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Spring back optimization in deep drawing using cuckoo search algorithm

#1Archana Patil, #2G. M. Kakandikar
[1]archanapatil2000@gmail.com
[2]kakandikar@gmail.com

#1Mechanical Engineering, Dnyanganga College of Engineering & Research, Narhe, Pune-41
#2Mechanical Engineering, Dnyanganga College of Engineering & Research, Savitribai Phule Pune University, Pune-41

ABSTRACT

Deep drawing is a one of the most important manufacturing process that is used extensively in the forming of sheet metal parts. It is used widely for mass production of hollow shapes in the packing industry. Deep drawing is the tensile compressive forming of a sheet blank .The friction between the work piece and the tool has a great influence on the process. Springback in sheet metal forming are influenced by parameters such as Blank Holder Force, Coefficient of friction, Radius on die and radius on punch. To find the springback between the die and work piece reduce the cost of product. The main objective of the deep drawing of sheet metal process is to produce good quality product. Cuckoo Optimization Algorithm is based on the life of a bird called cuckoo. Egg laying and breeding are Special characteristics of cuckoos and had been the basic motivation for development of this algorithm. All the cuckoo population moves to one best habitat with maximum similarity of eggs to the host birds and also with the maximum food resources. This habitat will produce the maximum profit ever. There will be least egg losses in this best habitat. Convergence of more than 95% of all cuckoos to the same habitat puts an end to Cuckoo Optimization Algorithm (COA). This paper describes the optimization of springback in deep drawing process by using cuckoo search algorithm.

Keywords— **Deep Drawing,Optimization, Cuckoo Search Algorithm, Springback.**

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I. Introduction

Deep drawing is one of the most important processes for forming sheets metal parts. It is used widely for mass production of hollow shapes in the packing industry, automotive industry etc. Deep drawing is the tensile compressive forming of a sheet blank (or, depending on the material, also of foils or plates) to a hollow body open on one side or the forming of a pre-drawn hollow shape into another with a smaller cross-section without an intentional change in the sheet thickness. The process limitations are laid out by the conditions required to transmit the force into the forming zone. The drawing force necessary for the forming is transmitted from the punch to the work-piece base and from there to the forming zone in the flange. The resulting limiting deformation in the force application zone has nothing to do with the depletion of the forming capacity of the material in the forming zone. The process limits are reached when the largest applied drawing force cannot be transmitted to the forming zone in the flange. From this condition, one can derive the characteristic behavior of deep drawing that a number of forming steps can be carried out consecutively without an intermediate annealing step.[1,2]

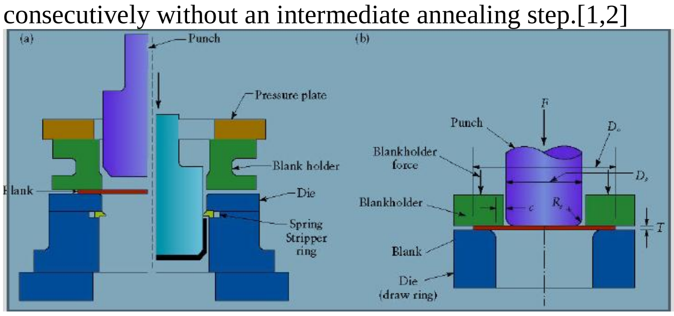

Figure 1 Deep Drawing Process

II. Spring back in deep drawing

Springback refers to the elastic recovery of deformed parts. Springback occurs because of the elastic relief from the bending moment imparted to the sheet metal during forming. Springback is common and inevitable in each stage of the production process where the material undergoes geometrical changes.Accurate prediction of springback of metal sheets is of vital importance for the design of tools in automotive and aircraft industries. [10] The springback will occur after removing the applied loads from the deformed sheet, resulting in the deviation of the product from the applied tooling .For obtaining good result and process controlling and/or minimizing springback .Springback is the geometric change made to a part at the end of the forming process when the part has been released from the forces of the forming tool.

