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Anti-pi1ling and hair- slip finish on semi-worsted knitted fabric

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Key words： Semi-worsted knitted fabric; hair-slip and pi1ling; finish; castor-oil plant oil modify acrylic acid polyurethane

Abstract, This paper explained question of semi-worsted knitted the hair—slip and pi1ling issue,and it's limit to resolve this problem by improving the equipment. This paper resolve this problem by chemical finish ,formula and condition is castor-oil plant oil modify acrylic acid polyurethane(bulk density 3%),soak time(10min),drying time（3min）,drying time (125˚C),PH (7), Softeners（2%）; the result is lousiness and pilling grade(≧ 4),handle (soft),bent long(≦ 7cm), ventilation property(≧ 1032.2L/m2·s), white content(≧ 87).

Introduction

Semi-worsted equipment is basically rebuilt from transformation and the adjustment of the cotton spinning equipment, its spinal fiber length is more close to fiber length of cotton fiber. If there are too many short fiber in wool yarn, the short fiber because its directional friction of wool fiber lamella and its deficient cohesive force are very easy to be separated from the yarn and the fabric and the hair-slip and pi1ling are coming to occurrence during wearing apparel. The pi1ling and hair-slip is often recessive. The problem of hair—slip and pi1ling with increased friction between the fibers will be gradually exposed in the process of wearing apparel, even if the material examination in accordance with relevant national standards is passed before apparel wearing. The primary cause of hair-slip and pi1ling of semi-worsted knitted fabric product is,

There are many short fiber in semi- worsted wool yarn and that the semi-worsted equipment and the spinning process not to be imperfect. Therefore, it's necessary to improve the wearing performance using the chemical finishing for semi-worsted knitted fabrics. At present the commonly used finishing agent against hair-slip and pi1ling are the epoxy resin and the polyurethane finishing agent und so on.

The water-based polyurethane has the character of good flexibility, not to burn well, anticorrosive, the weathering resistance, good adhesion properties and so on. However, with the not-fine water resistance, solvent resistance and other performance, the most water-based polyurethane coating limit its scope of application. In order to enable knitted fabric to win better wearing properties, the character of water-based polyurethane must be improved. Acrylate solution has very good character of the water resistance, the weathering resistance, the gloss retention and so on. Therefore, it's possible, carrying on the modification with the Acrylate solution to the water-based polyurethane can make the water-based polyurethane to integrate the high wearing resistance, the good mechanical property of water-based polyurethane with the good weathering resistance, the water resistance of the acrylic acid to get a very good organic union and to makes up for one's deficiency by learning from others' strong points, so that the performance of polyurethane paint film obtains the distinct improvement, further the by castor plant oil modified water-based polyurethane acrylic can effectively enhance the flexibility and the hand feel of finished knitted fabric.

Experimental

Maleic anhydride (MA), AR, produced by Tianjin Guangfu Fine Chemical Research Institute,castor-oil(C.O), PTMEG diol (PTMG), Hydroxyl value 77.9mgKOH /g, Average molecular weight of 2000, industrial products, in the 100-110 ˚C, O. 09 MPa under vacuum dehydration of 2.5h before using; Isophorone diisocyanate(IPDI), industrial products; dimethylol propionic acid (DMPA), industrial products, produced by Sweden, in the drying oven 11 O ˚C 2h before using; Hydroxyethyl acrylate (HEA), industrial, produced by KeYu Chemical Co., Ltd. Zibo ;1,4-Butanediol (BDO), acetone, reagent grade, produced by Ming Wang Chemical Co., Ltd. of Shenzhen; N. N dimethylformamide (DMF), produced by TianLin Fine Chemical Co., Ltd. Shanghai ; Triethylamine (TEA), produced by JinshanTing New Chemical Reagent Factory Shanghai; Diethylenetriamine (DETA), produced by Chemical Regent Co., Ltd. Tianjin; Ethylenediamine (EDA), produced by Experimental Reagent Co., Ltd. Shanghai; Castor oil-based polyurethane acrylic liquid; Penetrant JFC; Double strand 32 (20% wool / 75% cotton / 5% nylon) plain stitch weft knitted fabric.

Reference to the national standard GB/T18318-2001, the fabric bending length of the C was tested by using of the instruments for the LLY-01 Electronic Instrument stiffness. Reference to a national standard GB545- 85, the permeability of fabric was determined by using the instrument of the computer-controlled air permeability test YG461E. According to Pilling Evaluation level of GB/T4802.1-1997, YG50I, the fabric pilling was measured by using the anti-pilling device made in Shandong. The WSD whiteness of fabric was were mensurated by a whiteness meter type Ⅲ produced by KangGuang Science Instrument Factory Beijing.

Synthesis of modified Castor Oil (MCO)

The castor oil was poured into a four-stomas- flask, equipped by a stirrer, a thermometer and reflux condenser, slowly to add the malefic anhydride dissolved in acetone, then slowly heated to 71 ~ 78 ˚C, to react 2 hours, next heated to about 80 ˚C, continuing to react 5 hours until to remove the solvent in vacuum, cooling, now the red-orange oily is the modified MCO.

