The effect of beating-up mechanism type on the woven terry towels properties

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Abstract
The quality of woven terry textiles is a phenomenon that necessitates the simultaneous achievement of various qualities, including water absorption and abrasion resistance. We will study the impact of some variables on the performance of terry towel textiles in this study, including weft density, weft count, and beating-up mechanism. Terry fabrics are made up of loops that may absorb a large amount of water. Weaving or knitting can be used to produce it. Towels are woven on looms with two linear warp beams through which the weft is fed horizontally

Terry cloth is a thick, soft, and absorbent fabric that is commonly used for washcloths and towels. Certain clothes, such as robes and some athletics, are also made from it. Terry cloth is created in the same way as other fabrics, but the pile is shaped into loops that flow away from the base during the production process. Cotton or linen can be used to make terry cloth.

Terry towels are defined as woven fabrics with loops on the textile fibers' surface. Pure cotton yarns are usually applied as raw materials, with a few quantities of blending yarns or chemical fibers yarns to be added in to attain the quality of the textile product. The influence of structural factors and their effect on the quality of the textile product during the production stages is studied. The appropriate parameters for the mechanical sets of the machine during the manufacture of terry fabrics must be changed to get the optimal characteristics.

Keywords:
Terry towels properties, Water absorbency, Abrasion resistance, Beating-up mechanism.

1-Review of literature

1-1. Introduction:

Terry weaving is seen as a later stage in the evolution of the woven material of Turk Fabric', Turkish Toweling' or Turkish Terry' is still used to describe terry toweling. [1]

Because of their exceptional mechanical and functional features, such as softness, compressibility, dimensional stability, and water absorption, Woven Terry fabrics have a major role in the market for toweling fabrics. The word 'terry' comes from the French word 'tirer,' which means 'to pull out,' and it is referring to the pile of loops, the hand-pulled pile

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loops that form absorbent historical Turkish toweling. [2,3]

A towel loom was used to weave this. There are two types of knitting and woven towels, depending on the weaving method; there are sofa towels, towel covers, pillow towels, and face towels, depending on the purpose; and there are terry cloths for manufacturing clothes.

Terry surface is heavy, soft to the touch, has a high absorption capacity, it is durable, and provides warmth. They can be plain white, floral, silk, plain, or jacquard printed towels, they are all popular colors, to be used when scrubbing directly on the human body.

The Research problem

-It turns out that there are not enough studies about the effect and importance of the beat- up force on properties of the terry fabrics with changing the weft density and using different weft counts and their relationship to the functional performance of the terry towels.

- Customers are looking for more mechanical comfort from towels as they become more quality concerned.
- Because of the lack of standard technology and test procedures, these characteristics are not assessed in normal production operations.
- There is a need for high-quality toweling as a result of economic development and increased consumers' knowledge [4,5].

The importance of the research:

The purpose of this study is to produce samples of terry towel fabrics on two different machines with different beating-up mechanisms using variable weft densities and variable weft counts, also to study the effect of these variables on the characteristics of terry towels and obtain the best variables to produce the best fabrics of the highest quality.

Research objectives:

* To improve the properties and quality of the terry fabrics produced on the machines by controlling the settings of the machines.

To optimize woven terry towel fabric manufacturing variables.*

*To achieve maximum quality by optimizing the factors that affect water absorbency and abrasion resistance of woven terry textiles.

*To select the optimal type of beating mechanism and the best setting for the manufacturing machine.

*To identify the best and the worst fabric sample according to the functional performance of the terry towels.

Research hypotheses:

- The change in the mechanical settings (beating mechanism type) of the textile machine affects the functional properties of the terry fabrics produced.
- The use of different densities affects the properties of the terry fabrics produced.
- Influencing of changing the weft count with the beating force and the effect on the produced fabrics.

Research Methodology:

The analytical practical methodology.

1-2. Terry Pile

The terry pile is a warp pile structure with loops generated by some warp ends on its surface. Terry piles are made up of one weft thread series and two warp thread series, one for the ground and the other for the pile. The ground cloth is made up of the ground warp and the ground weft. The loops made by the pile ends which are being held in place by this ground cloth, which allows the looped section of the fabric to protrude. Single-sided (face) or double-sided (back) loops are available (face and back). The many types of terry structures are shown schematically in Fig.1. [6].

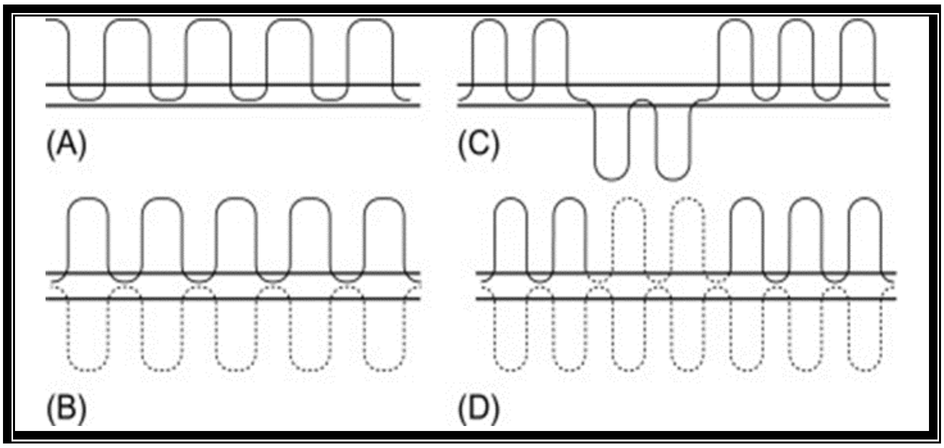


Fig. (1) The different types of terry pile

1-3. Classification of Toweling Fabrics:

The following are the two primary categories of terry fabrics:

Toweling fabrics are classified in a variety of ways, as shown in Fig. (2). The focus here is on a specific type of looped toweling fabric known as woven terry fabrics.