A. Blank Holder Force:

A deep drawn part's quality is affected significantly by the flow of metal into the die cavity .The force exerted by the blank holder on the sheet supplies a restraining force which controls the metal flow. This restraining action is largely applied through friction. Blank holding force is small at beginning, which is good for the flow of material towards die cavity. But if blank holding force is less than the chances of wrinkling is more and if blank holding force is higher than chances of tearing is higher. [3]

A. Coefficient of friction:

The most important one of them is the friction between the workpiece and the too in deep drawingl. Friction coefficient μ is usually used as a main indicator, which is dependent on material, contact surface and lubricant.In metal forming processes friction influences the strain distribution at tool blank interface and drawability of metal sheet. Also drawability of metal sheet affects wear of tool. [3]

B. Die and Punch Radius

There is no set rule for the size of the radius on the punch. A sharper radius will require higher forces when the metal is folded around the punch nose and may result in excessive thinning or tearing at the bottom of the cup.The draw ring causes the metal to begin flowing plastically and side in compressing and thickening the outer portion of the blank. However, if the draw radius is too large, the metal will be release by the blank holder too soon and wrinkling will result. [3]

III. PROBLEM FORMULATION

The optimization problem was formulated by linear regression analysis and the linear equations obtained were as follows:

$$SDM = 0.0239 + 0.000159 * BHF - 0.0324 * \mu + 0.001$$

Subject to

$2.5 < R_D < 8$

$3*R_D > R_P > 6*R_D$

Where –

$$BHF = \frac{\pi}{4}(d_o^{\ 2} + 2r)^2) * \text{, Where } P=2.5\ N/mm^2.$$

And

$$R_D = 0.035[50 + (d_0 - d_1)\sqrt{S_0}$$

Where . is the sheet thickness.

$$R_p = (3\ to\ 6)R_D$$

The problem is solved using Cohort Intelligence Algorithm and the results were obtained.

IV. COMPONENT DESCRIPTION

The component selected for Springback optimization is Sealing Cover. The thickness of the sheet was selected as 0.8 mm. The material used was UST 1203.

The springback in the component occurs at various regions is obtained and is optimized by the equation and optimized result is obtained.

