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IDENTIFICATION OF ELASTIC - PLASTIC DEFORMATION FOR DIFFERENT DEGREES OF DEFORMATION FOR FORMING SHEET METAL BY SWIVEL BENDING

Introduction

Definition of swivel bending

Swivel bending system is an example of flexibility when it is necessary to create valuable bent parts. This technology achieves high productivity of production of exact bent parts. (Okoličányi, 2009)

Handling large plates with swivel bending is much easier. There is only needed one type of tool for the huge range of products. Plates are formed without damaging the surface and it is also suitable for small as well as large parts. (Swivel bending goes ahead, 2010).

Principle

In swivel bending the sheet metal is lying on workbench. Locking jaw ensure the plate on the bent line. Upper and lower bending jaw tighten bending sheet. The new design of bending arm allows bent of 90° per second and with the automatic setting on the plate thickness is mainly an investment to productivity and flexibility . Long part of the bent material remains lying on a desk. Because the sheet may not be additionally supported, bending process is especially for large pieces much faster, safer and with higher quality. Ensure that there will not be shift of the sheets in bending, sheet metal can be held between the bending jaws with strength to 120 tons. Help of the operator in bending is unnecessary. (Swivel bending scores, 2006).

Advantages of swivel bending

In exact swivel bending ihe bending arm is bent with an accuracy of 0,1°. Flatness of the bent part is secured by flatness of the machine. In the swivel bending user bends with a single tool angles up to 150 °. (Swivel bending goes ahead, 2010).

The biggest advantage is the rapid change of the bending in small series. It is used by small plumbing operations to industrial applications thickness up to 6 mm with steel plate or sheet up to 4 mm of stainless steel. (Swivel bending goes ahead, 2010).

Application

- bending closed profiles, decorative aluminium sheets;
- advertising panels, tool boxes for installation vehicles;
- casing of air conditioners, furnaces and boilers;
- medicinal equipment and operation;
- kitchen and restaurant interiors;
- partitions, conveyors, metal furniture and doors;
- escalators, elevators and others. (Swivel bending goes ahead, 2010).

The design bending equipment

Principle

Bending equipment is a simple machine for bending sheet metal. Force required to deform (bend) must develop operator. The machine is designed to allow him to bend the sheet with the strength of 420 MPa and thickness of 1 mm to 15 mm length.

There is experimental bending equipment after assembly is shown in Figure 1.

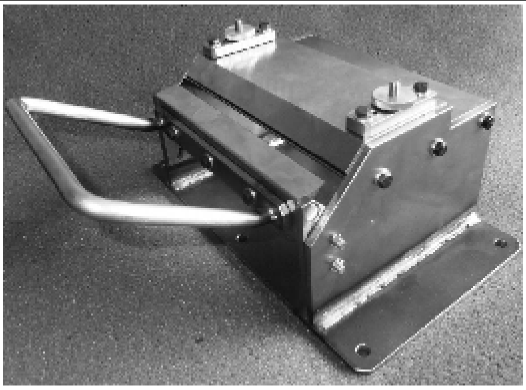
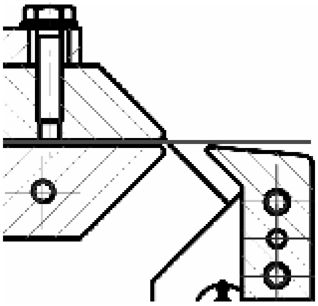
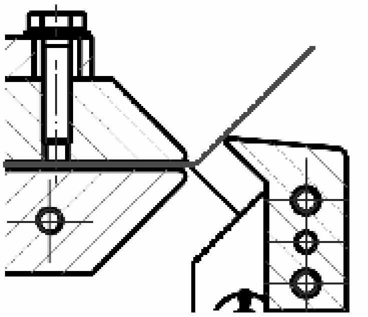


Fig. 1 – Constructed experimental bending equipment

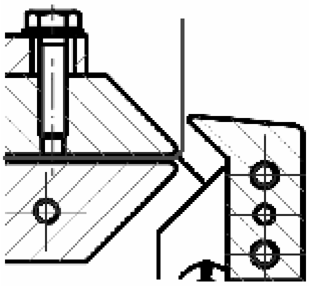
There is need to be done setting of the bending equipment for the plate thickness before bending the sheet. The characteristic mark of the bending equipment is swivel movement of the punch that makes it possible to bend the sheet to different angles with relatively small punch stroke (Fig. 2).



