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The Influence of Special Finishes on the Functional Properties of Warp Knitted Advertising Banners

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***ABSTRACT**: This study demonstrated that the changes in functional properties of warp knitted advertising bannerswere determined to evaluate the performance ofdifferent special finishes. Here, warp knitted advertising bannersfabrics were treated with differenttypes of finishing chemicals at different formulations.Dyeing & Finishing processes include heat-setting, dyeing, napping, embossing, pressing, calendaring, and using differenttypes of finishing chemicalsto improve the appearance & functionalproperties of the advertising banners. To assess the performance of different finishes on fabric properties, GSM, bursting strength, dimensional stability, air permeability,elasticity &recoverywithASTM and BS methods were done. The results showed that the functional properties of the finished warp knitted advertising banners depend to a great extent on the type of finish. [1]*

***KEYWARDS:** Advertising Banners,Dimensional Stability, Heat-setting, Functional Properties, Warp Knitted Structures*

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I. INTRODUCTION

Communication plays a significant role in the society as it is the foundation of all the human relationships. Outdoor advertising has been effectively used for hundreds of years as a part of the marketing communication. The technological explosion in the digital era has made advertising much easier, cheaper and customized. A Flex banner is a digitally printed advertisement which is primarily kept along the sides of the roads so as to attract the people's attention and make a memorable impression. It can be considered as the most widely used medium for outdoor advertising as it is extremely flexible, cost effective, durable, recyclable and portable. [2]

Flex banners have been placed under the category of Technical Textiles. A Flex banner is commonly known as a "PVC banner" which is a misnomer as it is a three-layer laminated structure where in the polyester fabric is sandwiched between the films consisting of compounded calcium carbonate ($CaCO_3$), polyvinyl chloride (PVC) resin, plasticizers and additives. The polyester fabric imparts rigidity and durability while the PVC films provide flexibility and enable low-cost digital printability of the Flex banners. [3]

Knitting is the process used for the manufacture of the polyester fabric in the form of a series of intermeshed loops from the industrial or fully drawn yarns. The knitted fabrics are more stretchable than the woven fabrics. The fabric is made of weft and warp yarns of 150-200 D and stitching yarns of 70 D. The loops (building blocks) are formed from each yarn and are present along the length of the fabric. The parallel warp yarns are supplied in the form of sheets that are extracted from a single or multiple warp beams. The stitching yarns are fed to the needles using guide bars which swing laterally. [4]

