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Change of Main Body Temperature and Reduction of Energy Consumption in a 1 Tube 2 Chamber Bent Silkworm Type Dyeing Machine

Choon Gil Lee and Woo Kyung Sung

Dept. of Textile and Fashion Technology, Kyungil University, Kyungsan, Korea

Abstract : The changes of the main body temperature of a 1 tube 2 chamber bent silkworm type dyeing machine and the reduction of energy consumption of the dyeing machine by the energy saving design are reported. This dyeing machine was developed for the purpose of the energy saving and high efficiency. In this study, the changes of the main body temperature of the 1 tube 2 chamber bent silkworm type dyeing machine were studied experimentally. Especially the effect of the blower motor electric current and the main body pressure at various blower frequencies were studied experimentally. In the experimental data for the changes of main body temperature, it was shown that the main body temperature increased as the blower motor electric current and the main body pressure increased.

Key words : 1 tube 2 chamber bent silkworm type dyeing machine, blower motor electric current, main body pressure, blower frequencies, energy reduction in dyeing machine

INTRODUCTION

The energy saving dyeing machines in textile industry play an important role for the reduction of energy because the dyeing process is a high energy consumption process. The air flow dyeing machine is one of the energy saving dyeing machines. The air flow dyeing machine is composed of main body, rotor, winch reel, air jet nozzle, air nozzle duct, spreading plate, heat exchanger, filter box, centrifugal pump, dye pump, dye tank, control plate, compressor and so on. The characteristics of the machine are energy reduction, minimizing liquor ratio, minimizing tension and high speed running system, shortening dyeing time, automation of operation, air jet nozzle and nozzle duct for the effectiveness of dyeing and so on.

The energy reduction is accomplished by the low water and steam consumption due to the low liquor ratio, the reduction of cooling water, the reduction of power consumption, the reduction of washing water and the shortening time of the operation of the dyeing machine.

The 1 tube 2 chamber bent silkworm type dyeing machine is one of the air flow machines. A remarkable distinction of the dyeing machine is a 1 tube 2 chamber system. The characteristics of this newly developed energy saving machine are low liquor ratio, stable filing and circulation, low tension by the pressure control of nozzle, increased productivity by preparation tank, bent silkworm type of the body, pneumatic system by air chute, effective circulation by disentangling apparatus and 1 tube 2 chamber system.

Corresponding author; Choon Gil Lee
Tel. +82-53-850-7203, Fax. +82-53-850-7605
E-mail: cglee@bear.kyungil.ac.kr

EXPERIMENT

Energy and water saving and high efficiency design of the 1 tube 2 chamber bent silkworm type dyeing machine

The 1 tube 2 chamber bent silkworm type dyeing machine was designed for the energy saving and high efficiency dyeing machine. Table 1 shows the productivity design of the newly developed dyeing machine compared with the jet circular dyeing machine SIDC 1,200. The productivity of the newly developed machine was designed higher than that of the jet circular dyeing machine about 25%.

On the other hand, Table 2 shows the water consumption design. The total water consumption of the newly developed machine in this Table is lower than that of the jet circular dyeing machine about 30%. It is possible to reduce water consumption by the adoption of a low liquor ratio system.

Table 3 shows the steam consumption design of the newly developed dyeing machine compared with the jet circular dyeing machine. The steam consumption of the newly developed machine was designed lower than that of the jet circular dyeing machine about 40%.

