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EFFECT OF PILE AND GROUND CONSTRACTIONS ON MECHANICAL PROPERTIES OF VELVET FABRICS

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ABSTRACT

Textile fabrics are manufactured for many different end uses, each of which has different performance requirements. The chemical and physical structures of textile fabric determine how it will perform, and ultimately whether it is acceptable for a particular use. Fabric testing plays a crucial role in gauging product quality, assuring regulatory compliance and assessing the performance of textile materials. It provides information about the physical or structural properties and the performance properties of the fabrics.

Velvet fabrics occurs in every segment of the textile market such as clothing ,upholstery , auto motive industry , decorative textiles and special fabrics for each end use velvets will differ in fabric design , thus in price , aesthetics and properties , in order to satisfy specific market needs.

Owing to this it is very important to study the effect weave structure variation for each pile and the ground on the mechanical properties of velvet fabrics (tensile strength, tear strength, abrasion resistance). To enriching it and also improving its properties so that to meet the functional purpose it is produced for. Also for facing the world variables in textile market that cannot be penetrated or even to be dealt with, but through high quality.

The produced fabrics differ from each other in pile and ground construction; these fabrics were then tested for some essential functional properties which reflect to their end uses. The received results demonstrate that, there is an inverse relationship between number of pile tufts per unit and tensile strength and the ground weave plain 1/1 has recorded high rates to tensile strength in both direction, and to abrasion resistance.

Keywords: Face To Face, Ground, Mechanical Properties, Pile, Velvet.

I. INTRODUCTION

Velvet Fabrics made from both natural and manufactured fibers have been extensively used for clothing, decoration and industrial applications. The physical and mechanical properties of these fabrics are affected by the fiber type, yarn construction and fabric structure, as well as any treatment that may have been applied to the materials. A range of fabric performance parameters are assessed for different end-use applications [1].

1.1 Fabrics Mechanical Properties

The mechanical properties are important for all textile users including fabric processors, garment manufacturers, designers and customers [2].

Tensile strength properties are the most common Mechanical measurement on fabrics. It is used to determine the behavior of a sample while under an axial stretching load. From this, the breaking load and elongation can be obtained. The principle of the tensile strength test is simple: a test piece is held in two or more places and extended until it breaks. The tensile properties measured are generally considered arbitrary rather than absolute. Results depend on specimen geometry, the fiber type and arrangement, as well as the fabric structure [3].

Tear strength has certain features: a) the cloth fails by the breaking of the thread one at a time, or at least in very small groups .b) distortion due to skewing of the threads. c) The occurrence of slippage of one set of threads over the others [4].

Tearing occurs when stress imposed on a fabric result in a concentration of stress at a point, leading the individual to failure [5].

The main factors that affect tear strength are yarn properties and fabric structure. The mechanism of fabric tearing is different from linear tensile failure and relates to the ability of individual yarns to slide, pack together or 'jam' into a bundle, increasing the tearing force. Thus an open fabric structure contributes to more yarn sliding and jamming, and higher tear strength. An increase in yarn density in a woven fabric will decrease the tear strength of a fabric as yarns are broken individually as they have more restriction, preventing yarn slide. A tightly mounted fabric is easier to tear than a slackly mounted fabric because the tear force propagates from yarn to yarn as the linear force in the yarn restricts yarn slide. Staple yarn has a lower tear strength compared to filament yarn. In a trapezoid tear test, an increase in ends and picks increases tear strength. Tear resistance can also be affected considerably by the speed of the test [2].

Abrasion is the physical destruction of fibers, yarns, and fabrics, resulting from the rubbing of a textile surface over another surface. Abrasion resistance of the textile materials is very complex phenomenon and affected by many factors, mainly classified as follows: Fiber type, yarn, fabric properties and finishing processes. Some of these parameters affect fabric surface whereas some of them has an influence on internal structure of the fabrics. For example the removal of the fibers from yarn structure is one of the reasons of the abrasion [6].

Yarn structure, count, twist and hairiness are the main properties which affect abrasion of the textile fabrics. Increasing linear density at constant fabric mass per unit area increases the abrasion resistance of the fabrics.

Fabric construction, thickness, weight, the number of yarn (thread density) and interlacing per unit area are the fabric properties affecting abrasion. Long yarn floats and a low number of interlacing cause the continuous contact area of one yarn strand to expand and this facilitates the yarn to lose its form more easily by providing easier movement as a result of the rubbing motion [3].

1.2 Velvet Fabrics Weaving Principle

Velvet fabrics produced by face to face method need two sets of warp threads (one for the pile and the other for the ground) and one set for weft [7].The main function of the ground yarn is to support the structure and create a base which meets tensile and seam fatigue requirements. The pile yarn is the main feature and must meet aesthetic design, color and the main technical requirements such as light fastness, abrasion, crush resistance, tuft adhesion [8].

