Machine Tonnage Optimization by Reused Scrap Material Applied for Car Propeller Shaft Guard

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***Abstract*— The purpose of this research is to analyze how the scrap material or metal scrap can be reused as a regular material in a production process. The reused scrap material is prepared to use in propeller shaft guard production. This propeller shaft guard is used with the main function to guard the propeller shaft in the car. Therefore, calculating the total mass of the scrap material and propeller shaft guard is needed to know the ratio of the usage of material, the machine tonnage calculation for propeller shaft guard production using reused scrap material, and the new design for blanking material. The total machine tonnage for producing propeller shaft guard using reused scrap material is 260.09 T. The new design for the propeller shaft guard can fit the reused scrap blanking material is created. The total usage of scrap material increased from 49.46% to 79.69% after the material was used in the propeller shaft guard production. The comparison between the condition before and after using reused scrap material as the propeller shaft guard indicates the factors of the total amount of blanking material, the total amount of dies, and *dandori* are described in this research.**

Keywords*— reused scrap, scrap material, propeller shaft guard, machine tonnage.

I. Introduction

As one of the largest automotive industries in the world, Indonesia should prioritize the development of manufacturing processes [1–3]. By developing the ability of our human resources, one of the biggest vehicle manufacturing companies that expanding their production base in Indonesia is growing to evolve along with society [3]. Most of the vehicle components of this manufacturing company assembled by this company, one of them is propeller shaft guard [4].

Propeller shaft guard is a shaft that guarding the propeller shaft. This component part is a guard for an instant-rotating propeller shaft in-vehicle machine wherein the pair of joints is connected to on either side of the sliding coupler in the drive shaft [5–7] . This propeller shaft guard has a pair of U-shaped members, one member affixed with a bearing connecting to the wall on the drive shaft in the front frame [5, 6]. On the other hand, the other member affixed on the rear frame [5, 6].

Not only the function of the propeller shaft guard but also the important things that have to be concerned is the production process. The production process simply uses raw material [8, 9]. According to the Institute for Development of Economics and Finance (Indef) research, Indonesia is too dependent on the imports of raw materials and capital goods in each industry, especially in the manufacturing industry [9]. Raw materials are left during the production process will usually be discarded, it is called scrap material [8].

Scrap material that is left after the production process is blanking material [10, 11]. This scrap material can be used in the blanking process for propeller shaft guard and becomes reused scrap material to improve the production process by using it as a regular material in propeller shaft guard on production without reducing the quality of the part [11]. This step is actually considered as the machine tonnage for the production process. The tonnage itself is about the clamp force of the machine. The amount of pressure the machine can exert on the mold, to keep it closed, while mold (tool) is being filled with molten plastic under enormous pressure. Typically tonnage is the defining size of the machine. Regarding the production process, the machine tonnage should be calculated to know the capacity of the machine itself because there are several aspects to be considered before the machine operates [12–15]. Furthermore, there are some stages that must be considered.

First, analyze the part's specification, comprising the area of the scrap material, material specification, and thickness of the material. Second, the production processes of propeller shaft guard, comprising the total mass of the scrap material, the total mass of the propeller shaft guard, the calculation of machine tonnage for propeller shaft guard production using reused scrap material, the ratio of the usage of material, and the new design for blanking material.

In this research, the improvements of using reused scrap material are considered to increase the ratio of material usage that is left after the production process, to decrease the number of dies, and *dandori* in before and after the condition in this vehicle manufacturing company, where *dandori* is a process of changing mold or material during the production [16, 17]. *Dandori* is come from Japanese language, which has means as creating a program, plans and/or arrangements for improving the production system. The research will show the specification of the scrap material that will be used for propeller shaft guard production, the allowable stress of the material, and the calculation of machine tonnage that is considered as the capacity for machine.

II. Research Methodology

The data is taken from production engineering division, vehicle quality in a manufacturing company, as shown in the Table I and Table II. The material specification data is taken from the company, part specification, design, and the production process for propeller shaft guard [5, 6].

TABLE I. Scrap Metal Specification

Commodity	**Hot Rolled Steel in Coil Pickled and Oiled Mill Edge**			**Specification**	**JIS G 3131 SPHC**
Dimension (mm)	**Tensile Test**			**Material Weight (kg)**	
(T *x* W *x* L)	YS (N/mm^2)	TS (N/mm^2)	*S* (N/mm^2)		
3.2 x 632 x 612	305	358	204.06	9.7	

The raw data from scrap material are the material specification and material size, including the thickness of the material [5, 6]. This data will be compared with the material specification for propeller shaft guard to using reused scrap

material for production. Material specification between scrap material and propeller shaft guard are matching. The total of the parts in the scrap material are four parts, as shown in Fig. 1 to Fig. 5. The material is SPHC-270.

