Development of Continuous Dyeing and Multi-color Printing System for Slivers

Part 3 : Development of Continuous Steamer and Benefits of New Developed Total System

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Abstract

Both the J-box and conveyer type are generally used as the conventional continuous steamer for slivers. The J-box steamer has some defects such as uneven steaming slivers and is apt to cause entangled slivers. On the other hand, the conveyer type steamer has defects such as requiring long-wide space and is apt to cause entangled slivers, too.

We developed the innovated continuous steamer which could keep and transfer slivers regularly without entanglement, and could steam slivers efficiently without levelness. This new developed system consists of continuous dyeing, multi-colored printing and continuous steaming. By using this system we can get high productivity, quicker delivery and lower costs in manufacturing melange top.

1. Introduction

Concerning steaming process of slivers after printing or ground dyeing followed by printing, there are two methods of batch and continuous process. In batch process, the vacuuming pressure can be kept high, so the de-airing or substituting air to steam into slivers is easily attained, and the steaming is efficiently performed, but its productivity is low. On the other hand, in conventional continuous steamer, the steaming is not generally performed efficiently but its productivity is high.

There are two type of continuous steamers for slivers, the J-box and the conveyer type. But they both have many problems[1]. It is difficult to fold the slivers stable in the J-box steamer. Slivers easily come to be in disorder and to be entangled. Therefore, the effect of steaming is generally uneven.

In the conveyer type, the density of sliver is small because slivers are simply hung down on the conveyer. So this type of steamer needs long-wide space and the slivers easily come to be entangled, too. Because of hanging down on the conveyer, it takes long time to pull them out to the entrance of the steamer when troubles cause such as entangling, cutting off and so on.

As the other type of continuous steamer, there is one with some cylinders[2]. It has good airtightness, but can steam slivers only for ten minutes or so. This steaming time is too short to steam materials like wool which requires considerably long time.

Concerning wool sliver steaming, the wet steaming is popular for the purpose of keeping moisture enough. So the steamer of new developed system is usually used without drying after printing, too.

In this third paper, a newly developed effective continuous steamer is reported. It improved various faults of conventional steamers. The obtained results were referred to rationalized color

top making system consisted of continuous dyeing/printing/steaming processes and recombining process.

2. The Development of Continuous Steamer

2.1 The substance for development

We aimed at the development of steamer in order to solve the faults of the conventional steamer and to have higher productivity.

The substance for development is as follows.

- ①small equipment, high airtightness, steaming in a short time.
- ②arranging slivers in good order during steaming in storing and transferring.

2.2 Folding, storing and transferring system of slivers in the new developed continuous steamer

The new developed continuous steamer is shown in Fig.1.

①As Fig.1 shows, continuous dyed or printed slivers were shaken down at upper down slope of the first conveyer and then folded and piled up.

②Slivers were horizontally folded at the upper side of conveyer but vertically came to rise as their transferring to the lower side. Because the part which attached to the transferring side of the conveyer (drawn in skew line in Fig.2) was transferred first, the upper side (drawn in dot dash in Fig.2) was delayed.

Slivers were continuously pushed out from the lower side to the second conveyer. On the second conveyer which attached to the transferring side of the conveyer was transferred first, the upper side was delayed and inclined back. By adjusting the ratio of velocity of these two conveyers, the standing angle of piled slivers was able to change freely.

③Piled slivers were steamed on to the second conveyer and

Fig. 1 New developed continuous steamer
 ①sliver, ②first conveyer, ③second conveyer,
 ④swing plate, ⑤suction fan, ⑥first chamber,
 ⑦second chamber, ⑧third chamber, ⑨steam pipes

Fig. 2 Transferring state of the piled slivers on the first conveyor
 ①transferring, ②first conveyer, ③sliver,
 ④upper part

dyestuffs were fixed.

