Finite Element Analysis of Power Spinning and Spinning Force for Tube Parts

Yang Yu[12], Xu Hongji[1]

1.Changchun University of Science and Technology, 130022,Changchun, Jilin,China

2.The 55th Institute of China North Industries Group Corporation, 130012, Changchun, Jilin,China

yangyu1983@sina.com

Abstract

The quality of spinning forming parts is closely related to the selection of spinning forces. In this paper, we use the finite element numerical simulation technology, establish a three-dimensional model and carry out a finite element analysis, to realize the simulation of variations of tube spinning parts' spinning forces with composite bars. This method provides a theoretical basis for selecting an accurate spinning force, and has a great significance for improving the spinning forming quality and productivity.

***Key words**: Power Spinning for Tube parts, Spinning Force, Finite Element Analysis*

1. Forewords

Spinning fabrication for tube parts refers to get a plastic working process [1] of hollow rotating parts, through semi-finished product mounted on the mandrel rotates along with the mandrel, at the same time, it revolves round semi-finished product with spinning tools, and there will be a relative feed between spinning tool and mandrel, which produces a press force on the semi-finished product that will produce a continuous deformation. The quality of spinning forming parts is closely related to the selection of a spinning force. The selection of spinning forces depends mainly on the experience of scientists in the nation, but also need to go through a lot of spinning experiments on the process parameters to be amended, which have wasted a great deal of resources and time[2]. In this paper, we use finite element numerical simulation techniques, through the establishment of a model and doing a finite element analysis to achieve the selection of an accurate size of the spinning force.

2. Establishment of Finite Element Mold

The motion trajectories of the spinning roller when spinning can be simplified for a space spiral movement [3], as shown in Figure 1.

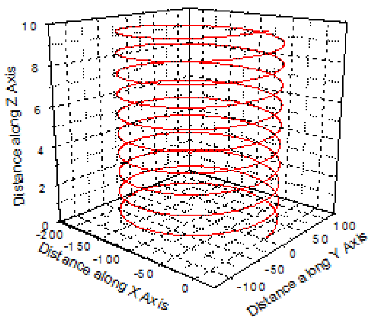


Figure 1, Space Spiral Motion of Spinning Roller

Its equation of motion is:

$$\begin{cases} x = d\cos\theta - d \\ y = d\sin\theta \\ z = z \end{cases} \qquad (1)$$

Where: θ means the rotated angle of the spinning roller; d means the distance between the centers of semi-finished product and spinning roller; z means the feeding distance along spinning roller's axis.

The establishment of three-dimensional models for rough parts, the mandrel, as well as spinning rollers, is shown in Figure 2.

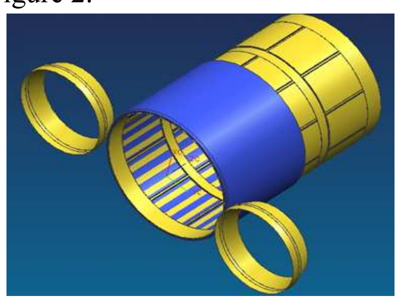
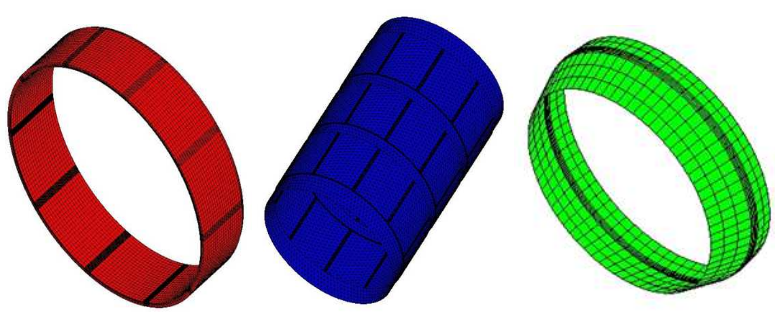


Figure 2, Three-dimensional models for semi-finished products, the mandrel, as well as spinning rollers

Carry out the finite element network dividing for three-dimensional models using FEM. As shows in Figure 3, a) the semi-finished product, b) the mandrel, c) the spinning roller



a) b) c)

Figure 3, FEM molds for semi-finished products, mandrel and spinning rollers

See table 1 for experimental conditions of double-roller stagger spinning of tube parts.

Table 1 Experimental Conditions

Rotate speed of main Axis	200r/min
Double-roller stagger spinning	3mm
Spinning roller contact angle	20°
Feeding capacity	150mm/min
Reducing rate	50%
Semi-finished product materials	StⅧu

3. Finite Element Simulation Results

Because use tube parts with composite ribs to do the spinning simulation, it is need to solve the longitudinal and transverse reinforcement bars of tube parts respectively.
Figure 4 shows the forming process of the longitudinal reinforcement section.