Face-to-face weaving represents an alternative method of manufacture of the cut warp pile fabrics in which two cloths are woven simultaneously. Two separate ground fabrics with a space between them, each with its own warp and weft, are woven on the unstitched double-cloth principle, while the pile warp threads interlace alternately with the picks of both fabrics and thus are common to both [1].As shown in Fig. (1). The distance between ground fabrics is regulated according to the required length of the pile and as the textures pass forward the pile threads extending between them are cut by means of a transversely reciprocating knife during the weaving process. Two cloths are thus formed the bottom cloth with the pile facing up, and the top cloth with a similar pile facing down,). The cloths pass in contact with separate take-up rollers and are wound on two cloth rollers as shown in Fig. (2). the delivery of the pile yarn ranges from five to ten times or more the length of the ground yarn [9].

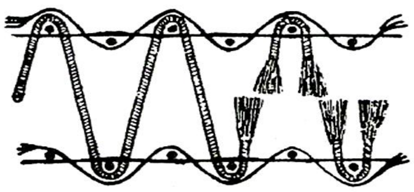

Figure (1) Face to face weaving principle

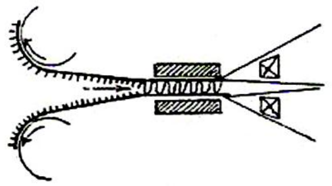

Figure (2) The path of velvet fabrics

1.3 Velvet Weaves Structure

Velvet weaves structure consists of two weaves, one for the ground and the other for the pile. The famous weaves for the ground are plain 1/1 and warp rib 2/1 or 2/2 as shown in Fig. (3) [10].

There are many different weave structures associated with the pile particularly in relation of interlacing of the pile yarns and often velvets (pile tufts) are referred to as (v), (u), or (w) shaped. This refers to the individual tuft formation as illustrated in Fig. (4). It is immediately apparent from this that the densest pile will be formed form (v) shape but it will also have the lowest tuft adhesion since each tuft is only anchored by one weft. The (u) shape has a lower pile density, and (w) shape has a low density but a high tuft adhesion since it is anchored by three weft [8].

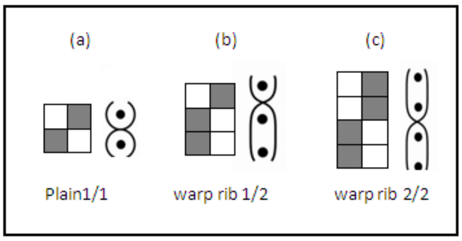

Figure (3) the famous weaves for the ground

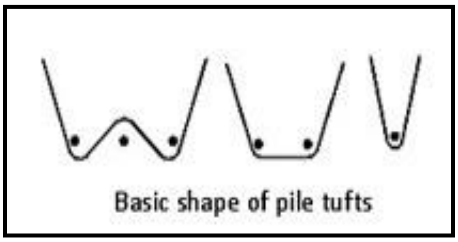

Figure (4) the basic shape of pile tufts

V-shaped is written as 1/2V. This means that the pile loop extends over one filling and the loop forming path is repeated after two fillings. W-shaped is written as 3/6W. This means that the pile loop extends over three fillings, and the loop forming path is repeated after six fillings, U shaped is written as U-2/4 this means that the pile loop extends over two fillings, and the loop forming path is repeated after four fillings as shown in Fig. (5). [11, 12].

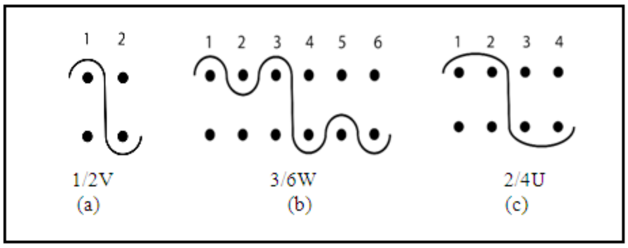

Figure (5): Pile structure 1/2V, 3/6W, 2/4U

II. EXPERIMENTAL WORK

This research is concerned with studding the Effect of pile and ground construction on mechanical properties of velvet fabrics (tensile strength, tear strength , abrasion resistance) To enrich it and also improving its properties, meeting the functional purpose it is produced for In this research 9 fabrics were produced according to 2 parameters.

2.1 The Parameters Used for Producing the Samples Under Study

2.1.1 First Parameter: **Pile structure**, this parameter consists from three levels.

I. **Pile structure 1/2V:** In this level pile structure is repeated on 2 wefts (means the pile tuft formed every 2picks) as shown in Fig. (5.a).

II. **Pile structure 2/4U:** In this level pile structure is repeated on 4 wefts (means the pile tuft formed every 4picks) as shown in Fig. (5.c).