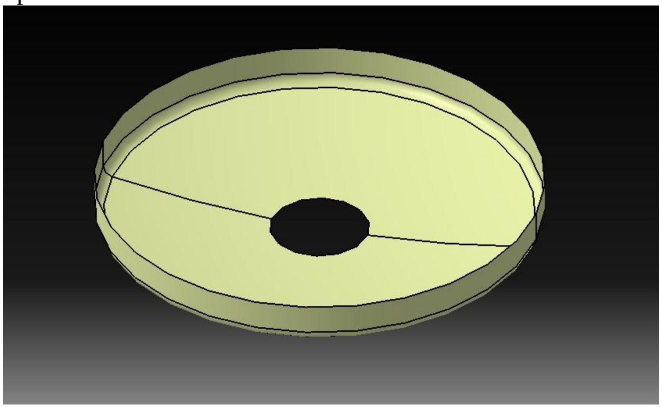

Figure 2 Sealing Cover

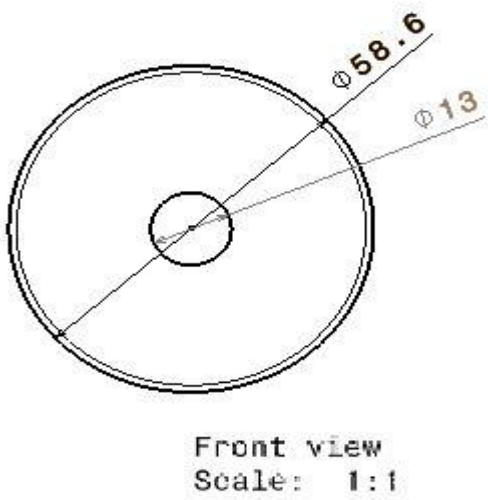

Figure 3 Front View of Sealing Cover

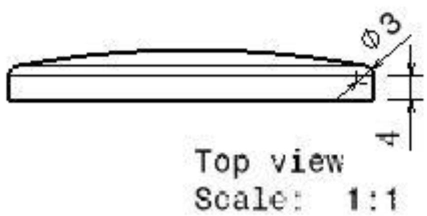

Figure 4 Top View of Sealing Cover

V. CUCKOO SEARCH ALGORITHM

Cuckoo Optimization Algorithm is based on the life of a bird called cuckoo. Egg laying and breeding are Special characteristics of cuckoos and had been the basic motivation for development of this algorithm. Cuckoo birds have an aggressive reproduction in which females hijack and lay their fertilized eggs in other birds' nests. Cuckoo are fascinating birds, not only because of the beautiful sounds they can make, but also because of their aggressive reproduction strategy .Some species such as the ani and Guira cuckoos lay their eggs in communal nests, though they may remove other eggs to increase the hatching probability of their own eggs. Quite a number of species engage the obligate brood parasitism by laying their eggs in the nests of other host birds (often other species).These observations are formulated into algorithms and implemented as a novel and new idea. CS is compared with other already existing popular optimization algorithms in connection with numerous optimization problems.[5,6,7,9]

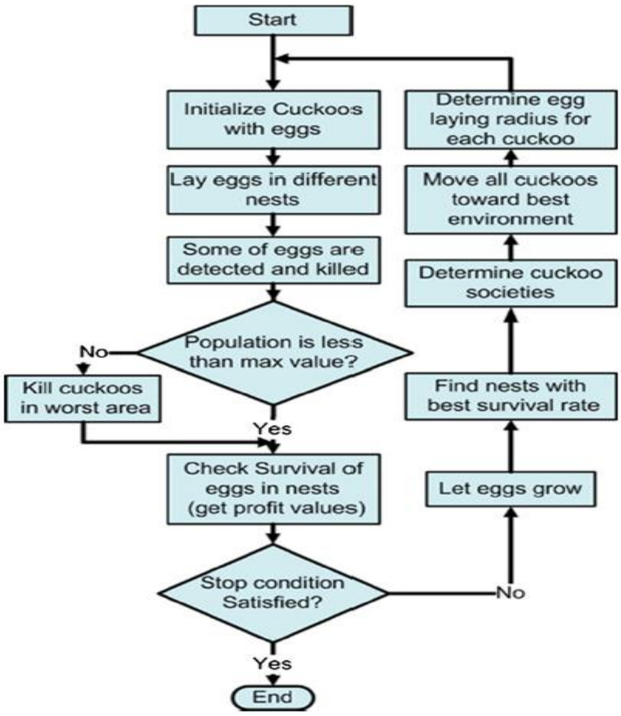

Figure 5. Cuckoo Search Algorithm Flowchart

PSEUDOCODE :

Begin
Objective function f(x), x = (x1, ...,xd)T;
Initial a population of n host nests xi (i = 1, 2, ..., n);
while (t <Max Generation) or (stop criterion)
Get a cuckoo (say i) randomly by Lévy flights;
Evaluate its quality/fitness Fi;
Choose a nest among n (say j) randomly;
if (Fi >Fj)
Replace j by the new solution;
end
Abandon a fraction (pa) of worse nests and build new ones at
new locations via Lévy flights;
Keep the best solutions (or nests with quality solutions);
Rank the solutions and find the current best;
end while
Post process results and visualization;
End
[8]

VI. OPTIMIZATION RESULTS

The formulated optimization problem was solved in Cuckoo Search Optimization Algorithm and the results were obtained as follows:

Springback Displacement Magnitude	0.06927 mm
Radius on Die	2.0650 mm
Blank Holder Force	0.8069KN
Radius on Punch	6.195 mm
Coefficient of Friction	0.15

The formability analysis was done on the original component and the springback displacement magnitude plots were plotted.FTI_Forming_Suite_2014_SP1_build_1956_SSQ software is used for formability analysis and analysis results of original component are displayed below along with the Springback Displacement Magnitude.

