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Study and Analysis of Springback of Work-hardening materials under bending Loading

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ABSTRACT

This paper manages the examination and investigation of springback of work hardening material under bending. Utilizing the plastic deformation hypothesis, a numerical plan based on the finite difference method has been recommended. The results have been representing the effect of different value of material thickness, bend angle and tool radius on the springback.

Keywords- Springback , Finite Difference Method, Theory Of Plasticity

I.INTRODUCTION

Spring back is defined as the recovery in the shape of a stressed material when the load is removed. As long as the material is stressed in the elastic range, there is a total recovery of the deformation and hence spring back. But when the loading is done to produce deformations in the plastic range even when the loads are removed plastic part of the deformation stays giving a new and permanent configuration of the material. Thus the final shape of the material achieved after the unloading is little different than the one which corresponds to the applied load. This discrepancy or differences in the shapes, which occurs due to the recovery of the elastic (temporary) deformation, is called the spring back. The phenomenon of spring back plays a very important role in the metal forming processes. Due to this spring back action it is difficult to get the exact desired shape out of a material by using die forming. For getting the desired shape it is necessary to compensate for the spring back either by changing the die design or by some other means. Therefore, it becomes essential to have a perfect knowledge of the mechanics of spring back in different forming processes. Sheet metal is changed in cylinder and helical form due to plastic deformation during the punch and dies operation under bending. At the end of this operation, the inner shape of the segment co-ordinate with the outer shape of the die. Hence, by removing the application of load, the obtain shape is differ from the desired shape due to the removal of strain energy. This elastic recovery of the deformation is known as spring back. On removal of the applied torque, at that time shaft was twisted completely. Then elastic recovery occurred. When plot the diagram between the twisting moment and the angle of twist per unit length then piece wise linear relationship obtained for work-hardening material.

Labuan and Sachs [1] tried to analyze the stresses and strains for an ideal plastic material under two limiting conditions: (a) a very wide plate (plane strain) and (b) a very narrow bar (plane stress). For both the cases, stress distribution was found through the elastic concept of the material and strain distribution was found by iterative method. Schroeder [2] concluded that the spring back ratio was a function of radius of bend (R) and thickness (t) since strain was a function of R and t only. Gardiner[3] develolop an expression for the spring back was obtained with the following assumptions (1) neutral axis was midway through the sheet metal. (2) No work hardening. (3) The strain at a fiber was proportional to Its distance from neutral axis. The expression was in the form of-

$$\frac{R}{r} = 4\left(\frac{RS}{Et}\right)^3 - 3\left(\frac{RS}{Et}\right) + 1 \qquad (1)$$

Where R= radius of curvature of sheet before bending.

r= radius of curvature after spring back.

S= yield stress of material

E= modulus of elasticity

t= thickness of strip

Shafe and Ungar [4] analized same problem considering the total plastic bending instead of elasto-plastic as in the previous paper. Alexandra [5] tried to solve the problem treating the sheet as a wide beam instead of a narrow one as in the previous discussion using the following assumption-

(a) Ideal plastic material
(b) The stress along the thickness is zero
(c) Lateral strain is zero.
(d) No shift in neural axis from central line.

Jhonson and Singh [6] published paper in which they tried to study the change in radius of curvature of cylindrical shapes formed in cylindrical dies. The dependence of spring back on tool radius , strip length , thickness of material and properties of materials were also examine. Wang et al.[7] created models for plane-strain sheet bending to foresee springback, bendability, least bending proportion, strain and stress dispersions, and the most extreme loads on the punch and the die. Leu [8] studied Hill's hypothesis for anisotropic materials what's more, propose conditions to assess the bend ability and springback in plastic bending of anisotropic sheet metals.Dwivedi et al. [9] investigated the effect of spring back of rectangular cross-section of strain –hardened metal during the torsional loading condition. Dwivedi et al. [10] has investigated the spring back effect of square section shaft strain –hardening metal during torsion loading condition. Dwivedi et al. [11] had too considered the spring back under torsional loading of L-modeled segment bars of strain-hardening materials. Lal et al. [12]

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deal with the spring back problems of channel cross-section bars of linear and non-linear work-hardening materials under torsional loading.