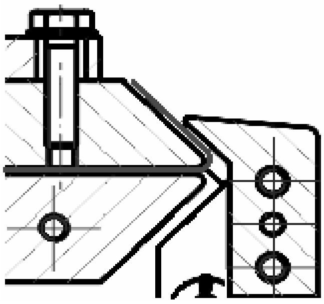
Start of the bending process



Bending angle 45°



Bending angle 90°



Bending angle 120°

Fig. 2 – Various settings of bending angles in the experimental bending equipment

Experimental part

The aim of the experimental tests was to verify the influence of strain on the accuracy and strength of stampings.

The samples were made of material 11321with thickness 1,0 mm and bend radius 1,0 mm. There were bend 12 pieces of samples by swivel bending on the experimental bending equipment. Based on experiments there were evaluate the effect of the degree of deformation on the accuracy of stampings and thinning effect of material thickness on the strength of stampings.

Thinning of the wall

Bending results is depletion of thickness of bent samples at the bending area from the value s to s_s. The table 1 below shows the thickness after thinning compared with baseline thickness. The values were measured using a digital meter.

Table 1

The thinning of the material thickness 1,0 mm

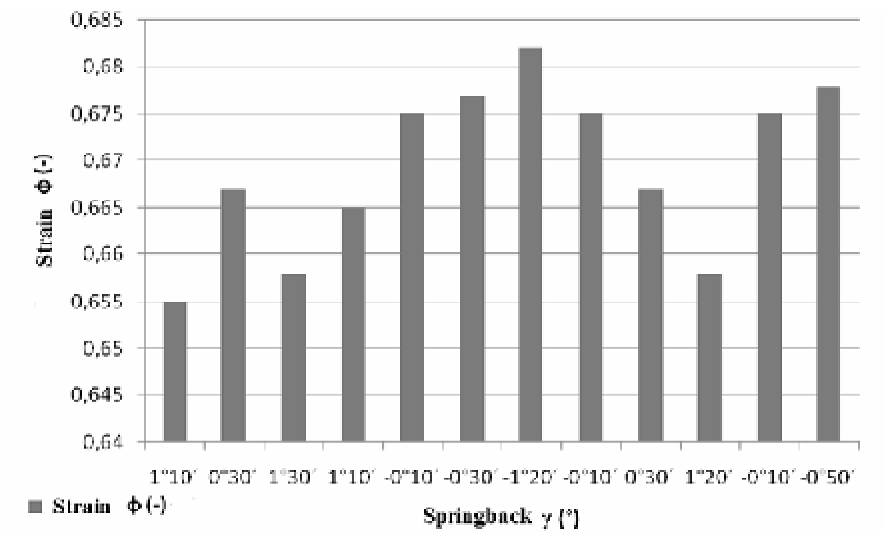
Sample	s_s, (mm)	h_s, (mm)	Thinning (%)
1	0,973	0,027	2,7
2	0,975	0,03	2,5
3	0,966	0,024	3,4
4	0,973	0,035	2,7
5	0,983	0,017	1,7
6	0,985	0,014	1,5
7	0,99	0,027	1,0
8	0,983	0,037	1,7
9	0,986	0,024	1,4
10	0,976	0,037	2,4
11	0,983	0,027	1,7
12	0,986	0,024	1,4

Accuracy of stampings

After bending process using an optical protractor measured the following data on springback and calculated strain in the bending.

The results from the experimental tests were focused on the influence of degree of deformation on elastic stress remaining in stampings after the bending process. There can draw the following conclusions:

- for the resulting deformation φ = 0,658 was measured maximum springback 1° 30' (Graph 1).



