STUDY OF SPRINGBACK ANALYSIS IN AIR BENDING PROCESS AFTER DIFFERENT HEAT TREATMENT OF ALUMINIUM 6063 ALLOY

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ABSTRACT

This study deals with the study of spring back effect during air bending of aluminium 6063 alloy during various types of heat treatments. One of the most important challenges for the automotive industry in the upcoming year is to meet the demand of reducing the fuel consumption with a simultaneous increase of the safety property and increase the efficiency of engine. It can be done by reducing the weight of the body by substituting traditional steel or aluminium alloys. Aluminium alloys can be formed into parts by a variety of process similar to those used for steel. Formability of aluminium sheet is under normal processing condition lower than that for typical mild steel. One of the current challenges in the bending operation is the prediction of material behavior after removal of load or pressure on it. Such as spring back control is essential in the production of parts with tight fit up tolerances as result in deviation from desired shape. Spring back is an elastically shape change that occur after forming upon unloading. Spring back commonly occur in forming process .The spring back phenomenon when bending is involved. become a major area of concern, because it is a kind of defect that results in deviation from designed bend angle, which is less than required bend angle, after removal of forming load.

I. INTRODUCTION

Sheet metal forming processes are commonly used in industry. Sheet metal forming processes are usually carried out at room temperature. Forming at elevated temperature could done, because of increase the formability of sheet, reduced spring back and decrease in maximum force. Bending is one most usual forming operation, in air bending a sheet is bent on après brake with help of a die and punch. During bending operation, previous heating of the sheet metal it would be provide some advantage, such as reducing the maximum force, spring back and increase the bend ability. Sheet metal bending is forming process. The elastic recoveries after unloading causes the spring back phenomenon in which radius of curvature slightly increase after bending moment is removed. Spring back is affected by several factors such as elastic modulus, yield stress, sheet thickness and work hardening exponents [31].

1.1 Metal Forming Process

In the forming process, under the application of large amount of mechanical force or by heating the metal and applying small force, the material deforms plastically [3,4].When plastic deformation occurs, the metal appears to flow in the solid state along specific directions, which depends upon the direction of force applied and type of process.

1.2 Air Bending

This process is also called Three Point Bending, because in this process, the work piece comes in contact with the outside edges of the die and with the punch tip. The punch does not come in contact with the bottom of v shaped die. Various bend angles can be obtained with the same tooling as shown in figure:

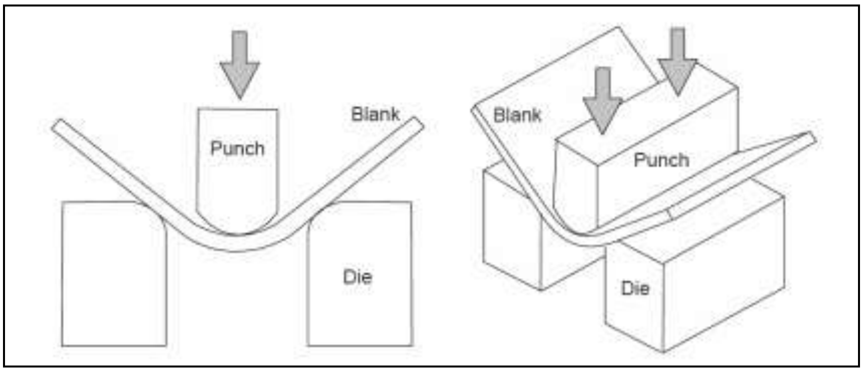

Fig1. : Air Bending Process [7].

II.A BRIEF OF HISTORICAL BACKGROUND EAHE SYSTEMS IN THE WORLD

J-Yanagimoto et al. [22] investigated spring back of high- strength after hot and warm sheet forming. An experimental study has been carried out on high-strength steel(HSS) sheet, using hot compression testing machine and the effect of forming temperature on the amount of spring back was also evaluated. Hot sheet is stamped and quenched between cold die. **Martensitic** transformation from austenite is due to rapid cooling. Tests were performed under precise control of temperature in plastically deformed zone. Temperature was controlled by induction heating. During the experiment temperature of plastically deformation zone was controlled within 10 k and target temperature around 773 k. Two precipitation hardened high strength steels are tested as fellows (a)HSS of 540 MPa strength. (b)HSS-2 of 340 MPa strength.

Material if die Tungsten Carbide

HSS-1 - 540 MPa, 0.80c-0.26 Si-1.09mm

HSS-2 - 340 MPa, 0.0015c- 0.01 Si- 0.3 mm

Heating rate – 50k/s

Punch speed – 1m/s

Punch stroke – 4.5 mm (v bending), 14 mm (hat bending).

It is clear that the amount of spring back decrease markedly when temperature higher than 750K and spring back can be reduced of plastic deformation zone which is far less than the recrystallisation temperature of steel at 750 K in ferrite pearlite phase. Some of experimental and numerical studies were also done in order to analyze the bending operation and spring phenomenon, reported by Hong et al., [23]. Numerical investigation on spring back characteristic of Aluminium sheet metal alloys in warm forming condition was investigated by Moon et al.[24] on Aluminium 1050 sheet and both hot die and cold punch could be improved the forming quality.