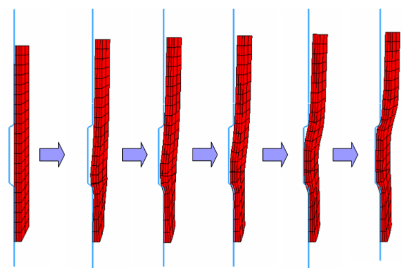


Figure 4, Forming Process of Longitudinal Reinforcement Section

Figure 5 shows the mean stress of the longitudinal reinforcement section.

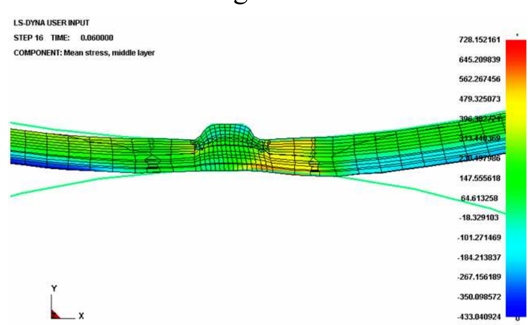


Figure 5, Mean Stress of the Longitudinal Reinforcement Section

Figure 6 shows the Mises stress of the longitudinal reinforcement section

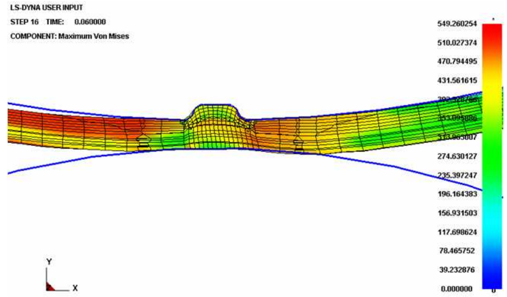


Figure 6, Mises Stress of the Longitudinal Reinforcement Section

Figure 7 shows the forming process of the longitudinal reinforcement section

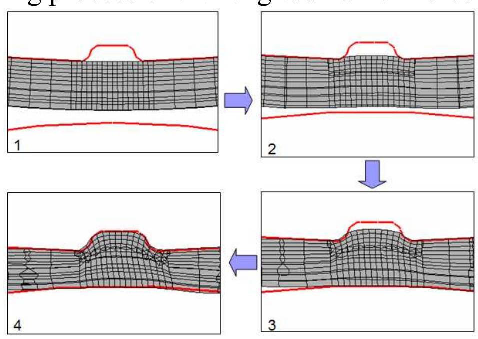


Figure 7, Forming Process of the Longitudinal Reinforcement Section

Figure 8 shows the mean stress of the transverse reinforcement section

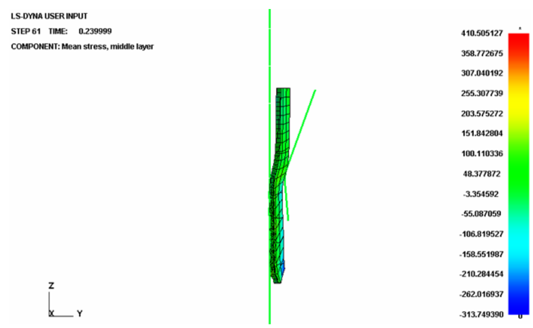


Figure 8, Mean Stress of the Transverse Reinforcement Section

Figure 9 shows the Mises stress of the transverse reinforcement section

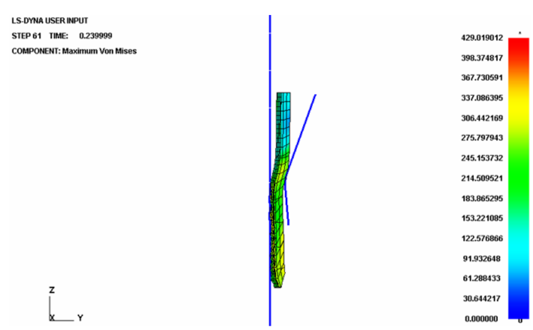


Figure 9, Mises Stress of the Transverse Reinforcement Section

Axial deformation as shown in Figure 10

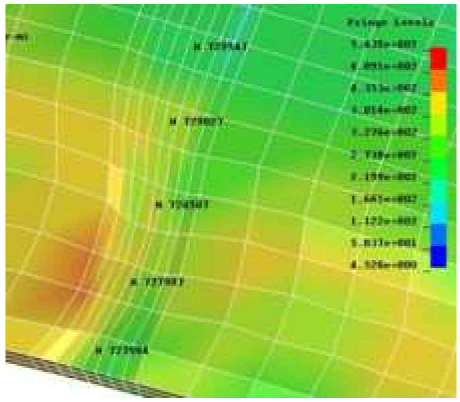


Figure 10, Axial Deformation

Radial deformation is shown in Figure 11.

