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New Materials and New Functions of Intelligent Interactive Textile

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Abstract: With the improvement of people's living standard and the huge change of consumption concept, various functions and comforts of clothing or clothing components have become the goal that people pursue, and the research of clothing materials is the first to occupy a crucial position. According to the needs of consumers for different functions of clothing, it is a higher level and ultimate goal for the innovation and development of functional clothing to directionally design new products with diversified functions that meet the requirements of consumers, and the matching degree between clothing and human body is the main factor for a clothing to achieve multi-functional features. Therefore, this paper mainly aims at the functional materials selected by orientation to match the corresponding parts of the human body locally, and on this basis, research and analyze the clothing combination design of different materials and fabrics. The research shows that the pilling property of fabrics made of untwisted yarns is generally lower than that of fabrics made of twisted yarns under the same proportion and same weave conditions, so the anti pilling property of twisted fabrics is better. All fabric samples meet the requirements of Grade B specified in the standard, and the antistatic property of twisted yarn is obviously better than that of untwisted yarn.

1. Introduction

With the improvement of people's living standards, people's consumption concepts and product requirements have undergone tremendous changes. The demand for clothing is no longer limited to simple shelter, strong and durable, traditional warmth and other practicality, but gradually pursues a variety of functionality and comfort. The development of high-tech has brought new strength into the traditional textile and clothing industries. The functionality of clothing or clothing components has gradually become a fashion trend. The internal functionality of colorful clothing products is also gradually enhanced [1-2].

In relevant research, Mohammad et al. introduced the design and analysis of a miniaturized, new wearable ultra wideband (UWB) band notch fabric antenna for body area network (BAN) [3]. The main goal of building an X-band notch antenna for wearable applications is to suppress the downlink frequency band (7.25 to 7.75 GHz) of satellite communications in the 3.1-10.6 GHz UWB frequency range to avoid interference. Use user-friendly and reliable computer simulation technology (CST) TM microwave studio to model and simulate the antenna. The results show that

the antenna achieves the design goal and performs well in free space and human body. Martin et al. proposed an unsupervised defect detection method for carbon fiber textiles [4], which meets four key industrial applicability standards: only using "normal" data can achieve high accuracy even on minor defects, allowing visual interpretation, and achieving real-time performance. The visual transformer encoder is combined with the normalized flow to collect the global context from the input image, directly generate the image possibility, and then use it as the exception score. Finally, it shows that the reasoning time of the model is acceptable in 32 milliseconds, and the real-time performance is achieved.

The main purpose of this paper is to study the development of new materials and new functions of intelligent interactive textiles. On the basis of matching design concept, this paper prepares directional functional knitting yarn applied to local matching clothing components, and applies the blended composite functional yarn and directional matching functional fabric to clothing. Through different process design methods, the blended clothing with directional or composite functions is designed, which makes it possible for the coexistence of comfort and local functionality of clothing. After the combination design, the quality of clothing can be improved, the grade of clothing can be improved, and the added value of clothing can be increased, which is of certain significance to both the industry and enterprises. Especially, due to the impact of the COVID-19, the market demand for antibacterial and antiviral functional fabrics and clothing has increased sharply [5-6].

2. Design Research

2.1 Functionality of Clothing

The function of clothing can be divided into three types, which can be distinguished according to the function of clothing, decoration and material [7-8], and these three types of functions are interspersed and related with each other:

(1) Wearing functionality refers to some joint parts of the clothing, such as sleeves, cuffs, joints, collars, plackets, hems, trouser cuffs, buttocks and some edge parts, which are easy to be damaged or stained due to frequent use. Therefore, it is necessary to use splicing technology in these joint parts to strengthen the durability of the clothing, in order to make the clothing more durable.

(2) Decorative functionality means that with the development of the times, on the basis of the above conventional functionality, some decorative means are gradually added to the design, aiming to improve the beauty of clothing. The decoration means refers to adding necessary decoration parts to the clothes after completion, such as edging, lace, ribbon, piping decoration, knitted fabric decoration, seam inlaid cloth strip, seam contraction decoration, ruffle, zipper and attached buttons, and most of the decoration parts have certain practical value while playing a beautifying role.

