

Discussion on the Splitting Technique of Segmented Type Bicomponent Spunbonded Nonwovens

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Abstract: Splitting spunlaid composite filament is a most significant technique to manufacture nonwoven with microfibers. The splitting effect of composite filament is a direct impact on the performance of the final products. The paper summarizes present methods of splitting composite fibers at home or abroad, and the principle and characteristic of each method is also described in order to discuss the most suitable fiber splitting technique to manufacture segmented type bicomponent spunbonded nonwovens.

Keywords: Segmented, bicomponent, nonwoven, splitting

1. Introduction

Microfiber commonly refers to any fiber with strand less than 1 denier. Textile synthetic microfibers have a diameter of about 10 microns or less. Synthetic microfibers have been developed in Japan in the early 1970s by Dr. Miyoshi Okamoto. Despite their great potential it took some years before they find various applications. It was later improved by Dr. Toyohiko Hikota who designed the first non-woven fabric, named "Ultrasuede", which production was started in 1989 by the US Company Dupont de Nemours^[1]. Microfibers are classified into two types^[2]: (1) a continuous filament type and (2) a random (staple) type. The continuous type has again two broad divisions—direct and conjugate spinning. The most common types of microfibers are made from polyesters, polyamides (e.g., Nylon, Kevlar, Nomex, Trogamide), and or a conjugation of polyester and polyamide.

Microfiber use in textile industry consecutively expanded, as it has lots of advantages, including greater surface area and flexibility, that can't get from conventional fibers. Microfiber can be processed into very lightweight fabrics with excellent draping qualities, good handing and luxurious appearance. When microfiber is made into nonwovens, they have even more properties: good isolation, impermeability, breathing ability, wrinkle-resistance, stain-resistance, easy washability^[3]. Their potentially greater comfort and functionality offer many applications in areas.

2. The technique of segmented type bicomponent spunbond

Segmented type bicomponent spunbond is a new technology of manufacturing fabrics with microfiber through the principle of conjugate spinning. The production process is shown in Figure 1.

Segmented type bicomponent fiber is one of most import splittable fiber, which is made from two incompatible polymers. The two polymers are alternative dis-

tributed in the fiber cross section, as shown in Figure 2. The manufacturing of spunbonded nonwovens made from splittable bicomponent filament is an innovative and flexible engineering process to enhance their fineness. Nonwovens made from bicomponent fibers have already been well known for some decades. However, the splitting technology of the segmented type bicomponent spunbonded filaments is still immature.

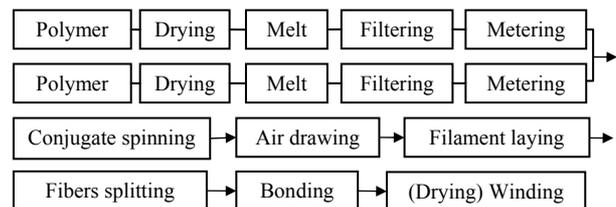


Figure 1. The production process of segmented type bicomponent spunbond

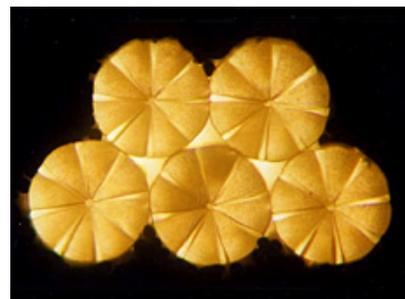


Figure 2. The cross section of segmented type bicomponent fibers

3. Splitting techniques

Researches on Splitting technique of bicomponent fiber are reported along with the development in bicomponent spinning. At present, there are many ways to split bicomponent fibers into microfibers at home and abroad. These

ways can be divided into three categories: chemical procedures, thermal procedures and mechanical procedures.

3.1. Chemical procedures

Chemical procedures are to use some chemicals to process the bicomponent fibers so that different components in fibers can separate to each other. In this way, chemicals can be evenly applied to fiber materials^[4]. Chemical procedures mainly include alkali deweighting, acid process and chemicals swelling.

Alkali deweighting is the most commonly used splitting method in the industrial production of microfibers at present. In this procedure, alkaline solution reacts with one of the two polymers in fiber and made it degraded. When the polymer is degraded to some extent, the two polymers in bicomponent fiber can automatically separate to each other. But this method will cause greater damage to fibers. Although with the alkali concentration, reaction time and temperature increases, splitting rate of fibers increases, the polymer is deweighted more, resulting in lower fiber strength and output^[5].

Different polymers have different shrinkage and swelling in acid solution. It will form a shear force that can split bicomponent fibers on the interface of two polymers when the polymers in fibers shrink and swell. Li Na et al.^[6] used her home-made GS acid process segmented type PA6/PET bicomponent fiber. She got a good fibers splitting effect on the condition of 35%GS concentration, 80°C, and 40 minutes. Gao Xushan et al.^[7] disclose a method of using acetic acid to split bicomponent fibers and fabrics made from them in a patent. The splitting rate of fibers is up to 95% and the fibers or fabrics can be uniformly dyeing according to the information disclosed in her patent.