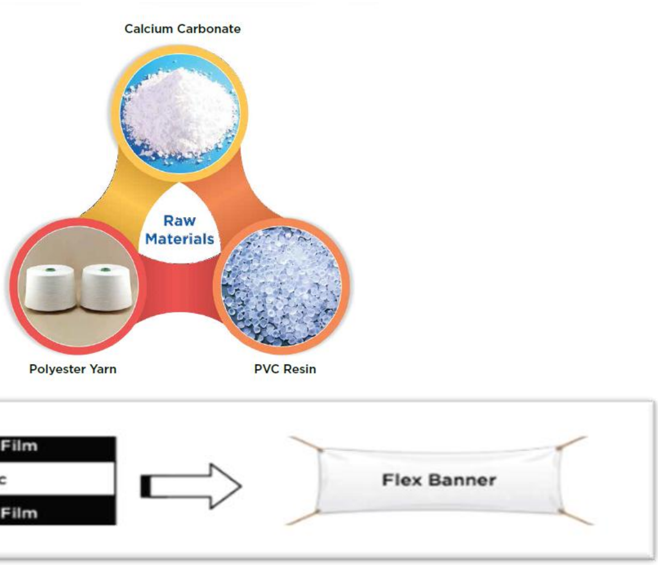

Fig. (1) Structure of a flex banner

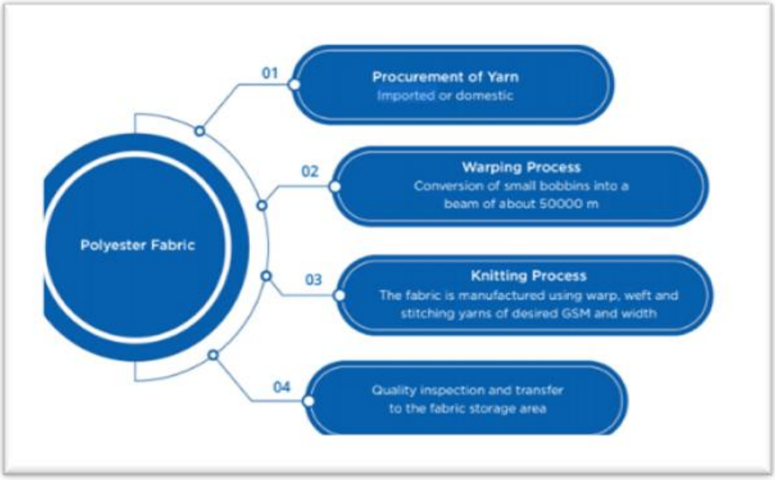

Fig. (2)Production of the polyester fabric

Fig. (3)Knitting of the polyester fabric

Printing onto fabrics in general is significantly different than printing onto paper, vinyl and lms. characteristics of the beers of the textile being printed and how they are woven and what treatments are present all act the printing. Considering these characteristics, there are significant advantages in printing digitally versus analog, such as screen printing, oset or gravure. The most obvious advantage is reduced run sizes. Being able to print short runs at a reasonable cost enables companies to produce samples and introduce a new line of printed fabrics to measure sales potential. With the advent of faster printers, now even production runs of thousands of yards can be efficiently printed. Another major advantage is the edibility of design. No longer does an image need to be separated into a manageable number of colors for screen printing or some other analog method.

Polyester fabrics comprise more than 40 percent of all of the printed textiles that are manufactured today. Its market share has increased over the past two years due to the global high prices of cotton caused by recent shortages. It is not clear if cotton will recover this share as prices have dropped recently, but there are certain markets that lend themselves to specific textiles.The use of the fabric is the most important starting point to identify what to produce as an end-product. The printing process should match with type of ink e.g. low energy sublimation (dye-sub), high energy sublimation (also known as disperse direct), reactive, acid and pigment. The ink chemistry should fit the requirements of the fabric (nylon, polyester, silk, cotton). On the bases of choosing fabric and ink combination is the process followed for heat-press sublimation, infra-red fixation or steaming.

Polyester fabric mostly printed with dye-sub or disperses direct ink, solvent inks, latex and UV. The sublimation ink colorants bond with the fiber during fixation or sublimation, as the inks are absorbed by the fabrics, then other medium in which the ink remains with the coating and on top of the fabric, as with UV-curable formulations. Many times, latex inks on porous textiles suffer crocking or 'rub-off' issues. [5, 7]

Digital textile printing technology has come a long way since the time it was first introduced a couple of decades ago. Initially driven by the need of simplifying and optimizing the sampling process, it has evolved into a new technology with several areas of application in mass customization and luxury markets. Technology-wise it is still a complex process that requires understanding many disciplines contributing to digital textile printing. Print head design, ink chemistry, pre- and post-treatment of fabric, design and pre-flirting are all influential in achieving a great quality of digital textile print. Yet, digital textile printing is still a relatively new technology. In the wide consumer market only parts of it have been utilized by small companies. Digital textile printing is a growing market and will continue to grow as a viable mainstream option in the specialty imaging community. Edibility in design, the favorable environmental impact and the increase in production speed all contribute to this market's growth. [5, 8]

II. MATERIALS AND METHODS

To achieve the goals of this research, the construction of warp knitting advertising banners and the parameters associated with are studied. These parameters along with well-known theories and shed insight hypotheses at steps which we have followed in designing warp knitting advertising banners as given under: -

- Selection of the type of fibers or yarns that could be used to produce advertising banners, including specification of these fibers or yarns.
- Selection of the manufacturing mechanism that could be used to produce advertising banners. Applying a definite mechanism is ruled by its theories and application forms.
- Studying the required machine adjustment and the different advertising banners mechanism leads to definite design parameters (choosing the appropriate fibers, yarn type, advertising banners construction, advertising banners specification…etc.) in order to fulfill the advertising banners knitting concept. This step is guided by both the production mechanism to be used, and the characteristic properties of the raw materials.
- Using Various Treatment processes and digital printing technology representing by inkjet technology affect the performance characteristics of produced advertising banners.
- Testing warp knitting advertising banners (functional properties, performance and mechanical properties) to determine the feasibility of the design.

