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Simulation production process database based on the whole process of large ring parts and its application

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Abstract: Ring rolling, also known as ring rolling or reaming, is a plastic processing technology of ring rolling equipment (ring rolling machine) to make the ring produce wall thickness or height reduction, diameter expansion and section contour forming. It is suitable for all kinds of seamless ring production and manufacturing, especially for large size ring. Compared with the traditional casting, forging, welding and forming methods, ring rolling technology has obvious technical and economic advantages such as energy-saving and material saving, high product precision, good internal quality, low production cost, etc. The complete technological process of ring rolling mainly includes a series of procedures such as blanking, heating, upsetting, punching, expanding and rolling. Through the numerical simulation of ring rolling, the stress and strain distribution, microstructure change and temperature change in the ring forming process can be obtained, which provides scientific basis for the formulation of processing technology. Therefore, scholars at home and abroad have begun to study the process of large ring.

1. Introduction

Ring production is mainly divided into two parts: blank manufacturing and ring rolling. Blank manufacturing process includes upsetting, punching, reaming. For upsetting process, Minting Wang [1], based on finite element simulation, set up the model of large forgings upsetting crack defects formation mechanism, analyzed the stress and the distribution of equivalent strain and strain rate, and by using forecast model obtained the forging center crack morphology and distribution, put forward to reduce the friction coefficient method to suppress the layer crack defects. Danshan Sui [2] studied the influence of single (upsetting) and multiple (upsetting - drawing) deformations in forging process on the microstructure evolution of 316 LN steel. The research on punching process is as follows. Based on FORGE finite element simulation software, Hu Yunbao [3] carried out numerical simulation research on the punching process of H13 steel roll ring forging process, and the shrinkage phenomenon in the simulation results was consistent with the actual production, verifying the effectiveness of the finite element simulation column. According to reasonable process parameters and appropriate control, Z.J Zhang [4] simulated the forging process of 42CrMo billet, and found that due to the existence of friction and uneven temperature distribution, part of the metal billet in the middle flows faster, and part of the head surface or nearby deforms slowly at the side, thus causing forging defects. Li Yongtang et al. [5] Defrom software carried out numerical simulation analysis on the hot rolling forming process of ring parts, and obtained the influence law of different process parameters on the model during ring rolling process.

2. Main process of ring forging production

The blank forming process of the ring is shown in Figure 1. The heated ring blank is upset first, then punched to obtain the required shape and size of the ring blank, and finally rolled on the ring rolling machine to obtain the required ring forging.

2.1 Analysis of technological parameters in upsetting process

Table 1 Three Scheme comparing

Outer diameter mm	The inner diameter mm	Material
8000	7000	316LN

SolidWorks 3D modeling software was used to create 316 austenitic stainless steel bodies. Deform-3d software was used to simulate the upsetting process numerically. The blank model as shown in Figure 1.1 was established, including upper cutting board, lower cutting board and blank. The upper cutting board moves down along the Z axis to simulate free forging upsetting. The material properties were obtained from the material warehouse, the coarse temperature of the pier was 800℃, and the pressing speed of the cutting board was 10mm/s.

Under the same forging temperature, the effect of billet with different height-diameter ratio on forming quality was studied. Through calculation, the blank model size of this project can be obtained as shown in Table 1.1

