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Effect of Plate Thickness on Springback in V-Bending of Aluminium Sheets

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ABSTRACT

Springback is very important to pay attention to in planning the plate bending process to obtain the desired bending angle. Thus, when designing punches and dies, it is necessary to consider the springback that occurs after loading. From the results of the research carried out, it can be concluded that the results of the angle of formation or bending of the "V" shape: Bending of an aluminum plate, if the bending pressure is minimum, will provide the smallest pressure on the plate so that when bending is carried out the springback effect is greater, the bent angle tends to return to its original position. bigger and vice versa. For bending thinner plates compared to thicker plates. The effect of springback is greater because the plate tends to return or there is a greater return force, and vice versa. In the analysis of changes in springback from the results of the "V" bending process for aluminum plates, it was found that springback is a counterforce generated due to the influence of the elasticity of the plate material undergoing the forming process.

Keywords: *Springback, Aluminum Plate, V Bending*

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INTRODUCTION

In the modern manufacturing industry, sheet metal forming processes play a crucial role in the production of automotive components, aircraft, and even household appliances. One of the most commonly used forming processes is V-bending, a metal folding technique using a V-shaped die to achieve a specific bending angle. While this method is considered efficient, a major challenge is the phenomenon of springback—the tendency of the material to partially return to its original shape after the forming force is released. This results in a discrepancy between the planned bending angle and the final product, which can reduce product precision.

Springback is influenced by various factors, including the mechanical properties of the material, die radius, pressing force, and the thickness of the metal plate itself. In particular, aluminum plate

thickness significantly influences the degree of springback. Aluminum, known as a lightweight metal with a high strength-to-weight ratio, is often used in engineering applications that demand structural efficiency. However, varying elastic characteristics and yield strength across plate thicknesses result in complex variations in springback behavior.

Given the importance of accuracy in metal forming processes, understanding the effect of plate thickness on springback in the V-bending process is crucial. This study is relevant especially for the development of forming tool designs and better product quality control.Springback is a condition that occurs in sheet metal during bending, where after the impact load is removed, the bent sheet metal tends to return to its original shape. Springback is very important to consider when planning the plate bending process. This plate forming test aims to analyze the springback phenomenon that occurs during the bending process. There are several problems that arise in the formation of metal plates, one of which is springback. The material commonly used for the bending process is steel. However, several references state that the use of urethane tools has proven to be better in producing products with small springback results. This occurs because in urethane tools, when the penetration punch penetrates the urethane pad, the applied force is transferred to the urethane pad evenly to all points. [1] To determine the results of forming/bending the "v" shape bending, it is necessary to analyze the change in springback from the results of bending formation on aluminum plates with varying thicknesses.

LITERATURE REVIEW

Understanding and principles of metal bending

A metal casting industry. The metal produced must undergo various testing stages, such as bending, tensile, compression, torsion, and other tests. These tests aim to determine the strength of the metal produced, which will affect product quality. [2] Sheet metal bending is a production method used in the company. Plates are bent to produce angles according to the job design requirements. [3] Bending strength, or bending strength, is the greatest bending stress that can be accepted due to external loading without experiencing significant deformation or failure. [4] It is also important that the distance between the punch and the die be sufficient to allow the workpiece to be easily installed or removed during the process. [5] One type of failure that occurs in components caused by dynamic loads (repetitive and changing loads) can cause a material to fracture or fatigue. [6] [7]

This phenomenon of sheet metal bending development occurs in industry, particularly in agricultural and household equipment maintenance and manufacturing workshops, which are spread almost throughout the country, even to remote rural areas. [8] Steel plate bending can be done using manual tools and machine skills.[9] There are systems or methods for bending that use manual systems, manual hydraulics, electric motors, or a combination of electric and hydraulic motors.[10] The change in shape of the material will be assisted by tools often called tools. These tools will provide compressive force to shape the iron shaft or round bar metal material according to the geometry and shape of the tools.[11]Bending is a machining process that changes the shape of an object from a straight line to a curved one. This results in tension on the outer part of the object and pressure on the inner part.[12] Bending parameters must be controlled because they affect the desired bending angle and dimensions. The resulting angle and dimensions of the workpiece are among the output variables that must be achieved in all bending processes.[13] Producing a project on target requires proper planning. One way to plan ahead is to create a Bar Bending Schedule (BBS) document.[14] Manual calculations of the Bar Bending Schedule require detailed calculations.[15] The Bar Bending Schedule (BBS) is a work planning method that contains detailed information about the shape of the material to be formed.[16]