The material dimension thickness and width are 3.2 mm and 1210 mm. SPHC-270 is hot rolled steel in coil pickled and oiling mill. Coil pickled and oiling mill means that this coil material is treated with metal treatment through an acid to remove surface oxides. Then, rinsing and oiling the metal to prevent corrosion or rust during storage and after descaling.

TABLE II. Propeller Shaft Guard Specification

Part name :		**Propeller Shaft Guard**	
Part Based on Position in Propeller Shaft Guard	**Blank Size Dimension (mm)**	**Material Weight (kg)**	**Material Specification**
Right Hand	355.4 x 37.7 x 3.2	0.336	SPHC 270
Center	200 x 48 x 3.2	0.24	
Left Hand	136 x 46 x 3.2	0.157	

The mechanic properties for scrap material is as follows:

- Blanking type : blank material
- Material Weight : 9.7 kg
- Part Weight : 1.91 kg
- Area : 1290 mm

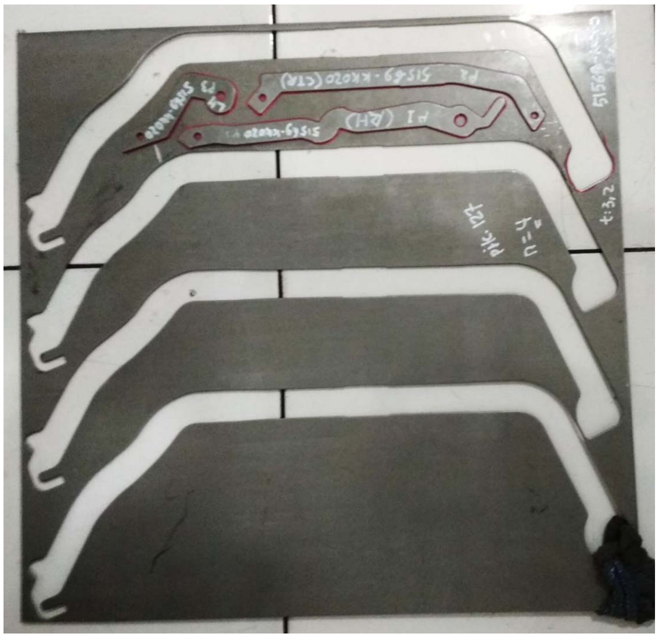

Fig. 1. Scrap Material SPHC-270 [5].

The mechanical properties for propeller shaft guard in one part as follows:

1. For Right Hand (RH)
   Blanking type : coil (1219 mm)
   Circumference : 715.6 mm
2. For Center (CTR)
   Blanking Type : coil (1219 mm)
   Circumference : 654.2 mm
3. For Left Hand (LH)
   Blanking Type : coil (1219 mm)
   Circumference : 277 mm
4. Propeller Shaft Guard (All joints in one part, in one blanking are four parts)
   Material : SPHC-270
   Part Dimension (TxWxL) : 3.2x163.2x434.4 mm
   Circumference : 2936.8 mm

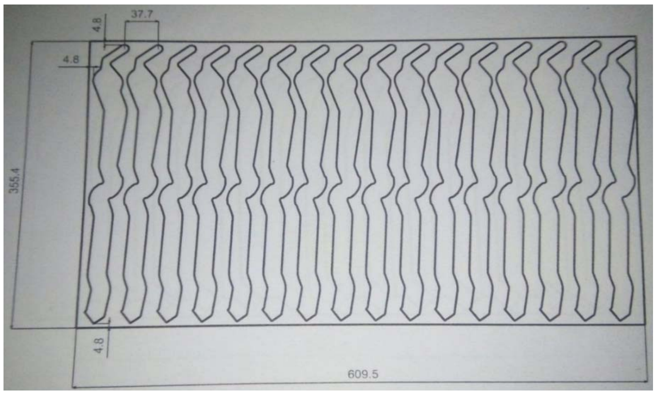

Fig. 2. Propeller Shaft Guard for Right Hand (RH) [5].

