Manufacturing Design of the Novel Multi-Layer Blending Machine

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Key words: multi-layer, blending, oscillator, fibrous layer, conveyer belt, front storage chamber, rear reserve tank

Abstract.

In this study, a multi-layer blending machine was designed to mix cotton evenly. Being put inside via the feeding port, cotton was spread evenly by the oscillator which moves from left to right back and forth successively. Subsequently, cotton was stored as the multi-layer fibrous cotton in the rear reserve tank. Delivered by the first and the second conveyer belt, the fibrous cotton was sent to the front storage chamber to be cut by a lattice which pulled and dragged the marching cotton vertically. Finally, the processed cotton was rolled out by a striper roller, falling at a certain spot as scheduled, after which spread and blended evenly and thoroughly.

Introduction

In the staple spinning manufacturing, it is common to spin two or more different fibers together. The market has become more and more competitive; therefore, less defects and color mottles are important for attracting more customers [1]. With fine availability and tangible comfort, natural fiber is hygroscopic, low irritating and biodegradable. However, its dimensional stability is too weak to implement quality control. In spinning industry, even fiber blending is crucial. The webs with mixing uniform are the one of the major productive goals for textile industry in the application fields [2-9].

Blending machines commercially available, such as Germany's TRÜTZSCHLER and Switzerland's RIETER, use higher chamber to blend fabrics; nevertheless, the blending effects are unsatisfactory. In this study, a blending machine was designed to blend about 200 fibrous layers at the same time.

Experimental

To improve the current blending technique, this multi-layer blending machine was designed by passing many computer simulated tests. It used the tilting guide to stabilize the sway frequency, so cotton of the same weight or size would land on the same spot to achieve the best blending effect. Figure 1 is the illustration of the multi-layer blending machine in which 1 is cotton；2 is the blending chamber；3 is the input channel；4 is the feeding port；5 is the oscillator；6 is the rear reserve tank；7 is the first conveyer belt；8 is the second conveyer belt；9 is the detecting device；

10 is the front storage chamber；11 is the third conveyer belt；12 is the lattice；13 is the striper roller; 14 is the output channel ； and A is the fibrous layer.

Results and Discussion

This apparatus was designed to spread cotton in 360°, as a whirlwind. However, the layer was not evenly placed. The layer was thicker on the fringe of the chamber, giving room to air turbulence which kept fiber tufts landing on the right spot. An oscillator was used as a guided laying mechanism. An exhaust net was installed near the fibers' landing area to counteract air turbulence, so the tufts would land where as expected. A swing type guiding apparatus and a sensor were equipped to stabilize the layering frequency, making more well-mixed layers.

The filter was designed according to the tradition module whose height and installed position were carefully evaluated. When the mesh was put on the top of the storage tank, fiber tufts at the bottom were crowded. The heavy loading was good enough to compress and thus clog the mesh below. Fibers had good air permeability, and allowed air osmosis downward, resulting in significant difference of density between layers. When the mesh was placed around half or one third of the height, the chamber's capacity declined. The fillings peaked exclusively at where the mesh was located. Thus, the filter was placed at the height around its 55-57 % of the chamber to minimize the density difference (as illustrated in Figure 2). Figure 2 illustrates the rear reserve tank in which 1 is the oscillator and 2 is the filter. The appropriate detective degree of pressure was 40 mm column of water. With higher pressures, the marching fiber did not float within the chamber and rub against the duct. In lower pressures, the cohesion was too insufficient to land the fiber tufts onto the expected area.