Metal forming work in the machining and welding fabrication industries is currently in high demand, especially for work requiring bending processes. The bending process is a metal forming process that generally uses sheet plates or rods, both from ferrous and non-ferrous metals by bending, which in the bending process will cause elongation or stretching on the neutral plane axis along the bending area and produce a straight bending line. [17] The use of appropriate technology has been widely used to

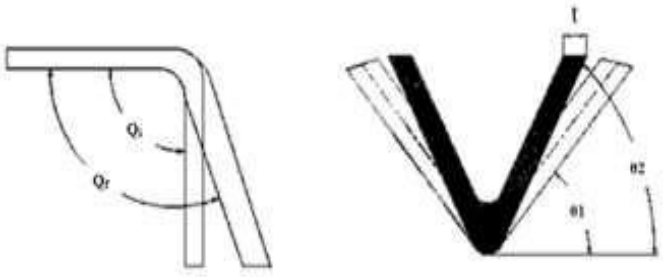
increase productivity, efficiency, and effectiveness in the production process in the machining industry and small and medium-scale welding fabrication. One of the appropriate technologies that can be applied in the production process, especially plate bending work, is a bearing press machine or tool by adding a press tool equipped with a punch and bending die. [18]

Based on previous related research, the analysis of the bending machine frame using SolidWorks software using U-profile steel material was obtained. The conclusion was drawn that the value of von Mises stress was obtained for AISI 316 with a maximum value of 895.721 N/mm2, AISI 1020 with a maximum value of 907.712 N/mm2, AISI 1045 with a maximum value of 903.226 N/mm2. The deflection analysis on the above materials obtained the respective values, namely AISI 316 with a value of 0.444 mm, AISI 1020 with a value of 0.430 mm, AISI 1045 with a value of 0.419 mm. The safety factor analysis for the materials above yielded values for each: AISI 316 had a maximum value of 3 and a minimum value of 0.192, AISI 1020 a maximum value of 3 and a minimum value of 0.387, and AISI 1045 a maximum value of 3 and a minimum value of 0.587. The maximum safety factor values for all three materials were the same, while the minimum values differed due to differences in yield strength. The frame material selected for this bending machine met the desired bending process objectives. The machines used to fold or bend the plates were a manual bending machine and a hydraulic pipe bender. The manual bender was used to fold or bend the completed work plates for the initial work. It can bend plates with a maximum thickness of 3 mm and a maximum length of 1.5 meters, while the hydraulic pipe bender was used to bend cylindrical workpieces. [19]

Mechanically, this bending process consists of two force components: tension and compression. The plate undergoing this bending process undergoes stretching, neutral deformation, and contraction. The stretch region is visible on the outer side of the bend, where elastic deformation or change in shape occurs.[20] This stretching causes the plate to experience an increase in length, which is known as the neutral zone, which is an area that does not experience changes. This means that in this neutral zone the plate does not experience an increase in length or shortening.

The inner side of the bend is the area that experiences compression, where this area experiences contraction and an increase in thickness, this is because this area experiences a change in length, namely shortening or becoming shorter due to the compressive force experienced by the plate.[21] This process is carried out by clamping the plate between the anvil and the clamp, then the bender is rotated upwards, pressing the part of the plate that will experience bending.[22]

A simple example can be shown during the bending process, if a 90° bending angle is desired, the pressure angle on the bender must be reduced from 90° (<90°). So that when the presser foot is released, the forming angle will be equal to 90°. The springback process in this bending forming can be seen in the image below [23]



(a) (b)

Figure 1. *Spring Back,* (a) (Qf>Qi), (b) θ1> θ2

RESEARCH METHOD

This research was conducted at the Workshop and Laboratory of the Mechanical Engineering Study Program at ITM Medan. The research period was approximately six months.