(3) Material functionality refers to the use of functional or composite functional materials in the parts of the human body that have corresponding needs, and the design of clothing matching with local functions, aiming to increase the added value of clothing and improve the wearing comfort. Material functionality mainly includes single or composite functions such as heat preservation (including intelligent heating), high moisture absorption, anti electromagnetic radiation, anti pollution, anti wrinkle, and anti-bacterial deodorization. It is an important high-tech industry in the clothing functional industry.

Realizing clothing functionality is an effective way to improve the grade of clothing products and the added value of clothing at present, and the negative impact caused by different production costs and human function needs of functional clothing should also be taken into account. Therefore, the use of directional matching of local clothing functionality can further improve the cost performance and comfort of clothing products [9-10].

2.2 Local Function Matching

The design concept of clothing partial function matching, as a bonus item of clothing, meets the Chinese consumers' requirements for improving clothing quality day by day in the face of the Chinese market pursuing convenience, comfort and diversified choices from a positive perspective. Functional clothing design that can be seen everywhere on the stage of Fashion Week is a powerful illustration.

The local functions of clothing are based on the functional requirements of specific parts of the human body, that is, clothing functions are dependent on the functional requirements of the human body, while different parts of the human body have different requirements for a certain function or multiple functions. Common human functional requirements include intelligent warmth preservation, anti-bacterial, anti-virus, intelligent monitoring, electromagnetic shielding, flame retardant, anti-static Sports and wearable micro interactive emotional and other functions. The functional requirements of the human body are constantly changing with the changes of living environment, climate and age. Therefore, in the context of environmental pollution, changeable climate and the impact of epidemic situation, this topic only focuses on the needs of human body parts for warmth preservation, anti-bacterial, anti-virus and other functions [11-12].

2.3 Perceptual Algorithm

In the case of direct communication, the input data is transferred from the input layer to the hidden layer, and then to the output layer. The functional relationship between the input and output of each neural layer can be expressed by an excitation function, which calculates the actual output and takes its error.

(1) The information input to the output layer is processed by the neurons in the hidden layer and output is obtained. Zk represents the output value of the kth neuron in the hidden layer, and the mathematical expression of Zk is.

$$z_k = f_1(\sum_{i=1}^{n} v_{ik} x_i), k = 1,2,\cdots,q \tag{1}$$

Wherein, f1 represents the excitability function between the input layer and the hidden layer, vik represents the connection weight between the i-th neuron of the input layer and the k-th neuron of the hidden layer, and $\sum_{i=1}^{n} v_{ik} x_i$ represents the sum of the information received by the k-th neuron of the hidden layer from the input layer.

(2) The information transmitted by the hidden layer is processed by the output layer neurons to get the final output. Oj represents the output of the jth neuron of the output layer. The mathematical expression of Oj is:

$$o_j = f_2(\sum_{k=1}^{q} w_{kj} z_k), j = 1,2,\cdots,m \tag{2}$$

Wherein, f2 represents the excitability function between the hidden layer and the output layer, wkj represents the connection weight between the kth neuron in the hidden layer and the jth neuron in the output layer, and $\sum_{k=1}^{q} w_{kj} z_k$ represents the sum of the information received by the jth neuron in the output layer from the hidden layer.

(3) Calculate the error value E, and the mathematical expression of E is:

$$E = \frac{1}{2}\sum_{j=1}^{m}(y_j - o_j)^2 \tag{3}$$

Where, yj is the actual output of the jth neuron in the output layer of BP neural network, and oj is the expected output of the jth neuron in the output layer of BP neural network.

3. Experimental Study

3.1 Far Infrared Heating Filament Yarn

Since the 1980s, researchers and social personages from different countries, fields and industries have been developing and researching far-infrared functional products. As shown in Figure 1, far-infrared clothing fabric refers to the effective combination of far-infrared ceramics and clothing fabric. Such far-infrared clothing products have the functions of promoting human blood circulation, adjusting body metabolism, reducing water molecule association and improving cell activity.

