Research on Intelligent Precise Pass Algorithm Based on Linked List Model

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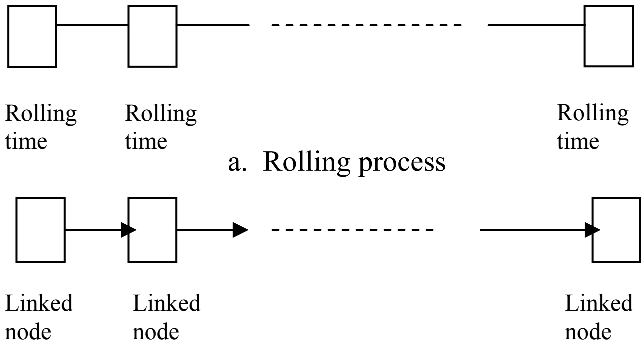
Abstract. With higher project demand for cold bending forming steel function, the geometry section of profiles is becoming more and more complicated, and pass design of rolling section steel is becoming more and more difficult. The design method based on experience and estimating doesn't meet the engineering requirements. How to build a stable pass design algorithm, has become the modern pass design difficulties. Although there are many theories studying cold bending forming, those guiding pass design is less. The paper is based on spline finite strip theory, studying how to establishing new rolling process model, using linked list model to build Agent structure for each forming stand and transition region, realizing the cold bending forming strain and stress description in a single intelligent stand, founding relationship between forming theory and the parameters of pass design, providing theoretical basis for precision deduction pass design.

Introduction

The successful application of cold-formed steel in many fields leads people to pay more and more attention to its new structure development. Although now cold bending forming theory is more, but which can guide pass design is few. And there isn't any theory to stably determine the accurate pass design algorithm. The wide and diversified demand of Cold-formed steel form huge contrast and the difficulty of pipe roller design algorithm infering form a huge contrast[1]. This bottleneck restricted the cold-formed steel manufacturing and application. At the same time,it also limited technical renewal and product development of the application of cold bending special-section enterprise. How to use the cold bending forming stress and strain theory to solve complex profile pass design algorithm is the urgent needs of industrial enterprises facing.

Relationship Between the Rooling Process and the Chain model

Cold-formed steel molding process is through the multi-channel times into the pass extrusion. It has the very big relation with the stress and strain, steel strip thickness, elastic modulus,fracture geometry shape and other factors.The pass number is decided by steel cross-section shape. Section geometric shape is more complex, the forming pass is more[1]. In order to analyse more precisely the stress-strain phenomenon in the cold bending forming process, we described the forming process of rolling as the chain structure model. Each pass is corresponding to each node of list, and what between passes is corresponding to the pointer of node. It is shown in figure 1 below. After extrusion from every pass, the steel belt gradually become the required section geometry. It has small deformation because of the function of tensile force in passes. So, the deformation of the steel belt mainly concentrated in the model node. The quantitative depict expression of deformation also mainly concentrated in node object. Steel belt forming analysis model figure in the pass is shown in figure 2 below. The deformation expression in forming pass is shown in type (1) below[2]. The dynamic deformation fictional equations in the chain structure are shown in type (2), (3) below. The steel belt excessive deformation between passes and the mathematics description is shown in type (4), (5) below.



a. Rolling process

b. Linked list structure

Fig. 1. Corresponding relationship between rolling process and linked list structure

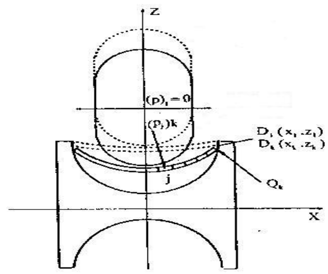


Fig. 2. Analysis model of steel strip forming in hole

$$\begin{cases} d\sigma_y = \frac{E}{A}\left(-\sigma_x\sigma_y + 2yB\right)d\varepsilon_x \\ d\sigma_x = \frac{E}{A}\left(\sigma_y^2 + 2B\right)d\varepsilon_x \end{cases} \quad (1)$$

In the equation, $A = C + 2\left(1 - y^2\right)B$ $\quad B = \frac{2H\overline{\sigma}^2}{9(E - H)}$

E, H, γ------ Respectively for material elastic modulus, strengthen coefficient and poisson's ratio coefficient.