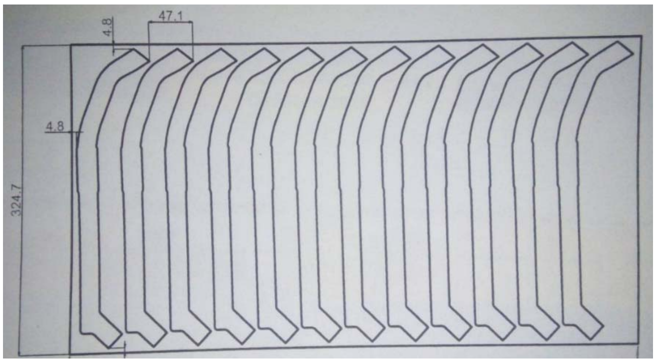

Fig. 3. Propeller Shaft Guard for Center (CTR) [5].

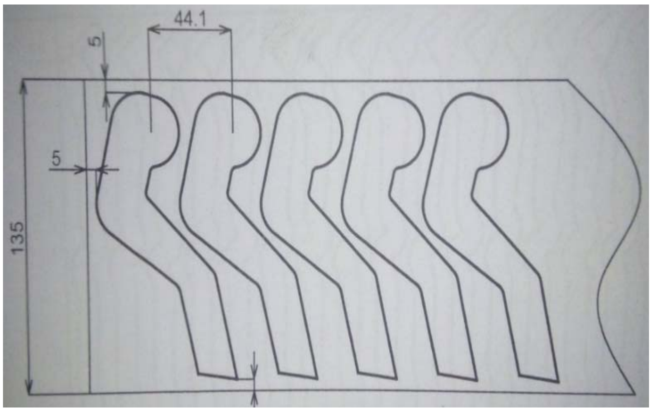

Fig. 4. Propeller Shaft Guard for Left Hand (LH) [5].

Fig. 5. Propeller Shaft Guard All Joint in one Part [5].

SPHC-270 uses JIS G 3131 (Japan Industrial Standard) with classification for hot rolled mild steel plates, steel, and strip [19, 20]. The characteristics and application for SPHC-270 are general steels used for general forming and deep drawing. Propeller shaft guard production uses reused scrap material and improvement dies for the production process. Also, the company stated for each *dandori* or a quick changeover time with a single minute's exchange of dies for this step needs 2716 second per step.

The analysis is done by using manual calculation for the total mass of scrap material and propeller shaft guard that consist of four parts comprising, right hand, center, and left hand. After calculating the total mass and ratio of the usage of material, we can analyze the total machine tonnage. Machine tonnage is the capacity of the machine to work properly while its processing the production. Calculate the machine tonnage is very helpful to determine the amount of tonnage that will use in doing a job. The analysis includes the new design for blanking material. The parts layout is improved to increase the material usage. After the analysis, we need to compare the usage of material, the total amount of scrap material, the total amount of dies, and the *dandori* in before and after condition.

III. Results and Discussion

The data calculation will be explained in this chapter in order to identify the data and solve the problem. Before making an analysis of the problem, the author starts with the total mass of scrap material and propeller shaft guard, machine tonnage calculation, a new design for blanking material, and the discussions of this research.

A. Total Mass of Scrap Material and Propeller Shaft Guard

To calculate the total mass of scrap material by using (1) and (2). The results of mass calculation of scrap material is 7.79 kg, where the weight of propeller shaft guard is 1.91 kg. The mass of propeller shaft guard on the right hand, center and left hand are 0.336 kg, 0.24 kg and 0.157 kg, repectively.

1. Scrap Material

$$M = [(L \; x \; W \; x \; T) \; x \; \rho] - W_{propeller\ shaft\ guard} \quad (1)$$

2. Propeller Shaft Guard RH (Right hand, center and left hand)

$$M = (L \; x \; W \; x \; T) \; x \; \rho \quad (2)$$

From the calculation above, we need to multiply the total of the mass for each part with four because on one blanking there are four parts.