2.1.Warping Process

The selected raw yarn is sent to the warping process, which is the adjustment process to supply the specified number of yarns at even tension. As the number of raw yarns differs depending on the type at the time of acceptance, it is correctly adjusted in this process and 600 yarns are wound on one beam. [6]

To produce a warp knitting fabric on the warp knitting machines its require a yarn which feed on the beams, although in some case the ends of the yarn from the cone or cheese can be feed directly into warp knitting machine using creel, mostly this method only for pattern yarn on the lace machines, however for the ground yarn always using the yarn on the warp beam. [7]

Warp beams produce at various warping machine, in this case for warp knitting, the warp beams produce on direct warping machines. Direct warping can be defined as produce in which ends of the yarn are wrapped in one operation from the yarn packages onto the warp beam.

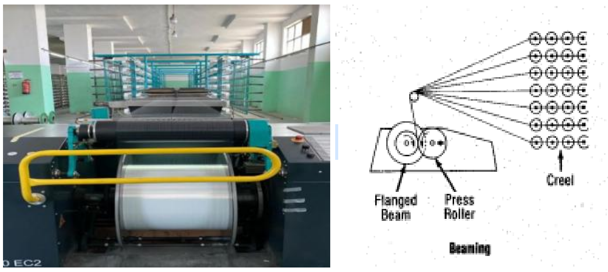

Fig. (4) Cylinder beam

Since the creel must supply the required number of the ends of the warp, there are two possibilities; either the creel can be very large or the width of the warp can be smaller. In order enable the use of moderate creel size and to simplify warp handling, section beams are warped. Each section its own flanges and number of section beams are placed on the common shaft to make up required number of ends for the warp.Most of modern warping machine, can be work with 21” beam to 42”, these sizes of the beam mostly use on the warp knitting machine now a day.

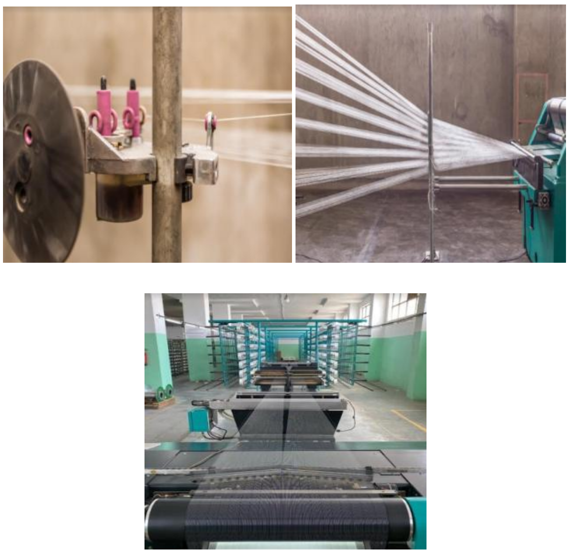

Fig. (5)Warping process

2.2. Warp Knitting Machine

In the warp knitting process, the warped yarn wound on the beam is sent to the knitting machine by the crane vehicle or lift, and set to the machine. The beam rpm and inch are entered into the computer, and the yarn is set. The yarns are prepared as warps on beams with one or more yarns for each needle. All the samples were produced on two different warp knitting machines; HKS 2 and HKS 3M.

Table (1) The specification of HKS 2 Tricot warp knitting machine

Model	HKS 2
Company	Karl Mayer - German
Average Speed	2200 RPM
Working width	130-186 Inch
Gauge	28
Numbers of guide bars	2 All bars are made of carbon-fiber-reinforced plastic
Needle bar type	Individual needle bar with compound needles

Table (2) The specification of HKS 3M Tricot warp knitting machine

Model	HKS 3M
Company	Karl Mayer - German
Average Speed	2500 RPM
Working width	130-186-218 inch

Gauge	28
Numbers of guide bars	3
Needle bar type	Individual needle bar with compound needles

2.3. Warp Knitted AdvertisingBanners
Table (3) shows the specification of the all produced warp knitted samples for advertising banners.

