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EDITOR'S DESK

Dear Readers,

Greetings!!

Research with persistent and focused efforts lead to a positive result. Fostering research and providing a platform to publish quality research papers and related articles has been a continuous effort of BTRA Scan. We are working hard to help the journal in climbing up the ranking ladder. In continuation to this effort, I am delighted to present to our readers the 1st issue of 52 Edition of BTRA SCAN.

This issue has papers from the different domains such as Dyeing with natural dyes and RE salt, Quality assurance in garment industry and Fabric Inspection in Folding - Current scenario in India. Now we are open for authors from outside so researchers can send their original articles, case studies, research reviews or empirical contributions for publication in our journal.

I thank my associate editor Dr. Prasanta K. Panda and the entire publishing team for all their support. Together we would work towards making the journal a truly influential publication. Comments and suggestions are always welcome.

Our sincere thanks to all the reader and contributors for their support and interest.

T V Sreekumar, PhD
Director, BTRA

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Sustainable Natural Dyeing of Garments with Rare Earth Salts

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Abstract

Sustainable Garment dyeing using natural dyes have been attained by augmenting with rare earth salts as mordants replacing the conventional mordants. This could be achieved using different dyeing techniques. Apart from Exhaust dyeing, Foam dyeing and Spray dyeing techniques were attempted. All the garment dyeing techniques yielded even dyeing and good fastness properties.

Keywords

Sustainable natural dyeing, Rare earth salts, Exhaust dyeing, Foam dyeing, Spray dyeing

Citation

Afreen Begum and Padma Shree Vankar- "Sustainable Natural Dyeing of Garments with Rare earth salts ", *BTRA Scan* - Vol. LII No. 1 January 2023, Page no. 1 to 3

1.0 Introduction

Garment dyeing has become an increasingly important part of dyeing industry in the recent years. There has been a significant growth in the demand of Garment dyeing due to rapid fashion response [1,2]. There are several advantages in switching over to garment dyeing. We have attempted to do garment dyeing with natural dyes using different techniques. All of them have yielded excellent results in terms of evenness of natural dyeing and fastness properties of the dyed garments. In our case we have used rare earth salts as mordants with natural dyes.

2. VERSATILITY of Rare Earth salts

Eco-friendly Natural Dyeing of natural fabrics such as Cotton, Silk as well as synthetic fabric like Polyester and semi synthetic fabric viscose using Rare Earths Metal Salts as Mordants by replacing traditional metal mordants signifies its versatility. We have carried out natural dyeing of these fabrics using nonconventional mordant salt. These nonconventional mordant are rare earth salt (RE salt) namely- Cerous sulphate, Lanthanum chloride and Yttrium chloride. It is for the first time that these rare earth salts have been used in the natural dyeing process.

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3. COMPATIBILITY of Rare Earth salts

The high coordination capability of the rare earth metal has been the cause of better dye uptake. Different natural dyes have been demonstrated to show better dyeing results with RE salt as compared to conventional mordants. Even the quantity of rare earth mordant required to get desired results is 1/10th quantity of the conventional mordants, thereby directing towards lesser effluent load. Thus the use of rare earth mordant has good prospects in the Natural dyeing of these fabrics. Natural dyeing of Polyester and viscose fabric is quite challenging. Since the polyester fabric has an inherent hydrophobic character the dye uptake under conventional method is very poor for Natural colorants. Dyeing of cotton and silk fabrics were dyed with 14 natural dyes- namely Indigo, Madder, Rheum, Punica, Lac, Leafy green, Henna, Yeliona, Myrobalan, Red Sandal, Walnut, Eupatorium, Turmeric and Catechu using all the three RE salts mainly to check the dye compatibility with the RE salt and also to demonstrate the improvement in dye uptake by the use of the one RE salt. Each of the natural dye showed unique reactivity towards a particular RE salt as shown in table-1. Figure-1 shows garments dyed by Natural dyes-Indigo, Madder and Yeliona.

Figure-1 Garments dyed by Indigo, Madder, and Yeliona natural dyes

Dyes compatibility with RE salts

SL NO	NATURAL DYES	COMPATIBLE RE SALT
1	MADDER (RUBIA)	YCl_3
2	EUPATORIUM	YCl_3
3	RHEOM EMODI	$Ce_2(SO_4)_3$
4	PUNICA	YCl_3
5	MYROBALAN	YCl_3
6	DRY WALNUT	YCl_3
7	TURMERIC	$LaCl_3$
8	RED SANDAL	YCl_3
9	CATECHU	YCl_3
10	LEAFY GREEN	Ycl_3
11	LAC (NIMBUS)	Y_2O_3
12	HENNA	YCl_3
13	YELIONA	$LaCl_3$

Table 1 Showing dye compatibility with different Rare earth salts

The chelation sites for Curcumin colorant of Turmeric dye and indigo molecule of Natural Indigo dye are shown in figure 2 as (a) and (b).

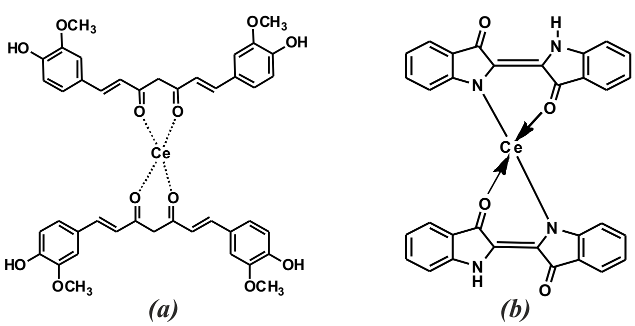

Figure-2 shows chelation of Curcumin molecule (a) and Indigo dye (b) with Cerium ion

4. SUSTAINABILITY with Rare Earth salts

In order to prove the aspect of sustainability of Rare earth salts which have been used as mordants in natural dyeing, the toxic index was evaluated by us. We were interested to find out the traces of RE salts on the fabric as well as on effluents. Cerium salt mordanted with 1 % owf for cotton fabric showed the following results:

Toxic Index study for Rare earth salt mordants

Cotton-dyed fabric treated with Cerium salt (when we used 1 %mordant solution)

- The total digestion method analysed by Method– DIN EN 1671-I is 313.9.mg/kg.
- Perspiration method analysed by Method --DIN EN 16711-II is 0.558 mg/kg.

Dye Effluent analysis showed the following results:

Now we are using only a 0.4 % mordant solution of Rare earth salts

- The total Cerium content in the used mordant solution is 1.09 mg/kg
- The total Yttrium content in the used mordant solution is 0.78 mg/kg

We can definitely use rare earth metal mordants safely during natural dyeing of fabrics and garments. This makes natural dyeing sustainable and safe for both human beings and environment.

4. Sustainable Natural dyeing of Garments

4.1 Exhaust dyeing:

Exhaust natural dyeing of jacket has been carried out using madder dye along with RE salts as shown in figure 1. Exhaust natural dyeing is a method of dyeing a textile material or garment using a natural dye and a mordant. The method involves the gradual transfer of dye from a dye bath to the fabric, the dye molecules move from the dye bath solution to the fibers of the fabric. This is due to its ability to coordinate with the fiber using a metal salt as bridging head between the two. The affinity of a dye can be influenced by chemical additives such as mordants or even by raising the temperature of the dye bath. In our case we have used RE salt as mordant as shown in figure-3.

Figure-3 Exhaust dyeing of the garment using natural dye Madder and RE salt

4.2 Foam Dyeing

Foam dyeing is an advantageous alternative to conventional dyeing methods due to its environmental benefits and mitigating effluent management issues. The primary dyeing element in this process is foam, wherein air is used instead of water to carry the dyeing process. Foam plays a key role in foam dyeing process as they are carrier of the dye molecules. Foams are formed using foaming agents dissolved in water to make aqueous solution which then spreads on the textile material [3] These agents must have the quality to produce foam immediately, they should be temperature resistant having quick wetting and stabilizing effects. Foam can be of two types- dispersion foam or condensation foam. Dispersion foam is prepared by mixing a gas with liquid while condensation foam is producing gas within the liquid either physically by aeration or by the addition of a chemical. Figure-4 shows garment dyed by Yeliona natural dye comprising of Tessu and Marigold flowers.

Figure-4 : Foam dyed garment with Yeliona natural dye

The continuous methods of foam dyeing have the following steps:

a. Foam generation.
b. Foam application to the substrate.
c. Foam distribution with simultaneous drainage and diffusion of the liquid into the substrate Foam collapse and release of active substance.
d. Fixation of the active substance.

Advantages

1. Fixation of dye into fiber can be improved.
2. Diffusion of dye into fiber can be enhanced.
3. Stability of the fiber dyed obtained is high.
4. Outcome is more in short time duration.
5. Waste generation is less and energy saving process.

4.3 Spray Dyeing Technology

In textile wet processing industry water-consumption is the highest industries.20% of global industrial pollution is a result of wet textile effluents. These textile effluents contain a large number of toxic chemicals. Thus, technologists have been working to reduce these water contaminations, by introducing a new technology called Spray dyeing technology. It is fairly new methodology which looks very promising.

