Development of an Auto-Doffer for Covering Machine Part 1: Apparatus for Drawing Spandex into Hollow Spindles

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Abstract

Double covered yarn is produced by a double covering machine equipped with hundreds pairs of upper and lower hollow spindles. Drawing Spandex to be a core yarn of covered yarn into the hollow spindles is so complicated that its automation is especially desired. So, we developed an automatic drawing-in apparatus that could draw Spandex in both upper and lower hollow spindles simultaneously. Results obtained are as follows: (1) The automatic drawing-in apparatus is comprised of both an injector and an ejector. Spandex was drawn into the lower spindle by the injection flow driven by the injector and was drawn from the upper spindle by the suction flow driven by the ejector.

(2) The auto-doffing apparatus developed for a model covering machine performed draw-in. It could draw-in 20 D Spandex that was widely used and was too thin to be easily drawn-in even by a manual doffing operation. So, this confirmed that the developed auto-doffing apparatus had practical utility in the drawing-in operation.

(3) The rates of success of Spandex drawing-in are influenced by the supplied air pressures for the injector and ejector and the feed rate of Spandex. High rate of success could be accomplished by the proper adjustment of those conditions.

1. Introduction

Recently, textile fabrics with superior elasticity used for swimsuits, sportswear, pantyhose, inner wear, and so on are in great demand. They are made of a kind of processed yarn called covered yarn. Covered yarn consists of highly-elastic core yarn called Spandex and Nylon or spun Rayon that covers spirally around Spandex[1]. It is processed by a covering machine (Fig. 1). The bottlenecks of covering process are to doff products, exchange hundreds of core yarn packages and covering yarn bobbins, and put yarns through each spindle mounted on the covering machine. Since all spindles are driven synchronously by a spindle belt, a lot of skilled labors exchange bobbins and put yarns through more than 300 spindles rapidly by manual operations.

In spite of strong demands for labor saving and rationalization in many covering factories, automation of the covering process is never attempted. One reason for difficulty of automation is that both Spandex and covering yarn are generally very fine as compared with yarns in other textile processes. Technical problems to handle very fine yarns have ever required manual operations. Another reason is that the scale of covering factories is almost quite smaller than that of other textile processes. Many small covering factories are short of hands, expert labors are aging and young labors are avoiding this kind of work. And market needs of productions that require smaller lot size and wider variety, increase load of labors. For these reasons, there have been strong demands for economical and proper scale automation of doffing operation in covering process.

In doffing operations, drawing Spandex into hollow spindles requires so much time even by manual operations of expert labors. Two conventional methods of drawing-in Spandex in many factories are shown in Fig. 2. In the method shown in Fig. (a) a wire is used to pull up

Fig.1 Schematic view of covering machine

Spandex from the top of the hollow spindle. Some labors breathe-in Spandex through the hollow spindle from their mouth as shown in Fig. (b). Because of the extreme fineness and high elasticity characteristics of Spandex, it is difficult even for expert labors to handle Spandex proficiently. And enormous numbers of spindles also require the automation of this operation.

Fig.2 Two conventional methods of draw-in yarn
(a)Drawing-in with wire
(b)Breathing in from mouth

It is not effective for small covering factories to install large automatic equipments and systems. Our research is to develop a simplified automation equipment which can be attached on covering machines at work. The development will finally perform all doffing operations and carriage, and take the place of labors.

In this report, we propose a novel method of drawing-in Spandex, and develop an automatic yarn drawing-in apparatus that can draw Spandex into both lower and upper hollow spindles simultaneously. The apparatus with simple mechanism has rapidity and high reliability.

2. Apparatus

Figure 3 shows the mechanism of the automatic yarn drawing-in apparatus. The apparatus applies both injection and suction air flows and enables to draw Spandex into a pair of lower and upper spindles on a double-covering machine simultaneously. It is primarily composed of the injection unit, the suction unit and the yarn feed unit. The injection unit and the suction unit are mounted on a stay, which moves between the drawing-in position (Fig.3 (a)) and the yarn setting position (Fig.3 (b)) by a linear slide guide driven by air cylinder. At the time of drawing-in, the slide unit sets the injection unit on the bottom of the lower

Fig.3 Schematic view of mechanism of automatic yarn drawing-in apparatus

spindle and the suction unit on the top of the upper spindle.

