Progressive Hybrid Stamping Tool Development on Automotive Components Stay Headlight Material SPC270C

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Keywords: Progressive Hybrid Tool, Stay Headlight, SPC270C.

Abstract: Stay headlight component is a product that requires several stages in its manufacture. The production process used one compound tool and one group tool mounted on two different press machines. Progressive hybrid tools can be used to reduce the number of operators, press machines, and speed up processing times. A progressive hybrid tool is a stamping tool used to produce components from sheet metal materials. In progressive hybrid tools, the combined process consisting of cutting and forming processes occurs continuously. In this study, the initial development of a progressive hybrid tool was carried out to produce a stay headlight component that functions as a vehicle headlight holder. The material used is SPC270C, with a thickness of 1.6 mm. The design method used is VDI 2222 (Verein Deutsche Ingenieure 2222), which consists of 4 main stages: planning, conceptualising, designing, and finishing. This early-stage development results in a progressive hybrid tool design consisting of 11 process stations with a material efficiency of 57.6%. The tool's dimensions are 845 mm long, 640 mm wide, and 370 mm high. The total force required on this tool is 64.86 tons.

1 INTRODUCTION

The automotive industry is one of the main sectors contributing to the national economy. The automotive industry is currently experiencing an increase. This is in line with the development of technology and components in vehicles. The development of manufacturing processes to improve the efficiency of the production process has become a necessity for the industry as an active player in manufacturing activities. The stamping process is one manufacturing process to produce components from sheet metal materials, for example, automotive components, medical equipment, household equipment, and so on (Thomas *et al.*, 2000; Su *et al.*, 2022). Automotive components are the most needed stamping products with a wide variety of materials, shapes, and dimensions. So that the development of process quality and production acceleration is necessary in line with the increasing demand for components (Silva *et al.*, 2021). The development of precision tool technology is an alternative solution that can be done to increase production efficiency without reducing the quality of the resulting product (Shakkarwal *et al.*, 2021).

The stay headlight component is one of the components on the front of the vehicle that functions as a vehicle headlight holder. This component is made of SPC270C material with a thickness of 1.6 mm. This product goes through several process stages: cutting, forming and bending. The process is carried out using two stamping tools, the compound tool (cutting process) and the group tool (forming and bending process). Both tools are installed on two different press machines with two operators.

Furthermore, based on the analysis of the stay headlight product, the result is that the product can be formed with a continuous process stage using one tool, namely the progressive hybrid tool. Progressive hybrid tools are often recommended for mass production of stamped parts requiring complex press operations (Karimov, 2021). By using one tool, the number of press machines and operators needed is reduced. This, of course, can also reduce energy consumption and production process costs (Gen and Yunong, 2020). Therefore, an initial step is necessary

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for developing the tool that will be used to produce the stay headlight component, namely the design of a progressive hybrid tool consisting of a combination of cutting and forming processes which are carried out gradually and continuously. The design method used is VDI 2222 (Verein Deutsche Ingenieure 2222), which consists of four main stages: planning, conceptualising, designing and finishing. The design of a progressive hybrid tool equipped with technical documents for each component to be fabricated as well as machine specifications following the tool geometry and machine tonnage required were carried out in this study.

2 MATERIAL AND METHOD

2.1 Stay Headlight

The stay headlight product functions as a headlight holder for two-wheeled motorised vehicles. This product is made of SPC270C material with a thickness of 1.6 mm and has Rm 270 N/mm^2. Figure 1 shows the shape of the stay headlight product.

Figure 1: Stay headlight.

Product shape analysis is carried out to obtain a fully defined product shape and size. Furthermore, with the help of modelling software, the shape and size of the stay headlight product are obtained. Figure 2 shows the flattened shape and the size of the stay headlight product before it is formed.

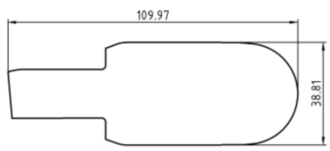


Figure 2: Flattened shape.

2.2 Design Method

The method used in the design process of the progressive hybrid tool for the stay headlight BEJ/AT is VDI 2222 (Verein Deutsche Ingenieure). According to VDI 2222, the design flowchart is divided into four major parts: planning, conceptualising, designing and completing. Figure 3 shows the VDI 2222 flowchart used.

