Synthetic Staple Fiber Spinning

Introduction

With the commercialization of polyester staple fiber in the early 1950s, the use of synthetic staple fibers took a great leap forward. Polyester fibers were available to be used in combination with cotton to make poly/cotton spun yarns or carded into webs for needle punching, hydroentangling, or thermal bonded into non-woven sheet products. Later polypropylene and other types of synthetic fibers became widely available including bicomponent synthetic fibers.

The step used to produce synthetic staple fibers consist of the following regardless of the type of polymer used (see Figure 1):

- Extrusion or Spinning
- Drawing
- Crimping
- Cutting
- Bailing

These are three basic process used to accomplish these stages. Each of these processes is described below.

Two-Step Process

A typical plant layout for spinning staple fiber is a two-step process as shown in Figure 2. This process is characterized by high spinning speeds (up to 1800 m/minute) and relatively few threadlines in spinning holes (generally less than 20,000 per machine). Polymer can either be made continuously and fed to spinning or melted from pellets and fed to spinning where it is pumped and metered as a bundle or tow to collectors called tow cans.

Once the tow cans are filled, they are arranged in a creel that collects the tow from each can together to make one large tow that is fed to a staple draw machine (Figure 3). In the staple draw machine, the tow of fibers will be heated, drawn, crimped, cut into staple of selected length, and fed to a baler. The process is now complete and the bale of fibers is available for use in downstream processing into woven, knit, or non-woven fabric.

One-Step Process

A typical layout for a one-step process is shown in Figure 4. This process is quite commonly used to make polypropylene staple fiber. The process is characterized by a high number of holes in the spinneret (generally 80,000 or more) of which several are used and by low spinning speeds (less than 300 m/minute). The low spinning speed is necessary in order to match the output of spinning with drawing, crimping, cutting, and baling, which is now coupled with spinning. In many cases, the speed of these lines is 100 m/minute or less due to the inability to get good crimp into the fiber at higher speeds. These lines are extruder fed since a breakdown in any one part of the process would case the entire process to come to a halt. This process is often called "compact spinning" because the height of the lines or equipment is approximately half that of the more conventional two-step process. A comparison of these two processes is shown in Figure 5. the largest difference in spinning is the hole spacing required in the spinneret used and the difference in the polymer throughput per hole. Typical spinnerets are shown for each process in Figure 6.

In-Line High Speed Process

In recent years, especially in Europe, a large amount of effort has gone into developing a new staple process that is one-step but can be run at high speeds (Figure 7). The spinning process is much like filament spinning but to make staple fibers it must be combined with crimping, cutting, and bailing. In this process, the fibers are spun and quenched at a speed of approximately 1000 m/minute. Instead of being taken into a tow, the fibers are kept in a sheet or wrap form and taken to a draw stand where they are drawn approximately three times (3X). The fibers are then combined into a flat tow form, fed into a high-speed crimper then cut, and bales. The number of filaments spun in this process is small compared to the older process (Figure 8). The equipment is also expensive due to the high speed involved and not very flexible. It remains to be seen if further development of this process will allow it to come into general use.

by
Dr. John Hagewood, Ph.D., P.E.