A Review on Compensation of Spring Back In Sheet Metal Bending Process

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***Abstract*- In sheet metal bending process, a sheet metal blank is plastically deformed between tools (dies) to obtain the desired final configuration. The sheet metal industry, a part of the wide metal forming industry, involves processes for producing sheet metal forming covers from very small electronic components to automobile parts and bodybuilding, aeronautical industries and many.. The accuracy in dimension is always remains a major concern in sheet metal bending process, owing to the considerable elastic recovery during unloading, which leads to spring back. Spring back is normally measured in terms of difference between the dimension of fully loaded and unloaded configuration. Tool shape and dimension, contact friction condition, material properties, thickness of sheet, sector angle are the major parameters that affect the spring back. The determination of spring back by means of trial and error technique not only increases the cost for the manufacturing and repair of the tool but also waste a lot of time, causing delay in the development of the product. The prediction of spring back using numerical simulation based on Finite Element Analysis (FEA) with mathematical and statistical modelling technique has been proofed a powerful tool and using by various researchers for determination of spring back accurately.**

***Index Terms*- Dies, FEA (Finite Element Analysis), Springback, Tools.**

I. INTRODUCTION

Bending is the plastic deformation of metals about a linear axis called the bending axis with little or no change in the surface area. Bending types of forming operations have been used widely in sheet metal forming industries to produce structural stamping parts such as braces, brackets, supports, hinges, angles, frames, channel and other nonsymmetrical sheet metal parts.

Press brake forming is a process in which the sheet material is placed over an open die and pressed down into the die by a punch. The primary advantages of the press brakes are versatility, the ease and speed with which they can be changed over to a new setup and low tooling costs. Press brake forming is applicable to any metal that can be formed by other methods, such as press forming and roll forming. Low carbon steels, high strength low alloy steels, stainless steels and aluminum alloys are formed in press brakes. It is necessary to select the proper bending method in accordance with the application and function of the product.

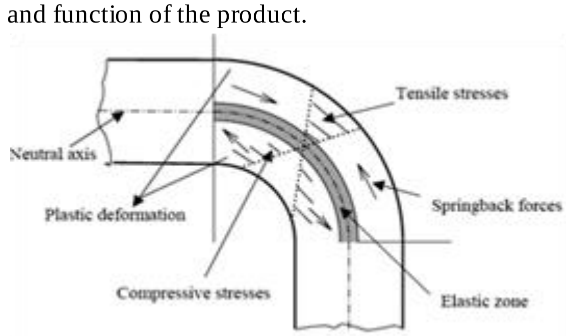

Figure-1 Stress Distributions in Bending

One of the important characteristics of bending operation is that the tensile stress decreases toward the center of the sheet thickness and becomes zero at the neutral axis whereas the compressive stress increases from the neutral axis towards the inside of the bend as shown in Figure 1. Even with large plastic deformation in bending, the central region (elastic metal band or zone) of the sheet remains elastic and on unloading, elastic recovery occurs.

V-Die bending process:

V-Die bending is the simplest bending process commonly used in automotive stamping and fabrication industries. In the fabrication industry, one of the critical challenges is to maintain close geometric tolerance in finished products. In the V-Die bending (three point bending), the required angle is produced on the work piece by adjusting the depth to which the punch enters the die opening and it is shown in Figure 2. This permits the punch to over bend the metal sufficiently to produce the required angle after spring back, thereby compensation is achieved. It can be considered as a flexible process In other words, this process allows obtaining a wide interval of bent parts.

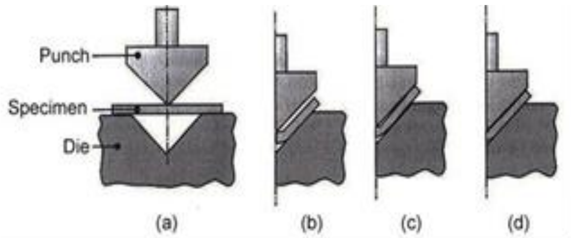

Figure 2 - Schematic illustration of stages in bending by V – dies

With the different tool configuration, different bend angles are obtained as well as different curvatures or curvature radius. The change in the size of die opening also changes the amount of load needed to make the bend. As the die opening increases, lesser force is required and as the die opening decreases, the bending leverage is less and more force is required.

The advantages of the V-Die bending process are

The easy control and compensation of spring back are possible.