III. **Pile structure 3/6W:** In this level pile structure h is repeated on 6 wefts (means pile tuft formed every 6picks) as shown in Fig. (5.b).

2.1.2 Second Parameter: Ground Weave, this parameter contains 3 levels.

I. **Plain weave 1/1:** this ground weave is repeated on 2 picks as shown in fig (4.a).

II. **Warp rib weave 1/2:** this ground weave is repeated on 3 picks as shown in fig (4.b).

III. **Warp rib weave 2/2:** this ground weave is repeated on 4 picks as shown in fig (4.c).

Table (1): Parameters used for producing the samples under study.

Samples	Parameters	
	Pile structure	Ground weave
Sample No. 1	1/2 V	Plain weave 1/1
Sample No. 2	2/4 U	Plain weave 1/1
Sample No. 3	3/6 W	Plain weave 1/1
Sample No. 4	1/2 V	warp rib weave 1/2
Sample No. 5	2/4 U	warp rib weave 1/2
Sample No. 6	3/6 W	warp rib weave 1/2
Sample No. 7	1/2 V	warp rib weave 2/2
Sample No. 8	2/4 U	warp rib weave 2/2
Sample No. 9	3/6 W	warp rib weave 2/2

2.2 Specifications (Machine and Fabrics)

2.2.1 The specification of the machine used in producing the samples:

1- Loom type : face to face machine.
2- Loom model: Gusken GMV-90.
3- Dobby model: Staubli 1230 DE 92.
4- No. of shafts: 16 shaft.
5-Machine speed: 230 pick/min.
6-Reed count: 8 Dent/cm.
7-Denting system : 6 ends/ Dent (2 for pile – 2 for upper ground – 2 for lower ground).

2.2.2 The specifications of the produced fabrics:

1-Material of warp ground ends: Cotton.
2- Count of the warp ground ends: 24/2 Ne.
3-No. of warp ground ends: 16 end/cm.
4-Material of warp pile ends: Acrylic.
5- Count of warp pile ends: 24/2 NM.
6-No. of warp pile ends: 16 end/cm
7- Material of weft: Cotton.
8-Count of weft: 10/1 Ne.
9-No. of picks: 16 pick/cm.

2.3 Laboratory Tests Applied to Samples Under Study

2.3.1. Tensile Strength Test

The test was carried out according to American standard specifications of (ASTM-D-5034-90) [13].

2.3.2. Tear Strength Test

The test was carried out according to American standard specifications of (ASTM-D-2661-71) [14].

2.3.3 Abrasion Resistance Test

The test was done according to American standard specifications of (ASTM-D-3885-99) [15].

III. RESULT AND DISCUSSION

The produced fabrics in this research were tested for some essential functional properties which reflected to their end uses.

Table (2): Presents the results of the tests to the produced fabrics.

	Parameters		Properties				
Samples	Pile structure	Ground weave	Warp tensile strength (kg)	Weft tensile strength (kg)	Warp tear strength (kg)	Weft tear strength (kg)	Abrasion resistance) (no. of turns)
1	1/2 V	Plain weave 1/1	96.7	120.2	10.3	7.9	4514
2	2/4 U	Plain weave 1/1	112	134.2	14.4	6	4008
3	3/6 W	Plain weave 1/1	119.2	142.4	17.1	5.1	3132
4	1/2 V	warp rib weave 1/2	67.4	90.5	18.9	14.9	2989
5	2/4 U	warp rib weave 1/2	75	103.2	23.1	12.7	2270
6	3/6 W	warp rib weave 1/2	87.7	111.3	28	8	1704
7	1/2 V	warp rib weave 2/2	42	61.1	27.3	19.6	1405
8	2/4 U	warp rib weave 2/2	57.1	74.6	31.4	17.5	990
9	3/6 W	warp rib weave 2/2	64.1	82.8	36.8	14	655

3.1 Tensile strength in Warp Direction

3.1.1 Effect of Ground Weave on Tensile Strength in Warp Direction.

It can be noticed from figure (6) that the ground weave plain1/1 scored the highest value for tensile strength in warp direction followed by rib 1/2 and rib 2/2 respectively. Because the numbers of intersections at plain 1/1 are greater than other ground weaves so the crimp of the warp ground ends increased leads to increase in the elongation as a result the resistance of the fabric to tensile strength in warp direction increased also.