Mechanism

This method is a waterless method for dyeing fabric, instead air is used to help the dye molecules to enter into fibers. In this method, Initially the fabric is heated and then the dye is injected from a sprayer directly into the fabric. As a result this technology is advantageous than any other conventional dyeing methods such as vat dyeing, cationic dyeing, etc. The color after dyeing process results in rich look and lasts for a longer period of time [4].

Advantages

- Spray dyeing uses 95% less water and 86% less energy than conventional fabric dyeing processes.
- Only 1% of spray Dyed fabrics are damaged during this process.
- It yield maximum color durability.
- The process does not require any post-treatment or finishing.

The Spray dye process substantially reduces the environmental load of the colored effluent and also improves the fastness performance of the finished fabric. By removing the requirement of water at the point of color application, Spray dye technology is recommended for regions which lack the water resources. It is very well known that traditional processes are energy and water intensive, Spray dye technology is best suited for textile coloration. Slowly Spray dye technology is maturing, and it is expected to find additional benefits from this technology wherein power usage, waterless direct application of dye is easily doable. Spray dye technology thus show apparent benefits over traditional dyeing processes and can be adapted as a new technology for improving the coloration of textiles. Figure-5 shows denim jacket spray dyed by Indigo.

Figure 5 shows a Denim jacket dyed with Indigo through the Spray dyeing method

5. Conclusion:

Garment dyeing with natural dyes using rare earth mordants has given very good results. Exhaust dyeing, Foam dyeing and Spray dyeing techniques were adapted for different natural dyes which yielded in even dyeing despite the fabric construction, sewing thread, buttons, zippers, jacket lining etc., dyeing process and the machine used for dyeing helped us to achieve uniform dyeing and good fastness properties of the dyed garments.

Acknowledgement:

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Quality Assurance in Apparel Industry

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Abstract
This article is about the evaluation of the quality and testing methods used in the apparel industry. Testing is the key to continued improvement of products and get an idea of how to improve performance in the future. Physical as well as chemical testing is performed on fabrics for quality assurance and identification. Several quality parameters and testing methods are described in this article starting from physicomechanical properties such as yarn count, GSM of fabric, tensile strength, strain, modulus, comfort properties such as moisture management, wicking, fastness, etc. Aesthetics of the fabrics on extended time usage is also very important in fashion wear and hence properties such as colour fastness to light, washing rubbing, etc are also discussed. A detailed description of the significance of each test and expected results are also discussed.

Key words:
Testing, Apparel testing, mechanical properties, physical testing, chemical testing

Citation
Shreyasi Nandy and T V Sreekumar - "Quality Assurance in Apparel Industry", *BTRA Scan* - Vol. LII No. 1 Jan. 2023, Page no. 4 to 12

1.0 Introduction:

Maintaining quality and consistency is one of the major challenges in any industry. For every apparel industry or business, it is important to maintain a level of quality to get increased sales and a better brand name amongst consumers and fellow companies. High quality is the main factor that ensures global business as a high level of quality will ensure the brand value and ensure better business globally. Strict quality control measures are required for sustainable business especially if the company is exporting its products. Good quality control of their products is very essential as export houses earn foreign exchange for the country. In the garment industry quality control is practiced right from the sourcing of the raw materials to the finished garment. In this industry, product quality is determined in terms of quality and standard of fibres, yarn, fabric construction, surface designs, fastness properties, and the final finished garment products. The quality expectations for export are related to the type of customer segments and the retail outlets.

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Several factors influence the quality fitness of a garment which is based on factors such as - performance, durability, and reliability, visual and perceived quality of the garment. Regulatory quality certifications such as the national regulatory quality certification and international quality programs like ISO 9000 series lay down the broad quality parameters based on which companies maintain the export quality in the garment and apparel industry. Quality needs to be defined in terms of a particular framework of cost. Some of the main fabric properties that are taken into consideration for garment manufacturing for export are the overall look of the garment, the right formation of the garment, feel and fall of the garment, physical properties, colour fastness of the garment, finishing properties, and final produced garments presentation.

2.0 Testing Requirements for Quality Assurance:

Assess the quality of your apparel materials and workmanship, using a number of quality control checks and tests, including:

Physical/ Chemical/ performance	Mechanical	Aesthetics
Fibre Content	Seam slippage /Strength (for woven garments)	Dimensional Stability to washing and dry cleaning
Count & Construction	Tensile Strength	Appearance after wash and dry cleaning
GSM	Pocket Attaching Strength	Pilling Resistance
Stitch Density	Tear Strength	Abrasion ResistancePile Retention
Cover Factor	Bursting Strength (Only for knitted fabric/garment)	Stretch and Recovery (All Stretch Woven Fabrics containing spandex) Spirality/Torque
Wicking Test	Fasteners fatigue and zip quality test	Color fastness to washing, dry cleaning, rubbing, perspiration, water, light, phenolic yellowing, and ozone.
Free formaldehyde	Button Pull Test	DP Rating
Oil/ Water Repellency, Soil Release, Rain Test		Stoll Flex Abrasion
Antibacterial Activity assessment		Whiteness Index(For White Fabric)
Burn Test (100% cotton garment)		Size fitting test
Mold contamination prevention		Care Labelling
Metal Contamination prevention		Needle damage Check (Knitted Fabric)
Ventilation Test		Adhesive check (logos, printings, markings fastness), Barcode Scanning Test

3.0 Test Methods

A number of test methods are available from country to country. Internationally, most organizations prefer the following testing and analysis standard methods:

- American Association of Textile Chemists and Colorists (AATCC)
- American Society for Testing and Materials (ASTM)
- International Organization for Standardization (ISO)
- British and Indian Standards (BS&IS)

Some of the most common and important parameters in the apparel industry are discussed below.

3.1 Grams per Square Meter- GSM

One of the most important parameters is the GSM of the fabric which indicates the weight of the fabric in gm/square meter. This parameter helps to easily understand which fabric is heavier and which is lighter. It is a way of comparing two fabrics. GSM helps to decide processing conditions and also helps to ensure whether the fabric will be able to take a particular force. While dyeing a fabric, it is the GSM that is taken into account to decide how much dye is to be used and what should be the processing conditions. For calculating, GSM one has to cut the fabric with the help of a GSM cutter and take the weight of the cut sample in electronic balance. Then the weight of the cut sample is multiplied by 100. This value is the GSM of the particular fabric. At least 5 readings should be taken for an accurate result. ASTM D 3776 [1] test method can be used for GSM. Tolerance limit should be within +/-5 % as per customer requirements.

Fig. 1. Weighing balance and GSM cutter

3.2 Fibre Content/ blend composition

The performance and price of fabric depend highly on the blend composition and fibre content of the fabric. It is one of the most important properties which will decide the feel, performance, comfort, etc. The apparel industry performs various tests to identify fibre types and content such as solubility, burning tests, and microscopy. Most natural fibres can be easily identified by the microscopy method and can be distinguished from synthetic fibres. The morphology of every natural fibre is unique. Thus cotton can be easily distinguished from wool and wool can be easily distinguished from coir and linen etc. Most synthetic fibres are circular and smooth surface finish. Acrylic would be either circular, oval, or kidney bean-shaped cross-sections. Thus, microscopical identification is a very reliable method. It gives an accurate result as this method denotes the cross-sectional and longitudinal view of the fibers.

Burning test fiber is another way of identification of fibres by the odour, residue, or how the fiber approaches the flame, burning slowly or rapidly, bead formation on heating, melting or not melting, etc.

Solubility is another easy way to identify fibre materials. Cellulose does not dissolve in most solvents. Cotton dissolves in cuprammonium solution while acrylic fibre dissolves in Dimethyl formamide (DMF) and polyester dissolves in Phenol/TCE (60:40) mixture while nylon dissolves in formic acid. By selecting suitable solvents, fibers can be easily distinguished from each other. AATCC 20/20A test method is mainly used for fibre identification. For single fibre tolerance is null and for blended fibre it should be within +/- 3% as per customer requirement.

3.3 Count

In the textile industry, the count is used to identify the yarn thickness or if the fibre is thin(fine) or thick(coarse). Higher yarn count indicates finer yarn. The finer yarn creates highly dense fabric and coarser yarn produce less dense fabric. It is measured by counting the number of threads present in one square inch or one square centimeter of fabric including both the direction of Warp and Weft. ASTM D 1059 [2] is used as a test method. The tolerance limit should be +/-5 % as per customer requirements.

