion, waiting, overproduction, over-processing, defects, and unutilised talent (Leksic et al., 2020).

Improvement tools for manufacturing vehicle components can reduce the eight wastes in the manufacturing process. Eco-design is one way to implement green manufacturing. Casamayor and Su, (2021) assessed each LED lighting production process. One of the processes that implement eco-design on products is optimising the amount of material used via simulation and optimisation, in that case, using SolidWorks simulation. Using the eco-design concept, the production process of vehicle components also can be faster and reduce the use of raw materials for tool making and press machines. Therefore, a tool improvement design was carried out to manufacture a Reinf-FR Towing Pipe using the tool group. It combines 2-3 types of work on a single die set, single operation. Usually, this tool group has no more of the two operations (Budiarto, 2012). Tool build, cost calculation, and tool life are not discussed. Currently, three machines are needed to produce the Reinf-FR Towing Pipe. By grouping multiple processes into one tool, only one machine is required.

2 METHODS

The VDI 2222 (Verein Deutsche Ingenieur) and ISO 14006:2011 methods are used to design a group tool because this method is suitable for the product development process based on eco-design. By using this method, scrap and cycle times are expected to be reduced. (Budiarto et al., 2022; Navajas et al., 2017). By reducing cycle time, energy consumption is also reduced. This method consists of 4 main stages, planning, conceptualising, designing and completion. Figure 4 shows the flow process of VDI 222.

In the planning stage, the first step is to analyse and identify the product so that a product requirement is generated (Sianipar et al., 2013). As a result of the product analysis, the cutting-forming process stages will be determined to produce products according to the specifications on the product working drawings. Tool design was developed using the layout process design for each function part of the tool. After the layout process is completed, a draft will eventually be detailed into an Assembly drawing and components drawing. Finally, the cycle time of the product production process is investigated to ensure that the design made is an eco-design.

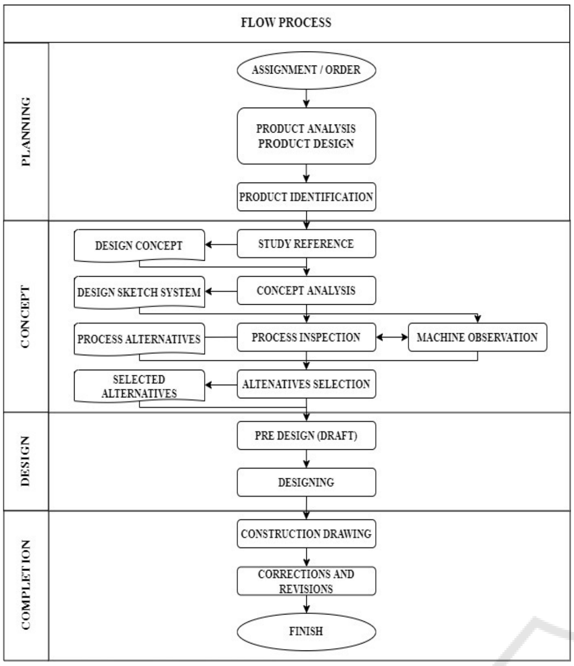


Figure 4: VDI 2222 Methods.

3 RESULTS AND DISCUSSIONS

3.1 Planning

Eco-design must be employed in the development of the tool designed. It is expected to reduce cycle time and production costs without compromising product quality. The production costs can be reduced by minimising the number of operators and machines. Table 1 shows the list of design requirements that have been compiled.

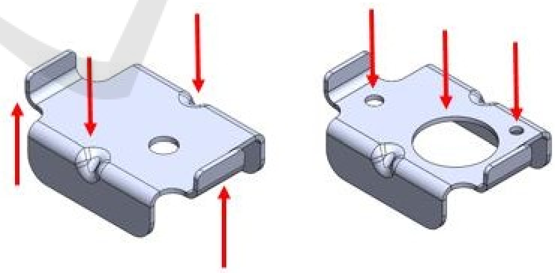
Table 1: Design Requirements.

Design Requirement	
Demands	**Qualification**
Product	
Product dimension	According to the 3D model
Thickness	2.3 mm
Grade	SAPH440-P
Tensile Strength	440 N/mm²
Tool	
Assy Process	Easy for maintenance
Clamping System	Strap clamp
Standard Components	MISUMI
Machine	
Machine capacity	Min. 120% of tool Force
Ram Dimension	Min. equal with an upper plate of the tool
Bolster dimension	Min. equal with a lower plate of the tool
Die height	Min. equal to a total height of the tool

3.2 Concepting

A construction design concept is developed based on the design requirements. The punch forming and piercing are located in the upper assembly of a push-through design, while the die is located in the lower assembly. Considering the limited space in this construction, no button die is used in the piercing process. A push-through mechanism is used to ensure scrap falls to the lower plate (Budiarto et al., 2022).

