CUTTING ANGLE AND SHAPE ANALYSIS TO INCREASE PRODUCTIVITY IN ROLL SHEET METAL CUTTING

Anıl ŞEKER
anilseker@hotmail.com, https://orcid.org/0000-0002-7460-0151
Demircioğlu Group, R&D Center, Bursa, Türkiye

Merve HATİPOĞLU
merve.hatipoglu28@gmail.com, https://orcid.org/0000-0003-3424-1489
Demircioğlu Group, R&D Center, Bursa, Türkiye

Mesut KARAKUŞ
mesutkarakusmm@gmail.com, https://orcid.org/0009-0008-7082-874X
Demircioğlu Group, R&D Center, Bursa, Türkiye

ABSTRACT: *Today, the use of rolled sheet metal materials in the automotive industry is quite common. These sheets are subjected to many processes such as cutting, bending and drawing. However, in order for these processes to be realized, first of all, the coil sheet metal must be cut to form the desired dimensions. The unusable part of the coil sheet metal that remains after the process is called "scrap". During the pressing of the coil sheet metal, the sheet metal is required to be placed in the press mold in the desired dimensions and position. In the cutting process of the coil sheet metal, the amount of scrap caused by the cutting geometry is of great importance, because less scrap indicates that the cutting process is performed efficiently. In this study, the efficiency of coil sheet metal cutting process was investigated. The optimization of the coil sheet metal cutting geometry designed with the help of CAD (Computer Aided Design) program was carried out in a virtual environment with CAE (Computer Aided Engineering) programs and compared with the cutting method used in the enterprise. As a result of the study, it was concluded that it is appropriate to perform the cutting process at 60° and in the infill pattern cutting geometry, where the least amount of scrap is released. This research provides important information to improve the efficiency of sheet metal coil cutting. Performing cutting operations with less scrap can save costs and reduce environmental impacts in the industry.*

KEYWORDS: *Rolled Sheet Metal, Sheet Metal Cutting, Shear Analysis*

Date of Submission: 10.05.2024 Date of acceptance: 23.07.2024
https://doi.org/10.5281/zenodo.13133826

1. INTRODUCTION

When we look at the processing of sheet metal materials from the past to the present, it is seen that metal sheet materials are the most used type. Metal sheet metal materials processing technologies are also constantly evolving. Given that sheet metal materials are subjected to many processes, such as bending, pulling, along with the cutting process, the importance of cutting becomes apparent (Donaldson et al., 1993). The cutting process can be carried out using both punch and die. Cutting molds are the most used types in sheet metal molding. Depending on the position of the sheared surface, various cutting processes are used according to the workpiece coordinates. In order to improve geometry performance, studies on the prevention of burrs are carried out in various experimental studies to increase the fatigue life of processing materials. (Hambli et al., 2003)

Cutting is the process of cutting between two different pieces of printing according to a predetermined cutting line. (Yıldız, 2013). The cutting process consists of 3 stages: the 1st stage, where the cutting starts, the 2nd stage, where the material begins to flow into the lower mold cavity, and the 3rd stage, where the punch dives into the material and completes the cutting process. (Demirtürk,2010). These stages are given in Figure 1.

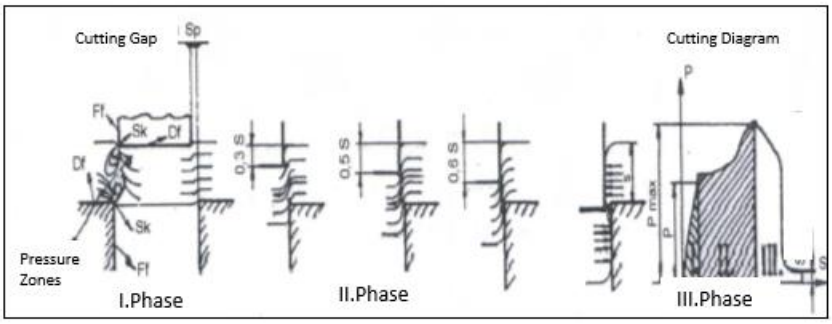

Figure 1. *Cutting process stages (Demirtürk, 2010)*

There are many parameters affecting the shearing process such as physical and chemical properties of sheet metal, die clearance, bending force and angle. Many researches have been conducted to solve the problems arising from the parameters affecting the shearing process. In 2002, Hambli et al. tried to predict the effect of material properties (type, thickness, mechanical properties) and punch geometry on the cutting surface by finite element analysis method. Finite element analysis with neural network was used to predict the shear and rupture surface area (Hambli et al., 2002)

