Application of Computer 3D Drawing Technology in the Design of Explosion-proof Electric Shell

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Abstract. Explosion-proof lamp shell products are widely used in die casting process. Die-casting can obtain products with complex shape and better performance, but combined with the characteristics of shell products, die-casting also has the disadvantages: due to the high temperature required for die-casting, combined with the complex structure of explosion-proof lamp shell, the mold temperature is not easy to be derived in die-casting process, so the die life is low and the production cost is high. Because the explosion-proof lamp shell belongs to the deep cavity thin-walled complex structure, the gas is not easy to discharge, it is easy to form pores, pinhole defects, and the waste rate is high; Due to the reason of die casting process itself, it is necessary to use heating furnace to melt aluminum liquid, which will emit a lot of smoke and dust in the process of melting metal, and the working environment of workers is poor. In the process of mass production, this kind of dust will undoubtedly increase the burden of the environment. According to the modified Archard wear model, the maximum damage value of the shell is 0.540, while the minimum damage value in the orthogonal test is 0.554, so the process parameters can be optimized. The stress field, temperature field and velocity field of each joint of the cavity are used to calculate the wear depth of the cavity.

Keywords: Explosion-proof Lamp Shell, 3D Drawing, Process Parameters, Structure Optimization

1. Introduction

Nowadays, the production of explosion-proof electrical appliances is developing rapidly, and there are more and more explosion-proof application scenarios, especially underground scenes. The space light under the mine can not reach the deep well, and is full of flammable and explosive gases, so the lighting quality plays a vital role in the normal work and safety production of the coal mine. With the development of mining technology and the requirement of coal mine mechanization, coal mines can no longer rely on headlamp lighting in the past. Explosion proof lamp is widely used in harsh environment with spark, electric spark and combustible gas. The shell of explosion-proof lamp
generally uses thick metal shell to isolate spark and combustible gas. In harsh environment of factories and mines, explosion-proof lamp is the most commonly used lighting tool [1].

Explosion proof lamp is an important safety lighting equipment in factories and mines, and its product quality and performance have an important impact on the safe life and production of factories and mines. Explosion proof lamp shell products are widely used in die casting process. Die casting process has many advantages, such as high productivity and low cost, but there are also some disadvantages, especially for the explosion-proof lamp shell complex die-casting die structure, the service life is greatly reduced under the repeated erosion of high temperature liquid metal. At the same time, due to its own process defects, the product will have die-casting defects such as pores, which has a certain impact on the product performance influence. Moreover, harmful smoke and dust will appear in the original die casting production mode, which will undoubtedly increase the burden of the environment in the process of mass production. In recent years, with people's increasing attention to production safety and environmental problems, more and more products begin to seek to change the production process. The production of explosion-proof lamp shell by extrusion can not only improve the quality of explosion-proof products, but also reduce the pollution to the environment. With the development of science and technology, 3D scanning technology is more and more applied to archaeological research. Based on the 3D model obtained by scanning, on the one hand, the dimension of data extraction is increased from the original two-dimensional plane to three-dimensional solid, and the range of data extraction is more diversified; on the other hand, the computer program is used to extract data quickly and accurately from the 3D model, which not only greatly improves the efficiency, but also can be used on a large scale [2].

In this paper, the concept of computer three-dimensional drawing technology is described and studied. Through the simulation analysis of various needs of explosion-proof lamp working in the mine, the structure size of explosion-proof lamp shell casting does not fully meet the requirements of extrusion forming process, so it is necessary to redesign the shell product size before the process design, and to improve the mechanical properties of plastic forming products, it is necessary to improve the anti explosion performance. The wall thickness of explosion lamp was optimized. The blank deformation process of explosion-proof lamp shell extrusion forming was simulated by finite element method, and the results were analyzed to optimize the forming method.