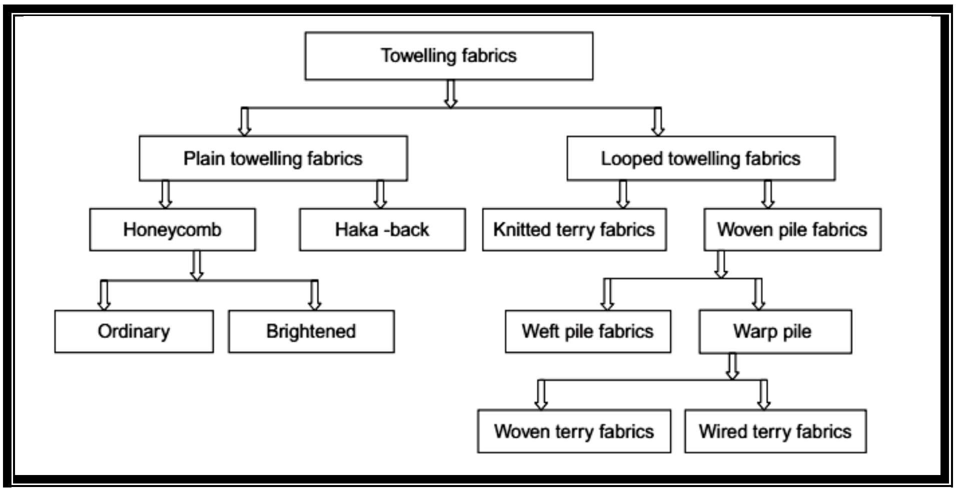


Fig. (2) Classification of toweling fabrics.

1-4. Methods of producing pile fabrics from warp and weft:

1-4-1. Warp Pile Fabrics:

Warp yarn piles or loops run lengthwise across the cloth in these fabrics. Weaving warp pile fabrics require two sets of warp yarn, namely pile and ground warp, as well as one set of weft yarn. The pile warps are woven under low tension from a variety of weaver's beams, similar to

the ground warp. There are two ways to make warp pile fabrics.
1. The terry fabric is made using two or three warp beams and a single weft system or two weft systems, in a first way. The pile isn't cut in any way. This class is widely used in the towel manufacturing industry.
2. Wires are inserted in a certain sequence by a special move into the shed generated by lifting the pile warp only, in the second way, in addition to typical picks inserted by a shuttle. After several revolutions of the main shaft, these wires are drawn out of the fabric, generating the warp pile on the fabric, using the same mechanism.

1-4-2. Weft Pile Fabrics:

Velveteen is a fabric with a weft pile. Two series of weft threads and one series of warp threads are used to create these fabrics. Weft threads produce loops; hence they require a greater proportion of weft threads than warp threads in their manufacture. The weft density of these fabrics is quite high, reaching up to 200 picks per cm in the finest fabrics. Low warp sett and higher warp tension can be used to achieve high weft density. Positive shedding mechanisms are required when the warp tension is high. Using reeds with particularly deep dent wires, high-speed automatic looms can make low- and medium-quality cloth. These fabrics have pick densities ranging from 50 to 100 per centimeter. Weft pile fabrics do not have yam loops, unlike warp pile fabrics.
They have long weft floats that can be clipped or uncut. Cotton is mostly employed in weft pile structures. Fig (3).

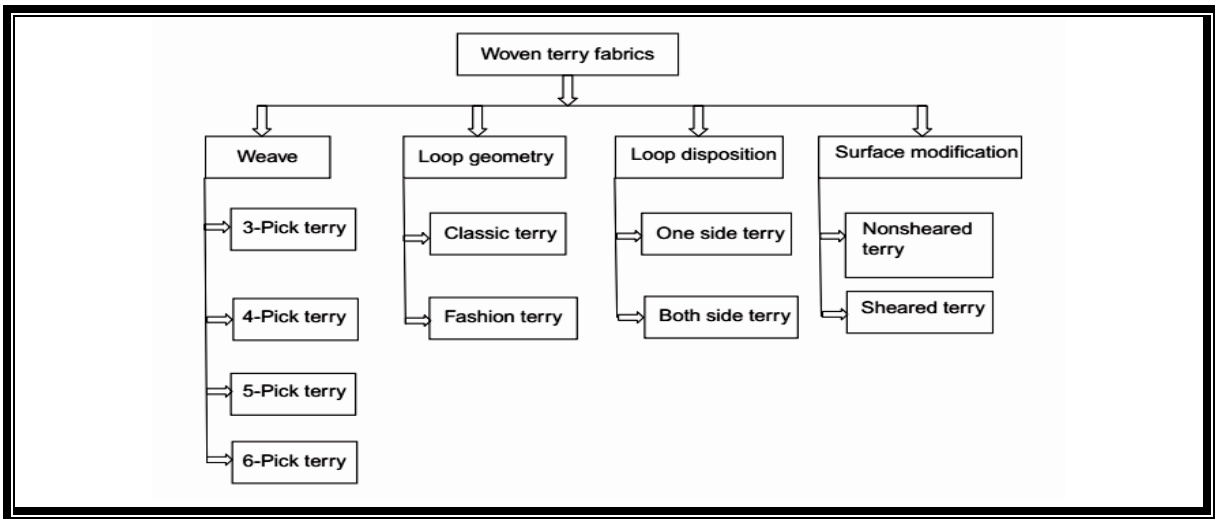


Fig. (3) Classification of woven terry fabrics.