One of the important factors in saving energy is to

Table 1. Productivity design for energy saving and high efficiency

Unit	Dyeing machine	
	The newly designed	Jet Circular
kg/once	300	300
kg/day	300×10 times=2,700	300×8 times=2,400

Table 2. Water consumption design of the dyeing machine

Classification	Dyeing machine		
	The newly designed	Jet Circular	Remark
Water supply(*l*/once)	1,500×3 times=4,500	1,800×3 times=5,400	pre-treatment, dyeing, washing
Cooling water(*l*/once)	1,500(100-80)/20=1,500	1,800(130-80)/20=4,500	cooling to 80°C
Washing water(*l*/once)	1,500×4 times=6,000	1,800×4 times=7,200	
Total(*l*/once)	12,000	17,100	30% reduction

Table 3. Steam consumption design for energy saving

Classification	Dyeing machine	
	The newly designed	Jet Circular
Dyeing(kg/once)	1,500(130-20)/498=331	1,800(130-20)/498=397
Pre-treatment(kg/once)	1,500(90-50)/498=120	1,800(90-20)/498=253
Post-treatment(kg/once)	1,500(50-50)/498=0	1,800(50-20)/498=108
Total(kg/once)	451	758

Table 4. Electric power design for energy saving

Classification	Dyeing machine	
	The newly designed	Jet Circular
Blower(kW)	22	–
Circulation pump(kW)	15	30
Winch reel(kW)	2.2×2=4.4	0.75×2=1.5
Dyes pump(kW)	2.2	2.2
Draw-in reel(kW)	0.75	0.75
Total(kW)	44.35	34.45
Actual electric power(kW)	100A×1.44×220V×2=64	100A×1.44×220V×2.5=80

reduce electric power in operating the dyeing machine. Table 4 shows the electric power design of the newly developed dyeing machine compared with the jet circular dyeing machine. The electric power of the newly developed machine was designed lower than that of the jet circular dyeing machine about 20%.

Schematic Design of the 1 tube 2 chamber bent silkworm type dyeing machine

The 1 tube 2 chamber bent silkworm type dyeing machine was schematically designed for the promoting efficiency and energy saving through the skills of the low liquor ratio of the dyeing machine, the stable filing and circulation of fabric, the low tension by the pressure control of nozzle, the increased productivity by preparation tank, the bent silkworm type of the body, the pneumatic system by air chute, the effective circulation by disentangling apparatus and 1 tube 2 chamber system.

Figure 1 shows the longitudinal section of the dyeing machine and Figure 2 shows the plane figure of the machine. In these Figures, each number indicates the following part respectively: 1; main body of the dyeing machine, 2; vessel, 3; winch reel, 4; fabric circulation tube, 5; jet nozzle, 6; distiller, 7; heat exchanger, 8; circulation pump, 9; washing nozzle, 10; entrance part, 10a; staying part, 10b; arrangement part, 10c; trumpet, 11; air fan, 12; staying bath, 13; entrance staying part, 13a; detainment staying part, 13b; arrangement staying part, 14; curved part, 20; door, 21; disentangling apparatus, 22; running fabric.

The circulation and filing of the fabric are very important factors for the production of the high quality fabrics. The main apparatuses of the circulation of the fabric are jet nozzle, fabric circulation tube, winch reel and disen-

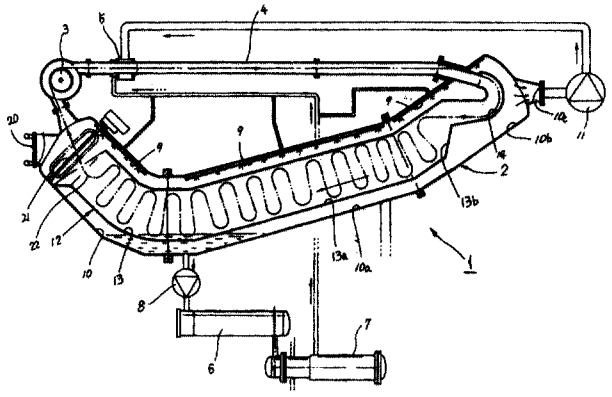

Fig. 1. The longitudinal section of the dyeing machine.

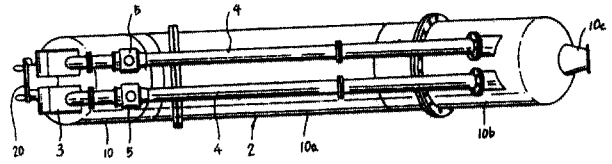

Fig. 2. The plane figure of the machine.

tangling apparatus and the main factors for the effective filing of the fabric are determined by the shape of detainment staying part and the shape of the arrangement staying part.