④The upper side of the piled slivers was regularly inclined back and guided to the outlet, so the uneven steaming caused by short-pass of steam and entanglement of slivers was able to be avoided.

2.3 Short time steaming system

In order to finish steaming completely in short time, ①steam-blow-off pipes were installed in the whole lower side of steaming chambers. The steaming chambers were separated in small parts and the levelling of steam flow was planned as Fig. 1 (three chambers of ⑥, ⑦, ⑧).

②especially in the lower side of the steamer entrance (⑨, Fig. 1), steam-blow-off pipes were concentrically arranged. In this part, the steam blew downward, it is forcibly vacuumed and exhausted from upper part at ⑤, Fig. 1. So the air in slivers was quickly replaced with steam.

2.4 Setting up the folding length of piled slivers

Setting up the folding length of piled slivers has an important factor for steaming. If it is long, it takes too long time for steam to diffuse into piled slivers, and piled slivers tends to slip down. With short length, it is necessary to lengthen the steamer because the volume of slivers per space decreases. According to the test results of trial and error, the most suitable folding length of sliver was 30cm, 0.5m/min. of the first conveyer velocity, 0.16 cm/min. of the second conveyer (the velocity ratio 0.5/0.16), and the folding height on the second conveyer was 25cm.

We considered these conditions most suitable, and made them our processing standard. When the velocity ratio got bigger than this, the folding length got long, and it became troublesome to transfer to the second conveyer. When the folding length became more than 40cm, it would be hard to steam equally.

2.5 Effect of exhaustion by vacuuming forcibly

At the entrance of steamer, the heat-up rate of continuously dyed slivers (60% moisture content after padding) and printed slivers (30% moisture content, printed/unprinted section was 50%/50% or half-print) without exhaustion by vacuuming forcibly was shown in Fig. 3. The moisture content of slivers had a great influence on the heat-up rate. Concerning the continuously dyed goods, the heat-up time to reach at 100°C differed from one part of slivers (upper, middle, lower) to the other, and even if the best conditions taken, it took more than 25min. to raise temperature to 100 °C. On the other hand, in case of exhaustion by vacuuming forcibly, there was no difference of heat-up rate in every part of slivers shown in Fig. 4, and if the moisture content was different like continuous printing and dyeing, the difference of heat-up rate to reach 100°C was within 10 min.

When the heat-up rate was slow in continuous dyed slivers, the dye liquid penetrate down from the upper piled slivers to those

Fig. 3 Correlation between of slivers temperature and time at continuous steaming (without vacuuming at first chamber)

Fig. 4 Correlation between of slivers temperature and time at continuous steaming (with vacuuming at first chamber)

of lower before dye fixing, and the lower parts came to be dyed deeply. So it was desirable to raise the temperature in short time as possible.

2.6 Comparison with batch steamer

The new developed steamer was extremely efficient as continuous process, but compared with batch process, it still had some problems which were not able to be overcome.

① The energy cost was expensive

The steam consumption in batch steamer for vagaries printing (30% of moisture content, at half-print) was 0.4~0.8 kg per 1 kg of wool. The steam efficiency of new developed continuous steamer got lower compared with batch steamer. Furthermore, 20% of the total steam consumption was forcibly exhausted out in to the atmosphere by the suction because of the necessity of short time steaming. Consequently, the steam consumption of the new steamer was about 1.6 ~ 2.0 kg per 1kg of wool. This is more than two times as that of batch steamer. But we believe that such increase in energy consumption was rather insignificant from total dyeing cost. The effect of shortening the steaming time

and improving working-efficient were extremely more important.

② Necessity of carrier dyeing

In case of the continuous steamer, the equipment costs would get very expensive if we want to get steam in high pressure by closed system. Furthermore, it would be impossible to use it practically if we want to prevent the disorder and entangling of slivers. Therefore, We had better use the atmospheric continuous steamer for polyester slivers with some carrier and disperse dyes of low molecular weight(E-type).