Table 2 Three Scheme comparing

H_0/D_0	H_0(mm)	D_0(mm)
1.5	2583	1722
1.8	2917	1621
2.0	3130	1565
2.5	3632	1452

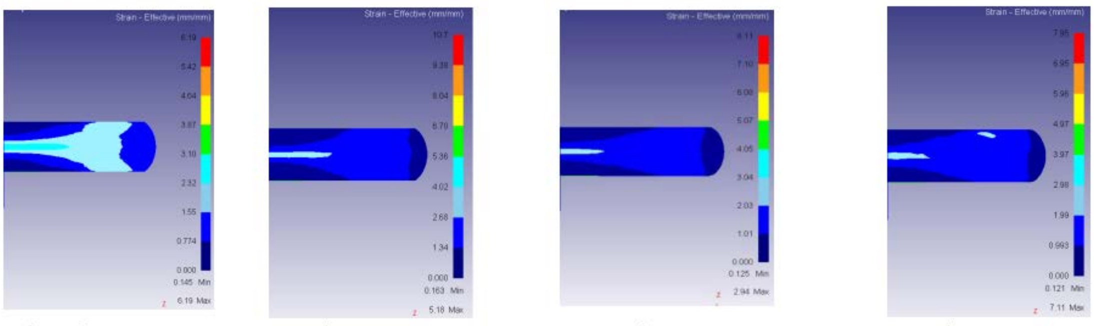

Figure. 1 Forming stress distribution diagram of 316 stainless steel with different aspect ratios

According to the calculation and prediction of the dangerous point of surface crack of ingot, in the upsetting forging process of 316 austenitic stainless steel, the ratio of billet height to diameter should be strictly controlled to ensure the quality of forging. The height-diameter ratio of billet should be 1.8, otherwise the ingot surface may crack. The workpiece size table is shown in Table 1.3. The simulation results are analyzed to select the optimal pier rough ratio, as shown in Figure 1.6. The data in the figure are fitted by polynomial, and the resulting polynomial is used for the process parameter recommendation module in the database.

2.2 Analysis of punching process parameters

Through calculation, the simulation effect of 316 austenitic stainless steel punch holes with diameters of 300mm, 400mm, 500mm and 600mm is shown in Figure 1.8. The punch with a diameter of 500mm has a good simulation effect with no cracks on the surface and shrinkage at the inner edge hole. The simulation results of punch with a diameter of 300mm show that serious damage occurs in the blank. FIG. 1.9 shows the equivalent strain distribution diagram when punching is completed. It can be seen that the strain is finally concentrated at the hole at the inner edge and below the inner wall.

2.3 Analysis of ring rolling process parameters

During rolling, the surface of billet in contact with main roll will sag, which is fishtail phenomenon. Three key process parameters, namely initial billet temperature, rolling curve and rolling speed, are more significant to the occurrence of fishtail defect, so in this paper, three factors and four levels of orthogonal test design are carried out for these three key process parameters. Qform software was used to simulate and measure the fishtail depth of the simulation results. Finally, the optimal process parameters for realizing the minimum fishtail defect were derived.

This experiment by orthogonal experimental method, temperature, ring rolling speed, rolling route as three experimental factors, found in each factor under the three levels of value, a total of nine groups of experiments, using Qfrom software simulation analysis of each group of the experimental results it is concluded that the workpiece fishtail depth, finally sailed to the tail depth is derived to realize optimum parameters of the minimum value. According to the actual production process requirements of this test, the initial billet temperature, rolling curve and rolling speed are taken as three factors. The initial billet temperature range is 430~470℃. The rolling curve is divided into upper convex type, straight type and lower concave type, and the rolling speed is divided into 35811, 46921, 571031

3. Database structure and analysis software function design

The software database is composed of upsetting process parameters, punching process parameters, ring rolling process parameters, and the whole process parameters data module. On this basis, there are data browsing, query, and process parameters recommended functions:

(1) Data summary and query. The database building process integrates the relevant data of each department, and establishes the corresponding relationship among the control parameters and products according to the process flow of the production ring. It can be used as the basis of the circular rolling process database, which is convenient for data collection, review and management, and further realize network data sharing. Categorize and query the input data.

(2) Process scheme recommendation. The module can recommend step-by-step process parameters, input workpiece size information, and make reasoning calculation according to empirical formula to get processing technology parameters suitable for the material with this size.

4. Conclusion

In this paper, with Access as the database management system and VBA programming language, the circular rolling process database system is designed and developed. The system can effectively manage and use the basic process data of each process of ring production, and apply the rule reasoning technology to realize the effective recommendation of process parameters. The system is stable and reliable in actual use, which can provide beneficial reference and guidance for ring rolling processing.

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