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Optimization of Fracture in Deep Drawing Process Using Bat-Inspired Algorithm

#1Trupti Bhoskar, #2G.M. Kakandikar

#1P.G Research Scholar in Mechanical Engineering, Dnyanganga College of Engineering & Research, Narhe, Pune-41
#2Associate Professor and Head, Mechanical Engineering, Dnyanganga College of Engineering & Research, Savitribai Phule Pune University, Pune-41

ABSTRACT

Deep drawing is a manufacturing process in which sheet metal is progressively formed into a three-dimensional shape through the mechanical action of a die forming the metal around a punch. The deep drawing process contains many components and steps. Pots and pans for cooking, containers, sinks, automobile parts, such as panels and gas tanks, are among a few of the items manufactured by sheet metal deep drawing. The Predominant failure modes in sheet metal parts (deep drawing process) are fracture. The prediction and prevention of fracture are extremely important in the design of tooling and process parameters in deep drawing process. Fracture or necking occurs in a drawn part which is under excessive tensile stresses. Fractures are the important defects in deep drawing operation, which can be prevented using blank holding force. Fracture limit depends on various tooling, process and material parameters. Bat algorithm (BA) is a new nature-inspired metaheuristic optimization algorithm for solving engineering optimization tasks. The Bat Algorithm, based on the echolocation behavior of bats .This paper describes the optimization of fracture in deep drawing process by using Bat Inspired algorithm.

Keywords— **Bat-inspired algorithm, Deep Drawing Process, Optimization, Fracture**

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I. Introduction

Deep drawing is a sheet metal forming process in which a sheet metal blank is radially drawn into a forming die by the mechanical action of a punch. One of the important sheet metal forming process is deep drawing which has been used in a wide range of industrial applications for converting the sheet into the hallow work piece. This operation is extensively used to for making cylindrical shaped parts such as cups, shells, etc from sheet metal.

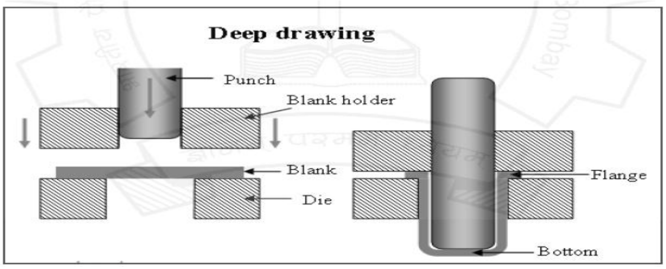


Fig.1 deep drawing process

As the blank is drawn into the die cavity compressive stress is set up around the flange and it tends to wrinkle or buckle the flange. During the process, the blank sheet is likely to develop defects if the process parameters are not selected properly. Therefore, it is important to optimize the process parameters to avoid defects in the parts and to minimize production cost. Optimization of the process parameters for instance die radius, blank holder force, coefficient of friction, etc. can concluded according to their degree of importance on the sheet metal forming characteristic.

II. FRACTURE IN DEEP DRAWING

In many cases after the sheet metal was successful draw in deep drawing process, the fracture at the shell of the specimens always occurred and thus cause the defects on the product. It is one of the most common undesired outcomes in deep drawing because if this happen, the product is in defects condition and the deep drawing process must be redone again using another specimen. This fracture is caused by excessive punch force, excessive blank holder

force excessive friction between blank and tooling, insufficient clearance between punch and die and insufficient punch or die corner radius. Hence, many experimental work that have been done lately to prevent or reduce this fracture when running a deep drawing process.
Shell fracture is one of the outcomes commonly observed in deep drawing process. Shell fracture is a fracture that occur on the cup on the sheet metal or blank after through the deep drawing process. Shell fracture in deep drawing is caused by excessive punch load on the blank that has resulted from several factors like excessive punch force (BHF), excessive blank holder force, excessive friction between blank and punch, insufficient clearance between punch and die and insufficient punch or die corner radius

A. factors in deep drawing process
In deep drawing process, there are several factors that can be affected the process which are categorized into two groups: Material and friction factors, and tool and equipment factors. Thus it is important before running the deep drawing process, these factors was considered well to prevent an undesirable result like earing, fracturing, and wrinkling.