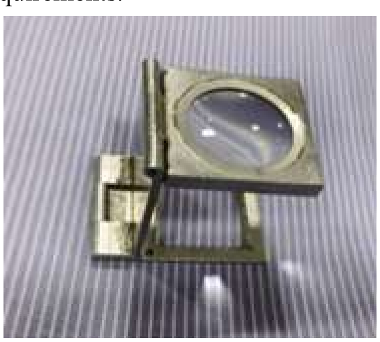

Fig. 2. Pick Glass

3.4 Construction (Ends/Inch& Picks /Inch)

It indicates the thread density of fabric and gives an idea about the compactness of the fabric. For denser fabric, ends per inch (epi) or warp thread density and picks per inch (ppi) or weft thread density should be denser and vice-versa. Generally, ends/inch is higher than picks per inch because weaving cost will be increased if we keep a higher ppi, and width-wise shrinkage is also maintained by maintaining the high epi/ppi ratio to strengthen the fabric. The epi/ppi is measured by the following method.

After marking a 1x1 inch square on the fabric, the warp and weft directions are marked if they are known. Then the number of ends and picks is counted by the pick glass with the help of a needle or pin. For finding epi and ppi, the ASTM D 3775 [3] method is used. The tolerance limit should be +/-3 % as per customer requirements.

3.5 Button pull test

The button Pull test is mandatory for any type of garment product which uses a button. It is used to determine the pulling strength of any type of button and snap used in garments. It is also used to determine the holding or breaking strength of the prong ring attached to snap fasteners onto garments to help button fix the garments properly. For this test, one needs to follow the buyer's requirement of pulling strength. Usually, the buttons subjected to testing are expected to withstand a minimum pull force of 7.72 kg and stay intact without unfastening, breakage, or damage for 10 seconds. Buttons used in child wear are expected to withstand a minimum pull of 90N, while button products designed for adult clothing should withstand a minimum pull of 70N.

3.6 Dimensional Stability and Appearance (After wash and dry clean)

One of the most important properties of garments is Dimensional stability. The significance of dimensional stability is that this property will decide whether a fabric would change its dimension after several processing. For example, one should identify whether the garment shrinks after washing or after dry-cleaning when subjected to standard detergent or solvent in a particular wash cycle, temperature, and time. In an ideal case, the fabric dimension should not change after washing or other processing.

For checking appearance always 2 garments are required. After washing or dry-cleaning washed garment should be compared under the colour matching cabinet in the different light source (Mainly D65) with the original or unwashed garment and check if any changes are happening in terms of puckering, shade change, creasing, etc.

Fig. 3. Dry cleaning machine and washing machine

AATCC 135/150/158 [4] methods are used for all woven fabrics or garments to measure dimensional stability. To obtain wearable condition tolerance limit should be +1/-3 %.

3.7 Tensile Strength

For textiles and apparel, Tensile Strength (TS) is the most important property which decides the longevity of the material. Both quality and performance depend on TS. When a fabric is under a tensile force, it first elongates and after a certain force, it breaks. TS is the maximum force a fabric can withstand before it breaks apart. Material can withstand the maximum amount of braking force. The manufacturer decides how much strength is needed for a fabric or garment depending on the end use. Fabrics used for household applications require only adequate strength to withstand handling at the time of production and use. However, fabrics for industrial applications have to be stronger. The base material and its tensile strength are chosen depending on the end use. Generally, the ASTM D 5034 [5] test method is used for breaking strength. This method is used for woven, nonwoven, and felted fabrics.

The below table shows the minimum breaking strength against GSM

GSM	Minimum Value(Kg) Warp x Weft
<90	10.5x9.5
91-130	11x10
131-180	15x12.5
181-240	18x18
>240	22x19

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Fig. 5. Tensile Strength and Seam Slippage Tester

3.8 Tear Strength

Tear strength is the force required to continue tearing a fabric either in the warp or in the weft direction. It is the resistance of the fabric against tearing. When a cloth gets hooked by a sharp object, the instant tiny puncher is turned into a lengthy rip. Tearing strength is important in the industry where the fabrics are under some stress and the value would determine how well a cloth can survive tearing or cutting when under stress.

The tear strength is a very important property for textiles, industrial wear, military uniforms, tents, apparel, sacks, and jackets. If the tear strength is high, means punctures in the fabrics do not propagate easily. Rip-stop fabrics are made to resist tears after a particular point.

Fig. 6. Elmendorf Tear Tester

The Elmendorf test testing machine uses a falling pendulum to tear a fabric specimen. ASTM D1424 Elmendorf-based tear test is the most popular test for measuring the tearing strength of most fabrics. It measures the amount of energy required to perform the tearing operation by measuring the peak follow-through angle of the pendulum after the tearing action. The lower the follow-through angle the more energy has been transferred into tearing the specimen.

The below table shows the minimum Tear strength against GSM.

GSM	Minimum Value(g) Warp x Weft
<90	650x650
91-130	700x700
131-180	1200x1200
181-240	1300x1200
>240	1400x1200

3.9 Seam Slippage/Strength

Seam strength refers to the strength when the seam finally ruptures or when the fabric breaks. While seaming slippage measures the unacceptable opening in the seam. Seam slippage occurs if the fabric is with a low stitch count, insufficient tension on threads, or improper stitch and seam selection. Seam slippage is weft yarns slipping over warp, or warp yarns over the weft; when the seam is subjected to a given load, its value depends on the fabric construction and finishing applied. Seam slippage causes partial or full distortion of the garment's appearance, but also reduces the usage life of the garment. Seam strength is a comparison between an unseamed test piece of fabric and the seamed fabric specimen. The specimens are subjected to tension and pulled apart till break. The woven textile is said to have 100% seam efficiency if the unseamed portion fails before the seam. If the seam fails at say, half the breaking strength of the regular test piece, the seam efficiency is said to be 50%.

ASTM D1683 covers a test for measuring the seam strength of a woven fabric.

Below table shows the minimum seam strength against GSM

GSM	Minimum Value(Kg)
<90	6x6
91-130	7x7
131-180	9x10
181-240	10.5x11.5
>240	12x13

3.10 Spirality

Spirality or twisting in a garment is appeared after washing (Generally after 3 or 5 washes). It can also be termed as fabric skew or fabric torque. Spirality is the problem that occurs when the wale is not perpendicular to the course direction. As a result one of the side seams comes at front of the garment when the wearer wears it. As the yarn is bent to form a loop, the outer part extends and the inner part compresses. This is the behaviour that results in a change in the geometry of spirals within the yarn, which ultimately results in making it unstable. The spirality percentage depends on fabric torque and garment structure. Percentage spirality is considered the sum of the net spirality caused by the yarn torque and the additional spirality caused by all other factors. Spirality is a serious problem in quality. There are certain standards and quality parameters for checking spirality. Three types of methods are there for spirality measurement. These are Diagonal Marking, Inverted T Marking, and Mock Garment Marking. AATCC 179 [6] test method is used for measuring spirality. It should be within 5 %.

3.11 Bursting Strength

The bursting strength of a fabric is the force required to break the fabric when the force or pressure is vertically applied to the fabric. In apparel, busting strength is normally performed for garments. In the case of a knitted garment equivalent stress is applied from all directions to rupture the fabric. In Diaphragm bursting strength, the sample is covered over the diaphragm by an annular clamping ring. The hydraulic pressure is created by using glycerine as the medium. The glycerine will keep exerting pressure until the sample ruptures.

ASTM D1424 is used as a test method. Min 60 Psi is required for accepting the fabric.

Fig. 7. Bursting Strength Tester

3.12 Pilling Resistance

Small balls of fibres protruding from the fabric due to surface aberration are called pills. Pilling is a fabric surface fault where little 'pills' of entangled fibre cling to the cloth surface and giving the garment an unpleasant appearance. If the fibres are weak, the pills break away from fabric and fall and if the fibres are strong the pills remain. Mostly fabrics made of synthetic fibres such as polyester form more pills and don't break and fall. The pills are formed during wear and washing by the entanglement of loose fibres which protrude from the fabric surface.

Generally, the ICI Piling method is used for pilling evaluation. At first fabric tubes are made and mounted on rubber tubes. In a cork-lined box, these tube samples are tumbled together. The usual number of revolutions used in the test is 18000 which takes 5 hours. Some specimens are required to run for different numbers of revolutions as per customer requirements. After completion of the required revolution, the specimens are removed from the tubes and viewed using oblique lighting to throw the pills into relief. Then the samples are given ratings between 1-5 grades with the help of photographs.

ISO 12945 -1 is used for ICI pilling test method and at 18000revolution 3.5 grade should be required for accepting the fabric.

Fig. 8. ICI Pill Box Tester

3.13 Martindale Abrasion Resistance

Abrasion resistance is the ability of a textile material to resist surface wear caused by flat rubbing contact with another material. It is the ability of a fabric to withstand surface wear due to flat rubbing contact with another material. The durability of textiles and clothing is greatly influenced by their abrasion resistance properties. In the abrasion test, a controlled amount of abrasion is given between fabric surfaces. Circular specimens are abraded under known pressure(Either 12 Kpa or 9 Kpa). Differences in appearance between an abraded and unabraded specimen should be assessed by visual appearance after completion of the test. The number of cycles required to produce a hole or broken threads should be noted and also measure the weight loss of the fabric after abrasion. ASTM D 4966 Part.1 test method is used for the abrasion test. Generally, for trouser, blazer, and suit this test is used to perform. If GSM is less than 150, there should be no thread breakage up to 10000 cycles and in case of greater than 150 GSM, it should be up to 15000 cycles to meet wearing needs.

