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Finite Element Simulation Study Based on Aluminum Alloy Sheet Rolling

Haijie Hong, Yongxian Ma

School of Materials Science and Engineering, Jiangsu University, Zhenjiang, Jiangsu, 212013, China

Abstract: *This paper explores the influence of the processing parameters setting on the aluminum alloy sheet rolling process with the help of finite element simulation, and mainly carries out the design and numerical simulation process of aluminum alloy sheet rolling processing, and carries out the manufacturing production and processing process from the way of finite element analysis, optimizes the processing parameters, improves the yield and production and processing efficiency, and thus brings great economic value.*

Keywords: *Aluminum Alloy; Plate Rolling; Finite Element; Numerical Simulation*

1. Introduction

With the development of industrial modernization, higher requirements have been placed on the production technology of manufacturing industry. Aluminum alloy has high strength, processing and molding, heat and corrosion resistance, etc., and plays a pivotal role in aerospace, aviation and other defense applications [1]. At present, China focuses on developing the research and development of metal materials and optimizing the production and processing technology, firstly, improving the mechanical [2] properties of metal materials in practical applications through composition design; secondly, adding elements to the surface of metal materials or forming dense surface micro-nano structures [3] with the help of surface treatment to achieve the improvement of the overall performance of materials, but it is still at a disadvantage compared with the advanced foreign metal material production and manufacturing technology, especially The production and processing technology of aluminum alloy.

This paper mainly explores the influence of processing parameters on the aluminum alloy sheet rolling process with the help of finite element simulation, and simulates the design of aluminum alloy sheet rolling processing and manufacturing production processing, so as to greatly improve the yield and production processing efficiency and obtain greater economic value by optimizing the processing parameters.

2. Physical modeling of the aluminum alloy sheet rolling process

Table 1: Aluminum alloy sheet performance parameters

Yield strength	Tangential modulus	Young's modulus	Bulk modulus	Shear modulus	Poisson's ratio
280MPa	500MPa	71GPa	69.6GPa	26.7GPa	0.33

Table 2: Aluminum alloy sheet rolling parameters

Upper roll diameter 1d/mm	Upper roll diameter 2d/mm	Variable speed ratio I= $_1d/d_2$	Roll angular speed ω(rad/s)	Initial length of rolled plate L/mm	Initial thickness of rolled plate h/mm	Depression rate r (%)
100	100	1.0	1.57	100	5	0,20,...50

Rolling of aluminum alloy sheet is a process in which the aluminum alloy sheet is compressed between two rotating rolls to produce violent plastic deformation. Aluminum alloy sheet can be set by the parameters of the rolling process to obtain the desired size and shape of the product, the specific parameters of aluminum alloy sheet are shown in Table 1. The research in this paper is to simulate the cold-rolling test mill and perform finite element simulation of the aluminum alloy sheet rolling process. Among them, the type of mill used for aluminum alloy rolling is a common two-roller mill, two rolls powered by an electric motor, both belong to the active rolls, and the two rolls have the same diameter

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and equal speed, the specific rolling parameters are shown in Table 2. The physical model of aluminum alloy sheet rolling process is shown in Fig.1