III. PROBLEM FORMULATION

Optimization process uses the linear mathematical relations and regression analysis.

A. Fracture

$$fracture = 68925 - 294BHF - 64880\mu - 15515Rd - 1456Rp$$

Subject to

$2<R_d<4$

$3Rd>R_p>6Rd$

Where

$$BHF = \pi/4[d0^2 - (d1 + 2R)^2] \times P$$

Where P=2.5 N/mm^2.

And

d_1 is (108 to 112)

The problem was solved using Bat optimization Algorithm and the results were obtained.

B. Radius on die

$$Rd = 0.035[50 + (d0 - d1)]\sqrt{S0}$$

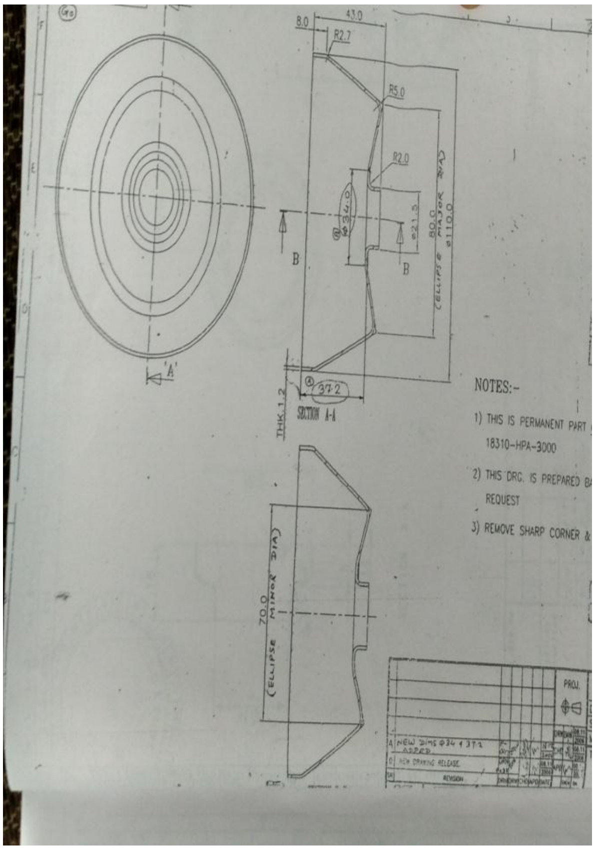
Where Rd is (2to 4)

Where $d0$ *is dependent on* $d1$ *and* $s0$

S_0 is sheet thickness.

IV. COMPONENT DESCRIPTION:

The component selected for wrinkling optimization was connector. The thickness of the sheet was selected as 1.2 mm.



BAT INSPIRED ALGORITHM:

Bat Algorithm is a powerful nature-inspired method for solving many multi-objective optimization problems. The standard bat algorithm was based on the echolocation or bio-sonar characteristics of microbats. Bat algorithm has been developed by Xin-She Yang in 2010. The algorithm exploits the so called echolocation of bats. Bats use sonar echoes to detect and avoid obstacles. It is generally known, that sound pulses are transformed to frequency which reflects fromobstacle. Bats can use time delay from emission to reflection and use it for navigation. They typically emit short loud, sound impulses. The pulse rate is usually defined as 10 to 20 times per second. After hitting and reflecting, bats transform their own pulse to useful information to gauge how far away the prey is. Bats are using wavelengths, that vary from range [0.7,17] mm or inbound frequencies [20,500] kHz. By implementation, pulse frequency and rate has to be defined. Pulse rate can be simply determined from range 0 to 1, where 0 means there is no emission and by 1, bats are emitting maximum. This behavior can be used to formulate the new bat algorithm. Yang used three generalized rules for bat
Algorithms:
1) All bats use echolocation to sense distance, and they also guess the difference between food/prey and background barriers in a some magical way.
2) Bats fly randomly with velocity vi at position xi with a fixed frequency f_{min}, varying wavelength and loudness A0 to search for prey. They can automatically adjust the wavelength (or frequency) of their emitted pulses and adjust the rate of pulse emission r ∈ [0; 1], depending on the proximity of their target.