An attempt has been made to estimate the optimum cutting clearance value for various material and thickness values in sheet metal cutting process. It was found that finite element analysis with the help of computer eliminates the cost of experiments and gives results quickly. The main purpose of the hypothesis is to find the crack initiation. In the hypothesis, the results of different values of shear gap were compared with the results of previous experiments and the results were close to each other (Faura et al., 1998).

The prediction of the shear surface is based on a numerical simulation method called the plastic element method. This method was developed to predict crack formation. In the computer aided finite element analysis method, 3 mm thick steels with different surface quality were used. The results of the analysis were similar to the results of previous practical experiments with the same materials (Hatanaka et al., 2003).

2. METHODOLOGY

In the industry, businesses are always working to reduce the amount of scrap. Especially rolled sheet metals used as raw materials are very important for businesses in terms of scrap amount. In this study, the cut roll sheet metal was modeled in the CAD program, the amount of scrap at different angles and the number of flakes to be obtained from the roll sheet metal were calculated. In addition, straight cutting and filling pattern cutting processes were designed and compared to determine the most suitable cutting method. The mechanical properties of the cut sheet are given in Table 1, and the chemical properties are given in Table 2.

Table 1. *Mechanical properties of sheet metal*

Material	Tensile Strenght (N/mm2)	Yield Strenght(N/mm2)	Elongation at Break A80 (%)
6224 (DD13)	381	267	46,5

Table 2. *Chemical properties of sheet metal*

Material	%									
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al
6224 6224 (DD13)	0,049	0,013	0,236	0,014	0,0032	0,027	0,0019	0,024	0,024	0,049

The visual of the rolled sheet metal cutting designed with the help of CAD program is given in Figure 2. In addition, sheet metal cutting optimization was performed in a virtual environment and compared with the cutting method performed in the enterprise. In order to make a comparison, a cross-section of the cut rolled sheet metal was taken and 3D scanned with the help of a measurement program. 3D scan images are given in Figure 3. It can be seen in Figure 3b that the cut coil sheet metal does not have a flat surface due to cutting, as shown. However, this situation on the surface does not prevent the measurement from being accurate.

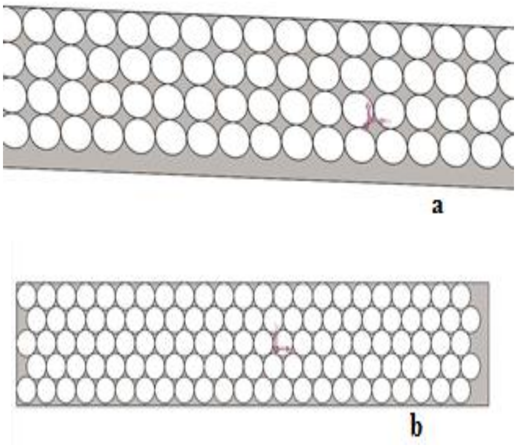

Figure 2. *Plain (a) and fill pattern (b) cutting*

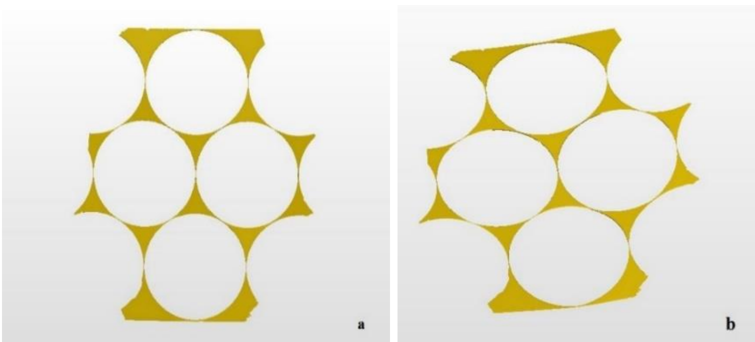

Figure 3. *Plain (a) and fill pattern (b) 3D scan images*

The amount of scrap obtained as a result of the designs, the number of pieces and also the angle values obtained as a result of 3D scanning are shared in the findings section.