1-5. Performance properties of terry towels

The performance of terry fabric may be measured by using absorption rate includes the fabric absorbing water, the dynamic water absorption, and the overall water retention capacity of the fabric [7]. The pile warps can produce the pile on one or two faces. Two-sided pile terry textile is more preferred than one-sided pile terry textile because one-sided has poor water absorption [8].

Towels are required to have characteristics such as high hydrophobicity, high wet tenacity, high color fastness, soft handling, and anti-allergenic properties. Cotton yarns are the most often used fiber in terry towels because they give all of the above-mentioned characteristics. Towel fabrics manufacturing also include maize, modal, Lyocell, bamboo, seaweed, and soybean, in addition to cotton. [9,10]

Formal study on terry fabric's water absorption began in the first part of the twentieth century1-3, with the theoretical basis of absorbency, absorption theory, and acceptable water absorption methods. [11,12]

In terms of water-related terry-woven fabric utilization, towels are the most common textile design. Users like ready-made robes and towels to be soft and refreshing, with a light and soft construction, to stay dry by fast transferring water and moisture from the body, and to be healthy and organically formed. As a result, comfort, which is an important quality for all textiles, is also a critical requirement for terry textiles in water-related applications. Therefore, terry textiles, like towels, should have special comfort characteristics. Air permeability, water vapor permeability, liquid transfer velocity, drying time, and water absorption are all comfort characteristics that will stand out in such textiles. [13]

The fabric system must have specific comfort characteristics to provide more comfort. Heat and moisture transfer, air permeability, heat retention capability, and electrification tendency are the essential characteristics [14].
Besides these parameters; the comfort parameters change by the usage, purpose, and environment of the towels and bathrobes. These include water, vapor, and air permeability; moisture permeability; Abrasion resistance and water absorption; no feeling of wetness; drying period; liquid transfer velocity; and being non-allergic, soft handling.

2 – Experimental Work:

The experimental program consists of two main parts:
1-The first part is the textile experiments where the research samples were produced.
2- The second part is conducting some tests on the research samples.

2-1 . Produced research samples:

In the experimental part of this study, twelve woven terry samples of different weft densities, weft count (Ne), and type of beating-up mechanism of production machine were produced. Usually, the structure of samples consists of three components, ground warp yarn, weft warp yarn, and pile yarn which form the terry woven fabric.

2-1-1. The specifications of ground warp, weft yarns:

-The specifications of pile and ground warp yarns are as follows:
The pile warp count is 24/2 Ne, 12 pile yarns/cm.
The ground warp count is 24/2 Ne, 12 ground yarn/cm, denting is 2 yarn/dent.
The warp density is 24 Ends/cm, and yarn type 100% cotton carded ring spun was used.
-The specifications of weft yarns are as follows:

Weft counts are 12/1, 16/1 Ne, Weft densities are 10,15,20 Picks/cm
and yarn type 100% cotton carded ring spun was used.

2-1-2. The specifications of produced fabrics:
Table (1) shows fabric specifications of woven terry fabrics:

Sample No.	Beating-up mechanism type	Weft count (Ne)	Weft density (picks/cm)
1	M	12/1	10
2	M	12/1	15
3	M	12/1	20
4	M	16/1	10
5	M	16/1	15
6	M	16/1	20
7	F	12/1	10
8	F	12/1	15
9	F	12/1	20
10	F	16/1	10
11	F	16/1	15
12	F	16/1	20

*M= Movable beating mechanism.
*F= Fixed beating mechanism.

Warps are arranged in a 1:1 pile and ground pattern across the cloth. Each ground warp yarn is joined by a pile warp yarn in a 1:1 warp sequence. Three wefts and four warp yarns make up the whole weave, which is made up of two warps (ground and loop).
The terry fabrics were woven at three different weft densities (10,15,20 picks/cm), two different weft counts (12/1 ,16/1 Ne), with loom speed (280 Rpm) and two different beating-up mechanisms of the production machine (Movable, Fixed).

2-1-3. Manufacturing Method of the Terry Fabrics:
The terry fabrics were produced on two different terry towels machines Vamatex ,SP1151es and Sulzer, Tps600 Terry Model.
These experiments were done at EL-FOWTY TEX Company for weaving in Mahlla, Egypt, and all tests were conducted in the laboratory of the Textile Consolidation Fund.

2-1-3-1. The Specification of the movable type of production machine:
Type of weaving machine is Vamatex , SP1151es , weaving machine speed is 280 rpm, cloth width is 240 cm, a width of the machine is 260 cm, loom height is 80 cm, max loom height is 110 cm, loom depth is 160 cm, shedding mechanism is electronic jacquard (Staubley – CX 870), take-up mechanism is electronic take-up roller, let-off mechanism is electronic let-off roller, picking method is a double flexible rapier, and year of manufacture is 2000.

2-1-3-2. The Specification of the fixed type of production machine:

Type of weaving machine is Sulzer, Tps 600 , weaving machine speed is 280 rpm, cloth width is 260 cm, a width of the machine is 280 cm, loom height is 90 cm, max loom height is 120 cm, loom depth is 170 cm, shedding mechanism is electronic jacquard (Staubley – CX 870), take-up mechanism is electronic take-up roller, let-off mechanism is electronic let-off roller, picking method is a double flexible rapier, and year of manufacture is 2002.

2-3. Test Methods:

*The measurement methods applied to the terry fabric samples are explained below:

2-3-1. Methods of measuring water absorbency properties:

2-3-1-1. Sinking time test:

The sinking time test was measured according to the stated method (En 14697: 2005 Annex B) **[15]**. Five specimens are tested, 10 *10 cm. The specimen is laid plain onto the distilled water surface as shown in Figure **(4)** and the time is recorded for how long time it takes before the specimen is completely immersed. An average of the time is calculated.