3) Although the loudness can vary in many ways, we assume that the loudness varies from a large (positive) A0 to a minimum constant value A_{min}.

The basic steps of the bat algorithm can be summarized as follow.

Step 1 Set the initial conditions: population x_i (i = 1, 2, ...n) and *Vi*, pulse frequency *fi* at *xi* and pulse rates *ri* and the loudness *Ai*.

Step 2 Calculate the average position Pad and the optimal position Pgd of the bat colony.

Step 3 Using the formula (1) to formula (3) update velocities and locations/solutions and Generate new solutions by adjusting frequency.

Step 4 If (*rand* > *ri*) then select a solution among the best solutions and generate a local solution around the selected best solution with formula (4); If not, skip this step.

Step 5 If (*rand* < *Ai* // *f*(*xi*) < *f*(*x*_))then accept the new solutions. Increase *ri* and reduce *Ai* with formula (5) and (6); If not, skip this step.

Step 6 Rank the bats and find the current best *X*.

Step 7 If the iterations attain to the maximum number, then stopped and output the global optimal solution Pgd. If not jump to step 2 to continue the search

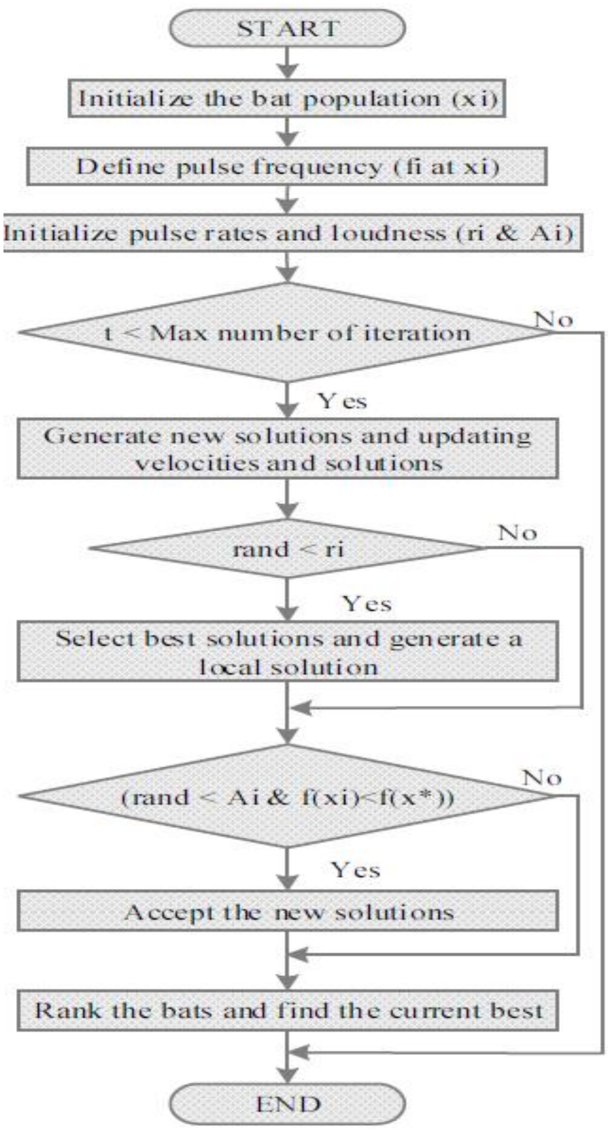


Fig.2 flowchart of Bat algorithm

Pseudo code of the Bat Algorithm is as follows

Objective function $f(x)$, $x = (x1, \dots, xd)T$

Initialize the bat population *xi* (i = 1, 2, …, n) and *vi*

Define pulse frequency *fi* at *xi*

Initialize pulse rates *ri* and the loudness *Ai*

While (t < Max Number of iterations)

