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Numerical Analasis of Magnetic-Electrospinning

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Abstract: *In this paper, a discrete model is used to simulate the bending instability phenomenon in electrospinning with and without magnetic field respectively. The jet can be simulated as many discrete electrified particles, which are joined by viscous-flexibility materials. The simulation results correspond well to the experimental data and show that the magnetic field can influence the jet with proper distance.*

1. INTRODUCTION

Electrospinning technology is a very effective method for producing nano-fibers economically. So it becomes a hot subject in the world [1-12]. But the charged jet is instable during the electrospinning process, which leads to the uneven construction of nano-fibers and the waste of energy as well as other bad sequents. Therefore many researchers have studied the instability and tried to control the instability of the jet. For controlling the instability, the magnetic-electrospinning is proposed, using a magnetic field to control the jet.

In this paper, the moving behavior of the jets in the electrospinng process with a magnetic field is analyzed. The result indicates that the magnetic field creates a radial Lorenz force on the jet and so the jet shrinks in the falling process. The relationships between the swing of the jet and the distance with or without magnetic field are obtained. From the relationships, we know that the swing scope with a magnetic field is smaller than that without a magnetic field.

2. EXPERIMENTAL PART

We apply a magnetic field in the electrospinning process, as illustrated in Fig. 1. The setup for electrospinning is essentially the same as the conventional configuration except for the use of two magnets positioned around the aluminum foil. The solution was driven from the syringe at a constant rate. The fibers were electrospun at appropriate voltages and collection distances. All electrospinning processes were carried out under room temperature in a vertical spinning configuration.

In our experiments, we fabricated fibers with different diameters by changing the excitation current applied. As a result the stability condition is enormously improved.

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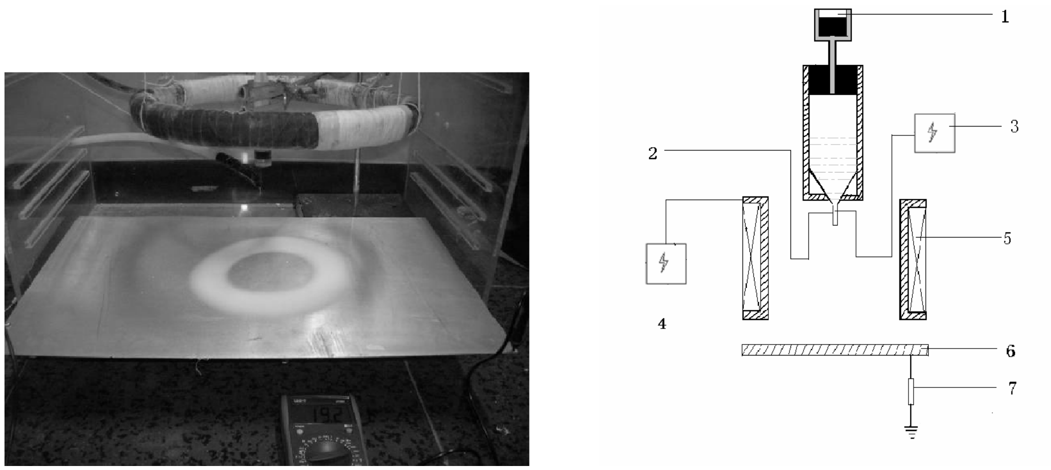


Figure 1: Magnetic-Electrospinning Setup (1-pump, 2- nozzle, 3,4-high voltage supply, 5- excitation coil, 6- grounded collecting plate, 7- resistance).

And with the increase of excitation current, there has appeared ever-decreasing the average diameters of the corresponding fibers.

Table 1
The Radius of the Whipping Circles with Different Excitation Current Applied in the Electrospinning Process