2.1 Injection unit

Figure 4 shows the injection unit. Its main block is a one-piece metal block. Compressed air to blow up Spandex enters at the joint and passes through the air nozzle. The round depression of the top surface of the main block is designed so that the air nozzle can connect with the bottom of the lower spindle easily. And its slit enables a yarn lead to inject into the lower hollow spindle by the injection air flow. The compressed air is supplied by an air compressor, through an air filter, a regulator and a solenoid valve. Supplied pressure can be adjusted by the regulator.

Fig.4 Injection unit

- 3) Opening the solenoid valve supplies compressed air for the injection unit. The injection air is blown from the air nozzle into the lower hollow spindle. The lead of Spandex in the slit is inhaled into the hollow spindle and driven by the injection air flow. At that time, the yarn feed unit starts to feed out Spandex at an adjusted speed.
- 4) The lead of Spandex passes through the lower spindle and reaches at the bottom of the upper spindle by the injection air flow. At the same time, suction air flow generated by the vacuum ejector effects to guide the lead of Spandex into the upper spindle as shown in Fig. 8.
- 5) The lead of Spandex is carried through the upper spindle by the suction air flow. Then, the lead passes the vacuum ejector from its vacuum port to its exhaust port and finally is exhausted with the exhaust air flow. The yarn feed unit stops feeding when it fed the set length of Spandex decided in advance by comparison with the distance from the bottom of the lower spindle to the top of the upper spindle.
- 6) Both the injection unit and the suction unit holding the lead of Spandex return to the original setting position. So, the sequence of drawing-in process finishes.

Fig.8 Photograph of yarn flying between lower and upper spindles

3. Experiment and Results

Experiments of the automatic drawing-in apparatus are performed on a model covering machine in order to confirm the practical utility of this development.

3.1 Model Covering Machine

Figure 9 shows dimensions of the model covering machine. Two hollow spindles of 5 mm in inner diameter and 262 mm in height are installed at a vertical interval of 146 mm.

3.2 Sample Spandex

Yarn drawing-in experiment is performed with 20 D Spandex used for panty hose.

3.3 Drawing-in Experiment and Discussion

In these experiments, four pressures are supplied for the injection unit; 0.6 MPa (6 kgf/cm²), 0.5 MPa, 0.4 MPa and 0.3 MPa. Three pressures are supplied for the suction unit; 0.5 MPa (5 kgf/cm²), 0.4 MPa and 0.3 MPa. Two yarn feed speeds; 1,019 mm/s (required time to draw-in is 0.8 s) and 1,332 mm/s (0.6 s) are set in order to finish drawing-in within one second. At each combination of experimental conditions, 66 tests are performed. Relations between these conditions and the rates of success to draw-in Spandex are shown in Figs. 10 and 11.

(1) Injection

With decreasing the supplied pressure for the injection unit, failure of drawing-in Spandex increases. If the supplied pressure is too low, the velocity of the injection air flow is insufficient to draw yarn. Generally, the force driving yarn is caused by the air drag and is proportional to the square of the relative velocity of the yarn and the flow[2]. If the yarn feed velocity is too high, drawing-in also results in the failure. In this apparatus, the air drag given in the lower hollow spindle by the relative velocity of the Spandex and the injection air releases Spandex from its package. If the lead of Spandex cannot get enough driving force, Spandex cannot be released from the package and the lead of Spandex is involved in the package. In consequence of observation of yarn behavior, most causes of the failure are insufficiency of the yarn tension to release Spandex from the package.

(2) Suction

In order to draw the lead of Spandex from the top of the lower spindle into the upper hollow spindle certainly,

Fig.9 Dimensions of model covering machine

Fig.5 Suction unit

Fig.6 Yarn feed unit

2.2 Suction unit

The suction unit consists of a vacuum pad and a vacuum ejector, connected by an air tube mutually as shown in Fig. 5. At the time of drawing-in, the vacuum pad is connected

with the top of the upper spindle and make an air channel from the bottom of the upper spindle to the exhaust port of the vacuum ejector. Inhaled Spandex is exhausted from the exhaust port of the vacuum ejector by the air. Compressed air for the vacuum ejector is supplied by the compressor, through an air filter, a regulator and a solenoid valve. Supplied pressure can be adjusted by a regulator.