It is possible to dye in deep shades by using the carriers derivated from phthalimide which have a high boiling point. However, it is very difficult to dye the regular type of polyester in very deep shades in terms of shade variation and fastness properties.

By using carrier and E-type dyestuffs, it is easy to get quality troubles such as the deterioration of color fastness to light, the increase of effluent treatment cost, post problems in the following processing caused by the deterioration of color fastness to sublimation.

Fig. 5 Comparison of blended colors between traditional system and new developed system

Fig. 6 The flow chart of new developed printing and steaming system

3. Obtained Results from The New Developed System

3.1 Development of new melange yarn

By this new system it was possible to color slivers in stripes up to four colors. Therefore, it gets easy to produce various kinds of multi-color melange yarn which had a subtle mixing color feeling never expressed by the conventional systems. The individual color effects of yarn produced by the conventional and the new system are shown in Fig.5. Especially, the melange yarn produced by printing after ground dyeing has no colorless parts and shows excellent blending effect.

3.2 Improvement of quality, labor-saving and short lead-time

The processing follow chart of new system is shown in Fig.6. The new system is rationalized for the processing as compared with the conventional system.

3.3 Offering prestigious goods

It comes to be possible to offer prestigious goods by some dyeing and chemical processes. Two examples of practical process are shown as follows.

3.3.1 Continuous dyeing of polyester slivers

It is possible to dye all kinds of polyester slivers in deep shades by the selecting of carrier. The strongest point of the continuous dyeing is the remaining crimps on fibers shown in Fig.7.

Consequently, the handle and the spinnability get better. The standard condition of dyeing /steaming is shown as follows.

Padding solution	Disperse dye	X	g/l
	Carrier	80	g/l
	(Derivative of phthalimide)		
	Wetting agent	10	g/l
	Acetic acid 80%	0.6	g/l
	Disperse agent	1	g/l
Pick up	60%		
Steaming	98°C × 45min		
Reduction cleaning	80°C × 2min

Continuous dyed sliver

Batch dyed sliver

Fig. 7 Comparison of appearance between batch dyed and continuous dyed polyester sliver

3.3.2 Antipilling treatment for wool slivers

Slivers were treated under the following condition such as spun into 2/48 MS yarns, and then knitted into the knitted fabric with cover factor 0.41, and finally evaluated the pilling resistance property.

(1) Recipe

Coikaline PH 535	1	g/l
(Koizumi Chemical LTD)		
Acetic acid 80%	50	ml/l
pp-40	80	ml/l
(Koizumi Chemical LTD)		
Penetrating agent	3	ml/l
Pick up	50%	
Steaming	85°C × 20min	
Neutralization	Sodium bisulfite	5 %owf

(2) Pilling resistance

The results are shown in Table 1. The pilling value of untreated wool yarn shows the grade 2~3. On the other hand, treated wool yarn shows the grade 3~5 depending on the processing condition.

4. Conclusion

We developed the new continuous steamer which arranges slivers stable and transfers in order. It composed of both the inclined and horizontal conveyer on which steaming is performed in short time. Owing to this new system, troubles such as irregularity and entangling of slivers, which were apt to be caused in conventional steamers, were solved, and the steaming

Table 1 Correlation between processing condition and quality of anti-pilling

Type of wool (μ)	Processing condition		Quality	
	PP-40 (g/l)	Steaming time (min)	Strength (gf) $\times 1/48$	Pilling (Grade)
21	Untreatment	10	390	2-3
21	200	10	320	5
21	100	10	350	3-4
24	200	10	310	5
24	100	10	330	4-5
21	100	40	310	5
24	100	40	320	4-5
21	50	40	360	3

has come to be attained effectively.

In addition, the productivity of making melange top was remarkably improved by connecting the continuous dyeing system with the continuous multi-color printing one.

Furthermore the patents about these new developed systems were already registered in the leading countries in the world[3].

References

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