Research on Defects of HastelloyC-276 Tube Stagger Spinning Process

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Abstract: The simulation of hastelloy-c276 tube stagger spinning process was carried out by the finite element software of simufact to reveal the reason of defects of the tube. The magnitudeand variation rule of uplift and diameter extension defects were analyzed under different technical parameters. Experiments were also performed to verify the validity of the simulation results. Whenfeed ratio is0.8 mm/roundat the end of the processthe other processchoose 2.0 *mm/round* , the forming angle of the roller is in the range of 25º~30º,reducing rate is 30%,there are smaller and homogenous equivalent stress, smaller bulge and diametral growth as well as steady spinning process. The results is helpful to the optimization of the practice productionand we successfully spinning out tubular product which meet the requirements.

Introduction

Spinning is a pressure processing method of forming hollow thin-wall revolving body parts,it has been used in aviation, aerospace, engineering machinery and other fields.The offset spinning is more than one wheel in axial, it has stagger distancein axialand radialtoundertakethequantityoftheprocedure.Compared with the general power spinning, offset spinning can improve the production efficiency, improve the dimensional accuracy and shape of the spinning parts precision and surface quality[1,2,3].But the influencing factors on the quality of the offset spinning has a complicated relationship with each other, reasonable forming process parameters selection become more difficult , such as cracking, wrinkling, uplift, end defects, expanding[4].Because of the complexity of the spinning process and parameters of diversity, at present about the high precision piece of power spinning process parameters are still largely by the designer's experience and a lot of process test to determine,so that subjectivity and uncertainty is bigger, manpower and material resources waste is bigger also. Based on this to do dynamic simulation for the process of spinning is necessary,analysis of different process parameters effects on the tube stress and strain, and the impact of possible defects, to determine the selection of technological parameters, provide a basis for the design of spinning equipment and tools.

The Establishment of the Model

Based on the finite element software simufact thin-walled tube spinning simulation numerical model is established. In order to simplify the calculation, the model to do the following assumptions: (1) the materials use the model of isotropic and homogeneous;(2) ignore the deformation of the thermal effect influence;(3) ignore the influence of gravity and inertia. Meshing the thin-walled tubemodel by usingringmersh module; set mold and mandrelto the rigid body, thin wall tube blank is set to the elastomer, using backward spinning sotail end fixed;the friction between the workpiece and mandrel and the friction between the wheel and the workpiece were picked from the revised coulomb friction model.

Thin wall pipe materials used for hastelloyC - 276 alloy, according to the sheet metal tensile test, the true stress - strain curve is shown in figure 1, other mechanical properties listed in table 1.

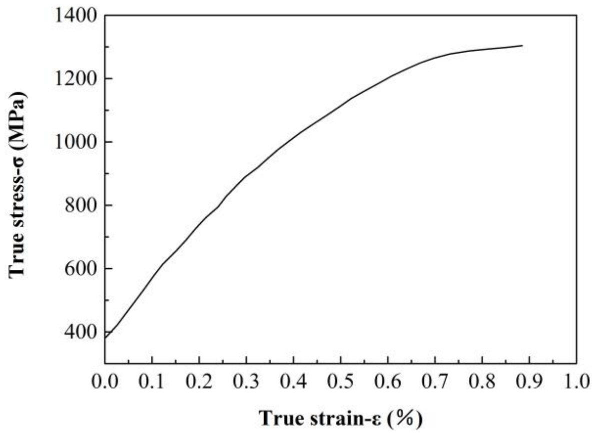


Fig 1.The true stress-strain curve of hastelloy c-276 alloy

Table 1 Mechanical properties

Density/[kg·m^{-3}]	Poisson ratio	Elastic modulus/[MPa]	Limit of yielding/[MPa]	Tangent modulus/[MPa]
8890	0.307	205000	347	79000

Change the spindle speed, the speed of feeding process parameters, such as multiple simulation, analysis of simulation results, the study of the influence of various process parameters on the spinning deformation stability.