Fig. 9. Martindale Abrasion Tester

3.14 DP Rating

Durable Press (DP) rating gives an idea of the smoothness appearance of fabric, seams, and pressed-increases in garments and other textile products after being subjected to home laundering procedures after general 1st and 5thwash. Washed fabric should be visually compared with different rating replicas.AATCC124/143 methods are used for this test. Generally, the customer acceptance rating is 3.5 after 1st wash and 3.0 after 5th wash.

3.15 Colour Fastness

Colour fastness is the resistance of colour to fade. It is a very important property of dyed fabric or apparel. Colour of dyed fabric is prone to fade when it is subjected to light, water, heat, perspiration, etc. The fastness value gives an idea of after how many washes the fabric retains the required colour intensity or after how much exposure it retains its colour to the required level. It is the property to withstand colour reduction from the surface of textile materials while undergoing different processes and treatments.

There are different types of colour fastness tests such as colour fastness to washing, fastness to dry cleaning, rubbing, perspiration, light, ozone, etc. Important tests are discussed below:

3.15.1 Colour fastness to washing

This measures the colour intensity (as per the gray scale) after subjecting the fabric to a standard soap solution. The rating is from 1-5. Test specimens are attached with a multifibre swatch and stainless-steel balls are loaded into stainless-steel containers to give abrasion to the fabric. The container is then loaded into the machine and the test starts at a fixed temperature and time. After completion of the test, the specimens are dried, conditioned, and evaluated with both grey scales (Colour change and staining). The AATCC 61,2A test method is generally used.

Change in colour (CC):4, Change in Shade (CS):4, Self Staining(SS):4-5 are the grades generally required to meet wearing needs

Fig. 10. Washing Fastness and Dry Cleaning Fastness Tester

3.15.2 Colour fastness to dry-cleaning

This test also is performed in garments as most garments undergo dry cleaning during usage. It gives the fading resistance of a fabric to dry-cleaning. A specimen of the textile is agitated in perchloroethylene for a fixed temperature and time in contact with steel discs of specified quality to simulate the situation in a dry-cleaning machine. The sample is then squeezed or centrifuged and dried in air. Any change in colour of the specimen and coloration of the solvent is then assessed with the standard Grayscale (Grade 1-5).AATCC 132, test method is used for colour fastness to dry cleaning. A colour loss of 4 on the gray scale is acceptable.

3.15.3 Colour fastness to rubbing

Rubbing fastness means a change in colour of dyed textile/apparel after rubbing. Both dry rubbing and wet rubbing fastness are measured in garments. In this test, a crock meter is used to test the specimen. In both cases, the rubbing fastness refers to the situation of fading and staining of dyed fabric when rubbed with a standard white cloth. Crockmeter rubs a finger, covered with cotton rubbing cloth, 10 times to and fro over the sample under test at a fixed pressure. The staining of the two cotton rubbing cloths is assessed using the grey scale for staining. Rubbing fastness test conducted as per AATCC 8 method. Dry/Wet:3/2 grade is usually required to meet wearing needs.

Fig. 11. Rubbing Fastness Tester

3.15.4 Colour fastness to perspiration

Textile materials are in close contact with the skin for a long time and come into contact with the sweat secreted by the skin. This may lead to the transfer of dyes to the skin. So it is important that the dyes do not get extracted with sweat and absorbed in the body. Thus colour fastness to perspiration is a very important test of clothing products. This test method evaluates the colour fading of dyed fabrics to the action of acidic and alkaline perspiration. Acid and alkaline perspiration solutions are treated with two dyed textile specimens differently in contact with multifibre to simulate the perspiration condition which is then subjected to a fixed mechanical pressure and allowed to dry slowly at an elevated temperature. After conditioning, the specimens are evaluated for colour change and colour transfer. AATCC 15 is used as the standard test method. Change in color(CC):3, Change in Shade(CS):3-4, Self Staining(SS):4 These grades generally require to meet wearing needs.

Fig. 12. Screen and acrylic plates for perspiration fastness

3.15.5 Colour fastness to light

Colour fastness to the light of a fabric is the ability to withstand fading when the specimen is exposed to light. In the laboratory, the artificial light is generated by a Xenon arc lamp. The test sample together with a series of eight blue wool standard fabrics is simultaneously exposed to intense artificial light for a certain time of about 24 hours to 72 hours or by customer/buyer demand and compare the change with the original unexposed sample the changes are assessed by Blue Scales. The tests are performed under controlled atmospheric conditions of humidity and temperature. This is one of the most important properties of any fabric used in all wears as fashion or general textiles are always exposed to sunlight. The light fastness rating system is based on the rate of fading of eight blue-dyed wool samples which are rated from 1 (poor) to 8 (excellent). AATCC 16 E (20 AFU) test method can be used for light fastness testing.

Fig. 13. Light Fastness Tester

3.15.6 Colour fastness to ozone

Textile materials while used outdoors get exposed to ozone also along with oxygen and sunlight. This test is used to determine the resistance of colour on textile material to the action of ozone contamination present in the atmosphere. This test is mainly applied on the textile materials which has been dyed with indigo dyes and bleached materials treated with optical brightener. The test is conducted at room temperatures with relative humidities not exceeding 67%. The test sample and the reference sample are exposed in a chamber generating ozone at a specified concentration(ppm) of ozone level with a specified atmosphere to obtain a definite colour change. Depending on the sample cycle should be decided. Usually, denim samples are exposed for 2 cycles, and white fabric is for 1 cycle. Generally, AATCC 109 test method is used for testing. Immediately after the test evaluation should be done with the help of a grey scale.

Fig. 14. Ozone Fastness Tester

Colour fastnesses to phenolic yellowing, Colour fastness to water, etc are also carried out as per customer requirement.

3.16 Free formaldehyde

Free formaldehyde is the uncombined monomeric formaldehyde that exists in a finishing or a textile material. Agencies have classified formaldehyde as hazardous and Acute Toxicity 3. It is carcinogenic and corrosive to skin with irritation. The formaldehyde test method applies to textile fabrics that involve formaldehyde, particularly fabrics finished with chemicals containing formaldehyde. Formaldehyde emission is strictly prohibited due to its harmful nature to human health. If the fabric contains formaldehyde then it can be dangerous to the skin. It is the buyer's one of the important tests which must be passed. This measurement is to determine the level of Formaldehyde present in the fabric or product which will indicate the 'risk' in handling the product. EN ISO 14184 / 1 is generally used as a test method.

3.17 Wicking property

The wicking behaviour of fabrics is a very important property that greatly influences the comfort of textile materials. It also influences dyeability, filterability, finishing, etc. Wicking property happens due to capillary phenomenon and is the ability of water or any other liquid to penetrate the fine pores of fibres due to liquid to fibre surface interaction. In the case of garments, it is the water wicking that is most important as comfort is the major objective. As wicking is a surface to water interaction behaviour, it is greatly influenced by surface morphology, fibre composition of the yarn, and chemical composition of the materials with which the fibres are made off. Thus the wicking behaviour of cotton is completely different from that of polyester.

During hot summer days, the body produces excessive sweat which gives discomfort to the person wearing any garment. The water droplets produced due to sweat have to be immediately removed for better comfort. Wicking of garments is the property that makes sure how the water droplets are removed from the skin to the fabric and then to the atmosphere keeping the body dry and cool.

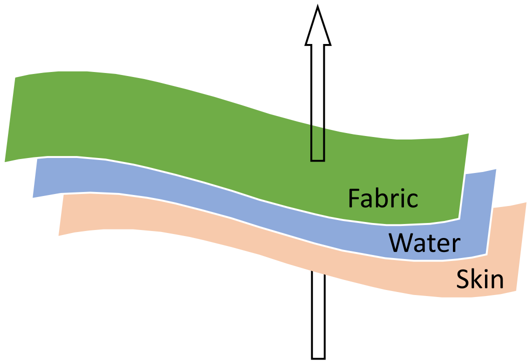

Fig. 15. Wicking mechanism of perspiration through fabrics

AATCC197 (Vertical Wicking Rate of Textiles) is used for checking the wicking property of textiles (Woven, Knitted, and Non woven Fabrics). This test should be done mainly for moisture-absorbent fabrics. Wicking Rate should be 8cm after 10 minutes. This grades generally require to meet wearing needs. The test should be done with the original and after the 5th wash.

3.18 Moisture Management

The controlled movement of perspiration from the skin surface to the environment through the fabric is referred to as Moisture management. It is an important factor that provides comfort to the user and maximizes performance. As wicking refers mostly transport of liquid water, moisture management is the transport of water in the form of vapour from the skin to the atmosphere which regulates the body temperature and maintains heat balance thus controlling the comfort level of environmental conditions and activity. Thus moisture management is essentially a combination of wicking, absorption, and vaporization of sweat.