Table (3) The specification ofwarp knitted samples for advertising banners

Sample No.	Number of Guide Bars	Yarn Count Denier/Type	Guide Bars Movement	Thickness mm	Wight Gm/m^2	Courses/Cm
1	3	GB1:50/36 SD Polyester	1-0\5-6	0.41	267	36
		GB2: 50/36 SD Polyester	0-1\1-0			
2		GB3: 50/36 SD Polyester	3-4\1-0	0.4	176	28
3	2	GB1:50/36 SD Polyester	1-0\3-4	0.33	124	23
4		GB2: 50/36 SD Polyester	1-0\1-2	0.32	95	17

SD: Semi Dull Yarn
Tex: Texture

2.4. Dyeing Process
Figure (6) shows the dyeing machine, the main objectives of dyeing are;

- To impart color to the Textile substrates fibers, yarns, fabrics uniformly and producing uniform leveling.
- To achieve acceptable color fastness (durability of color) to wash, UV, wet rubbing, further treatments in production and normal end use.
- To reproduce the required shade from batch to batch.
- To use reasonably priced dyes and dyeing procedure.
- To provide and use ecofriendly process.
- Fixing the color in the shortest possible time.

Fig. 6) The dyeing machine

For a broader understanding, of the dyeing machines, the most common types Dyeing machines are classified:
1. Rope Dyeing Machine
2. Open Width Dyeing Machine
3- Beam dyeing

We have been used Rope Dyeing System. In this process, the fabric gets transported via the machine in a loosely collapsed form that looks like a rope. Rope dyeing has the tendency for abrasion of fabrics that can result in permanent, cracks, creases and streaks.

Beam dyeing machine was used for dyeing warp knitted fabrics that have been wound onto a special beam, the barrel of which is evenly perforated with holes.As shown in Figure (7), the dye liquor is forced through the yarn or fabric from inside to outside and vice versa. [10]

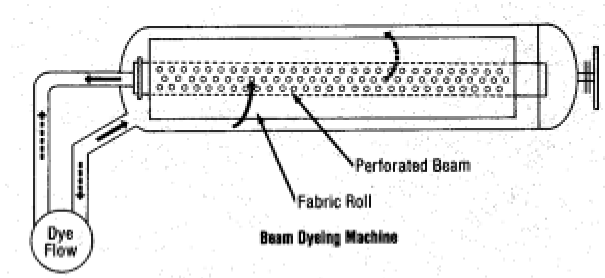

Fig. (7) Beam dyeing machine

Two operations were done in rope dyeing machine as following:
- Scouring.
- Optical Brightness.

2.4.1. Scouring

The Scouring is a cleaning treatment in which oil, waxes and residual sizes are removed from the fabric by the chemicals. After scouring the fabric becomes absorbent in nature.In this process, fabric is treated with strong alkali solution (5-10 gm/lit NaOH or mixture of NaOH & Sodium Carbonate) close to or above the boiling temperature for 1-2 hours with hot rinse and final cold rinse with acetic acid. The final rinse with acetic acid is also called souring process.

There are two methods to carry out scouring;
1. Alkali Scouring.
2. Solvent Scouring.

Normally, alkali scouring is carried out and the alkali used is sodium hydroxide (NaOH).

2.4.2. Optical Brightness

- A colorless compound that, when applied to fabric absorbs the ultraviolet radiation in light but emits radiation in the visible spectrum.
- Fluorescent materials added to polymer in manufactured fiber production that emits light in the visible spectrum, usually with a blue cast.

2.4.3. Padding

As shown in Figure (8), the application of a liquor or paste to textiles either by passing the material through a bath and subsequently through squeeze rollers, or by passing it between squeeze rollers, the bottom one of which carries the liquor or paste.

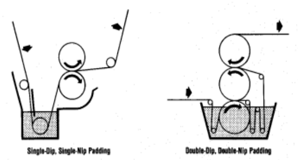

Fig. (8) Padding process

Padding machine is used for dyeing garments, hosiery, and other small pieces that are packaged loosely in mesh bags. The unit consists of an open tank and revolving paddles that circulate the bags in the dye bath.

2.4.4. Thickeners

Migration inhibiter is to prevent the ink droplet from penetrate the fabric, this will help the ink on the surface result in color brightness, sharpness, and color fastness. The thickener should be compatible with dyes and should not have affinity or reactivity with dyes and other chemical present in the fabric. The commonly used thickener are Starches and Gums, Sodium Alginate, Carboxy Methyle cellulose, Methyle Cellulose, ethyle cellulose and emulsion thickener.