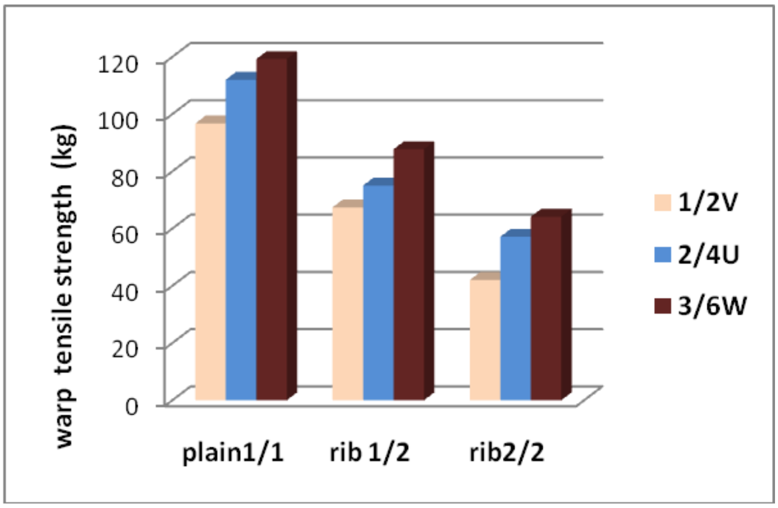

Figure (6) The effect of Pile Structure and Ground Weave on Warp Tensile Strength.

3.1.2 Effect of the Pile Structure on Tensile Strength in Warp Direction.

Figure (6) shows that the pile structure 3/6W has recorded the highest rates for warp tensile strength followed by pile structure 2/4U and 1/2V respectively. Because as number of pile tufts per unit increase the strain on warp ground ends increase as a result the tensile strength in warp direction decrease and vice verse.

At pile structure 3/6W one tuft formed every six picks ,at pile structure 2/4U one tuft formed every four picks and at pile structure 1/2V one tuft formed every two picks revealing in an increase in tensile strength by using 3/6 W.

3.2 Tensile Strength in Weft Direction

3.2.1 Effect of Ground Weave on Weft Tensile Strength.

It is clear from Figure (7) that plain weave 1/1has recorded the highest rates for tensile strength in weft direction followed by warp rib weave1/2 and warp rib weave2/2 respectively. Due to the number of intersections in plain1/1 are greater than other ground weaves so the crimp of weft increased which leads to increase in the elongation at weft direction revealing in an increase in weft tensile strength.

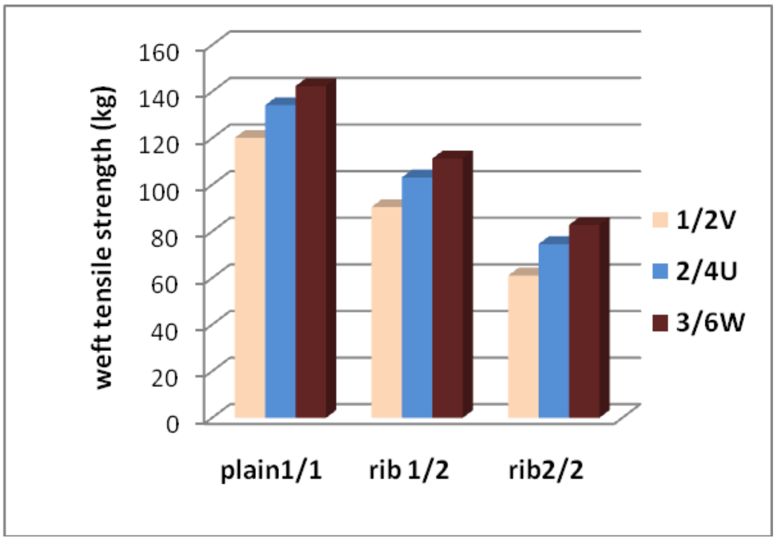

Figure (7): The Effect of Pile Structure and Ground Weave on Weft Tensile Strength

3.2.2 Effect of Pile Structure on Weft Tensile Strength.

It can be noticed from figure (7) that using pile structure 3/6W has recorded the highest rates for weft tensile strength followed by pile structure 2/4U and 1/2V respectively. Because number of tufts per unit at 3/6W (one tuft formed every six picks) is less than number of tufts per unit at 2/4U and 1/2V. As number of tufts per unit increase the strain on wefts increased also as a result the tensile strength in weft direction decreased, it can be observed that there is an inverse relationship between number of pile tufts per unit and tensile strength.

3.3 Warp Tear Strength

3.3.1 Effect of Ground Weave on Warp Tear Strength

From Fig (8) it can be observed that warp rib weave 2/2 has scored the highest rates for warp tear strength followed by warp rib weave 1/2 and plain weave1/1 respectively. Because the number of interlacing between the threads at warp rib weaves 2/2 is less than the number of interlacing between the threads at warp rib weave2/1 and plain weave1/1 so the ends become more free to move and group together presenting bundles facing the tear load. While at the plain weave the structure is compact (narrow structure) as a result the movement of the ends inside weave structure decreased so the tear strength reduced.