Graph 1 – The values of springback and strain for the base material thickness = 1,0 mm

Strength of stampings

Strength of stampings was determined on the basis of material in bending strength σ_0, which is defined as the maximum bending stress in bending, due to the hardening caused by thinning of the sample in the bend area. For the thickness of 1,0 mm were calculated maximum σ_0 : 365,99 MPa for thinning of material thickness 0,973 mm.

Hardness of stampings

The above-mentioned weakening of thickness had results in local reinforcement material bent parts, which was detected by measuring the Vickers microhardness (STN 420375).

Experimentally measured values of Vickers hardness on the device HV1/10 INNOVA TEST 412D were reported in Table 2 for a sample thickness of 1,.0 mm.

Table 2

The microhardness values for the thickness of 1,0 mm

Sample thickness	1,0 mm					
Number	1	2	3	4	5	6
Hardness HV in bending area	172	178	173	174	180	176
HV hardness of the base material	162	161	165	162	162	161

Discussion

Objective was to identify elastic - of plastic deformation for different degrees of strain of metal sheet by swivel bending. There were use the literature to analyze the stress - strain state in the process of bending and their effect on the final precision of the final stampings. Then it was designed and constructed a bending equipment to perform experimental tests needed to determine the impact of the degree of strain. Based on experiments there were conduct to evaluate the degree of strain, springback, bending strength and thinning of the material thickness. The specimens were made of sheet metal 11321 with material thickness 1,0 mm and with bend radius 1 mm. There were bend 12 pieces of samples with both methods.

Accuracy of stampings

From the results of experimental tests to influence the degree of elastic deformation on residual stress remaining in stampings after bending process can be evaluated following conclusions:

Thinning of the thickness of the material:

The thickness of the sample s = 1,0 mm were measured following values thinning material thickness s_s max: 0,966 → 3,4 %

Springback of the material:

The thickness of the sample s = 1,0 mm were measured following values γ suspension: deformation at $\varphi = 0{,}658 \rightarrow \gamma = 1°\,30'$.

It can be concluded that by the swivel bending was achieved smaller springback angles of the material and smaller size of resulting thinning of the strain area of the stamping, it was achieved in some cases greater precision of bent part.

Strength of stampings

Strength of stampings was determined on the basis of material strength in bending σo due to hardening caused by thinning of the sample in the bend area.

The thickness of the sample s = 1,0 mm were measured following values of bending strength σ_0 : for swivel bending: the thinning $s_s = 0{,}973 \rightarrow \sigma_0 = 365{,}99$ MPa

It follows that the thinning increased strength of stampings in the bending area.

Hardness of stampings

Based on the results observed when measured by Vickers microhardness is possible to argue that the bending was established to increase the hardness of the samples:

The thickness of the sample s = 1,0 mm were measured microhardness values following:

for swivel bending: in bending area: 180 HV

basic material: 165 HV

Based on the results, we can conclude that the hardness was increased in the bending area.

The advantage of the bending equipment is the possibility of bending sheet metal into different bending angles. This means that in bending of the part to an angle of 120° for example, it would be needed to replace the classical bending punch. Resulting in increased costs to the utility.

Conclusion

Following the global trend, and having regard to the specific situation should solve the problem of forming metals in the whole complex - forming material, forming tools, forming machines and automation, including management.

The work aims to highlight the high bending progression, which is increasingly emerging new technologies and innovative solutions of traditional problems.

Progressive method of bending the technology is now undoubtedly the swivel bending, which is a great advantage to bend large parts (4 × 3, 7 m), automatic programming, and further advantages are the very structures swivel bender, for example programmable position of the upper jaw, lower jaw robustness, there is the deflection and bending jaw speed is up to 90 ˚ / s.

As for the solutions work, the task was to design a bending equipment to produce desired components. They were therefore made technological and constructional calculations, determine the force necessary to bend the shape parts and work.

Upon completion of the experimental equipment for swivel bending, there were made samples, which are evaluated on the thinning of the sheet thickness, angle of springback of stampings and deformation in the bending area, which resulted in an increase in strength and hardness of the bending area of stampings.

Literature

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