Optimization of a Tenter Machine for Energy Saving and High Performance

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1. INTRODUCTION

Textile dyeing and finishing industry uses dryers/tenters for drying and heat-setting fabrics. A very large fraction of the heating value of the fuel consumed in the burner ends up as waste in the dryer exhaust. An initial calculation showed that up to 90% of the energy consumed in the tenter is wasted. Therefore, quantifying the energy waste and determining drying characteristics are vitally important to optimizing the tenter and dryer operations. For low-demanding heat-setting situations, energy savings can be realized quickly. On the other hand, there are demanding situations where fabric drying represents the production bottleneck. The drying rate may be governed either by the rate of heat transport or by the rate of moisture transport. A mathematical model is being developed that incorporates both these processes. The model parameters are being obtained from bench-scale dryer studies in the laboratories.

This research developed the low energy consumption and high performance tenter machine with optimization of flow rate uniformity and heat flux efficiency. The optimum tenter machine which is designed by Computational Fluid Dynamics is enhanced the quality of fabrics and reduced the energy consumption.

2. RESULTS

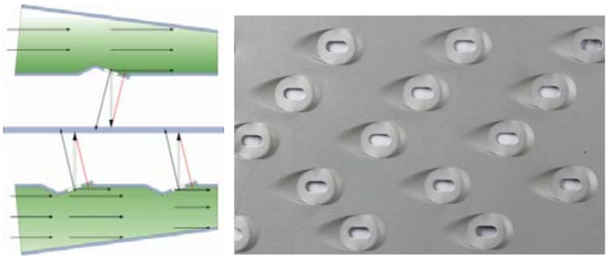
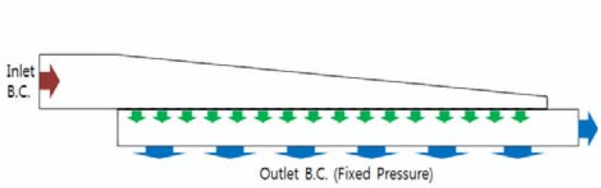
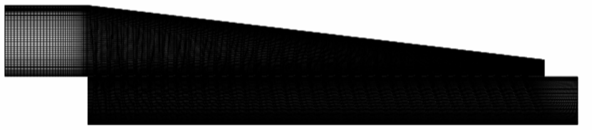


Fig. 1 Embo-type Nozzle

Figure 1 shows the shapes and flow behaviors of embo-type nozzle. In case of flat type nozzle hole, the nozzle jet cannot be injected the perpendicular direction to the fabric, because of inertia force. The emboss hole make the injection flow direction perpendicular and the angle of emboss hole is very important design parameter to determine the intensity and the angle of injection flow. To determine the optimum emboss angle, we calculate injection flow distribution for various emboss angle hole and analyze flow rate distribution and flow direction. Figure 2 represents computational model and mesh.



(a) Numerical model & boundary conditions

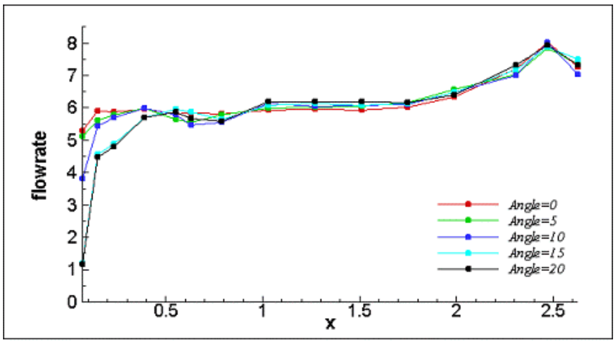


(b) Generated mesh

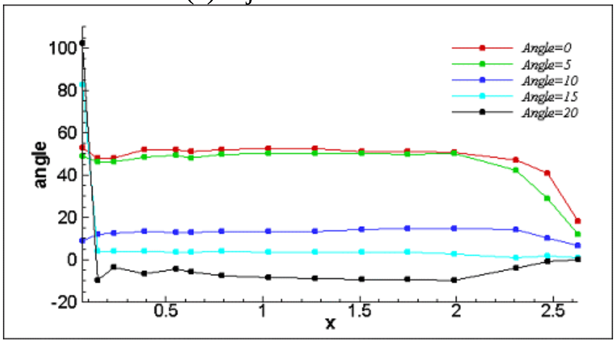
Fig. 2 Computation model for embo-nozzle

Figure 3 represents the variations of flow rate and directional angle of nozzle injection flow as a function of the angle of emboss hole. Figure 3(a) and (b) show the change of injection flow rate and injection angle along the main flow direction, x-axis, in nozzle duct, respectively. The injection flow rates are almost same behavior for the various hole emboss angle, but the flow injection angles are seriously affected by emboss angle. Consequently, the optimum angle of emboss hole is about 12 degree.

