

## **CHAPTER 5**

### **Conclusion**



## Conclusion

The internal flow field of the pneumatic spreader was first simulated by numerical investigation, and the work successfully developed a new and efficient fiber pneumatic spreading system. The spreading process of a carbon fiber tow was first visualized by the photographic technique. By the fiber pneumatic spreading system, a thin and uniform nickel film was successfully coated in a carbon fiber tow. The carbon fiber tow was easily spread out at the test conditions and the performance was better than the previous studies. The major results and conclusions from this work are summarized as follows:

1. By the three-dimensional mathematical model of the fiber pneumatic spreader, the simulated flow patterns are helpful to analyze the variation of airflow and to understand the internal flow-field of the spreader at different conditions.
2. The simulation results are in excellent agreement with the experimental measurements downstream, and the result can be used to analyze the flow field upstream. Therefore, the designed parameters are determined; the height of the spreader is 5 mm, and the distance from clapboard to symmetric plane is 25 mm.
3. The three-dimensional simulation is successfully combined with experiment for the application of carbon fiber tow spread, and this methodology can also used in other fiber spread processes.
4. The spreading evenness is first used and discussed in spread carbon fiber tow, and it is more useful than spreading degree in elucidating the spreading process of the fiber tow. The newly defined variable, spreading evenness, facilitates a quantitative comparison among the spread fiber tow under various test conditions, and the optimum conditions for the spreading process can thus be obtained.

5. The pneumatic spreading system outperforms systems described elsewhere, and a carbon fiber tow can be uniformly and efficiently spread out. The optimum conditions for fiber spreading are  $V_F = 7$  m/min and  $Q = 80$  L/min, for the nine slot pneumatic spreader, with a evenness of spread of 62.3(%). The spreading evenness of a carbon fiber tow was constrained by the large air velocity; therefore, when eight slots in the spreader were sealed, the evenness of the fiber tow reached 83 (%), differing considerably from that in the flow field of the spreader with nine slots.
6. The fiber spreading procedures are proposed in detail by computational fluid modeling and experiment, and they can help in understanding the spreading process and the design of a pneumatic spreader.
7. Two different controlled reaction mechanisms simultaneously occur in an unspread carbon fiber tow as the electroless plating reaction proceeding, which resulted in non-uniform nickel coating, one is diffusion-controlled reaction; another is activation-controlled reaction. For the spread fiber tow, the chemical reaction process is governed by the activation-controlled reaction.
8. By the fiber pneumatic spreading system, a carbon fiber tow can be uniformly spread out, and a uniform Ni coating can be obtained on each fiber. The system can be applied to get a thin and uniform metallic or non-metallic film for a fiber tow.