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Finite Element Simulation and Stress-Strain Study of Beam Rolling Forming

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ABSTRACT

Variable cross-section roll forming is a new forming process developed on the basis of traditional constant cross-section roll forming. It can produce variable cross-section products flexibly and efficiently, which is of great significance to automobile lightweight. In this paper, the rolling forming process of automobile variable section longitudinal beam is simulated, the finite element model of roll and sheet metal is established in ABAQUS software, and the deformation and stress distribution of sheet metal in variable section rolling forming process are analyzed. It is concluded that the stress and plastic strain in the forming corner area are much higher than those in the web area and flange area, followed by the flange area, and finally the web area.

Keywords: variable section longitudinal beam; flexible roll forming; finite element analysis

INTRODUCTION

In truck, heavy vehicle and other models, the frame is the backbone element of the vehicle chassis, which is used to support and install the vehicle engine and other components [1]. At the same time, the frame is an important force transmission component of the vehicle. The engine output power transmits the torque to the drive axle through the transmission and transmission shaft to drive the vehicle [2]. The mass and power of the vehicle act on the frame; The longitudinal beam is an important component of the frame, the key bearing component of the vehicle and the assembly of other parts, and it is also the bottleneck restricting the quality and capacity of the frame [3].

The rolling forming process of longitudinal beam belongs to flexible forming process [4]. Its processing process is generally flexible, which can adapt to various sizes and various kinds of plates, and integrate various processes such as embossing, punching, slotting and bending into the same production line [5].

Longitudinal beams often use high-strength steel as raw materials, which not only has high strength, but also conforms to the principle of lightweight [6]. Due to the poor formability of high-strength steel, compared with traditional stamping, roll forming is easier to control spring back, has better forming quality, and can well control the cost [7].

Beam structure size and material parameters

Taking the automobile longitudinal beam provided by an enterprise as the research object, the finite element simulation is carried out. One side of the longitudinal beam wing plate is a fixed section and the other side is a variable section. The material of the longitudinal beam is Q420 steel, the size and shape are shown in Figure 1, and the material properties of the longitudinal beam are shown in Table 1.

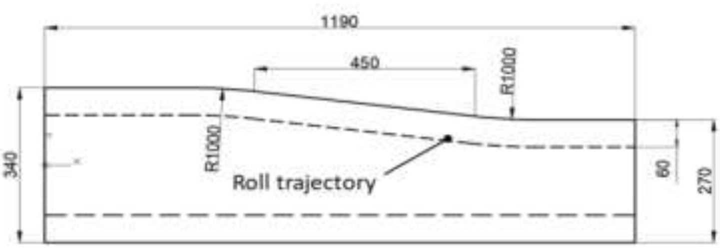

FIGURE 1: Blank size and shape

TABLE 1: Q420 material parameters

Material	Density/Kg/m³	Modulus of elasticity/GPa	Poisson's ratio	Yield strength/MPa
Q420	7850	203	0.3	420

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The material parameters are obtained through tensile test, and the strain rate set in the test is 0.001s-1. The stress-strain curve is shown in Figure 2.

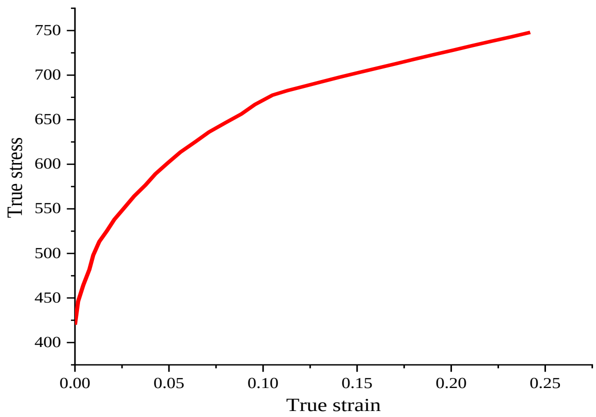

FIGURE 2: Q420 material stress-strain curve

Establishment of finite element model

Import the model into ABAQUS software for assembly, the forming angles are 10°, 17°, 25°, 32°, 40°, 60°, 75° and 90° respectively [8]. In order to prevent the influence of plate spring back on the final forming, a 90° shaping roller is added in the last pass. The roll spacing is set to 400mm, the shell element S4R is selected for the sheet metal grid, and the forming corner area is locally refined, as shown in Fig 3. Since the deformation of roll can be ignored, analytical rigid body is selected for modeling. In order to improve the simulation efficiency, the roll motion speed is set to 2000mm/s and the total simulation time is set to 2.4S. The general assembly drawing is shown in Figure 4.

