Investigations on Peen Forming (3rd Report: Applications for the Improvement of Shape Accuracy)

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ABSTRACT

The shape accuracy of the products in press bending is rather low because of spring back phenomenon. In this report the application of peen forming as a means for the improvement of shape accuracy is dealt with. Peen forming accompanying elastic pre-bending enables stable precise V-bending of thin phosphor bronze sheet regardless of the fluctuation of the sheet thickness. By applying auxiliary peen forming at the final stage of the press U-bending just before taking out the product, the desired fit product to the punch shape can be obtained.

KEYWORDS

Shape accuracy; Stable precise bending; Auxiliary means; U-bending.

INTRODUCTION

In the former reports the forming mechanism, the optimum working conditions and several features of peen forming were investigated. In press forming of sheet metals spring back phenomenon deteriorates the shape accuracy of the products. But peen forming has a feature of the compression type forming and is thought to be much easier to deal with spring back. In this report the applications of peen forming as a means for the improvement of the shape accuracy in bending operations are dealt with and the possibility of this process as a general forming method is made clear.

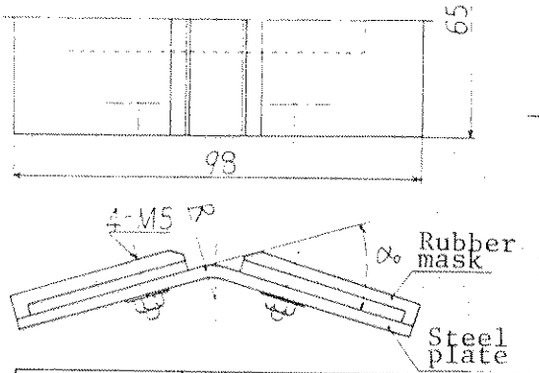
EXPERIMENTAL METHODS AND CONDITIONS

Tests are carried out by the centrifugal throwing type peening machine which was used in the former reports. Test materials are phosphor bronze sheets of 0.2mm thick which are difficult to form in ordinary press forming and half-hard commercially pure aluminium sheets of the same thickness as comparative materials which have good formability. Mechanical properties of these materials are shown in Table 1. Adopted diameter of the shot is 0.2mm which gives good surface finish of the products. In bending accompanying auxiliary pre-bending, that is, in stress peen forming, a holding tool

TABLE 1 Mechanical Properties of Test Materials

Material	A1100P-H24	C5210P-H
Thickness (mm)	0.2	0.2
Tensile strength (Kg/mm^2)	13.0	62.0
Work-hardening index n	0.14	0.02
Vicker's Hardness Hv (50g)	37	241

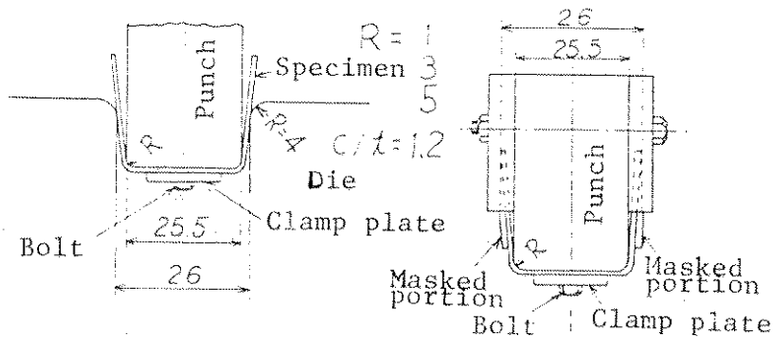
shown in Fig. 1(1) is used. Tested bend angles are small ones such as 10°, 20° and 30° which are difficult to bend precisely because of large spring back. Specimens are clamped in this holding tool to give pre-bending. In the case of phosphor bronze sheet this pre-bending is completely elastic, so if clamping is relieved specimens are recovered initial flat states. By stress peen forming specimens fit to tool shape. The peripheral length between two clamping tools masked with rubber is used as peening width. In U-bending operation, after press bending is carried out the specimen is held by a holding tool which has the same shape as the punch and the same clearance and is peen formed. In U-bending the deflection at the lower punch face influences remarkably the formed shape. So, to simplify the working phenomenon, the specimen is held down to the punch face by a clamping tool and its deflection is suppressed as is shown in Fig. 1(2).



