**Z. C. LV, K. LIU, J. W. QIU, G. Y. MA, C. P. LIU**

ISSN 0543-5846
METABK 57(1-2) 62-66 (2018)
UDC – UDK 669.041-621.771.002.69:518.1:621.3.036-001.7 = 111

# A STUDY ON EXPERIMENT AND NUMERICAL SIMULATION OF HEAT EXCHANGER IN HEATING FURNACE

Received – Primljeno: 2017-08-17
Accepted – Prihvaćeno: 2017-11-19
Original Scientific Paper – Izvorni znanstveni rad

In this paper, air preheater is used the research object and its heat transfer law is studied by experiment and numerical simulation. The experimental data showed that with the increases of inlet air velocity, the comprehensive heat transfer coefficient and heat transfer efficiency increase, but the temperature efficiency decreases and the resistance loss on the air side increases. The numerical simulation results showed that the larger the diameter of the tube, the better the heat transfer effect. When horizontal spacing in the range of 290 - 305 mm and longitudinal spacing is 70 - 90 mm, the heat transfer effect is best. The optimized heat exchanger structure is that diameter is 60 mm, horizontal spacing is 300 mm, longitudinal spacing is 90 mm. As the inlet air flow rate increases, the heat transfer efficiency increases, but the temperature efficiency decreases and the resistance loss on the air side increases.

*Key words*: rolling furance, heat exchanger, numerical simulation, heat transfer, optimization

## INTRODUCTION

Rolling furnace is the main energy consumption of rolling equipment, its energy consumption accounted for more than 40 % of the entire rolling mill production process [1]. The heat taken by the flue gas accounts for more than 30 % of the heat supplied by the fuel, resulting in serious energy waste. The waste heat recovered from high temperature flue gas can is used to preheat the combustion air or gas, which will greatly improve the energy efficiency [2]. The air preheater can be used to recover the waste heat of the high temperature flue gas [3]. In this paper, the influence of different structural parameters of heat exchanger is studied by experiment and numerical simulation.

## EXPERIMENTAL PART

The heat exchanger used in this experiment is the heater tube air preheater, and it uses a four-stroke reverse flow structure. The pipes are 18, 2 rows, 9 columns, the length is 1,2 meters, totally 72. The diameter is 50 mm and the horizontal spacing is 280 mm and the vertical spacing is 95,25 mm.

The contrast experiment was done by changing inlet air velocity, and the effect on the heat transfer efficiency and air pressure drop are analyzed. First, changing the amount of air and the inlet flue gas temperature changes at this time. Experiments were conducted in the order of flue gas temperature from low temperature to high temperature (650 ~ 850 °C) and check the pressure, the composition of the smoke, the temperature and pressure of the hot air and so on.

The comprehensive heat transfer coefficient, heat transfer efficiency, temperature efficiency and pressure drop on the air side at different inlet air velocity are shown in Figure 1.

With the increases of inlet air velocity, the turbulent degree of the fluid in the pipe increases and the comprehensive heat transfer coefficient increases. It can be learned from the Figure 1 that heat transfer efficiency shows an increasing trend and the maximum can reach 33,35 %, but the temperature efficiency decreases. In addition, with the increases of inlet air velocity, the resistance loss at the air side increases.

## NUMERICAL SIMULATION PART

### The influence of pipe diameter on heat transfer effect

The air inlet velocity is 4,65 m/s, the air outlet pressure is 10 000 pa, the flue gas inlet velocity is 1,64 m/s and the flue gas outlet pressure is -47 pa. Change the diameter of the pipe, the temperature contours of central section are obtained and shown in Figure 2.

It can be drawn from Figure 3, as the pipe diameter increases, the temperature difference between air outlet and flue gas outlet decreases gradually and the heat transfer efficiency increases continuously and the pressure drop begins to decrease rapidly and then slows down, as a result, there is a suitable pipe diameter to minimize the pressure drop.