Polymers can be swollen when they are immersed in some organic solvents. Splitting fibers by the different swollen properties of polymers in organic solvents is a environmentally friendly procedure as the solvents can be recycled^[8].

3.2. Thermal procedures

Most of polymers will swell when heated, and shrink when cooled. The swelling and shrinking of polymers will form a shear force on their interface to split them. That is the principle of thermal procedures. Heating ways in this method can use any type that can cause differential heat shrinkage and separation of the fiber components, including, but not limited to: hot air, steam, radiant heat and combinations thereof. Heat can also be applied by subjecting the fibers to hot or boiling water. Hills Inc. in America disclosed a thermal procedure of for in-line splitting of plural-component fibers in a patent. In this patent, plural-component fibers are deposited on a web-forming belt and conveyed to a heater which heats the web to a temperature sufficient to cause differential heat shrinkage of the polymer components, thereby causing

the fiber segments formed of the components to separate in less than approximately a second^[9].

3.3. Mechanical procedures

Mechanical procedures are exerting external force on the bicomponent fibers to split them. The external force can be the impact of high-pressure water or needlepunch, pressure, tensile force and so on. The two polymers in composite fibers are thermodynamically incompatible system, but not completely separate system. One polymer disperses in the other polymer with a form of micro-domain that forms an intermediate zone in the interface of two phases. The intermediate zone is thin, only a few tenths of nanometers to a few nanometers, so that it is easy to separate the two polymers when an external force is applied on them. Mbwana Suleiman Ndaro et al.^[10] split modified PA6/COPET sea-island bicomponent fibers by spunlace in his research. The results showed that fiber splitting and entangling effect is better with the pressure of water increase. When the pressure of water is 200bar, the fiber splitting rate is up to 80%.

4. Splitting techniques of segmented type bicomponent spunbond

The filament in segmented type bicomponent spunbond is a kind of splittable fiber. Splitting techniques mentioned above can be used in the production of segmented type bicomponent spunbond in theory, but not all of them are suitable in fact.

Alkali deweighting is a mature technology in the splitting of sea-island bicomponent fiber. The author have ever processed a segmented type bicomponent spunbond sample on the condition of 5% alkali concentration, 80°C, and 5 minutes in the laboratory and got nearly full splitting rate. But this method is a long process, and it should increase a number of devices and operating costs. In addition, it will detract some raw materials, resulting in large strength loss and a greater waste. What is more, alkali solution may cause serious environmental pollution, if not properly handled. Acid process is a most complex splitting technique. It will take much time to split fibers and acid is apt to etch equipments. Otherwise, the treatment of acid solution is a troublesome problem too. Though splitting fibers by swellers is a pollution-free technique, the splitting rate is generally low. Because of the limits of processing conditions and splitting effect, the later two methods are only used in laboratory.

Thermal procedures can get a good splitting effect only if there is enough difference in shrinkage between the two fiber-forming polymers in segmented type bicomponent filament. But most of polymers that have enough difference in shrinkage can't meet the requirements of segmented type bicomponent spunbond process. The author have ever process the PA6/PET segmented type bicomponent filaments at 90°C in water and 160 °C

in air for three minutes respectively and got a low splitting rate.

Mechanical procedure, especially spunlacing, is considered to be a most suitable process for splitting segmented type bicomponent spunbond. In the past, a combination of spunbonding and spunlacing was not economical because of the difference in speed. The spunbonding technology had already reached high speeds, while spunlacing was still operating at moderate speeds because of the limited water pressure resulting from the line design. But now the state of development reached for spunbonding and spunlacing lines makes a combination of both methods useful. At present, there are three companies (Freudenberg Inc. in Germany, Phoenix Inc. in Netherlands and Sanjiang Inc. in China) that have already used spunlacing technology to process segmented type bicomponent spunbond. The spunlacing process has little damage to fibers and won't pollute environment. What is more, it can make fibers entangled while splitting fibers. Only if the pressure of water jets is high enough, can we get a good splitting effect. The pressure of water jets that Freudenberg Inc. used in their production is up to 230bar^[11]. But higher pressure requires more expensive equipment, and energy consumption will rapidly increase with the pressure increasing. It is inadvisable to use the only spunlacing technology to split segmented type bicomponent spunbond filaments.

Besides, the author has ever process PA6/PET segmented type bicomponent spunbond filaments with needlepunch, tensile force and pressure respectively, but didn't get an ideal splitting effect.

5. Conclusion

Segmented type bicomponent spunbond will get lots of excellent properties, including soft handing, compact fiber structure, good barrier and filtration, etc., only if

there is a good splitting effect of the filament in fabric. So splitting process is particularly important in the whole flow of production. From the previous discussion we can draw a conclusion that we may get an ideal splitting effect if we combine some splitting technologies together in the process of segmented type bicomponent spunbond. It will be a significant development for the whole nonwoven industry if we can develop a simple, efficient and environmentally friendly fiber splitting technology to segmented type bicomponent spunbond.

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