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A General System of Handmade Carpet Geometry

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ABSTRACT: *The carpet has a complex structure in which their geometry is not been studied. It is composed of independent nodes. The Tunisian knot is a Turkish knot which is also known as symmetrical or Ghordes knot. This type of knot especially used in Armenia, Iran and Turkey. This type of knot symmetrically matches around two neighbor warps, which are completely twisted by pile yarn. In this type, there are some little gaps which make it the fluffier. A new system is developed for measuring parameters of construction of handmade carpets and for describing this new structure. The study of geometry handmade carpet allows a prediction of the mass, texture, warp and weft account and the height of the node. The simulation results are reported herein with experimental verification.*

Keywords*: diameter, handmade carpet, node, mass, geometry, texture*

I. INTRODUCTION

Carpet weaving is a very ancient tradition of many cultures. At present, the carpet market is still an important branch of industry. Carpets are used in houses as floor coverings, blankets, tablecloths and for decoration purposes. The term carpet means one type of thick fabric equipped with extra yarn on its surface, which is termed the pile [1]. The handmade carpet is a carpet with knotted, cut regularly and woven in cloth face on a vertical loom. The term carpet means one type of thick fabric equipped with extra yarn on its surface, which is termed the pile [2]. In producing the fabric, two sets of yarns, which traverse each other at right angles, are used. The first set extends in the length wise direction of the fabric, known as the warp, while the other set of yarns, called the weft, extends across the width. The pile of a carpet is produced with the support of the warp and weft, inserting or bonding extra yarn into the base fabric and knotting extra yarn on two warp pairs (Fig.1).

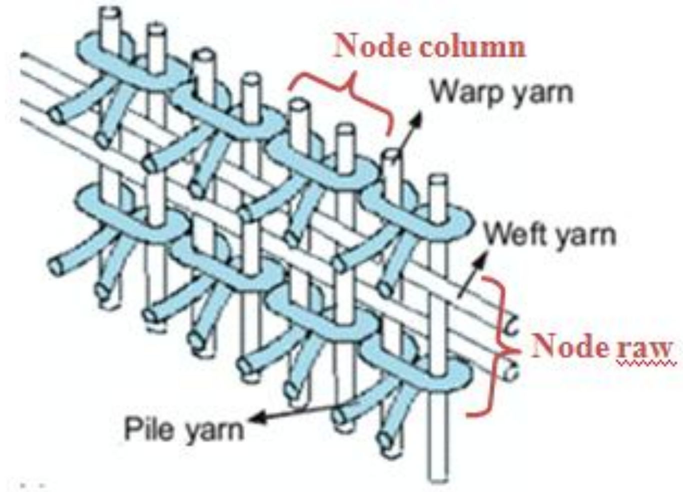

Figure 1. Carpet texture

The study of woven fabric geometry was pioneered by Barker and Midgley [3] and Peirce [4], and many of the later investigations have been based on their models. A simpler geometrical model, proposed by Peirce is shown in Fig. 2. This geometrical model assumes that the threads have circular cross-sections and are incompressible.

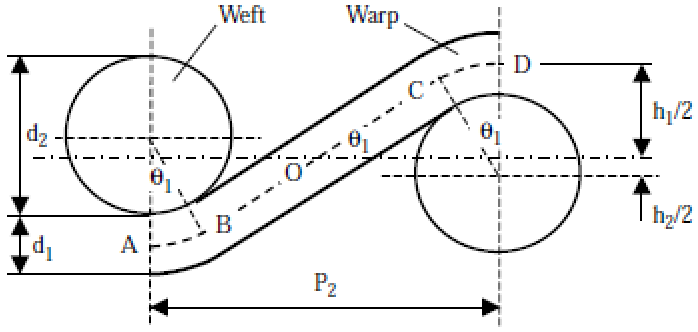

Figure 2. Geometrical model of Peirce

The Peirce model is of limited practical use unless supported by computer calculation. Further research shows an updating of the geometrical model of the unit cell of plain weave by Peirce, in particular, the replacement of the circular cross-section of the warp and weft with an elliptical [4]. In an attempt to reflect the actual behaviour of threads within woven fabrics many authors have offered other geometrical models which take into account the deformation of the threads within the structure [5] [6]. Kemp [7] presented the theory called "Racetrack" that could represent the section stuck in son floats well. Hamilton [8] constructed a geometric model based on the theories of Peirce and Kemp and pulled the equations of the model to calculate the coverage factor. Love [9] developed equations for Peirce fabric other than plain weave.