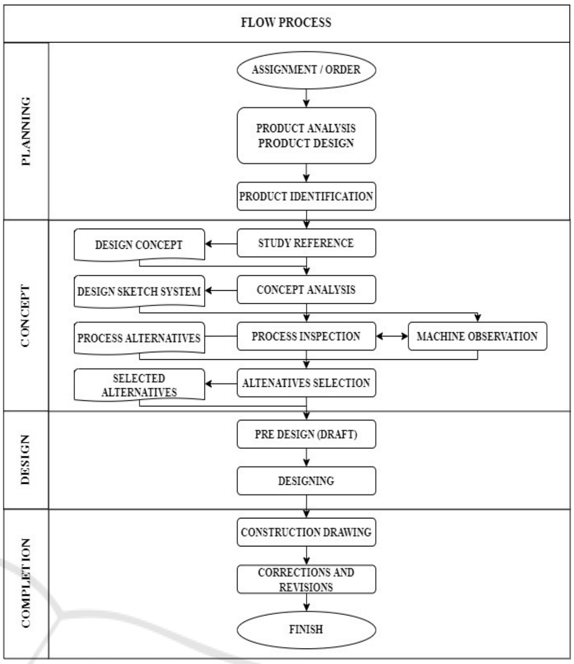


Figure 3: Design method VDI 2222.

2.2.1 Design Parameters

The design parameters are used as a reference to achieve the given requirements. Table 1 shows the design parameters for the developed progressive hybrid tool.

Table 1: Design parameters.

Demand	Qualification
Product	
Dimension	According to the working drawing
Product thickness	1.6 mm
Material	SPC270C
Tensile stress	270 N/mm^2
Press Tool	
Tool assembly process	Easy to install and maintain
Tool clamping	T-slot bolt
Use of standard components	Misumi
Die height	340-450 mm
Tool safety	Miss feed sensor
Machine	
Machine type	AIDA A-04
Press machine capacity	200 tons
Slide adjustment	110 mm
Upper bolster dimension	1850 × 650 mm
Lower bolster dimension	2420 × 680 mm

2.2.2 Design Concepting

The design concept consists of several stages: making the layout and selecting materials for the main components. Figure 4 shows the planned progressive process layout. The process layout consists of 11 process stations, namely 4 piercing process stations, 2 piercing notching processing stations, 1 flanging process station, 1 bending process station, 1 embossing process station, 1 parting process station and 1 idle station.

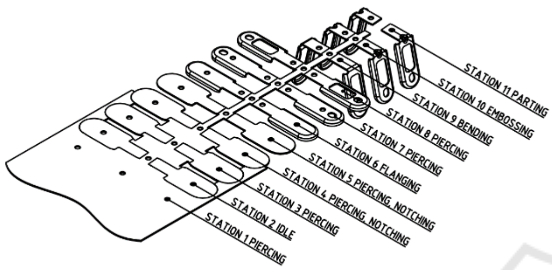


Figure 4: Process layout.

Materials for the main components of this progressive hybrid tool are shown in Table 2.

Table 2: Material of tool's component.

Category	No.	Component Name	Material	Advanced Work	Aperture
Machinery steel	1	Base plate	1.0112	-	Lower die
	2	Spacer block	1.0112	-	
	3	Spacer plate	1.0112	-	
	4	Dies support	1.0112	-	
	5	Dies holder	1.0112	-	
Tool steel	6	Insert dies	1.2379	Hardened 63-65 hrc	
Machinery steel	7	Backing punch	1.1213	-	
	8	Guide rail	1.1213	-	
	9	Base guide rail	1.0112	-	
	10	Lifter	1.1191		
Sheet metal	11	Shutter	1.0330	-	
Tool steel	12	Insert punch	1.2379	Hardened 63-65 hrc	Upper die
Machinery steel	13	Stripper plate	1.1213	-	
	14	Punch holder	1.0112	-	
	15	Punch support	1.0112	-	
	16	Upper plate	1.0112	-	

2.3 Tool Design

At this stage, a tool design construction calculation is carried out, which will determine the tool's performance and the quality of the resulting product. This construction calculation consists of calculating the clearance between the punch and the die cutting, the penetration length of the punch to the die, the stamping force, the stripper force, and the process's center of gravity to result in the pre-design of a progressive hybrid tool.

2.3.1 Cutting *Clearance*

Calculation of cutting clearance refers to the analysis and table of standard MISUMI clearance selection. Figure 5 shows the cutting clearance.

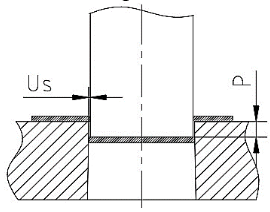


Figure 5: Cutting clearance.

$$Us = T \times c\% \tag{1}$$

Where Us is the clearance, T is the material thickness, and c is the working factor. The working factor is selected to be 6% for the category of extra soft clearance on steel material. So, the cutting clearance is 0.1 mm/side.