Keum and Han (2002) measured the spring back performance which varies bending test at different temperature for Al 1050 and 5032 Alloy. They showed that spring back reduced in warm condition when forging temperature exceeds above 150C. Spring back amount was first studied in isothermal condition where tool and blank were heated up to the same temperature levels and spring back was effected by Blank Holding Force (BHF), in warm forming condition at three different conditions:

(i) At room temperature

(ii) Isothermal heating (T die and T punch=250 ^{0}C)

(iii) Non-isothermal heating (T die=250^{0}C and T punch=25^{0}C)

It was also found that spring back reduced to increase the Blank Holding Force (BHF) which was explained by simple moment curvature relation. In this paper, investigation on spring back effected by following:-

(i) Elevated temperature

(ii) Effect of BHF

(iii)Friction condition punch speed

(iv)E value

Jenn et al., [25] was conducted the spring back on brass in macro sheet forming and low cast 3 point bending experiment { brass 2600 ½ spring back amount and T/D ratio(thickness /average grain diameter) when thickness is less than 350um. The influence of the size effect on screen of Brass 2600 ½ hard (HO2) was investigated by Tsai et al., [26]. Some experiments, for understanding the spring back were conducted in such manner [27] where some mathematic models was developed by Gau et al., [22]. Brass 2600 ½ Hard (HO2) subjected to various heat treatments on sheet samples of dimensions 10mmx80mm. Heat treatment took place inside the electric furnace and cooled in air. A solution of 25ml NH_4OH, @% ml H_20 and 50ml H_20_2 (3%) used for polishing and catch of brass sample. Area average grain size determined with help of ASTM-E12 standard [28]. All the samples were tested at rate of 10, /min. images were taken to measure the bend angle using an Olympus E300 digital camera. It can be observed that spring base amount increase with decrease t/d ratio which is from 1 to 2.5 and if the brass thickness is less than 350um the convention spring back concept cannot be applied , and spring back in micro sheet forming can be expended as a function t/d ratio instead thickness.

III.METHODOLOGY

The prediction of spring back by means of Trial & Error method consumes a lot of time, thus increases the cost of product, its manufacturing cost, the time of product introduction or launching into the market as well as the development time of the existing product.

The Spring back refers to the elastic recovery of non uniformly distributed stresses in a deformed part after removal of bending force [16]. After removal of punch or unloading the sheet, during bending of sheet metal parts, the change in bend part dimension occurs results in deviation in bend angle which is different from designed (required) bend angle. This phenomenon occurs not only in sheet metal parts but also results in rods, wire & bar of any cross section [17].The variations in bending stresses cause spring back after bending. At the bend, the tensile stress occurs is more in the outside surface metal. This tensile stress is zero at neutral axis & decrease towards the centre of sheet thickness & the metal farther from axis, stressed above the yield strength has been plastically or permanently deformed .After the removal of load, the bend tries to return its original shape, but due to plastic deformation zones restriction, it slightly return as the elastic & plastic zones reach an equilibrium & this elastic recovery is called as spring back [18].

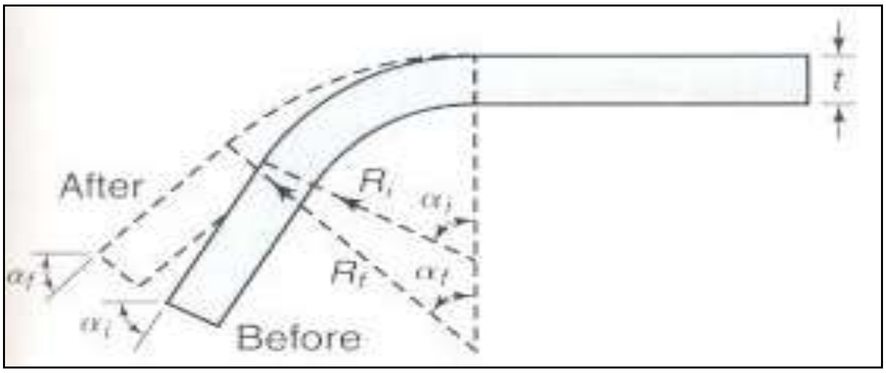

Figure2 : Springback In Bending Process

Experimental Set up

Geometry of Punch & Die

In this work, Die and Punch were assumed as a rigid body and sheet metal was considered as a deformable body. Punch and die are shown in Fig3.

The extruded aluminium alloy sheet with a thickness of 1.5 mm were cut into specimen with a length of 150 mm and a width of 35 mm. Aluminium alloy with chemical composition, shown in table 1 was obtained from NARANGE METALLIURGICAL & SPECTRO SERVICES, new Delhi – 110055.The receive sheet was cut and machined into standard tensile test pieces as shown in Figure 3.2 conformity with ASTM standard. The tensile sheet had gauge length 50 mm with a thickness 1.5 mm.

