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Research Article

DESIGN AND DEVELOPMENT OF JACQUARD FABRICS WITH MULTIFUNCTIONAL FINISHES

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| <p>*Correspondence</p> <p>Latha M Associate Professor and Head, Dept. of Costume Design and Fashion Park's College, Tirupur, Tamil Nadu, India</p> <p>DOI: 10.7897/2321-6328.02356</p> <p>Article Received on: 03/05/14 Accepted on: 20/06/14</p> | <p style="text-align: center;">ABSTRACT</p> <p>The present study was aimed to design and develop jacquard fabrics with multifunctional property. A market survey was carried out in 50 leading jacquard fabric manufacturing units in order to find the availability of the furnishing items made of jacquard designs, details about jacquard fabrics such as colour, size and type of jacquard fabrics which includes bed sheets, mats, pillow covers, floor mats, curtains, cushion covers, tea towels, decorative mats and shirting in the market. From the consolidated results of market survey, Cotton dyed yarn of 30's count jacquard weave with animal and floral design was selected for the present study. A total of 30 meters of jacquard fabrics was woven, six meters each in five designs from each set of jacquard fabrics were selected for the weave and changes were made in the tie up of the treadles. The jacquard samples were finished with the antibacterial agent "Quaternary ammonium compound". The functional finishes such as antibacterial finish, water repellent finish, flame retardant finish, stain release finish and mosquito repellent finish were given using finishing agents and the efficiency of each finish on the fabric was tested according to the standard methods.</p> <p>Keywords: Jacquard fabrics, antibacterial activity, flame retardancy, stain release, water repellency, mosquito repellency</p> |
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INTRODUCTION

Jacquard fabrics of cotton are highly durable, comfortable and good conductor of heat. The fabric and design development in jacquard weave is primarily based on creative science of textile technology⁴. Various scientific techniques which can allow the designer to possess creative abilities to design a woven product called a creative product have been designed. The art of jacquard weaving signifies man's aspiration to combine beauty with utility. Woven fabrics manufactured by using the jacquard attachment on the loom also provides versatility in designs and permits individual control of each warp yarns. Jacquard weave is universally used in the industry for production of large figure designs. The unique combination of low cost, easy washing ability and comfort characteristics, have made jacquard fabrics superior to other materials like summer clothes, work clothes, sheets and towels¹¹.

Jacquard weaving provides the opportunity to design complex pictorial and other patterning effects from the combination of warp and filling colours and weaves³. At present, the application of jacquard CAD system has improved the efficiency of jacquard fabric design. Latest textile CAD/CAM systems and other technological developments have given a substantial boost to the manufacture of fabrics, in particular reference with jacquard fabrics. The major fields of production of jacquard are for upholstery, furnishing, mattresses, airbags, tablecloth, sheeting, drapery, tapestry, pictorial images and apparel.

With increasing demand of the products, the jacquard head capacity is getting higher every year allowing every warp yarn to be controlled independently. During last few years, major weaving machine manufacturers introduced to the jacquard woven fabric producers a sizeable number of technological advances⁶.

The attractiveness of the jacquard fabrics is enhanced materially by a coloured border of several colours or a plain border, coloured, parallel, striped borders are probably the most common type; more unusual border, floral, animal and geometrical motifs are made in jacquard weaves. Along with this characteristic features, the jacquard fabrics were made multi-functionalized in the present research. The motivation behind this research work is that although many weaving mechanisms are working to produce woven fabrics, a jacquard fabric has an important place in a textile product. It has been investigated for many of its properties and end users; still there are many gaps which exist in the scientific literature. As a major objective, in the present study the multifunctional finishes such as antibacterial property, flame retardancy, water repellency, stain release and mosquito repellency were analyzed for the selected jacquard fabrics. The fabrics were finally developed with all above properties for healthcare applications¹⁰.