Z. C. Lv, K. Liu (lk651206@163.com), J. W. Qiu: School of Materials and Metallurgy, University of science and technology Liaoning, AnShan, China; G. Y. Ma, C. P. Liu: Anshan Iron and Steel Group, AnShan, China

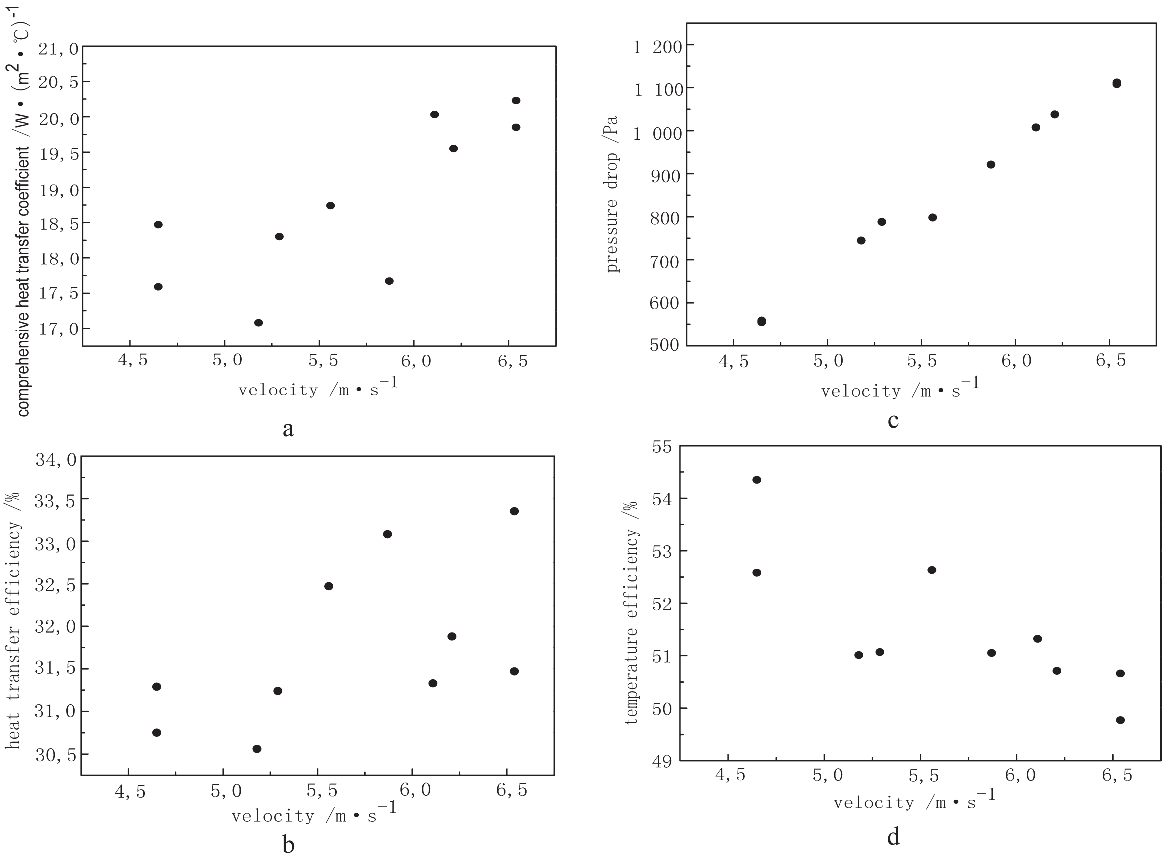


**Figure 1** Relationship between inlet inlet air velocity and other parameters, a, b, c and d.

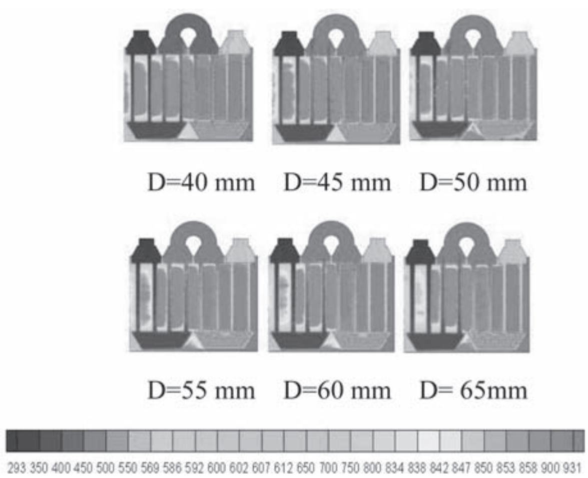


**Figure 2** Cross-sectional temperature contours of different pipe size

## The influence of horizontal spacing on heat transfer effect

The numerical results obtained by changing the horizontal spacing of the pipes are shown in Figure 4.