Effect of Plate Thickness on Springback in V-Bending of Aluminium Sheets

1. Test materials as samples
a. Aluminum plate material
b. Plate thicknesses varied: 1 mm, 1.5 mm, and 2 mm
2. Sample material dimensions
a. Sample length 100 mm
b. Sample width 50 mm

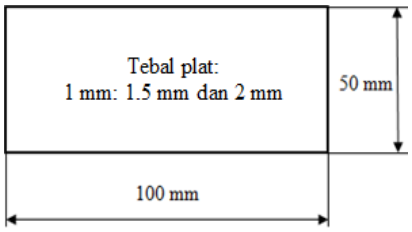


Figure 2. Test sample size

1. Specimen size after forming

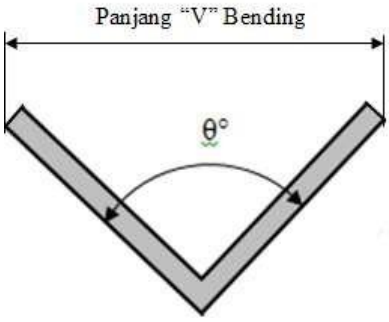


Figure 3. Shape and Size After Bending ("V" Bending)

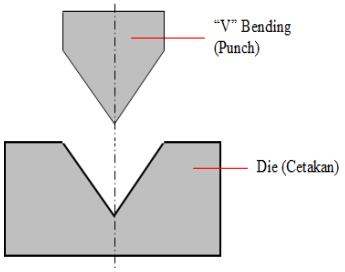


Figure 4. Alat penekan "V" bending (*punch*) dan cetakan (*die*)

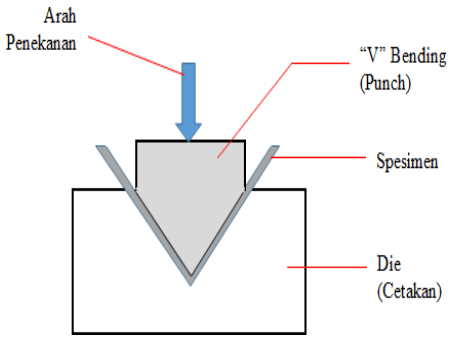


Figure 5. Penekukan "V" Bending (Punch) dan Cetakan (Die)

No.	Tools/machines	Picture	Description
1	Measuring tool steel measuring ruler		Steel measuring ruler with a length of 300 mm with an accuracy of 0.5 mm
2	Scope		Scope with 150 mm measuring capability.
3	Blade arc angle measuring device (bevel protractor)		Bevel protactor is a measuring instrument used in measuring the angle between two surfaces of a measuring object with a level of accuracy smaller than one degree, namely with an accuracy of up to 5 minutes.
4	Scraper measuring tool		Scraper for drawing on the tool
5	Plate cutting tool/machine		Manual plate cutting machine with the ability to cut 1.5 mm thick plates.
6	Special fine file finising tool		A special fine file is used for scraping the workpiece to remove sharp edges on the plate.

Table 2. "V" Bending Test Result Data for Plate

Ketebalan Bahan (mm)	Tekanan Penekukan (ton)	Nomor sampel	Hasil Pengukuran Sampel (Benda Uji) (°)
1,0	Min. 0,5	1	88 °40″
		2	88 °45″
		3	88 °50″
	Medium 1,0	4	88 °35″
		5	88 °30″
		6	88 °25″
	Maks. 1,5	7	88 °30″
		8	88 °10″
		9	88 °20″
1,5	Min. 0,5	1	86°35″
		2	86°30″
		3	86°25″
	Medium 1,0	4	86°20″
		5	86°15″
		6	86°25″
	Maks. 1,5	7	86°05″
		8	86°15″
		9	86°25″
2,0	Min. 0,5	1	85°30″
		2	85°20″
		3	85°25″
	Medium 1,0	4	85°05″
		5	85°20″
		6	85°20″
	Maks. 1,5	7	85°10″
		8	85°05″
		9	85°00″

	Nomor Sampel	Hasil Pengukuran	Hasil Pengukuran Sudut Sampel Rata-Rata (°)

Ketebalan Bahan (mm)	Tekanan Penekukan (ton)		Sudut Sampel Benda Uji (°)	(Derajat dan menit)	(Di desimalkan) (°)
1,0	Min. 0,5	1	88°40″	88°45″	88,75°
		2	88°45″		
		3	88°50″		
	Medium 1,0	4	88°35″	88°30″	88,50°
		5	88°30″		
		6	88°25″		
	Maks. 1,5	7	88°30″	88°20″	88°
		8	88°10″		
		9	88°20″		
1,5	Min. 0,5	1	86°35″	86°30″	86,50°
		2	86°30″		
		3	86°25″		
	Medium 1,0	4	86°20″	86°20″	86,33°
		5	86°15″		
		6	86°25″		
	Maks. 1,5	7	86°05″	86°15″	86,25°
		8	86°15″		
		9	86°25″		
2,0	Min. 0,5	1	85°30″	85°25″	85,42°
		2	85°20″		
		3	85°25″		
	Medium 1,0	4	85°05″	85°15″	85,25°
		5	85°20″		
		6	85°20″		
	Maks. 1,5	7	85°10″	85°05″	85,08°
		8	85°05″		
		9	85°00″		