2.4.5. Hydrophobic agent
Means "water-hating". Chemical groups that tend to make substances Lack the ability to absorb water.

2.4.6. Sharpness agent
Chemical solution to enhance the color sharpness of the ink on the substrate.

2.4.7 Heat Setting
As shown in Figure (9), The process of conferring dimensional stability and often other desirable properties such as wrinkle resistance and improved heat resistance to manufactured fibers, yarns, and fabrics by means of either moist of dry heat.

Fig. (9) Heat setting machine

As shown in Figure (10), thermal fixation is a process for dyeing polyester whereby the color is diffused into the fiber by means of dry heat.

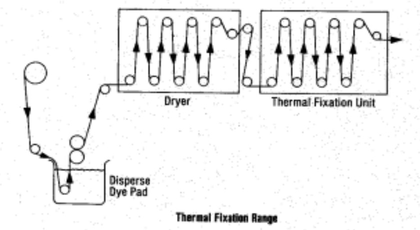

Fig. (10)Thermal fixation process

III. RESULTS AND DISCUSSIONS

Results of testing of advertising banners are illustrated and discussed to optimize the functional and performance properties of advertising banners design. For convenience, the results are presented under: -

- Air permeability test (ASTM D737 - 04(2012).
- Bursting strength test (ASTM D3786 / D3786M – 13).
- Dimensional Stability test.
- Elasticity & Recovery test (BS EN 14704-1:2005).

Four different warp knitted samples of advertising banners were produced to achieve the best functions and performance properties. Table (4) shows the laboratory tests results for all advertising banners samples

Table (4) The laboratory Tests Results for Advertising Banners Samples

No.	Air Permeability Cm³/Cm³. Sec	Bursting Strength Kg/Cm²	Elasticity & Recovery Horizontal		Elasticity & Recovery Vertical		Dimensional Stability %	
			After 1 min	After 30 min	After 1 min	After 30 min	Length wise	Width wise
1	4.34	0	96	100	100	100	100	0
2	5.014	0	92	100	100	100	100	0.4
3	218	0	48	93.2	94	100	100	0
4	237.8	0	42	96	97.2	100	100	- 0.8

3.1. The Effect of Treatment Process on Advertising Banners Functional Properties

Fabric that is ready for the market, has been passed through the necessary dyeing & finishing processes. The term finishing includes all the mechanical and chemical processes employed commercially to improve the appearance & functionally of the product .Dyeing & Finishing includes such operations as heat-setting, dyeing, napping, embossing, pressing, calendaring, and the application of chemicals that change the character of the fabric.

Figure (11) shows same structure of two applied samples (No 1&2) by using three guide bars. Figure (12) shows same structure of two applied samples (No 3&4) by using two guide bars with same other manufacturing parameters before and after treatment process.

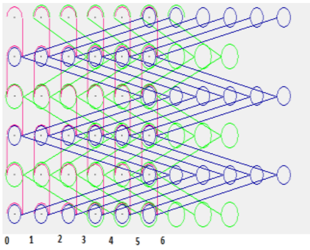

Fig. (11)Pattern (1&2) G1:1-0\5-6 G2: 0-1\1-0 G3: 3-4\1-0

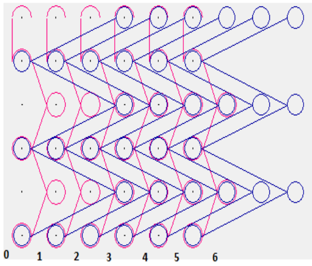

Fig. (12)Pattern (3&4) G1:1-0\3-4 G2: 1-0\1-2

3.1.1. The Effect of Treatment Process on Advertising Banners Air Permeability Property

Figure (13) shows the effect of treatment process on fabric air permeability property (cm^3/cm^2. sec) using three guide bars while Figure (14) shows the effect of treatment process on fabric air permeability property (cm^3/cm^2. sec) using two guide bars with same other manufacturing parameters before and after treatment process.