The handmade carpet weaving structures can be a pile weave or fancy weave, including a plain or twill construction to produce a flat surface on the carpet. This article presents the study of its structure by relying on the structure of the plain weave developed in the first model of Peirce. As a basis for his mathematical treatment, Peirce assumes circular thread cross-sections.

II. NEED OF CARPET GEOMETRY

Before looking at these relations in detail, it is necessary to spend a short time considering in very broad terms why we need carpet geometry. The factors that determine the character of a particular carpet are the knotting, number of nodes per m2, warp and weft account, yarns properties, its mass. There are, in addition, the conditions of manufacture, the latter involving the type of loom, the loom settings, and the tension warp and weft. If the fabric has been completed, there are also the different effects of a large number of possible sequences of mechanical and chemical finishing process and the conditions under which the operations are carried out. It can be seen that to describe a carpet is completely a very complicated business; indeed, the aim of our approach is to measure the properties that define the characteristics and structure of carpet.

From what we know of the number and complexity of the variables in yarn and carpet construction and in the processes of spinning, weaving, and finishing, it is obvious that any simple assumptions concerning the form taken by the yarn in a carpet can give but a poor picture of the actual configuration. Nevertheless, we shall find the subject very intractable unless we use simple assumptions, but we can only expect formulae derived in this way to serve as an approximate guide to the geometry of handmade carpet.

III. SYMBOLS AND DEFINITIONS

Wherever possible, the symbols used by Peirce and Kemp have been retained. Subscripts 1, 2 and n are used through out to denote warp, weft and node, respectively. Dashes are used to distinguish symbols relating to the partial node unit (Fig. 3, Fig. 4).

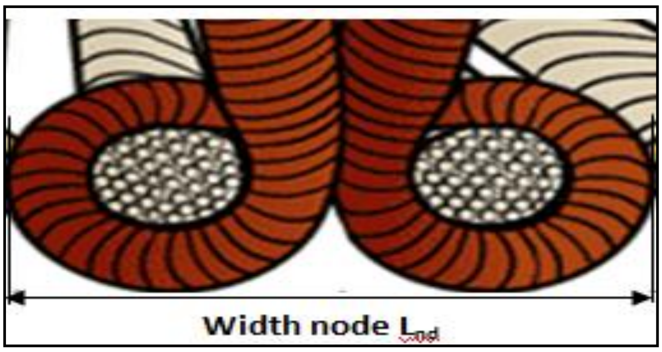

Figure 3. A transversal section of carpet unit.

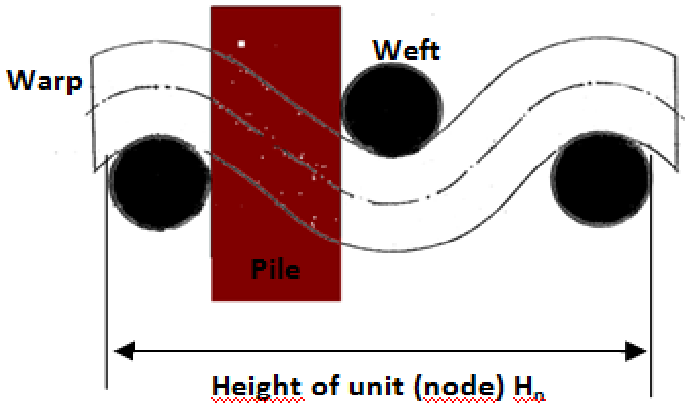

Figure 4. A longitudinal section of carpet unit

d_1, d_2 and d_n are thread circular diameter respective of warp, weft and node.

IV. GEOMETRY OF HANDMADE CARPET

With all handmade carpet, complete node units is formed by one raw of node in the weft direction and one column in the warp direction. With woven fabrics, all weave units are composed only with warp and weft threads. With carpet fabrics, however, the carpet unit is composed by the same unit of plain weave in which a node is inserted.

4.1 The textre

The texture of the Tunisian handmade carpets is the number of knots per square meter. It ranges between 12 000 and 490 000, but the standard is 40 000 (20x20), that is to say, 20 rows by 20 columns of node every 10cm.This node density depends mainly on the node thread; it depends on their diameters and also the diameter of warp and weft thread. It also depends on the regularity of mass node thread. Other construction parameter that may be involved in the variation of the node density of the carpet, it is the tension of thread and the stuffing strength during weaving.