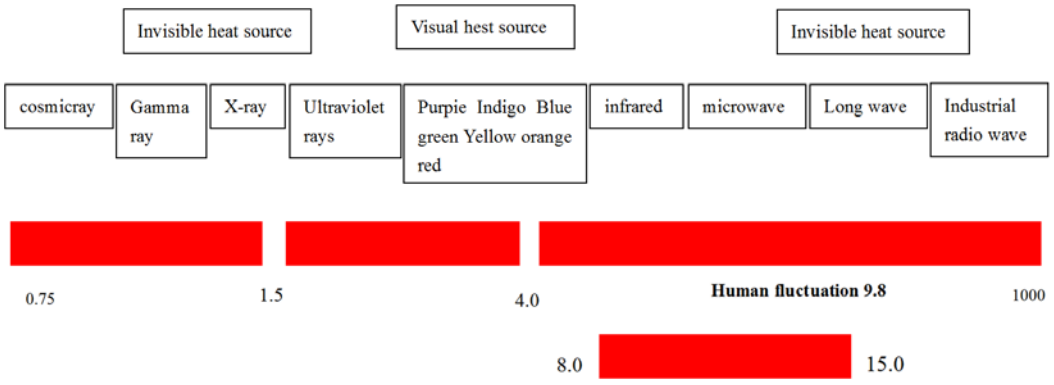

Figure 1: Far infrared emissivity

(1) Product introduction

The far-infrared heating clothing material is made of artificial fiber synthesis technology, and the far-infrared radioactive ceramic powder is added into the fiber quantitatively, so that the clothing materials can complete the transformation from far-infrared solar energy to clothing heat energy, and the far-infrared heating clothing material can also reflect and insulate the heat source of the human body.

Far infrared heating fiber is prepared by combining ceramic powder and fiber forming polymer through reasonable selection of far infrared ceramic powder and mature production process. The far-infrared heating clothing material produced by far-infrared radioactive ceramic powder has good physical and mechanical properties and can keep warm at 2~4 ℃.

(2) Application field

1) The far infrared heat insulating material can absorb and store solar energy and reflect it to the human body at the same time, which can increase the body feeling temperature of the human body by 2~4 ℃, and can be made into intelligent warm clothing, efficient heat insulating products, etc. Far infrared heating fiber can be used alone in thermal insulation products, and can also be used together with various natural fibers such as wool or artificial synthetic fibers such as poly (phthalide) and poly (phthalide).

With its excellent intelligent heating and warmth keeping function, far-infrared heating fiber is particularly suitable for making various clothing and parts such as waist protector, cold proof clothing, gloves, ski clothes, scarves, sportswear and trousers in autumn and winter, and can also be

made into warm sheets, insoles, cushions, sports belts, blankets and carpets. The functionalization and compound functionalization of clothing and its parts and household goods are the current world development trend.

2) Medical supplies

Far infrared heating fiber also has special antibacterial and deodorant functions in the medical field, which can be used as medical and health supplies, including hospital sheets, gauze, deodorant pantyhose, patient clothes, etc. In addition, the far-infrared heating fiber can also promote the blood circulation of the human body, which can be made into personal health care clothing. At the same time, some researchers have also made the far-infrared heating fiber into food fresh-keeping bags.

3.2 Antibacterial Filament Yarn

In daily life, people often contact with various bacteria, fungi, mycotoxins and other microorganisms. The clothes they wear are good habitats for various microorganisms and important sources of disease transmission. It is of great practical significance to study antibacterial materials, and clothing materials with antibacterial or bactericidal effects meet the needs of modern people for clothing health care. Antibacterial and sanitary finishing is to use an antibacterial finishing agent that is beneficial to human health. After physical or chemical processing, it will be placed on the clothing fabric, so that the clothing has antibacterial, bactericidal, mildew proof, odor proof and other functions to maintain the cleanliness of clothing.

(1) Antibacterial series

Source of silver fiber: silver ion has a unique antibacterial effect. In ancient times, people used silver to make all kinds of jewelry, tableware and currency. However, it was only in recent years that the metallic silver element was added to the clothing fabric. Silver fiber sterilization is a physiological process that destroys bacteria. Under the conditions of human body temperature and humid environment, silver ions have higher biological activity and better sterilization effect, so silver plated materials are very suitable for domestic textile products.