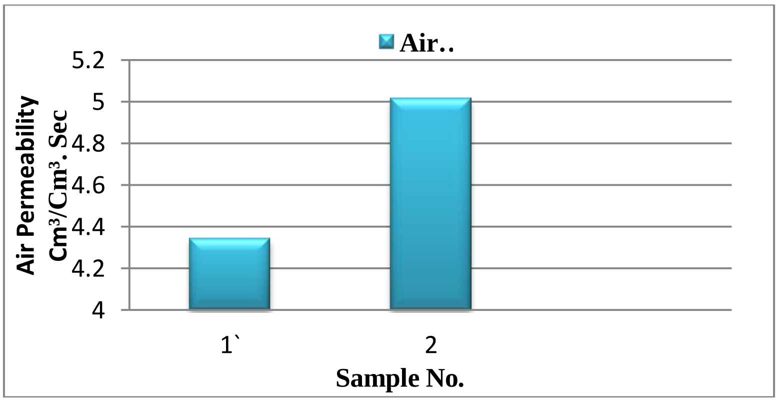

Fig (13)The Relationship between Treatment Process and Fabric Air Permeability Cm^3/Cm^3. Sec Using Three Guide Bars

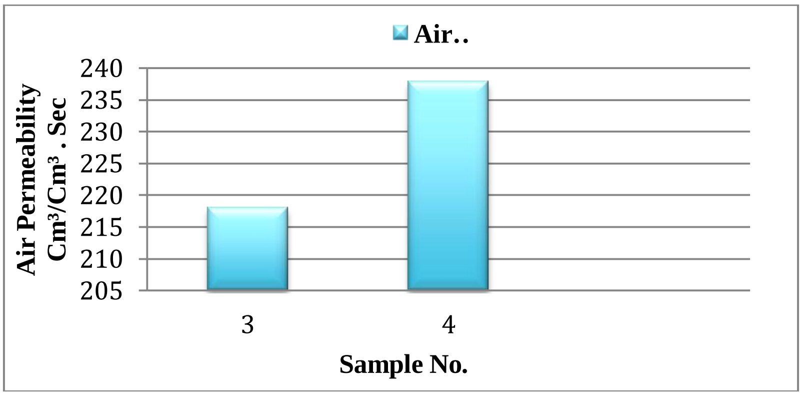

Fig (14)The Relationship between Treatment Process and Fabric air permeability Cm³/Cm³. Sec Using Two Guide Bars

As shown in Table (4) and Figures (1) & (2), it is cleared that; there is difference in air permeability values according to treatment process. There is an inverse relationship between treatment process and air permeability value. The higher air permeability value is (sample No.2&4), however the lower air permeability value is (sample No.1 &3). This can be due to the increase of stitch density and fabric cover factors which prevent air to pass smoothly.

3.1.2. The Effect of Treatment Process on Advertising Banners Bursting Strength property

Figure (2) shows the effect of treatment process on fabric bursting strength property (Kg/Cm²) using three guide bars while Figure (3) shows the effect of treatment process on fabric bursting strength property (Kg/Cm²) using two guide bars with same other manufacturing parameters before and after treatment process.

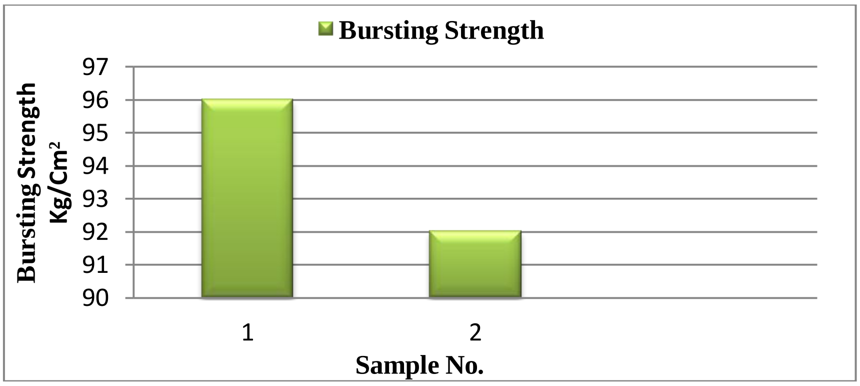

Fig (15)The Relationship between Treatment Process and Fabric Bursting Strength test Kg/Cm² Using Three Guide Bars

