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EFFECT OF PROCESS PARAMETERS ON FORMING QUALITY OF Mg ALLOY(MZ21)-Al ALLOY(7075) COMPOSITE PIPE

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This paper mainly studies the effect of process parameters on the deformation mechanism of MZ21 magnesium alloy and 7075 aluminum alloy bimetal composite pipe in spinning process.The two parameters of spinning, the rotary wheel feed ratio and the double tube wall thinning rate were selected to study, and the influence rule of each process parameter on the forming quality of composite tube was simulated by Simufact software. Under different thinning rates of the total wall thickness, the coordinated deformation and the rebound law of the wall thickness of the composite pipe are obtained. The results provide a certain reference for the preparation of magnesium aluminum composite pipe and the selection of reasonable spinning parameters.

Keywords: composite pipe, MZ21-7075, process parameters, forming quality, simulation

INTRODUCTION

With the development of modern science and technology, more and more stringent requirements are put forward for the comprehensive performance of metal pipe: pipe can adapt to the complex service environment and appropriately reduce the production cost. Bimetal composite pipe has the best performance of two kinds of metal materials, giving full play to the excellent performance of two kinds of pipe, so that the bimetal composite pipe has been widely used in ocean pipeline, mechanical engineering, aerospace and other fields. Therefore, it is imperative to develop and study the forming process of metal composite pipe [1].

For the application of spinning composite technology to the study of bimetal composite pipe forming, many scholars have done a lot of work in this aspect: Mohebbi M S et al studied the influence of process parameters such as forming temperature, wall thickness thinning rate and spinning wheel forming Angle on the interface bonding strength of AA1050 bimetal composite pipe [2]. Zhang Zhipeng analyzed the influence of different process parameters on the bonding performance of bimetal composite pipe. The results showed that: with the increase of interface friction coefficient, the interface bonding strength of bimetal composite pipe increased. When the yield stress of the base pipe and the liner is close, the interface bonding of the bimetal composite pipe will be beneficial [3].

On the basis of the previous work done by scholars, this paper will explore the influence of spinning parameters on the deformation mechanism of MZ21 magnesium alloy and 7075 aluminum alloy bimetal composite pipe in the spinning process.

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PRINCIPLE OF SPINNING FORMING COMPOUND PIPE

The principle of strong spinning forming process for composite pipe is shown in Figure 1. The main body movement is driven by the workpiece with the core mold rotation, rotating wheel along the cylindrical workpiece axial feed, the selection wheel due to the action of friction, its own passive rotation. Magnesium aluminum composite pipe is formed by tangential and radial forces formed by radial and axial motion of the roller [4].

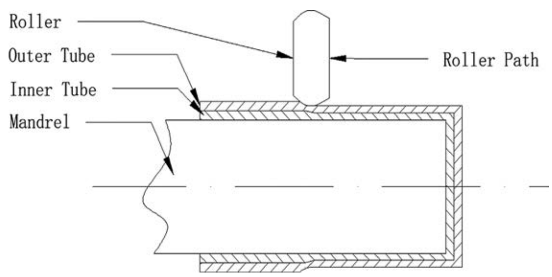

Figure 1 Schematic diagram of strong spinning

Because the billet of composite pipe has two layers, when its application scenarios are different, two layers of pipe with different thickness will be needed. Due to the different material properties of the two tubes, when the total thinning rate changes, the thinning rate of the two tubes is also different. And because the pipe is often used in a variety of assembly environment, so for the composite pipe, its surface quality and surface size error control is particularly important.

Therefore, the evaluation of coordinated deformation mechanism of composite pipes in this paper mainly summarizes the thinning laws of the two pipes under different total thinning rates. The surface quality of composite pipe is mainly analyzed from the flatness of pipe wall surface. The dimension error of the surface of the composite pipe mainly comes from the rebound rate of the wall thickness of the composite pipe.

FINITE ELEMENT SIMULATION MODEL

In order to explore the influence of process parameters on forming quality of composite tube spinning process, this paper selects two factors which have great influence on forming quality, namely, wheel feed ratio f and wall thinning ratio φ, under the conditions of spindle speed of 300 r/min and spinning temperature of 350°C. Three groups of data were selected for feed, and four groups of data were selected for wall thinning rate. The single-factor experimental parameters of seven groups were shown in Table 1.

Table 1 **Parameters of spinning model**

The parameter name	The numerical
Mandrel diameter/ mm	50
Spindle speed/ r/min	300
The spinning Temperature/ °C	350
Roller feed ratio/ mm/r	0,8/1,0/1,5
Thinning rates/ mas.%	5/7,5/15/30

The simplified model of spinning process is shown in Figure 2. In consideration of the assembly problems of composite pipe and the reasons for reducing the amount of calculation in the spinning process, the composite pipe is designed as a cylindrical part with a hole dug in the middle as shown in the following figure. In order to save time and reduce the amount of calculation, the blank that does not need to be analyzed is simplified, and then the proportion is reduced to 50 % of the original, and the length direction is further shortened by 50 %.

