The Soft Reconstruction of Stacker Machine Based on H Shape Steel

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Abstract. In view of the blocking problem existing in automatic production line for certain large H-shaped steel at the stage of production, the paper will analyze the cause and put forward optimization method for the motion of stratifying machine. Under the circumstance of no increase of equipment hardware, technical transformation (soft reconstruction) will be made only for the flow procedure of S7-400PLC, which will not only improve the working efficiency, but also resolve the problem of steel blocking thoroughly.

Introduction

Large H-shaped steel is the main material for construction of steel structure. Stratifying machine is the chief equipment for the stacking area of large H-shaped steel production, serving as the stacking bed of transmitting shaped steel well cut according to its length in cold sawing area to stacking area via roller bed. Then, the shaped steel will be transmitted to the front baffle plate of stratifying machine through delivery trolley and delivery chain, lift up by electromagnetic lifter to stacking platform, i.e. the place for stacking. Generally the stacking will be delivered to roller bed by exit delivery trolley when 6 layers of them are met, and then they will be packed in packing area.

An imported automatic production line for large H-shaped steel suffered steel blocking after one production stage. The reason is that standard length of large H-shaped steel differs from practical application in China. In fact, the specification and variation of using length are various under different environment, and the length of single steel is generally required to be shorter than standard length. Therefore, the number of steels to be packed is increased with the unchanging weight, which imposes higher requirements on the stratifying machine. Through analysis, the optimization and transformation of S7-400PLC procedure will solve the problem of steel blocking with no need of increasing investment.

Description of Stratifying Machine

Main Equipment of Stratifying Machine [1,2]

- Measuring meter
  - 4 linear sensors for detecting the horizontal location of proportion valve;
  - 4 approaching switches for detecting if the upward and downward movement of stratifying machine is in place.
- Executing body
  - 4 proportion valves to control baffle plate (being able to move forward and backward in horizontal direction)
  - 4 cut-off valves matching the proportion valves
1) **First layer forming principle of stratifying machine** \([1, 2, 3]\). The first layer forming principle of stratifying machine is shown in figure 2, and the detailed description is as follows:

a) After calculating the bundle of stacking PB, the stratifying machine moves to the location of first shaped steel of the first layer \(S_{\text{LayerForming}} = -\frac{PB}{2} + H - \frac{LV}{2}\), then it ascends. When the first shaped steel is located in shaped steel route equipment, No. 3 chain-type steel-moving machine stop, and then the stratifying machine descends.

b) In accordance with the calculation, stratifying machine shift to place underneath the shaped steel \(S_{\text{takeove}} = S_{\text{LayerForming}} - (H + SV)\).

c) The stratifying machine lift up shaped steel from No.3 chain-type steel-moving machine.

d) After the first shaped steel is transmitted, stratifying machine (above which is the shaped steel) moves back to the location of second shaped steel described in (1) \(S_{\text{LayerForming}} = -\frac{PB}{2} + H - \frac{LV}{2}\).

As for the last shaped steel on the layer (usually the third shaped steel), stratifying machine, in this case, will lift up the last shaped steel, and take the shaped steel of first layer away from No.3 chain-type steel-moving machine at the same time. Then, stacking manipulator will transmit all the shaped steel to stacking platform.

2) **Second layer and other layer forming principle of stratifying machine**: As shown in figure 3, after shaped steel is moved away from stacking manipulator, stratifying machine moves to the location of \(LV\) opposed to first layer shaped steel, in order to transmit the first shaped steel of the second layer.
(S_{\text{LayerForming}} = -PB/2+H+Lv/2). The second layer averagely increases the displacement of $L_V$ length compared with the first layer, and the third layer is the same as the first layer, only one more layer on the second layer, aligning with the first layer in vertical direction. The odd layer is identical with the odd layer, while the even layer is the same with the even layer. The difference between odd layer and even layer in horizontal direction is $L_V$ displacement.

3) Description of shaped steel parameters: The shaped steel parameters are as shown in figure 4, among which B stands for width of shaped steel; H for height of shaped steel; T for thickness of steel margin; S for thickness of web plate; and R is radius.

Stacking parameter:
- Shaped steel displacement value $L_v$ produced by shaped steel route equipment; Central displacement $M_v$ produced by shaped steel route equipment; stacking size, including deviation obtained from the shaped steel parameter of upper computer. The displacement of shaped steel is calculated as follows:

$$L_v=2*T+R+PLE_1$$
$$PB=n*H+Lv$$

where, $PLE_1$ generally takes 1 mm, or -1 mm, and n refers to the number of shaped steel of each layer.