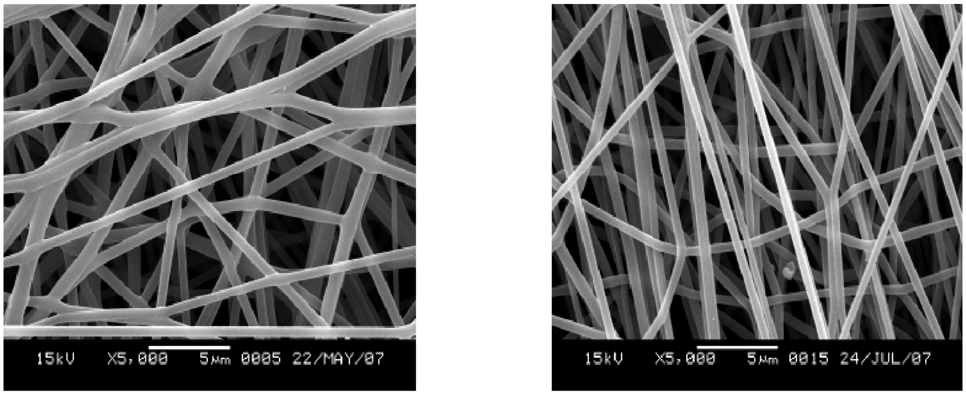
Excitation current (A)	*Radius of whipping circle (cm)*
1	15.1
2	14.8
3	13.7
4	12.5

Table 1 shows the radius of whipping circle with different excitation current applied in the electrospinning process. The applied voltage connected to the needle is 20KV. It can be seen that with the increase of excitation current, there has appeared shrinking of the radius of the corresponding whipping circles. The experimental results shows that the magnetic approach is the effective way to control instability.

Fig.2 shows the average diameters of the fibers with different excitation current applied in the electrospinning process. The applied voltage connected to the needle is 20KV. It can be seen that with the increase of excitation current, there has appeared ever-decreasing the average diameters of the corresponding fibers. Comparison with the experimental datas shows that the numerical simulation is effective.

3. NUMERICAL RESULTS AND DISCUSSION

In this paper, a discrete model [1] is used to simulate the bending instability phenomenon in electrospinning with and without magnetic field respectively. The jet can be simulated



(a) 0A (b) 4A

Figure 2: The Diameters of the Fibers with Different Excitation Current Applied in the Electrospinning Process.

as many discrete electrified particles, which are joined by viscous-flexibility materials. The mathematical model provides a reasonable representation of the experimental data.

When we apply a magnetic field in the electrospinning, the problem can be completely overcome [2]. The current in the jet, under the magnetic field, produces a centripetal force, i.e., the direction of the Ampere force is always towards the initial equilibrium point, leading to the swing scope with a magnetic field is smaller than that without a magnetic field. The calculated results is shown as follows:

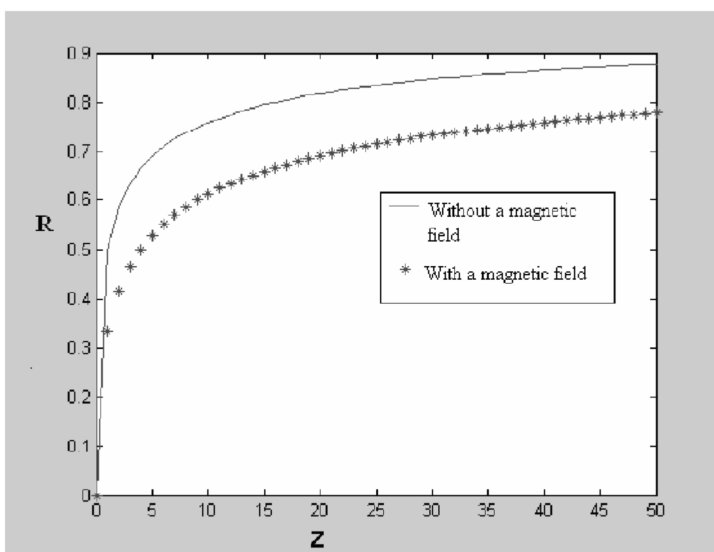


Figure 3: The Relationships between the Swing of the Jet and the Distance from Nozzle to Grounded Collecting Plate with or without Magnetic Field (R-the Swing of the Jet; Z-the Distance from Nozzle to Grounded Collecting Plate).

Fig. 3 shows the relationships between the swing of the jet and the distance from nozzle to grounded collecting plate with or without magnetic field. It can be seen that the swing scope with a magnetic field is smaller than that without a magnetic field. Comparison with the experimental datas shows that the numerical simulation is effective.

4. CONCLUSION

In conclusion, the magnetic approach is the most effective and economical way to control instability. A discrete model is used to simulate the bending instability phenomenon in electrospinning with and without magnetic field respectively. And the simulation results correspond well to the experimental data and show that the numerical simulation is effective.

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