3. DISCUSSION

In the study, it was investigated whether the way of applying the sheet metal cutting process made in the enterprise is appropriate. As a result of the study, the measurements made from the sample taken from the sheet metal with the data obtained in the virtual environment were compared. As a result of the reviews, it was discussed that the cutting process should be carried out in 60°', where the minimum amount of scrap is exposed and in the form of a filler pattern as a cutting type.

4. FINDINGS

The calculations were made on a sample sheet metal with a length of 5000 mm and a width of 951 mm and a thickness of 3 mm. As a result of cutting the Ø208 mm diameter washer with flat placement, the amount of scrap is 38116,01 gr.

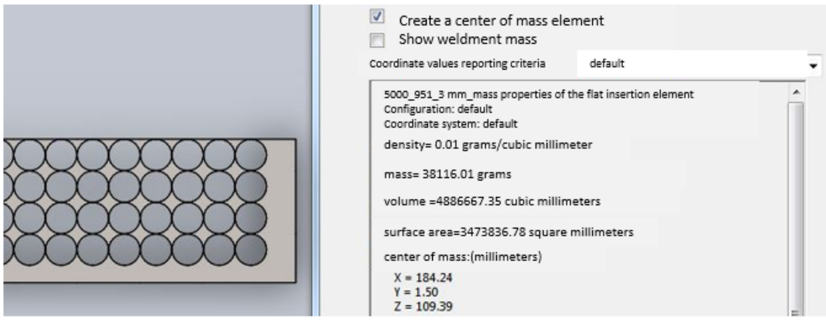

Figure 4. *Straight cut scrap weight*

The amount of scrap and the number of pieces according to the angles resulting from cutting the Ø208 mm diameter washer with filler placement are given in Table 3 below. While the minimum amount of scrap was 19828.26 g at 60°, the maximum scrap amount was 41296.48 g at 48°. Additionally, the calculated angle representation is given in Figure 4.

Table 3. *Amount of scrap by angle and number of pieces produced*

Angle	Amount of Scrap (gr)	Piece
30°	25394,09	108
35°	33345,29	98
36°	30164,81	102
40°	39706,24	90
43°	34935,53	96
45°	32550,17	99
48°	41296,48	88
50°	39706,24	90
51°	37320,89	93
52°	35730,65	95
53°	33345,29	98
55°	31755,05	100
56°	29369,69	103
57°	25394,09	108
58°	23803,85	110
59°	21418,5	113
60°	19828,26	115