2.3.2 Die Penetration

Dies penetration is the penetration of the punch from the thickness of the material strip and pushes the scrap out of the die. Equation (2) shows the calculation of the penetration of the die.

$$L_{\text{die penetration}} = 1 \text{ to } 3 \times T \tag{2}$$

Where $L_{\text{die penetration}}$ is the length of the die penetration. So, the die penetration is 1.6 mm to 4.8 mm. The die penetration length for this progressive hybrid tool design is 3 mm.

2.3.3 Stamping Force

The stamping force is calculated based on the type of process that occurs in the tool. The calculation of the stamping force on this progressive hybrid tool is shown in Table 3.

Table 3: Stamping Force calculation (Budiarto, 2009; Luchsinger, H R.,198)).

Process	Equations	Force [N]
Cutting	$= 0.8 \,.\, 1 \,.\, s \,.\, Rm$	399,164.58
Flanging	$= \frac{B \times s \times Rm}{3} \times n$	20,691.18
Bending	$= \frac{b \times T \times Rm}{3} \times n$	2.631.10
Embossing	$F_{Embossing} = Ae \text{ x } Kr \text{ x } n$	44,278.92
Stripper Force	= 10% . F Proses	46,700.66
Total Tool Force		538,082.62

Table 3: Stamping Force calculation (Budiarto, 2009; Luchsinger, H R.,198))(cont.).

Process	Equations	Force [N]
Minimal Machine capacity	= 120% . F *tool*	648.624,19

2.3.4 Center Gravity of Tool

The position of the center of gravity of the tool is important in determining the placement of the tool on the press machine. The calculated center of gravity is the position of the center of gravity of the process and is usually indicated by the installation of the shank component. The position of the center of gravity of this progressive hybrid tool is shown in Figure 6. This data is poured into a pre-design, as shown in Figure 7.

$$x = \frac{\sum Lx}{\sum L} \tag{3}$$

$$y = \frac{\sum Ly}{\sum L} \tag{4}$$

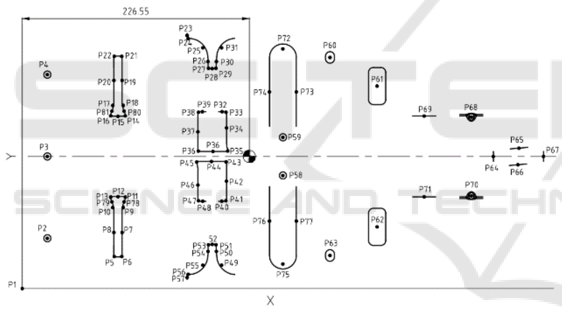


Figure 6: Center gravity of tool.

3 RESULT AND DISCUSSION

The pre-design obtained results in a tool with dimensions of 845 mm in length, 640 mm in width, and 370 mm in height. The minimum machine capacity required is 64.86 Tons. The specifications of this tool meet the machine specifications specified in Table 1.

Validation of tool construction is carried out through construction inspection calculations, including spring components and punch components. The performance of spring components must be carried out to ensure the spring can work properly. Figure 8 below shows the spring step diagram.

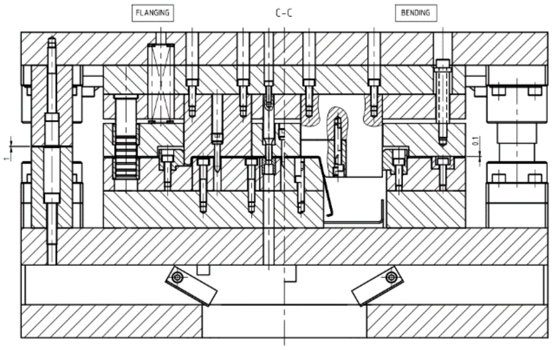


Figure 7: Pre-design.

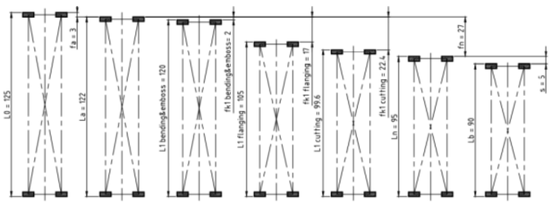


Figure 8: Spring step diagram.

The spring used must fulfil its function as a stripper or lifter where the selected spring force must be greater than the required force. The results of the inspection calculations are shown in Table 4, where all the springs used can meet the required spring force.

Table 4: Spring performs validation.