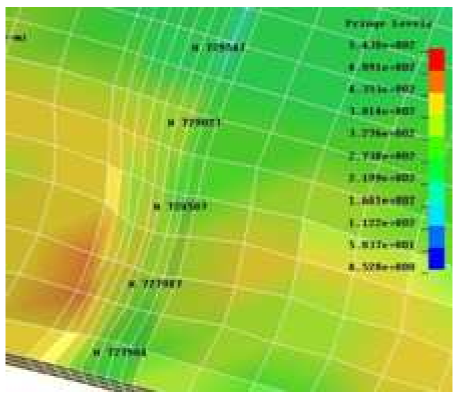


Figure 11, Axial Deformation

Tangential distortion is shown in Figure 12.

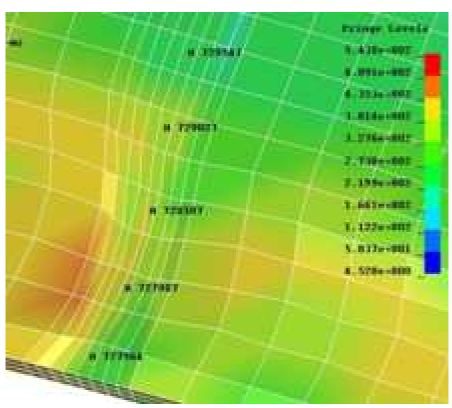


Figure 12, Tangential Distortion

4. Thamastt Algorithm for Calculation of Spinning Force

Thamastt algorithm is based on the similarity calculation of rolling forces, the difference is:

deformed materials flow along the direction of development when pressing, while materials flow along the direction of spinning when power spinning.

The value of Radial force with Thamastt Algorithm is：

$$P_r = \Delta t ctg\alpha_p \sqrt{R_y f tg\alpha_p} \frac{\overline{\sigma_m}}{\eta} \tag{2}$$

Axial force：

$$P_z = \Delta t \frac{\overline{\sigma_m}}{\eta} \sqrt{R_y f tg\alpha_p} \tag{3}$$

Tangential force：

$$P_i = \Delta t f \frac{\overline{\sigma_m}}{\eta} \tag{4}$$

The calculated results of the longitudinal reinforcement cross-section spinning force are shown in Table 2.

Table 2, Calculated Results of Longitudinal Reinforcement Cross-section Spinning Force

Measurement results	Axial force（N）	1653
	Radial force（N）	1879
	Tangential force（N）	190

The calculated results of transverse reinforcement cross-section spinning force are shown in Table 3.

Table 3 Calculated Results of Transverse Reinforcement Cross-section Spinning Force

Measurement results	Axial force（N）	1702
	Radial force（N）	4483
	Tangential force（N）	167

5. Spinning Force Measurement Experiment

Measure the ongoing spinning force with the electrical measuring method, in order to make a comparison with the finite element simulation results.

The measurement results of the longitudinal reinforcement section spinning force are shown in Table 4.

Table 4 Measurement Results of Longitudinal Reinforcement Section Spinning Force

Measurement results	Axial force（N）	1470
	Radial force（N）	1520
	Tangential force（N）	137

The measurement results of the transverse cross-section spinning forces are shown in Table 5.

Table 5 Measurement Results of the Transverse Cross-section Spinning Force

Measurement results	Axial force（N）	1578
	Radial force（N）	3381
	Tangential force（N）	111

6. Conclusions

Through comparing the finite element simulation results with the Thamasett algorithm calculation results of spinning forces, the finite element simulation results are differ slightly from the Thamasett algorithm calculation results of the spinning force, and in line with the spinning force measurement experimental results. It means that the finite element simulation of spinning forces can provide a scientific basis for selecting an exact size of spinning force. It has a great significance for improving the spinning forming quality and productivity.

References

[1] Zhao Yunhao, Li Yanli. Spinning Technology and Applications. Beijing Mechanical Industry Press, 2008:5 ~ 6

[2] Liu Fen-ni. Tube Part Spinning finite Element Analysis: [a master's degree thesis]. Chengdu Sichuan University, 2006

[3] Chen Shixian. Analysis of Plastic Flow Field and Spinning Force of Tube-shaped Parts. Journal of Mechanical Engineering. 1982, 18 (3): 41 ~ 50

Biographical notes

YangYu, China. born in 1983. respectively got bachelor, master degree in Changchun University of Science and Technology,2006and 2009, now he is a doctor student in Changchun University of Science and Technology, work in the 55th Institute of China North Industries Group Corporation, for the main research direction of powerful spinning.

Tel:13604411193; E-mail:yangyu1983@sina.com