MODELING TURBULENT FLOW AND TEMPERATURE FIELDS FROM MULTIPLE INTERACTING JETS

H. M. Krutka, D. V. Papavassiliou, and R. L. Shambaugh

School of Chemical, Biological and Materials Engineering
University of Oklahoma
Norman, OK 73019, USA
Holly.M.Krutka-1@ou.edu

Nonwoven polymer fibers are used in a range of practical applications, such as filters, medical gowns, diapers, insulation, and many other common products. Melt blowing is a process that is used to convert polymer pellets to the elongated fibers that are used in the aforementioned applications. During the melt blowing process, molten polymer exits a capillary and is contacted by heated, high velocity air. The drag force exerted on the polymer by the air leads to a rapid decrease in the diameter of the polymer fiber (resulting in a final diameter often less than 1 micrometer) [1]. Some melt blowing dies use round air jets with a polymer capillary inside, which creates an annulus for the air flow. The Schwarz die uses such annuli to produce multiple fibers simultaneously, which leads to the creation of a nonwoven mat of fibers [2]. The air and temperature fields depend on the configuration of the melt blowing die, and the fiber properties are determined by the flow and temperature fields.

Computational fluid dynamics (CFD) can be used to model the turbulent air flow field generated by the Schwarz melt blowing die. The k-epsilon turbulence model has been applied, and this model has successfully simulated experimental velocity and temperature data. The flow and temperature fields from six different melt blowing dies were simulated; the only difference between the simulations is the distance between the air jets. The flow and temperature fields generated by different jet configurations were compared so as to predict the best geometry for creating optimal melt blowing conditions.

In comparison with the flow field of a single annular jet acting alone, the velocity maximums occurred closer to the die face for an array of jets. The spreading rates for the center jets of the multi-hole dies were similar to each other, and close to 0.5, while the spreading rate of a single annular jet has been observed to be nearly twice this value. Using CFD to examine these turbulent flow fields has lead to a greater understanding of multiple jet interactions. For instance, the distance required for the inside column of jets to affect the outside jets was determined as a function of the jet orifice spacing. Finally, the turbulence intensity of all the simulated flow fields did not vary as significantly as the velocity profiles.

Similar to the velocity profiles, the temperature field from the array showed significant variations from that of a single annular jet. The temperature field from the multiple jet dies decayed more slowly than from a single annular jet. In addition, the temperature fields from the different die geometries showed variations from each other, leading to observations relating to the interactions between multiple jets. As the spacing between the jets increased, the distance required for the temperature fields from neighboring jets to converge also increased.

References

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