Preparation and characterization of flame retardant automobile fabric

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Abstract. The flame retardant polyester fiber used in seat cover of automobile is very important, because it has excellent function of safety when a car spontaneously ignites. In order to reduce material cost, several fabrics were designed and developed using flame retardant polyester fiber and ordinary polyester fiber interweave in this work. After test weaving and testing, the 8 fabric samples of the flame retardancy were all up to the national standard in flame-retardant function. The 1# fabric sample was 76.32% in ratio of flame-retardant polyester and the small jacquard stitching double weave, it was not only reached flame retardant best but also better decoration function. Meanwhile, flame retardant performance would be improved with coverage ratio of flame-retardant polyester on fabric surface. So, this conclusion can be useful to development of flame retardant fabric in automobile seat cover. The new product of development will be security, comfortable and beautiful and will adapt to needs of automobile industry.

1. Introduction
With the development of automobile industry, textile products of automobile have a wide space in market of china[1-2]. From material, production technology, equipment and product design of automotive textile, there are many places to improve [3]. Seat fabric is a major category of automotive textile, an important part of car interior decoration, having to decorate the interior environment, taking functions of flame retardant and other safety. Therefore, the design and development of multifunctional automobile seat fabric has important significance. The design of car seat cover should not only meet the standard requirements of ordinary decorative fabric, but also has two major requirements, such as decorative and functional [4-6]. Decorative design includes color, pattern and fabric structure design. Functional design includes flame retardant, antifouling, antibacterial and deodorant, ultraviolet resistance, sun resistance, easy to clean, stable size, breathable and moisture [7-8]. This work is mainly about application and development of the polyester flame retardant fiber in the car seat fabric. Because the cost of flame retardant polyester fiber is higher than ordinary polyester fiber, in order to reduce the production cost, using flame retardant polyester fiber and ordinary polyester fiber interweave, jacquard and double structure can improve fabric’s decoration, develop suitable for automobile seat fabric and having the purpose of luxury, comfort, safety.
2. Experimental

2.1. Design and weaving
In this work, 300D/96F (33.3Tex) flame-retardant polyester yarn and 300D/96F (33.3Tex) ordinary polyester low-elastic yarn was selected to develop flame-retardant automobile seat cover fabric as material. Both of two polyester yarn has better strength and could be directly used for weaving. But the ordinary polyester yarn had stable performance and cheap price, it was used to instead of flame retardant polyester yarn in certain amount, automobile seat cover fabric could be not only in required function, but also in the cost lower.

The 8 kinds of automobile seat cover fabric with flame retardant polyester interwoven were designed. Table 1 showed every fabric’s basic technical parameter and structure design. It could be seen that fabric’s structure, weft ratio of flame retardant polyester interwove, density of warp and weft, surface density. The jacquard pattern and plain were combined together and got to stitching double weave and weft double weave. The use of different structure could not only get rich pattern of the fabric, but also improved its permeability. The all-fabric samples were weave in SGA598 Semi-automatic Weaving Machine by handwork.

Table 1 Technical parameter of sample designed

| Fabric number | Weft material ratio (ordinary polyester: flame-retardant polyester) | Fabric structure (face weave: back weave) | Density / ends (10cm)\(^1\) (warp*weft) | Surface density /g.m\(^{-2}\) |
|---------------|---------------------------------------------------------------------|------------------------------------------|-----------------------------------------|-------------------------------|
| 1#            | 1:1                    | Stitching double weave (jacquard pattern: plain) | 500*450                                | 350.54                        |
| 2#            | 2:1                    | Stitching double weave (jacquard pattern: plain) | 500*400                                | 318.83                        |
| 3#            | 3:1                    | Stitching double weave (jacquard pattern: plain) | 500*350                                | 308.12                        |
| 4#            | 4:1                    | Stitching double weave (honeycomb: plain)       | 500*400                                | 320.83                        |
| 5#            | 1:1                    | Weft double                                      | 500*450                                | 346.34                        |
| 6#            | 2:1                    | Weft double                                      | 500*350                                | 301.32                        |
| 7#            | 3:1                    | Weft double                                      | 500*300                                | 283.32                        |
| 8#            | 4:1                    | Weft double                                      | 500*300                                | 289.40                        |

2.2. Instruction and methods
(1) The instruments were used for experiment, such as SGA598 Semi-automatic Weaving Machine (Jiangyin Tongyuan Textile machinery Co., Ltd., Jiangyin, China); LFY-601 fabric burning performance tester (Shandong Textile Science Research Institute, Qingdao, China)

(2) The performances of samples were tested by standards GB/T17591-2006, Test for flame resistance of fabrics (vertical combustion method).