Texture denoted N is the node column number C multiplied by the raw node number R. To calculate the texture, we may calculate first the node column number and the raw node number. As for the weave, to calculate the density of carpet threads and nodes we may assume that the threads are incompressible and with circular section and the maximum distance between two threads equal to the diameter of thread [10] [11].

The node column number C:

The number of nodes per column cm is: $C=1/L_n$

The width of a node is: $L_n=4d_n+2d_1$

Thus $$C = \frac{1}{4d_n + 2\,d_1} \qquad (1)$$

The number of knots rows per cm R is: $R=1/H_n$

Thus $$C = \frac{1}{4d_n + 2\,d_1} \qquad (2)$$

The texture of handmade carpet is given by: $N=C\times R$

Thus $$N = \frac{1}{d_1 + d_n + 2\,d_2} \times \frac{1}{4d_n + 2\,d_1} \qquad (3)$$

For the handmade carpet, the node column number is equal to the number of knots rows per cm, so we have $d_1 + 2\,d_{t2} + d_n = 4d_n + 2d_1$

Thus $$d_n = \frac{2\,d_2 - d_1}{3} \qquad (4)$$

This formula allows us to have a relationship between the node thread diameter and those of warp and weft thread to have the same number of nodes in both directions.

4.2 Density of warp and weft thread D_1

The texture depends also on the number of warp and weft threads. It is necessary to measure the density of warp and weft thread because the texture depends on the number of warp and weft thread. The density is a number that accounts for the number of interlacements of warp and weft in a given repeat. It is also equal to average float and is expressed as: D=E/I

Where E is number of threads per repeat, I is number of intersections per repeat of the cross thread.

The weave interlacing patterns of warp and weft yarns may be different. In such cases, weave factors are calculated separately with suffix1 and 2 for warp and weft respectively.

Therefore $D_1=E_1/I_1$; E_1 and I_1 can be found by observing individual pick in a repeat and $D_2=E_2/I_2$; E_1 and I_2 can be found by observing individual pick in a repeat [12].

It is given so by: $$D_1 = \frac{1}{d_1+2d_N} \qquad (5)$$

The weft density is given by devising the number of weft in one unit by the length of this unit. It is given so

by: $$D_2 = \frac{2}{2\,d_2+d_1+d_n} \qquad (6)$$

4.3 The weight of handmade carpets

The weight is an important parameter for the market and the transport of Tunisian handmade carpets. Even in the standard stamping of office, carpets are light ranked in the top choice. The weight of a carpet depends on the density of the raw material used. The weight per m2 depends on the texture and the height of the node. And because the amount of wool used for carpet is more important than cotton, weight depend mainly thread node (linear mass or diameter). Practical problems are commonly of the form in which the scales of two or more similar fabrics are determined by their weight .It is therefore useful to express the weight as the product of a form factor and the scale unit, the inverse square root of the warp count. A simple calculation gives this formula for the weight in ounces per square yard.

4.3.1Weight of thread nodes:

N is the number of nodes in 1 cm^2 and l_{ab} is the thread length absorbed by nodes is given by:

$$l_{ab} = 2\,h_n + 4\pi\left(\frac{d_1}{2}+\frac{d_n}{2}\right) = 2\big(h_n + \pi(d_1+d_n)\big) \qquad (7)$$

The length of node thread in 1 cm^2 is: $N\times l_{ab}=C\times R\times l_{ab}$

Thus $N \times l_{ab} = \frac{2(h_n+\pi(d_1+d_n))}{(d_n+2d_1)^2}$

The $Nm = \frac{L(m)}{m(g)}$

The mass of node thread is: $$m_n(g/m^2) = \frac{2\big(h_n+\pi(d_1+d_n)\big)}{(d_n+2d_1)^2}\times\frac{100}{Nm} \qquad (8)$$

4.3.1. Weight of warp thread

On the assumption that the maximum distance between two thread equal thread diameter (Case of Ashenhurst model), we have the warp thread length l_1:

$$l_1 = \frac{3}{4}\pi\left(\frac{d_2}{2}+\frac{d_1}{2}\right) + \sqrt{(d_1+d_2)^2 + {d_n}^2} \qquad (9)$$

The mass have be determined by consideration of the formulas: $m_1 = \frac{D_1\times l_1\times 100}{Nm_1}$