II. BASIC THEORY

2.1 Calculation of Forces In Bending

P.C. Venter [13] tried to find expression for force required for forming by using the theory developed Gardiner and Schroeder etc. Using the relation $\sigma_y = e\left(4x\,{}^{y}/_{r}\right)^m$ author calculated the value of M/b as and for unloading the expression for $\frac{M}{b}$ was derived as

$$\frac{M}{b} = \frac{Eh^3}{12}\left(\frac{1}{r_o} - \frac{1}{r}\right) \qquad (2)$$

Equating these two and simplifying

$$\frac{r}{r_o} = 1 + \frac{3c}{E(n+2)} E_o(1-m) = \text{spring back ratio} \qquad (3)$$

Where ,

r= radius after spring back

r_o = radius before bending

E= modulus of elasticity

h= the thickness of strip

b= breadth of strip

m= moment

c= care constants

E_o = Max bending strain at outer fibre

The author applied some theory to force in V bending and in U bending for V bending the force comes out to be F $\frac{cbh}{(n+2)(2f+1)n+1}$ tan $\frac{cc}{2}$.

Where, $f = \frac{r_t}{h}$

For constant f, F is proportional to h.

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From which spring back comes out to be nearly 15%

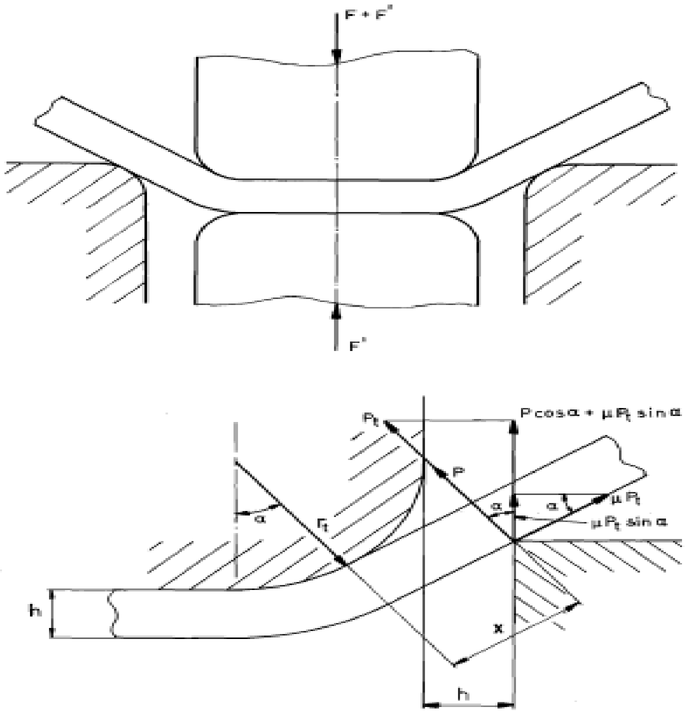

Fig.1 Bending of U-profiles[13].

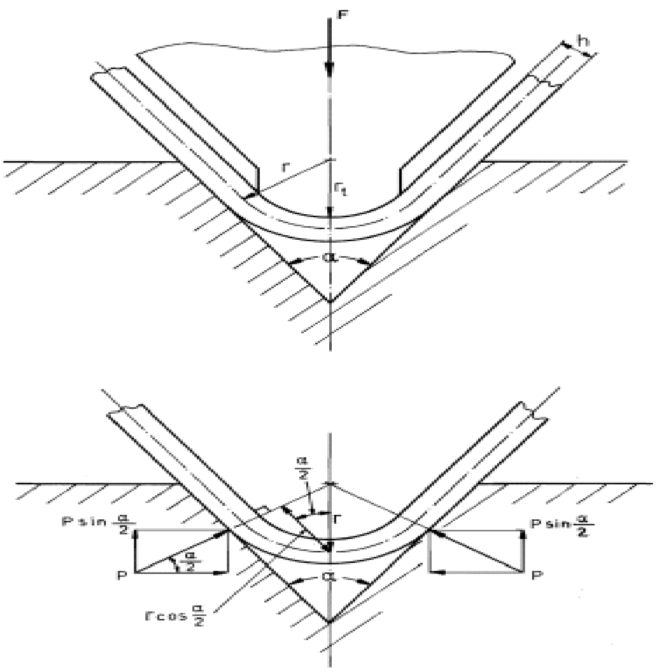

Fig.2 Bending with bending tools[13].