(2) Production process flow

Silver ion antibacterial fiber is a kind of fiber with permanent antibacterial function, which is made by dissolving silver ion antibacterial material into spinning solution and spinning.

(3) Function principle introduction

The mechanism of silver ion sterilization is that silver ion combines with bacterial protein and causes it to solidify, thus causing damage to its structure change, and can also continue to react with enzymes and DNA, resulting in dysfunction, thus inhibiting the respiration and metabolism of bacterial cells to achieve bactericidal and antibacterial effects, as shown in Figure 2.

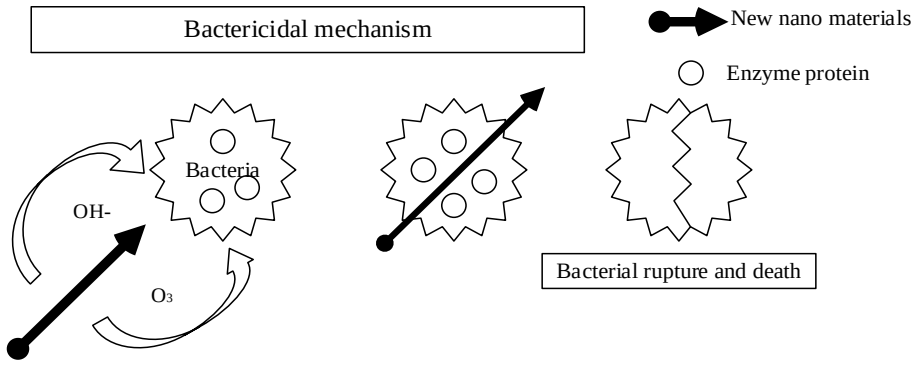

Figure 2: Sterilization mechanism of new nano silver ions

(4) Function of silver ion fiber

Silver ion broad-spectrum antibacterial, high efficiency; The antibacterial effect is extremely durable; Silver ion antibacterial products are widely used; It is safe for human body, non-toxic and harmless.

(5) Use of silver fiber

In daily life, silver fiber is widely used, including towels, shirts, pajamas, bras and underwear, close fitting clothes and bedding, etc; In medical and health products, there are masks, sanitary pads, baby diapers, medical sheets and dressings, medical uniforms, nano silver wound bandages and other antibacterial products; In addition, antibacterial products include air conditioning antibacterial filter media, antibacterial clothing linings, antibacterial shoulder pads and insoles.

3.3 Design of Matching Relationship of Directional Material Selection Knitting Yarn

In order to improve the function and comfort of clothing, the subject conducts directional selection of raw materials for different composite functional clothing components, that is, take far-infrared heating filament yarn ("Y" for short) and antibacterial filament yarn ("K" for short) as the test materials for directional matching selection. By using two kinds of yarns with different properties, far-infrared heating filament yarn and antibacterial filament yarn, products with different varieties and different properties are prepared through different blending ratios. Through a series of preparation tests, the products can not only reflect specific functionality, but also greatly improve their wearing performance.

It is a concept of fashion design to cater to the current social trend that knitting yarns with different functions are combined in different matching relationships. With the development of the times, a single function, material, design, etc. can no longer meet people's life and aesthetic needs. It is recognized that different directional functions are given to various parts of the human body on the basis of the current aesthetic needs of clothing design to highlight the pertinence of the design and improve the added value of clothing. The following details the process flow of splicing and twisting of directional functional filament yarn with different matching relationships and the preparation of splicing untwisted yarn, so that the filament yarn with different functions can be used for composite functions.

Table 1: Matching relationship design of filament yarn with different functions

Material Abbreviation	Y1K0	Y7K3	Y1K1	Y3K7	Y0K1
Splicing twist	Untwisted	Untwisted	Untwisted	Untwisted	Untwisted
Splicing matching relationship	100:0=1:0	70:30=7:3	50:50=1:1	30:70=3:7	0:100=0:1
Material abbreviation	Y1K0	Y7K3	Y1K1	Y3K7	Y0K1
Splicing twist	Twisted	Twisted	Twisted	Twisted	Twisted
Splicing twist	100:0=1:0	70:30=7:3	50:50=1:1	30:70=3:7	0:100=0:1