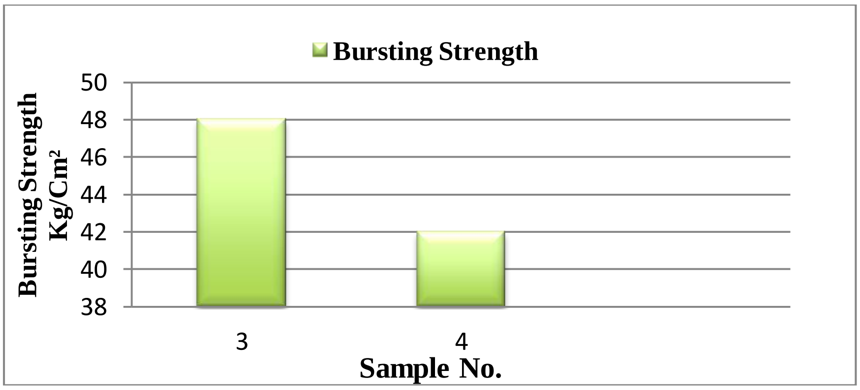

Fig (16)The Relationship between Treatment Process and Fabric Bursting Strength test Kg/Cm² Using Two Guide Bars

As shown in Table (4) and Figures (15) & (16), it is cleared that; there is difference in bursting strength values according to treatment process. There is a direct relationship between treatment process and bursting strength value. The higher bursting strength value is (sample No.1&3), however the lower air permeability value is (sample No.2&4). As we mentioned there is a positive correlation between stitch density, thickness, weight of the fabric and burst strength vales. As the value of stitch density rises, burst strength of the fabric rises. Finally, the weight of the fabric has a significant direct effect on bursting strength.

3.1.3. The Effect of Treatment Process on Advertising Banners Dimensional Stability property

Figures (17) & (18) show the effect of treatment process on fabric dimensional stability % in length wise while Figures (19) & (20) show the effect of treatment process on fabric dimensional stability % in width wise.

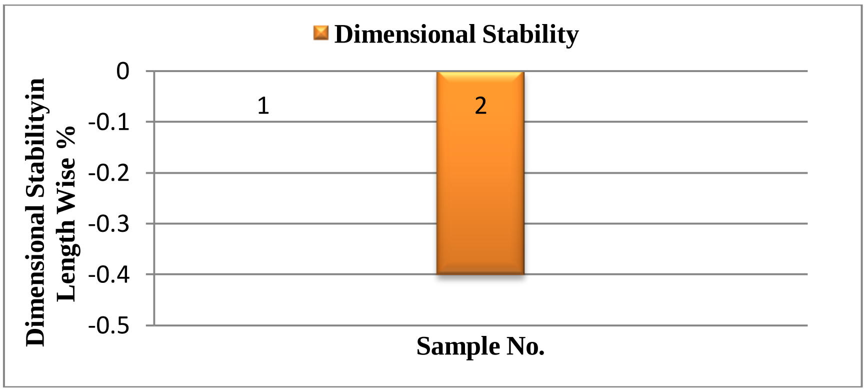

Fig (17) The Relationship between Treatment Process and Fabric Dimensional Stability length wise % Using Three Guide Bars

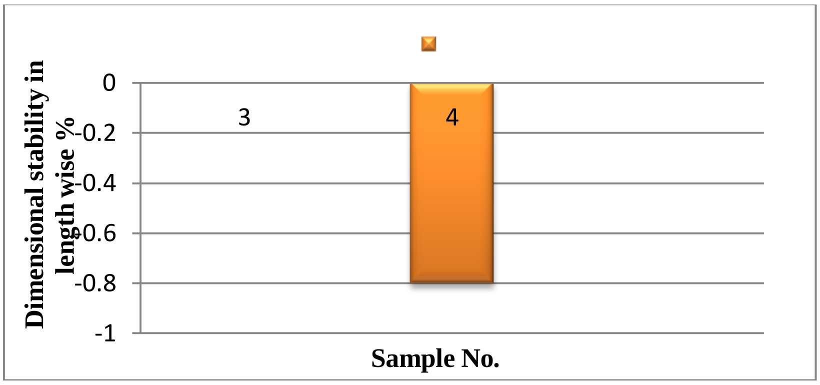

Fig (18)The Relationship between Treatment Process and Fabric Dimensional Stability length wise % Using Two Guide Bars

