ATLANTIS PRESS

Advances in Engineering Research, volume 146

4th International Conference on Material Engineering and Application (ICMEA 2017)

Research on Thickness Distribution of Super Metal Forming of Simulated Annealing Genetic Algorithm

Zhanjun LIU
Faculty of Aerospace Engineering,
Shenyang Aerospace University,
Shenyang, China
e-mail: lzjlzjf@163.com

***Abstract*—The reason of super plastic forming of sheet is concluded. Using simulated annealing genetic algorithm does a kind of nonlinear optimization to reason of super plastic forming of sheet control. The diagnosis knowledge warehouse and controlling parameter of super plastic forming of sheet is built. It greatly improves the method of convergence on using the adaptive stretch. A diagnosis of simulated annealing genetic algorithm is constructed. At last, analyze of testing best result is given. The theory of super plastic forming of metal sheet is rooted. The thickness uneven reason and control way of sheet super plastic expand forming is summarized, the thickness even theory and exactly control way of super plastic expand forming is studied.**

Keywords-super plastic; thickness distribution; simulated annealing; genetic algorithm

I. INTRODUCTION

Genetic algorithm cannot deal directly with the parameters of the space problem, which must put them into space of genetic gene, according to certain structure of chromosomes. In general, due to the robustness of genetic algorithm, it is not strictly to the requirement of code, the program has adopted based on symbol, it sets sampling encoding binary minimum margin of database information. A type of test covering parts is steel yield strength, tensile strength, thickness, die verticality and positioning accuracy, it is showed that blank holder force, elongation and surface roughness are nine kinds of influence factors, in turn, giving 1~9 number, program is about 1~ 9 binary code. Using a weight is to weight stored within the factors, influencing the sampling information. In the C language program, using the decode function is to decode.

II. THE GENETIC ENCODING METHOD OF AFFECTING FACTORS

In stamping production, stamping conditions is such as the blank-holder force, lubrication condition, blank positioning and precision equipment, etc. Material properties and mould wear often fluctuate, the deformation of the blank is to be influenced by produce change. To prevent caused by the above factors, the blank is in the stamping process of plastic failure, the maximum deformation of the blank must be controlled in a certain range, a certain amount of way can ensure the stability of the stamping production.

Deformation degree of margin is blank of the difference between the actual deformation and limited deformation. The blank is under the deformation degree, deformation still has the ability of continuation along the original path. If stamping is in a particular position of the maximum principal strain, the maximum principal strain is under the deformation path of ultimate strain of epsilon k, and then the deformation of the measuring point is margin degrees with delta epsilon. In the blank of the deformation zone, the deflection of the different parts is different. Every measurement point, therefore, has a delta epsilon, and there will be a measurement point in all points of delta, epsilon is as the minimum value, the notes is for delta epsilon min, it can be seen as the stamping parts in stamping forming, under the present condition of deformation degree of margin.

The size of the deformation degree of margin is said the stamping on deformation, maximize is close to limit the extent of the stability of the stamping production. The delta epsilon min is the greater than the stamping production stability. On the other hand, the delta epsilon min is smaller; the worse is stamping production stability.

III. THE SETTING SAMPLING OF INITIAL POPULATION OF GENETIC ALGORITHM

Genetic operation is too many factors affecting minimum margin sampling individuals at the same time, the minimum margin factors is affecting individual sampling bit string, to make up the population. In the genetic algorithm, the minimum margin degrees of influence factors is in the sampling process, the starting point is for the minimum margin degree of factors, influencing the sampling evolution, generation after generation is that the evolution algebra terminates the stopping criteria of evolution, it get the smallest margin of the last generation ideal degree of factors, influencing the sampling information. Genetic factors is affecting operation minimum, margin sampling is initial set of individual population, it is randomly generated, and this program adopts function to generate random initial population individuals.