In the Figure 4, the air outlet temperature and the flue gas outlet temperature have little change as the horizontal spacing increases. When the horizontal spacing is between 290 and 305 mm, the temperature difference between the air outlet and the flue gas outlet is minimum, and it increases rapidly when the horizontal spacing more than 305 mm. When the horizontal spacing is 270 mm, the heat transfer efficiency reaches the maximum. When it is between 260 and 305 mm, the pressure drop changes small. Overall, the horizontal spacing should be between 290 and 305 mm.

## The influence of vertical spacing on heat transfer effect

The numerical results of changing the vertical spacing are shown in Figure 5.

As can be seen from Figure 5, with the increases of the vertical spacing in the range of 70 ~ 95,25 mm, the temperature difference increases gradually, and the heat transfer efficiency increases continuously and when the vertical spacing is 90 mm, the heat transfer efficiency remains basically the same. The pressure drop increases gradually when the vertical spacing is between 70 and 90 mm. Overall, the vertical spacing of the pipes should be between 70 and 90 mm.

Therefore, compared with the experimental heat exchanger, the structure parameters of the optimized heat exchanger are that the pipe diameter is 60 mm, the horizontal spacing is 300 mm and the vertical spacing is 90 mm.

## RESULTS AND ANALYSIS AFTER CHANGING THE PROCESS PARAMETERS

Changing the inlet air velocity, compared the original heat exchanger with the optimized heat exchanger. The numerical results are shown in Figure 6.

