Influence Anisotropy in springback for Ultra High Strength (JSC 980Y) Sheet by U-Bending

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Abstract

Ultra high strength steels (UHSS) recently play an important role in the automotive industries because they can provide higher strength to weight ratios for structural parts of automobiles. However, the structural parts made of UHSS show more springback than other steel. Moreover, the variations of the incoming material, such as anisotropy of material and process condition could cause the differences in the springback characteristics. In this study, springback of dual phase JSC980Y was investigated by using of the experiment methods. The experiment was conducted by considering the influence of material anisotropy on the springback behavior of JSC980Y by based on the simple U profile test in numisheet'2011. The blank sheet was bended in U bending die, and the parameters (Blank holding pressure, Punch radius) were varied. The results were analyzed the effect of springback occurring on anisotropic material. In addition, the strain measurements were conducted to measure strain distribution after springback. The results demonstrated that the variation of springback with orientation of anisotropic sheet in U-die bending process. Therefore, the automotive industry needed to consider these parameters in order to tread the springback problem.

***Keywords**:* Ultra high strength steel, anisotropy, springback, blank holder force.

1. Introduction

Ultra high strength steel (UHSS) have been increasingly used for automotive structure, Because it has high strength and light weight compared with mild steel. Dual phase steel is one of Ultra high strength steels which have unique elastic and plastic behaviors. The cold forming is normally employed to manufacture the automotive parts, especially body structure. This process could promote the elastic recovery causing of springback. The amount of springback is influenced by process parameter, such as material anisotropy, wall-thickness, die geometries and process condition. In this study, the effect of anisotropy was considered as a primary influential factor causing springback.

The Springback behavior of sheet materials has been studied for many years. Zhang and Lee[1] showed the influence of blank holder force, elastic modulus, strain hardening exponent, yield strength on the magnitude of the final springback strain in a part. Carlos J. Gomes et al[2]. studied springback behavior in High Strength Steels using FEM. A U-shaped cross-section was analyzed and forming process is preformed in an explicit and implicit simulation. Geng and Wagoner[3] studied the effect of plastic anisotropy and its evolution in springback. Leu[4] formulated a mathematical model to study effect of the sheet anisotropy value, the strain-hardening exponent on the springback in sheet metal forming. Hill's yield criterion was adopted and the Bauschinger effect was not considered in the analysis. It was reported that the higher the *R-value*, the greater the springback and the higher the strain hardening exponent *n* the lower the springback. Tan and coworkers[5] studied the effect of anisotropy on pure bending of sheet metals. It was found that sheet experience little less resistance to thinning when the axis of bending is aligned with the rolling direction of the specimen. The attention of the present is on the experimental of the springback characteristics of the strong anisotropic sheet metal. The effect of some tool and die condition (Blank holder force and radius of punch) on characteristics are carefully discussed

2. Experimental condition

2.1 Material characteristics

The steel investigated in this study is the dual phase steel JSC 980Y with the blank size has 350 x 30 x 1.4 mm.The as-delivered material is a cold-rolled steel sheet. The steel sheets rectangular were cut at different orientations to the rolling direction, namely 0^0, 45^0 and 90^0 Fig.1 shows the schemes followed in bending specimens from the original sheets. Tensile specimens were used to plastic strain ratio (R-values).

Table. 1 Material Properties of the JSC980Y

Specimen orientation (deg.)	TS (MPa)	YS (MPa)	Work – hardening (n-value)	Plastic strain ratio (R-value)	Poisson's
0^0	1087.5	881.5	0.095	1.21	0.71
45^0	1098.9	900.2	0.098	1.11	0.69
90^0	1098.3	886.1	0.092	1.64	0.76

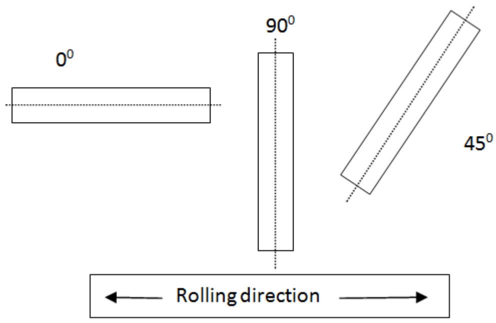

Fig.1 Schematic drawing showing the specimen orientation on the sheet

2.2 U bending

The U-shape cross section presented in NUMISHEET'2011 was selected for this study. For the U-shaped geometry there is a standard method to measure springback

In order to perform U-bending experiment, which test equipment had to be considered[6]. To perform the test, a hydraulic tensile test machine with capacity of 250 kN. Fig. 2. Shows the setup U-bending mold, which consists of a die, a punch, a blank holder, and upper and lower platens, which are separated from the blank holder by springs. The blank holder can move up and down freely on the two guide posts attached to the lower plate. The lower-springs hold the blank holder at a small distance for die surface, for very easy insert the blank to the die. The upper-springs are used for the transmission of blank holder force. The insert punch was designed for changing the radius of punch in this study. The guide posts and guide bushes, standard parts were used that could provide perfect fit. The four pins for spring guides were attached to the lower plate. The die and the lower plate are fixed to the hydraulic ram after alignment with the punch

The punch speed was set at 1 mm/sec. The punch travel was selected at a specified distance of 72 mm and radiuses of punches were 3, 5 and 8 mm. The blank holder forces were varied at 3 kN, 4.5 kN and 6 kN. The three plates were made from S50C. The insert punch and the die were made from SKD11, which had been heat-treated by Nitriding to increase its surface hardness to 58 HRC following by hard chrome plating. The thickness of SKD11 after hard chrome plating was 50 μm. Figure.3 gives the details of the geometry studied for experiment. Typical measurement method of springback values was explained formerly.