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In this technique, utilization of bending moment and curvature relationship under the forming operation large sheet of metal formed around the cylindrical shape of die and derive spring back relation. By using the bending operation apply the relation b/w bending moment and curvature under the sheet metal forming operation.

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R} \quad (4)$$

$$\frac{M}{EI} = \frac{1}{R} \quad (5)$$

The schematic diagram of applied bending moment and radius of curvature is appeared in fig3 and the stress strain diagram for elastic- plastic material utilization of Ramberg- Osgood relation in fig 4.

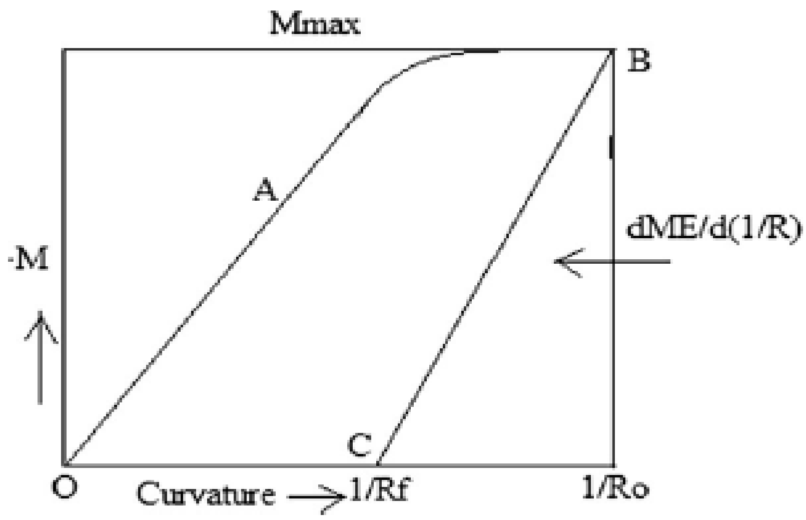

Fig. 3 Schematic representation of curvature vs applied moment during bending [14].

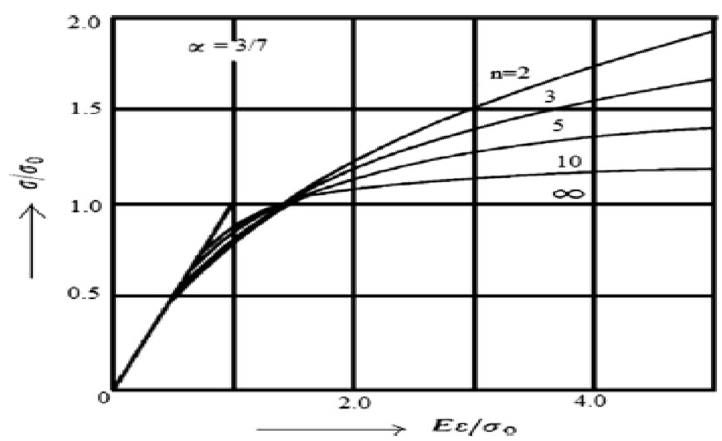

Fig.4 Emperical stress- strain curve for elastic-plastic material using Ramberg –Osgood relation [14].

III. NUMERICAL METHOD

3.1 Finite Difference Method:-

To obtain finite difference equations, differentials of variables are replaced by the differences taken over finite intervals. The area is therefore replaced by a net of grid lines. The points of intersection of these lines are known as nodes. we are interested in the values of variables at these nodes are. This method, thusly prompts the substitution of differential equations by an arrangement of difference equations which are set of simultaneous equations involving the unknown variables at nodes only. The solution of these simultaneous equations gives the numerical values of the unknowns at these nodal points.

IV. CONCLUSION

The accompanying conclusions can be drawn from the above literature review. Spring back dependent on tool radius, strip length, thickness of material and properties of materials. Spring back ratio was a function of radius of bend (R) and thickness (t) since strain was a function of R and t. For V bending use of bottoming die can reduce spring back but the compression force that is needed is for larger than this method. In usual V bending, control of pad pressure may reduce the spring back slightly. But this is only for small radius bending.

For the sheet thickness the spring back increments with increment in sheet thickness. For blank holder force the spring back builds first with increment in blank holder force and after that consistently diminishes with increment in blank holder force. The variation of torque with width is dependent on size and material properties. The parabolic nature of torque- thickness variation also confirms that torque is size and material dependent parameter.

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