IV. THE FACTORS SETTING OF AFFECTING THE FITNESS FUNCTION

In this paper, it is based on simulated annealing tensile method, the fitness of function uses V function, each chromosome is in the population Vi of setting a probability, in order to make the possibility of the chromosome, it is selected with other chromosomes in the population, it is proportional to the adaptability. Through the way of roulette,

adaptability good chance of chromosome is selected to produce offspring. On the simulated annealing tensile, fitness is for the following method. In high temperature, the probability of fitness of similar individuals is produce offspring. When the temperature is falling late genetic algorithm, tensile is increased, it makes the fitness of the individual fitness difference amplifier, which makes excellent individual advantages more apparent.

A. *The Influencing Factors of Genetic Operations Diagnosis*

Minimum margin factors are influencing diagnosis, including selection, crossover and mutation genetic operations are three basic genetic operators. Genetic operation and the effect of the above three are basic genetic operators in the operation of the probability, individual coding method, the initial population and the setting are closely related to the fitness function. In this program, to use fitness proportion method, selection operator is the selecting function. The crossover operator is by crossover function. The mutation operator is by mutation function.

Super plastic gas bulging forming is typical applications of super plasticity in sheet metal forming processing, the deformation resistance of sheet metal is low in the condition of super plastic deformation, the plastic is very good. Super plastic gas bulging forming are less working hours, low tooling cost, mould cost is low, no rebound, and many other advantages. But it is the most serious defects during super plastic gas bulging forming that parts of uneven thickness[1]~[4], which bring many adverse effects on the use of the products, it severely restricts the development of super plastic gas bulging forming technology, so the super plastic bulging rehearsals of plate thickness uniformity design is given scientific and accurate evaluation of research, which improves the level of corporate stamping technology and process, especially it has important practical significance to improve the enterprise economic benefit.

B. *The Cause and the Conventional Control Method of Superplastic Gas Bulging Forming Parts of Uneven Thickness*

1) *The Cause of Wall Thickness Uneven Phenomenon*.

In the process of super plastic bulging, due to the deformation of sheet metal material in the surrounding mold clamp, which do not participate in shape, and parts area increase is completely produced by sheet metal thin, stress and strain field distribution is caused by the final part wall thickness of the obvious difference, even if the strain rate of sensitivity coefficient is close to 1.0, it also hard to avoid uneven wall thickness distribution of obvious problems. The main reason is that the first sheet metal under the action of gas pressure is evenly free bulging, when a local contact with the mold cavity plate, under the influence of frictional resistance, this local no longer participate in deformation. As sheet metal mold, the deformation area of sheet metal can be smaller and smaller, which parts of the sheet metal thickness will continue to become thinner[5].

C. *The Conventional Control Method of Wall Thickness Uneven Phenomenon*

First of all, parts structure design should be reasonable, parts radius should be greater 2 times than the wall thickness. Parts adjacent sides angle as far as possible choose obtuse. Parts draft is not less than 5°. Parts should not be too great depth ratio and width. In die forming, H/B is less than 0.4. In punch forming, H/B is less than 0.6.Second, the punch forming of sheet sizes is not too small, which should make the sheet blank expanding rate not greater than the total original area of 2.5 times, it should try to increase the slope of the medial surface of the frame and projection profile radius. In the last case, it can be appropriately increase the sheet metal original area. Finally, the forming of super plastic gas bulging of forming speed cannot too fast, the smaller the radius parts, sheet metal is thicker, the H/B value is the greater, the increase of gas forming pressure should be more slowly, so as to slow speed[6].

D. *The Distribution Principle and Method of Superplastic Gas Bulging Forming Parts Precision Control Wall Thickness*

The conventional control method is hard to achieve the purpose of precise control part wall thickness distribution, this paper proposes to precise control parts from a quantitative point of view, which is wall thickness distribution of the two methods.

In Super plastic forming process, the m value of the same material is the greater, the strain rate to strengthen is the more obvious, the deformation is also more evenly. And the m value is a function of deformation temperature and strain rate, when the temperature optimization, the m of the maximum strain rate is referred to as the best strain rate. For certain shape and size of the parts, it uses the mechanical analytic method, which can find that the thinner of the worst parts of the strain rate remains the best of the strain rate compression rule, namely the p - t curve[7]. In the first phase of the bulging, and decreases as the surface curvature, bulging pressure increases, but rise gradually slows down. In the second phase of the bulging, the straight wall materials and concave die stage, the bulging pressure slows down. In the bulging of the third stage, namely, it is filling the rounded stage, because the parts radius decreases rapidly, so the bulging pressure increases quickly. Strain rate forming is the best in the whole process of forming, which adopt manual or computer system to control gas pressure, it make it according to the optimal pressure load ensure that the strain rate and deformation on parts of the reinforcement effect is most obvious, which prevents the further concentrated of thin material, the most powerful makes parts tend to be relatively uniform wall thickness distribution. This is a more accurate quantitative method of the distribution of wall thickness control parts.