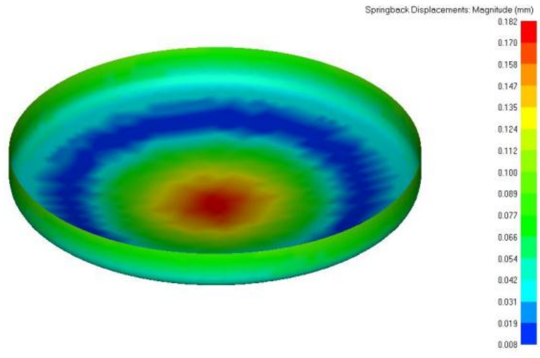

Figure 3. Springback Displacement Magnitude

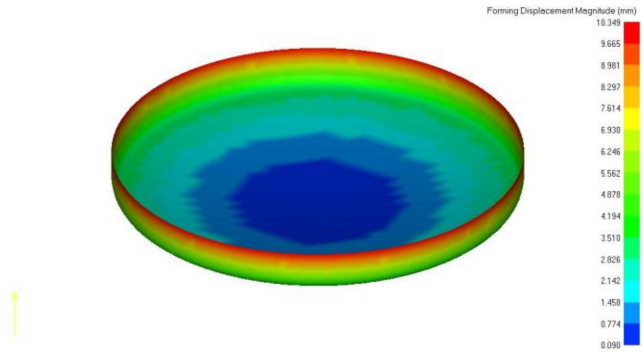

Figure 4. Forming Displacement Magnitude

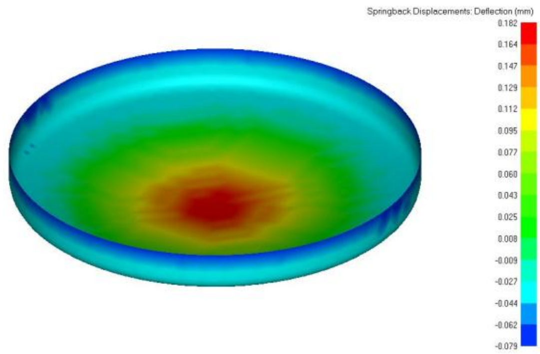

Figure 5. Deflection

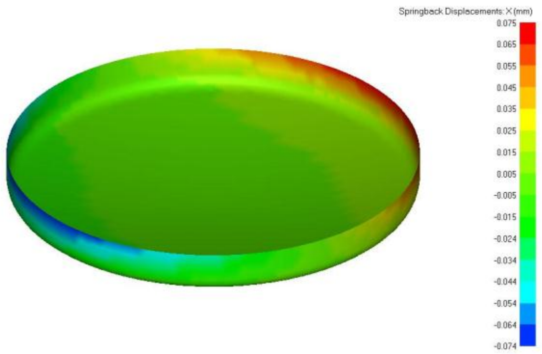

Figure 6. Springback Displacement X Direction

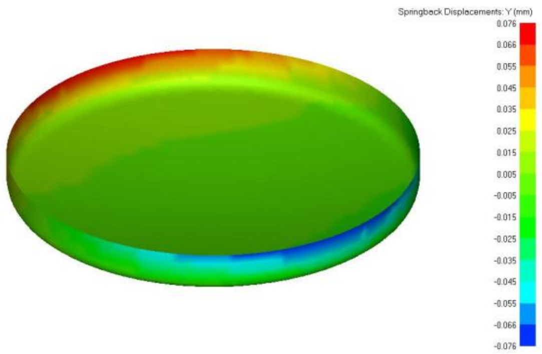

Figure 7.Springback Displacement Y Direction

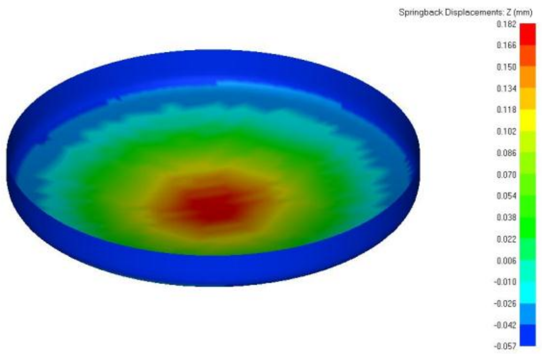

Figure 8.Springback Displacement Z Direction

VI. CONCLUSIONS

Springback Displacement is an extremely vital parameter which needs to be optimized so that deviation of product can be controlled. Springback displacement is dependent on four parameters viz. BHF, Coefficient of friction, Die radius and punch radius. Cuckoo Search Optimization algorithm is a very new and efficient algorithm which gives fast results having high convergence rate. These four parameters are optimized using CS algorithm and the springback analysis is performed on the original part.

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