$F_{Stripper}$ or F_{Lifter} [N]	F_{Spring} [N]	Conclusion
$F_{Stripper\ 1}$ = 26,895.63	31,363.9	Well performed
$F_{Stripper\ 2}$ = 19,805.03	31,363.9	Well performed
$F_{Stripper\ 1}$ = 90.04	91,2	Well performed

The reaction force of the punch shall not exceed the allowable stress of the upper plate component material in direct contact with the top surface of the punch. Suppose the reaction force exceeds the allowable pressure of the material. In that case, it is necessary to add an insert plate of a material with a higher hardness level so that the upper plate components are not damaged.

$$p = \frac{Fs}{A} \leq p\ allow \tag{5}$$

Where p is the surface pressure, A is the punch head cross-sectional area, Fs is the processing force, and p allow is the allowable surface pressure. The allowable surface pressure for unhardened steel with impact loading mode is 40 N/mm^2 (Budiarto, 2012). From the calculation of the surface pressure at each punch that cuts the strip of material, it is found that most piercing process stations need an insert plate.

In addition, to examine the punch construction based on surface pressure, the punch buckling phenomenon was also checked. Buckling is instability that leads to failure, caused by a structure's inability to maintain its original shape so that it changes form to find a new balance. In this case, the processing force that occurs in the punch ($F_{process}$) must be less than the force that will cause buckling in the punch ($F_{buckling}$). The magnitude of this buckling force is strongly influenced by the free length of the punch in the punch mounting construction model, as shown in Figure 9.

$$F_{buckling} = \left(\frac{\pi^2 \times E \times I}{l^2}\right) \div Sf \geq F_{process} \quad (6)$$

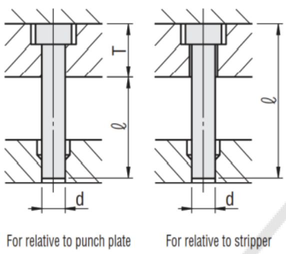
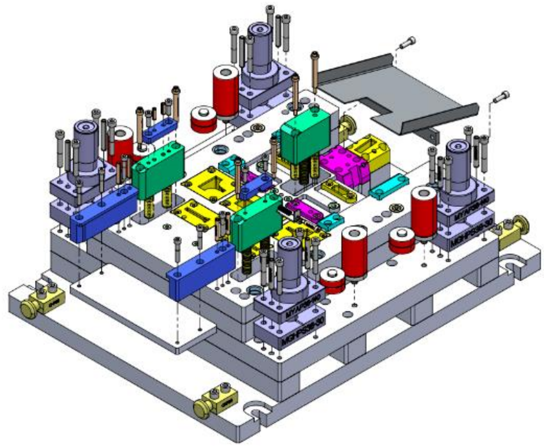


Figure 9: Free length of punch.

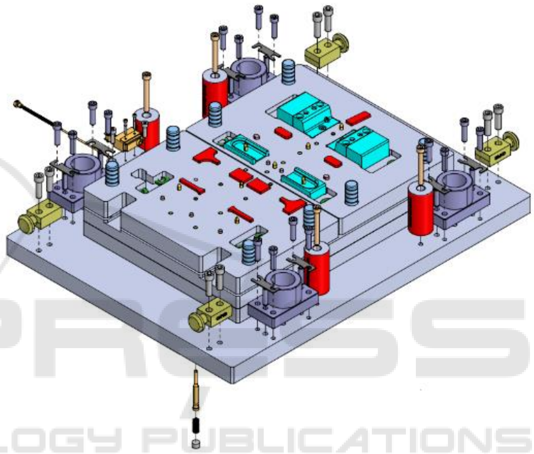
Considering the punch construction that has the most potential for buckling, piercing the slot shape at station 7, it is found that the force that will cause buckling, $F_{buckling}$ = 2,321,081.56 N, while the process force that occurs at the station is 11,567.24 N. Thus, it can be seen that the punch will not undergo buckling during the cutting or forming of the product.

Construction validation carried out on spring and punch components can meet the construction requirements of the designed progressive hybrid tool, which is then tested after the tool fabrication is completed. The overall tool design can be seen in Figure 10.

The results of this progressive hybrid tool design contribute to the use of the press machine and the number of operators. In addition, increasing the amount of production in one manufacturing process because with the layout process applied to this tool, two products are obtained in 1 stamping process. The following Table 5 shows a comparison of the production process of stay headlight components using the previous tool and the progressive hybrid tool.



(a)



(b)

Figure 10: Progressive hybrid tool (a) top opening and (b) lower opening.

Table 5: The comparison of stay headlight production process.

Comparison	Compound tool & group tool	Progressive hybrid tool
Number of machines	2	1
Number of operators	2	1
Number of products in one stroke	1	2

4 CONCLUSION

The development of a stamping tool for the production process of stay headlight components has resulted in a progressive hybrid tool with 11 process stations. Tool dimensions are 845 mm long, 640 mm wide, and 370 mm high. The force required on this tool is 64.86 Tons and can be used on the press machine AIDA A-04 engine with a capacity of 200 tons. By using a progressive hybrid tool, the number of machines and operators can be reduced, and even the production speed can be increased by increasing the number of products produced in one stamping process.

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