- As less force is required, small capacity press is sufficient, preventing excessive strain on the press brake.
- The disadvantages of the V-Die bending process are
- The possible inconsistency is evident in the bends because of variations in dimensions and temper of the work metal as it is received from the mill.
- Spring back in the V-Die bending process is large because of the absence of bottoming.

Some important issues in V-Die bending are minimum bending radius, spring back, bend force and anisotropic properties of the sheet.

II.LITERATURE REVIEW

Mathematical Modeling:

The mathematical modeling for process simulation has become a major tool in modern metal forming technology. Many researchers conducted in the last three decades have indicated that spring back has a very important role in sheet metal industry and studied how this permanent physical variation can be avoided. The challenge is how to predict the spring back and thus design a tooling to compensate for the amount of spring back. It helps in predicting the spring back, bend allowance, bend force etc of sheet. Peng Chen and Muammer Koc (2007) studied to predict the variation of spring back in an open channel drawing considering the variation of material and process. This approach provides a rapid and accurate understanding of the influence of the random process variations on the spring back variation of the formed part using FEA techniques eliminating the need for lengthy and costly physical experiments.Rahul K.Verma and Haldar (2007) presented the effect of anisotropy on spring back using finite element analysis and the analytical model. An analytical model is developed to cross check the trends predicted from the finite element analysis. The effective stress has not been treated as a constant and the radial stress is considered in the present model. In (2008), S.A. Asgari et. al., investigate the simulating TRIP steel with current commercial packages, there are several parameters that might counteract each other in terms of increasing or decreasing the accuracy of the prediction and consequently masking each other. For a specific case study with a complex geometry, it was shown that the tool offset and the number of integration points through the thickness are of significant importance when modeling a TRIP steel using both implicit and explicit forming packages. On the other hand, the effects of variation were insignificant in increasing the accuracy of predictions of these codes. The current sheet metal forming software packages are powerful enough to predict accurate results for conventional steels, but this paper shows the precautions necessary to achieve improved simulations for AHSS grades such as TRIP steels. In (2009), G.M. Kakandikar et. al. have discussed the application of evolutionary strategies to optimize the geometry parameters such as die design and punch design, process parameters such as forming load, blank holder pressure and coefficient of friction, the spring back, hammering sequence etc. Evolutionary algorithms offered many advantages over traditional methods. Those are widely used now days for sheet metal industry. In (2012) Hani Aziz Ameen investigate the effect of the spring back on the bending operation of different materials. Dies were designed and constructed in cylindrical shape. Three types of alloys are used; aluminum alloy 7020 T6, copper alloy and lead alloy. These alloys have different sheet thickness (2 and 4) mm. Bending was done by using the press of 80 ton. The spring back is calculated by published equation. It can be concluded that, the Aluminum sheets (AA7020 T6) have the biggest spring back factor, the spring back factor equal one in lead alloy of 2 mm thickness that indicated there is no spring back in this sheet. Also concluded that the hardness of the sheet increased, the spring back factor increased too. In the aluminum and copper sheets when the thickness increased the spring back factor increased while in the lead alloy when the thickness increased the spring back factor decreased.

Statistical Modeling and FEA Modeling:

The statistical design can be used to obtain as much information as possible from a minimum number of experiments. Over many decades the bending of sheets and their spring back has been studied by analytical approach and many useful results have been obtained. However, much less attention has been paid to the case of bending of sheets and spring back through statistical approach. Delivering reliable, high quality products at a low cost has become the key factor for survival in today’s global economy. For this act, the prediction of spring back of the product at the design stage is very essential. Designing for quality is cheaper than trying to inspect after production. So, new philosophy, technology and advanced statistical tools must be employed to design the products of high quality at low costs. Senthilvelan et. al. (2003) developed mathematical models for P/M working process using regression analysis and the models could be used to predict the strength coefficient and strain hardening exponent of P/M copper performs. In 2006, R. Bahloul et. al. have discussed the sheet metal forming by bending modeled by using specimens with an oblong hole which is representative of an automotive safety part. With FEM, it is possible to predict both the magnitude and distribution of stresses in the work piece due to forming and thus it is possible to optimize the forming process with regard to stresses and the maximum punch load during the bending operation. The parameters related to the process, the relative die radius Rd/t and the relative sheet-punch clearance C/t were used in non-dimensional form. To carry out these analyses, numerical experimental designs were developed by finite elements modeling. In (2010), Sutasn Thipprakmas concluded that the FEM was used to investigate the effects of punch height on the bending angle in the V-bending process. With respect to the punch heights, the FEM simulation results showed that the effects of punch height on the bending angle could be theoretically clarified based on the material flow analysis and the stress distribution analysis. The application of a too-small punch height resulted in a large gap between the work piece and the die, as well as a small reversed bending zone; therefore, the effect of the stress distribution generated on the bending allowance zone was not sufficient to make the work piece open to the die side. In (2011), Guangyong Sun et. al. have proposed a two-stage multi-fidelity method to better compromise the uses of low-fidelity and high-fidelity solutions. A correction response surface (RS) was first constructed based on the ratio or difference between high-fidelity and low-fidelity solutions at fewer sample points. Then the low-fidelity analysis was further replaced by a moving least square (MLS) approximation to enhance its accuracy. To demonstrate the present design procedure, multi objective optimization of draw-bead restraining forces for an automobile inner panel was exemplified. The results significantly improved the computational efficiency and accuracy of optimizing sheet-metal formability without wrinkle and fracture. In (2012), B. Chongthairungruang et. al. proposed that the spring back characteristics of the dual phase steel sheet DP780 with respect to the pre-strain effect and material orientation. By the comparison between the experimental and numerical FE results from the S-rail stamping test, it was found that the Barlat–Lian’s (1989) model MAT-036 is not sufficiently accurate for predicting spring back of high strength steels, but more accurate than the conventional Hill’s (1948) model.

Artificial Neural Network Modeling:

The artificial neural networks have emerged as a problem solving technique for many metal forming problems. As the computation of spring back is expensive, an ANN model applied for spring back prediction leads to significant reduction in the computational time. There has been considerable focus on ANN over the last few decades as it is widely applicable with highly nonlinear and complex data.Forcellese et. al. (1998) focused on the development of an intelligent air bending process using a neural network based control system and laid emphasis on the effect of the training set size on the predictive performances on the neural networks Inamdar et. al. (2000) developed an ANN model used to train and predict the punch travel and spring back and subsequently studied the prediction of spring back in air vee bending of metallic sheets using the neural network.Recep kazan et. al. (2008) developed the artificial neural network prediction model of spring back in wipe-bending process. They discussed the prediction model of spring back in wipe-bending process of sheet metal was developed using artificial neural network (ANN) approach. In their work, several numerical simulations using finite element method (FEM) were performed to obtain the teaching data of neural network. The learned neural network was numerically tested and can be easily implemented spring back prediction for new cases.

III.CONCLUSION

Following conclusions are drawn from the above literature review and pre experimentation. In sheet metal bending Spring back depends upon different variable parameters like sheet metal material grain direction punch height sheet metal material, punch angle, sheet metal thickness, , punch radius, punch load, die opening, die lip radius, , pre bend strip condition etc.. Grain direction of sheet metal material is also affecting on spring back due to its different yield strength along different grain direction..

Study of the process variables in sheet metal bending has been of considerable interest for a few years. Most of the researches use only aluminum or other commercially available materials and these studies do not consider the bending behavior of different grades of steel sheet during air bending process. Most of the earlier studies have been made on smaller curvature bending to explore various parameters on spring back during air bending process and the studies on larger curvature bending has not yet been attempted. Most of the researchers have analyzed bending behavior of plain sheets with same cross section not on varying width cross section sheets. The study of the bending behavior with several combinations of process parameters for different steel grades sheets and the relation between spring back and bend angle, thickness and varying width of three different steel sheet during air bending process is also new scope for researchers. Analytical approach can provide underlying physical insights of the spring back. However it is usually developed by ignoring some unknown effects or assuming some ideal situations. As a result, accuracy of analytical based modeling is often undermined.

It is evident that accuracy of the FE model depends very much on the type of modeling technique, which is to be selected for analysis. In some cases it will be almost impossible to find an analytical solution for the entire deformation process. The empirical modeling based on experimental observations is appropriate in such cases. In the field of sheet metal bending, very few studies deal with MRA/RSM for the prediction responses. A number of research works are currently being carried out in the development of prediction system for spring back using the ANN techniques in sheet metal bending. The realization of an accurate system for prediction has not yet been achieved.

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