The detail drawings of the disentangling apparatus, winch reel, circulation pump, and heat exchanger are shown in Figure 3, 4, 5 and 6 respectively. The disentangling apparatus is newly designed for effective circulation in this system.

In Figure 3, 1 represents hanging bars, 2 guidance reel, 2a and 2b supporting shafts, 3 a dyeing bath, 3a and 3b supporting part and tube, 4 supporting bearing, 5 supporting frames, 6 shaft rods, 7 large gears, 7a small gears, 8 air actuators. In Figure 4, 3 indicates a steam and solution supplying tube, 4 winch reel trunk, 4a entrance, 4b outlet, 5 winch reel, 8 bracket, 9 screw, 16 sensor 17 sensing plate.

Figure 5 shows the circulation pump which circulates the chemical and solution for the treatment on the surface of the fabric. This circulation pump is connected with distiller and heat exchanger and transmits the solution of the dye bath to the connected distiller and heat exchanger. And Figure 5 shows the detail drawing of the filter box which gets rid of the sediment that was taken shape during the dyeing process.

Driving of the 1 tube 2 chamber bent silkworm type dyeing machine

Driving of the 1 tube 2 chamber bent silkworm type dyeing machine was controlled by the TLC. Increasing

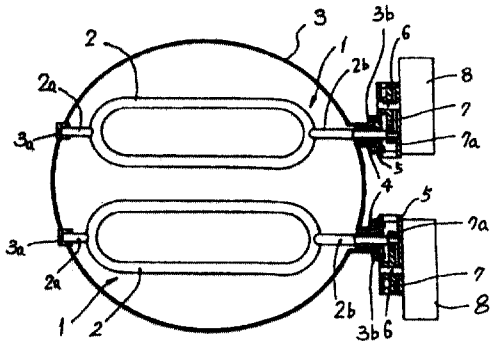

Fig. 3. The detail drawings of the disentangling apparatus.

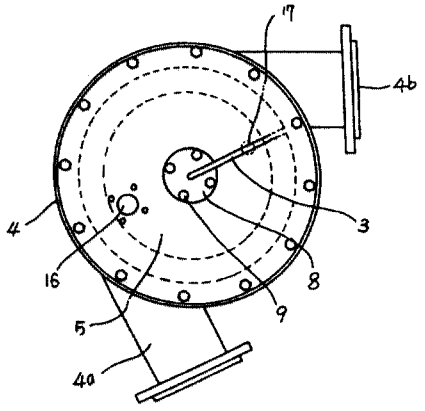

Fig. 4. The detail drawings of the winch reel.

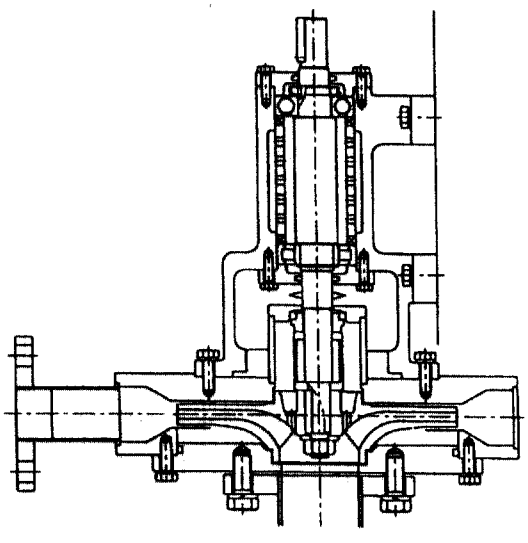

Fig. 5. The detail drawings of the circulation pump.

and decreasing temperature curves were controlled linearly. The start temperature was 30°C and during 60 minutes the temperature was raised up to 80°C. At that temperature, 10 minutes was passed and the temperature was raised up again to 130°C.