Antibacterial textiles continue to gain popularity because of their fresh smelling, skin friendly, and high performance nature. Water-repellent finishing, the oldest repellent finishing is an important process in textile industries as well

as other finishing processes⁷. The purpose of this finish is to prevent drops of water from spreading on the surface. Consumers' attitude towards a product depends not only on its price and quality but also on its functional attributes. One such attribute in a fabric-based industrial set up is the 'Soil Release' (or stain release), which is essentially a measurement that quantifies the ability of a fabric to release stains after laundering⁵. Stain release property is the degree to which a stained substrate approaches its original unsoiled appearance as a result of care procedure. Low visibility textiles are used in military and defense purposes⁵. Light weight garment with a flame retardant property is the present need and for a fire fighter, the moisture transferability along with flame retardant property becomes a special requirement. The property of flame retardant clothing includes the ability to offer protection from the flame, without compromising the comfort property and durability of such flame retardancy⁸. The first line of defense against mosquitoes, the vector of potentially lethal diseases such as malaria, dengue and West Nile virus is to reduce the likelihood of being bitten by the mosquitoes. Several natural and synthetic chemical repellents applied on the skin provide a chemical barrier and protect only for a short period of time. Therefore, using insect repellents is one of the most efficient ways to prevent disease transmission. The insect repellent commercially named as DEET is effective against a variety of medically important pests, but its mode of action and toxicity still draws considerable debate⁸.

MATERIALS AND METHODS

Fabrics used in the Present Research Work

Cotton yarns were selected for designing and developing jacquard fabric with appropriate design by jacquard weaving. Dyed cotton yarns of Ne 30's count were selected for fabric construction.

Chemicals used in the Current Research Work

Chemicals and different finishing agents used for the present research have been obtained from Himedia, Lobachime, Nice and Rankem Laboratories, Mumbai, India and Jiangsu Huaxi International Laboratories, China and these are of the highest purity available. The chemicals used for each process are presented in Table-1.

Construction of Design

The whole design was drawn using Adobe Photoshop tools which are the basic element for creating a design. Tools vary from package to package but their aim is to create efficient design with less effort. The tools were classified as Vector tools and Bitmap design tools. They were further classified as Design creating and Design editing tools. This software is easy to handle and to produce jacquard fabrics with cost effective method without any special costly software.

Point Paper Preparation

The created designs in the software were made as a point paper in the Adobe Photoshop software and it was punched in the cards.

Construction of Squared Paper Designs

The construction of jacquard design included the following steps:

- Preparation of card-cutting,
- Planning on a squared paper.

The point paper design was constructed from an original sketch or design from a woven sample. This process involved enlargement of the designed paper according to the smoothness in set of the cloth. The constructions of jacquard designs were chosen as shown in Table 2.

Weaving

Five novel designs were designed using computer aided software. The prepared yarn samples were taken for weaving and changes were made in the tie up of the treadles. In each set, about six meters of jacquard designed fabrics were produced. In total, 30 meters of jacquard with 5 different designs have been prepared for this work.

Antibacterial Finishing and Testing

The processed fabric samples were finished with the antibacterial agent "Quaternary Ammonium Salts (Methacryloxyethyl benzyl dimethyl ammonium chloride-DMAE-BC)". The designed and developed jacquard fabrics were finished according to the following process parameters (Table 3).

Antibacterial Tests

Samples of the test material including corresponding untreated controls of the same material were placed in intimate contact with nutrient agar, which has been previously inoculated with test bacteria (*Staphylococcus aureus* (ATCC 6538) and *Escherichia coli* (ATCC 11230) used as standard Gram positive and Gram-negative organisms respectively). After incubation, a clear area of interrupted growth underneath and along the sides of the test material indicated antibacterial activity of the specimen. Test specimen (Antibacterial treated) and the untreated fabric samples (control) were taken and were cut into pieces according to convenient size (20 ± 2 mm radius) in round shape.