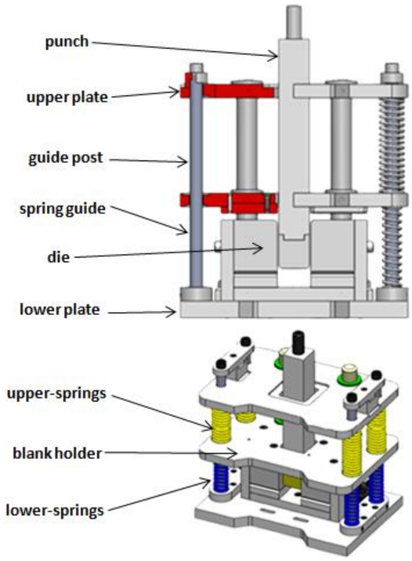

Fig.2 Schematic illustration of the draw-bending fixture.

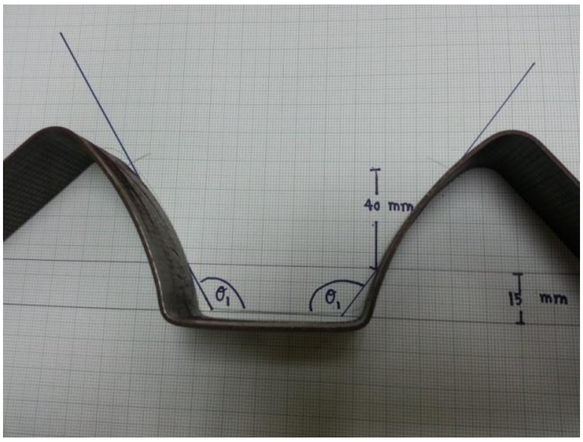

Fig.3 Measurement of springback angle.

The samples were prepared by cutting in to strips. A grid of square each of 2.0 mm diameter was etched electro-chemical on the samples to facilitate measurement of the strain distribution on the surface of the strip after forming.

3. Results and discussion

3.1 Effect of blank holding pressure(BHP) on force displacement curve

Figure 4. Shows the difference of the force displacement curve with in blank holding pressure And were tested by varying the blank holding pressure from 3 kN, 4.5 kN and 6 kN at punch radius 3 mm in U-die bending and 0^0 from rolling direction. It was found that the increase in blank holding pressure will increase the load required for the bending operation. The higher blank holding pressure averts the specimen from sliding easily between the die and the blank holder, which will cause the specimen to be stretched and accordingly resulting in more plastic deformation.

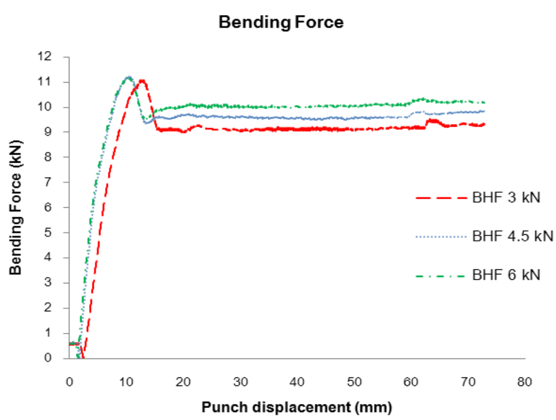

Fig.4 Effect of blank holding pressure on forming load for minimum, intermediate, and maximum at punch radius 3 mm, specimen with 0^0 to rolling direction

3.2 Effect of blank holding force on the springback angles

The springback angles after bending shown in Fig. 5 And were tested by varying the blank holding pressure from 3 kN, 4.5 kN and 6 kN at punch radius 3 mm in U-die bending. The amount of springback is inversely proportional to blank holding force. Certainly, the increase of the blank holding force increases the stretching force on the sheet. It becomes the predominant loading as compared to bending. Accordingly, the stress distribution is more uniform and residual bending moment is smaller as the blank holding force increase.

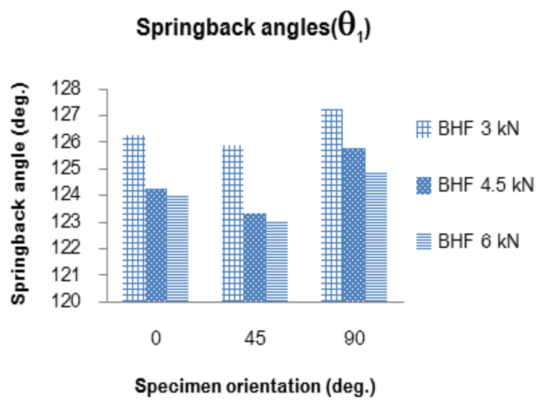

Fig.5 The angle of springback with the different Blank holding pressure under punch radius 3 mm.

