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A STUDYOF THE EFFECTOF SOME FABRIC PARAMETERSONLIQUID TRANSMISSION PROPERTIES

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ABSTRACT

Human is exposed to different types of liquids during day life, some are harm to skin such as chemicals, and some are unpleasant such as rain, blood or various contaminants. So this work is an attempt to find out how fabric parameters affect liquid transfer properties. In this study 45 fabric samples were executed, these samples are different in materials and fabric constructions. Five fabric structures were used for fabric samples these are: plain 1/1, basket 2/2, twill 2/2, twill 3/1 and satin 4. In the experimental part of this work, fabric water repellency, fabric wetting and fabric wicking were tested. It was found that fabric structure has no great effect on fabric water repellency. Both fabric yarn densities and fabric structure have a remarkable effect on fabric wetting and wicking. Summary of the results suggested that plain 1/1 of cotton fabric is the best among other samples to give a better protection against liquid transfer.

Keywords*:*Fabric Parameters, Fabric Transmission Properties, Fabric Wetting, Fabric Wicking, Protective Textiles

I INTRODUCTION

Scientific advancements made in various fields have undoubtedly improved the quality and value of human life. It should however be recognized that the technological developments have also exposed us to greater risks and danger of being affected by unknown physical, chemical and biological attacks. In addition, we continue to be exposed to hazards from fire, contaminant liquids andradiation.

Man is exposed to different types of liquids during day life, some are harm to skin such as chemicals, someare unpleasant such as rain,blood or various contaminants. Fabrics are considered the first defense layer that protect human body from liquid transmission. Fabric parameters such as material, yarn count, yarn setting, and weave structure play a major role in determining fabric transmission properties.This work aims at finding out the effect of each of these parameters on the transmission of liquids in a form of water by examining number of related properties for fabric samples with different specifications.

Nowadays safety and protective textile have become an integral part in one or other form of the whole human been protection system. Safety and protective textile refer to garment and other fabric related items are designed to protect the wearer from harsh environmental effects that may result in injury or death. Protective textiles are a part of technical textiles that are defined as comprising all those textile-based products which are used principally for their performance or functional characteristics rather than their aesthetic or decorative characteristics.Protective clothing is manufactured using traditional textile manufacturing technologies such as weaving, knitting and non-woven and also by specialized techniques such as 3D weaving and braiding using natural and man-made fibers. Today, the hazards that we are exposed to, are often so specialized that no single type of fabric will be adequate for protection. Extensive research is being done to develop protective clothing for various regular and specialized civilian and military occupations [1].

Textile materials play an important function in the development of a range of protective products. The introduction of new materials, the improvement in production techniques and fiber properties, and the use of more accurate and comprehensive testing have all significant influence on advancing fibers and fabrics for different applications [2].Fabrics can be constructed in a variety of ways, ranging from the matting together of fibrous materials to the intricate interlacing of complex yarn system.Each of textile techniques represents a very specific architecture of fibers, which can be used to create a wide variety of materials for design.

Utility characteristics are changes in the fit, comfort, and wearing functions of the garment when the fabric engages a mechanical thermal, electrical, or chemical force during the utilization of the garment. The two major types of utility characteristics are transmission and transformation. A transmission characteristic transmits mass or energy through the fabric.

Transmission characteristics include:

- Air permeability (includes all gases and vapor)
- Heat transmission (thermal conductivity)
- Light permeability
- Liquid transmission
- Moisture transmission
- Radioactivity transmission

Water transport properties of fabric and clothing are important, especially for clothing worn under hot and humid conditions or under conditions for high physical activity, when evaporation of perspiration is a major means of body cooling. The ideal fabric should prevent the accumulation of perspiration on the human skin so as to keep it dry by allowing the respired body water to flow to the outer layer of clothing.