In this paper, the combination and integration of composite functional materials include the combination of twisting and untwisting, and the combination of two different functional filament yarns in different proportions is carried out. The purpose is to make clothing materials have directional and multiple functions according to one or more functional requirements of different parts of the body, so as to achieve the directional function matching design of clothing and its components in Chapter 5. The specific matching relationship design scheme is shown in Table 1. The far-infrared filament yarn (75D/72F) and antibacterial filament yarn (75D/72F) are used as the raw materials for blending, and the blending ratio is 100:0, 70:30, 50:50, 30:70, 0:100 (also can be expressed as 1:0, 7:3, 1:1, 3:7, 0:1). The specifications and colors of the two kinds of filament yarns are the same, and a variety of blended yarns are prepared by changing the content of different raw

materials (from 0% to 100%) and whether they are twisted.

4. Experiment Analysis

4.1 Test and Analysis of Pilling Resistance of Knitted Fabrics with Directional Material Selection

The anti fuzzing and pilling property is a basic physical and mechanical property of clothing fabric. When the clothing fabric contacts and rubs during wearing, the short fibers or yarns in the clothing fabric will be pulled out. After further friction, wool balls will form on the surface of the knitted fabric, which seriously affects the beauty, feel, wear resistance and luster of the clothing fabric. Therefore, the anti fuzzing and pilling property of the knitted fabric is required to be high in clothing design.

(1) Experimental test standard: circle locus method.

(2) Experimental testing instrument: circular trajectory pilling instrument.

(3) Preparation for experiment test: cut each fabric sample into round pieces with a diameter of 113mm ± 0.5mm. At the same time, place the fabric pieces in the required temperature and humidity environment conditions (temperature 20℃± 2℃, relative humidity 65% ± 2%), and place them for more than 24h.

(4) Test steps:

The operation process is as follows:

1) Install the required weights on the "grinding head" according to the experimental requirements, and select 780c N as the pressure.

2) After installing the small pieces of cut fabric sample into the upper chuck, press the upper grinding head onto the lower grinding head or brush.

3) Turn on the power switch. Set the "preset times" and "magnification" according to the experimental requirements

4) Press the "Reset" key to make the "Actual Times Display" window display "0".

5) Press the "Start" key, and the instrument starts to run.

6) When the preset number of turns reaches 600, the instrument stops running, and the surface of the fabric sample forms fuzzing and pilling. At the end of the experiment, the fabric sample is rated and calculated.

After the test measurement is completed, under the specified standard light source, compare and analyze the fabric chips after the test with the standard sample, and then determine the pilling level of each fabric chip. Considering the subjectivity of the evaluation, 6 students in this major are asked to evaluate the fuzzing and pilling grades of all fabric chips respectively, and calculate the average value of each student's grade of each fabric chip. According to the rounding off rules in the circle path method, if it is between two levels, it is recorded as level 0.5. Table 2 shows the fuzzing and pilling properties of 40 fabric samples measured in this experiment.

Table 2: Pilling resistance of each fabric sample

Fabric serial number	1#	2#	3#	4#	5#	6#	7#	8#	9#	10#
Sample level	2	3.5	2.5	3	4.5	3.5	3	3	3.5	5
Fabric serial number	11#	12#	13#	14#	15#	16#	17#	18#	19#	20#
Sample level	2.5	3.5	4	5	2.5	4	4.5	3.5	2	3.5
Fabric serial number	21#	22#	23#	24#	25#	26#	27#	28#	29#	30#
Sample level	3.5	5	3.5	3.5	3	5	3.5	2.5	4	3
Fabric serial number	31#	32#	33#	34#	35#	36#	37#	38#	39#	40#

