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Analysis of the Springback Phenomenon of the Material Aluminium Alloy 6063-T5 With Punch Angle Variation

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ABSTRACT

Springback is a phenomenon that frequently occurs in bending processes and is detrimental to the manufacturing industry. Typical disadvantages include the incompatibility of the product's final dimensions and the need for additional processing. Indeed, these must also incur additional expenses and result in the inefficient production process flow. Consequently, the analysis of springback is attracted to studies to obtain a bending product that meets expectations. This study examined the springback phenomena on 60 mm x 19 mm x 2 mm aluminium alloy 6063-T5 materials using V-bending processes and approximately 40°, 50°, and 60° punch angles. This study also utilized the die opening and bending force variables, 35 mm and 2500 N, respectively. It was anticipated that these procedures would produce a 6063-T5 aluminium alloy with a bending angle of approximately 90 degrees. The results indicate that the bending angles produced by these processes with the various punch angles are 91.50°, 91.42°, and 91.67°, respectively. It indicates that the excess bending angle was referred to as springback. Consequently, a bending angle of approximately 90° can be obtained on aluminium alloy 6063-T5 using V-bending processes with the set parameters of die opening in 35 mm and bending force in 2500 N, in addition to the punch angle that was reduced based on the known springback value. In addition, it is anticipated that this result will contribute to the development of the manufacturing industry, particularly the aluminium alloy 6063-T5 materials industry, or serve as a reference for other relevant studies.

***Keywords**: Aluminium Alloy 6063-T5, Springback material, V-Bending.*

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1. INTRODUCTION

One area of life that continues to experience rapid development is the industrial sector, especially the manufacturing industry. The manufacturing industry innovates to meet customers' needs [1]. In preparing for this, the manufacturing industry must consider converting the material into a product so that the resulting product is in line with expectations. In a sense, manufacturing industry players must be able to maintain and improve their performance and productivity [2]. One process that is often used is the bending process. Bending is bending to produce a material with a certain bending angle [3]. The bending process consists of several types: V-bending, U-bending, L-bending, and Z-bending [4]-[7]. However, one type of bending commonly used is V-bending [8]. The bending process consists of several types: V-bending, U-bending, L-bending, and Z-bending [9]. The springback phenomenon cannot be avoided, so a solution is needed to overcome it. Consequently, the analysis of springback is attracted to studies to obtain a bending product that meets expectations

Springback is a reversible force that occurs due to its elasticity when forming or bending a material [10]. Springback is also referred to as a change in a material's size or dimensions, which indicates that the material's final dimension after being formed is not what was expected [11].

The manufacturing industry will suffer losses as a result of the discrepancy between the final dimensions of the material formed; for example, more expenses due to an advanced process to improve the shape of the material to match expectations [12].

The manufacturing industry highly avoids the existence of a springback phenomenon in the material formation process. Therefore, research on the springback phenomenon has become an exciting thing to do. The result of this study is the tested material's springback value. According to Manihuruk (2011), the springback value must be subtracted from the angle of attack during the bending process in order to obtain a material with the desired bending angle [13]. The springback value of a material is significant for the manufacturing industry to know. That is, before the forming process is carried out, the manufacturing industry must first know the springback value of the related material in order to be able to adjust the value of the angle of impact in the bending process so that the standard dimensions are obtained. In other words, springback is very useful for the manufacturing industry as part of an effective design process [14]. This value can be found through research, and the manufacturing industry can use the results as a reference point.

In accordance with the background of the literature review, this study performed a springback analysis on the 6063-T5 aluminium alloy material in the hopes of obtaining a springback value that can be used as a reference by the manufacturing industry, particularly those engaged in processing 6063-T5 aluminium alloy material to obtain the final shape of the 6063 aluminium alloy material. -T5 as anticipated In this study, an aluminium alloy 6063-T5 was formed using a V-bending process to achieve a 90-degree bending or bending angle. Different punch angles were tested to determine the optimal punch angle for bending 6063-T5 aluminium alloy. The objective was to optimise the process by determining the optimal punch angle for bending 6063-T5 aluminium alloy.

2. METHODOLOGY

2.1. Measurement

The angle measuring instrument used in this test is a bevel protector or arc blade with a 5 minute accuracy, which is 0.0833 ° when converted to degrees. A bevel protractor is a measuring tool that is used to measure the angle between two surfaces of a measuring object with an accuracy of less than one degree and up to five minutes. Figure 1 depicts the bevel protractor image.