2. Related Concepts

2.1 3D Model Retrieval Method:
Distance based method: Hausdorff distance and nearest neighbor are distance based methods. In this type of method, firstly, views are clustered, and each cluster center represents the corresponding model. The difference between NN and Haus is that Haus takes the farthest distance between cluster centers as model similarity, while NN takes the nearest distance between cluster centers as model similarity [3].

\[
HAUS(V_1, V_2) = \max \left\{ \max_{\alpha \in V_1} \min_{\beta \in V_2} d(\alpha, \beta) \right\} \]

\[
NN(V_1, V_2) = \min_{\alpha \in V_1, \beta \in V_2} d(\alpha, \beta)
\]

Probabilistic model based method: camera unconstrained method (ccfv) learns the probabilistic model of each object to infer the comparability between the query model and each category. Let Q and m be query model and candidate model respectively. The relationships between models are defined using the. If q is similar to m, then \(\xi = 1\), otherwise \(\xi = 0\). Ccfv eliminates the constraint of static camera array for view capture and 3D model retrieval.

\[
S(Q, M) = P(Q| M, \xi = 1) - P(Q| M, \xi = 0)
\]
Method based on graph matching: weighted bipartite graph matching (wbgm) belongs to graph matching algorithm. Wbgm constructs weighted bipartite graph based on 2D perspective, selects representative views by clustering multi view images of the model, then calculates the clustering proportion to initialize the weight, and gradually calculates the view matching degree to update the view weight. Finally, the weighted matching algorithm is used to complete the retrieval.

$$\Lambda^* = \arg \max_{\Lambda} \sum_{i=1}^{n} C_{1,3}^{1}$$

(4)

2.2 Mold design of Explosion Proof Lamp Shell
The traditional extrusion forming process has large flash, serious material waste and low dimensional accuracy. In the extrusion forming process of explosion-proof lamp shell, it is difficult to form, and the required forming force is large. According to the principle of minimum resistance, when the metal flows to the die, it is easier to flow to the flash groove, resulting in insufficient filling and can not get qualified products. Therefore, in this paper, no flash extrusion process is selected to make the pre extruded blank form in the closed cavity, which improves the forming quality and reduces the waste of materials [4].

2.3 DEFORM Software
In the use of plastic finite element, deform is the most widely used plastic finite element simulation software. After nearly 40 years of development, DEFORM software has been used to simulate the plastic forming process The development of alpid software is now an integrated system software, which integrates thermal coupling analysis, stress-strain analysis and other forming analysis in the plastic forming process, as well as quenching, tempering and other heat treatment process analysis. It basically covers all the analysis systems in the whole plastic forming process. The pre-processing setting system and intuitive post-processing interface of deform can greatly reduce the learning cycle for technicians, which can save more time and solve practical problems by means of finite element method Another reason for the popularity of the software is its built-in rich material library, which basically has all the most widely used material brands in the world, including steel, aluminum alloy and other materials. Technicians can easily call them when using them. Even if they can't find the required materials, they can input their own material models through the built-in material definition method of the software [5].

In addition to the simple and intuitive operation, the tetrahedral mesh generation method and mesh generation technology of DEFORM software greatly reduce the shape error caused by the change of mesh volume in the process of forming simulation, and greatly improve the accuracy of simulation [6].

2.4 Establishment of Finite Element Simulation Model and Parameter Setting
(1) Finite element geometric modeling: DEFORM software built-in three modeling tools, but can only complete a simple three-dimensional modeling, and explosion-proof lamp shell products and their mold structure are very complex, so the author uses the three-dimensional modeling software UG, first through UG to complete the modeling of flangeless extrusion die and blank, and then export the suffix STL The STL file is imported into DEFORM-3D for assembly, which is the finite element model of the two process schemes: before simulation, set the top die and bottom die as rigid body, and set the work piece as plastic body without considering the deformation of the die; then set the motion relationship, and set the top die here As an initiative, given the motion speed and direction, the bottom die speed is set to 0, and then the three contact each other to reduce the unnecessary simulation time [7].

(2) Mesh generation: for the use of finite element software to simulate metal plastic forming, mesh generation of finite element model is an essential prerequisite, and whether the mesh generation is reasonable has a great impact on the simulation results. Tetrahedral mesh is used in eform-3d, and the default mesh generation method of deform can be divided into absolute mesh generation method and
relative mesh generation method. The shell structure of explosion-proof lamp is complex, and there are many high rib structures, which make many corners on the surface of the workpiece. The minimum feature size is the basis for selecting the grid size when dividing the grid. Here, after measuring the minimum feature size of the workpiece of 6 mm, the minimum grid size is set to 6 mm, and the size ratio is 3. In the process of billet deformation, some previous meshes will be re-meshed due to excessive distortion, and the re-meshing condition of the default system is adopted here. The step size of each simulation unit is set to be one third of the smallest.