Sample level	4	3.5	3	5	3.5	3	4.5	4	4.5	3.5

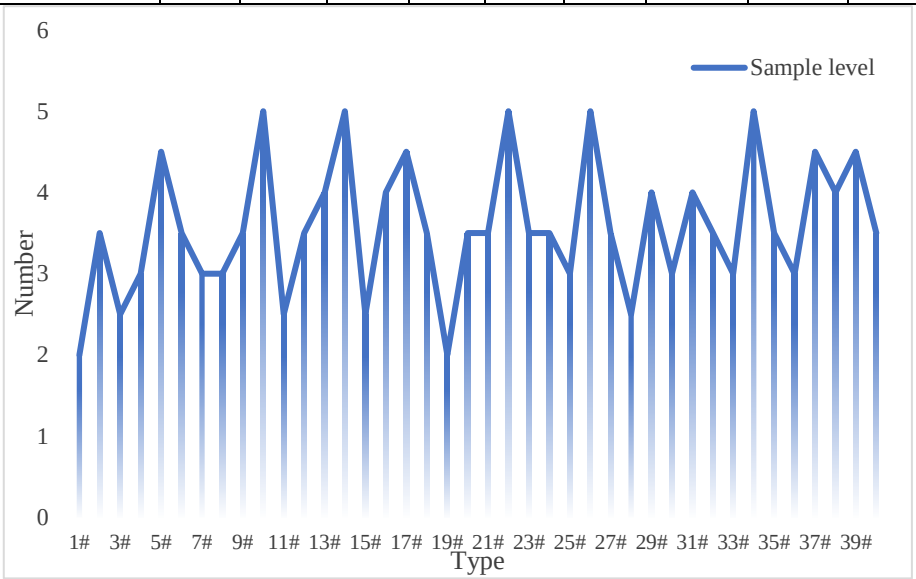

Figure 3: Analysis of anti pilling performance of each fabric sample

It can be found from Figure 3 that different material selection and matching relationships, fabric structure and whether the fabric is twisted have different effects on the anti pilling performance of fabric samples. There are 10 #, 14 #, 26 # and 34 # fabric samples with the fuzzing and pilling grade of 5 determined in the test. These four fabrics are rib weave structures, and the anti fuzzing and pilling grades of other rib weave samples are relatively high, while the anti fuzzing and pilling grades of the other three weave structures have no significant difference. In addition, the pilling property of fabrics made of untwisted yarns is generally lower than that of fabrics made of twisted yarns under the same mix ratio and same weave condition, so the anti pilling property of twisted fabrics is better.

4.2 Test and Analysis of Anti-Static Property of Knitted Fabrics with Directional Material Selection

Static electricity is a kind of static charge. In life, if static electricity is generated in people's daily clothes, it will absorb the dust in the surrounding environment, and the dust usually contains viruses and some harmful substances, which are easy to stimulate the skin, induce skin diseases and other symptoms, thereby endangering people's mental health and physical health. Therefore, the antistatic property of clothing fabric is an important research index of wearability.

(1) Test standard: friction electrification voltage.

(2) Experimental testing instrument: fabric friction electrostatic tester.

(3) Test preparation: cut 8cm from each fabric sample × 16 pieces of 4cm fabric chips (4 pieces of fabric chips are a group: 2 pieces in radial direction and 2 pieces in weft direction respectively), and then place the fabric sample under the environment of temperature 20 ± 2 ℃ and relative humidity 35% ± 5% for balance.

(4) Test steps:

The operation process is as follows:

1) Turn on the power and preheat the tester for 30min.

2) Parameter setting: pressurization time is 60s, test times are 5, test method is timing method, and attenuation time is 8s.

3) Clamp the standard cloth (friction cloth) onto the clamping device and apply 500g tension to

it.

4) A group of four small pieces of fabric samples prepared for the experiment are respectively clamped on the four protrusions of the drum.

5) Start the test, press the "Start" key, the drum starts to rotate, after 2s, lift the clamping device and stay for a period of time until the clamping device is fixed until the instrument stops rotating. After the automatic test of the instrument is completed, record and save the test data for five times as well as the maximum, minimum and average values.

6) Replace the sample and repeat steps 4 and 5

Friction electrification voltage indicates the amount of charge exchanged between two fabrics through friction. The less the exchanged charge is, the smaller the friction electrification voltage is. In the fabric antistatic test, the friction electrification voltage is divided into A (<500V), B (≥ 500V, <1200V) and C (≥ 1200V, ≤ 2500V). The lower the friction electrification voltage, the better the antistatic performance of the fabric. Table 3 shows the test data of friction electrification voltage of each fabric sample, among which fabric sample 13 # has the lowest friction electrification voltage and the best anti-static performance; Fabric sample 20 # has the highest friction electrification voltage and the worst anti-static property.