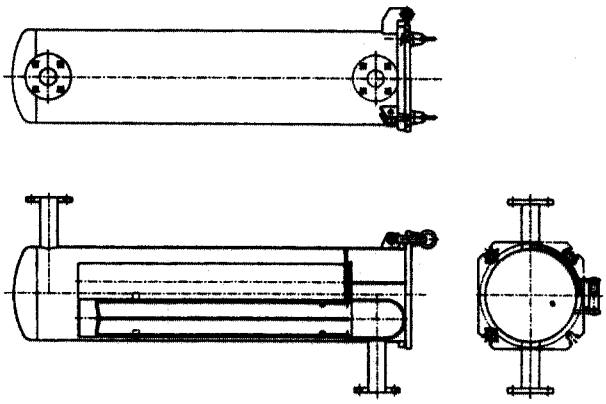

Fig. 6. The detail drawings of the filter box.

The measurement of the blower motor electric current was accomplished by PLC and the main body pressure at various blower frequencies were measured by a pressure gauge attached at main body. The measurement of water, steam and electric power consumption was performed bythe water, steam and electric power measurement gauges.

RESULTS AND DISCUSSION

The performance and the energy reduction by the energy saving design

Table 5 shows the result of a energy saving design of the 1 tube 2 chamber bent silkworm type dyeing machine. This result is due to the water consumption design, the steam consumption design and the electric power design for energy saving. The total energy reduction of the newly designed compared with Jet Circular dyeing machine is 37%, that is, 119 toe/yr reduction for a dyeing machine.

Table 6 shows the performance of the energy reduction designed 1 tube 2 chamber bent silkworm type dyeing machine. The number of entanglements a day of the newly developed was reduced 70% compared to the Jet Circular dyeing machine. The variance of nozzle pressure of the newly developed was controlled under 5%. Therefore the variance of nozzle pressure of the newly developed was reduced 10% compared with the Jet Circular dyeing machine and the winch reel of the newly developed was driven without a driving power apparatus. And the running speed of the newly developed was 400~500 m/min and the liquor ratio was 1:3. The fabric running system of the newly developed is assembled to be possible by the air flow only for a high degree of efficiency. Therefore this system is designed in distinction from the Jet Circular dyeing machine which is assembled to operate the fabric running by the liquid flow. And, above all things, the most distinguished characteristic of the newly developed dyeing machine is a specially designed main body of the 1 tube 2 chamber

Table 5. Result of energy saving design

Classification		Dyeing machine		
		The newly designed	Jet Circular	Reduction
Steam and power consumption	steam (toe/yr)	0.451ton×667days×10times ×539,000×10^{-7}=162.1	0.758ton×833days×8times ×539,000×10^{-7}=272.2	
	electric power (toe/yr)	64kW×667days×10times ×860×10^{-7}=36.7	80kW×833days×8times ×860×10^{-7}=45.8	
Total	toe/yr	198.8	317.8	37% reduction (119toe reduction/1 machine)

Table 6. Performance of energy saving design

Classification	Dyeing machine	
	The newly designed	Jet Circular
Number of entanglement (per day)	3	10
Variance of nozzle pressure	under 5%	15%
Winch reel	no driving power	difficulty in revolution control
Running speed (m/min)	400~500	300~350
Liquor ratio	1:3	1:6~8
Fabric running type	possible by air flow only	by liquid flow
Blower	existence	none
Main body type	1 tube 2 chamber	1 tube 1 chamber