Cotton has a natural way of moisture management. Polyester microfibers with surface modification, fibres with special grooves, and many such modifications are proposed to improve moisture management. Finer fibres give better moisture management properties. Cotton has an inherent attraction towards moisture due to its cellulosic structure having hydroxyl groups that can form hydrogen bonds with water vapour. This helps in better moisture management. The Moisture Management Tester (MMT) measures, evaluates, and classifies liquid management properties of fabrics per AATCC Test Method 195.

In the apparel industry, some tests like care labeling, colour shading, size fitting test, fatigues and zip quality test, adhesive check, down feather leakage testing, needle damage check, barcode scanning test, burn test, mold-contamination prevention, metal-contamination prevention, ventilation test are sometimes done as per customers requirement.

Some special types of testing are also done as per the needs of the customer.

3.19 Oil Repellency:

Oil repellency is very relevant in industrial fabrics used in the oil industry and work wear involving oily matters. It is required in industries where workers are frequently prone to oily matters, such as the petrochemical industry. Due to low surface tension, oil keeps spreading over surfaces quickly, instead forming into droplets the way water does. Oil spread is very difficult to clean and oil repellency on textiles is so very important. This test method detects resistance to wetting of a surface of the fabric by a selected series of liquid hydrocarbons of different surface tensions. Drops of standard test liquids consisting of selected series of hydrocarbons with different surface tensions are placed on the fabric surface and the wetting and wicking characteristics and contact angle are observed. The oil repellency grade is the highest-numbered test liquid that does not wet the fabric surface. AATCC 118 method is used for oil repellency testing. The original garment is generally compared for oil repellency with the 5th washed and 20th washed garments. Higher the oil repellency grade, the better resistance to staining by oily materials, especially liquid oil substances.

3.20 Water Repellency

Water repellency is the property of a textile material to resist wetting by water or resistance of water to penetrate through the fabric. It depends mostly on the type of fabric construction, the base material composition, and the kind of water-repellent coating applied to the fabric. The effectiveness of the surface layer will determine how efficient the water-repellent fabric, be it an umbrella fabric, outwear, raincoat, or tent and tarp, is in keeping the user dry.

AATCC 22: Water Repellency: Spray Test and AATCC 42: Water Resistance: Impact Penetration are the two main tests carried out for Water Repellency. Under controlled conditions, water sprayed against the taut surface of a test specimen produces a wetted pattern, whose size depends on the relative repellency of the fabric. Evaluation is accomplished by comparing the wetted pattern with pictures on a standard chart. Water repellency should be compared for the original garment with the 5th washed and 20th washed garment.

3.21 Stretch and Recovery

One of the key consumer requirements in the fashion garment industry is stretch. Elastomeric fibres such as spandex are blended with cotton or polyester to bring this quality to the fabric. Depending on the garments, the extent of elasticity varies. Skinny tight fit garments require super stretch or power stretch and casual garments require medium to low stretch. Stretchable fabrics are widely used in undergarments, casual wear, tights and jeans, performance wear, sports, and swimwear. The right quality of stretch needs to be quantified and assessed to make sure the quality of stretch and recovery. Differences in the level of stretch growth and level of recovery are very important for fabric functionality and performance.

ASTM D 3107 is used for measuring stretch and recovery for all woven fabrics containing spandex. Stretch should be >15%, Growth should be a maximum 5%and recovery should be a minimum of 85%. These grades generally require to meet wearing needs. For knitted garments, ASTM D 2594 method is used to measure stretch and recovery.

Antibacterial Activity Assessment (AATCC 100), Rain Test (IS 392), Whiteness Index (AATCC 110), Pile Retention (AATCC 4685 opt.B),Colour Fastness to Phenolic Yellowing (ISO 105 X18), Soil Release: Oil Stain Release Method (AATCC 130), Stoll Flex Abrasion (ASTM D 3885), etc tests can also be carried out for garment as per customer's requirement.

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Fabric Inspection in Folding: Current Scenario in India

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Abstract

Over the years, our fabric manufacturers have geared up their manufacturing process to meet global export as well as domestic quality standards. To meet the required quality standards, various quality control parameters have been followed at various stages of manufacturing right from raw material selection, in-process quality control, on-machine inspection, etc. Even after controlling those quality control parameters, there are chances of the appearance of defects in the fabric which decided the quality of the final products. Therefore fabric inspection, the last major quality control activity before reaching the customer, is the most important process of the manufacturing supply chain. Considering this, various assessments and observations related to the inspection system at the final inspection stage i.e. at folding, have been done during our various inspection assignments as well as training program conducted for various mills/fabric suppliers. This paper is focussed on the various aspect of the fabric inspection system followed in the Indian textile industry i.e. inspection set-up, its functioning, and maintenance, the methodology followed during the inspection, quality of Inspection &skill of fabric checkers, etc. Views about similarities and dissimilarities in inspection systems observed at various inspection places are also given in the articles. In general, the overall functioning of the fabric inspection system at various inspection places in India is elaborated on in this article.

Key words:

Inspection, 4-point inspection system, Comparison; Quality Standards, Inspection Criteria

Citation

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1.0 Introduction

The textile and apparel industry which was once the backbone of developed countries has lost its base due to cost economic structure and has shifted to many developing countries such as India, Bangladesh, Sri Lanka, etc. The textile and apparel industry is one of the leading segments of our economy and the largest source of foreign currency earnings and employment for our country. Over the years, our fabric manufacturers have geared up their manufacturing process to meet global export as well as domestic quality standards. Our they are now in a position to supply various types of fabric as per required quality standards at market competitive rates.

To meet the required quality standards as per buyer's requirements, various quality control parameters are being followed at various stages of manufacturing right from raw material selection and its quality parameters confirmation, in-process quality checks, on-machine inspection, etc. However, even after controlling the above aspects, there are chances of the appearance of various defects in the fabric on which its selling and acceptance criteria are dependent. Therefore fabric inspection, the last major quality control activity before reaching the customer, is one of the most final important activities in the fabric manufacturing supply chain. It is also well-known that on average, around 40% to 60% of garment defects are associated with fabric defects, and this truly highlights the importance of assessing the quality of fabric. A proper fabric inspection can do just this and can ensure the quality of key materials from the beginning as far as apparel manufacturing is concerned. Considering this aspect, most of the fabric manufacturing units are carrying out fabric inspections at greige or finished stages. Over the last 25 years, BTRA is carrying out fabric inspection activities for third parties at various locations in India as well as conducting many training and awareness programs related to fabric inspections. Due to the above activities, we come across various similarities, differences, and limitations in the inspection system carried out by the various manufacturing units. Although a 4-point inspection system is being followed by most of the unit, the interpretation of various checking/inspection points of the same system are found to vary from unit to unit as well as among the persons within the same units. Some of these points are elaborated in this article.

1.1 Importance of fabric inspection

As mentioned above, a proper fabric inspection can minimise the rejection % of the final product i.e. apparel or made-up but there are other reasons which are crucial element for any factory. Whether it is a reduction in productivity or an increase in overheads, processors or

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garment manufacturers can face production challenges from defective fabric such as:

- Inconsistencies in the cuttable width will impact their fabric consumption/realisation.
- Different colour shades among rolls or within the same roll impact product quality and requires special management during the cutting/sewing/packing and other production steps to segregate by colour shades.
- High defect rates in the fabric will impact the consumption per garment and increase the risk of defects found in the garment.

2. Inspection system used in fabric inspection

There are several grading systems adopted for fabric inspection all over the world such as Graniteville "78" system, Dallas system, 4-point system, 10-point system, etc. Among all, the 4-point system has become the most commonly adopted system in the world as well as in India due to its practical, impartial, and worldwide recognition. The 4-point system works on a penalty point basis and as its name has probably suggested, points are given from 1 to 4 depending upon the length and in a few cases, the severity of the defect. In most cases, the activities of inspection, as well as mending of small to medium-type defects, are being carried out by a checker whereas another mending person carried out major or repeated type of defects which are normally tagged/flagged by the 1st checker. In these cases, a major trend has been found related to either thorough inspection of fabric at recommended speed(up to 15 meters per minute) or inspection at abnormally high speed. In the case of inspection and mending by same checker, there are chances of loss of concentration due to frequent mending work and chances of ineffective inspection work due to inspection at abnormally higher speed and production target constraints. the inspection departments/persons are found to be balancing the above activities as far as production/dispatched target and the defect-free product is concerned. As mentioned above, the checkers were found to be performing the inspection at an abnormally high speed to achieve the daily inspection target leading to more chances of non-detection of smaller defects (mainly 1 to 2-point defects). In the above cases, effective supervision and frequent cross-checking of inspected fabric are very much essential to supply defect-free fabric within the targeted schedule time. Regular third-party inspection assessment is another solution to cross-check the proper functioning of inspection and mending related activities. BTRA is regularly carrying out such inspections for two prominent mills in India. In this activity, BTRA shop-floor technologists from the weaving and process field is carrying out the inspection work at regular intervals and give details assessments of inspection as well as co-related fabric manufacturing / processing aspects.