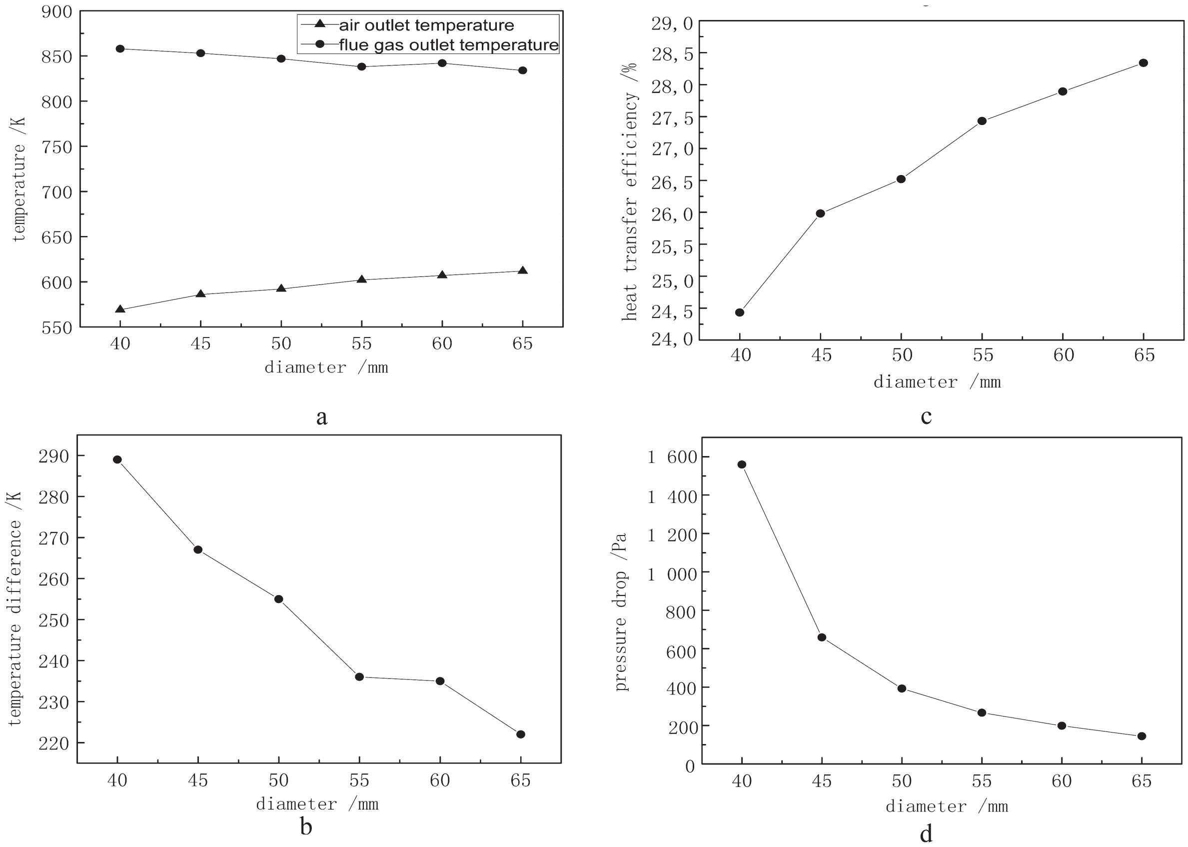


**Figure 3** The curve of the pipe diameter and other parameters, a, b, c and d.

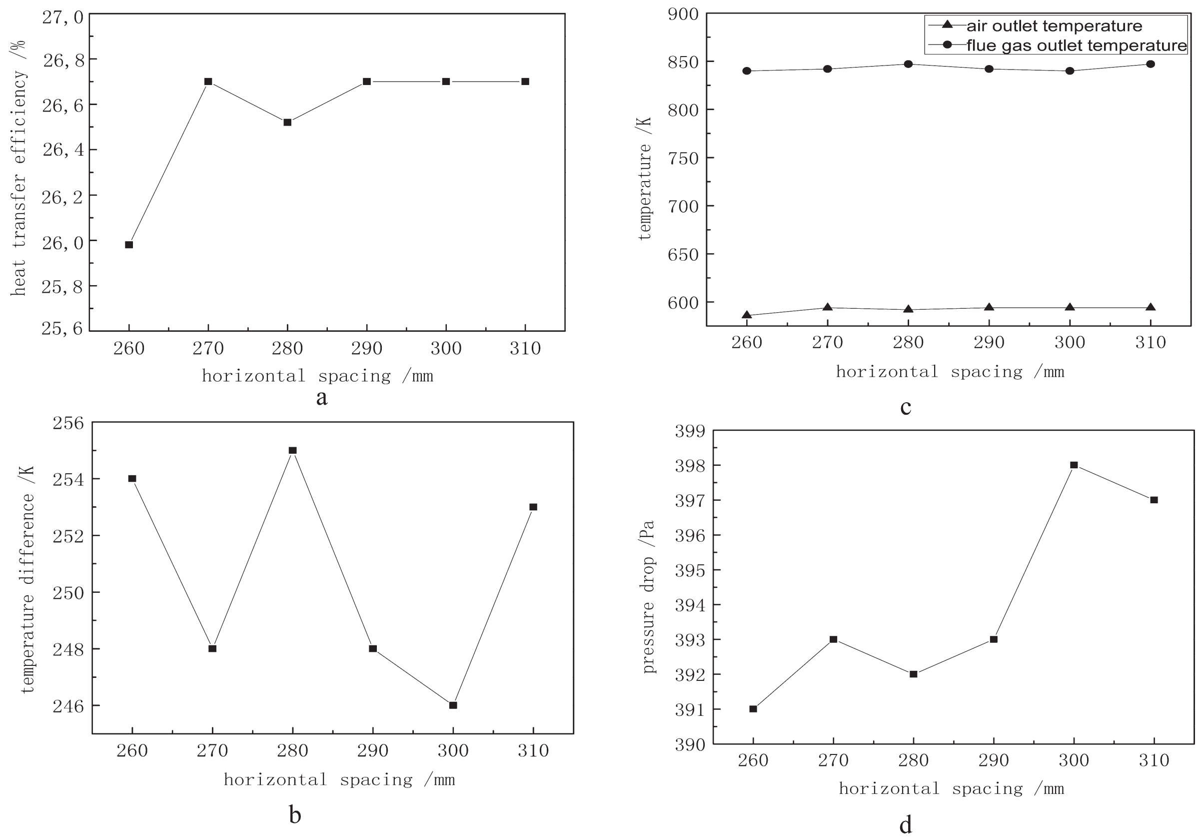


**Figure 4** The curve of horizontal space and other parameters, a, b, c and d.

As can be seen from the Figure above, the air outlet temperature of the optimized heat exchanger is high and the heat exchange efficiency is great but the air pressure drop is small, which is obviously superior to the heat transfer effect of the original heat exchanger.