We can write:

$$m_1 = \frac{\frac{3}{4}\pi\left(\frac{d_2}{2}+\frac{d_1}{2}\right)+\sqrt{(d_1+d_2)^2+{d_N}^2}}{d_1+2d_n}\times\frac{100}{Nm_1} \qquad (10)$$

4.3.2. The weight of weft thread

The weft thread weight is calculated by the same methods:

$$m_2(g) = \frac{\pi(d_2+d_1)}{2\,d_2+d_1+d_n}\times\frac{100}{Nm_2} \qquad (11)$$

Where the weft thread length $l_2 = \pi\left(\frac{d_2}{2}+\frac{d_1}{2}\right)$

4.3.3. The weight of the carpet

The weight of the carpet in m_2 is the sum of warp threads mass m_1, the weft threads mass m_2 and the pile thread mass m_n:

$$M\left(\frac{g}{m2}\right) = \frac{2\big(h_n+\pi(d_1+d_n)\big)}{(d_N+2d_{ch})^2}\times\frac{100}{Nm_n} + \frac{\pi(d_2+d_1)}{2\,d_2+d_1+d_n}\times\frac{100}{Nm_2} + \frac{\frac{3}{4}\pi\left(\frac{d_2}{2}+\frac{d_1}{2}\right)+\sqrt{(d_1+d_2)^2+{d_n}^2}}{d_1+2d_n}\times\frac{100}{Nm_1} \qquad (12)$$

4.4. Carpet thickness

The thickness is a magnitude usually measured for fabric, but it can also be measured for handmade carpets. Here, it is equal to the sum of pile thickness and thickness of the woven mat of a folder. The pile thickness is an important construction parameter with relevance to the sustainability of carpet, comfort, appearance and cost. Knowledge of the pile thickness is often necessary to classify carpet and in the study of the wear of the carpet.

Fabric thickness (E) is given by:

$$E=h+e_{ds} \tag{13}$$

Where (h) is the pile thickness and $e_{ds} = d_1 + 2 * d_n$ is the woven folder thickness

V. CONCLUSION

The geometry described is primarily a development of complex structure. The main contribution of the present paper is an extension of Peirce's geometry of plain weave to handmade carpet. The geometry of the plain weave is given, first by rigorous formulae in terms of the diameter of node, warp and weft threads. The relation between the texture of handmade carpet and the threads diameter is given as a simple, algebraic function. Explicit relations between the carpet weight, threads per cm and thread diameter, are obtained by computation, in an approximation of lower precision but equal to that of actual measurements.

REFERENCES

[1]. A. Crossland, *Modern Carpet Manufacture*, (Columbine Pres., Manchester & London, 1958).

[2]. P. Topalbekiroğlu., A. Kireçci. and L. Canan Dülger. Design of a Warp Control Mechanism for Handmade Carpets, *Fibres and Textiles in Eastern Europe*, *18*, 2010, 51-55.

[3]. A.F. Barker and E. Midgley, *Analysis of Woven Fabric*, (Scott, Greenwood & Son, London, 1914).

[4]. F. T. Peirce, The Geometry of Cloth Structure, *Journal of the textile institute*, *28*, 1937, 45-96.

[5]. E.K. Zvorikina, *Investigation of the phenomenon of weft contraction on weaving* (dissertation, Textile Industry, Moscow, Russian, 1946).

[6]. H.F. Surnina, *The Design of Woven Fabric on Set Parameters*, (Light Industry, Moscow, 27-48 1973).

[7]. A. Kemp, Modeling of Woven Fabrics Geometry and Properties, *Journal of textile institute*, *49*, 1958, T44

[8]. J. B. Hamlton, A general system of woven-fabric geometry, *Journal of textile Institute*, *24*, 1964, T66-T82,

[9]. L. Love, Graphical relationships in cloth geometry for plain, twill, and sateen weaves, *Journal of Textile Institute, 40*, 1949, 1073-1083.

[10]. T.R. Ashenhurst, *Design in Textile Fabric* (1882).

[11]. A. Seyam, and E.E. Aly, A mechanics of woven fabrics, Part III: Critical review of weavability limit studies, *Textile Research Journal*, *63*, 1993, 371-378.

[12]. Behera. B. K, Jiri Militky, R. Mishra and D. Kremenakova . (*Woven Fabrics, 2012)*