SURFACE ROUGHNESS OF POLYAMIDE KNITTED FABRICS

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ABSTRACT

Fabrics are never ideally smooth. Their texture varies between fine and coarse, quantified through the surface’s vertical deviation. Fabric roughness, or its opposite smoothness, is employed as measure of the surface texture of fabrics. In general, texture depends upon fiber properties, yarn count, yarn twist, and fabric structure and fabric design). This research aims to determine the limitations in visual perception of surface roughness in comparison to objective surface roughness measurements of low weight polyamide fabrics. Subjective evaluation is used for the visual assessment, while instrumental measurement of the properties was conducted using a noncontact laser profilometer. Subjective evaluation was conducted by a panel of forty untrained evaluators on a sample of seven polyamide knitted fabrics with different yarn count and composition. The roughness profile parameters were measured using Talysurf CLI 500 according to ISO 4827. Although the surface roughness measured as arithmetic mean deviation (Ra) and roughness through visual inspection of the fabric are correlated, instrumental measurements of roughness are more precise. Differences in the surface roughness arising from significantly different yarn structures will be observed, while those due to the knitted fabric structure are negligible in visual inspection.

KEYWORDS

Texture; Surface roughness; Knitted fabrics; Visual inspection.

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INTRODUCTION

Surface roughness is a tactile property of fabrics that has been widely investigated by many researchers for both woven and knitted fabrics. The research application is mainly dedicated to defining the sensorial or tactile comfort. Tactile comfort properties are complex concepts which include dimensional changes at small forces such as tensile, shear, compression, and bending, surface properties (friction and roughness) and warm/cool feeling evaluate via the Kawabata evaluation system [5]. Numerous research works [1,2,3,4,6] have studied the effect of different fiber materials, fiber blended ratios, fiber morphology, yarn properties, finishing treatments, and fabric constructions on the hand feel properties of knitted fabrics. Furthermore, surface roughness has been used to distinguish between various types of structures [7].

This research aims to investigate the visually perceived surface roughness and luster of pantyhose fabrics. Subjective evaluation is used for the visual assessment, while instrumental measurements of the properties was used to obtain objective fabric parameters.

EXPERIMENTAL

Materials

Samples were knitted from commercially available yarns on industrial circular knitting machine with four systems, diameter of four inches and 400 needles. The physical and structural properties of the samples are presented in Table 1. The pure polyamide knits single jersey, while the addition of elastane was through knitted hopsack structure. Sample S22T was with increased luster, in a plated knit from a covered elastane yarn and a trilobal increased luster filament. The samples are made of fine filaments, with low weight and high cover factor. Figure 1 shows the microscopic images of selected samples, taken on Olympus BX51 microscope at a magnification of 5×.

Table 1. Sample structure.

Sample		S5E	S17P	S17E	S22PP	S44CE	S78CE	S22T
Yarn count (dtex)		5.5/2	17/3	17/3	22/5	44/13	78/24	22/5
Density	**Wales (cm-1)**	28.6	42.9	33.3	23.8	23.8	28.6	23.8
	Courses (cm-1)	28.1	24.6	28.1	31.6	21.1	24.6	35.1
Sample code: Number-yarn count, P- polyamide 6.6, PP- polyamide 6, E-polyamide-bare elastane blend, CE- polyamide-covered elastane blend								

S5E S17P S17E S22T S22PP S44CE S78CE

Figure 1. Microscopy of samples.

Methods

Subjective evaluation was conducted on a knee-height leg model. To standardize the evaluation, evaluators were asked to describe the shin part of the leg. The model was placed in a black viewing cabinet (length 60cm, height 50m, depth 45cm), with a D-65 light source, illuminating the leg surface under a 15° angle. Samples were evaluated from a distance of 1.5m. The evaluators were 40 women aged 20 to 60, with normal visual acuity. A semantic differential method in a five-scoring system was used to assess texture, evaluated by bipolar opposites of rough-smooth and uneven-even.

To evaluate surface roughness, Talysurf CLI 500, a noncontact laser profilometer was used. Roughness profile parameters were measured according to ISO 4827. For global evaluation of the roughness amplitude profile the arithmetic mean deviation (Ra, µm) in wales and courses direction on a length of 5±0.05mm was used. This measurement quantifies the absolute values of the profile variations (peaks and valleys) from the mean line in the evaluation length. However, Ra does not give information on the shape of the profile. Therefore, a pseudo-color map was used to assess the reasons for variation of the surface.

RESULTS AND DISCUSSION

The results of the subjective and objective evaluation of pantyhose are presented on Figures 2 and 3. A Pearson correlation coefficient of 0.79 was found between the visually perceived roughness(VR) and the instrumentally measured roughness (Ra) in the wales direction, while a lower correlation (Pr=0.69) was found in the course direction. This points out two important differences between the visual and haptic assessment of fabric. Firstly, the correlation between visual assessment and roughness measurements is not strong. Small differences in roughness that may be instrumentally measured will escape the human eye. Secondly, the direction of viewing will influence the surface roughness visual perception, as lower correlation was found in the courses direction. As roughness is a three-dimensional property assessment of the fabrics can be made despite directionality.