Considering the movement of liquid, water through a fabric, two comfort aspects may be identified. First is water from an external source, e g rain, should be prevented from reaching the body, an aim that is achieved by using a water-resistant barrier [3]. On the other hand, water generated at the body surface as perspiration should be removed as quickly and as efficiently as possible if comfort is desired, a process that is encouraged by absorption within a body-covering. Both mechanisms are generally needed simultaneously although two requirements are diametrically opposite. Moisture management property is an important aspect of any fabric meant for apparels, which decides the comfort level of that fabric. Every human being sweats during different kinds of activities. An important feature of any fabric is how it transports water out of the body surface so as to make the wearer feel comfortable [4].

In order to keep the wearer dry and hence comfortable, clothing that is worn during vigorous activity, such as sports clothing, has to be able deal with the perspiration produced by such activity. Secondly after the activity have ceased, there is a need for the moisture that is contained in the clothing layer next to the skin to dry out quickly. This ensures that the wearer does not lose heat unnecessarily through having a wet skin. Some workers also consider that the extent to which the wet fabric clings to the skin is also important to the comfort of a garment.

Wetting and wicking are important phenomena in the processing and applications of fibrous materials. Various aspects of liquid–fiber interactions such as wetting, transport, and retention have received much attention both in terms of fundamental research and for product and process development [5]. In fiber composites, the performance of the composites is governed by the adhesion between the fibers and resin binders. The adhesion between the fibers and resin is influenced by the initial wetting of the fibers by the resin as this decides the subsequent resin penetration between the fibers and voids content.

Wetting of a fibrous assembly affects many manufacturing processes, as well as the end use performance of materials. Wetting is a complex process complicated further by structure of the fibrous assembly e.g. yarns, woven/nonwoven/knitted fabrics, and pre-forms for composites.

There is clear distinction between two terms that are sometimes used interchangeably, 'wetting' and 'wettability'. The wetting of a solid surface is understood to be the condition resulting from its contact with a specified liquid under specific conditions. Wettability is the potential of a surface to interact with liquids with specified characteristics [6].

According to Harnett and Mehta [7], 'wettability' is the initial behavior of a fabric, yarn, or fiber when brought into contact with a liquid. It also describes the interaction between the liquid and the substrate prior to the wicking process. For a liquid to move in a fibrous medium, it must wet the fiber surfaces before being transported through the inter-fiber pores by means of capillary action. While the interactions of molecules in the bulk of a liquid are balanced by an equal attractive force in all directions, the molecules on the surface of a liquid experience an imbalance of forces. Hence, there is presence of free energy at the surface of the liquid.

The term wicking has taken on many definitions and has been the subject of many research papers. In general, wicking takes place when a liquid travels along the surface of the fiber but is not absorbed into the fiber. Physically, wicking is the spontaneous flow of a liquid in a porous substrate, driven by capillary forces. This type of flow in any porous medium, caused by capillary action, is governed by the properties of the liquid, liquid-medium surface interactions, and geometric configurations of the pore structure in the medium [8] , [9].

Liquid properties such as surface tension, viscosity, and density, as well as the surface wetting forces of the fibers are known or can be experimentally determined, but the pore structure of a fibrous medium is complicated and much more difficult to quantify. The complexity of a fabric structure makes it impossible to measure an accurate pore structure. Furthermore, movement and interaction of a liquid through pores can cause both shifting of fibers and changes in pore structure.

“Wickability", is the ability to sustain capillary flow, whereas wettability describes the initial behavior of a fabric, yarn, or fiber when brought into contact with water. While wetting and wicking are still argued to be separate phenomena, they can be described by a single process– liquid flow in response to capillary pressure [10].

More completely, in the absence of external forces, the transport of liquids in a porous media is driven by capillary forces that arise from the wetting of the fabric surface. Because capillary forces are caused by wetting, wicking is a result of spontaneous wetting in a capillary system. Hence, they are coupled and one cannot occur in the absence of the other.

Capillarity describes the phenomenon when liquids in narrow tubes, cracks, and voids take on motion caused by the surface tension of the liquid. Capillarity is based on the intermolecular forces of cohesion and adhesion. If the forces of adhesion between the liquid and the tube wall are greater than the forces of cohesion between the molecules of the liquid, then capillary motion occurs. This flow is similar to other types of hydraulic flow in that it is caused by a pressure difference between two hydraulically connected regions of the liquid mass [11]. The direction of flow is such as to decrease the pressure difference. Flow would cease when the pressure difference became zero. According to the laws of capillarity, fluid flow would be faster in a void with a large capillary radius than that in one with a small radius. Though that may be true, the smaller radius capillary can transport moisture to a greater height.