B. Total Machine Tonnage Calculation

After doing the calculation for allowable stress of the material, the next stage is calculating the machine tonnage (MT) for the production process. Equation is used to calculate the machine tonnage for producing scrap material is (3). The results of F_m and F_s is 95.5 T and 19.1 T, respectively, as calculated by (3) and (4).

$$F_m = S \; x \; T \; x \; L \quad (3)$$

The stripper force (F_s) for the machine can be calculated using the (4).

$$F_s = 20\% \; x \; F_m \quad (4)$$

The total tonnage for producing scrap material is 114.6 T, as calculated using (5).

$$MT_{before} = F_m + F_s \quad (5)$$

To calculate the machine tonnage for producing propeller shaft guard using (6). The results obtained is 121.92 T. The total tonnage for producing scrap material and propeller shaft guard machine using (7), as result obtained, the total force is 217.42 T.

$$F_m = S \; x \; T \; x \; L \quad (6)$$

$$F_{total} = F_{p\ scrap} + F_{p\ propeller\ shaft\ guard} \quad (7)$$

The stripper force (F_s) for the machine to produce a propeller shaft guard using reused scrap material can be calculated using (8). The results obtained of the F_s and the total tonnage (MT_{after}) is 43.48 T and 260.9 T, respectively. The total tonnage for the machine as calculated, using (9).

$$F_s = 20\% \; x \; F_{total} \quad (8)$$

$$MT_{after} = F_{total} + F_s \quad (9)$$

So, the difference between total machine tonnage for producing scrap material and producing both of the parts including propeller shaft guard are:

$$MT_{after} - MT_{before} = 260.9\ T - 114.6\ T$$
$$= 146.3\ T$$

C. *New Design for Blanking Material*

The are some considerations after doing the calculation above. One of them is a new design for the blanking material. The new design uses the scrap material for the propeller shaft guard production, as shown in Fig. 6. Before producing the propeller shaft guard with reused scrap material, the machine tonnage was 114.6 T. After producing the scrap material and propeller shaft guard, the machine tonnage is 260.9 T.

The new design for production of the propeller shaft guard uses scrap material comprising the right-hand, center, and the left-hand part of the guard. Fig. 7 is a new design using the scrap material.

After trial and measurement from the company, the placement of the propeller shaft guard can be fitted to the scrap material. This is one step to reduce the cost by maximizing the usage of material using scrap material.

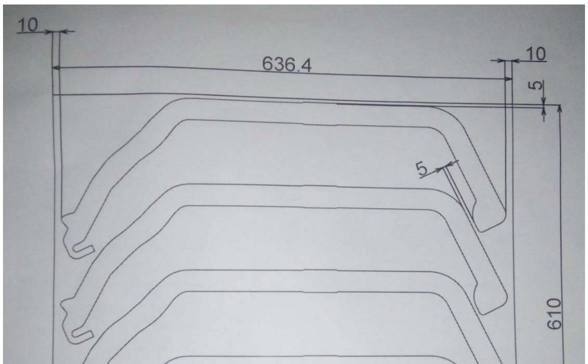

Fig. 6. Scrap Material Design.

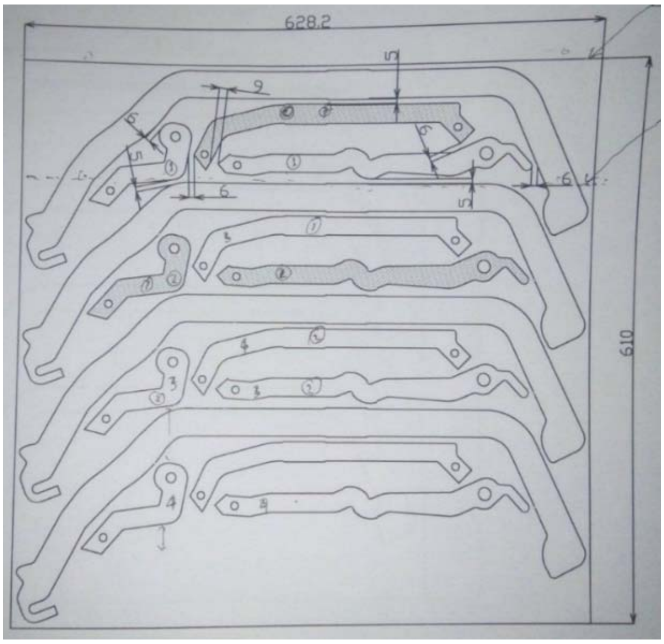

Fig. 7. New Design Propeller Shaft Guard using Reused Scrap Material.

D. *Comparison of The Amount of Usage Material Before and After Condition*

Before we use the new design, the ratio of scrap material and the total material can be calculated using (10).