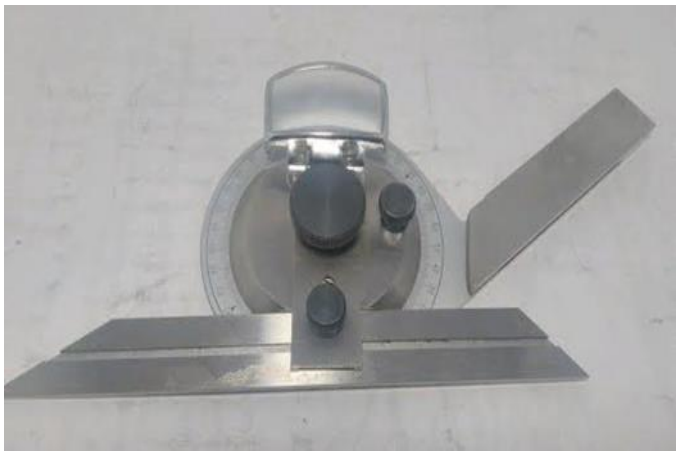

Figure 1. Bevel Protector with five-minute precision

2.2. Material of Aluminium Alloy 6063-T5

Aluminium Alloy 6063-T5 is one of the Aluminium Alloys in the 6XXX series. As the primary alloying elements, silicon and magnesium are combined to create this series. T5 is the alloy code for the to-be-analyzed material in the 6XXX series. Code T5 signifies cooled from a high-temperature forming process. The material used in this test is aluminium alloy 6063-T5 with dimensions of 60 mm x 19 mm x 2 mm as illustrated by **Figure 2**. The material is bent in the hope of forming an angle of 90°.

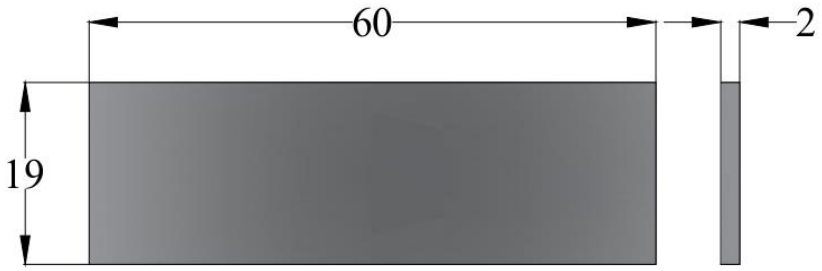

Figure 2. The dimensions of the 6063-T5 aluminium alloy used for testing.

The process of bending is accomplished using the V-bending technique, as depicted in **Figure 3**, and the test parameters are listed in Table 1. To facilitate the testing procedure, the 6063-T5 aluminium alloy series was chosen due to its malleability. 10 kN-capacity Shimadzu engine model AGS-X 10Kn STD E200V is utilized in the testing procedure. Three variations of the punch angle were utilised in this test. It aims to determine the optimal condition of the punch angle that produces the best springback and as expected. The bending radius of the punch has a significant impact on the quality of the resulting bends. The radius of bending of a punch affects the final dimensions of the workpiece and can also lead to material cracking. A too-small bending radius will cause the workpiece to crack, while a too-large radius will result in material waste. Die punches and V-dies have a radius of 1.0 mm. When determining the bending radius, the material's mechanical properties and thickness must be taken into account.

Figure 3. Illustration of the V-bending test for the aluminium alloy 6063-T5.

Table 1. V-Bending Test Parameters

Sample code	Die Opening (mm)	Punch Angle (°)	Punch Speed (mm/minutes)	Bending Force (N)
A	35	40	40	2500
B	35	50	40	2500
C	35	60	40	2500

3. RESULT AND DISCUSSION

The procedure for analysing the effect of punch angle variations on the springback of the 6063-T5 aluminium alloy material using a test specimen is demonstrated in **Figure 4**. After the V-bending

process, the 6063-T5 aluminium alloy material is expected to bend 90°.