In most cases, the fabric is found to be inspected and graded on one side only. However, as per certain end uses or buyer requirements, it may be inspected and graded on both sides. As per our observations, 95 to 98% of fabric qualities are inspected on one side of the fabric only. There is no fixed trend observed as far as inspection carried out through the front light or back light source.

At most of the composite manufacturing units, inspection is found to be done at greige as well as finished folding stages (post chemical processing). While the result of the inspection done at finished folding/packing is more useful to the buyers in terms of fabric quality as well as the back process for controlling the quality, the result of the inspection done at greige folding is more useful to controlling the yarn and fabric defects at spinning and weaving.

3. Fabric Inspection Set-up

Presently, inspection in India is carried out through 3 major means i.e. on the slanted table, horizontal table, and inspection machine having illuminated glass either from top-front or backlight. Among these, the majority of the inspections are carried out on inspection glass machines (70 to 80%) due to their suitability for a faster, more convenient, and more effective inspection process. Therefore, in this article, more emphasis will be given to the process carried out on fabric inspection machines.

Normally, at small manufacturing/fabric supply units, inspection is carried out on Horizontal or Slanting Inspection tables illuminated from the top and bottom. This is a very simple low-cost entry-level arrangment on which a fabric inspector pulls the fabric over the lighted inspection table and the defects are located, marked, and recorded in the inspection form manually. For the easy flow of fabric, a top fabric guide roll is provided, with an option of adding an edge guide and a meter counter. In another case, inspection is carried out on a horizontal table surface. This is also a low-cost alternative as compared to fabric inspection machines and is more affordable to a small fabric manufacturer. This system is more convenient for the inspection of wider-width fabric if there is a fabric width-related limitation on an already installed inspection machine. However, due to less inspection speed along with the employment of two persons per table for carrying out the inspection, the inspection cost is found to be higher. In most of the manufacturing/inspection places in India, the inspection is carried out on mechanical/semi-automatic fabric Inspection machines which are power-driven with variable frequency drive motors for precise speed control and proximity sensors to control the uniformity of edges, with an auto-stop option. The machine speed can be controlled precisely as per requirement in relation to required quality of inspection and inspection rate. Some models have provisions to inspect delicate fabrics at zero tension to avoid damage to the structure of the fabric. Some of these machines are fitted with electronic wheel-type encoder to measure the length of the inspected fabric as well as monitor the width of the fabric. While the length measurement helps define the number and length of lays, even the width of the fabric during rolling maximizes fabric utilization. All these factors help in achieving better and faster inspection. Nowadays, few fabric manufacturing units are either installed or in the process of installing software add-ons for defect documentation on the machines for documenting, analysis, and decision-making about the defect pattern. This 'fabric inspection defect analysis software' (DEFECT MAPPING SYSTEM) is available in the market and can be installed on any fabric inspection machine of any brand and make. It is used for recording point for defect or any other related entry through a touch screen monitor while inspecting the fabric thereby avoiding the time-consuming work of writing the fabric details and recording the defects in the checklist. The person can concentrate more on inspection work. This digital system performs automatic fabric gradation based on several defects, providing aid in choosing appropriate fabric roll with fewer defects and can be easily integrated with all the existing CAD and ERP software in the unit to obtain efficient marker and cutting plans. The software works on the 4-point system for fabric inspection as per ASTM standards, the most commonly used system for inspection.

The comparative study of inspection with and without the Defect Mapping System carried out by us indicates that inspection production can be increased by 10 to 20% depending upon no. of defects in the cloth roll (Refer Table 1). However, more than this, there is a marked improvement in the checker's concentration and quality of work due to less documentation work. Also, in the case of inspection with the Defect Mapping System, the quality of mending work was found to be more effective along with less skipping of defects to be documented where both inspection as well as mending work was being performed by the checker. The supervision, production control, and analysis work related to inspection will be greatly reduced as the Defect Mapping System will take care of the same. The reports generated through such a system are instrumental in planning the consecutive processes as well as maintaining a library of the defects that occurred for future reference.

Table 1: Comparative study of inspection with and without Defect Mapping System

No. of meters checked @avg. 15 meters per minute	No. of defects observed and documented for a given length	Total time is taken for inspection, without out Defect Mapping System(minutes)	Time is taken for inspection with Defect Mapping System (minutes)	% gain in inspection rate
300	24	23.7	20.2	17.4
320	15	24.0	21.5	11.6
282	28	23.0	19.0	21.4
314	12	23.3	21.1	10.3
			Avg.	**15.2**

For specific requirement, additional systems are available with the inspection machines which simplify the operator's work, achieve the good wounded quality of cloth rolls, removes suspended fluff/waste from the fabric surface before inspection, etc. These are End of Roll Sensor, Edge Control System, Tension Control System, and Air Blow System. So, depending upon the quality requirement and additional cost factor, some of the units are either already installed or planning to be installed the same .

As far as inspection quality is concerned in all the above cases, no significant difference is found considering the other standard condition maintained during inspection i.e. lightning arrangement, working comfort, etc., and mainly depends on the skill and expertise of the checker. Therefore, while setting-up inspection machine, manufactures of fabric consider various aspects for carrying out inspection at feasible cost and is depended on various parameters i.e. the scale of production, affordability, frequency or requirement of inspection, type of product w.r.t. buyers/market (export / domestic / brand / Institute buying, etc.).

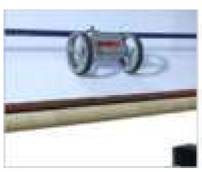
3.1 Observations and maintenance of inspection set-up at workplaces

During various training programs and inspection assignments, we observed various points related to inspection set-up which were affecting the inspection quality. It is also observed that maintenance of the inspection machines was the last or least priority subject as far as preventive maintenance of all productive machines is concerned. We found this aspect was affecting the inspection quality as well as targeted inspection production. A few of the observations are given below;

Lighting: Poor or insufficient lighting arrangement is one of the major issues we observed which affects the inspection work quality greatly. Normally inspection of fabric(front or back side) is illuminated from the front and/or backlight depending on the type of fabric and buyer's requirement. As per the requirement of sufficient lighting i.e. provision of backlighting (transmitted) light and the overhead direct lighting source to get a surface illumination level of a minimum of 1075 lux (100-foot candles), there were incidences of very poor lighting. We observed insufficient attention was given even after installing good quality machines. In most of these cases, a few backlights under the inspection glass were found to be not working resulting insufficient light at inspection position. As mentioned in detail in the following topic 4, there is a tendency to inspect the fabric at abnormally high speed. Therefore, there are always chances of non-detection of certain defects due to poor light arrangements, particularly at selvage side fabric and wider width fabric.

Quality of Inspection Glass: Quality of inspection glass i.e. white frosted glass was found to be satisfactory on most of the machines as far as the front surface of the glass. Except few incidences of stains on inspection glass, the condition of the same was found satisfactory at most places. Cleaning of glasses with a soft cloth (scratches should be avoided) at a regular interval (preferably once in 3 months) and complete overhauling including cleaning of the glass from the back side and checking of light sources under the inspection glass once in a year is recommended to keep the satisfactory condition of glass and working of Machine.

Maintenance of rollers, controls, and other mechanisms: Quality of inspection is inversely related to fabric running speed on glass. Incidences of inspection at much higher or improper speed due to faulty speed control knobs were observed on many machines resulting in poor quality of the inspection. Improper functioning of front/backlight sources, improper functioning of forward and reverse mechanism, threads/waste around the bearing/shafts of different rollers of inspection machine, improper functioning of fabric edge control mechanism, etc. were others major parameters found to be put extra stress/workload on the checker thereby affecting inspection quality and production. As mentioned above, regular preventive maintenance of all aspects related to the inspection machine is the only solution to achieve effective inspection at a higher production rate. in Speed control, roller cleanliness, edge control mechanism



Calibration of meter counter: On all mechanical / semi-automatic fabric Inspection machines, the fabric length measuring device is either mechanical or Electronic Encoder type with a measuring roller surface of metal knurling or rubber. In the case of metal knurling rollers, the chances of slippages are more leading to improper length measurement. Considering the number of fabric rolls inspected daily on the inspection machine, fractional variation in length measurement may lead to high uncounted fabric length losses to the supplier. Rollers with a rubber surface layer are more suitable to get an accurate reading as compared to knurled roller devices. However, over prolonged uses, the diameters of the roller will be reduced due to friction of the rubber surface leading to improper length measurement. Therefore it requires calibration at a fixed interval(preferably once a year) to ascertain accurate length measurement. In this matter, only a few companies are found to maintain the system of calibration through a third party.

Other Machine Aspects: Other machine aspects are aiding to improve checkers' performance in terms of inspection quality and production e.g. at some workplaces, sliding (attached with the machine) or movable type sitting arrangements for fabric checkers were found. Regarding the provision of this arrangement, different opinion was found among various shopfloor management. However, most of them are supportive of such a system since it relieves the fatigue of checking a person working continuously in a standing position.