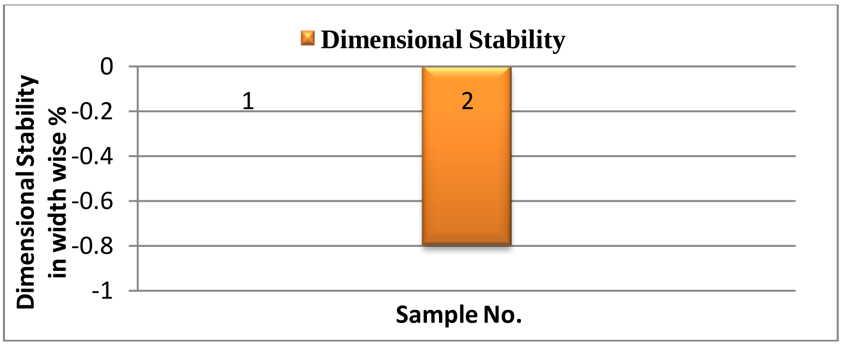

Fig (19)The Relationship between Treatment Process and Fabric Dimensional Stability width wise % Using Three Guide Bars

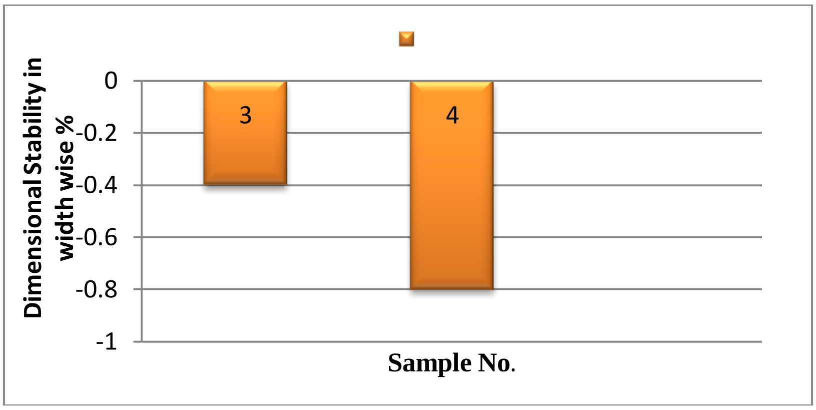

Fig (20)The Relationship between Treatment and Fabric Dimensional Stability width wise % Using Two Guide Bars

As shown in the Figures (17) & (18) & (19) & (20), the higher dimensional stability % in both length and width wise is (sample No.1 &3), however the lower dimensional stability % in both length and width is (sample No.2&4). Treatment process causes better dimensional stability property by using the same other manufacturing parameters. The existence of this decline is most probably a consequence of the stitches interlacing, stitches density, the structure and the fabric thickness due to the treatment process.

IV. CONCLUSIONS

Digital textile printing is still a relatively new technology. In the wide consumer market only parts of it have been utilized by small companies. Digital textile printing is a growing market and will continue to grow as a viable mainstream option in the specialty imaging community. To achieve the goals of this research, the construction of warp knitting advertising banners and the parameters associated with are studied.

Fabric that is ready for the market, has been passed through the necessary dyeing & finishing processes. The term finishing includes all the mechanical and chemical processes employed commercially to improve the appearance & functionally of the product. Dyeing& Finishing includes such operations as heat-setting, dyeing, napping, embossing, pressing, calendaring, and the application of chemicals that change the character of the fabric.

The effects of special finishes were observed on warp knitted advertising banners. Various treated fabrics samples were tested and obtained resultswere evaluated. Different physical test results showed that different special finishessignificantly are influenced on warp knitted advertising banners. This studymainly focused on the impact of heat-setting, dyeing, napping, embossing, pressing, calendaring, and using differenttypes of finishing chemicalson the functional properties of warp knitted advertising banners. The obtained results show that the dimensionalstability and bursting strength propertiesare improved after treatmentwhile the air permeability is decreased. The existence of this decline is most probably a consequence of the stitches interlacing, stitches density, the structure and the fabric thickness due to the treatment process.

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