RESEARCH RESULT

Results of average forming angle or "V" shape bending of aluminum plate.Table 3. Data Results of Bending "V" Bending on Aluminum Plate Material Hubugan material thickness and bending pressure variation on bending angle due to the influence of springback Tests were conducted using various aluminum plate materials that have three different thicknesses, namely, 1 mm, 1.5 mm, and 2 mm. The results of tests conducted on the bending of Aluminum plate material with a thickness of 1 mm with three variations in pressure.

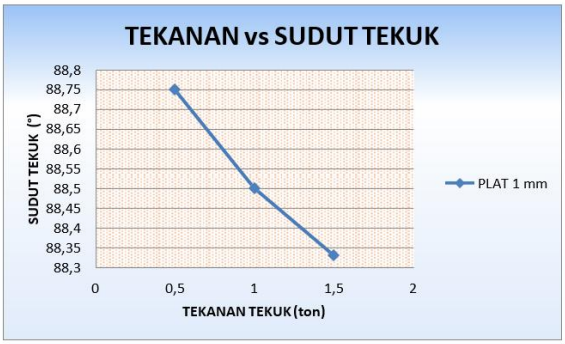


Figure 7. Bend Angle Vs Variation Size Chart

Bending Pressure 1 mm Thick

The results of tests carried out on the bending of Aluminum plate material with a thickness of 1.5 mm with three pressure variations.

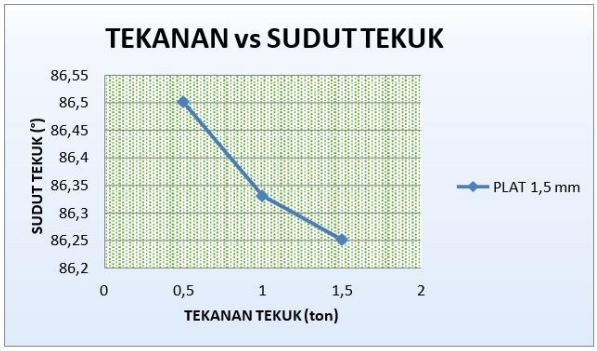


Figure 8. Graph of Bending Angle Size Vs Bending Pressure Variation 1.5 mm Thick

The results of tests carried out on the bending of Aluminum plate material with a thickness of 2 mm with three pressure variations.

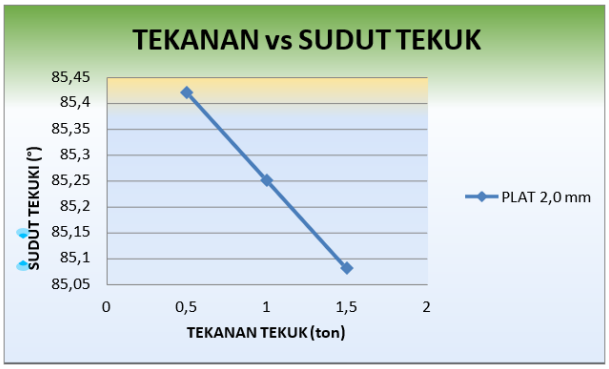


Figure 9. Size Chart of Bending Angle Vs Pressure Variation 2 mm Thickness

Relationship of variation in material thickness and *bending* pressure *to bending angle due to the effect of springback*

PENUTUP

Berdasarkan hasil penelitian, dapat disimpulkan bahwa springback merupakan faktor krusial dalam proses *V-bending* pelat aluminium karena sangat dipengaruhi oleh besarnya tekanan saat pembentukan dan ketebalan pelat. Semakin kecil tekanan yang diberikan saat proses bending, semakin besar efek springback yang terjadi, yang menyebabkan sudut hasil pembengkokan cenderung kembali ke posisi semula. Selain itu, pelat aluminium yang lebih tipis menunjukkan efek springback yang lebih besar dibandingkan pelat yang lebih tebal, karena gaya elastis balik yang ditimbulkan lebih dominan. Fenomena springback ini terjadi sebagai akibat dari sifat elastisitas material setelah proses pembebanan dihentikan, sehingga perlu diperhatikan secara cermat dalam perancangan punch dan dies untuk memperoleh sudut bending yang sesuai dengan perencanaan.

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