E. *The forming of transitional surface*

According to the different shapes and sizes of the parts, it analyses forecast directly after the bulging parts of simple die wall thickness distribution, and designs the reverse transition bulging die profile shape and size. Principle is that

the transitional surface after the bulging parts of cross section of neutral layer length is about 70% ~ 80% of the final size parts; Second principle is to make simple die bulging time-varying thin of the worst place in reverse transition bulging deformation hardly, which close to the original material thickness, and the positive blow molding of thin small parts, are much thinner as far as possible when the transition bulging. Such parts forming are in two steps, in the first step, it first will reverse blowing bulging on the sheet metal with the transitional surface concave die, then it loads in the forward, which make its first open and then bulging, the last it is on the consistent with the final part shape and size of concave surface model. This is a transient shape size and thickness of material that is more accurate and reliable, it is more significant to improve the part wall thickness distribution effect [8].

In metal forming, the geometry of the work piece is established entirely or partially by the geometry of the die. In contrast to machining processes greater forces are necessary in forming. Due to the complexity of the parts, forming is often not carried out in a single operation. Depending on the geometry of the part, production is carried out in several operational steps via one or several production processes such as forming or blanking.

During the design phase, the necessary manufacturing methods as well as the sequence and number of production steps are established in a processing plan. In this plan, the availability of machines, the planned production volumes of the part and other boundary conditions are taken into account. The aim is to minimize the number of dies to be used while keeping up a high level of operational reliability. The parts are greatly simplified right from their design stage by close collaboration between the Part Design and Production Departments in order to enable several forming and related blanking processes to be carried out in one forming station.

Obviously, the more operations which are integrated into a single die, the more complex the structure of the die becomes. The consequences are higher costs, a decrease in output and a lower reliability.

The type of die and the closely related transportation of the part between dies are determined in accordance with the forming procedure, the size of the part in question and the production volume of parts to be produced.

Large size single dies are installed in large presses. The transportation of the parts from one forming station to another is carried out mechanically. In a press line with single presses installed one behind the other, feeders or robots can be used, whilst in large-panel transfer presses, systems equipped with gripper rails or cross bar suction systems are used to transfer the parts.

Transfer dies are used for the production of high volumes of smaller and medium size parts. They consist of several single dies, which are mounted on a common base plate. The sheet metal is fed through mostly in blank form and also transported individually from die to die. If this part transportation is automated, the press is called a transfer press. The largest transfer dies are used together with single dies in large-panel transfer presses.

In progressive dies, also known as progressive blanking dies, sheet metal parts are blanked in several stages; generally speaking no actual forming operation takes place. The sheet metal is fed from a coil or in the form of metal strips. Using an appropriate arrangement of the blanks within the available width of the sheet metal, an optimal material usage is ensured. The work piece remains fixed to the strip skeleton up until the last operation. The parts are transferred when the entire strip is shifted further in the work flow direction after the blanking operation. The length of the shift is equal to the center line spacing of the dies and it is also called the step width. Side shears, very precise feeding devices or pilot pins ensure feed-related part accuracy. In the final production operation, the finished part in the sequence is disconnected from the skeleton. A field of application for progressive blanking tools is, for example, in the production of metal rotors or stator blanks for electric motors.