3.3.2 Effect of Pile Structure on Warp Tears Strength

It is clear from fig (8) that pile structure 3/6W has recorded the highest rate for warp tear strength followed by pile structure 2/4and 1/2V respectively. Because number of tufts per unit at pile structure 3/6W is less than number of tufts per unit at pile structure 1/2V and 2/4U these allow more freedom for warp yarns to move and group together forming bundles of yarns facing the tear load. While pile structure 1/2V gives greater tufts per unit than pile structure 3/6W and 2/4U, so the fabric become more compact (crowded with tufts) which leads to restriction on warp ends and less tendency to slip so the tear strength decreased.

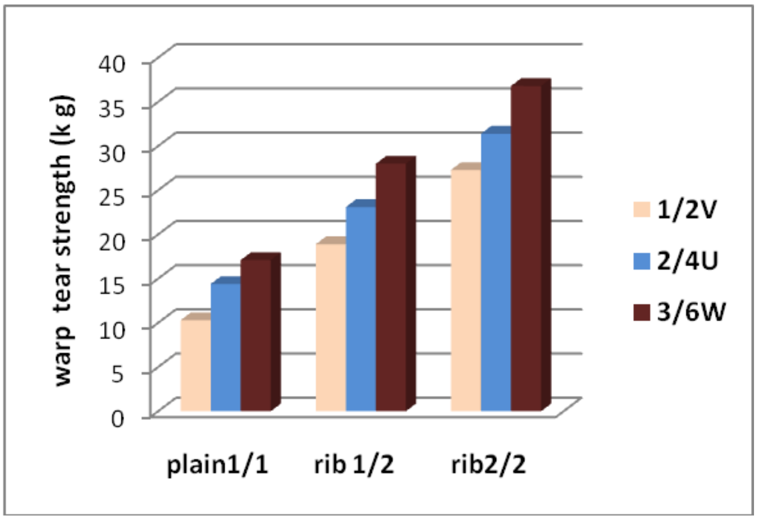

Figure (8): The Effect of Pile Structure and Ground Weave on Warp Tear Strength

3.4 Weft Tear Strength

3.4.1 Effect of Ground Weave on Weft Tear Strength.

Figure (9) shows that warp rib weave 2/2 has recorded the highest rates for weft tear strength followed by warp rib weave 1/2 and plain weave respectively. Because the number of interlacing between the threads at warp rib weave2/2 less than the number of interlacing between the threads at warp rib weave 1/2 and plainweave1/1, so as a result the fabric become loose and the wefts are more free to move under loading causing an increase in tear strength.

3.4.2 Effect of Pile Structure on Weft Tear Strength.

It can be noticed from figure (9) that pile structure 1/2V has scored the highest rates followed by 2/4U and 3/6W respectively. These because each pile tuft at 1/2V is anchored by one weft, at 2/4U each pile tuft is anchored by two wefts and at 3/6W each pile tuft is anchored by three wefts. So the wefts become more free to move at pile structure 1/2V as a result the weft tear strength increased, while at pile structure 3/6 the wefts became more restricted and the tendency of the wefts to slip decreases as a result the weft tear strength decreased.

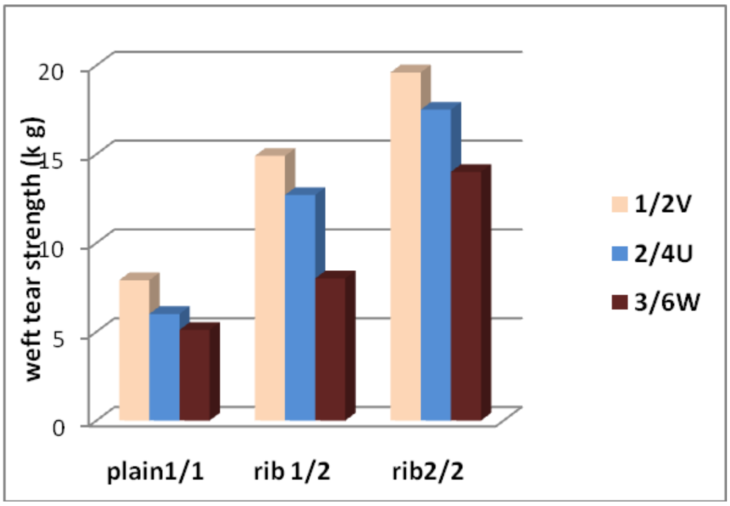

Figure (9) The effect of Pile Structure and Ground Weave on Weft Tear Strength.

3.5 Abrasion Resistance

3.5.1 Effect of Ground Weave on Abrasion Resistance.

It is clear from figure (10) that plain weave1/1 has scored the highest rates for abrasion resistance followed by warp rib weave 2/1 and warp rib weave 2/2 respectively. Because the narrow weave for the ground like plain 1/1 increase the interlacing between yarns inside weave structure so this increase the cohesion of pile tufts around wefts, and the pile tufts become tightly holded so tufts loss will decrease and abrasion resistance increase.