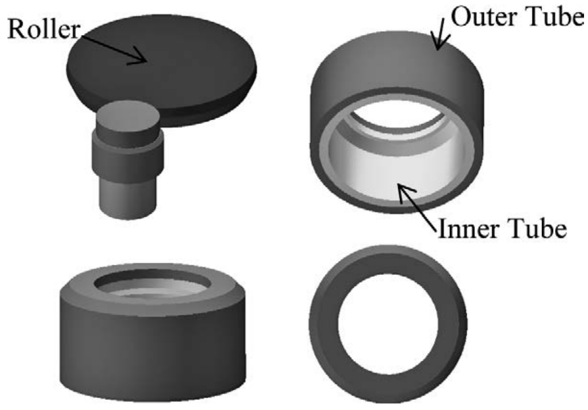

Figure 2 Simplified model

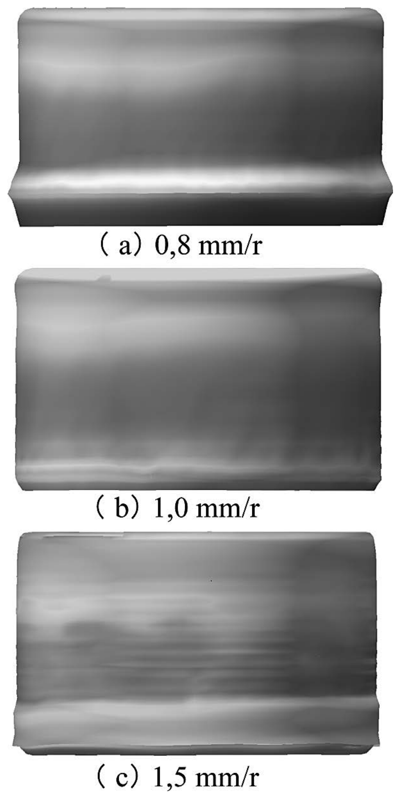

Figure 3 Surface quality diagram of composite pipe with different feed ratios

INFLUENCE OF PROCESS PARAMETERS ON FORMING QUALITY

The feed ratio is the distance that the workpiece moves along the axial direction per revolution of the rotating wheel, which has great influence on the dimensional accuracy of workpiece forming. When the feed ratio decreases, the inner diameter of the workpiece increases and the dimensional accuracy decreases. When the feed ratio increases, the contact area between the rotary wheel and the workpiece increases, and the deformation force increases, which is helpful for the workpiece to stick to the core die. However, too large feed ratio will lead to the increase of the rebound of the spinning wheel, which will increase the wall thickness of the workpiece after spinning and increase the wall thickness error.

Figure 3 shows the influence law of surface forming quality of dual tubes at different feed ratios of 0,8 mm/r, 1 mm/r and 1,5 mm/r under the conditions of 300 r/min

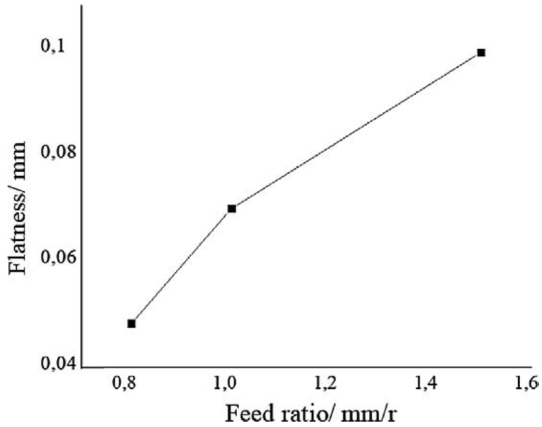

Figure 4 Flatness under different feed ratios

spindle speed, 350°C spinning temperature and different feed ratios.

At intervals of 6 points on the resulting surface, the least square method is used to calculate its flatness. The results are shown in Figure 4.

The results show that under the condition of fixed spindle speed, the surface quality of tube wall decreases when the feed ratio increases. When the spindle speed is 300 r/min, the spinning temperature is 350°C and the feed ratio is less than 1 mm/r, the surface quality of pipe fittings is significantly improved. In order to improve the forming quality of pipe wall and speed up the production efficiency, the feed ratio should be 1mm/r.

SPRINGBACK ANALYSIS UNDER DIFFERENT THINNING RATES

The wall thickness of workpiece will produce a certain amount of rebound after spinning, the amount of rebound depends on the type of material and wall thinning rate and other factors. As shown in Figure 5, the theoretical spin back wall thickness is 't_1', the actual spin back wall thickness is 't_2', and the initial wall thickness is t. The final rebound rate is defined as 'φ_0'.

$$\varphi_0 = \frac{(t_2 - t_1)}{t} \quad (1)$$

Under the feed ratio of 1mm/r and the total thinning rate of 5 %, 7,5 %, 15 % and 30 %, 6 points were selected to calculate the rebound rate in Formula 1. The

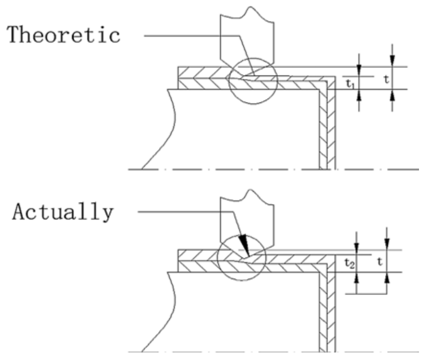

Figure 5 Schematic diagram of rebound

Table 2 **Rebound rates under different thinning rates**

Thinning rates/mas.%	Resilient rate/mas.%
5	1,75
7,5	3,5
15	4,25
30	6

rebound rates under different thinning rates are shown in Table 2 .