Angle	10.9	20.3	30.3
Radius R	13.0mm	7.5mm	6.0mm

(a)Holding tool of specimen

(1) V-bending.



(a)U-bending tool.

(b)Holding tool for peen forming.

(2) U-bending.

Fig. 1 Experimental tools.

APPLICATION TO V-BENDING

Press bending has the feature of high productivity but the shape accuracy of the products is rather low because of spring back phenomenon. For instance, in V-bending when the bend angle is small and the work material is thin and has small Young's Modulus, it is difficult to obtain the desired bent angle of the products and even the unavoidable small fluctuation of the blank thickness may cause fairly large change of the bent angle. For these cases, peen forming accompanying elastic pre-bending is applied and the possibility to improve the shape accuracy is examined. Figure 2 shows the effects of shot speed (represented by rpm of the impeller) and the pre-bending on the progress of bending by peen forming. Test material is phosphor bronze sheet of 0.2mm thick. Dotted lines in the figure indicate the

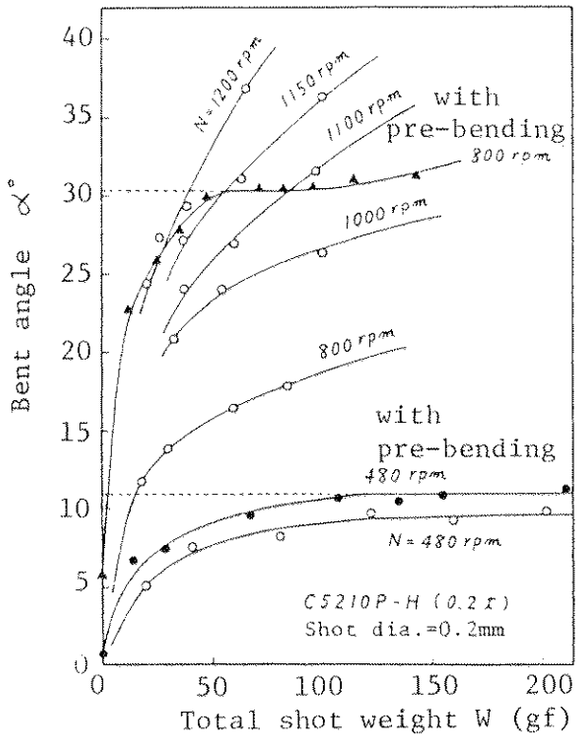


Fig. 2 Effect of pre-bending in V-bending.

die angle of the holding tools. When the pre-bending is not applied, bent angle of the products increases monotonously with the increase in total shot weight and the increasing rate of the bent angle becomes larger as the shot speed increases. In these large increasing rate conditions it is difficult to obtain a desired shape precisely because the exact regulation of the total shot weight or stop timing of the peening operation is not so easy. On the other hand, when the pre-bending is applied, the bent angle increases rapidly in earlier stage and settled down to the desired die angle for a while as is shown by solid marks. This is because during continuous peening the elastic pre-bending moment is diminished and the bent angle saturates for a while. So, this saturated bent angle gives the stable bent angle of the product regardless of the fluctuation of the stop timing of peening operations. Figures 3 and 4 show the effect of the fluctuation of the shot speed on the settled bent angle. The change of the bent angle owing to the fluctuation of the shot speed is not so large. Hence the

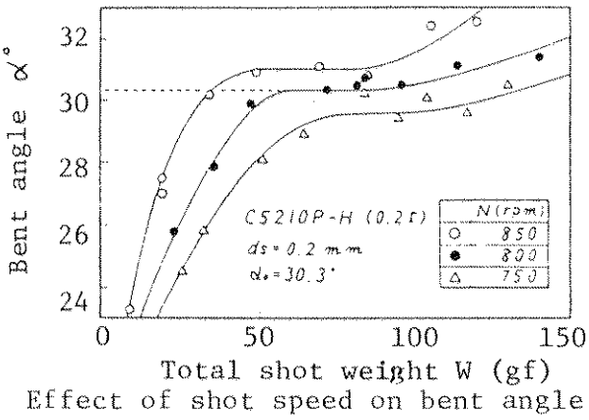


Fig. 3 Effect of shot speed on bent angle (α_0=30.3)