The most important design parameter affected the flow rate distribution as a position of nozzle hole is the ratio of cross section area between the inlet and end plate of nozzle duct. Figure 4 shows the injection flow rate distribution as a function of change ratio of cross section area. The more the cross section area change ratio is decreased, the more uniform nozzle flows are injected in whole nozzle duct and the optimum ratio is about 0.086. Under this optimum value 0.086, the uniformity of injection flow rate distributions are almost same value but the energy loss is increased.



(a) Injection flow rate



(b) Injection angle distribution

Fig. 3 Injection flow rate and angle distribution as a flow directional position in nozzle duct

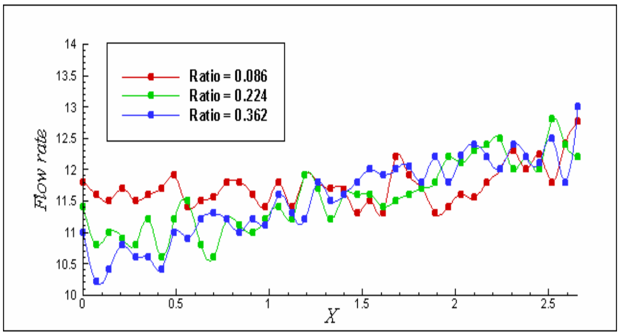


Fig. 4 Injection flow rate distributions as a function of change ratio of cross-section area in nozzle duct

Figure 5 represents the computation model and boundary condition for optimization of angle of guide impeller and axial fan blade, flow path of guide duct and branch duct. We choose the important design parameter such as arrangement of guide impeller and axial fan, angle of fan blade, and inlet area and branch angle of each nozzle duct.

Figure 6(a) and (b) show flow velocity profiles of general and optimum tenter model, respectively. In case of general tenter, because of counter-clockwise swirl flow generated by axial fan, the flow are concentrated at the right-upper and the left-lower nozzle duct.

3. REFERENCES

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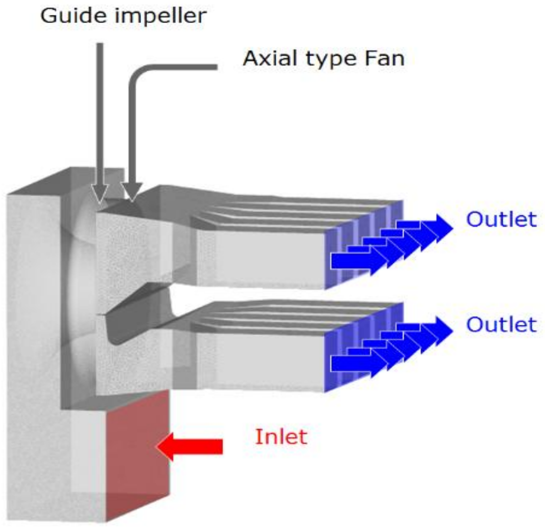
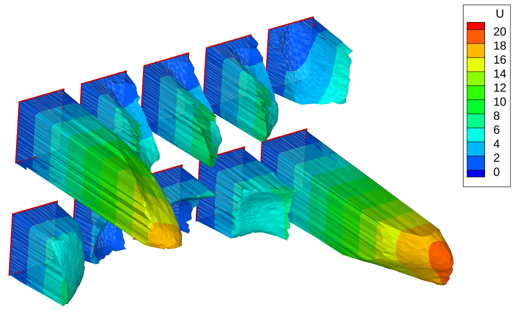
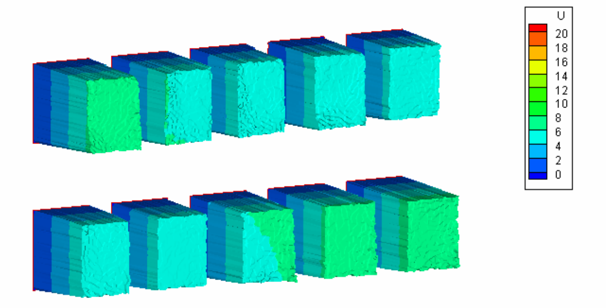


Fig. 5 Computation model to optimize blower, guide impeller, and guide duct



(a) General tenter



(b) Optimum tenter

Fig. 6 Flow distribution at inlet of each nozzle duct