Sterilized nutrient/bacteriostasis agar medium previously sterilized and cooled to 47 ± 2 °C (117 ± 4 °F) was dispensed by pouring 15 ± 2 ml into each of standard (15 x 100 ml) flat-bottomed Petri dishes. The agar was allowed to solidify and inoculated with a day culture (slant cultures) of the test organisms. These were placed on to Petri dishes and allowed to harden. The textile test specimen was placed on the solid agar and attached to it. For conditioning, the test dish was stored for 24 hours at 5 °C and then placed in an incubator. If the fabric curled preventing intimate contact with the inoculated surface, small sterile glass plates were placed on the ends of the fabric to hold it in place. The plates were then incubated at 37 °C for 18-24 hours. At the end of the incubation time, the test dishes were observed. The agar under the sample was also evaluated. This assessment was made by visual examination as well as under a microscope with 40 X magnification. The evaluation was made on the basis of absence or presence of an effect of bacteria in the contact zone, under the specimen and the possible formation of a zone of inhibition around the test specimen and the zone of bacteriostasis were measured in millimeter (EN ISO 20645).

Flame retardant Finishing and Testing (ASTM D6413 / D6413M)²

Flame retardancy was imparted to the antibacterial finished jacquard fabric using flame retardant agent and the efficiency was tested according to the standard methods.

The flame retardant finishing agent, "Tris (2-Chloroethyl phosphate)" was used for finishing. The finished fabric

samples were tested for the flame retardency efficiency using auto flame chamber method. The finishing has been carried out according to the following process parameters (Table 4). The flame retardant finished fabrics were tested for efficiency of finish using auto flame chamber (Plate 3.2) inclined at 45°. The samples were taken in 5 X 15 cm. A dried specimen was inserted in a frame and inserted in the auto flame chamber at an angle of 45°. A standardized flame was then applied to the surface of the sample near the lower end for 5 seconds. Finally the time required for the flame to proceed up the fabric for a distance of 127 mm was recorded. The flammability of the fabrics was measured as the length of char in millimeters.

Water Repellent Finishing and Testing (AATCC- TM 22-2010)¹

The best selected jacquard fabrics with antibacterial finish (six numbers) were imparted with the water repellent agent and the finished fabrics were tested according to standard test methods. The water repellent finishing agent “Elastomeric (Polydimethyl siloxanes) compound” was used in combination with “Acetoxy Silanes” in the ratio of 100:5. The fabrics were finished with the following process parameters (Table-5). The finished fabrics were tested by spray method and the results were determined by measuring the amount of wetting at the spray points.

AATCC- TM 22-2010 spray testers were used to detect the efficiency of the finished fabric samples. The test specimen was fastened securely in the 15.2 cm (6 inch) metal hoop. The hoop was then placed on the stand of the tester with the fabrics uppermost surface in such a position that the center of the spray pattern coincided with the center of the hoop. About 250 ml of water was poured into the funnel of the tester and allowed to spray onto the test specimen for 25 – 30 seconds. The hoop was taken by one edge and the opposite edge was tapped smartly once against a solid object, with the fabric facing the object, then the hoop was rotated to 180° and tapped once more on the point held previously. Immediately after tapping, the wet or spotted patterns were compared with the standard. The sides of the fabric impacted by water upon spraying were rated.

Stain Release Finishing and Testing (AATCC 130-2000)¹

The jacquard fabrics with antibacterial finish were imparted with the stain release agent and the finished fabrics were tested for the stain release property. The stain release finishing agent “Perfluoro Octane Sulfonic acid” was used to impart stain release property to the jacquard fabrics by the following method. The fabric was finished by immersing in the following process parameters (Table-6). The finished fabrics were tested for their stain release property according to AATCC 130-2000 test method.