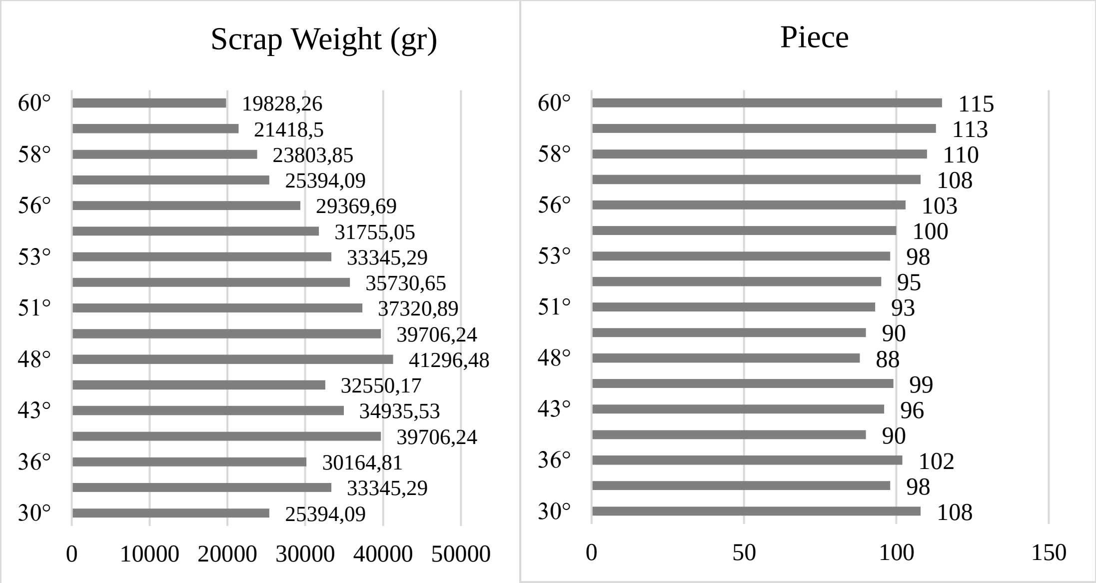

Figure 5. *Variation of scrap weight and number of pieces removed according to angle*

As seen in Table 3, scrap weight decreased with increasing cutting angle. At the same time, increasing the cutting angle also increased the amount of product obtained as a result of the cutting process.

The visual of the rolled sheet metal measured after the 3D scanning is given in Figure 5.

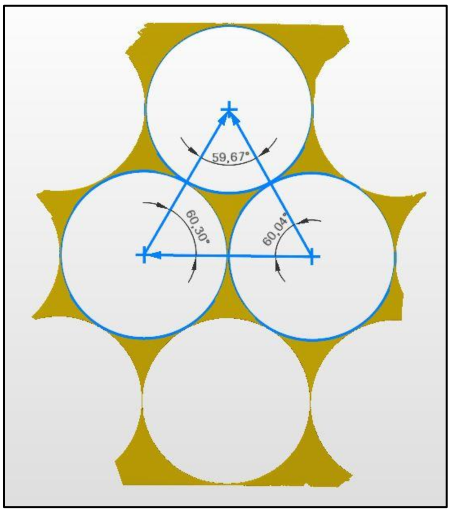

Figure 6. *3D scanning angle measurement result*

As a result of the measurement, it was concluded that the ideal cutting angle is 60°.

5. CONCLUSION

As a result of the optimization made in the virtual environment above;

- The angle value at which the scrap amount is the lowest is 60° and the angle value at which the scrap amount is the highest is 48°.

- In direct proportion to the low amount of scrap, the highest amount of product was realized in the 60° cutting process.

- It was concluded that the cutting process should be carried out at 60°, which is the angle value where the scrap amount is the lowest, and in the filling pattern given in Figure 1.

ACKNOWLEDGEMENTS

This project was supported by Demircioğlu Group R&D Center. For their support We thank Demircioğlu Group management and employees.

REFERENCES

[1]. Demirtürk, O. (2010). Precision Sheet Metal Drive Design and Unmanned Removal of Sheet Metal Waste from the Line (Master's thesis, Celal Bayar University Institute of Science).
[2]. Donaldson, C., Le cain, Goold, V. (1993). Tool Design: McGraw Hill Book Company, Third Edition.
[3]. Adult, Y. (1986). Applied Sheet Metal Construction. Ankara: Gazi University Technical Education Faculty Publication.
[4]. Faura, F., Garcia, A., & Estrems, M. (1998). Finite element analysis of optimum clearance in blanking process. Journal of Materials Processing Technology, 80, 121-125.
[5]. Hambli, R., Potiron, A., & Kobi, A. (2003). Application of Design of Experiment Technique for Metal Blanking Processes Optimization. Mecanique & Industries, 4(4), 170-180.
[6]. Hambli, R., & Guerin, F. (2002). Application of a neural network for optimum clearance prediction in sheet metal blanking processes. Finite Elements in Analysis and Design, 90, 1-14.
[7]. Hatanaka, N., Yamaguchi, K., & Takakura, N. (2003). Finite element simulation of the shearing mechanism in the blanking of sheet metal. Journal of Materials Processing Technology, 139(1-3), 64-70.
[8]. Yıldız, Y. (2013). Modeling of Sheet Metal Cutting Process (Master's thesis, Gazi University Institute of Science).