Unlike a capillary of a given dimension, the capillaries that constitute the flow boundary in a yarn are made up of a distribution of pore radii. Due to the mechanisms of capillarity, the moisture front moves from the larger pores to the smaller pores as height increases. This would indicate that the moisture flows from a region of low capillary pressure to a region of high capillary pressure. In general, the moisture begins in all the pores, but can travel only to certain heights in the larger pores where it then migrates to the smaller pores. So as the height increases, moisture held in the yarns of a fabric decreases because all pores are not filling. If the pores or capillaries do not fill, then they do not contribute in the transport or wicking of the moisture.

In the experimental part of this work, Fabric water repellency, fabric wetting and fabric wicking for some fabric samples with various materials and construction will be tested.

II EXPERIMENTAL

In this study 45 fabric samples were executed in the workshop of the Department of Spinning, Weaving and Knitting at the Faculty of Applied Arts, these samples are different in materials and fabric structures.

2.1. Samples Specifications

The warp thread was of 50/2 cotton material for all samples, while three different weft materials were employed, they are cotton 100%, polyester 100%, and 50% cotton, 50% polyester, all with a yarn count of 30/1.The warp setting was 36 threads per cm., while three settings were employed for weft yarns they were: 20, 24, 28 wefts per cm.. Five fabric structures were used for fabric samples these are: plain 1/1, basket 2/2, twill 2/2, twill 3/1 and satin 4.

2.2. Laboratory Testing

Laboratory and experimental testing for samples were performed at the Textile Testing Lab. at the Faculty of Applied Arts, Helwan University. All tests were carried out under standard conditions of temperature (20°C ± 2) and relative humidity (65% ± 2%) according to the American Society for Testing Materials (ASTM), and British Standards (BS).

2.2.1. Water repellency test (spray test)

The spray rating test is used to measure the resistance of a fabric to surface wetting but not to penetration of water. It is therefore a test which is particularly used on shower proof fitness. In the test three specimens are tested, each one 180mm square. Each specimen in turn is held over a 150mm diameter embroidery hoop which is mounted at 45º to the horizontal. A funnel which is fitted with a standard nozzle is held 150mm above the fabric surface. Into the funnel is poured 250ml of distilled water at 20º C to give a continuous shower onto the fabric. After the water spray has finished the hoop and specimen are removed and tapped twice smartly against a solid object on opposite points of the frame, the fabric being kept horizontal. This removes any large drops of water. The fabric is then assigned a spray rating as shown in table (1), either using the written grading or from photographic standards (American Association of Textile Chemists and Colorists scale).

Table (1) represents standard spray test ratings

Rating	Classification	Description
100(ISO 5)	No sticking or wetting of the upper surface.	Excellent
90(ISO 4)	Slight random sticking or wetting of the upper surface.	Very Good
80(ISO 3)	Wetting of upper surface at spray points.	Good
70(ISO 2)	Partial wetting of whole of upper surface.	---
50(ISO 1)	Complete wetting of whole of upper surface.	---
0	Complete wetting of whole of upper and lower surfaces.	---

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2.2.2. Wettingtest

Wettability is defined as the time in seconds for a drop of water or 50% sugar solution to sink into the fabric. Fabrics that give times exceeding 200s are considered un-wettable.In the test the specimen is clamped onto an embroidery frame 150mm in diameter so that it is held taut and away from any surface. A burette with a standard tip size (specified in the standard) is clamped 6mm above the horizontal surface of the sample. The fabric is illuminated at an angle of 45º and is viewed at 45º from the opposite direction so that any water on the surface reflects the light to the viewer. At the start of a test a drop of liquid is allowed to fall from the burette and the timer started. When the diffuse reflection from the liquid vanishes and the liquid is no longer visible, the timing is stopped. Five areas on each specimen are tested, three samples in all, to give a total of 15 measurements.