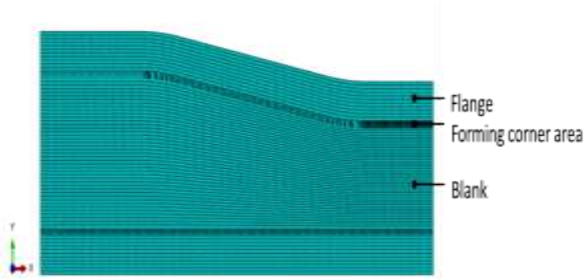

FIGURE 3: Mesh generation of blank

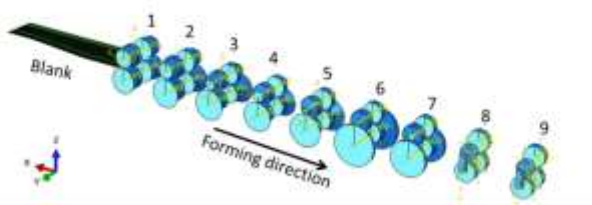

FIGURE 4: Finite element model of flexible roll forming

Analysis of simulation results

The stress cloud Figure 5 of the plate is shown in the figure. It can be seen from the figure that the stress increases gradually from bottom to top, with the lowest stress value and the highest stress value. It can be seen from the figure that the stress is concentrated on the flange, and the maximum value is 647MPa, while the stress of the part that does not need to be formed in the middle of the longitudinal beam is almost zero, which is consistent with the actual situation. The stress on the flange is greater than the yield stress, which indicates that the plastic strain occurs in the flange of the plate, and the forming result meets the actual requirements.

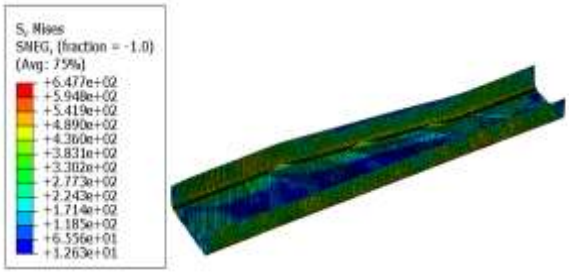

FIGURE 5: Stress nephogram

The cloud diagram of equivalent plastic strain is shown in Figure 6. In the figure, the equivalent plastic strain at the corner is the largest, and there is strain at the edge of the flange. With the larger the angle of the corner, the greater the value of the equivalent plastic strain, which is consistent with the theoretical situation.

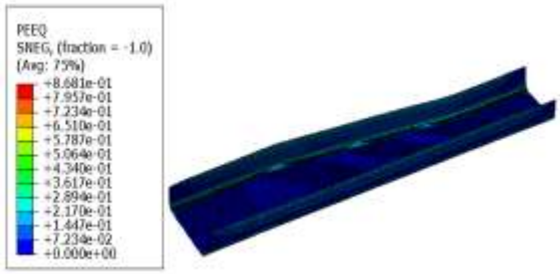

FIGURE 6: Strain nephogram

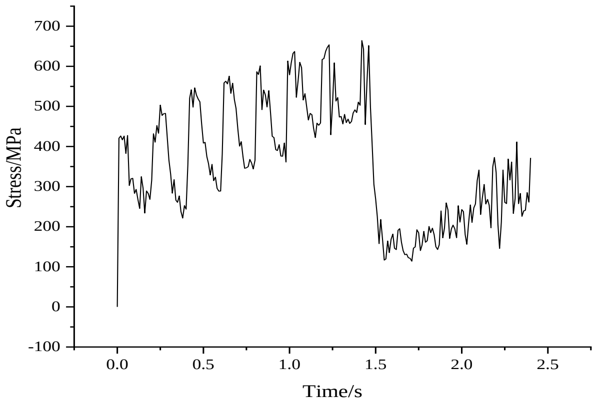

FIGURE 7: Stress history curve of the forming corner area

Figure 7 shows the variation law of stress in the forming corner area. When the roll is about to pass or is passing through the plate, the stress increases, and when the roll is separated from the plate, the stress decreases. When the sheet forming time exceeds 1.5s, the initial meshing section of the sheet has been formed and separated from the milk roller, but it is still affected by the subsequent sheet forming stress, so the stress in the forming corner still exists, and its stress is far lower than the yield strength of the material.

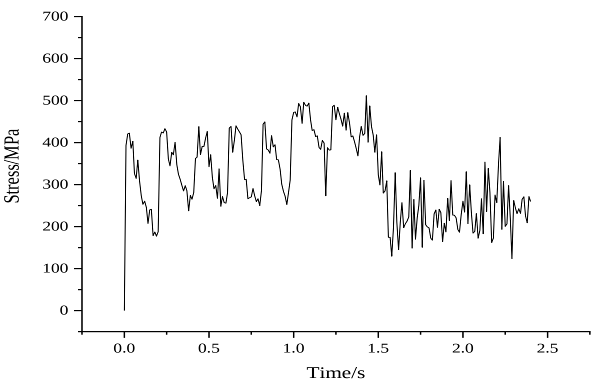

FIGURE 8: Stress history curve of the flange

As shown in Figure 8, the stress variation law in the flange area is shown. It can be seen that the overall stress is lower than that in the forming corner area, and the maximum stress is 489MPa. The overall trend is consistent with that in the forming corner area.

