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Application of the Water and Oil Repellent Finishing Agent EX-910E in Polyester Nonwovens

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Abstract

By the experiment, the optimal technological conditions that the water and oil repellent finishing agent EX-910E is applied in polyester nonwovens were confirmed. The technological conditions include that EX-910E usage is 40g/l, the bridging agent F-2921E usage is 6g/l, the pre-curing condition is 100℃× 2/3min, and the curing condition is 160℃× 2.5 min. The results of the experiment indicated that the nonwovens finished by the optimal conditions possessed good water and oil repellent effects.

Keywords: Water and oil repellency, Finishing, Nonwovens

Nonwovens possess many characteristics such as soft handle, good drapability, good hydroscopic property, good ventilation property and slippery appearance. Nonwovens are mainly applied in (1) base fabric materials such as synthetic leather base fabric and auto interior trims, (2) medical fabrics such as gauze, operating gown and bandage, (3) home adornments such as sofa, portiere and curtain, (4) dining-room fabrics such as dishcloth and damp towel. Because the technology of nonwoven is simple and its cost is low, it has entered into various industries in the life, and the post-finishing of the nonwovens should be implemented, and the manufacturing method and the structure of nonwovens directly influence the technology of finishing, and the finishing effect. Therefore, before the nonwovens are finished, the manufacturing method and cloth cover should be cognized comprehensively, which can obtain satisfactory finishing performance.

Waters and oils in the life are easily to pollute the shell fabrics, but the water and oil repellent fabrics can prevent the pollution of water feculences and oil feculences, and the finished fabrics will not change their original styles and produce new damages and flecks. In recent years, with the enhancement of human living level and the quickness of living rhythm, people more and more require high functional fabrics which should be washed machine and tended easily, and the water and oil repellent finishing of fabrics has been a sort of product function finishing with high added-value pursued by people. More and more application of nonwovens in the accouterments and family products also urgently require anti-pollution finishing function.

The water and oil repellent agent EX-910E adopted in the article is the fluorite macromolecule polymer, and fabrics are finished by fluorite resin, the hydrophobic oil fluorite alkyl will be arranged on the surface of the fiber thick and fast directionally, and point to the air layer, so it possesses perfect water and oil repellence. Convenient for the research, the water and oil repellent effects all refer to national standards and are classified by classes. The water repellence is tested by the "GB/T 14577-93 Textiles-Determination of water repellency of fabrics by the Bundesmann rain-shower test", and the oil repellence is tested by the "GB/T 19977-2005 Textiles-Determination of oil repellency of fabrics by the Hydrocarbon resistance test". In the article, the EX-910E is used in the water and oil repellent finishing for the nonwovens, and the main technological parameters are discussed, the influences of the finishing agent and cross-linking agent to the finishing effect are analyzed, and the optimal technological conditions are obtained (Liu, 2002), which could offer references for the water and oil repellent finishing of nonwovens and correlative technological parameters for the nonwoven finishing of the enterprise.

1. Experiment

1.1 Materials

1.1.1 Fabrics

The fabrics in the experiment are polyester stitch-bonded nonwoven cloths.

1.1.2 Reagents

The reagents in the experiment include the finishing agent EX-910E (made by Tianjin Dai-lchi Fine Chemical Co., Ltd) and the bridging agent F-2921E (made by Tianjin Dai-lchi Fine Chemical Co., Ltd).

1.1.3 Instruments and equipments

The instruments and equipments in the experiment include bench mangle NM-450 (Japan), laboratory modeling dryer DK-5E (Japan), electronic balance and self-made Bundesmann rain-shower test equipment.

1.2 Experiment contents and methods

1.2.1 Water and oil repellent finishing technology

The basic technology includes grey cloth rinsing and drying→ bathing and mangling twice in the finishing liquid (mangle expression is 70%) → pre-curing (100℃, and 2 or 3min) → curing.

According to the basic finishing technological conditions of fabrics, the orthogonal experiment is adopted in the experiment, and the three-factor and three-level orthogonal experiment is designed through changing the usages of the finishing agent and the bridging agent, and the curing temperature. The factor-level table is seen in Table 1.

1.2.2 Optimization experiment (Hang, 2007)

Because the optimized values obtained by the data analysis method in the orthogonal experiment can only been certain combinations of the level in the experiment, and the optimized results can not exceed the range of the level in the experiment, and the definite direction of the further experiment can not be confirmed, and the experiment still has strong exploring color and is not exactly enough, so in the primary selection, the orthogonal experiment method will have slow constringency speed, and can not confirm the data change law, and the optimization experiment is adopted based on the good technological conditions from the orthogonal experiment.

(1) Finishing agent optimization experiment

Respectively take 20g/l, 25g/l, 30g/l, 35g/l, 40g/l and 45g/l finishing agents (EX-900E) to pre-cure in 100℃ (2.5min) and cure in 170℃ (1min) in 6g/l bridging agent.