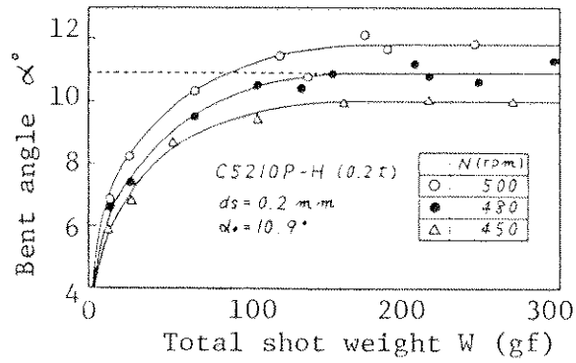


Fig. 4 Effect of shot speed on bent angle (α_0=10.9)

desired bent angle can be obtained fairly easily regardless of the fluctuation of the working conditions. But the excessive peening must be avoided because further progress of the bending occurs beyond constrained die angle especially when the bend angle is large.

Next, concerning to the factors which deteriorate the accuracy of the bent angle, fluctuation of the supplied sheet thickness can be considered besides fluctuation of these working conditions. Figure 5 is a data shown by Y.Tozawa which points out the fact that in the ordinary press bending of thin sheets fluctuation of the sheet thickness brings about large change of the bent angle of the products. From this data it can be recognized that in order to keep the accuracy of the bent angle within 1° deviation, the thickness fluctuation must be severely controlled within 1 μm. However, this is almost impossible in practice. So, paying attention to this problem, the change of the bending angle in peen forming according to the fluctuation of supplied sheets is studied.

Although our available sheet lot has a thickness fluctuation of about 0.01mm, much larger fluctuation can be assumed in the industrial use. So, maximum fluctuation of 0.04mm is given intentionally to the test specimens by polishing operation. Experimental results in Fig. 6 show that the bent angle can be settled within 1° deviation from the desired angle if the fluctuation of the sheet thickness is less than about 0.02mm.

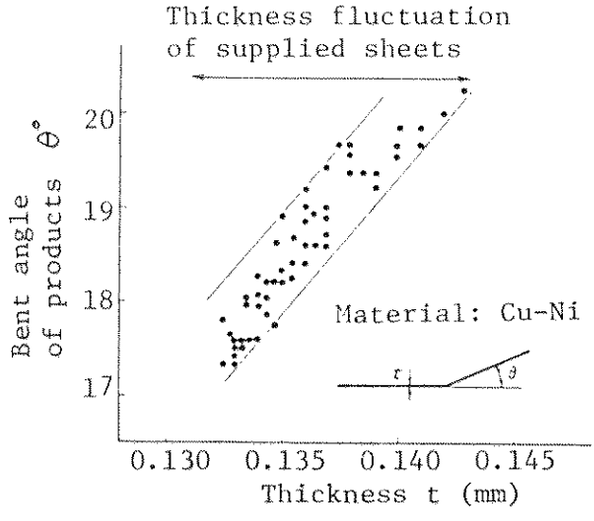


Fig. 5 Change of bent angle of products.

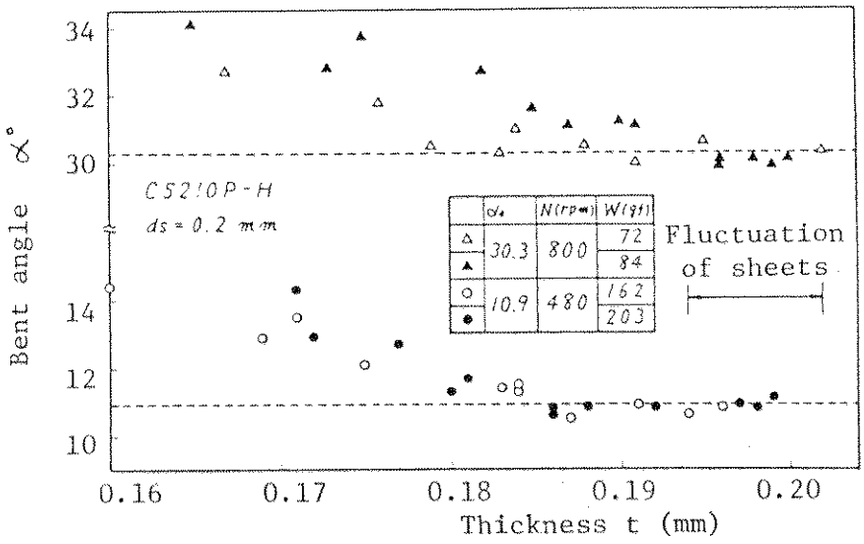


Fig. 6 Effect of thickness fluctuation on bent angle of products.