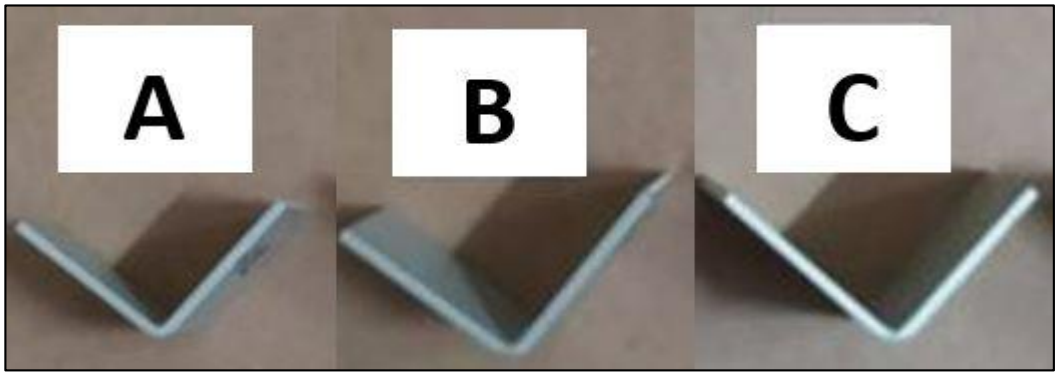

Figure 4. Aluminium alloy 6063-T5 V-bending test sample

In addition, the analysis of springback with variations in the punch angle was computed using equation 1 [15], and the obtained results are presented in ***Table 2.*** *The punch angle and springback material test result*Table 2. Based on these findings, the material composed of 6063-T5 aluminium alloy exhibited positive springback. The punch angle of 55 °, which is 1.42 °, produces the least amount of springback possible. According to Khoirudin (2021), a good springback has a ratio value that is relatively close to zero (0), and this is the condition that is anticipated the most in the manufacturing industry [15].

$$k_R = \frac{a2}{a1} \text{ dan } \emptyset = a_2 - a_1 \quad (1)$$

Figure 5. *The relationship between punch angle and springback material.*Figure 5 illustrates the influence of punch angle on the springback of 6063-T5 aluminium alloy material. Figure 4 indicates that the punch angle has a negligible effect on springback, but it must still be considered. In addition, these results can be used as a guide or reference in the process of forming aluminium alloy 6063-T5 material for the manufacturing industry in able to manufacture suitable products. This process can also be a part of the optimization that can be used as a reference in future studies to maximise the potential of 6063-T5 aluminium alloy in the manufacturing industry.

Table 2. The punch angle and springback material test result

Sample Code	Die Opening (mm)	Punch Angle (°)	Punch Speed (mm/minutes)	Bending Force (N)	Springback
A	35	40	40	2500	1.50
B	35	50	40	2500	1.42
C	35	60	40	2500	1.67

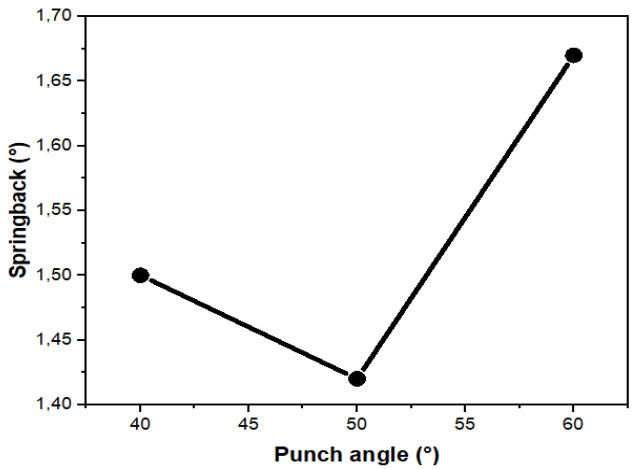

Figure 5. The relationship between punch angle and springback material.

4. CONCLUSIONS

The bending process of 6063-T5 aluminium alloy material with dimensions of 60 mm x 19 mm x 2 mm was conducted using a V-bending test with punch angle parameters of 40°, 50°, and 60°. Other test parameters, including die opening, punching speed, and bending force, are fixed at 35 mm, 40 mm/minutes, and 2500 N, respectively. The test results indicate that there is a springback phenomenon at each variation of the punch angle value, which is approximately 1.50 degrees, 1.42 degrees, and 1.60 degrees. In addition, this value can be used as a reference in the manufacturing industry for the process of forming or bending 6063-T5 aluminium alloy material to obtain a product with a 90-degree bending angle. To obtain a material product with the desired shape, the angle of impact is decreased during the process by springback.

AUTHOR'S DECLARATION

Authors' contributions and responsibilities

The authors contributed significantly to the conception and design of the study. The authors were responsible for data analysis, results interpretation, and discussion. The authors read the final manuscript and gave their approval.

Availability of data and materials

The authors have made all data available.

Competing interests

The authors declare that they have no competing interests.

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