3.5.2 Effect of Pile Structure on Abrasion Resistance

From Figure (10) it obvious that the pile structure 1/2V has recorded highest rates for abrasion resistance followed by pile structure 2/4U and 3/6W respectively. This due to at pile structure 1/2V one tuft formed every two picks, at pile structure 2/4U one tuft formed every four picks and at pile structure3/6W one tuft formed every six picks so 1/2V gives more tufts per unit than 2/4Uand 3/6W, increase in pile tufts density in fabric surface makes it to stand vertically and facing the rubbing surface as a result fabric abrasion resistance increased. As the pile density increase the tufts become held more tightly and the chance to pulled away decreases.

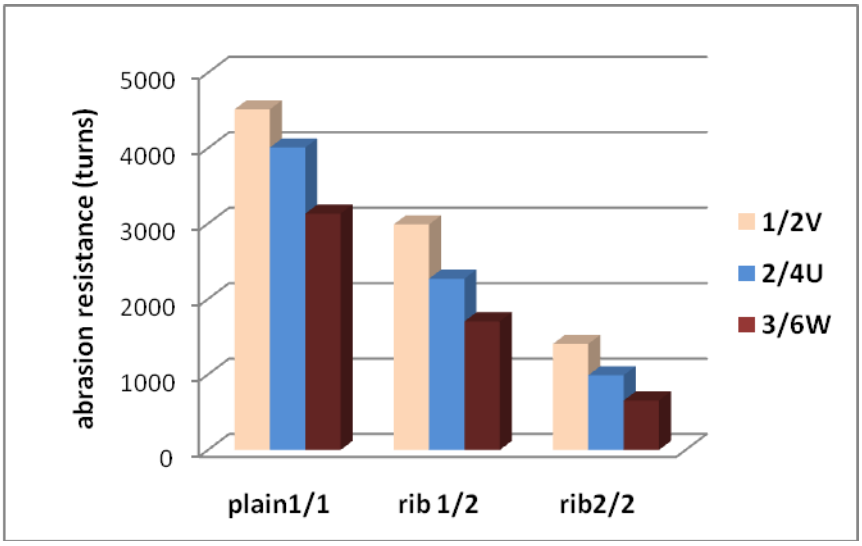

Figure (10): The Effect of Pile Structure and Ground Weave on Abrasion Resistance.

3.6 Velvet Fabrics Quality Evaluation

The velvet fabrics were evaluated to determine the best samples which fulfill the functional performance it is produced for and these through the studying of the numbers equivalent to the areas of radar chart.

The averages Results measurements of the samples tests were converted to comparison relative values (without units) ranges from (0 – 100) called quality factor , where the greatest comparative value is the best with all the properties. The following equation was used to calculate the relative value comparison (quality factor).

Where: Q F (quality factor)

$$QF = \frac{X}{X} \max$$

X (reading for each sample)

X max (the highest reading)

To calculate the total areas of radar charts which is equivalent to the performance for each fabric the following equation was used

Total area =0.5(sin 360 ÷ number of tests)*[(a*b)+(b*c)+(c*d)+(d*e)+(e*f)+(f*g)+…… +(g*a)]

Where a,b.c,d,e,f,g represents tests results of the produced fabrics.

Table (3) Illustrate the Relative Value Equivalent to the Samples Tests Results and Samples Arrangement

Samples	Parameters		Warp tensile strength %	Weft tensile strength %	Warp tear strength %	Weft tear strength %	Abrasion resistance %	Quality factor %	Total area	samples arrangement
	pile	ground								
1	1/2 V	Plain 1/1	81%	84%	28%	40%	100%	67%	2853	3
2	2/4 U	Plain 1/1	94%	94%	39%	31%	89%	69%	3148	1
3	3/6 W	Plain 1/1	100%	100%	46%	26%	69%	68%	3122	2
4	1/2 V	warp rib 1/2	57%	64%	51%	76%	66%	63%	2480	5
5	2/4 U	warp rib 1/2	63%	72%	63%	65%	50%	63%	2487	4
6	3/6 W	warp rib 1/2	74%	78%	76%	41%	38%	61%	2427	6
7	1/2 V	warp rib 2/2	35%	43%	74%	100%	31%	57%	2072	9
8	2/4 U	warp rib 2/2	48%	52%	85%	89%	22%	59%	2235	8
9	3/6 W	warp rib 2/2	54%	58%	100%	71%	15%	60%	2272	7

It is clear from Table (3) that sample no.2 which produced from ground structure plain1/1 and pile structure 2/4U has recorded the highest performance to studied properties while sample 7 which produced from ground structure warp rib weave2/2 and pile structure 1/2V has recorded the low performance to studied properties .

Fig. (11) illustrates all the samples which produced from ground structure plain weave 1/1 it was clear that the sample which produced from pile structure 2/4U scored the highest area so it is give the high functional performance so it is recommended to use this pile structure with ground structure plain weave 1/1.