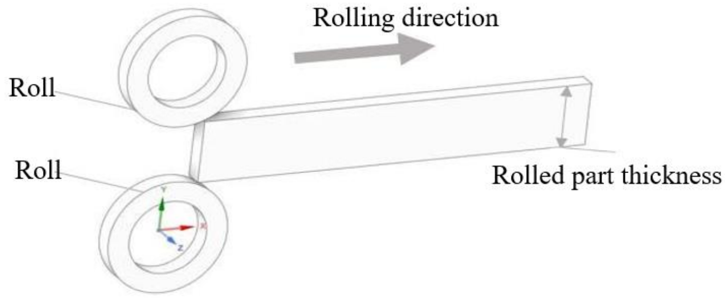

Figure 1: Physical model of the aluminum alloy sheet rolling process

3. Finite element modeling of aluminum alloy sheet rolling

In actual production applications, it is difficult to study the plastic deformation of aluminum alloy sheet rolling process and optimize the rolling process. The traditional production site relying on production experience to adjust the processing parameters will cause a lot of waste of resources and increase the cost of research and development, therefore, the finite element simulation method can be used to achieve the theoretical calculation of aluminum alloy sheet rolling process and the debugging and optimization of rolling processing parameters. The key steps of finite element simulation of aluminum alloy sheet rolling process include: (1) establish physical model. ANSYS19.0 analysis software modeling tool is used, and according to the size of the test prototype to establish the physical model of the drive roll, work roll, rolling parts, etc., as shown in the Fig. 2. (2) Setting of material properties. The two roll materials are determined according to the actual work requirements and the choice of structural steel materials, ideal conditions can ignore the deformation of the roll, therefore, the work roll material is selected with a certain degree of elasticity. Aluminum rolls mainly produce plastic deformation in the rolling process, but also consider its process hardening, choose isotropic follow-hardening processing model. (13) Dividing the mesh. For finite element analysis, the mesh division is one of the most critical steps, the mesh division directly affects the accuracy and speed of the solution. There are three steps in meshing: defining the cell properties (including real constants), defining the mesh properties on the geometric model, and dividing the hexahedral mesh, as shown in Fig. 3. (14) Define the contact. The contact process often sets up three kinds of nonlinearities at the same time, in addition to the material nonlinearity and geometric nonlinearity caused by large deformation, there is also the nonlinearity of the contact interface. The basic process in the finite element simulation of the contact problem is to first define the contact type, this model uses explicit face-to-face contact, the active surface is the outer surface of the two work rolls, the passive surface is the upper and lower surface of the rolled part, respectively, to establish two contact pairs. Then comes the definition of contact properties, which mainly include the tangential and directional effects between the contact surfaces, where the relative sliding relationship between the two contact surfaces and the friction model are the important factors affecting the contact relationship. (52) Define the boundary conditions and loads. According to the physical model to add boundary conditions for the finite element model, the roll has no displacement in the width direction, the rotating roll has only the motion in the rotation direction, and the rotating roll defines a rotation speed according to the actual roll speed.

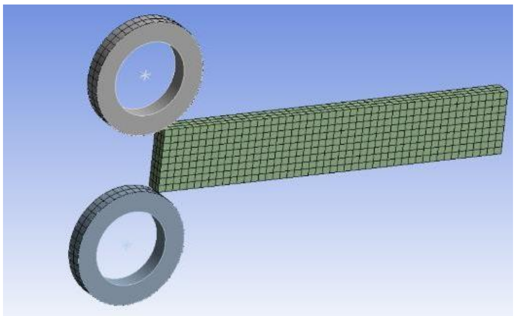

Figure 2: Meshing of aluminum alloy sheet rolling simulation process

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The use of finite element simulation greatly reduces the R&D cost and improves the efficiency. In this paper, a specific finite element simulation was carried out based on the field test simulation prototype, and the sub-step convergence results are shown in Fig. 4 (a) shows the process of force convergence with the cumulative number of iterations in the finite element simulation, specifically the force in a certain range for fluctuation change4. (b) shows the change of time with the number of cumulative iterations, and the time required increases with the increase of the number of cumulative iterations.