The obtained data are put into MATLAB software. After five times polynomial fitting, the relationship between the final springback rate 'ϕ_0' and thinning rate 'ϕ' is finally obtained when the thinning rate is 5 % to 30 %:

$$\phi_0 = 7\times10^{-6}\,\phi^5 - 6,8\times10^{-4}\,\phi^4 + 0,025\,\phi^3 - 0,44\,\phi^2 + 3,8\,\phi - 8,9$$

COORDINATED DEFORMATION LAW OF COMPOSITE PIPE

In the composite pipe, the thickness of magnesium tube and aluminum tube has different thinning rate. In the actual production process, there are often different requirements for the thickness of the two tubes because of different needs in practical application. Therefore, the deformation coordination behavior of composite pipe is studied by analyzing the thickness of two pipes under the total thinning rate of 5 %, 7,5 %, 15 % and 30 %. Figure 6 shows the simulation analysis results of the two composite pipes at the total thinning rates of 7,5 %, 15 % and 30 %.

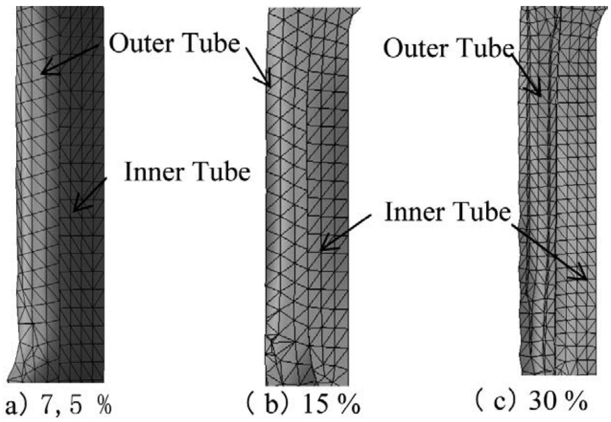

Figure 6 Wall thickness of two tubes at different thinning rates

As can be seen from the figure, with the increase of thinning rate, the difference between the thinning rate of aluminum tube and magnesium tube gradually decreases. Therefore, the deformation difference coefficient 'k' of two tubes can be defined to judge the difference of thinning rate of two tubes.

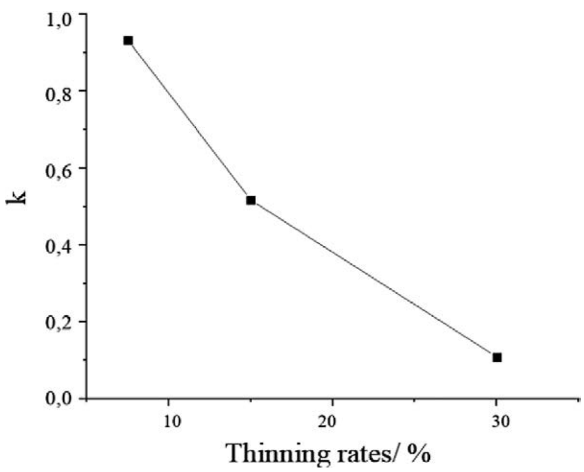

Figure 7 Variation pattern of deformation difference coefficient under different thinning rates

$$k = \frac{\varphi_{al} - \varphi_{mg}}{\varphi}$$

Where 'ϕ_{al}' is the thinning rate of aluminum tube at the total thinning rate of 'ϕ', and 'ϕ_{mg}' is the thinning rate of magnesium tube at the total thinning rate of 'ϕ'. After the calculation , as shown in Figure 7, 'k' decreases gradually with the increase of the total thinning rate. This means that with the increase of thinning rate, the deformation coordination of the two tubes becomes better.

CONCLUSIONS

In this simulation experiment, three groups of different feed ratio simulation results were used to determine the optimal feed ratio. Under the optimal feed ratio, four groups of simulation results with different thinning rates are obtained. Based on four sets of results, the functional relationship between the rebound of composite pipe wall thickness and the total thinning rate is deduced, and the variation rule of the deformation difference coefficient of two pipes under different thinning rates is obtained. This paper provides reference for selecting suitable spinning process parameters in preparing suitable size magnesium aluminum composite pipe.

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Note: The responsible translator for English language is J. B. Zheng, Ningbo, China