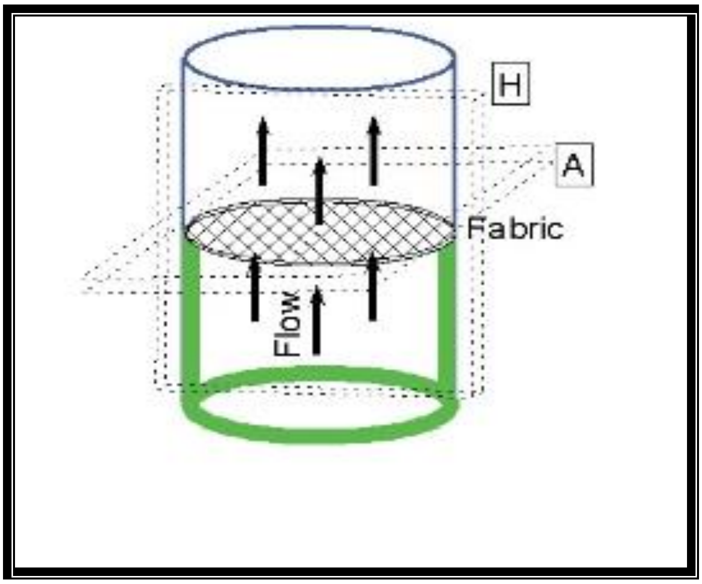


Fig (4) Flow cell to study the flow of water through a fabric.

2-3-1-2. Drop absorption time test:

The surface wetting properties of the fabrics were determined by a drop absorption technique. The wetting time test was measured according to the stated method (AATC 79-2007) **[16]**. A burette is placed 9.5 mm above. A 0.2 ml drop of distilled water was placed carefully on the fabric surface and covered with a petri-dish to prevent variations due to uncontrolled air movement. The time taken for the drop to disappear was adopted fig (5) as the drop absorption time, and the time is measured until the drop loses its specula reflection. This is the wetting time. An average time is calculated for the five specimens.

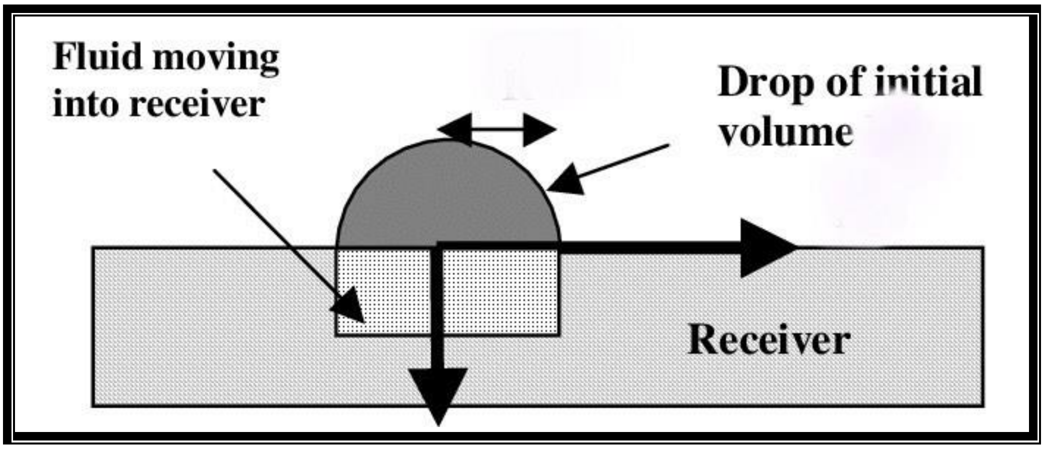


Fig (5) absorption time till the drop disappear.

2-3-1-3. Methods of measuring Abrasion resistance:

The abrasion resistance test was measured according to the stated method (ASTM D3884) as shown in fig (6).

By cutting ten square samples with side length about 15cm, five pieces for abrasion test with a hole (ø6mm) in the center, five pieces reserved for control. For specimens with a width of 125mm or more, sampling at a distance of 25mm from the cloth edge. For specimens with a width less than 125mm, sampling with the entire width. Test the prepared specimens in the standard atmosphere at a temperature of (21±1) ℃ and relative humidity of 65%±2% .

Weight Loss:

Compute weight loss, *L*, the weight loss of the required rotation cycle.

L = A – B

where:

A = weight of the test specimen before abrasion, mg.

B = weight of the test specimen after abrasion, mg.

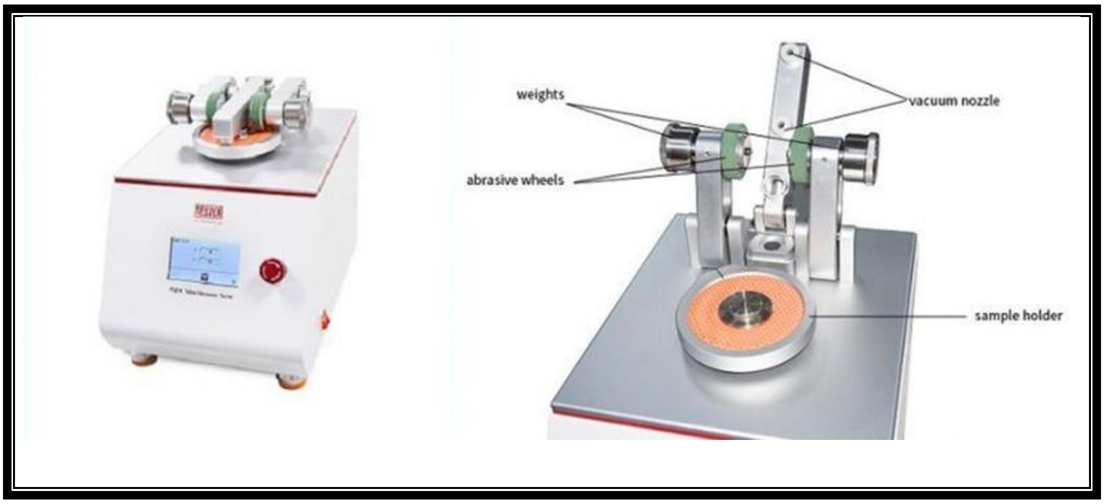


Fig (6) Taber abrasion tester

3. Results and Discussion

3-1. The results of the produced fabrics tests:

Table (2) shows the experimental analysis for water absorbency and abrasion resistance properties of the produced fabrics:

Sample No.	Water absorbency		Abrasion resistance
	Sinking time (sec)(-)	Drop absorption time (sec)(-)	Weight loss (%)(-)
1	25	15	0.7
2	35	50	1.0
3	30	46	0.5
4	30	48	0.7
5	37	59	1.7
6	33	50	0.6
7	24	40	0.7
8	42	108	0.8
9	26	45	0.5
10	37	75	0.7
11	50	110	1.3
12	45	95	0.7

3-2. The relationship between research variables and the different properties of samples:

3-2-1. Water absorbency properties:

The terry fabric, as well as its absorbent qualities, are clearly distinct from ordinary plain cloth. It's crucial to figure out what the essential fabric variable is so that you may change it to make highly absorbent cloth.

A time dependent water absorption property of terry fabric is known as the rate of water absorption. It is one of the most important properties of terry fabric which tells that how quickly a fabric can absorb water. Water absorption rate can be measured by various methods such as Sinking time test and Drop absorption time test, which results in that the higher rate of absorption, the less sinking and drop absorption time.

3-2-1-1. For Movable Mechanism:

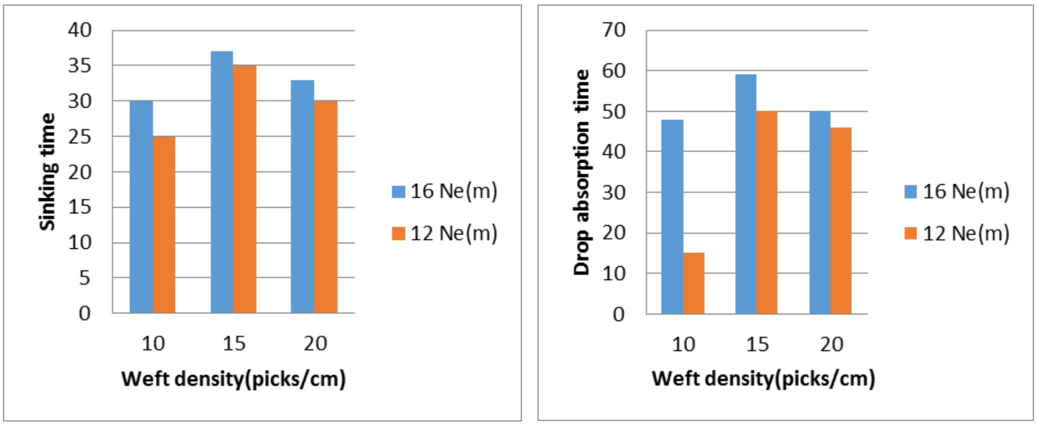


Fig (7) Water absorbency properties Movable Mechanism (Sinking time, Drop absorption time).

3-2-1-2. For Fixed Mechanism:

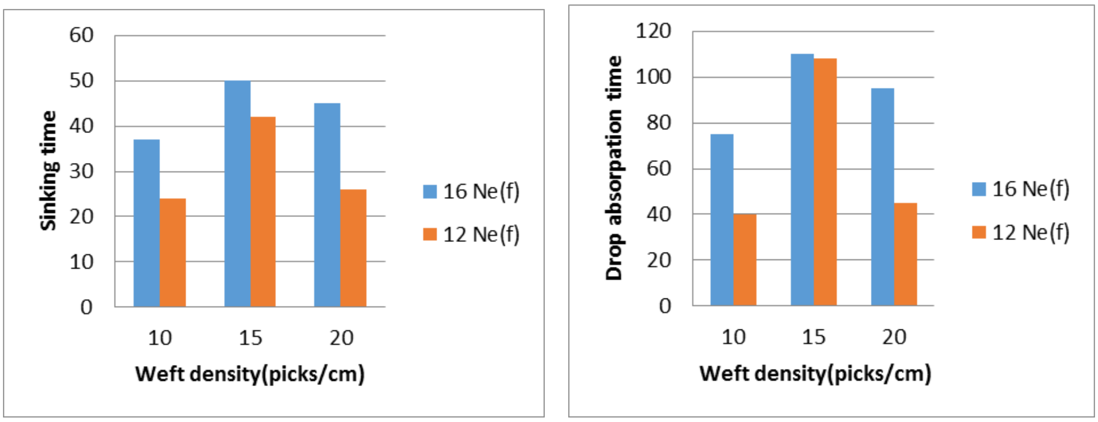


Fig (8) Water absorbency properties Fixed Mechanism
(Sinking time, Drop absorption time).

Which

Water absorbency property =1/Sinking time
=1/Drop absorption time

*From the previous results, it is clear to us that the highest water absorption rate was at a weft density (10 picks/cm) and then decreases at a weft density (20picks/cm), and the lowest water absorption rate is at a weft density (15 picks/cm) (medium weft density).