Table 3: Test Data of Friction Charged Voltage of Each Fabric Sample

Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Untwisted	2	3.5	2.5	3	4.5	3.5	3	3	3.5	5	2.5	3.5	4	5	2.5	4	4.5	3.5	2	3.5
Twisted	3.5	5	3.5	3.5	3	5	3.5	2.5	4	3	4	3.5	3	5	3.5	3	4.5	4	4.5	3.5

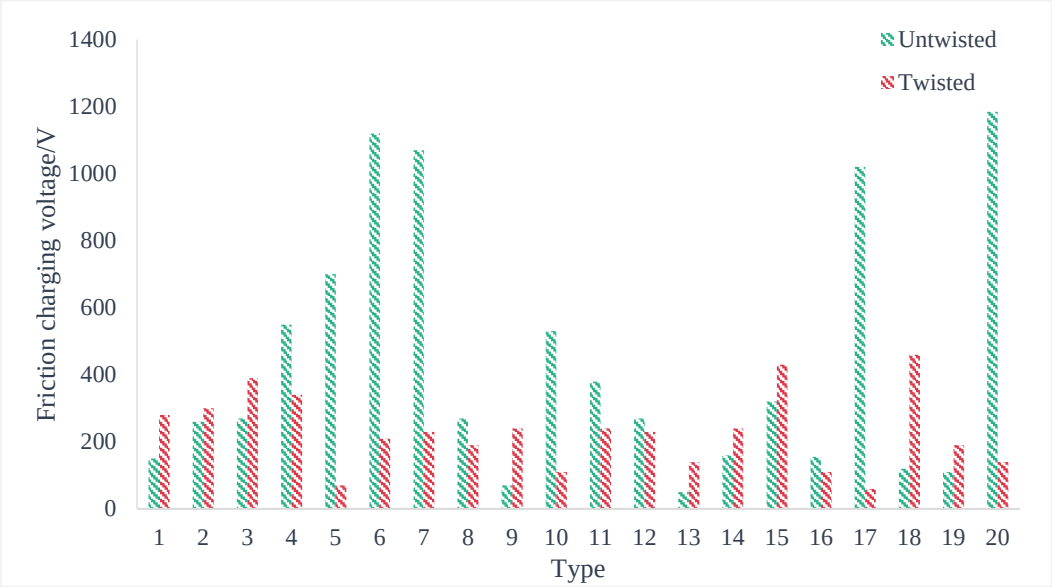

Figure 4: Analysis of Friction Charged Voltage Test Data of Fabric Samples

It can also be seen from Figure 4 that the friction electrification voltage of all fabric samples is less than 1200V, and the friction electrification voltage of 7 fabric samples is greater than 500V, that is, the grade is B; The friction electrification voltage grade of the remaining 33 fabric samples is Grade A. Therefore, all fabric samples meet the requirements of Grade B specified in the standard, and the antistatic property of twisted yarn is obviously better than that of untwisted yarn.

5. Conclusions

Functional clothing has transited from a single function to a diversified product era dominated by

intelligent heating, anti-bacterial, anti-virus, comfort and other functions. The functionalization of clothing fabrics has become the mainstream of the development of contemporary textile and clothing industry. In the development and design of functional clothing fabrics, we should neither blindly abandon the traditional clothing fabrics, nor one-sided think that non-traditional and rare functional fabrics are good. Instead, we should carry out further theoretical research and experimental verification on the new clothing fabrics and the combination of new clothing fabrics and traditional clothing fabrics. The protective performance of clothing is mainly determined by the performance of functional clothing materials and the level of design and processing technology of clothing. The emergence of new clothing materials and new fabrics and their combination and collision make functional clothing present a development trend of high performance and functional diversification. High tech textiles are the combination of new fibers and new technology and technology. Now it is possible to realize the functional characteristics of clothing raw materials through molecular and structural design, further process and produce high-tech fabrics, and then develop new functional clothing that can adapt to special conditions to protect human body. At the same time, the combination of new materials and traditional materials can also save production costs and help promote the developed products to the market.

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