$\overline{\sigma}$ ---- Equivalent stress $\quad \sigma_x^{`}, \sigma_y^{`}$ ----- stress deviator

The dynamic fiction equation analysis in rolling process is spread over time. The initial configuration changes with the present configuration. the current configuration at the T moment is the initial configuration at the $t + \Delta t$ moment. So, it’s needed to adjust the coordinate and stress value of material point after finishing every step loading.

$$^{t+\Delta t}x_i = {}^t x_i + \Delta^{t+\Delta t}\delta_i \qquad ^{t+\Delta t}\sigma_{ij} = {}^t\sigma_{ij} + \Delta^{t+\Delta t}\sigma_{ij} \qquad (2)$$

In the formula, $\Delta^{t+\Delta t}\delta_i$ is the incremental displacement that loading step from T to $t + \Delta t$.

The corresponding virtual work equation is shown below, $\int_{{}^t v} {}^{t+\Delta t}_{t}S_{ij}\delta_t^{t+\Delta t}E_{ij}dv = \delta^{t+\Delta t}W$ (3)

In the formula, $\delta_t^{t+\Delta t}$ is a virtual displacement from T to $t + \Delta t$.[4]

The steel belt deformation between passes and the mathematics description

The moderate filtering area Between passes mainly is the steel strip edge tensile deformation, Tensile rate is shown as expression (3).

$$\varepsilon = [\sqrt{L_B^2 + 2a^2[1 - \cos(\Delta\theta_i)]} - L_B] / L_B \qquad (4)$$

The simplified third order spline function used by describing comprehensive stretching deformation. It is shown as expression (4) [3].

$$f(x) = \sum_{i=-1}^{m+1} \alpha_i \Phi_i(x) \qquad (5)$$

Intelligent Processing of Deformation Passes

In the expression describing the single pass, there are some parameters which is similar to the elastic modulus and the strengthen coefficient that we need to adjust. Some expressions in operation process need to ignore certain conditions and equation in order to find out the exact solution. But these ignoring may cause that the expression of stress and strain cannot accurately reflect the actual stress and strain process. So, this needs to complement through other ways. It is better to manage the expert experience and knowledge to make decision. It can fix the gap between theoretical model and the actual model in order to make the theory model approach the actual model as far as possible[2]. The specific means is below.

(1) set a corresponding Agent to each deformation finite strip;

(2) set the chain node knowledge container and pointer knowledge container in each Agent;
(3)make sure reasoning rules of knowledge compensation;
(4) Construct the rational reasoning mechanism.

Basic Agent structure is as follows:

```
Class Agent
      {
        Node number  Pointer number  record
        Node deformation formula
        Node knowledge
        Pointer----
        Reasoning mechanism
              }
```

Reasoning rules form is as follows:

IF (Conditions set) THEN result

For example: the value reasoning rules to elastic modulus[3].

If steel belt thickness =x1&&material = x2&& forming angle =x3 then Elastic modulus =y1
else if steel belt thickness=x4&& material = x2&& forming angle=x3 then Elastic modulus=y2
else if steel belt thickness=x1&& material = x5&& forming angle=x3 then Elastic modulus= y3
else if steel belt thickness=x1&& material = x2&& forming angle= x6 then Elastic modulus= y4

The reasoning rules set forms a single Agent knowledge structure in order to realize the correction to single finite strip deformation theory of some pass[4].

