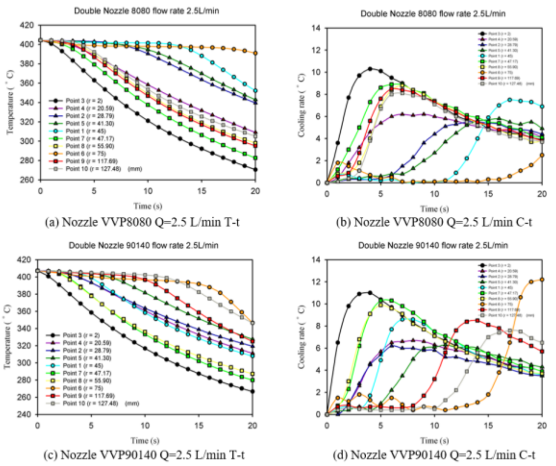
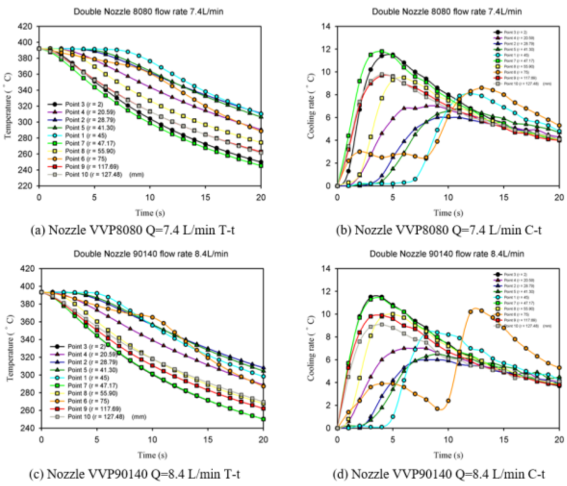


(a) Nozzle VVP8080 Q=2.5 L/min T-t (b) Nozzle VVP8080 Q=2.5 L/min C-t

(c) Nozzle VVP90140 Q=2.5 L/min T-t (d) Nozzle VVP90140 Q=2.5 L/min C-t

Fig. 9. Experiment temperature and cooling rate varied with time (Low Q)



(a) Nozzle VVP8080 Q=7.4 L/min T-t (b) Nozzle VVP8080 Q=7.4 L/min C-t

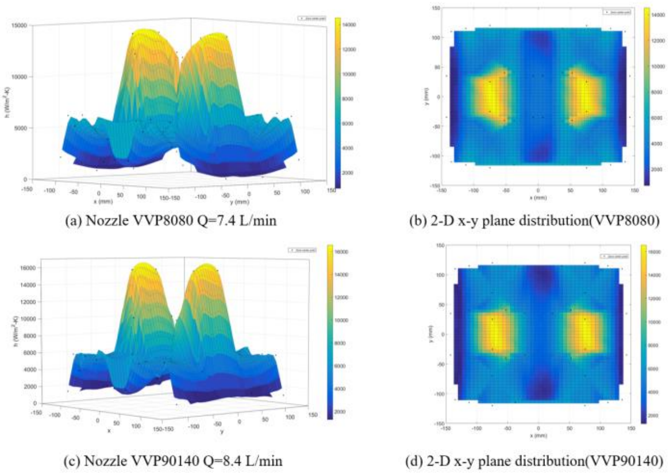
(c) Nozzle VVP90140 Q=8.4 L/min T-t (d) Nozzle VVP90140 Q=8.4 L/min C-t

Fig. 10. Experiment temperature and cooling rate varied with time (High Q)

D. *Double Nozzle Heat Transfer Coefficent*

According to the simple conjugate gradient method of inverse heat transfer, the surface heat transfer coefficient distribution of the surface of the stainless steel plate at 20 seconds is solved and the trend of the 26 zones heat transfer coefficient values is used to perform the three-dimensional trend Contour diagram as shown in Fig.11 (a) (c). The heat transfer coefficient figure is projected to the x-y plane as shown in Fig.11 (b) (d). It can be found that when the two nozzles reach the maximum flow, their heat transfer coefficients are distributed at the center and have a limited number of peaks and begin to decline around the center zone, and can be seen from the Fig.11. Seeing that the VVP90140 has a uniform distribution at the centerline of the two nozzles is consistent with the flow field distribution discussed earlier.

The average heat transfer coefficient value is calculated by averaging the heat transfer coefficient distribution of each zone, and the average heat transfer coefficient value calculated at five different flow rates can be found in the value level. The nozzles have similar order, but it can be clearly seen that the VVP8080 has a better heat transfer effect at this distance and height than VVP90140. It can be seen from the Fig.12 that the heat transfer coefficient of both increases with the nozzle at a small flow rate. The area of the impact gradually increased. When the flow rate reached 5L/min and 6L/min respectively, the rising trend of the average heat transfer coefficient of the two nozzles gradually became smooth, mainly because the nozzle spray angle of the two nozzles just impacted the whole heating test-piece at both flow rates. After exceeding these flow rate, the heat transfer effect is enhanced by the effect of increasing the impact force as the flow rate increases.



(a) Nozzle VVP8080 Q=7.4 L/min (b) 2-D x-y plane distribution(VVP8080)

(c) Nozzle VVP90140 Q=8.4 L/min (d) 2-D x-y plane distribution(VVP90140)

Fig. 11. 3-D & 2-D heat transfer coefficient distribution contour

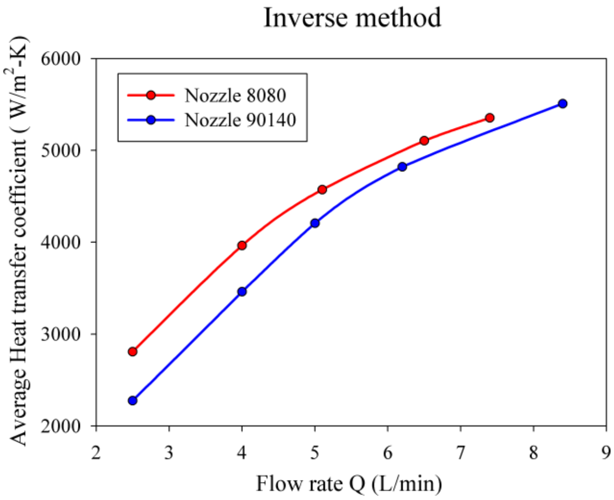


Figure 12 Average heat transfer coefficient v.s flow rate

VI. Conclusion

(a) From the observation of the flow field, it can be seen that as the flow rate increases, the fan-shaped nozzle also gradually expands in the impact area.

(b) The double nozzles have different interference distances under different flow rates. Through experimental observations, it was found that when the interference phenomenon occurs, the flow in the interference area will decrease, also the effect of heat transfer will be reduced greatly.

(c)According to the inverse heat transfer result, it can be found that fan nozzle's rapid cooling has a high order of the heat transfer coefficient up to about 5,000. It has excellent cooling effect on the rolling cooling in the steel industry, and it can also controls and improve the quality of steel.