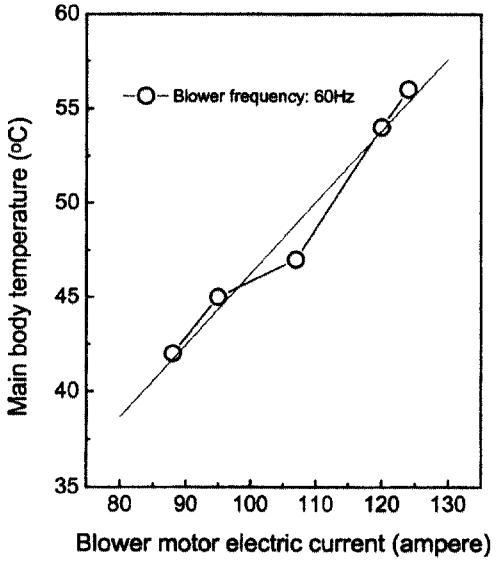

Fig. 7. Effect of the blower motor electric current on the main body temperature at the blower frequency of 60 Hz.

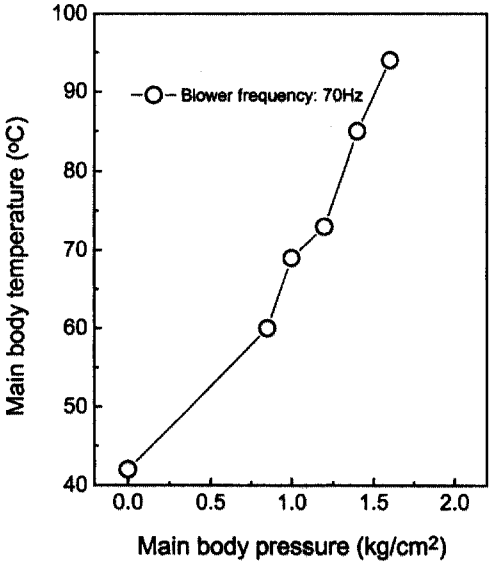

Fig. 8. Effect of the main body pressure on the main body temperature at the constant blower frequency of 70 Hz.

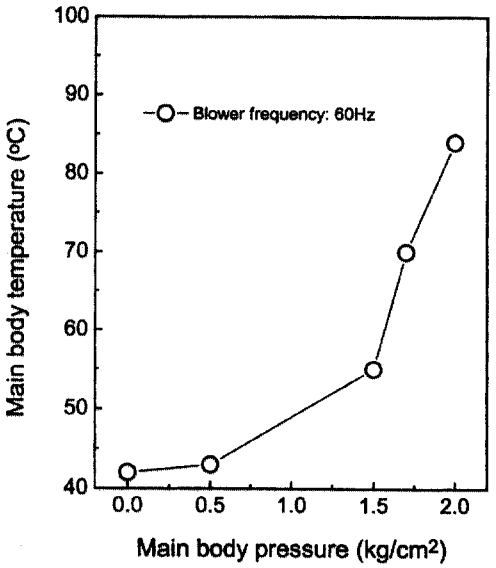

Fig. 9. Effect of the main body pressure on the main body temperature at the constant blower frequency of 60 Hz.

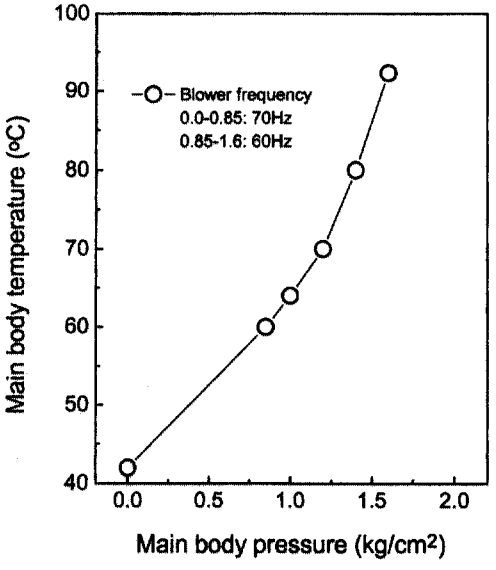

Fig. 10. Effect of the main body pressure on the main body temperature by the control of the blower frequency from 70 Hz to 60 Hz.

system.