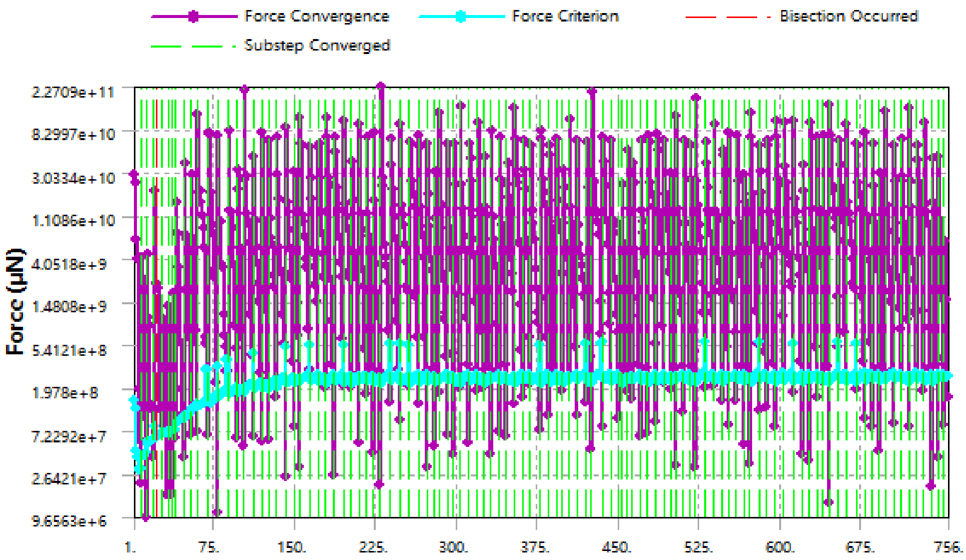

Figure 3: Finite element simulation of aluminum alloy sheet rolling process

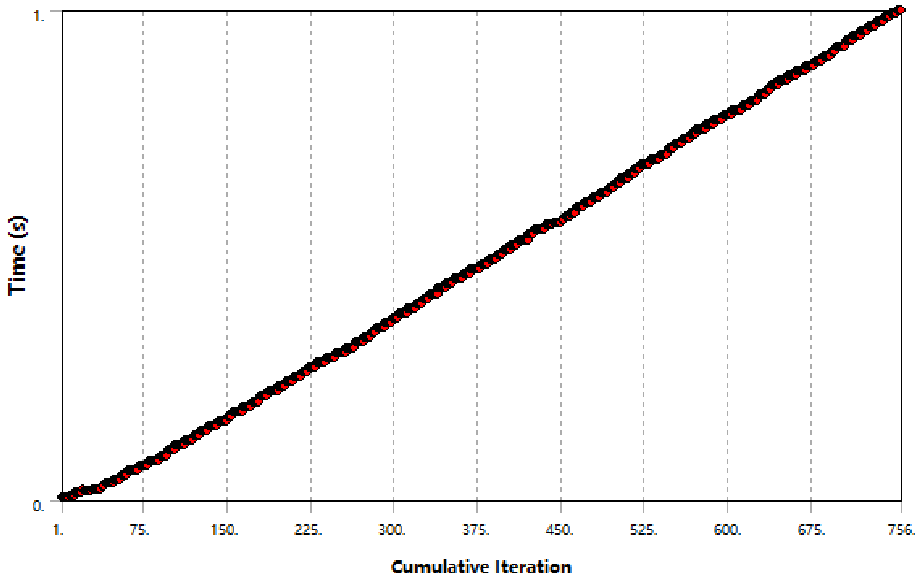

Figure 4: Finite element simulation of aluminum alloy sheet rolling process

Further simulation analysis of the total deformation of the aluminum alloy sheet rolling process is shown in Fig 5. According to the results of finite element simulation, it can be seen that the deformation of the aluminum alloy sheet in contact with the rolls is larger in the process of the rolls advancing with the rolling direction, and the deformation along the rolling direction increases gradually, and the maximum deformation can reach 95.29 mm. The elastic strain results are shown in Fig.6. The elastic strain at the contact position with the roll is higher, and the elastic strain at the center of the sheet away from the roll and the end of the sheet is smaller. The results of the equivalent force are shown in the Fig. 7. The equivalent force along the rolling direction and in contact with the roll is larger, and the maximum equivalent force can reach 455.6MPa, while the equivalent force away from the center of the roll and the end of the plate is smaller.