V. THE UNIFORMITY DESIGN CASE STUDY OF HALF SPHERICAL SUPERPLASTIC BULGING REHEARSALS PLATE

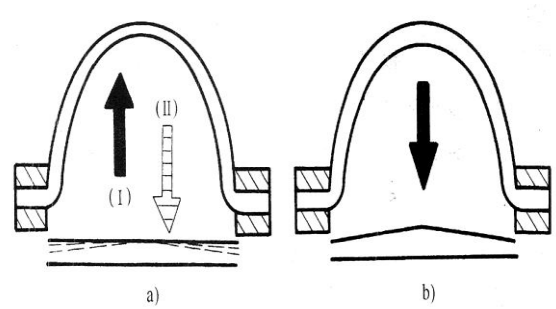
The Uniform Method Research of Hemispherical Pieces of Super plastic Bulging Sheet. Super plastic forming can make top hemisphere severe thinning, usually after the bulging at the top and the peripheral wall thickness difference is about 40%. It is proposed in this paper for sheet metal wall thickness distribution of the two methods, as shown in Fig.1. Through it is as shown in Fig.2, it is the each micro positioning of geometric relationships [9].

Plastic forming force formula is as follows:

$$F = \frac{2\pi rESl\ (f - \tan\varphi)}{(1+\mu+k_1)k_2} + 0.1A \tag{1}$$

$$k_1 = 2\lambda^2 / \left(\cos^2\varphi + 2\lambda\cos^2\varphi\right) \tag{2}$$

$$k_2 = 1 + f\sin\varphi\cos\varphi \approx 1 \tag{3}$$



a) test adjustment method b) reverse modeling method

Figure 1. Adjustment method of sheet thickness.

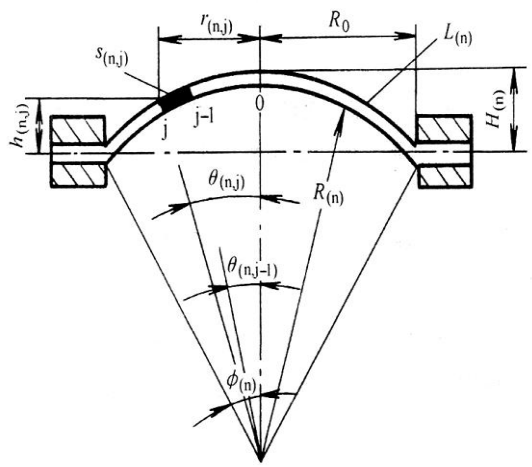


Figure 2. illustrates of bulge forming model.

VI. CONCLUSION

The reason of super plastic forming of sheet is concluded. Using simulated annealing genetic algorithm does a kind of nonlinear optimization to reason of super plastic forming of sheet control. The diagnosis knowledge warehouse and controlling parameter of super plastic forming of sheet is built. It greatly improves the method of convergence on using the adaptive stretch. A diagnosis of simulated annealing genetic algorithm is constructed. At last, analyze of testing best result is given. The theory of super plastic forming of metal sheet is rooted. The thickness uneven reason and control way of sheet super plastic expand forming is summarized, the thickness even theory and exactly control way of super plastic expand forming is studied.

REFERENCES

[1] Lin ZhaoRong, Principle and Application of Metal Superplastic Forming, Aviation Industry Press(1990):p3.

[2] KMB, Super plastic Application Technology, Mechanical Industry Press(2005)p130.

[3] Li Shuoben, Stamping Technology, Mechanical Industry Press (1993)p26.

[4] Liu Zhanjun, Sheet Deep Drawing Based on Wavelet Neural Network Information Fusion Fault Diagnosis Research, Plastic Engineering Journal (2005), p24.

[5] Zhao Jun, Conical work piece deep system in intelligent material parameters and the friction coefficient of on-line identification, Beijing: plastic engineering journal, pp.48-50, 2001.

[6] Zhao ZhenDuo , The friction and lubrication of metal plastic forming technology , Beijing: chemical industry press, pp. 50-53, 2004.

[7] Wen WeiDong, Prediction model based on the fuzzy reliability , aircraft engine ,pp. 322-323, 2004.

[8] Middleman S, An introduction to fluid dynamics ,John Wiley and Sons Inc, New York, pp.16-17,1998.

[9] Liu ZhanJun, Difficulty reliability prediction research of titanium plate stamping forming based on the fuzzy control, plastic engineering journal, Beijing, pp. 63-66, 2005.