(2) Curing condition optimization experiment

Mix 40g/l finishing agent with 6g/l bridging agent, and cure the mixture respectively in the curing conditions of 150℃×3min, 160℃×2.5min, 170℃×1min and 180℃×40s.

(3) Bridging agent optimization experiment

Under the curing conditions of 40g/l finishing agent and 160℃×2min, and respectively take 2g/l, 4g/l, 6g/l and 8g/l bridging agents to do the experiment.

1.2.3 Water repellent effect test

Test the water repellent effect according to the "GB/T 14577-93 Textiles-Determination of water repellency of fabrics by the Bundesmann rain-shower test", and under certain flux, observe the residual fluid drops on the surface of the sample cloth to grade the water repellent effect.

1.2.4 Oil repellent effect test

Test the oil repellency according to the standard of "GB/T 19977-2005 Textiles-Determination of oil repellency of fabrics by the Hydrocarbon resistance test".

2. Experiment results and discussions

2.1 Orthogonal experiment result discussion

Analyze the orthogonal experiment by the intuitive analysis and variance analysis, and the result is seen in Table 2.

2.1.1 Intuitive analysis

From the analysis result in Table 3, with the increase of the concentration of the finishing agent EX-910E, the finishing effect is better and better, and the concentration of the bridging agent should not be excessive, or else, the water and oil repellent effect will be influenced, and with the gradual increase of the temperature, the effect increasing is not so obvious, and the results of the curing condition of 150℃×3min and the curing condition of 170℃×1min are almost same, and to save the time and enhance the efficiency, the curing condition of 170℃×1min is selected to be one of the technological conditions, so the technology of $A_3B_2C_3$ can be primarily confirmed as the optimal technological condition, i.e. 30g/l finishing agent, 6g/l bridging agent, pre-curing condition of 100℃ (3min) and curing condition of 170℃ (1min).

2.1.2 Variance analysis (results seen in Table 4 and Table 5)

The critical value $F_{0.05}(2,2)$ is 19, and according to the experiment result, the F values of A, B and C are all smaller than the critical value, so they influence the water and oil repellent effect little. But for the comparison of three parties, the usage of the finishing agent can largely influence the experiment result. The concentration of the finishing agent directly influences its film forming performance on the surface of the fabrics, and influences the final water and oil repellent effect. Therefore, in the future experiment, the concentration of the finishing agent should be emphasized specially, and the economic and proper concentration should be sought to confirm the optimal technological conditions.

2.2 Optimization experiment result discussion

2.2.1 Finishing agent optimization experiment result discussion

From Table 6, the finishing agents with different concentrations will produce different water and oil repellent effects, and the effects after water bathing will be reduced a little, and the water and oil repellent effect of 40g/l finishing agent is good, so it can be selected to be the proper finishing agent in the experiment.

2.2.2 Curing condition optimization experiment result discussion

The experiment was performed under the conditions of 40g/l finishing agent, 6g/l bridging agent and pre-curing condition of 100℃ (3min).

From Table 7, their water and oil repellent effects after water bathing will be decreased to different extents, and through the comparison, under the condition of 160℃×2.5min, the finishing effect is good, but the handle of the sample cloth is hard under this condition, and though the finishing effect is not ideal under the condition of 170℃ or 180℃ and the cloth cover is little yellow under the condition of 180℃, but the handle is soft, so there still is hope to find the finishing result with good water and oil repellent effect and good handle through the technology selection.

2.2.3 Bridging agent optimization experiment result discussion

The experiment was performed under the conditions of 40g/l finishing agent, pre-curing condition of 100℃ (3min) and curing condition of 160℃×2.5min.

From Table 8, the usage of bridging agent should be proper, and with the increase of the usage, the water and oil effect will be enhanced, but when the concentration of the bridging agent exceeds 6g/l, the increase of the finishing agent has not significantly enhance the water and oil repellency of nonwovens. So the concentration of the bridging agent is selected as 6g/l.

As with all things, the proper technological conditions should include 40g/l finishing agent, 6g/l bridging agent, pre-curing condition of 100℃ (3min), and curing condition of 160℃×2.5min.

3. Finishing effects of fabrics with different structures

In the experiment, two sorts of polyester stitch-bonded nonwovens were selected. One is the white sample cloth, and its thickness is thin, and the polyester silks shuttle in nonwovens along one direction. The other one is the pink sample cloth which is thick, and the polyester silks shuttle in nonwovens along certain angle. Above technology was used to process these two sorts of sample cloth, and for the former, the water repellency was class 3, and the oil repellency was class 3, and after water bathing five times, the water repellency was class 2, and the oil repellency was class 2, and the effects was bad. For the latter, the finished water repellency was class 4.5, and the oil repellency was class 4, and after water bathing five times, the water repellence was class 4, and the oil repellency was class 3. Though the effect was enhanced a little comparing with the former, but the effect was still not ideal. From the finishing effects of two sorts of fabric, the ideal water and oil repellent class can be achieved through changing the structure of the fabrics or perfecting the components of the surface.