Keep the other conditions constant and change the inlet air velocity. As the inlet air velocity increases, the temperature difference increases gradually, the heat transfer efficiency increases continuously, the temperature efficiency decreases continuously, the pressure drop increases.

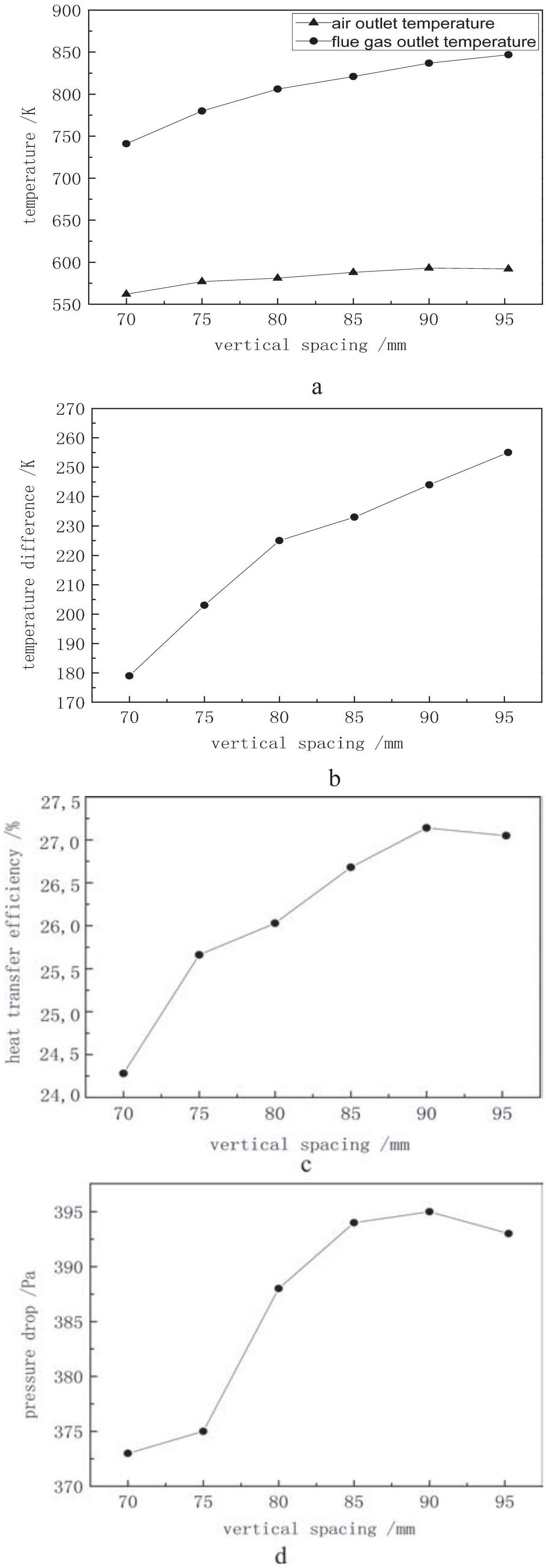


Figure 5 The curve of longitudinal space and other parameters, a, b, c and d.