Synthesis of the modified waterborne acrylic polyurethane (MCPU) using the modified Castor Oil

Under a nitrogen atmosphere, the measured MC0, PTMG, IPDI, water-based polyurethane were poured into a four-stomas- flask filled with 500ml water, equipped by a stirrer, a thermometer and reflux Condenser; after slowly being heated to 80 ˚C, reacting 2 hours, then cooled to 70 ˚C, next to add the measured hydrophilic chain extender DMPA (dissolved by a small amount of DMF) and the moderate amount of acetone, initiator dosage of 2.5% for the acrylic monomers, then again to react one hour, after the step to add the small molecule chain extender BDO and to react with constant temperature until the-NCO mole fraction to reach to the theoretical value, the temperature down to 30 ˚C. After the steps to add the Triethylamine with equimolar amount of dimethylol propionic acid as salt, again to reaction 10 min to make all reagents to spread in the right amount of demonized water, then to extend the chain with the amine, up to now the castor oil modified water-based polyurethane acrylic in liquid is made.

Finishing

Finishing solution formula:

the castor oil modified water-based polyurethane acrylic JFC 2g/L

Process:

The knitted fabric were impregnated into the finished solution →

drying →curing → ironing

The concentration of treating solution of the castor oil modified water-based polyurethane acrylic, the fabric soak time, the fabric soak temperature, the curing time, the curing temperature were used as 5 experimental parameters in condition. If only a condition is changed and the other conditions remain unchanged during fabric finishing, the bending length and permeability of the finished fabric were tested to determine the appropriate experimental parameters with relative value or range.

Experimental results and analysis

Determination of the concentration of treating solution

The knitted fabric were treated by using the castor oil modified water-based polyurethane acrylic, the concentration of treatment solution was controlled under 7%.

During experiment the concentration of treatment solution were set to 5%, 3% and 1%, the PH is set to 7, the soak time l0 min, the soak temperature at 40 ˚C, the curing time 3 min, the curing temperature of 135 ˚C. After the finishing process the whole fabric the Martindale pilling tests were executed through the whole finished fabric. The experimental results are shown in Table 1.

Table 1, Properties of the treated fabric under different concentrations of the Castor oil modified water-based polyurethane acrylic

Concentration of solution （%）	Bending Length /cm	Hand Feel	Mass Increase （%）	Permeability /（L/m2·s）	Piling (Level）
5	11.67	rigidity	6.16	652.1	4.5
3	6.39	normal	4.23	1032.2	4
1	3.32	less Soft	2.56	1326.8	2.5
0	1.28	Soft	---	1580.2	2

As shown in table 1, with increasing of the concentration of castor oil modified water-based polyurethane acrylic, the fabric pilling performance is improved more clearly, because the castor oil modified water-based polyurethane acrylic can build a tough film on fabric surface, The short fiber in fabric yarn are adhered to this thin layer and slip out difficultly from the film to form hair ball, so that the piling is significantly reduced. However the bending length of fabric is clearly increased, the hand feel, the drape and the breathable of fabric become worse, because the film also prevents the slippage between fiber, yarn and fabric when the castor oil modified water-based polyurethane acrylic builds the film on the fabric surface.

When the concentration of treat solution reaches to 5%, the bending length of fabric grows even more than 30%, so that the fabric is losing its soft character. Therefore, the concentration of treating solution is unable to be too high and better under 3%.

Determination of fabric soaking time

If the fabric soaks in the treating solution with the castor oil modified water-based polyurethane acrylic in the longer time, it can absorbs more solution fully, the formed film is better. In the process a film is not only on fabric surface, but also in the internal in fabric and yarn because more the castor oil modified water-based polyurethane acrylic come into internal of fabric during soaking.

The formed inner film in fabric increase the hold force and friction force between the fibers and reduce the yarn slippage. At this experiment the solution concentration is constantly to 3%, it's the PH is 7, the soaking temperature 40 ˚C, the curing time 3min, the curing temperature of 135 degrees, the PH is 7, and selecting three levels of the soaking time for 5 min, 1O min, 20 min. The test results is shown in Table 2.

Table2. Properties of the treated fabric under different fabric soaking time

Fabric Soaking time（min）	Bending Length /cm	Hand Feel	Mass Increase （%）	Permeability /（L/m2·s）	Piling (Level）
5	2．5	normal	3.6	1387.4	3
10	6.1	normal	5.2	1253.2	4.5
20	11.1	less rigidity	5.8	903.3	4.5

As can be seen from Table 2, with increasing of the soaking time of the fabric in the treating solution with the castor plant oil modified acrylic polyurethane, the level of fabric pilling decreases. When the immersion time exceeds 10 min, the quality of fabric don't significantly increase, its bending length has only little change. This indicates that the saturation time of fabric soaking is about 10 min under same solution concentration and same soaking temperature. Therefore, the soaking time of fabric in the treating solution is suitable for 10 min.