As mentioned above, most of the units are planning to install the Software add-on 'DEFECT MAPPING SYSTEM' for defect documentation on the existing machines to be purchased. This is also helping to increase inspection production by 10 to 20% due to the ease of detection & documentation process.

Effective Material Handling within the folding department is another important factor and modern and medium to bigger size textile units are using various equipment i.e. trolleys, battery operated pallet trucks, hand pallets trucks, overhead cranes, etc. to ease the loading/unloading operation of cloth rolls. This helps in saving the inspection process time considerably.

4. Methodology of the 4-point inspection system followed in India

As mentioned above, fabric inspection is carried out as per a 4-point inspection system, according to ASTM D5430 – 13(2017) which is a standardized Test Method for Visually Inspecting and Grading fabric. Under the above standards, inspection is carried out as per certain major criteria's which are following:

- Assign no more than a total of 4 points to any one linear meter or yard of fabric, regardless of the number or size of the detected individual defects.
- Assign 4 points to each consecutive linear meter or yard in which a continuous running defect exceeds 230 millimeters or 9 inches.
- Assign 4 points to each linear meter or yard of the fabric where the useable width is less than the minimum specified.
- Assign 4 points to each seam or other full-width defect or seam if applicable.
- Defects not visible on the face of the fabric shall not be counted unless an agreement to the contrary has been made between the purchaser and the supplier.
- Each roll or bale shall be rejected if inspection and grading result in a total number of defect points exceeding the maximum acceptable level mutually agreed upon by the purchaser and supplier.
- The total shipment shall be rejected if the sample inspected exceeds the maximum acceptable defect level mutually agreed upon by the purchaser and supplier.

In most of the cases, inspection were found to be carried out as per above mentioned criteria. However, over the years, apart from the abovementioned clauses, several other inspection clauses have been added to the above standard method as per the requirements of buyers and a few of them now become a common part of the inspection method which is being followed by most of the units in India. Some of these points and their adaptability in the existing system are mentioned below in Table 2;

Table 2: Addition of other inspection clauses and their adaptability in the process

Inspection clauses	Adaptability / Trends observed at different workplaces
1) Severe defects are assigned a maximum of four points for each meter in which they occur. For example: regardless of size, the hole would be penalized four points.	This parameter is adapted by most of the units during the inspection. However, in some units, the fabric will reject in case of detection of a major defect e.g. hole, major crack, major float, and no 4 points will be assigned
2) A hole or torn is considered to be a major defect and shall be penalized four points	
3) Any running defect of more than 4 continuous yards or meters will cause the roll to be rejected.	This parameter is adapted by most of the units.
4) Continuing conditions such as barre, side center side shading, roll-to-roll shading, narrow or irregular width, creasing, and uneven finish shall be counted as four points for every meter within the roll that is found to contain these conditions.	Although known to most of the concerned persons, adaptability was found poor (Awareness or seriousness about such clause was found poor due to very a smaller number of fabric rejection incidences from buyers).
5) No roll that contains more than four full width defects per one hundred linear meters, shall be accepted as first quality.	This parameter is adapted by most of the units during the inspection.
6) No piece shall we accept as first quality with more than 3 full width majors per 100 linear yards.	This parameter is adapted by most of the units during the inspection.
7) No piece shall be accepted with 50% of the defects which are 1-point defect	Very few units have adapted this point. In most cases, points are not assigned to small defects (1 or 2 points related to defects). Not aware by many units.
8) Fabric width should be checked at three positions of the same roll during the inspection (beginning, middle, and end of a piece). Rolls having a measurement of less than the specified purchased width will not be accepted except by the term agreed by the buyer.	This parameter is known to many inspection persons (checkers, supervisors, etc). However, most of them were not performing during the inspection. It was also observed that measuring tape was not available with the checkers.
9) For woven fabric, rolls having a measurement of 1" wider than the specified purchased width will not be accepted. But for the stretched woven fabric, it can be accepted 2" wider than the specified purchased width unless an agreement to the contrary has been made between the purchaser and the supplier.	This parameter is adapted by most of the units during the inspection. But the acceptability criteria may vary as per the buyer's requirement.
10) No piece shall be accepted that contains a full width defect in the first and last three meters or yards	This parameter is either not aware by the inspection persons or if known, then the same is found to be not followed during the inspection mainly due to negligence or lack of attention during loading and restarting of the new fabric roll. This parameter is more suitable for fabric selling through retail sale i.e. suiting, shirting, dress material, furnishing fabric
11) Waviness, tightness, ripples, and puckering in the body of fabric which would prevent the fabric from lying flat when spread conventionally is not acceptable.	This parameter is known to many concerned persons (checkers, supervisors, HOD, etc). However, most of them are not checked for the mentioned defects during the inspection. (Awareness or seriousness about such clause was found poor due to very a smaller number of fabric rejection incidences from buyers)
12) No roll shall be accepted as a first quality that exhibits a noticeable degree of loss or tightness along either or both selvages, or ripples, puckers, folds, or creases in the body of the fabric that would prevent the fabric from lying flat when being spread conventionally.	
13) **Shade Matching:**	
· Rolls with side-to-side, side center side, or end-to-end shading must be no less than a 4 Grey Scale rating according to the AATCC Grey Scale. Four points shall be assigned to each yard of the inspected roll that contains this type of shading defect.	This parameter is adapted by most of the units mostly before packing. A strip of fabric is found to be cut from each inspected fabric and packed according to the group of matching shades.
· If the shade of the fabric being inspected does not match the provided approval sample, which must be no less than a 4-5 Grey Scale rating, the shipment will fail the inspection. No penalty points will be assigned to the rolls for the offside condition. The inspection of	This parameter is adapted by most of the units mostly before packing.

Inspection clauses	Adaptability / Trends observed at different workplaces
1) **Splices / TP:** For woven fabric, rolls can be composed of several spliced parts. No roll shall be accepted that contains a splice less than forty (40) yards in length unless otherwise stated in the purchasing agreement.	This parameter is adapted by most of the units. The final decision will be taken as per the buyer's requirements.
2) **Bowing & Skewing:** For both woven & knit fabric, no rolls shall be accepted as a first quality that exhibits bow or bias or more than 2% for print or stripe fabric & 3% for solid/single coloured fabric.	This parameter is adapted by most of the units during the inspection. But the acceptability criteria i.e. % bowing or skewing were found to vary among the unit. Also, in general, less understanding of the measurement of bowing % was observed.
3) **Fabric Odors:** No roll shall be accepted that exhibits objectionable odors.	This parameter is adapted by most of the units during the inspection.
4) **Hand / Feel:** The hand /feel will be checked between rolls and to a reference sample. If there is a noticeable difference, the roll will be classified as second quality, and 4 points assigned to every yard. If all rolls do not match the reference, the inspection will be put on hold and no points will be assigned.	This parameter is known to most of the concerned persons (checkers, supervisors, HOD, etc). However, most of them are not checked for the mentioned defects during the inspection. (Awareness about such a clause was found poor due to very a smaller number of fabric rejection incidences from buyers).
18) Following defects are cuttable and the fabric will be rejected: · Frequent kinks, knots, slub, contamination, spots, etc · Any continuous defect · More than one meter broken end, double end, wrong draw reed mark · Holes were torn and floated above ¼ “ · Irregular selvage, light weft bar, count variation, Lecco, shade variation · Heavy weft bar above 6: in length	These clauses are adapted by most of the units during the inspection. But rejection criteria were found to vary from unit to unit and mainly depend on the buyer’s acceptable terms & conditions. The buyer may specify the cuttable defects as per his selling/usage requirements.
19) Fabric lot will be rejected if the average points of the fabric lot will be higher than the acceptable points per fabric roll or bale and both are specified by the buyer **.**	Acceptable points per individual fabric roll or bale to be inspected are always higher than the average points calculated for that fabric lot. The final decision about dispatching the lot was found to be taken by Folding HOD / Management

From above Table 2, it can be seen that various clauses are being followed along with the specified clauses mentioned under ASTM D5430. The buyers/sellers are either found to be adapting certain clauses as per their requirements or not following certain points due to less awareness about those points.

Because of a lack of clarity and/or different interpretation about such clauses among the various user, there is a wide difference found about following certain common points. This is one of the major reasons for various dissimilarities observed among various units although they follow one common inspection system i.e. 4-point inspection system. A few dissimilarities are as follows

A) In some of the units, points have been assigned and recorded for 3 to 4 points related defects only whereas no penalty points are recorded or assigned for minor defects. In these cases, a significant difference will be found between the points recorded by checkers and the points noted by the third-party inspectors who may inspect the fabric on behalf of buyers. It has been seen that almost 2 to 3 times difference was observed and most of the time chances of rejection of fabric or lot based on the third-party inspection points will be more.