* Hence, we can clearly see that the water absorption rate decreases with the increase of weft density for the following reasons:

- This is because the less weft density product (10 picks/cm) has more air gaps and higher pile height, so it takes less sinking time and has a higher water absorption rate.
- We also find that the highest density product (20picks/cm) has the fewest air gaps and the lowest pile height, so it takes more sinking time and the water absorption rate decreases.
- As for the product with a medium density (15picks/cm), we notice an increase in the weft density, a decrease in the air gaps, and a decrease in the pile length. Therefore, we find that in this case this product has the lowest water absorption rate.

* We also find that the water absorption rate at weft Ne (12) is higher than weft Ne (16), and this is due to the use of thicker weft thread.

3-2-1-3. The difference between the two mechanisms:

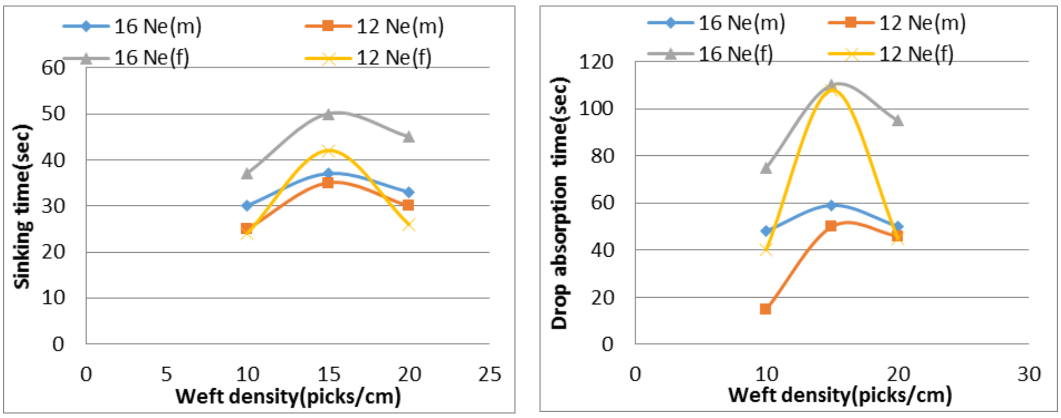
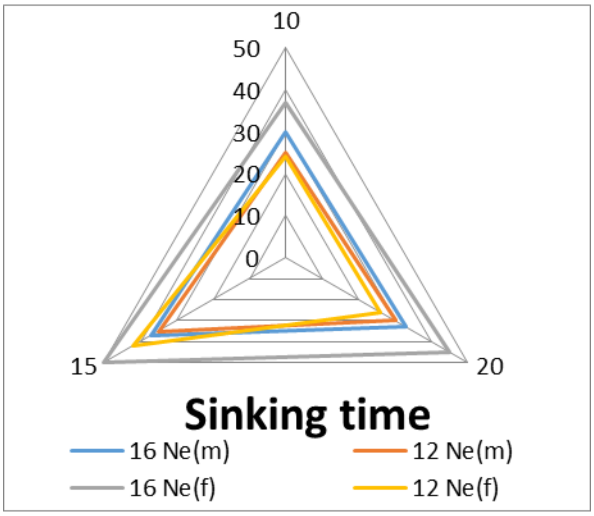


Fig (9) Water absorbency properties for both Mechanisms
(Sinking time, Drop absorption time).



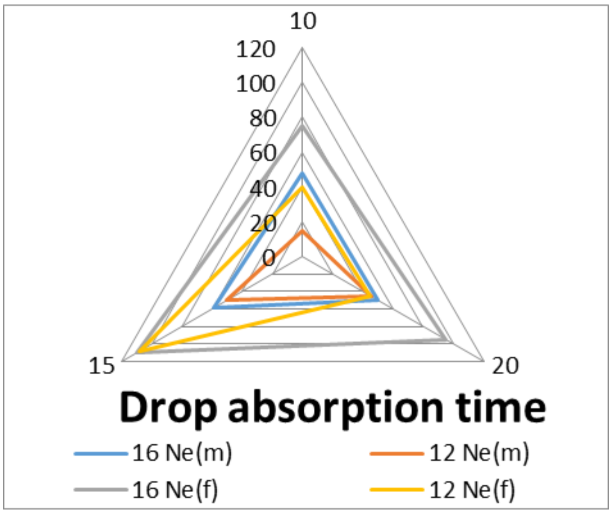


Fig (10) Radar chart of water absorbency properties

* As shown by previous results, the machine with a movable mechanism results the best water absorption rate products, but the lowest water absorption rate is from the machine with a fixed mechanism.
* From the above radar chart we conclude that when producing sample with the thickest thread (12Ne) and using a machine with a movable beating mechanism at the lowest weft density (10) , we get the best sample in terms of higher water absorption, higher production rate and lower production cost, but without being linked to the value of the weight per square meter.
And the worthiest sample with the thinnest thread (16Ne) and using a machine with a fixed beating mechanism at a medium weft density (15).
* The effect of weft density on water absorbency of fabric tested by the drop test method. It is clear that at the lowest weft density water absorbency is more. This is because the highest pile height values are thought to make more water penetration inside piles. The results show that the surface water absorption for less density and high pile height towels is better than that of the normal towels. It was concluded that the percentage of water absorption decreases with increasing warp and weft densities as the terry fabric structure becomes dense, whereas it increases with an increase in pile height because of the increased pile warp yarn surface area. The impact of pile density on fabric water absorption, it was discovered that when the pile height increases, the water absorbency increases as the weft density decreased. This is due to the fact that as the pile height increases, fewer piles form on the fabric's surface, as a result, the increased surface area is accessible for water absorption. [17]

3-2-2. Abrasion Resistance properties:

Abrasion resistance of woven fabrics is a complicated phenomenon that is influenced by a variety of elements, which may be divided into four categories: fiber, yarn, fabric characteristics, and finishing procedures. Some of these factors have an impact on the fabric's surface, while others have an impact on the fabric's interior structure. Surface abrasion is influenced by fiber properties such as cotton ratio and fineness, whereas structural abrasion is influenced by yarn and fabric parameters such as yarn count and interlacing coefficient **[18].**

3-2-2-1. For Movable Mechanism:

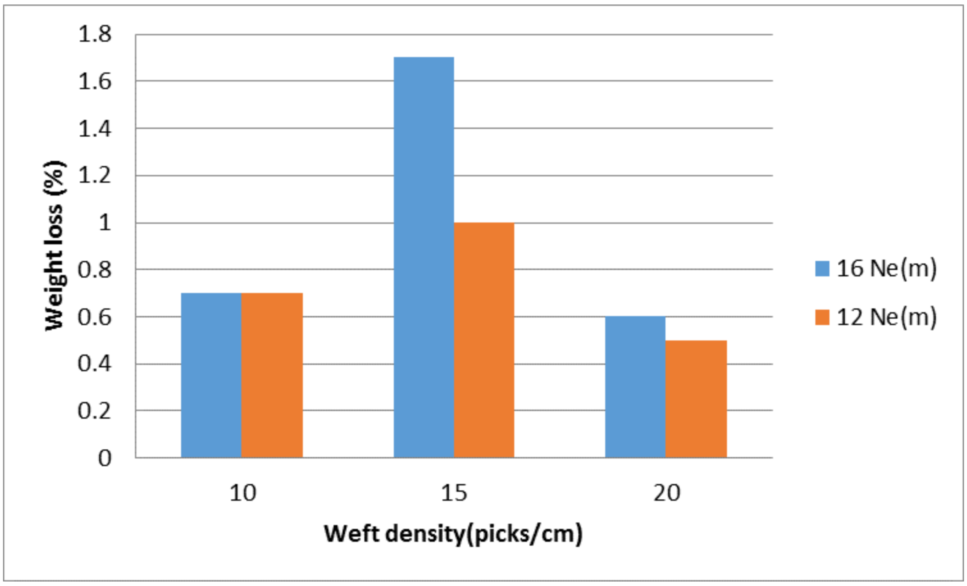


Fig (11) Samples Weight Loss for Movable Mechanism

3-2-2-2. For Fixed Mechanism:

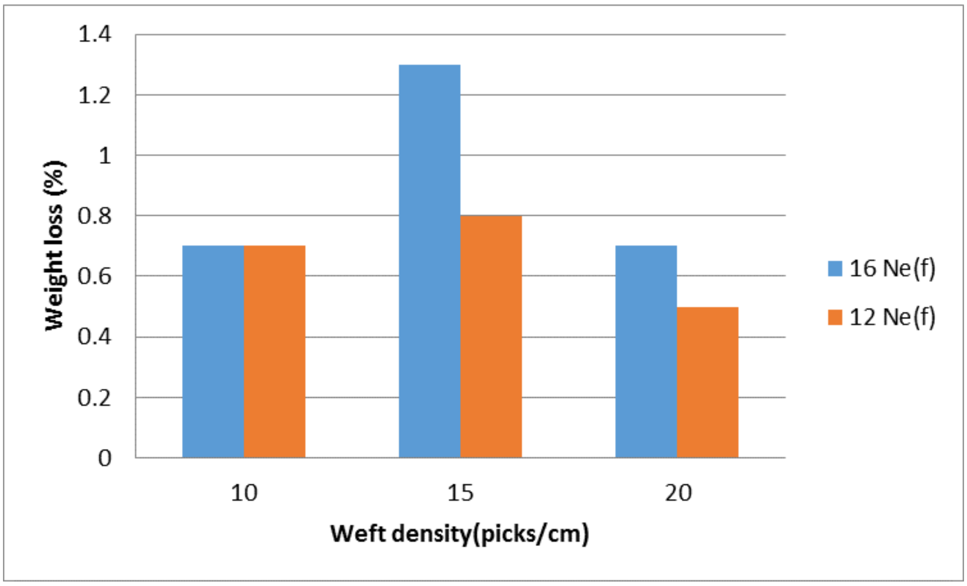


Fig (12) Samples weight loss for Fixed Mechanism.

Which

Abrasion resistance property=1/ Sample weight loss (%)

* It is apparent to us depending on previous outcomes, that the highest abrasion resistance was at a weft density (20 picks/cm) and decreases at a weft density (10picks/cm), and the lowest abrasion resistance is at a weft density (15 picks/cm) (medium weft density).

* As a result, it is obvious that the abrasion resistance increases with the increase of weft density for the following reasons:

- This is as a result of the fact that the less weft density product (10 picks/cm) has a higher pile height, so it is exposed to more abrasion, thus has lower abrasion resistance.

- We also find that the highest density product (20picks/cm) has the lowest pile height, and it is exposed to less abrasion so the abrasion resistance increases.
- As for the product with a medium density (15picks/cm), we notice an increase in the weft density, and a decrease in the pile length. Therefore, we find that in this case this product has the lowest abrasion resistance (the highest amount of weight loss).

* We've also discovered that the abrasion resistance at weft Ne (12) is higher than weft Ne (16), and this is due to the use of thicker weft thread which bears more abrasion.