2.2.3. Horizontal wicking test

The AATCC horizontal wicking test method (198-2011), measures the transport rate of liquid along and through the horizontally aligned fabric specimens. A volume of water is deposited with a burette mounted above a fabric sample, which is mounted to a beaker using an embroidery hoop. The rate of horizontal wicking is visually observed and manually timed, measured, and recorded.This method is primarily applicable to fabrics that absorb the full volume of the test liquid, without pooling on the surface or allowing dripping. If the full volume of the test liquid is not available to measure the wicking rate, inconsistent results should be expected. Hence, the results obtained on fabric that fully absorb the test liquid cannot be compared with those obtained on fabrics that do not. In addition, the movement of liquid within a fabric may be influenced by fiber content, fabric construction, mechanical or chemical processing or a combination of these.This method evaluates the wicking ability of horizontally aligned test specimens to distilled or deionized water. In this test, wicking may be influenced by the properties of the test liquid, but not by gravity.

III RESULTS & DISCUSSION

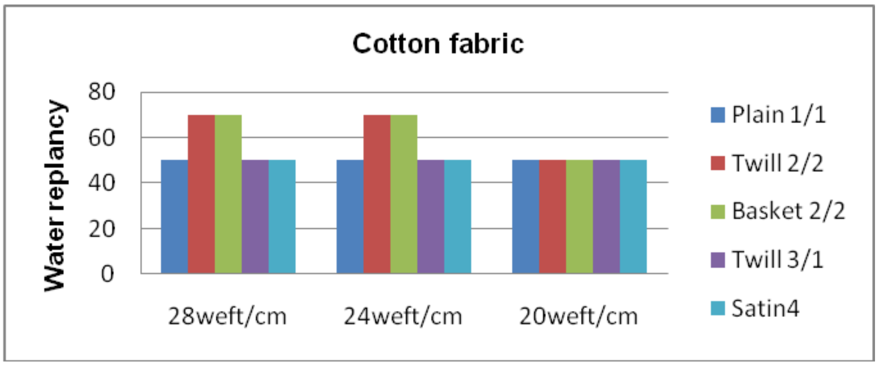

Fig. (1) The effect of weft densities on water repellency for all weaves structure

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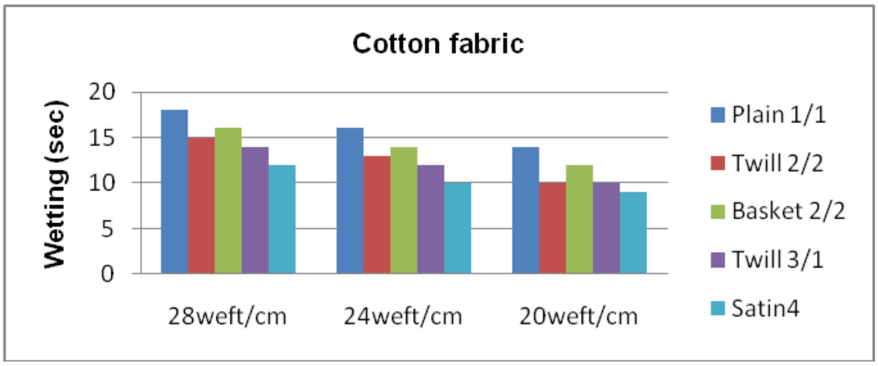