APPLICATION TO U-BENDING

It is also not so easy to obtain the accurate shape of the bent products in U-bending because of the spring back phenomenon. Suppression of the spring back itself is principally possible by the superposition of the stretching. But in the press bending this superposition is not easy to practise. So, techniques such as ironing or addition of the back up pad pressure is adopted to improve the product shape. But as the optimum working condition of these techniques to obtain the desired shape is severly limited to narrow range, the product shape fluctuates easily. For these cases, the application of peen forming as an auxiliary means for the improvement of the product shape is examined. The relations between the spring back angle and the punch profile radius in ordinary U-bending of half-hard aluminium and phosphor bronze thin sheets are shown in Fig. 7. The spring back angle increases with the increase in punch profile radius and the extent is much larger in phosphor bronze. As an example, Fig. 8 shows the effect of the

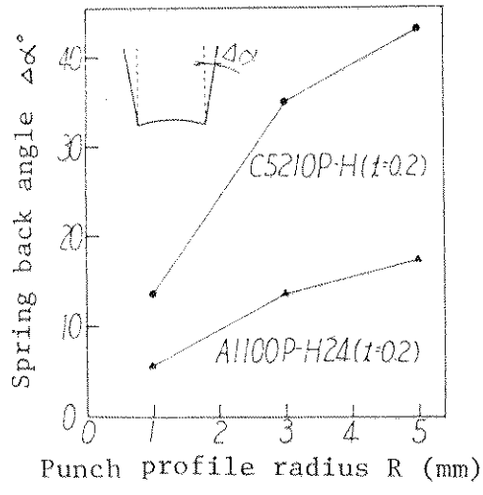


Fig. 7 Relation between spring back angle and punch profile radius.

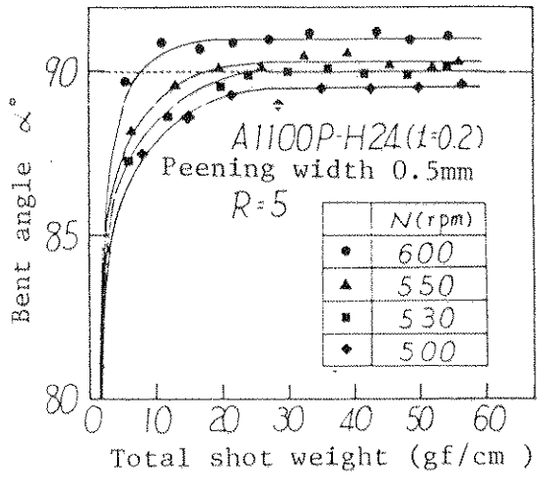
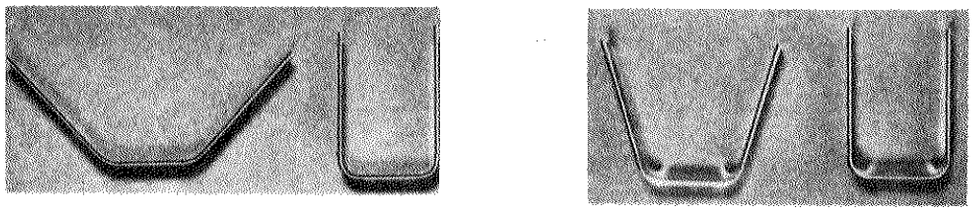


Fig. 8 Effect of shot speed on bent angle.

auxiliary peen forming on the bent angle of the products when the punch profile radius R is 5mm. There exists the optimum condition when the bent angle is saturated to the die angle as well as the cases of peen forming with pre-bending in the former section. This result shows the usefulness of peen forming as the auxiliary means for the setting of precise product shape. Figure 9 is a photo of the bent products in this experiment. These fit well to the punch shape.



Ordinary U-bending. With peen forming. Ordinary U-bending. With peen forming.

C5210P-H,0.2mm A1100P-H24,0.2mm

Fig. 9 Effect of auxiliary peen forming in U-bending.

CONCLUSIONS

The usefulness of peen forming as the means for the stable setting of the precise product shape is confirmed in V- and U-bending.

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