Determination of curing time

After the fabric is treated by the castor oil modified water-based polyurethane acrylic, the curing time plays a great role on the degree of integration between the fabric and finishing agent and on the film degree of finishing agent.

Generally longer the curing time of the fabric is, the higher the degree of integration between the fabric and finishing agent, the better the formed film. But the too long curing time will affect the hand feel, whiteness etc. Here the bending length, the hand feel, the pilling and the whiteness of fabric were choired as examination factors and the relationship between them and the curing time will be discussed. At the point the concentration of the castor oil modified water-based polyurethane acrylic in treating solution was set to 3%, the PH is 7, the soaking time l0 min, soaking temperature is 40 ˚C, curing temperature of 135 ˚C.

Table 3. The effect of curing time

curing time (min)	BendingLength (cm)	Hand Feel	Piling (Level）	Whiteness (%)
2	3.1	soft	3.5	90%
3	7.2	soft	4	87.2%
4	10.6	normal	4	79%
5	13.2	rigidity	4.5	70%

As known from table 3, when the curing time is 3 min, the fabric pilling level achieved the best 4.5. If the curing time takes 2 min, the film will not be complete. If the curing time takes 4 min and 5 min, the fabric hand feel hard, yellowed phenomena of fabric serious, so the curing time of 3 min is best appropriate.

Determine the curing temperature

The concentration of finishing solution, the soaking temperature and time has also an impact to the pilling and the hand feel of fabric. Now we study the impact of curing temperature on the fabric finishing. The too high and too low temperature will influence the film quality on fabric surface, and further on fabric pilling performance. Here we take the concentration of the castor oil modified water-based polyurethane acrylic as 3%, the soaking time as l0 min, the soaking temperature as 40 ˚C,the curing time as 3 min, the PH as 7, and select the curing temperature to be 125 ˚C, 135 ˚C, 145 ˚C and 155 ˚C. The test results are shown in table 4.

Table 4. The affect of the curing temperature on the finishing effect

curing time (min)	BendingLength (cm)	Hand Feel	Piling (Level）	Whiteness (%)
115	4.2	soft	3	90%
125	5.6	soft	4	85%
140	6.1	normal	4	75%
160	10.3	rigidity	4.5	70%

As can be seen from Table 4, with increasing of the curing temperature of fabric, the fabric pilling is reached a higher degree because the temperature is easy to make cross-linked sub-chain of fiber to break, thus affecting the fabric pilling. If the curing temperature exceeds 135 ˚C, the fabric hand feel become worse, yellowed phenomena of fabric serious, so the appropriate temperature is 135 ˚C for the curing fabric.

Determination of PH value

PH value is one of the important factors to finishing the fabric. Table 5 shows the examination result under the following test conditions: the concentration of the castor oil modified water-based polyurethane acrylic 3%, the curing time 3 min, the curing temperature 125 ˚C. The result indicate the fabric finishing under neutral conditions was the best.

Table 5. PH value and finishing effect

PH Value	3	5	7	8
Piling (Level）	3	3.5	4	3.5

Determination of the amount of softener

Softener is helpful to improve the hand feel of fabric, but the binding mode between the most current softener and fabric are overlay-type and graft-type. With graft-type exist the scramble phenomenon between softener and finishing agents, so that softener can be brought forward to occupy the space where should be used to combination between the finishing agents and fabric, further, this will reduce the fabric finishing effect. With overlay-type the softener builds film on surface of fabric and the film has the isolation effect against the combination between the finishing agents and fabric, then this can also affect the effect of fabric finishing.

This test uses a graft-type softener. The data of fabric finishing performance is indicated in Table 6.

Table 6, The effect of softener amount on the fabric finishing

amount of softener	0.5%	1%	2%	3%
Piling（Level）	4	3.5	4	2.5
Hand Feel	poor	normal	better	soft

Conclusion

By studying the concentration of the castor oil modified water-based polyurethane acrylic, the soaking time, the soaking temperature, the curing temperature and the curing time, the conclusion is acquired that the castor oil modified water-based polyurethane acrylic has positive effect for the finishing of semi-worsted knitted fabric and it can effectively reduce the pi1ling and hair- slip of semi-worsted knitted fabric during wearing. The optimal technology is shown in Table 7. The finished effect of semi-worsted knitted fabric is , the pilling level ≧ 4, the fabric hand feel better, the bending length ≦7cm, the Permeability ≧ 1032.2L/m2 • s, the whiteness ≧ 87.

This indicates that this method can effectively solve the problem of pi1ling and hair- slip of semi-worsted knitted fabric and has great significance to improve the wearing ability of semi-worsted knitted fabric.

Table7. Castor oil modified polyurethane water-based acrylic worsted knitted fabrics for semi-pilling finishing the optimum

Solution concentrtion（%）	Sosking time (min)	Curing time（min）	Curing temperature（°C）	PH value	softener amount（%）
3	10	3	125	7	2%

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