Each of the specimens of fabric was cut at 150 mm (6 inch) square for each test to be performed. The fabrics were then piled side up on a non-absorbent surface for 24 hours at standard condition of 21 ± 1°C (70 ± 2°F) and 65 ± 2 % RH. Contamination by contact with extraneous materials was avoided. About 50 mm diameter staining ring was then placed in the center of the test specimen. 20 ml of staining solution (100 mg of FD and C Red 40 in 1 liter of distilled or deionizer water at 24 ± 3°C) was poured upon the fabric. The bottom of the stain cup was pressed through the ring into the pile, moving up and down 5 times to facilitate wetting of the pile fiber from top to bottom. The staining ring and stain cup

were removed carefully. The stained specimen was kept for 24 ± 4°C h in a flat position, piled side up at standard condition of 21 ± 1°C (70 ± 2°F) and 65 ± 2 % RH. Stained specimen were rinsed with running water at 21 ± 6°C until the rinsed water was colourless which indicated the removal of all unfixed red dye.

Mosquito Repellency Finishing and Testing

Aqueous extracts of lemongrass was obtained by mixing dry powdered leaves with demonized water and leaving the mixture overnight at 20-22 °C. The mixtures were then filtered through four folds of cheesecloth followed by sterile filtering through a 0.2µm filter, before use. The method was performed by immersing the fabric material in the treatment bath containing the lemongrass oil extract for 1 to 5 minutes and then pulled up from the bath followed by squeezing and shade drying. The mosquito repellency efficiency of the finished fabrics was tested using the modified excito chamber method. The test method adopted in the present study for testing the mosquito repellent property is modified excito chamber method.

Specially designed two excito repellency test chambers were used to evaluate the efficiency of repellency activity. The wooden outer chamber of excito-repellency testing device measures 34 cm × 32 cm × 32 cm and faces the front panel with the single escape portal. The box is composed of a rear door cover, an inner Plexiglas glass panel with a rubber latex-sealed door, a Plexiglas holding frame, a screened inner chamber, an outer chamber, a front door, and an exit portal slot.

Mosquitoes were deprived of all nutrition and water for a minimum of 4 hours before exposure. Laboratory tests were performed during daylight hours only and each test were replicated four times. Observations were taken at one-minute interval for 30 minutes. After each test was completed, the number of Escaped specimen and those remaining inside the chamber were recorded separately for each exposure chamber, external holding cage, and paired control chamber. Escaped specimen and those remaining inside the chamber, for the treated samples were held separately in small holding containers with food and water.

Development of jacquard fabric with multifunctional property

The multifunctional properties were imparted to the designed and developed jacquard fabrics in the following method. The selected fabrics (A4 and A5) were first imparted antibacterial finish by diluting one portion of the antibacterial agent with one portion of water and the fabrics were immersed in the bath for 30 minutes at room temperature. The finished fabrics were squeezed and air dried. Then these fabrics were imparted with flame retardant finish by immersing the fabrics in flame retardant agent with the concentration of 200:300g/l. The finished fabrics were squeezed and dried. Drying was carried out between 100°C and 130°C and curing at 150°C for 3 - 5 minutes. Then these fabrics were imparted with water repellent property by immersing the fabric into the solution containing water repellent agent of concentration 200:300g/l for 30 minutes. The finished fabrics were squeezed and air dried. Then these fabrics were imparted with stain release finish by immersing the fabrics in stain release agent with the concentration of 2 - 4% for 20 minutes at room temperature. Drying was carried out between 100°C and 130°C and Curing at 150° C for 3 - 5 minutes. Then these

fabrics were imparted with mosquito repellent property by immersing the fabric in the bath containing the aqueous extract of lemongrass oil for 1 to 5 minutes and then pulled up from the bath followed by squeezing and drying.

RESULTS AND DISCUSSION

Assessment of efficiency of antibacterial finished jacquard fabrics

The designed jacquard fabrics finished with the antibacterial agents were tested for their efficiency by performing agar diffusion method (EN ISO-20645). The antibacterial activity was identified by zone of inhibition in mm against test organisms after 24 hours of incubation. In Table-7 the efficiency of antibacterial finish against two bacterial strains were presented. From the Table 7, it is evident that in the sample A4 showed maximum inhibitory zone of 30mm and 28mm against *Staphylococcus aureus* and *Escherichia coli* respectively. Similarly another sample A5 showed maximum inhibitory zone of 35mm and 25mm against the test organisms respectively.