Location of first stratifying machine

$$S_{\text{LayerForming}}=PB/2+/-M_v+/_-_Lv/2$$

Corresponding distance in horizontal direction of $S_{\text{LayerForming}}$ below the shaped steel in route.

$$S_{\text{takeover}}=S_{\text{LayerForming}}-(PB+PLE_2)$$

where, $PLE_2$ generally takes 50 mm; the rest layers can be done in the same manner.

Problem Analysis

The large H-shaped steel automatic production line in the Steel Company was found to suffer blocking of material flow when entering into the stacking area after operation for a period of time. There are 3 stacking bed in the stacking area, and the situation of waiting for steel tapping in cold saw area also appears when the three stacking bed are used simultaneously, which affect the output of the whole automatically controlled production line.

Reason: the design is conducted in line with standard steel-sawing length, which is able to meet the output. However, a great many users in China are in need of slightly shorter shaped steel, leading to the number of steel with the same weight increases, so the occurrence of steel stacking is understandable. It is unrealistic to ask users to alter the size, and the only way out is to reform the production line, that is to say, to improve the efficiency by transforming stacking bed automatic control of the stacking area.

![Figure 4. Parameter of shaped steel.](image-url)
Solution and Effect

Through analyzing the working process of stratifying machine, it is known that the upward and downward movements can be omitted, and the distance of upwards and downwards can be solved by adjusting the distance of electromagnetic lifter. The initial location of stratifying machine is in the upward location, waiting in different preset location according to the shaped steel with different width. Hence, to control the advance and recession of the four proportion valves in horizontal direction is enough. Further recession only needs to move \( L_v = T + S_v + R \) (\( S_v \) is the displacement between layers) \([1, 2, 3, 4]\)

Time for each steel in stratifying machine before

\[ T_{\text{old}} = T_{\text{down1}} + T_{\text{bwd2}}(T_{L_v} + T_{H}) + T_{\text{up3}} + T_{\text{Down4}} + T_{\text{fwd5}}(T_{L_v} + T_{H}) + T_{\text{up6}} \]

Time for each steel in stratifying machine now

\[ T_{\text{new}} = T_{\text{bwd2}}(T_{L_v}) + T_{\text{fwd5}}(T_{L_v}) \]

Obviously, a large amount of time for working process of each steel is saved.

\( T_{\text{down1}} \) refers to the time used for descending movement from beginning to ending, when shaped steel descends after reaching the stratifying machine at the initial location; \( T_{\text{bwd2}} \) refers to the time used for backward movement from beginning to ending, when stratifying machine moves below shaped steel at the descending location; \( T_{\text{up3}} \) refers to the time used for pull-up movement from beginning to ending when stratifying machine pull up the steel after recession is in place; \( T_{\text{Down4}} \) refers to the time used for descending movement from beginning to ending when stratifying machine is falling after shaped steel is lifted up by electromagnetic lifter; \( T_{\text{fwd5}} \) refers to the time used for forward movement from beginning to ending when stratifying machine reaches preset place at descending location; \( T_{\text{up6}} \) refers to the time used for upward movement from beginning to ending when stratifying machine is prepared to ascend for the next steel after forward movement is in place; \( T_{L_v} \) refers to the time used for movement of stratifying machine from beginning to ending at the transverse crossing distance of shaped steel between layers; \( T_{H} \) refers to the time used for movement of stratifying machine from beginning to ending at the distance of stratifying machine moves one shaped steel. The sub-procedure block diagram of S7-400PLC transformation is as shown.

The transformation modifies the controlling procedure of S7-400PLC for stratifying machine, leaving the hardware of mechanical equipment alone, which makes the equipment to operate in the manner after technical transformation in accordance with optimization analysis. The result is satisfactory. Before the transformation, three stacking beds are not enough in the course of operation, however, after transformation, only two stacking beds are sufficient. The operational movement of equipment is decreased, and the equipment is energy-saving with desirable effect. The transformation technology provides a reference for other enterprises in the same industry. The statistics of application results in the first seven days of the current month and that of the next month is shown.

Conclusions

(1) Through studying the movements of equipment and working requirements, some unnecessary movements can be cancelled, some movements can be transformed, and the procedure of PLC can be changed, so as to achieve optimization of operation.

(2) The reduction of unnecessary movements contributes to energy saving and improve service life of the equipment.
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