The Results of Simulation and Analysis

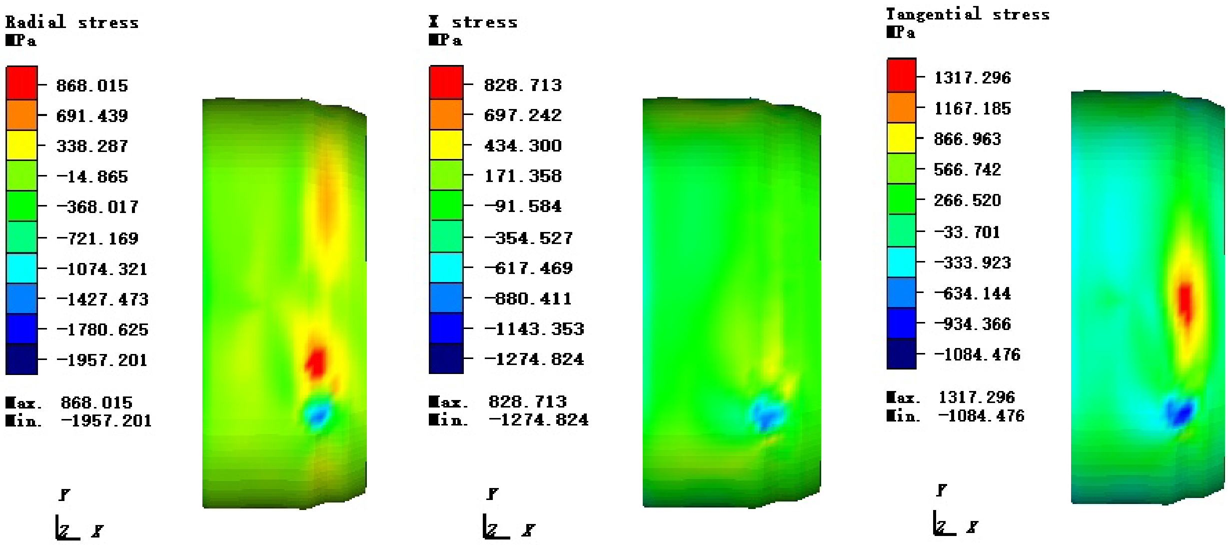
Change the process parameters to analysethe influence of them on simulation results, study of the influence of various process parameters on the spinning deformation stability.

The uplift Defects Analysis of Tube Stagger Spinning

The uplift defects is the common defects in power spinning, show the metal accumulation in front of the wheel .The uplift degree usually expressed as a factorξ.

$$\xi = (t-t0)/t. \qquad (1)$$

Figure 2is the state of triaxial stress field distribution and the equivalent stress and equivalent strain field distribution,take the cross section measuring the uplift height shown as figure 3.