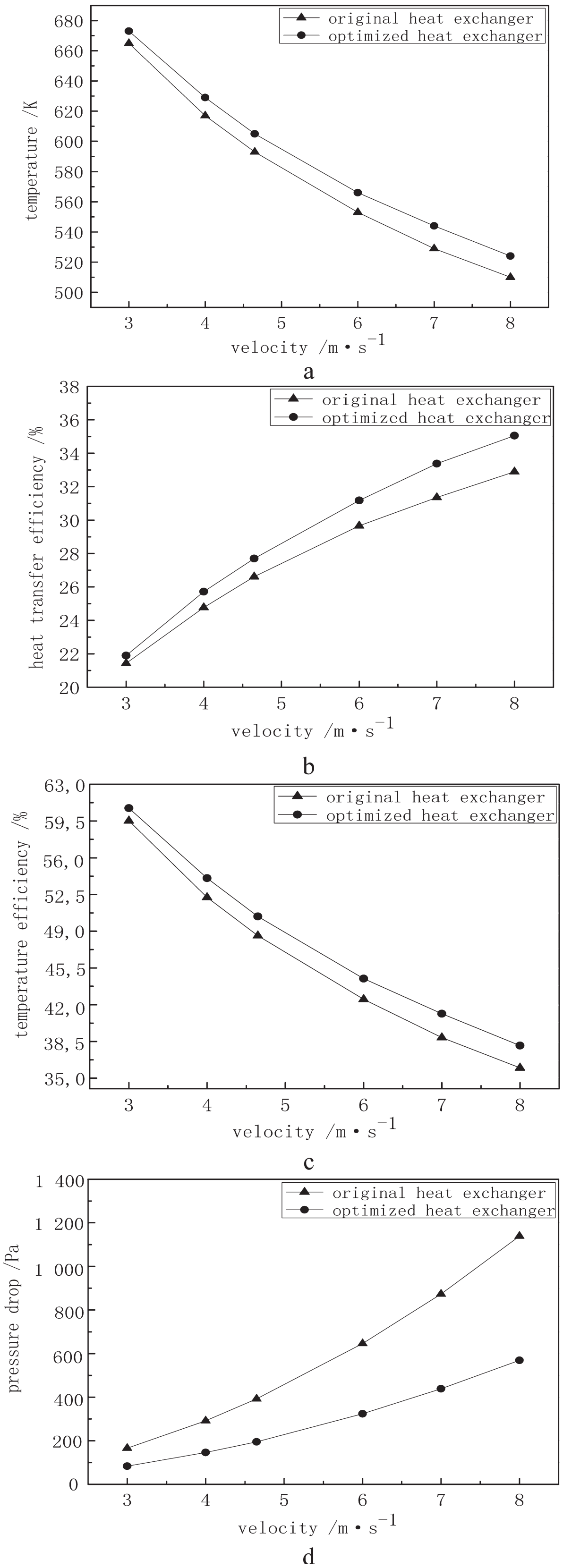


Figure 6 The curve of inlet air flow rate and other parameters, a, b, c and d.

## CONCLUSION

Through the numerical simulation analysis on heat exchangers, the following conclusions can be draw:

In a certain range, the greater the diameter, the better the heat transfer effect.

The heat transfer effect is better when the horizontal spacing is 290 ~ 305 mm and the vertical spacing is 85 ~ 90 mm.

The design scheme of the ideal heat exchanger is that the diameter is 60 mm, the horizontal spacing is 300 mm and the vertical spacing is 90 mm.

As the inlet air velocity increases, the heat transfer efficiency increases and the temperature efficiency decreases and the pressure drop increases.

## REFERENCES


[1] Z. Yan. Analysis of factors affecting energy consumption in rolling process and energy saving measures[J]. Metallurgical Power, 5(2013): 83-85.

[2] P. Wang. Design of waste heat recovery scheme for flue gas of steel rolling furnace[J]. Energy Conservation, 35(2016): 25-29.

[3] G. Shao. Common troubles of tube type air preheater and preventive measures[J]. Private Science and Technology, 3(2010): 17-18.

[4] W. Tao. Numerical heat transfer (Second Edition)[M]. Xi'an: Xi'an Jiao Tong University press, 2001, 5.

[5] Q. Zhang. Numerical analysis method of multi field coupling of heat transfer tube and internal and external fluid[D]. Daqing: School of civil engineering, Northeast Petroleum University, 2011.


**Note**: Kun Liu is the responsibile for English language, Anshan, LiaoNing, China