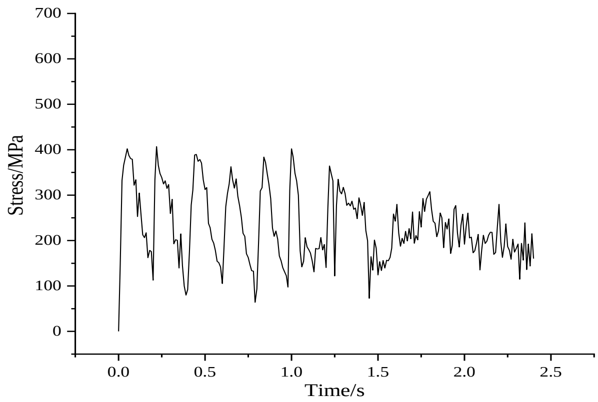

FIGURE 9: Stress history curve of the blank

As shown in Figure 9, the stress variation law in the web area is shown. It can be seen that the overall stress is lower than that in the forming corner area and flange area, and the maximum stress is 389MPa. The overall trend is consistent with the first two.

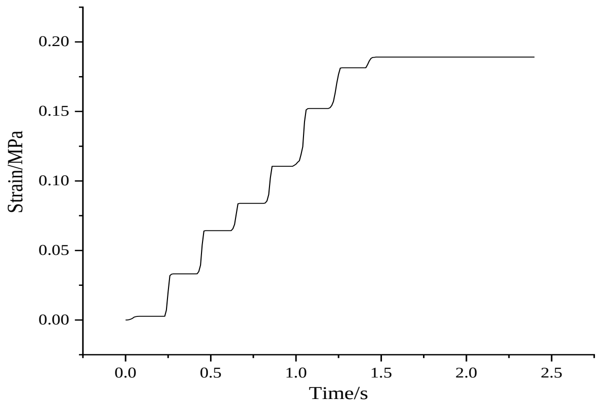

FIGURE 10: Strain history curve of the forming corner area

Figure 10, is the equivalent plastic strain change history curve with node number 35001 in the forming corner area. The figure shows that the maximum equivalent strain of the sheet in the forming corner area gradually increases with the increase of passes. It can also be said that the equivalent plastic strain of the sheet increases with the increase of forming angle, and the maximum value is 0.19.

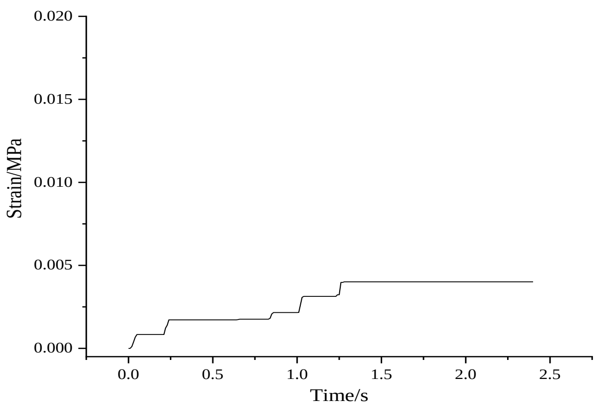

FIGURE 11: Strain history curve of the blank

Figure 11, is the equivalent plastic strain change history curve with the node number of 10035 in the web area. The figure shows that the maximum equivalent effect of the plate in the web area gradually increases with the increase of passes, and the trend is consistent with the forming corner area, but the maximum value is much smaller than the forming corner area, and the maximum value is 0.0017.

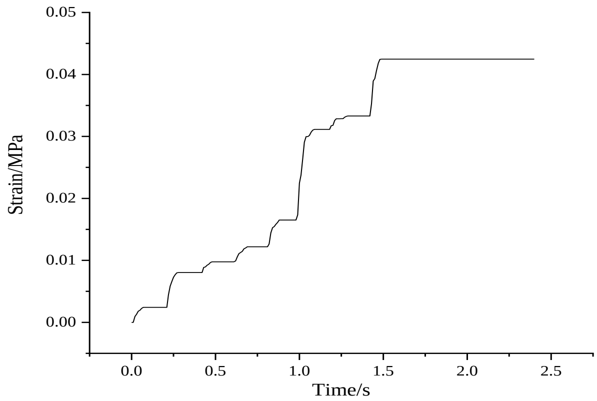

FIGURE 12: Strain history curve of the flange

Figure 12, is the equivalent plastic strain change history curve with node No. 40435 in the flange area. The figure shows that the maximum equivalent effect of the plate in the wing plate area gradually increases with the increase of passes, and the trend is consistent with the first two, but the maximum value is between the two, and the maximum value is 0.042.

CONCLUSIONS

This paper mainly uses ABAQUS software to simulate the sheet roll forming process, and analyzes the stress and strain in the simulation results to predict the change state and forming performance in the sheet roll forming process.

By simulating the distribution of stress and equivalent plastic strain in the process of sheet roll forming, it is concluded that the stress and plastic strain in the forming corner area are much higher than that in the web area and flange area, followed by the flange area and finally the web area. The simulation results show that the forming condition of the longitudinal beam is good. Using the simulation software to simulate the roll forming of the variable section longitudinal beam can effectively reduce the cost and improve the production efficiency of the enterprise.

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