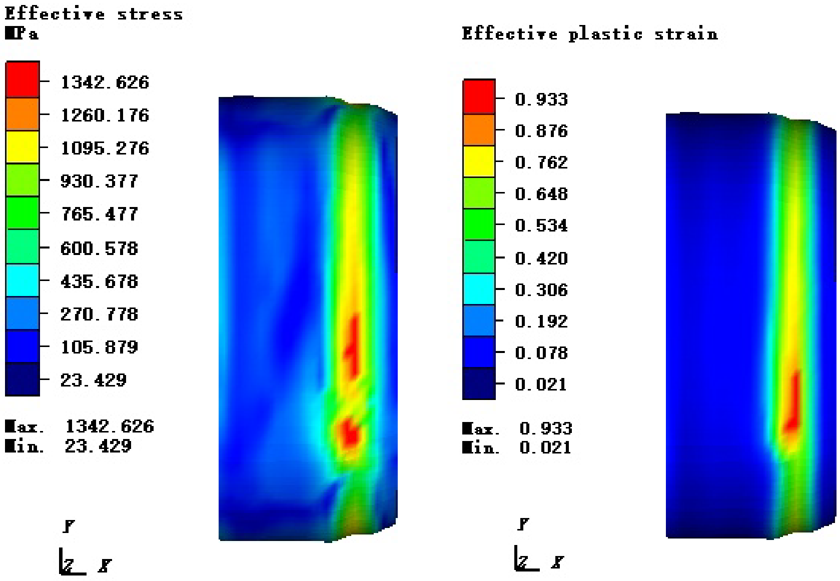


Fig 2. Stress and strain field distribution

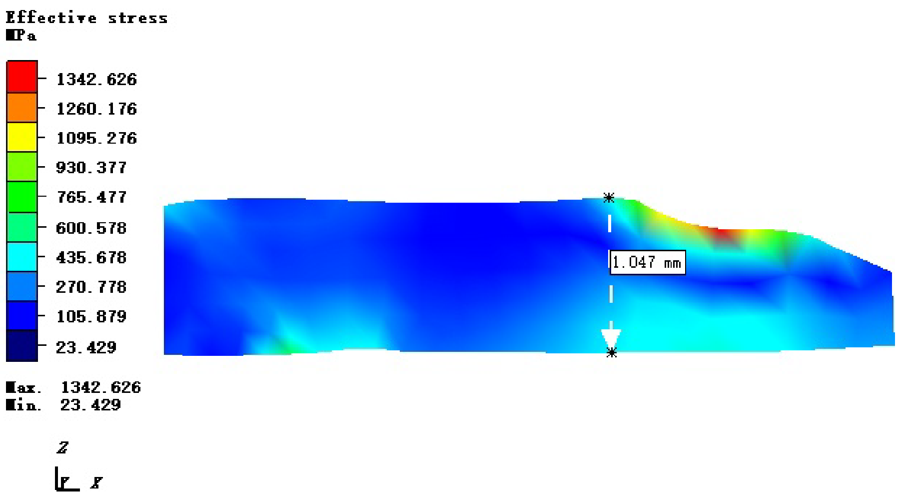


Fig 3. Take the cross section uplift measurement

There are many factors that affect stagger spinning uplift: thinning rate, the feed ratio *f*, roller roundness radius *r*, wheel forming angle *n*[5,6,7] figure 4 for the above the influence law of process parameters on the uplift rate of simulation results.

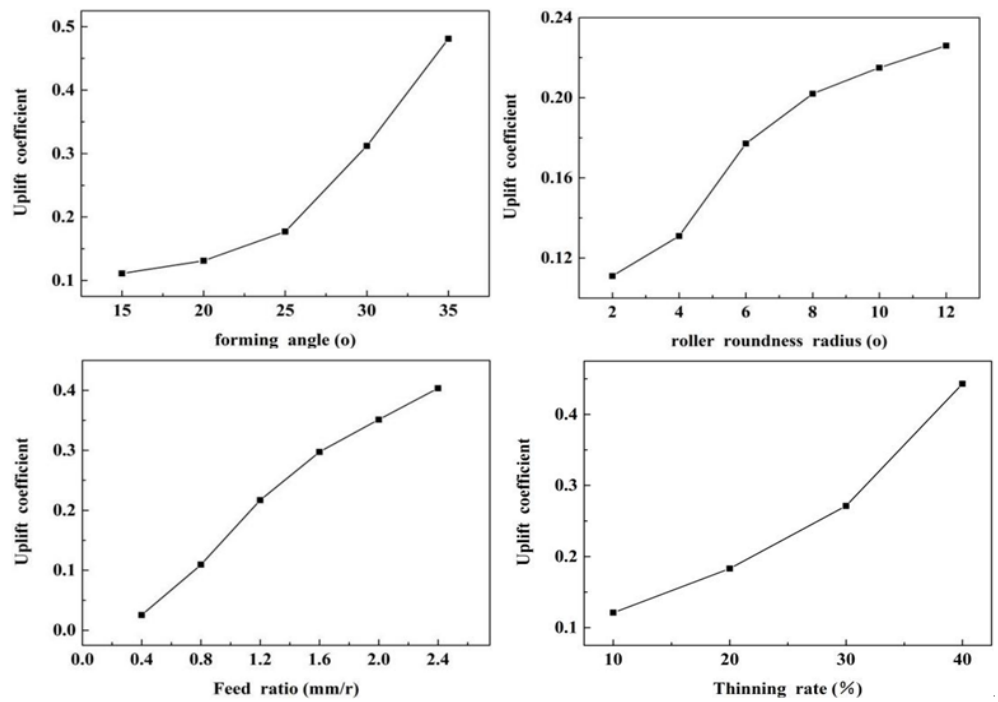


Fig 4. Uplift coefficient under different parameters

When α_ρ=25°~30°, *f=0.8mm/r*, the uplift height is small and spinning deformation is stable, spinning forming effect is good.

From the figure 4 we can see that with the increase of forming angle and roller roundness radius, uplift coefficient increases gradually. When the forming angle greater than *30°*, the radius is more than *10 mm*, uplift is more serious; with the increase of feed ratio and thinning rate, uplift coefficient increasing obviously.Therefore, reduce the forming angle and choose a reasonable thinningrateisthe strong measures to reduce uplift defects.

What's more,with the increase of thinning rate and feed ratio, uplift coefficient were increased. When feed ratio more than *0.8mm/r*, thinning rate greater than *30 percent*, the uplift is greatly increased. The generation of uplift associated with spinning force, when uplift large axial spinning force is bigger also,this will lead to large pressure, increase equipment load, and easy to make the billet cracks.