Fig. (12) illustrates all the samples which produced from ground structure warp rib weave1/2 it was clear that the sample no. 4 which produced from pile structure 2/4U scored the highest area so it is give the high functional performance so it is recommended to use this pile structure with ground structure warp rib weave 1/2.

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Fig. (13) illustrates all the samples which produced from ground structure warp rib weave2/2 it was clear that the sample which produced from pile structure 3/6W scored the highest area so it is give the high functional performance so it is recommended to use this pile structure with ground structure warp rib weave2/2.

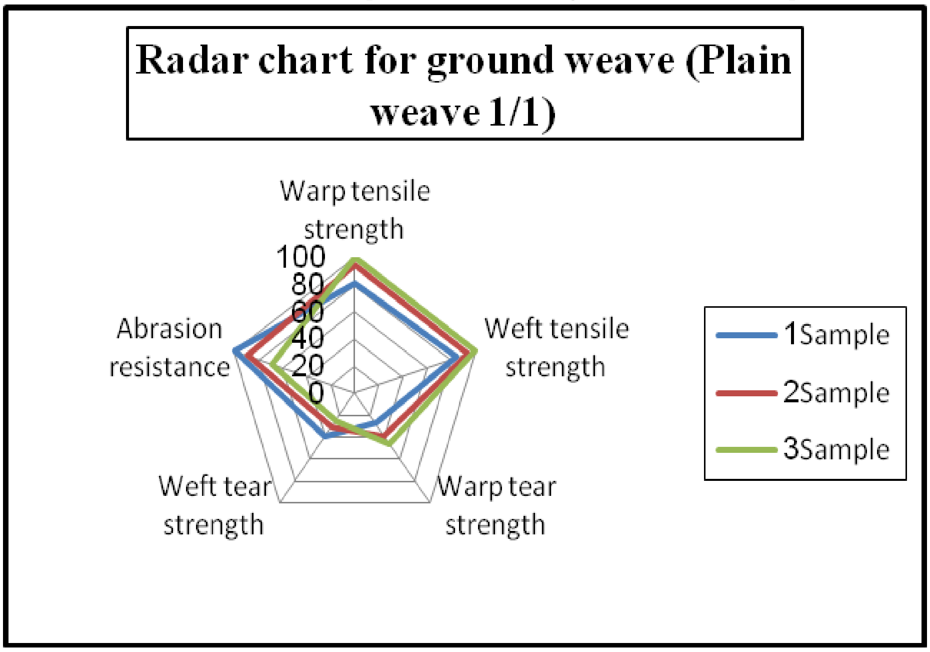

Figure (11) Illustrate Radar Chart for the Samples Produced by Using Ground Weave Plain1/1.

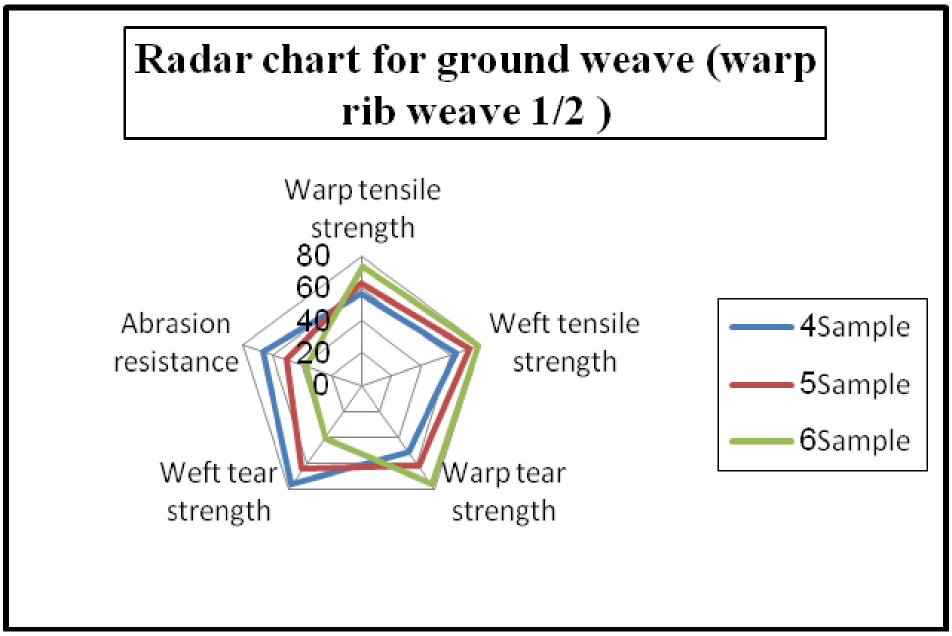

Figure (12) Illustrate Radar Chart for the Samples Produced by Using Ground Weave Warp rib1/2.