R = (Total scrap of material/Total usage of material) *x* 100 %
= (4.798 kg / 9.7 kg) *x* 100 %
= 49.46 %

After we use the new design for the production of the propeller shaft guard using the scrap material, we calculate it using (2) and the ratio becomes:

R = (Total scrap of material/Total usage of material) *x* 100 %
= (7.73 kg / 9.7 kg) *x* 100 %
= 79.69 %

So, after comparing the result from each condition, we conclude that we can reduce the scrap as much as 27.23 %, as shown in Fig. 8. The usage of the material for the after-condition is only 72.27%. According to before and after-conditions graph, the total usage of material decreases by about 27.23 % can be conclude. After the propeller shaft guard into the scrap material is fit, the usage of scrap material can be reduced, then use it as a regular production for producing propeller shaft guard.

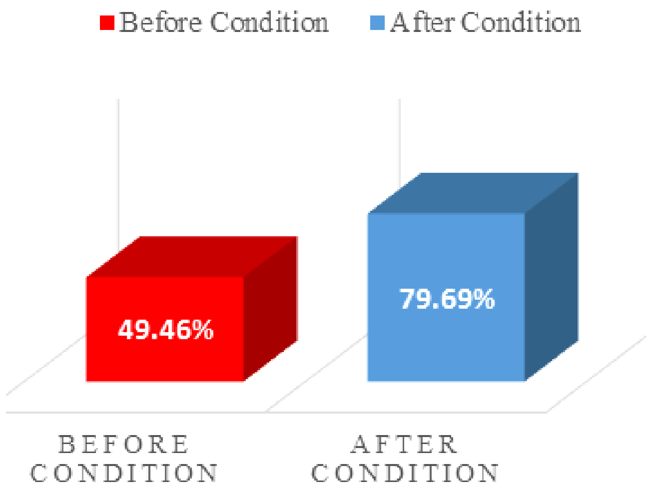

Fig. 8. Chart of Material Usage (Before and After Condition).

E. Comparison of The Usage of Blanking Material Before and After Condition

After calculating and analyzing the data, we found that reused scrap material is ready to produce propeller shaft guard, and the material has received the maximum force of the machine. The total machine tonnage to produce scrap material and propeller shaft guard is 260.09 T. We can compare the condition before and after.

Before we used the scrap material, the propeller shaft guard still used the regular material for production. From Fig. 8. we know that the usage of the material decreased by about 27.23 %, and it is related to the usage of blanking material as seen in the Table III.

TABLE III. COMPARISON OF THE USAGE OF MATERIAL

Condition	
Before	**After**
4 blanking materials	1 blanking material

From Table III, the total blanking material in before condition is four. After the propeller shaft guard used the scrap material as the production material, the blanking material becomes one. This phenomena occurs is because the production only used the scrap material.

F. Comparison of The Number of Dies in Before and After Conditions

The propeller shaft guard consists of the right hand, center, and left hand before it joints into one part. The machine used one die to produce each part including the right hand, center, left hand, and the recent production for scrap material. The comparison of the number of dies in before and after conditions, as shown in Table IV.

TABLE IV. COMPARISON OF THE NUMBER OF DIES

Conditions	
Before	**After**
4 dies	1 die

G. Comparison The Dandori or Quick Change of Dies

There are four dies that need to produce the scrap and propeller shaft guard that consists of the right hand, center, and left hand. However, if the new design of the die is used, it only one die for production. The total time for a quick change of dies will be decreased.

From Table IV and Table V, we can conclude that in before condition, the total time for quick change die is so high. For the after condition, time to change the dies is not required. This is because, only one die is used and the total quick change of the dies decrease by about 100 % than before condition.

TABLE V. COMPARISON OF THE DANDORI

Condition	
Before	**After**
4 *x* 2716 s	-

IV. CONCLUSIONS

The optimization of machine tonnage by scrap material applied for car propeller shaft guard has been investigated in this research. The conclusions are as follows:

1. The scrap material that is left during the production can be used for propeller shaft guard production.
2. Material specification and thickness material between scrap material and propeller shaft guard material are the same. Therefore, the new layout is rearranged so that material usage is improved.
3. The total machine tonnage to produce scrap material and propeller shaft guard is 260.09 T.
4. The new design of propeller shaft guard can fit the reused scrap blanking material.
5. The total blanking material reduces from four blanking materials to one blanking material.
6. The amount of dies reduces from four dies to one die.
7. The amount of die change time decreases by 100 %.

Thus, by decreases, the total usage of the material up to 27.23%, the optimization of machine tonnage is achieved and the propeller shaft guard can be produced with higher saving cost.

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