Fig. (2) The effect of weft densities on fabric wetting for all weaves structure

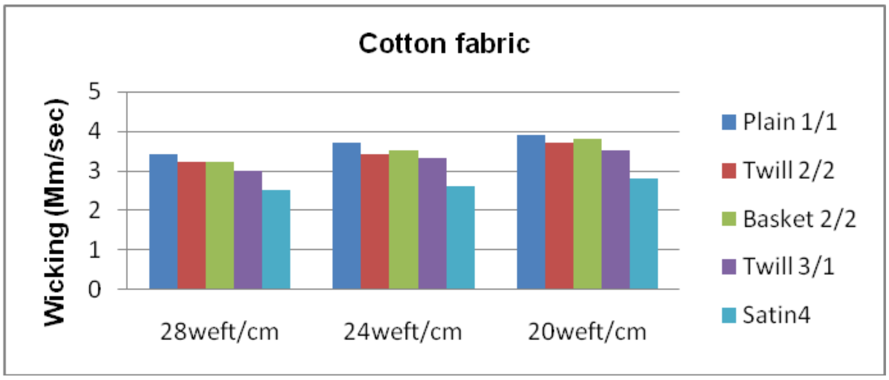

Fig. (3) The effect of weft densities on fabric wicking for all weaves structure

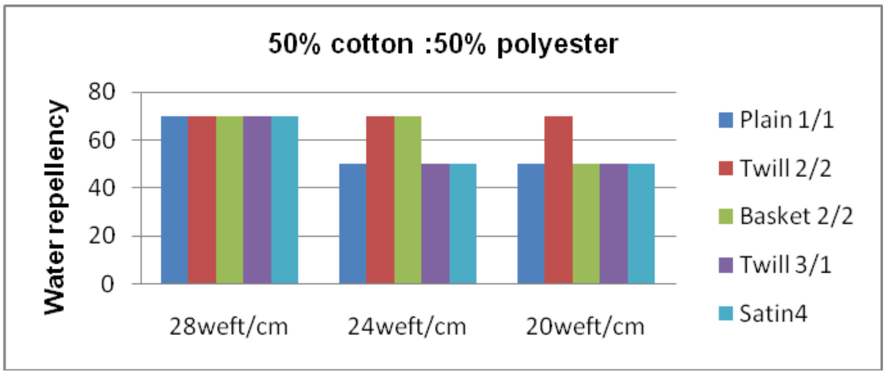

Fig.(4) The effect of weft densities on fabric water repellency for all weaves structure