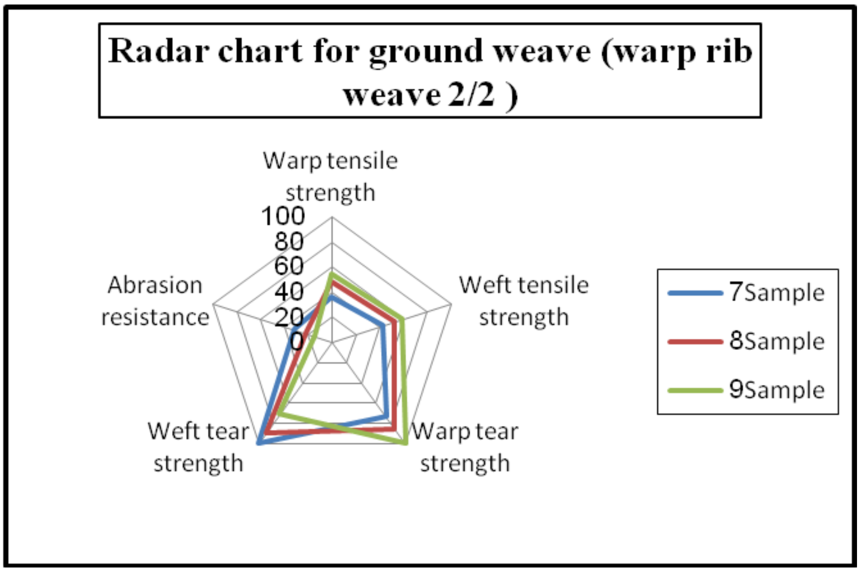

Figure (13) Illustrate Radar Chart for the Samples Produced by Using Ground Weave Warp Rib2/2.

Fig. (14) Illustrates that sample 2 which produced from ground structure plain1/1 and pile structure 2/4U has recorded the highest performance to studied properties, so it is recommended to use this pile structure2/4U with ground structure plain weave 1/1.

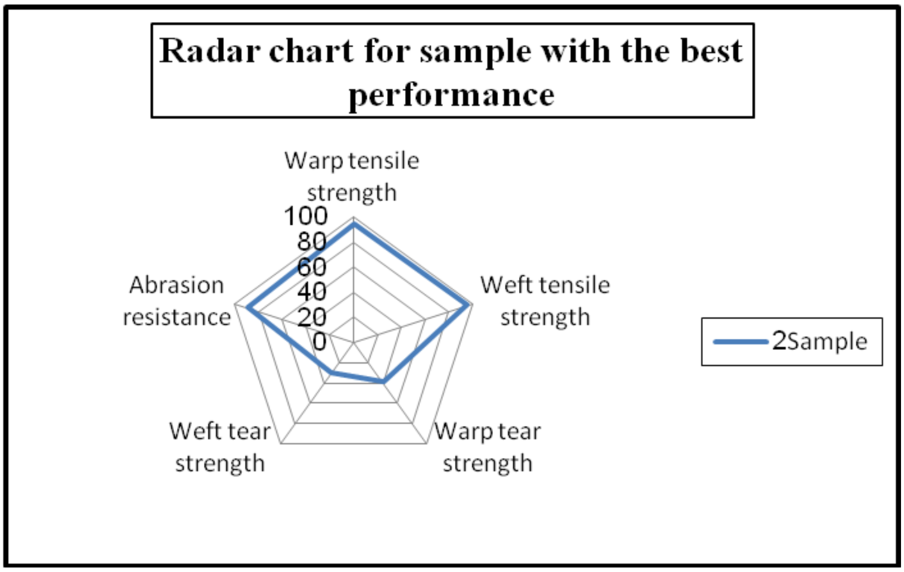

Figure (14) Illustrate Radar Chart for the Sample with Best Performance.

IV. CONCLUSIONS

From the previous results and discussion concerning with velvet fabrics (face to face technique) properties such as tensile strength, tear strength, and abrasion resistance some conclusions were achieved benefiting from it in the production of velvet fabrics and these could increase the efficiency of the functional performance of those fabrics. These conclusions are:

The pile structure 1/2V has recorded high rates to tear strength in weft direction, and also abrasion resistance.

The pile structure 3/6W has recorded high rates in tensile strength in both directions and tear strength in warp direction.

The ground weave plain 1/1 has recorded high rates to tensile strength in both direction, and abrasion resistance.

The ground weave warp rib 2/2 has scored high rates at tear strength in both directions.

There is an inverse relationship between number of pile tufts per unit and tensile strength. .

6- sample 2 which produced from ground structure plain1/1 and pile structure 2/4U has recorded the highest functional performance to studied properties.

This dose approve that the variation in pile structure and ground weave dose affect the velvet fabric properties.

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