3-2-2-3. The difference between the two mechanisms:

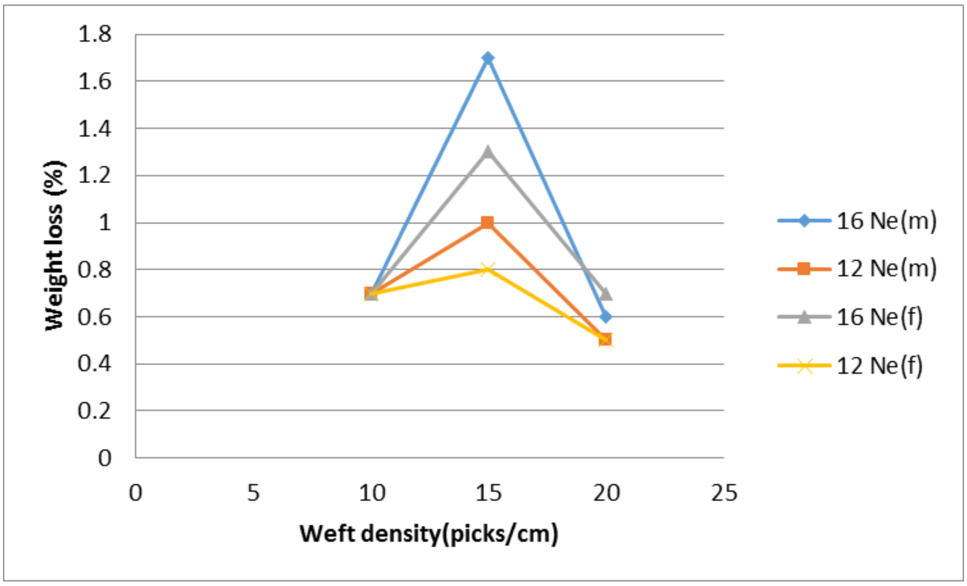


Fig (13) Samples weight loss for both Mechanisms.

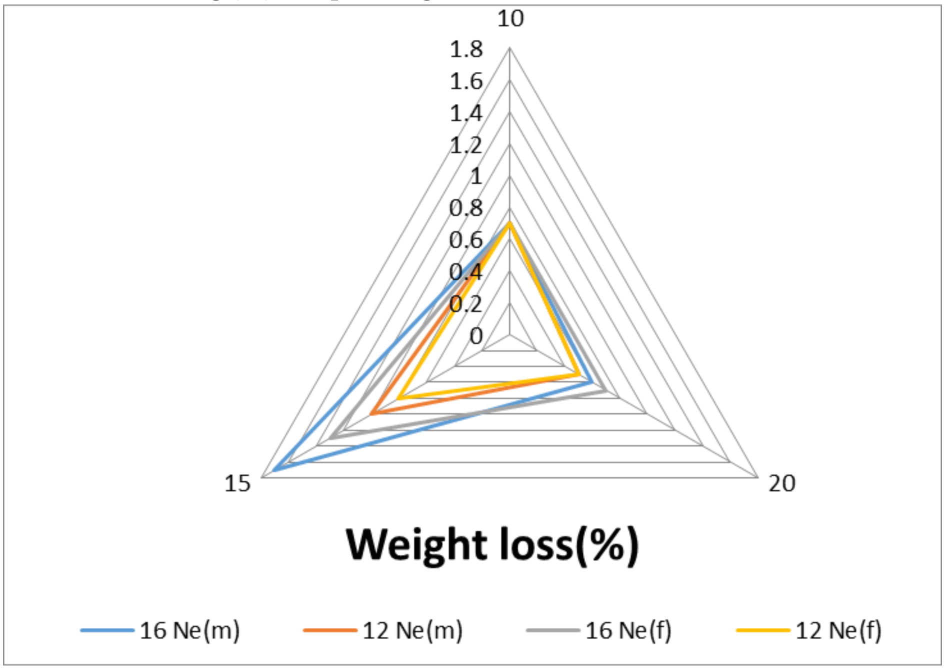


Fig (14) Radar chart of samples weight loss

* As illustrated by previous outcomes, the machine with a fixed chest mechanism results the best abrasion resistance products, but the lowest abrasion resistance is from the machine with a movable chest mechanism.

* Based on the abovementioned radar chart, we may assume that when producing samples with the thickest thread (12Ne) and using a machine with a fixed beating mechanism at the highest weft density (20), we get the best product in terms of higher abrasion resistance, and lower stress.
The worthiest sample with the thinnest thread (16Ne) and using a machine with a movable beating mechanism at a medium weft density (15).
* The percentage of fabric weight loss was used to assess the woven fabric's abrasion resistance. The abrasion resistance of woven textiles improves as weight loss reduces. The rate of weight loss in the textiles sample increased as the weft density increased, then it is reduced as the number of weft threads in the fabric structure increased. This is because the fabric tightness will rise as the fabric weaves elongation**. [19]**

3.3-Conclusions:

The following conclusions have been deduced based on the results of this study:

1. Optimization of major groups of woven terry fabric characteristics which are the water absorbency and abrasion resistance were studied; this method considers the end uses of the fabric by defining the aims and limitations of each property.
2. The research variables as weft densities (picks/cm), weft count (Ne) and beating-up force (N/beat) affect to a great extent on all the properties.
3. The weft densities, weft count and beating-up force that affect the quality of water absorbency and abrasion resistance are estimated and the results were graphically represented to obtain the targeted values of the selected properties for the studied woven terry fabrics.
4. The customer may select the best features that will result in the most efficient use of terry towels and modern construction parameters to reach the required quality of woven terry towel textiles.
5. With the help of radar chart, according to water absorption it was found that the best sample is No. (1) and the worst sample is No. (11), according to abrasion resistance it was found that the best sample is No. (9) and the worst sample is No. (5).
6. According to water absorption, the optimum sample has a lower weft density (10) and a thicker thread (12Ne) and using a machine with a movable mechanism, thus we can get the best product in terms of higher water absorption.
7. We produce twelve different samples of woven terry textiles with varied constructional variables in this study, but the current approach may be used for any type of fabric.

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