The effect of the blower motor electric current on the main body temperature

Figure 7 shows the effect of the blower motor electric current on the main body temperature at the blower frequency of 60 Hz. The main body temperature increased according to the increase of the blower motor electric current. This result stands for the fact that the blower motor electric current affect the main body temperature almost linearly. The reason why the above result occurs is that the electric current causes raising temperature of the main body. The linear regression equation of the Figure 7 is given by the following equation:

$$T_{60}=0.37889A+8.33403$$

where T_{60} is main body temperature(°C) and A is blower motor electric current (Ampere).

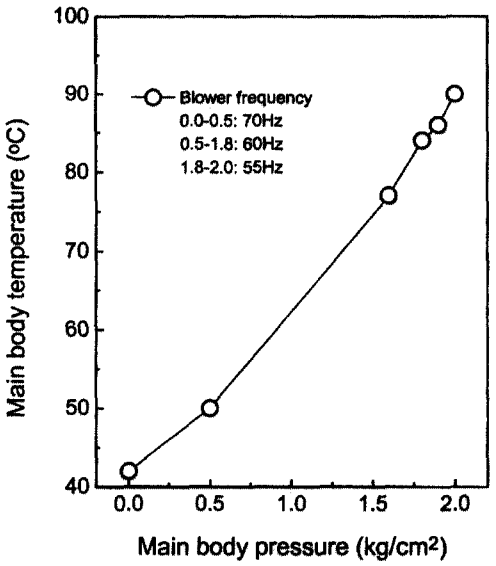

Fig. 11. Effect of the main body pressure on the main body temperature by the control of the blower frequency from 70 Hz to 60 Hz and next to 55 Hz.

The effect of the main body pressure on the main body temperature

Figure 8, 9, 10 and 11 show the effect of the main body pressure on the main body temperature at various blower frequencies.

Figure 8 illustrates the effect of the main body pressure on the main body temperature at the constant blower frequency of 70 Hz. The increasing curve of the main body temperature shows a steep slope. Figure 9 indicates the increasing curve of the main body temperature at the constant blower frequency of 60 Hz. In Figure 9, the increasing rate becomes a dull shape when it compares with Figure 8. This result is very important to control the temperature of the main body for the production of the high quality textile goods. The reason of the increasing temperature is due to the increasing pressure and to become a dull slope is due to the decreasing pressure.

Through Figures 8 and 9, the linear increasing of the main body temperature can be deduced by controlling the blower frequency. Figure 10 shows the control of the blower frequency from 70 Hz to 60 Hz. The slope of Figure 10 became blunt after the change of the blower frequency to 60 Hz. In order to make the slope more linear, it requires to control more exquisitely as shown in Figure 11. The blower frequency of 70 Hz was changed to 60 Hz and next to 55 Hz. Because of the blower frequency control, the increasing curve became more linear in Figure 11. This controlled result can be put to practical use in operating a dyeing machine for the high quality and regular products.

CONCLUSIONS

For the newly designed 1 tube 2 chamber bent silkworm type dyeing machine, the effect of the blower motor electric current and the main body pressure at various blower frequencies were studied experimentally. The characteristics of this newly developed energy saving machine are low liquor ratio, stable filing and circulation, low tension by the pressure control of nozzle, increased productivity by preparation tank, bent silkworm type, pneumatic system by air chute, effective circulation by disentangling apparatus and 1 tube 2 cham-ber system. Through the experimental values, the following results were obtained.

1. The newly designed 1 tube 2 chamber bent silkworm type dyeing machine is the energy saving and high efficiency dyeing machine. The newly designed reduces 37% energy consumption compared with the Jet Circular machine.
2. The higher the blower motor electric current, the higher the main body temperature of the newly designed machine.
3. Through the experimental data of the effect of the main body pressure on the main body temperature at various blower frequencies, it is possible to make the increasing slope more linear by the control of the blower frequency.

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