After the results of numerical simulation analysis, we know that the wheel forming angle should choose*25°∼30°*,radius should choose 10 *mm*; thinning rateshould choose *30%*. In this condition the rotating pressure isin the middle value and uplift height issmaller, spinning forming process is in a state of good stability.As to the feed ratio, because of it has a great influence on expanding diameter so we will have a specific discussion in the following section.

The Expanding Diameter Defects Analysis of Tube Stagger Spinning

The diameter of workpieceand its numerical fluctuation is the main factor that affected the accuracy of spinning parts in the spinning process .Expanding cause greater error of the size and cylindricity ofthe spinning parts.Control of tube diameter is the key to the spinning forming [8].Choose stable spinning stage under different parameters then take cross section, measure its diameter, as shown in figure 5.

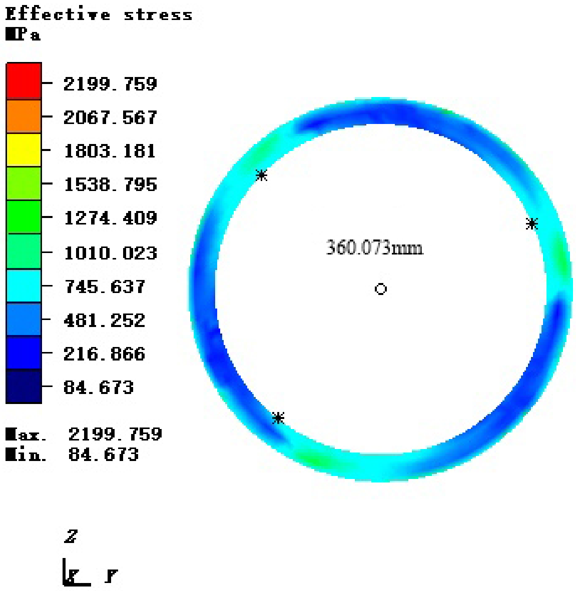


Fig 5. Inside diametercross sectionmeasurement

Figure 6.shows the influence curveon the diameter expansion in different process parameters.