2.3 Yarn feed unit

Figure 6 shows the schematic view of the yarn feed unit. To prevent a damage of the package surface, the inside of the core tube of the yarn package is held by a rotary drum. The rotary drum is rotated by a stepping motor directly. The yarn feed unit releases Spandex when the lead of Spandex is driven by the injection air flow. The stepping motor enables exact adjustments of the yarn feed rate and the feed length.

2.4 Drawing-in motion

Figure 7 shows the continuous drawing-in process on a pair of spindles.

1) Both the injection unit and the suction unit mounted on the stay are initially located at the yarn setting position. The Spandex package is held by the yarn feed unit. The lead of Spandex is set along the slit of the injection unit by a manual operation.

2) The slide unit puts forward the injection unit and the suction unit to the drawing-in position. The injection nozzle is settled on the bottom of the lower spindle and the vacuum pad of the suction unit is connected with the top of the upper spindle.

Fig.7 Drawing-in process

enough suction air flow rate is required. Experiments are performed under various supplied pressure conditions.

Under the constant injection air pressure and yarn feed speed conditions, the rate of success is higher when the higher pressure is supplied for the vacuum ejector. And when the yarn feed speed is 1,332 mm/s, with the increment of the supplied pressure scatters of the rate of success become greater compared with the feed speed of 1,019 mm/s. Almost failures that Spandex can not be led into the lower hollow spindle, are caused by a poor air driving force given by the injection air flow. And when Spandex can be drawn-in the lower spindle, it also can be drawn into the upper spindle in almost cases. If Spandex can be drawn into the lower spindle under proper injection air pressure and yarn feed speed conditions, suction air flow don't affect the rate of success. This is because the suction air flow is sufficient in this apparatus. Though it is necessary to examine the capacity of the ejector and the air flow system, the apparatus has ability enough to draw-in Spandex with this air application.

(3) Yarn feed

Faster yarn feed speed is required for saving time and usage of compressed air. But when the yarn feed speed is

large, the lead of Spandex cannot be given the driving force sufficiently by the injection air flow, and is involved in Spandex package. The results of this experiment show that under constant pressure conditions of injection and suction, the lower the yarn feed speed, the higher the rate of success. Most reliable drawing-in, minimizing air consumption, can be performed by adequate pressure and yarn feed speed adjustment.

Yarn drawing-in experiment in this apparatus can be performed within totally a few seconds, and accordingly this apparatus has the ability of saving operation time in comparison to about 10 seconds by a manual operation.

3.4 Summary

Nearly 100% success testified practical utility of the developed apparatus to draw-in Spandex. If the drawing-in experiment is performed under proper condition, improvement of the rate of success can be expected.

This apparatus requires to set the lead of Spandex on the suction unit initially by a manual operation. For the purpose of automating the whole doffing operations, it is required to solve following problems: carriage and continuous supply of Spandex packages, precise yarn manipulation, a detector that discriminates if drawing-in succeeded, and mechanism to retry the automatic drawing-in process if it failed.

4. Conclusion

In this report, after consideration of the method of drawing-in core yarn into hollow spindles, an automatic yarn drawing-in apparatus is developed and examined. Following results are obtained:

- (1) An automatic yarn drawing-in apparatus that applies combination of injection and suction air flow and draws Spandex into both lower and upper spindles simultaneously was developed.
- (2) Yarn drawing-in experiment in the developed apparatus equipped on a model covering machine was performed. The results have proved adequacy of the method of drawing-in Spandex by combination of air flow.
- (3) The apparatus consists of relatively simple mechanisms.
- (4) Spandex of 20 D which is too thin to draw-in even by a manual doffing operation could be easily drawn-in by the developed apparatus.
- (5) With proper adjustment of supplied pressure for the injection and the suction units, and the yarn feed speed, improvement of reliability can be expected.

References

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- [2] Nihon Sen-i Kikai Gakkai Syokki Kenkyu-iinkai;"Jet Loom Weaving"(in Japanese),p.16,The Textile Machinery Society of Japan,(1989)

Fig.10 Relation between supplied air pressures for injection and suction units and rate of success (Yarn feed speed: 1,332 mm/s)

Fig.11 Relation between supplied air pressures for injection and suction units and rate of success (Yarn feed speed: 1,019 mm/s)