B) As mentioned above, chances of fabric rejection will be more due to the non-recording of minor defects, alongwith repetitive nature of certain defects e. g. although 1 point is assigned to a small slub, the frequent or repetitive occurrence of the same in the same fabric may lead to a higher number of points than the acceptable point per 100 linear meters resulting rejection of fabric.

C) Different opinions were observed about assigning the points to the certain severe/critical defects e.g. in some cases, hole irrespective of size, are assigned a maximum of four points for each meter in which they occur but the same is counted as a cuttable defect by others and the fabric will either cut at the defective portion to make it as TP or will reject.

D) In the case of bowing or skewing, the interpretation of the acceptability % was found to vary at a different unit. As stated above, we recommend 2% for print or stripe fabric & 3% for solid/single coloured fabric.

E) Regarding Clauses related to 'No piece shall be accepted that contains a full-width defect in the first and last three meters or yards', very less seriousness was observed among industry persons. This parameter is either not aware by the inspection persons or if known, then the same is found to be not followed during the inspection mainly due to negligence or lack of attention during loading and restarting of the new fabric roll.

F) Coding of defects: A system of mentioning the defect types in short letters(code) while recording the point in the checklist based on its dimensions observed at all workplaces. This gives a fair idea about the type of defect and its severity enabling controlling the same effect in the back process as well as during packing. So proper recording of the type of defect and its point is very much essential. The code of the different defects was found to be different from unit to unit. In this case, we are finalizing these codes so that common codes can be used in the industry.

G) As per clause 10.6.1 mentioned in ASTM D5430, no more than a total of 4 points can be given to any one linear meter or yard of fabric, regardless of the number or size of the detected individual defects. In this case, different opinion is found regarding the recording of the point e.g. if there are 4 defects of 1, 2, 1, 2 points appearing in the same plan(meter) of fabric, then different opinion are existed as follow;

1. Should record 4 points irrespective of a total of all points i.e. 6
2. Should record 2 points which is the point of major defect appearing on the same plan
3. Should mention all the points like 1,2,1,2 to get a clear understanding of the defect and consider 4 points while calculating points per 100 linear meters.

We found adopting option 1 at most of the inspection places. However, it gives a false impression of the major defect as 4 point is normally assigned to the major defect which is not the condition that appeared in the plan of fabric and there are chances of wrong interpretation by the back process. The selection of option 2 is also adapted at various inspection places. We normally recommended recording the points as per option 3, particularly in case of greige fabric inspection.

5. Quality of Inspection & Skill of Fabric Checkers:

We assessed the skill of the checking persons and their quality of inspection work at different workplaces. The following points are observed:

I) As far as inspection by experienced checkers is concerned, their skill of detecting defects were found satisfactory at most of the inspection places. However, apart from knowing about a few major inspection clauses e.g. decision-making about major and critical/cuttable defects, no. of 4-points defects allowed in 100 meters, maximum points no. of points per 100 meters, etc., the knowledge or more clarification about other inspection clauses needs to be acquired to carry out effective inspection work.

ii) At many places, the inspection was found to be carried out by checkers at a much higher speed (sometimes 30 to 40 meters. per minute) than the specified speed of up to 15 meters. per minute. Although the detection skill of the checkers was found to be satisfactory, there is a limitation to the human eye to detect very small defects (usually 1 to 2 points) on running fabric and the same can be detected at a speed lower than 15 meters per minute. Therefore, there is always a difference in the number of points noted by checkers at higher speeds and third-party inspectors who check the fabric at a specified speed.

iii) At most of the inspection places, inspection and mending of medium to small defects is being carried out by checker only. Various accessories are found to be used during the mending of defects e.g. small metal comb, needle, U-shaped scissor, etc. The quality of mending work of experienced persons was found satisfactory at most of the inspection places. In the case of achieving the required inspection skill for a new person, approximately 2 to 3 months of inspection work practice along with proper training is required whereas 6 to 8 months of mending work under an experienced mender are required to achieve the required mending skill. We found incidences of improper mending work even in the case of fabric mended by an experienced person, particularly incidences of comb marks where a metal comb is used for correcting the affected area after mending the defect. In these cases, checker-cum-mender is usually either skipped to record the points as per defective part (comb mark as mentioned above) or doesn't give the point at all thinking he has corrected the defect.

At some places, a few of the above-mentioned accessories particularly metal comb are not allowed due to the creation of another defect like a comb mark. In such cases, checker-cum-mender faces difficulties in rearranging the threads at the affected area. In this case, there are chances of appearing this affected area as a major defect e.g. after removing the big slub or knot in the fabric, hole like appearance will be created which is a 4-point defect and the same can not be corrected due to non-availability of proper tools e.g. comb. In these cases also, the checker-cum-mender doesn't record the point for such a defective portion created after mending work leading to the improper recording of the defect.

iv) The most important factor of any pointwise fabric defect detection system is the points assigned w.r.t. dimension of the defect, mainly its length. In the case of the 4-point inspection system, the following points are assigned as per the length of defects;

Up to 3"	–	1 Point
> 3" to ≤ 6"	–	2 Point
> 6" to ≤ 9"	–	3 Point
> 9" and above	–	4 Point

Our assessment during the training program revealed that almost 90 to 95% of persons related to the inspection category are wrongly interpreted the length of the defect i.e. their understanding of the length of the defect found to be improper e.g. as per checker's understanding of 1 point defect based on his visualisation of defect might have an actual length of more than 5". In the same manner, there are chances of recording 2 points for the defect which may be more than 6" dimension. This mainly happened due to a lack of understanding about the length aspect. Our unique explanation and practical method during the training program will make the inspection persons thorough in understanding the above aspect.

All the abovementioned points lead to the improper recording of defect points as compared to third-party inspection.

In the case of fabric inspection, BTRA, through its extensive shopfloor training program, will help the manufacturers / sellers to train their inspectors / checkers / supervisors to achieve the required inspection skill and standards. BTRA training program will be a 2-days duration consisting of classroom sessions as well as practicals. BTRA also conducts an assessment of the existing inspection system by inspecting fabrics checked by the company's checkers and giving a detailed report about various parameters related to inspection activities and set-up. In this way, the mill can verify its existing system compared to the other best units and improve the level of inspection quality.

References

[1] ASTM D 5430 – 07 (Reapproved 2017) Standard Test Methods for Visually Inspecting and Grading Fabrics

[2] Camera Based Visual Fabric Inspection by Prabir Jana 01-February-2013 https://apparelresources.com/technology-news/manufacturing-tech/technology-levels-for-fabric-inspection/

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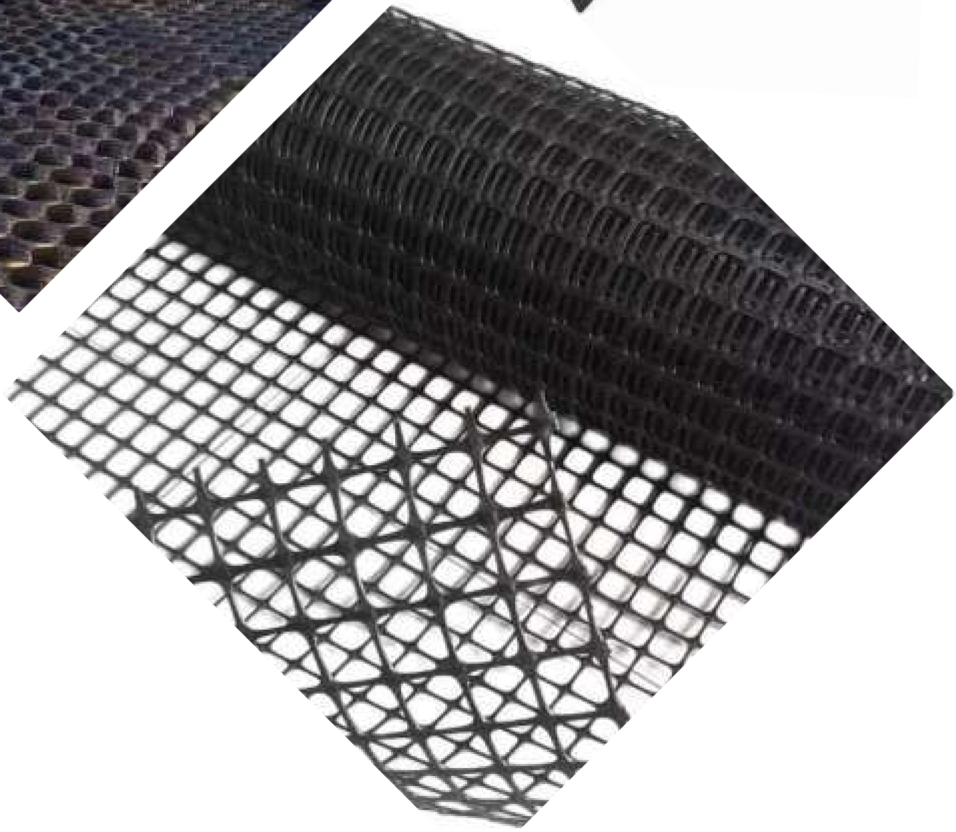

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