3. Results and Discussion

3.1. Relationship in effect of flame retardant and ratio of flame-retardant polyester
It can be seen from Table 2 that the 8 kinds of flame retardant polyester interwoven with ordinary polyester designed in this experiment have good flame retardant properties, and all fabrics can meet the standard of Class B1 except for the 4# fabric, which has a duration of over 5s and is Grade B2. From Table 2, it can be seen that:(1) the damage length of fabric increases with the decrease of the percentage of flame retardant polyester used;(2) 4# fabric using flame retardant polyester proportion is the smallest, the damage length is the longest, the flame retardant effect is the worst; (3) The ratio of flame retardant
polyester used in 2# and 3# fabrics, 6# and 7# fabrics is similar, but the damage length of 3# and 6# fabrics is obviously smaller than that of 2# and 7# fabrics, and the flame retardant effect is better, which is related to the fact that the surface of 3# and 7# fabrics has more tissue points and close structure. Therefore, when the use percentage of flame retardant polyester is close to the same, keeping the structure point of flame retardant polyester on the surface of the fabric is beneficial to improve the flame retardancy of the fabric.

| Fabric number | Continue burning time /s | Smoldering time /s | The length of the damaged /mm | Ratio of flame-retardant polyester /% |
|---------------|--------------------------|--------------------|------------------------------|-------------------------------------|
| 1#            | 3.36                     | 0.30               | 80                           | 76.32                               |
| 2#            | 3.90                     | 0.32               | 96                           | 70.37                               |
| 3#            | 4.06                     | 0.36               | 78                           | 69.12                               |
| 4#            | 5.28                     | 0.56               | 115                          | 64.44                               |
| 5#            | 3.02                     | 0.30               | 76                           | 76.32                               |
| 6#            | 3.86                     | 0.38               | 78                           | 72.55                               |
| 7#            | 3.40                     | 0.42               | 90                           | 71.88                               |
| 8#            | 3.98                     | 0.46               | 94                           | 70.00                               |

Note: GB/T17591-2006 standard shows that decorative fabric must be degree B1 (damage length ≤150mm, continued burning time ≤5s); degree B2 is damage length ≤200mm and continued burning time ≤15s.

3.2. The change of fabric surface in ironing by cigarette

Because the fire inside the automobile will bring huge danger to the drivers and passengers, flame retardancy fabric will be important and necessary to the car seat cover inflammable. Nowadays, people smoking in the car are everywhere, cigarette butts will fall on the seat and the car seat fabric would be hurt by cigarette butts. In order to simulate in real time, referring to the method of testing the flame retardant fabric properties with cigarette in American testing company, two groups of realistic simulation experiments were added to make the experiment closer to life that were ironing test in the surface of fabric with a cigarette end and time of burnt in cigarette.

After ironing the surface of each fabric with a cigarette end for 10 second, the change in the appearance of the fabric would be observed. The results were shown in Figure 1 that 1# fabric had excellent ability to resist hurt of cigarette, because 1#fabric had the biggest percentage of flame retardant polyester and this flame retardant polyester covered more in surface of fabric by designed.

3.3. The variety of time of burnt in cigarette

The burning time of each fabric by cigarette was record by watch and the average value was obtained by testing 10 times. The test results were shown in Figure 2. It could be seen that 1# fabric had excellent ability to resist burnt in cigarette as well, because 1#fabric had the biggest percentage of flame retardant polyester and this flame retardant polyester covered more in surface of fabric by designed.
The experiment showed that the cigarette ends could not cause open fire during the ironing process of 8 kinds of fabrics. It can be seen from Figure 2 and Figure 3 that the burning time of the fabric by cigarette ends was mainly affected by the ratio of flame retardant polyester used in the fabric and the thickness of the fabric. Generally, the larger the ratio of flame retardant polyester used and the thicker the fabric, the more resistant the fabric was to smoke burning. 4# fabric used the least percentage of flame retardant polyester, but the ironing time was longer, which was related to the large thickness of 4# fabric. Therefore, in the design of flame retardant fabrics, in order to achieve the same flame retardant effect, increasing the thickness of the fabric was beneficial to reduce the use of flame retardant polyester to a certain extent and save costs. The three tests showed that the factors affecting the flame retardant performance of the fabric include the percentage of flame retardant fiber used, the coverage ratio of flame retardant fiber on the fabric surface, the thickness of the fabric, etc.

4. Conclusions
(1) The 8 kinds of automobile seat cover fabric with flame retardant polyester interwoven were designed, weave and tested, the result could be showed that all fabrics could meet the standard of Class B1 in flame retardant except for the 4# fabric. Meanwhile, all fabric had decorative and flame retardant function. So, it was practicable and useful that the structure of stitching double weave and ordinary polyester yarn instead of flame retardant polyester yarn in certain amount.
(2) When ratio of flame-retardant polyester reached 76.32%, flame retardant effect was best in flame retardant test and cigarette ironing test. When ratio of flame-retardant polyester reached 69.12%, flame retardant effect could meet the standard of Class B1 according decorative fabric requirements.

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