Material selection: there are two kinds of materials in deform material library, namely 6061 machine and aluminum-6061 [500-900F (260-480 °C)]. However, after the simulation of two different materials, it is found that the results are quite different. In this chapter, the author chooses to import the material model by inputting the material constitutive equation [9]:

\[ \varepsilon = 1.46 \times 10^{19} [\sinh(0.0198\sigma)]^{8.926} \exp(-236858/RT) \]  

(3) Model boundary condition setting: after the model is imported and established, define the contact surface between the blank and the die, including the friction conditions, and set the proposed coefficient as 0.2 here.

2.5 Simulation Analysis of Preform Process and Optimization of Billet Structure

Because of the preform structure designed in this paper, the qualified preform has a great influence on the forming quality of the final extrusion parts. In this paper, the cylindrical bar, T-bar and T-bar are selected. The preforming process is simulated by using two different schemes, i.e. the pre-extruded bar and trapezoidal section, and then the maximum forming load and deformation uniformity are analyzed to obtain a better shape of the pre-extruded billet.

Compared with the three forming schemes, the cavity can be filled, but the deformation uniformity of the round blank is the worst among the three schemes, and it cannot be located in the die, so it is excluded first. Compared with trapezoidal blank, the deformation resistance of T-shaped blank is lower than that of trapezoidal blank, but the deformation of trapezoidal blank is more uniform. Considering that the non-uniformity of deformation will be greatly improved by adding annealing step before the subsequent final extrusion, the economy of forming is given priority in the forming of this step, so T-shaped blank is selected as the final scheme among the three pre-forming schemes [9-10].

3. Multi Objective Optimization of Forming Process Parameters of Explosion-proof Lamp Shell

3.1 Influence of Single Factor on Final Extrusion Properties
In order to obtain a reasonable combination of process parameters through orthogonal experiment, it is necessary to explore the influence of different process parameters on the target. The objective functions selected in this paper are equivalent stress, equivalent strain, damage value and forming load. In the study of single factor influence, first of all, in addition to the factors studied, the other parameters are determined as follows: upper die pressing speed: 10mm / S; billet heating temperature: 440 °C; friction coefficient: 0.2; the preformed structure and size are obtained through optimization design in Chapter 3 of this paper.

The equivalent stress, equivalent strain, forming load and material damage of different single factor forming results are compared, and the mechanical properties and economy of products produced by production process are considered comprehensively.

3.2 Influence of Billet Heating Temperature on Each Target
The initial heating temperature of the billet is 440 °C, 450 °C, 460 °C and 470 °C, and the other forming parameters are upper die pressing speed of 10 mm / s and friction coefficient of 0.2.

4. Multi Objective Optimization of Process Parameters and Prediction of Die Life
It can be seen from the research that the optimal values of each optimization objective for different process parameters are different, so it is impossible to achieve the optimal solutions of different objectives by selecting a group of parameters. In order to obtain the optimal solutions of multiple optimization objectives, it is necessary to first find the optimal parameter combination of each single objective. Finally, the optimal combination of process parameters for multiple optimization objectives is found.

### 4.1 Determination of Factor Level and Selection of Orthogonal Table

The ultimate goal of process parameter optimization of thin-walled and high rib products is to reduce product defects and improve product quality on the premise of obtaining complete products, which has the greatest impact on product quality. At the same time, the parameters that can also be changed artificially are billet temperature, mold pressing speed and friction coefficient. Therefore, the author takes these three factors as the horizontal factors of orthogonal table. Taking 6061 aluminum alloy as an example, the heating temperature level of billet is 435 °C, 445 °C, 455 °C, 465 °C and 475 °C, the pressing speed of upper die is 2mm / s, 5mm / s, 10mm / s, 15mm / s and 20mm / s, and the friction coefficient is 0.15, 0.25, 0.3, 0.4 and 0.5.