Generate new solutions by adjusting frequency

And updating velocities and locations/solutions:

$$fi = f_{min} + (f_{max} - f_{min})\beta,$$

$$v_i^t = v_i^{t-1} + \left(x_i^t - x_*\right) f_i,$$

$$x_i^t = x_i^{t-1} + v_i^t$$

VI. OPTIMIZATION RESULTS

The formulated optimization problem was solved in flower pollination algorithm and the results were obtained as follows

Radius on Die	3.834mm
Blank Holder Force	8.7862 KN
Radius on Punch	6.3595 mm
Coefficient of Friction	0.005

The formability analysis was done on the original component and the forming limit diagrams were

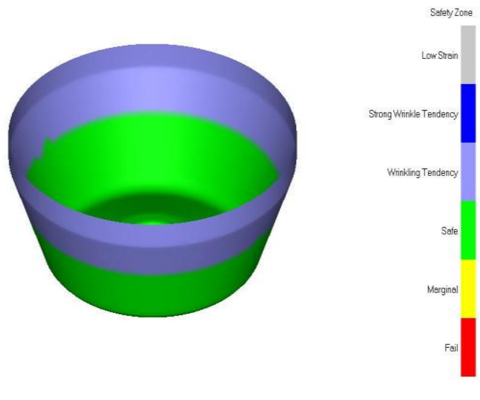


Figure 1. Safety Zone of Original Component

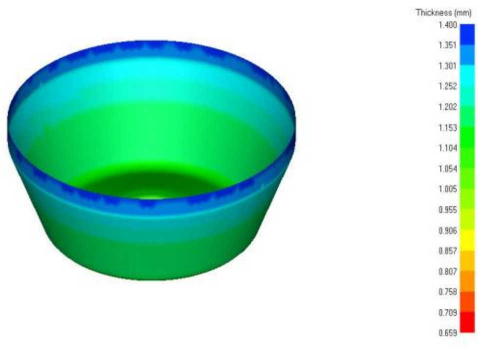


Fig. 4 Thickness of the original component

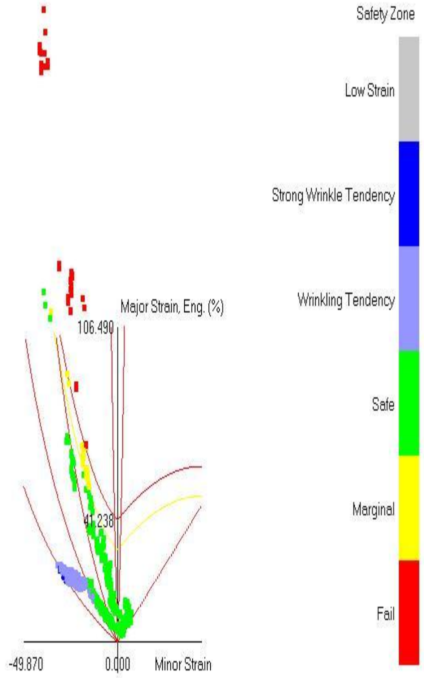


Fig.4 Forming Limit Digram of original component

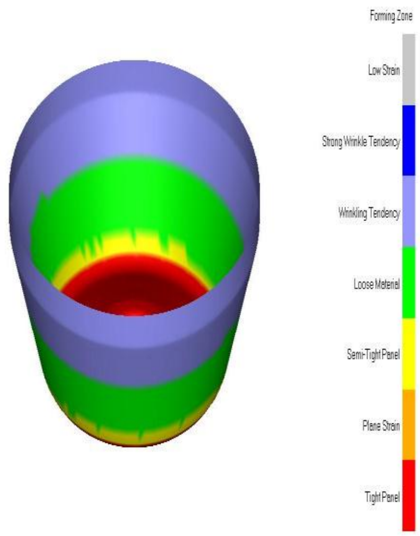


Fig.5 forming zone of original component

I. CONCLUSIONS

Bat Optimization Algorithm have the advantage of simplicity and flexibility. In this report, the concept of optimization, various optimization techniques, the demerits of traditional methods, the basic BAT Optimization algorithm and its working principle and its application areas are represented.

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