4. Conclusions

The experiment indicated that the optimal technology conditions of EX-910E for the nonwovens included 40g/l finishing agent, 6g/l bridging agent, pre-curing condition of 100℃ (3min), and curing condition of 160℃×2.5min.

The concrete conclusions from the experiment include following aspects.

(1) The organizational structure of fabrics influences its strength, and further influences the water bathing fastness. Concretely speaking, for two sorts of sample cloths in the experiment, the polyester silks in the white sample cloth

shuttled in nonwovens along one direction, which induced that the result of low strength, and the polyester silks in the pink sample cloth shuttled in nonwovens along certain angle, and the strength was a little higher, so the effects of two sorts of sample cloth after water bathing were very clear, the effect of the white sample cloth was much less than the pink sample cloth. The reason is that the white sample cloth fluffed after water bathing, and the organizational structure of the surface was damaged, and the film structure of the finishing agent was damaged on the surface of the fabrics, which made the film fastness reduced largely, and the water and oil repellent effects was largely reduced.

(2) The density and the thickness of the fabrics also influence the evaluation effect of the water and oil repellence. The water and oil repellent effect of white sample cloth was not ideal because of its low density and thin thickness, and comparatively the water and oil repellent effect of pink sample cloth was better because of its high density and deep thickness.

(3) The instrument needed by the water repellent evaluation test in the experiment was self-made according to the standards of “GB/T 14577-93 Textiles-Determination of water repellency of fabrics by the Bundesmann rain-shower test”, and it was not standard enough, which would influence the evaluation effect to some extent.

(4) The evaluation of the water and oil repellence could not be quantified, and it contained certain subjective factors, which also would influence the evaluation effect to some extent.

References

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Table 1. Factor-level table in the orthogonal experiment

Factor / Level	Finishing agent A (g/l)	Bridging agent B (g/l)	Curing condition C (℃×min)
1	20 g/l	5 g/l	150℃×2.5min
2	25 g/l	6 g/l	160℃×2min
3	30 g/l	7 g/l	170℃×1min

Table 2. Results of the orthogonal experiment

Factor / Level	A	B	C	Experiment test results	
				Water repellency	Oil repellency
1	1	1	1	2	2
2	1	2	2	3	2
3	1	3	3	3	3
4	2	1	2	5	4
5	2	2	3	5	4.5
6	2	3	1	2	2
7	3	1	3	5	4
8	3	2	1	5	3.5
9	3	3	2	5	4

Table 3. Intuitive analysis

Factor / Level	A	B	C	Experiment test results	
				Water repellency (Y)	Oil repellency (Z)
1	1	1	1	2	2
2	1	2	2	3	2
3	1	3	3	3	3
4	2	1	2	5	4
5	2	2	3	5	4.5
6	2	3	1	2	2
7	3	1	3	5	4
8	3	2	1	5	3.5
9	3	3	2	5	4
Y average 1	2.667	4	3		
Y average 2	4	4.333	4.333		
Y average 3	5	3.333	4.333		
Z average 1	2.333	3.333	2.5		
Z average 2	3.5	3.333	3.333		
Z average 3	3.833	3	3.833		
Range 1	2.333	1	1.333		
Range 2	1.5	0.3	1.333		

Table 4. Water repellency variance

Source	Deviation	Freedom degree	Mean square deviation	Value of F1
A	8.227	2	4.1135	5.294
B	1.54	2	0.77	0.990
C	3.538	2	1.769	2.277
Error	1.554	2	0.777	
Sum	14.859	8		

Table 5. Oil repellency variance

Source	Deviation	Freedom degree	Mean square deviation	Value of F2
A	3.723	2	1.8616	2.274
B	0.223	2	0.1115	0.136
C	2.723	2	1.3616	1.664
Error	1.637	2	0.8185	
Sum	8.306	8		

Table 6. Results of the finishing agent optimization experiment (water bath conditions: bath ratio is 1:25, the washing-powder usage is 2g/l, the bath temperature is 45℃, the time is 40min, and the rev of the test glass is 40±2r/min)

Finishing agent (g/l)	Effects after finishing			Effects after bathing five times	
	Water repellency	Contact angle	Oil repellency	Water repellency	Oil repellency
20	2	121°	3	2	2
25	3	123°	3.5	2	2
30	3	123°	3.5	3	2.5
35	4	125°	4	4	3
40	5	127°	4.5	4.5	3
45	5	128°	4.5	4.5	3

Table 7. Results of curing condition optimization experiment

Curing conditions	Effects after finishing		Effects after bathing five times	
	Water repellency	Oil repellency	Water repellency	Oil repellency
150℃×3min	5	4.5	4	3
160℃×2.5min	5	5	4.5	3
170℃×1min	3	3.5	2	2.5
180℃×40s	3	3.5	3	2

Table 8. Results of bridging agent optimization experiment

Bridging agent (g/l)	Effects after finishing		Effects after bathing five times	
	Water repellency	Oil repellency	Water repellency	Oil repellency
2	2	2	2	2
4	3	2	2	2
6	4	3	3	2.5
8	4	2.5	2	2