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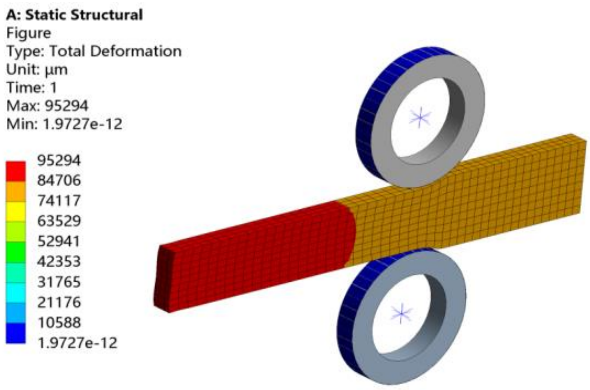

Figure 5: Total deformation during rolling of aluminum alloy sheets

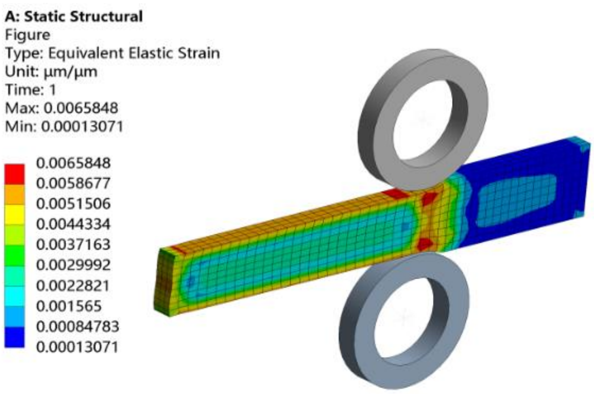

Figure 6: Elastic strain results

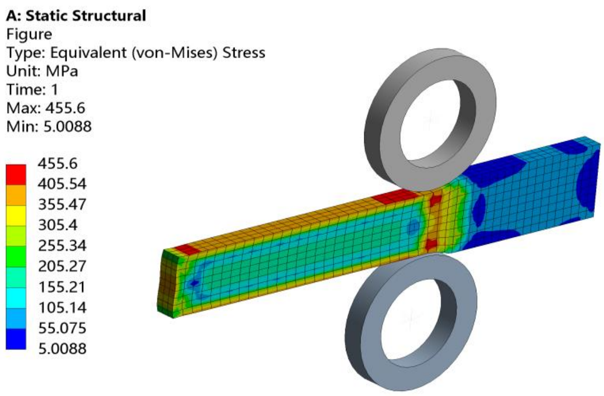

Figure 7: Equivalent force results

4. Conclusion and Outlook

This paper uses ANSYS 19.0 software for finite element simulation of aluminum alloy sheet rolling process. Combined with the actual rolling prototype, the numerical simulation finite element simulation was established, and the parameters set were continuously optimized by the measured data in the field. On the whole, the finite element simulation results of the aluminum alloy sheet rolling process are convergent, and the results show that the deformation of the aluminum alloy sheet in contact with the rolls is larger in the process of the rolls advancing with the rolling direction, and the deformation along the rolling direction increases gradually, and the maximum deformation can reach 95.29mm. The elastic strain and equivalent force along the rolling direction and in contact with the rolls are larger (the maximum equivalent force can reach 455.6MPa). The elastic strain and equivalent force at the center of the plate away from the roll and at the end of the plate are smaller. The model can be applied to the simulation analysis of the actual processing of aluminum alloy plate, and the process parameters can be optimized continuously to investigate the influence of the process parameters on the deformation and

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stress of the rolled plate, which can avoid the processing defects caused by pores or other defects in the ingot and greatly reduce the probability of defective products in the rolling process. Therefore, finite element simulation of rolled plates brings great economic benefits to the processing and manufacturing of metal materials.

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