3.3 Effect of punch radius on the springback angles

Tests were performed under different punch profile radii (Rp) 3, 5 and 8 mm. at blank holding force 3 kN Frome Fig. 5, it can be seen that the springback increases as the punch profile radius increases. This resulted in increased plastic deformation. It is noted that the stress over the punch corner was the most important factor governing the magnitude of springback.

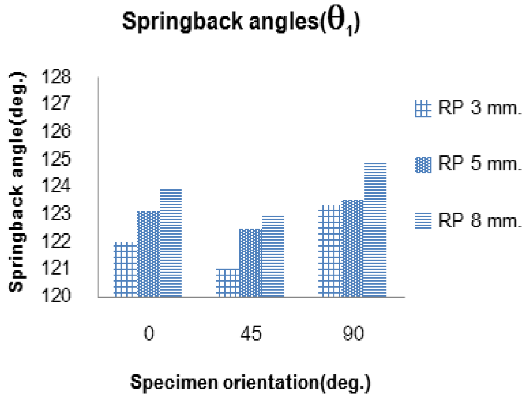

Fig.6 The angle of springback with the different punch radius under blank holding pressure 3 kN.

3.4 Effect of specimen orientation on springback angles

The effect of specimen orientation was also studied. Fig. 5 and Fig. 6 show that there is a slight difference in the springback angles with respect in three directions 0^0,45^0 and 90^0 to rolling direction. It found that, under varying blank holding pressure and punch radius. Table 1 show the mechanical properties of JSC 980Y. that It can be found that as the R-value for each sheet. It is shown that for each specimen orientation there is a different R-values. It indicates that sheet anisotropic properties depend on the orientation to the rolling direction. It can be found that as the R-value increase, the springback increase.

3.5 Strain measurement

The effect of specimen orientation and radius on the strain distribution of the outer surface of the specimen, It is expected that there should be the strain distribution of the outer surface with the increase in the punch radius, due to the stretch in the specimen and the assumption of the constancy of the volume of the material. Fig.8 show the effect of punch radius on the strain distribution on the surface of the strip after forming. The total plastic strain was tested different punch radius 3, 5, and 8 mm. under blank holding pressure 3 kN. It can be seen that total plastic strain of the contact surface between die corners and punch was decreased as the punch profile increased. Initially, the material gets bent at punch radius and inner surface is stretched. After leaving the punch radius it gets unbent. However, a small amount of strain, the residual strain remains. As the inner surface is now longer than the outer surface. When the punch radius increase, the strains decrease dramatically with major strain can be observed.

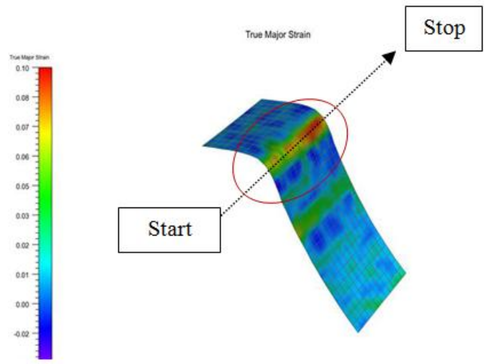

Fig.7 Strain distribution on the surface of the strip after forming.

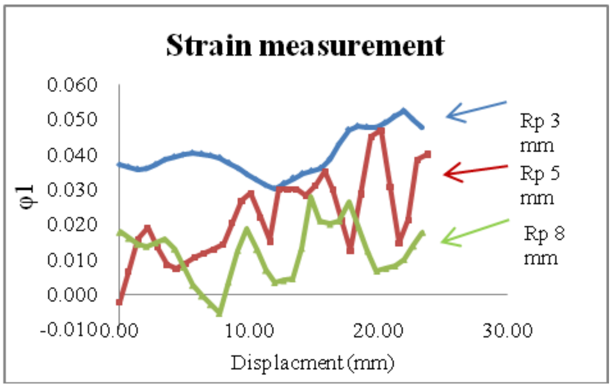

Fig.8 Major strain (φ_1) of the outer surface after springback with varying punch radius at blank holder pressure 3 kN

4. Conclusion

Though an example of the U-draw bending process, the influences of anisotropy of material and process variables on springback are investigated. The effect of anisotropy of material, blank holder force and punch radius condition on the springback based on experimentation results about springback are extracted. Based on these studies, the following remarks are drawn.

1) Springback in U-draw bending increase with plastic strain ratio increase.
2) As the punch radius increases the springback effect will also be increase.
3) The amount of springback is inversely proportional to blank holding force
4) As the punch radius increase. The strains will major strain φ_1 of the outer surface decrease.

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