After 100% of the punch displacement the sheet metal fully bends and the bend angle was measured at loading condition as shown in fig.3.3 (a). The punch is gradually elevated after complete displacement. The sheet gets deflected from its loading shape due to the elastic recovery of sheet metals. The final bend angle was measured from the final bent sheet as shown in fig.3.4 (a).

The Spring back is calculated in terms of change in angle, the difference between loaded bending angle & unloading bending angle.

$$\boldsymbol{\alpha} = \Psi - \Phi \qquad (3.1)$$

where,

α = Springback angle in degree.

Ψ = Loaded bending angle in degree.

Φ = Unloaded bending angle in degree.

$$\psi = Tan^{-1}\left(\frac{y_1 - y_2}{x_1 - x_2}\right). \qquad (3.2)$$

x_1, x_2, y_1, y_2, are the co-ordinates of two nodal points on the bend sheet (loading).

$$\phi = Tan^{-1}\left(\frac{y' - y''}{x' - x''}\right) \qquad (3.3)$$

x', x'', y', y'', are the co-ordinates of two nodal points on the bend sheet (unloading). The Fig. 3.3(a) below shows the loaded bend angle, **Ψ** and Fig.3.4 (a) shows unloaded bend angle **Φ**.

Figure3 : Initial Geometry Of Punch, Die And Sheet.

IV. EXPERIMENTAL RESULTS

Scanning electron microscopy (SEM) is a useful technique to study the surface morphology of the materials. The scanning electron microscope (SEM) is the most widely used types of electron microscope. It examines the microscopic structure by scanning the surface of materials, similar to scanning con-focal microscopes, but with much higher resolution and much greater depth of field. An SEM image is formed by a focused electron beam that scans over the surface area of a specimen; it is not formed by the instantaneous illumination of a whole field as for a TEM. Perhaps the most important feature of an SEM is the three-dimensional appearance of its images because of its large depth of field.

A scanning electron microscope consists of an electron gun and a series of electromagnetic lenses. In an SEM, however, the electron beam emitted from an electron gun is condensed to a fine probe for surface scanning. The electron gun for generating an electron beam is the same as in a TEM; either thermionic or field emission type guns are used.

Advanced SEM systems use a field emission gun because of its high beam brightness. Beam brightness plays an even more important role in imaging quality in an SEM than in a TEM. The acceleration voltage for generating an electron beam is in the range 1–40 KV, which is about one order of magnitude less than that for a TEM. An SEM optical path goes through several electromagnetic lenses, including condenser lenses and one objective lens. The lenses are made of a soft iron core, around which the wire is coiled. Current flows through the wire creating a magnetic field in the air gap of the iron core. When the current in the condenser and objective lens changes, a proportional change occurs in the field strength (B), thus alters the focal length of the lenses. The electromagnetic lenses in an SEM are for electron probe formation, not for image formation directly as in a TEM. The two condenser lenses reduce the crossover diameter of the electron beam; then, the objective lens focuses the electron beam as a probe with a diameter on the nanometre scale. The objective lens should be considered as the third condenser lens in the SEM because it functions more like a condenser than an objective lens. The reason is that the objective lens in SEM demagnifies the cross-section of the electron beam; thus, it functions very differently from the objective lens in a TEM, which magnifies the electron beam. Two types of images may be obtained from SEM, secondary and backscattered. Secondary electrons have low energy typically <50 eV and escape from the first 20 nm of the sample surface. Backscatter electrons escape from the bulk of the sample (500 nm) and have energy >50 eV. Separate detectors are used for detecting secondary and backscattered electrons due to the nature of the radiation

Figure: 4 Deformed Sheet at 100% Displacement

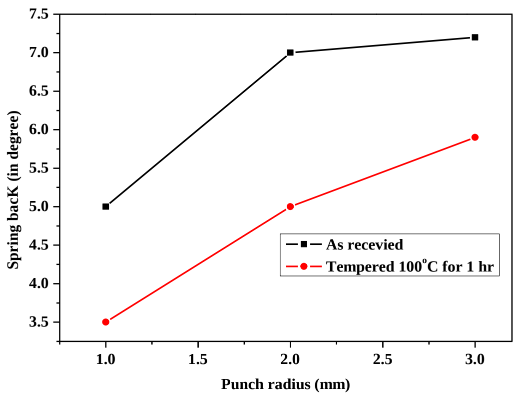

Fig 5: Effect On Spring Back For Different Punch Radius In Air Bending Process Of Sample (A) As Received (B) Tempered At 100˚C For 1 Hour

V. CONCLUSION

In this analysis, we investigated the amount of spring back in aluminium alloys 6063 sheet by changing the punch radius and different heat treatment. Sheet metal air bending of aluminium alloys with respect to the major geometrical parameters associated with the process. The effect of spring back cannot eliminate, but can be minimized by using a suitable die and punch design. This thesis work presents some trends to understand the effect of punch radius and temperature on spring back.The following conclusions has been obtained from results, during the Air Bending Process.

- The spring back increases with increase in punch radius.
- The spring back decreases with increase the temperature.
- Ultimate tensile stress increase with increase tempering temperature.
- Percentage of elongation increase with temperature.

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