Based on the assessment of efficiency of antibacterial finish, the fabric which showed good antibacterial effect was selected for further finishes such as flame retardant finish, water repellent finish, stain release finish and mosquito repellent finish.

Flame retardant finishing of the jacquard fabrics

The samples were taken and was inserted in a frame and inserted in the auto flame chamber at an angle of 45°. A standardized flame was then applied and the time required for the flame to proceed up the fabric for a distance of 127 mm was recorded. The flammability of the fabrics was measured as the length of char in mm. The results were presented in the following Table-8. It was evident that both the samples have considerable flame retardant efficiency due to its compact structure.

Testing of water repellent finished jacquard fabrics

The finished fabrics were tested by spray method (AATCC - 22) and the results were determined by measuring the amount of wetting at the spray points. Both A4 and A5 samples fell in the third category indicating that the sample was wet of face at spray points. A4 showed 87 points of water repellent efficiency similarly, A5 showed 88 points of water repellency which was clear that the samples have excellent water repellent property (Table 9).

Testing of stain release finished jacquard fabrics

The finished fabrics were tested for their stain release property according to AATCC 130-2000 test method. The results for efficiency of finish were presented in Table 10. The test result revealed that both the samples, snow creep fabric (A4) and fiery sky fabric (A5) have very good stain releasing properties.

Development of mosquito repellent finished jacquard fabric

The mosquito repellent finish was imparted to all the prepared samples. The finished fabrics were then tested for

the mosquito repellent efficiency by using standard test methods. Maximum of 92% followed by 88% of mosquito repellent action was revealed for the respective A4 and A5 samples when tested using standard test method (Table 11). Interestingly 9 specimens were found dead for A4 sample out of 25 specimens. This indicated that the chemical agent has good affinity with A4 sample than A5 sample.

Assessment of multifunctional finished jacquard fabrics

The multifunctional finished jacquard fabrics were tested for its antibacterial efficiency by performing agar diffusion method, EN ISO 20645. The antibacterial activity was identified by zone of inhibition in millimeters (mm) against test organisms after 24 hours of incubation. The results are presented in the following Table 12.

Antibacterial activity of multifunctional finished fabrics

Antibacterial activity against the two bacteria was found impressive. Almost all the finishes showed good antibacterial activity. Maximum inhibitory zone was observed for the sample finished for antibacterial activity. Fiery sky fabric (A5) sample showed maximum of 35mm and 29mm against *Staphylococcus aureus* and *Escherichia coli* respectively (Table 12)

Flame retardancy of multifunctional finished fabrics

The flame retardant property of the fabric samples were found satisfactory for almost all the finishes. Maximum flame retardancy was observed even after mosquito repellent finish. The char length of 6 was found to be maintained after each type of finishes. This proved that even after each type of finishes, the fabric was resistant and proved to possess consistence flame retardant property (Table 13)

Water repellency of multifunctional finished fabrics

About 90% water repellent efficiency was observed for A4 samples after water repellency, stain release and mosquito repellency finishing (Table 14). This showed that water repellent property was durable even after mosquito repellency finishing. Another fabric sample, A5 also showed equally good water repellent efficiency of 80% when compared to A4 samples.

Stain release property of multifunctional finished fabrics

Stain release property was found more reliable for A5 sample fabrics since it showed a grading point of 9 even after mosquito repellent finish. The obtained result thus proved that the chemical agents treated for stain release property was durable even after mosquito repellent finishing (Table 15)

Mosquito repellency of multifunctional finished fabrics

Maximum of 92% followed by 66% of mosquito repellent action was revealed for the respective A4 and A5 samples when tested using standard test method (Table 16). Interestingly 9 specimens were found dead for A4 sample out of 25 specimens. This indicated that the chemical agent has good affinity with A4 sample than A5 sample.