**Table 1.** Experimental factors and levels

| horizontal | Blank temperature | Lower pressure velocity | friction factor |
|------------|-------------------|-------------------------|-----------------|
| 1          | 435               | 2                       | 0.15            |
| 2          | 445               | 5                       | 0.25            |
| 3          | 455               | 10                      | 0.3             |
| 4          | 465               | 15                      | 0.4             |
| 5          | 475               | 20                      | 0.5             |

### 4.2 Analysis of Simulation Results

**Table 2.** Orthogonal test arrangements and results

| test number | level of factor | bear fruit |
|-------------|----------------|------------|
|             | Blank temperature | Lower pressure velocity | friction factor | Equal effect variation difference | Maximum damage | Maximum forming load |
| 1           | 435             | 2           | 0.15          | 8.3                      | 0.661          | 135                   |
| 2           | 435             | 5           | 0.25          | 8.79                     | 0.646          | 151                   |
| 3           | 435             | 10          | 0.3           | 10.87                    | 0.634          | 161                   |
| 4           | 435             | 15          | 0.4           | 11.77                    | 0.624          | 174                   |
| 5           | 435             | 20          | 0.5           | 12.77                    | 0.611          | 200                   |
| 6           | 445             | 2           | 0.25          | 7.36                     | 0.742          | 135                   |
| 7           | 445             | 5           | 0.3           | 7.88                     | 0.672          | 150                   |
| 8           | 445             | 10          | 0.4           | 8.42                     | 0.638          | 158                   |
| 9           | 445             | 15          | 0.5           | 8.79                     | 0.608          | 166                   |
| 10          | 445             | 20          | 0.15          | 7.5                      | 0.776          | 149                   |
| 11          | 455             | 2           | 0.3           | 7.24                     | 0.664          | 134                   |
| 12          | 455             | 5           | 0.4           | 7.48                     | 0.650          | 146                   |
| 13          | 455             | 10          | 0.5           | 7.77                     | 0.554          | 156                   |
| 14          | 455             | 15          | 0.15          | 7.48                     | 0.703          | 135                   |
| 15          | 455             | 20          | 0.25          | 7.77                     | 0.650          | 154                   |

After DEFORM-3D simulation, the results are shown in Table 2.
4.3 Optimization of Process Parameters Based on Deformation Uniformity
According to the simulation results of equivalent strain difference of different experiments, the range analysis is carried out to get the mean value of different factors.

According to figure 4.13, it can be seen that with the increase of temperature, the difference of equivalent strain increases; with the increase of pressing speed, the difference of equivalent strain gradually increases; with the increase of friction coefficient, the difference of equivalent strain gradually increases. It can be concluded that the optimized combination of process parameters for deformation uniformity is \( a5b1c1 \). When the temperature is 455 \(^\circ\)C, the pressing speed is 2mm / s and the friction coefficient is 0.15, the deformation is the most uniform.

![Figure 1. Trends in the variation of the equivalent effect of different process parameters](image1)

![Figure 2. Trends in the impact of different process parameters on the maximum value of damage](image2)

4.4 Process Parameter Optimization Based on Damage
It can be seen from the orthogonal test that the damage value of the optimized process parameters is 550.540.

5. Conclusion
In this paper, the isothermal extrusion forming process of 6061 aluminum alloy explosion-proof lamp shell is studied. By means of computer simulation, the deformation process of the blank is simulated, and the production process is optimized. Through orthogonal test and multi-objective optimization, the reasonable forming process parameters are obtained. After that, the life of the final extrusion die with complex deformation is predicted, which lays a foundation for the comprehensive process comparison when the products are put into production in the future. The main conclusions of this paper are as follows. Combined with the process characteristics of die casting process and extrusion process, the structure of explosion-proof lamp shell is modified to meet the requirements At the same time,
according to the better mechanical properties of extruded products, the wall thickness of explosion-proof lamp shell is optimized, which can save the production cost on the premise of meeting the use requirements. The die wear was simulated by finite element method, and the point e with the most serious die wear was found. Taking point E as the research object, the changes of temperature, normal pressure and other parameters of point E in the process of multiple extrusion were studied. The die wear model is used to modify the results, and a more accurate die life prediction is obtained, which provides a reference for the actual production of products.

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