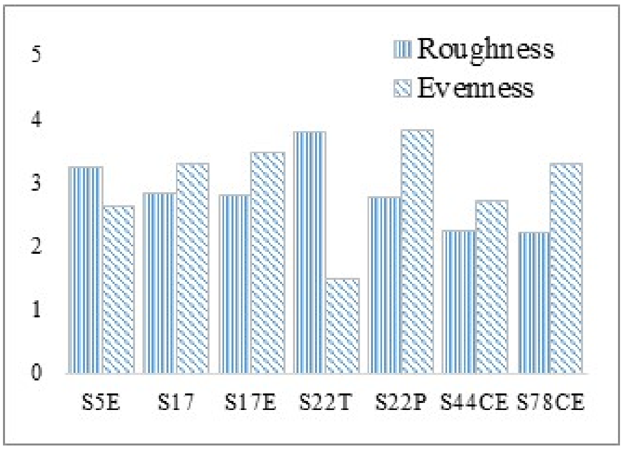


Figure 2. Visual assessment of pantyhose roughness and evenness.

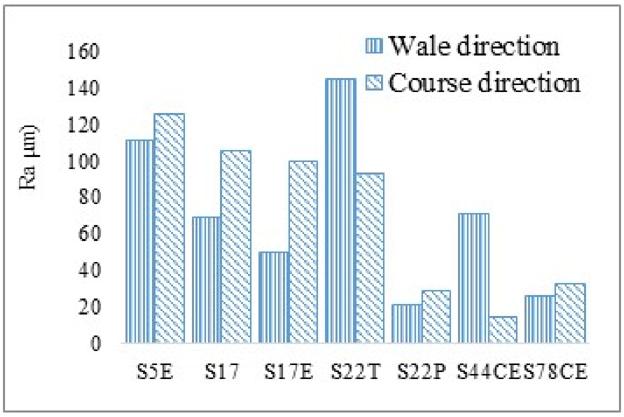
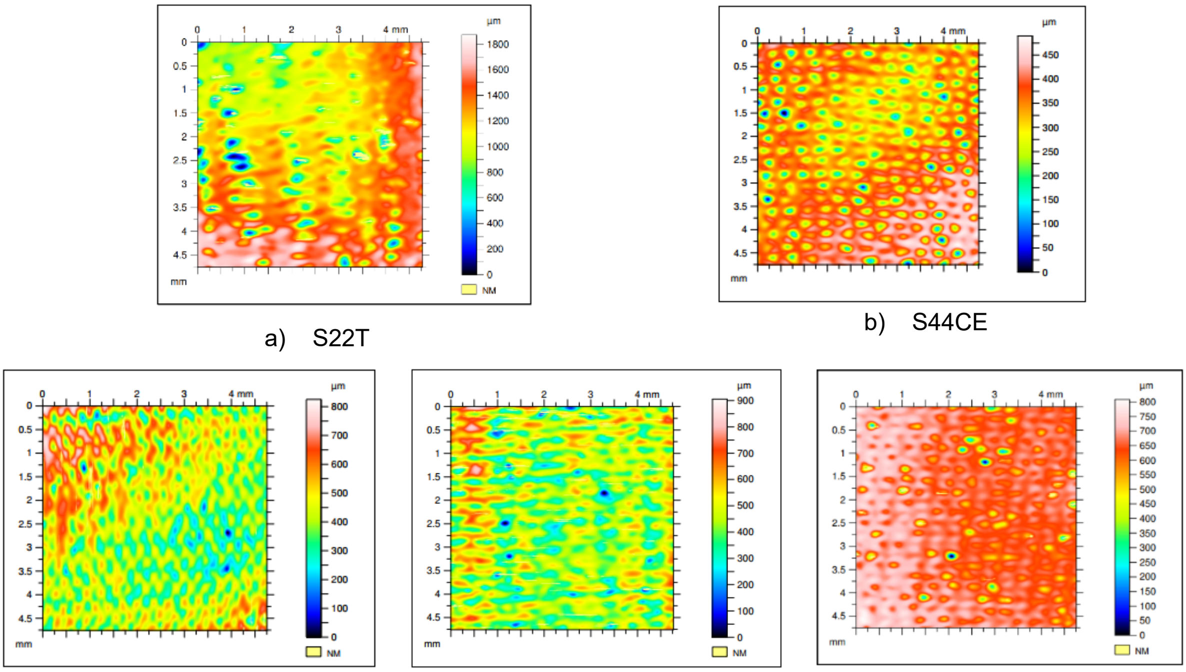


Figure 3. Arithmetic mean deviation of the roughness profile.