Table 1: Chemicals Used in the Current Research Work

| Chemicals | Experiment |
|--|---------------------------|
| Nutrient agar medium | Antibacterial testing |
| “Quarternary Ammonium Salts (Methacryloxyethyl benzyl dimethyl ammonium chloride-DMAE-BC)” | Antibacterial finish |
| “Elastomeric (Polydimethyl Siloxanes) compound” in combination with “Acetoxy Silanes” in the ratio of 100:5. | Water Repellent Finish |
| “Tris (2-Chloroethyl Phosphate)” | Flame Retardant Finish |
| Perfluoro Octane Sulfonic Acid | Stain Release Finish |
| Lemongrass Oil | Mosquito Repellent Finish |

Table 2: Development of the Jacquard Design (First set)

| Nomenclature of sample | Design |
|------------------------|--|
| A1 | Dark orange colour with flower motif |
| A2 | Dark and light colour with flower motif |
| A3 | Dark and light colour with geometrical motif |
| A4 | Dark blue colour with orange flower motif |
| A5 | Dark grey colour with flower motif |

Table 3: Process Details for Antibacterial Finish

| Particulars | Process details |
|-------------------------------|---------------------------|
| Dosage of the finishing agent | 1:1 proportion with water |
| Time of treatment | 30 minutes |
| Temperature | Room temperature |
| Drying | Air drying |

Table 4: Process Details for Flame Retardant Finish

| Particulars | Process details |
|-------------------------------|-------------------------|
| Dosage of the finishing agent | 300 – 600 g/l |
| pH | 6 |
| Wet pick up | 70 – 90 % |
| Drying | 100°C to 130°C |
| Curing | 150°C for 3 - 5 minutes |

Table 5: Process Details for Water Repellent Finish

| Particulars | Process details |
|-------------------------------|-------------------------|
| Dosage of the finishing agent | 200 – 600 g/l |
| pH | 6 |
| Wet pick up | 70 – 90 % |
| Drying | 120°C |
| Curing | 150°C for 3 - 5 minutes |

Table 6: Process Details for Stain Release Finish

| Particulars | Process details |
|-------------------------------|---------------------|
| Dosage of the finishing agent | 2 – 4percentage owf |
| pH | 6 |
| Time | 20 minutes |
| Temperature | Room temperature |

Table 7: Antibacterial Testing for the Finished Jacquard Fabrics

| Sample No. | Antibacterial activity (Zone of Bacteriostasis – mm) | |
|------------|--|------------------------------|
| | <i>Escherichia coli</i> | <i>Staphylococcus aureus</i> |
| A1 | 24 | 30 |
| A2 | 25 | 27 |
| A3 | 28 | 28 |
| A4 | 30 | 28 |
| A5 | 35 | 25 |

Table 8: Efficiency of Flame Retardant Finished Jacquard Fabrics

| Sample No. | Flame Retardency efficiency (Char length in mm) |
|------------|---|
| A4 | 5 |
| A5 | 4 |

6 – Excellent, 5 – very good, 4 – good, 3 – considerable, 2 – weak

Table 9: Efficiency of Water Repellent Finished Jacquard Fabrics

| Sample No. | Water Repellency efficiency |
|------------|-----------------------------|
| A4 | 87 |
| A5 | 88 |

0 – Complete wetting, 70 – Partial wetting of the whole of the upper surface, 80 – Wetting of face at spray points, 90 – Slight random sticking or wetting of the upper surface

Table 10: Efficiency of Stain Release Finished Jacquard Fabrics

| Sample No. | Stain Resistance efficiency |
|------------|-----------------------------|
| A4 | 9 |
| A5 | 8 |

Grade of 10 – no staining and 1 – severely stained.

