NUMERICAL SIMULATION AND DESIGN OF CONTROL DEVICE FOR COLLECTING COLD ROLLED STEEL STRIP DUST

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ABSTRACT

After coming out from hot rolling machine, the cold rolled steel strip is slowly cooled. Then, the surface of the steel strip is oxidized into oxide scale. After extruding, stretching, bending, straightening and other processes^[1], the oxide scale begins to fall off, that producing a lot of dust and posing a threat to the health of workers. This paper designed a kind of device to control the oxide scale dust. Through numerical simulation and theoretical calculation, the specific equipment parameters were put forward, which providing the basis for the control of the cold rolled steel strip dust.

1. INTRODUCTION

In the production of the cold rolling mill, the main parts of the dust produced including pickling unit, smoothing unit and roller unit etc. The resulting dust is the most serious in the straightening machine and welding machine of the pickling unit. As the strip comes out of the hot rolling mill, it enters the water-spraying device first of all. And then, it is rolled into coil and slowly cooled. During this time, the surface of the steel strip is oxidized into oxide scale. When the strip passes through the pinch roller straightening machine, drawing straightening machine and flash butt welding machine of the pickling unit inlet end, the oxide scale begins to fall off, producing a lot of dust and posing a threat to the health of workers after extruding, stretching, bending, straightening and other processes^[1]. Three points were selected to measure the dust concentration in the horizontal direction from the strip one meter. The results showed that the dust concentrations were 35.40mg/Nm³, 66.67mg/Nm³,

30.15mg/Nm³, and the average was 44.07mg/Nm³. In order to exclude these dust-laden gases, a dust control device must be provided.

As a widely used dust removal method, the push-pull Ventilation method has a good effect on the control of the cold rolled steel strip dust. The most effective method of controlling industrial dust is local exhaust, and the key equipment is local ventilation equipment. Exhaust hood size, air volume and other parameters play a decisive role for the energy consumption and cost. The push-pull Ventilation is not a good combination of push air flow and pull air flow. It just uses the characteristics of the jet to control flow area of the inspiratory flow, reduce the design difficulty of the exhaust hood, and make the air flow to achieve the same single-suction effect. In this paper, a dust control device for cold rolled strip steel is designed based on the theoretical knowledge of jet and industrial ventilation, combining with numerical simulation. And the specific engineering parameters of the device had been clear about^[2].

2. Introduction of push-pull dust source control device

In view of the characteristics of wide scope of dust during the operation of the strip, the dust control device should be installed at the beginning of the strip running. It can remove most of the dust and reduce the amount in the follow-up process.

This paper presents a design technical solution of the dust source control device. In this technical solution, the upper nozzle and the lower nozzle are connected with the compressed gas pipe (medium is air). When the

steel strip running, the upper and lower nozzles work at the same time, and the compressed gas ejects and scours the upper and lower surfaces of the strip at a high speed. It can make cold rolled steel strip dust of the upper and lower surface to fall off effectively. In the role of the jet, the dust rushes toward the suction hood which is connected to the dust duct. Eventually,

The dust is trapped in the removal system.

By adopting the technical proposal, it can effectively reduce the amount of dust extraction fan and save the running cost because of eliminating the need for multiple suction hoods in the production line. For wider steel strip, the number of upper and lower nozzles can be increased appropriately to achieve the desired capture effect.

1 upper and lower nozzles, 2 steel strip, 3 suction hood

Fig1 technical schematic of push-pull dust source control device

3. Numerical simulation and optimum design of the device

The diameter of the nozzles, the installation angle, and the injection speed are the key factors that affect the dust control effect. In this paper, CFX software is applied to simulate the effect of the device. It can optimize the angle between the nozzle and the plane of the strip under specific site conditions to ensure good control effect.

The nozzle diameter 25mm, Strip width 2m, Strip transmission speed is 10m /site angle α between nozzle and strip plane is initially set at 5°, 10°, 15° and 20° to compare and analyze through numerical simulation.

3.1 Calculation conditions

(1) The medium is air at room temperature, and the nozzle velocity is set at 100 m / s.

(2)The outlet is a flow boundary condition.

(3)The wall is no slip boundary conditions, and the steel strip along the Z axis transmission speed is set 10m / s.

3.2 Comparison and analysis of simulation results

Four different nozzle mounting angles (5°,10°, 15°and20°)

Were simulated and calculated, and the velocity distributions on different planes in the calculation domain were obtained. At the same time, a representative Z=0 plane (center plane) and Y=0 plane (strip plane) are selected for comparison and analysis. The simulation results are shown in Figures 2 and 3.

It can be seen from the two Figures that as the nozzle installation angle increases, the reflection phenomenon becomes more and more serious and the speed decay is quicker when the high-speed airflow coming out of the nozzle reaches the steel strip. Therefore, in order to make the jet stream can effectively blow the surface dust to the hood, the angle should not be too large. Less than 5 degrees is appropriate^[3].

Fig2 Z=0 plane (center plane)

gas velocity vector

space is called jet. The jet is assumed to be an isothermal free jet in the direction perpendicular to the plane of the strip^[4] [~6]. Isothermal circular jet structure is shown in Figure 4.

Fig4 Isothermal circular jet structure

Strip 2 meters wide, 10 m/s speed, and the nozzle and the steel with a certain distance, it gets the following results calculated by isothermal circular jet structure model:

Take: s = 2.5m;

$$\text{Then: } x_o = \frac{7.5}{\tan 13^\circ 35'} \text{ mm} = 31 \text{ mm} \quad (1)$$

$$\text{According to the formula: } \frac{R}{x} = \frac{R}{2.53} = \tan \alpha \quad (2)$$

The radius R of the jet at the suction hood is 0.611mm. So diameter d is 1223 mm. The size of the suction port should be greater than the jet diameter. Therefore, it can choose the size of 1300mm×1300mm. In addition, according to the actual situation of the factory, combined with the work space and other factors, the exhaust hood can set the flange edge.

5. Comparison of measurement results before and after device opening

Three points were selected to measure the dust concentration in the horizontal direction from the strip one meter. Before the device is turned on, Comparison of field measurements before and after opening of the device is shown in Table 1. As can be seen from the table, the device played a very good dust removal effect.

Table 1 Comparison of field measurements before and after opening of the device

the dust concentration before the opening(mg/Nm3)	the dust concentration after the opening(mg/Nm3)
35.40	8.96
66.67	6.65
30.15	6.71

6. Conclusion

Through this study, the following conclusions are drawn:

(1) In the process of running, the cold rolled steel strip prunes to iron oxide dust after stretching, bending, straightening and other processes. Due to the requirements of the production process and operating costs, it is impossible to set closed enclosure in the entire production line. In view of this situation, a dust control device for cold rolled strip steel is designed based on the theoretical knowledge of jet and industrial ventilation, combining with numerical simulation.

(2) Through the numerical simulation and theoretical calculation, the nozzle diameter is 25mm, the installation angle below 5 degrees is appropriate, and the suction hood size is 1300mm×1300mm. The flange edge can be set up according to the actual situation.

(3) Through the field measurements show that, setting the dust source control device can effectively reduce the dust emission in the process of cold rolled strip running. At the same time, it plays a positive role to clean up the workshop environment and protect the workers health.

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