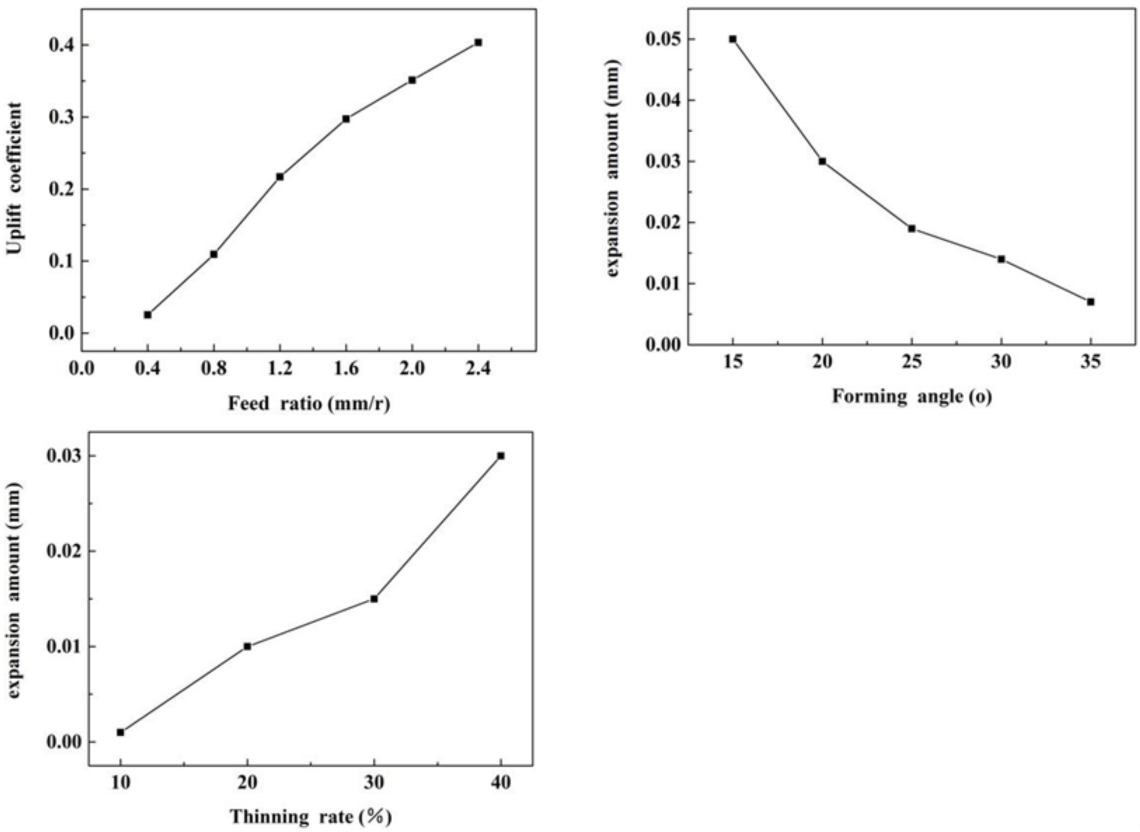


Fig 6.Expansion amount under different parameters

As is shown, with the increase of feed ratio, the expansion of the inner diameter decreased. This is because the large feed ratio condition cause axial flow of metal under the wheel is more faster, the tangential deformation decrease. Secondly, with the increase of wheel forming angle, diametersize present decreasing trend. what's more,with the increase of thinning rate, inner diameter size quantity increasing trends. From the above we know that feed ratio affect the most obviously. Therefore at the end of the processfeed ratiochoose 0.8 *mm/r*, it is advantageous todemould, the rest choose 2.0 *mm/r*to increasethe fittabilitythus to improve the quality of the workpiece.

Experimental Verification

Materials and Equipment

Experiment materials: nickel base alloy C - 276;Experimental equipment: QX63-400CNC power spinning machine;Process parameters: according to the result of numerical simulation of the selected (see table 2).

Table 2.Process parameters

Diameter of coremould d/mm	Spin roller fillet radius r/mm	Spindle speed v/(r.min^{-1})	Spinning pass m	Spin roller feedrate f/(mm/min^{-1})
400	6	180	2	40

The Result of the Experiment and Analysis

Large diameter-thick ratio experiment was conducted under the above conditions, successfully spinning out diameter-thick ratio of 1000 nickel-based alloy tube, after spinning the product surface is smooth, no crack and peeling phenomenon, but there are bright spinning lines, only in the end position have small helical form bulging, the product meet the test requirements(see figure 7). For *x*-ray scanning detection not found macro micro defects, using ultrasonic thickness gauge measuring wall thickness The measured results for spinning pieces of wall thickness measurement error is less than ±0.03 mm, error of±0.1 mm in diameter, satisfies the requirement of shielding pump use.

Fig 7. Large diameter-thick ratio tube

Conclusion

When the feed ratio more than 0.8 mm/r, forming angle greater than 30 °, the uplift is greatly increased. The wheel forming angleshould bein the range of25°~30°; radius should be 10 mm; at the end of the process,feed ratio should be in the range of0.5~ 0.8mm/r, it is advantage todemould, the other process should be2.0 mm/rfor snuggling closely to the mould to improve the quality of the workpiece; thinning rate should be30%.In this way there are smaller and homogenous equivalent stress, smaller bulge and diametral growth as well as steady spinning process.

We spinning out diameter-thick ratio of 1000 hastelloy C-276 alloy tubesuccessfully, after spinning workpiece surface is smooth, no crack and peeling phenomenon, but obvious spinning lines.

References

[1] Xia Q, Cheng X, Long H, et al. The International Journal of Advanced Manufacturing Technology, 2012, 59(1-4): 263-272.

[2] C.C. Wong, T.A. Dean, J. Lin, Int. J. Mach. Tools Manuf. 43 (2003) 1419–1435.

[3] K.X. Chen, W.D. Jia, G.S. Cao, H.W. Zhao, Beijing, 1986 (in Chinese).

[4] Ma F, Yang H, Zhan M. Journal of Materials Processing Technology, 2010, 210(1): 180-189.

[5]Ma F, Yang H, Zhan M. Materials Science Forum. 2007, 561: 885-888.

[6]Hua F A, Yang Y S, Zhang Y N, et al. Journal of Materials Processing Technology, 2005, 168(1): 68-74.

[7]Teng-lun Z, HUANG J, ZHANG Q, et al. Forging & Stamping Technology, 2008, 1: 020.

[8]Xue K, Wang Z, Lu Y, etal.Journal of Materials Processing Technology, 1997, 69(s 1–3):172-175.