Table 11: Results for Mosquito Repellent Efficiency of Jacquard Fabrics

| Fabric Samples | No. Of specimen Exposed | No. Of specimen in the cage | No. Of specimen Escaped | No. Of specimen Dead | Mosquito Repellency in % |
|----------------|-------------------------|-----------------------------|-------------------------|----------------------|--------------------------|
| A4 | 25 | 2 | 14 | 9 | 92 |
| A5 | 25 | 3 | 17 | 5 | 88 |

Table 12: Antibacterial activity of the Multifunctional Finished Jacquard Fabrics

| After finishing | Fabric sample | Zone of inhibition in mm | |
|----------------------------|---------------|--------------------------|----------------|
| | | <i>S. aureus</i> | <i>E. coli</i> |
| Antibacterial finish | A4 | 30 | 28 |
| | A5 | 35 | 29 |
| Flame retardant finish | A4 | 30 | 27 |
| | A5 | 32 | 28 |
| Water repellency finish | A4 | 29 | 26 |
| | A5 | 28 | 27 |
| Stain release finish | A4 | 27 | 30 |
| | A5 | 27 | 27 |
| Mosquito repellency finish | A4 | 28 | 28 |
| | A5 | 26 | 29 |

Table 13: Flame Retardency Activity of the Multifunctional Finished Jacquard Fabrics (Auto Flame Chamber)

| After finishing | Fabric sample | Flame Retardency efficiency (Char length in mm) |
|----------------------------|---------------|---|
| Flame retardant finish | A4 | 5 |
| | A5 | 6 |
| Water repellency finish | A4 | 5 |
| | A5 | 5 |
| Stain release finish | A4 | 5 |
| | A5 | 6 |
| Mosquito repellency finish | A4 | 6 |
| | A5 | 5 |

Note: 6 – Excellent, 5 – very good, 4 – good, 3 –considerable, 2 – poor

Table 14: Water Repellency Activity of the Multifunctional Finished Jacquard Fabrics (AATCC TM 22)

| After finishing | Fabric sample | Water Repellency efficiency |
|----------------------------|---------------|-----------------------------|
| Water repellency finish | A4 | 90 |
| | A5 | 80 |
| Stain release finish | A4 | 90 |
| | A5 | 80 |
| Mosquito repellency finish | A4 | 90 |
| | A5 | 80 |

0 – Complete wetting, 70 – Partial wetting of the whole of the upper surface
80 – Wetting of face at spray points, 90 – Slight random sticking or wetting of the upper surface

Table 15: Stain release property of the Multifunctional Finished Jacquard Fabrics (AATCC 130)

| After finishing | Fabric sample | Stain Resistance efficiency |
|----------------------------|---------------|-----------------------------|
| Stain release finish | A4 | 9 |
| | A5 | 7 |
| Mosquito repellency finish | A4 | 9 |
| | A5 | 8 |

Grade of 10 – no staining and 1 – severely stained

Table 16: Mosquito Repellency Activity of the Multifunctional Finished Jacquard Fabrics (Modified Excito chamber)

| Fabric Samples | No. Of specimen Exposed | No. Of specimen in the cage | No. Of specimen Escaped | No. Of specimen Dead | Mosquito Repellency in % |
|----------------|-------------------------|-----------------------------|-------------------------|----------------------|--------------------------|
| A4 | 25 | 2 | 14 | 9 | 92 |
| A5 | 30 | 10 | 10 | 10 | 66 |

CONCLUSION

The multifunctional finish of jacquard fabric for five different properties proved that the chemical agents responsible for each factors were durable. Antibacterial activity, flame retardency, water repellency, stains release and mosquito repellency was found consistent during the multifunctional testing. All the factors were found durable till the satisfactory level according to the standard methods. From the present findings we revealed that multifunctional properties were durable and consistent; also the chemical finishing was found suitable and reliable for the jacquard fabrics. The fabrics may be suitable for manufacturers like bedsheets, pillow covers and curtains. The present research work has opened up many new approaches for further studies like, different yarns like Jute, Linen and Sisal with different counts may be used for the development of novel designed jacquard fabrics, extend the use of multifunctional finishes to various other home textile products, selection of finishes can be varied to determine the different end products, developing multifunctional knitted fabrics using other suitable finishes, exploring the use of design development, fabrics with fancy weaves can be created for garment construction.

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