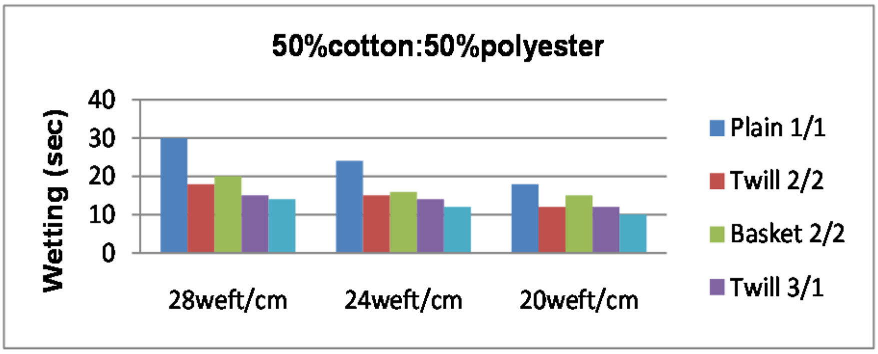

Fig. (5)The effect of weft densities on fabric wetting for all weaves structure

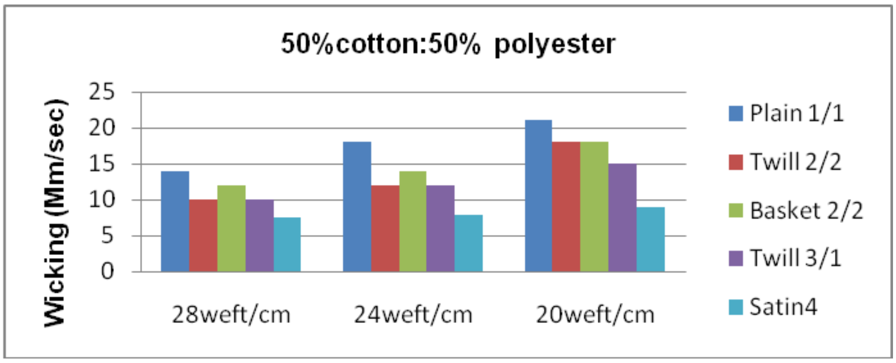

Fig. (6) The effect of weft densities on fabric wicking for all weaves structure

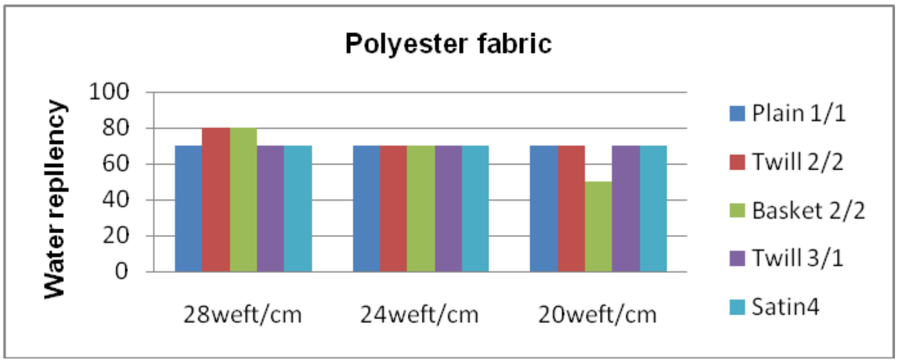

Fig. (7) The effect of weft densities on fabric water repellency for all weaves structure

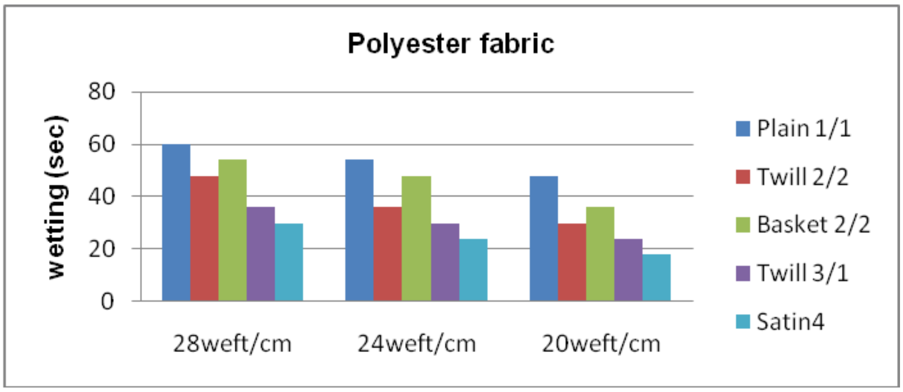

Fig. (8) The effect of weft densities on fabric wetting for all weaves structure

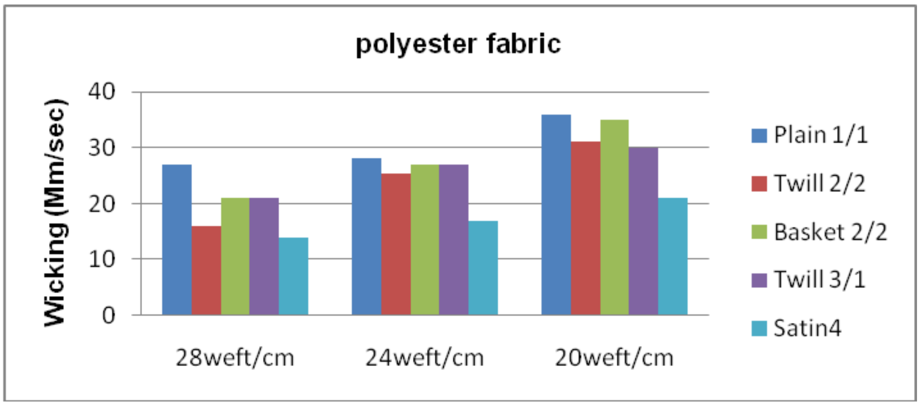

Fig. (9) The effect of weft densities on fabric wicking for all weaves structure

From the above figures we can see that:

Fig. (1) which represents the relationship between weft density and fabric water repellency for different fabric structures, indicates that the rating of water repellency of a 100% cotton fabric with different fabric structures is between 50 to 70, which indicate almost a whole wetting of upper surface. This result is due to the hygroscopic property of cotton fiber which leads to water absorption in cotton fabric in general. From this figure we can see that fabric structure has no great effect on water repellency.