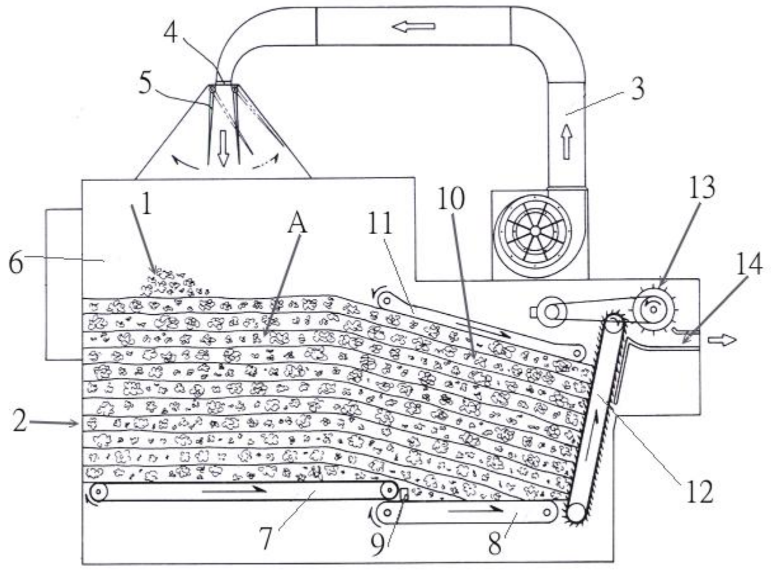
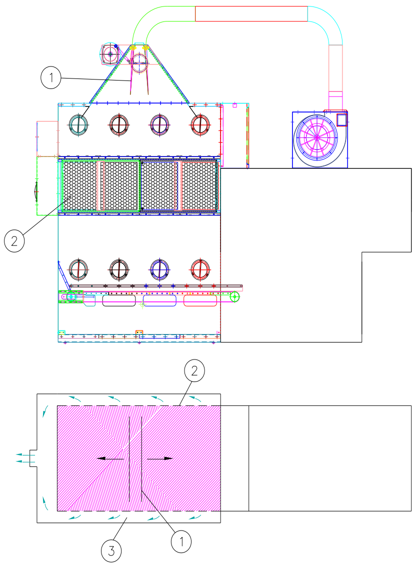


Figure 1. Structure of the multi-layered chamber

The Air-stream Carry Theory suggests that the air stream, with a certain flow speed, is able to carry the fiber tufts in a duct. In a vertical duct, the speed of air stream is expected to beat the suspension forces or terminal velocity. In a horizontal duct, the speed of air stream should beat the fiber's suspension velocity, which was triple of terminal velocity and thus suspension velocity was crucial. On the other hand, the lattice was common in a fiber opening and delivery device. Its vertically-arrayed steel needles determined the cutting position. The partial stripping cotton staples were then compressed, overloading the card flat to output, so fiber tufts of all sizes were produced. To overcome this drawback, we rearranged needles. The needles were arranged densely with a twill pattern like a rhombus, thoroughly cutting the fibrous multi-layers and generating fluffy and tiny fiber tufts. Finally, the cotton was compressed with the automatic plucker in the chamber, and then placed on the conveyer belt inclinedly instead of leveled. Then, a two-stage conveyer belt was designed to replace the original one. A third-conveyer belt was installed right above the second conveyer belt. Because of the two-stage procedure, the first conveyer belt would stop when the rear reserve tank was jammed with the multi-layered fibrous cotton marching horizontally.

Table 1 summarizes the comparison between different blending methods in a variety of aspects. The multi-layered blending machine produced more fibrous layers with an appropriate density and smaller fiber tufts, and landed the fibrous tufts as expected until well-mixed multi-layer fibrous layers were obtained.



1. oscillator；2. filter

Figure 2. Structure of the rear reserved chamber

Table 1 The comparison of different blending methods

Description	Bin-mixing	Multi-mixer	Multi-layered
Thickness of fibrous layer (mm/layer)	No visible layers	500	10
Fibrous layer (layers)	None	4 - 10	180 - 200
Filling direction	Randomly	Vertically	Horizontally
Density	30 kg/m^3	80 kg/m^3	50 kg/m^3
Fiber tufts	10 mg	20 mg	1 mg
Landing way	Uncontrol	Controlled	Controlled

Conclusion

In this study, we designed and developed a multi-layer blending machine successfully. The modes of operation were as follows: Cotton was fed via the feeding port and diffused evenly in the rear storage chamber, forming multi-layered fibrous mixed cotton. The leveled layer was transmitted via the first conveyer belt and the second belt horizontally. The first conveyer belt did not start until the rear reserve tank was full with planned layers. Then the multi-layer fibrous cotton was sent to the front storage chamber where cotton was held in parallel horizontally by the second and the third conveyer belts simultaneously. The second and third conveyer belts were installed at the top and the bottom respectively, and operated in chorus. This multi-layer fibrous cotton was cut by the vertically-installed lattice and then rolled out. When the loading amount on the second conveyer belt was insufficient, the sensor would speed up the first conveyer belt automatically. In sum, this multi-layer blending machine was able to process 200 bags of cotton; featured storage, cleaning, opening and blending; mixed cotton fully; as well as controlled blended yarn ratios effectively.

Acknowledgement

This work would especially like to thank National Science Council of the Republic of China, Taiwan, for financially supporting this research under Contract NSC 99-2622 -E-035-008-CC3.

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