When examining the values presented in figure 3 S22T is a clear outlier. Unlike the rest of the series which is knit of smooth multifilament yarns, this sample was made of a single covered yarn with an addition of a profiled trilobal filament, thus the uneven structure of the yarn contributes to surface roughness. However, in the objective assessment of the surface roughness an additional outlier was found with sample S44CE. To examine the differences in the surface roughness figure 4 a) and b) presents a pseudo-color map of the two samples. The map the roughness profile of the sample to a color spectrum, with peaks shown as red-white and valleys shown as red green. As can be seen on the representation of the pseudo-color map for sample S22T the roughness in the sample is due to the uneven distribution of peaks and valleys in the sample, caused by the covered yarn, as well as the protrusions of the trilobal filament. On the other hand, the sample S44CE has a fairly even structure with deep valleys occurring periodically, consistent with the knitted structure and the loop shapes within it. The roughness of knitted fabrics comes from the applied yarn, as well as the structure of the fabric, with the former having greater influence on the visual perception of fabrics.

When the outlier sample S22T is removed from the analysis a correlation coefficient of 0.9 is obtained between visually assessed surface roughness and yarn count. However, low correlation (0.54) existed between objectively measured Ra and the yarn count. To illustrate this difference pseudo-color maps of fine filament pantyhose of 17dtex (S17P and S17E) and coarse filament pantyhose (S78CE) are presented on figure 4 c), d) and e). As can be seen from the figure increased yarn count contributes to less differences in height along the roughness profile of a surface, creating a closed, smooth surface. This is due to the even packing of filaments within the loop structure when the yarn count increases. The presence of elastane yarns in the knit (S17E) stabilizes the loop structure, leading to a more even distribution of the peaks and valleys on the fabric surface compared to a sample with no elastane (S17P). Even though these differences in surface can be seen via instrumental analysis, they are not perceivable visually in real conditions of wear.

Furthermore, during visual assessment of pantyhose yarn count is a more important parameter compared to fiber composition, as can be seen by the assessment of sample S22PP made of PA6 in 22dtex. In the visual assessment of the set this sample is seen to have similar roughness to samples with fine yarn count of 17dtex. However, due to the fiber composition the roughness Ra of the sample are closer to those of coarser yarns. Although the difference in roughness caused by different fiber composition will influence the general surface related properties, such as comfort it will not be immediately visually perceivable.



a) S22T   b) S44CE

c) S17P   d) S17E   e) S78CE

Figure 4. Pseudo color maps of samples.

CONCLUSIONS

This study investigated roughness as a property of knitted fabrics. Although the measured arithmetic mean deviation (Ra) the surface roughness and roughness through visual inspection of the fabric are correlated, instrumental measurements of roughness are more precise. Differences in the surface roughness arising from significantly different yarn structures will be observed, while those due to the knitted fabric structure are negligible in visual inspection.

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REFERENCES

1. Atalie, D., Gideon, R. K., Ferede, A., Tesinova, P., Lenfeldova, I. (2021): Tactile Comfort and Low-Stress Mechanical Properties of Half-Bleached Knitted Fabrics Made from Cotton Yarns with Different Parameters, Journal of Natural Fibers, 18(11), 1699-171.1 https://doi.org/10.1080/15440478.2019.1697989
2. Balci Kilic, G,, Okur, A. (2018). Effect of yarn characteristics on surface properties of knitted fabrics. Textile Research Journal, 89 (12). https://doi.org/10.1177/0040517518797337
3. Demiryürek, O., D. Uysaltürk. (2013). Thermal comfort properties of Viloft/cotton and Viloft/polyester blended knitted fabrics. Textile Research Journal 83 (16):1740-53. https://doi.org/10.1177/0040517513478458
4. Mahar, T.J., Wang, H., Postle R. (2013). A review of fabric tactile properties and their subjective assessment for next-to-skin knitted fabrics. The Journal of The Textile Institute, 104:6, 572-589. https://doi.org/10.1080/00405000.2013.774947
5. Mooneghi, S. A., S. Saharkhiz, and S. M. H. Varkiani. 2014. Surface roughness evaluation of textile fabrics: A literature review. Journal of Engineered Fibers and Fabrics 9 (2):1-18. https://doi.org/10.1177/155892501400900201
6. Vasile, S., Malengier, B., De Raeve, A.,Deruyck, F., (2017). Influence of selected production parameters on the hand of mattress knitted fabrics assessed by the Fabric Touch Tester. Textile Research Journal, 89(1). https://doi.org/10.1177/0040517517736471
7. Vassiliadis, S.G. and Provatidis, C.G. (2004), "Structural characterization of textile fabrics using surface roughness data", International Journal of Clothing Science and Technology, Vol. 16 No. 5, pp. 445-457. http://dx.doi.org/10.1108/09556220410554633