Fig. (2) which represents the relationship between weft density andfabric wetting for different fabric structures, indicates that cotton plain 1/1 weave has the highest wetting rate. This result is due to the increasing of interlace points between warp and weft yarns inside the fabric which leads to a compact structure that able to keep more water inside the fabric. Satin 4 weave gave the lowest value among all samples for wetting rate, this may be due to the nature of the structure which is in a more loser condition than other structures.

Fig. (3) which represents the relationship between weft density and fabric wicking for different fabric structures, indicates that plain 1/1weave structure made of cotton fabrics has the highest horizontal wicking rate. This can be attributed to the fact that every intersection point acts as a routing point to the flow of the water by capillary action, which in turns is translated in higher wicking rates especially with narrow pores of the compact structure.Satin 4 gave the lowest value among all samples; this may due to the larger spaces between yarns inside the satin lose structure.

Fig. (4) represents the relationship between weft density and fabric water repellency for different fabric structures, we can see that the rating of water repellency of a 50% cotton: 50% polyester fabric with different fabric structures is between 50 to 70.This result may be due to the hygroscopic property of cotton fibers which leads to water absorption.It was also found that twill 2/2 structure gave a high repellency value at all fabric densities, but generally we can see that fabric structure as mentioned above has no great effect on water repellency.

Fig.(5) which represents the relationship between weft density and fabric wetting for different fabric structures, indicates that plain weave structure recorded the highest wetting rate, and satin structure has the lowest wetting rate.This result may due to the nature of plain weave with more compact structure and this may increase the ability of fabric to absorb and keep more water inside the structure.

Fig. (6) which represents the relationship between weft density and fabric wicking for different fabric structures, indicates that plain weave fabric structure recorded the highest horizontal wicking rate and satin structure has the lowest horizontal wicking rate. As plain weave has one intersection every one threads and satin structure has one intersection every four threads,it can be observed that the wicking value increases, when the number of intersections increases.

Fig. (7)represents the relationship between weft densities and fabric water repellency for different fabric structures with wefts of 100% polyester. It also can be seen that in general fabric structure has no great effect on water repellency, this is agrees with the results of both fig. (1) and fig. (4).

From fig. (8) which represents the relationship between weft densities and fabric wetting for different fabric structures, it is clear that plain weave recorded the highest fabric wetting rate and satin structure recorded the lowest fabric wetting rate when was compared to all weave types.In general, it was found that as weft densities decreases, the wetting rate decreases for all fabric structures.

From fig. (9) which represents the relationship between weft densities and fabric wicking for different fabric structures, it is clear that plain weave recorded the highest fabric wicking and satin structure recorded the lowest fabric wicking rate when compared with all weave types.It was found that in general as weft densities decreases, wicking rate value increases.

IV CONCLUSION

As the main idea of this work is to find out how fabricparameters affect liquid transmission properties in order to control the transfer of liquids through fabrics and clothes, experimental have introduced some related results. It was found that fabric structure has no great effect on fabric water repellency although twill 2/2 and basket 2/2 gave a little higher value among other tested samples especially with 100% polyester.It was found that fabric structure has a clear effect on fabric wicking. Plain 1/1 fabrics gave the highest values especially with 100% cotton, while satin 4 gave the lowest values especially with blended fabrics; this means more protection against liquid transfer.Both fabric yarn densities and fabric structure have a remarkable effect on fabric wetting and wicking. It was clear that as yarn densities increases, the fabric wetting increases. Plain 1/1 structure gave the highest value among all other samples especially with polyester fabric, while cotton satin 4 gave the lowest value, this indicates that plain 1/1 gives more protection for liquid transfer as it takes longer time to absorb liquids.Summary of the results suggested that plain 1/1 structure of cotton fabric is the best to give a better protection against liquid transfer. Twill 2/2 and basket 2/2 structures also gave good results against liquid transmission. Cotton material seems to be the most protective material of all other materials in this study.

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