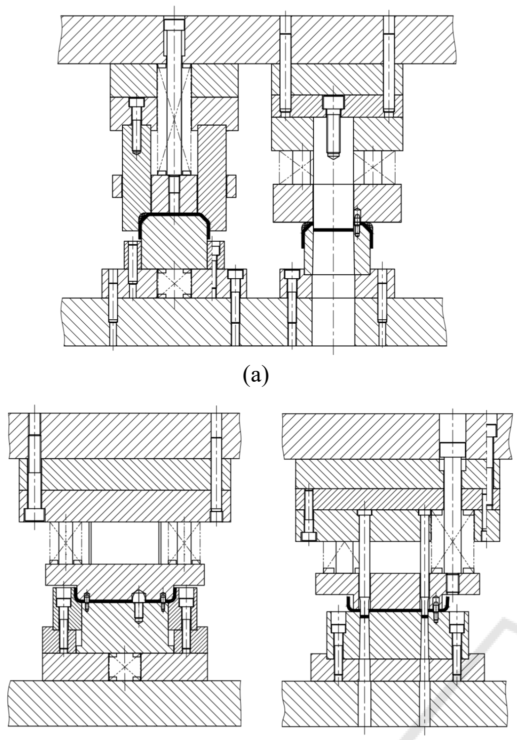
The process involves merging the same two processes in one station and creating a tool group consisting of two stations. The first station is used for u-bending and embossing, while the second station is used for piercing. Figure 5 shows the process from each station.



(a) (b)

Figure 5: (a) Station 1: u-bending and embossing (b) Station 2: piercing.

As part of the process layout, a punch is also used as a blank holder to hold the material flow rate. The punch will form the U-bend first and then, when bottoming, act as a stripper for the second bending and embossing (Patriatna & Budiarto, 2015). Figure 6 shows the design construction from the front and side views.



(a)

(b) (c)

Figure 6: Design construction (a) front view of station 1 (left) and station 2 (right); side view (b) station 1 (c) station 2.

3.3 Design Calculation and Control Processes

3.3.1 Blank Calculation

SolidWorks software was used to perform a blank calculation using the K-factor and neutral axis settings. Figure 7 shows the blank from the software calculation.

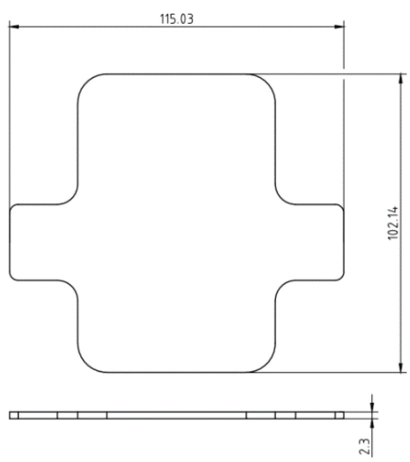


Figure 7: Blank from Software calculation.

3.3.2 Press Tonnage Calculation

Machine control calculations are performed to ensure that the force required by the tool is consistent with the machine being used. Table 2 shows the press tonnage calculation.

Table 2: Press tonnage calculation (Budiarto, 2012; Heinz Tschaetsch, 2015; Rahmi, 2021).

Parameter	Equations	Result
Piercing Force	= 0.8 · l · s · Rm	127.1 kN
Bending Force	= (1.7 · B · s^2 · Rm) / L	5.7 kN
Embossing Force	= A proj . Kr	92.2 kN
Penetration	= (1 ~ 3) · s	3,5 mm
Stripper Forming Force	= 10% · F Process	9.68 kN
Stripper Piercing Force	= 10% · F Process	12.71 kN
Pad Force	= (30 ~50) % (Fb + W)	0.342 kN
Total Tool Force		247.68 kN
Clearance	= s · c	0.15 mm/ side
Machine capacity	= 120% · F tool	29,7 Ton

The press machine used is AIDA NC 1-1500 (2) E, one of the references in selecting the minimum press machine that can be used is the machine tonnage based on calculations. Once the tonnage of the press machine has been calculated based on the required machine force, the dimensions of the ram and bolster should be examined. The die height of the machine must be taken into consideration if the dimensions of the ram and bolts have been met.

Completion. The draft that has been made is then converted into a 3d model and developed into an Assembly drawing and parts. Figure 8 shows the 3D model of the group tool for the Reinf-FR Towing Pipe.

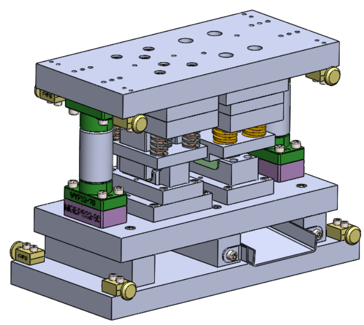


Figure 8: 3D model of group tool Reinf-FR Towing Pipe.

3.4 Cycle Time Investigation

Further, the estimated processing time is calculated to predict the products that can be completed in one cycle. Table 3 shows the results of the cycle time comparison.

Table 3: The comparison of cycle time.

Type of Tool	Cycle Time (seconds)	Setting time (seconds)	Time Process + Time setting
Single tool 1	8	3.600	3.608
Single tool 2	12	3.600	3.612
Single tool 3	8	3.600	3.608
Total			**10.828**
Group Tool	15	3.600	3.615
Reduction Time (second)			**7.213**

Based on the calculation of processing time, group tool can reduce the processing time by almost 66%. Furthermore, efficiency can also be measured by the number of machines used. The existing process requires three machines to produce the same product, but only one machine will be required if this tool is used. The reduction of the number of machines and the cycle time of the process will also reduce the electrical energy consumption.

4 CONCLUSIONS

A 260 mm x 386.3 mm x 550 mm tool group has been produced for Reinf-FR Towing Pipe components considering VDI 2222 methods and eco-design. The group tool is designed using a push-through system, station 1 forming (bending and embossing), and at station 2 a piercing process, then processed by an AIDA NC 1-1500 (2) Press Machine. Moreover, with this group tool design, the processing time can reduce almost 66%.

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