Precise Pass Design Calculation Method Extrapolation

How to make the cold bending forming theory to guide practical pipe roller design is the important bottleneck problem in the cold bending forming field. The pass design quality fluctuation is big is because the quantitative algorithm of the design has a larger gap with the actual plasticity deformation. It is a good method to improve the quality of the pass design that the reasonable cold bending forming theory is used for guiding pipe roller design. The pass design basis is section's forming roller diagram which comes from section geometry shape and forming stress-strain theory analysis. Overlarge deformation may cause a tear of the steel belt, too much stress leads to roll's damage easily, and too small deformation will increase forming passes. All will reduce forming efficiency.

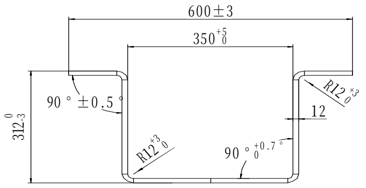


Fig3 sectional drawing of cold-formed

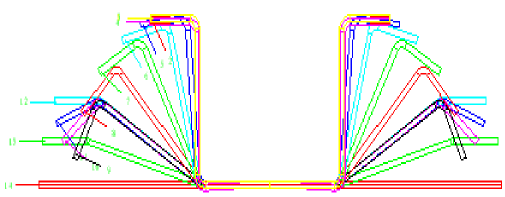


Fig4 Pass flower chart of roller

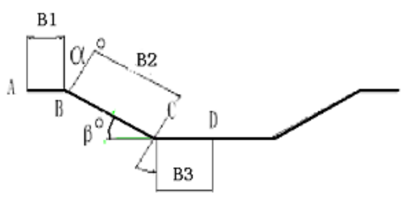


Fig5 Counting graph of each forming Sortie

To the cold bending center sill, here is showing the idea of seeking the precision pass design. According to the roller diagram, we can calculate pass by joining and removing corner factors of elastic deformation. Figure 3 gives the sectional drawing of the cold bending center sill. Figure 4 gives the forming roller diagram of the cold bending center sill. Figure 5 gives the calculation charts of the cold bending center sill in every pass[5]. From the figure 5, B, C (and its symmetrical) happened some drastic change. But the rest didn't change almost. The calculation formulas in every middle deformation pass is shown such as type (5) [5].

$$\begin{cases} B_1 = AB - R_m \times \alpha/2 \\ B_2 = BC - R_m \times \alpha/2 - R \times \beta/2 \\ B_3 = CD - R_m \times \beta/2 \end{cases} \qquad (5)$$

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According to the characteristics of the chain structure model, each node is corresponding to a pass. And nodes of chain model should contain type (5) formula. According to the spline theory,we can set a number of finite strips in B and C point. The finite strips' stress and strain relationship is shown by type (1). The $d\sigma_y$ and $d\sigma_x$ in type(1) have the close corresponding relation with the α and β in type (5). The corresponding relation is not easy to say clearly with expression, but we can use artificial intelligence method to solve. We can store each data in table 3[5] in every Agent of the chain structure corresponding node. According to the node $d\sigma_y$, $d\sigma_x$, choose α, β, and we can get the precise holed algorithm ultimately.

Tab.3. Assignment of bending angle

sortie	1	2	3	4	5	6	7	8	9	10	11	12
β°	0	15	30	30	30	30	45	60	75	85	90	92
α°	0	15	30	50	70	92	90	90	90	90	90	90

Summary

The pass design is based on the design of the forming roller diagram, and the forming roller diagram is designed according to section geometry shape and the force of the deformation. Deformation force depends on the forming theoretical analysis. Under reasonable model, it is in anticipation of engineering how to use the cold bending forming theory to guide pass design, make the pass design get rid of the influence of experience as far as possible, regulate to the method of quantitative and expert knowledge, and make the pass designs' forming roller diagram design and roll curve design gain the stable quality[6]. While the people studying the theory of cold bending molding and shaping theory is more, but the people using deformation theory to guide practical pass design is less. This paper tries to link theory with practice. It uses the cold bending forming theory to depict quantificationally the pass design algorithm, and adds the correction of artificial intelligence, so that we can get stable quality roll designing algorithm.

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