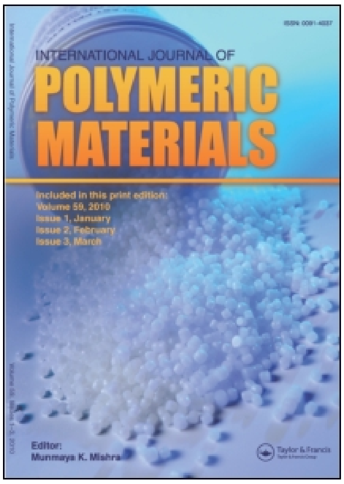

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Determination of Structural Characteristics of Stitched and Knitted Fabric

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The mechanical properties of stitched-bonded fabrics are investigated in the paper. The main structural characteristics of stitch-and-knitted nonwovens ric in two different density made on automatic warp knitting machine with compound needles and with one laying bar were calculated. Breaking strength of the fabric is determined by means of tensile tester with a constant speed of specimen deformation and at the ball burst test. The tensile test showed a 100% bigger breaking force in warp related to weft direction, while the breaking elongation is 50% greater in weft direction for both of samples. Results of this measurements were showed in diagram.

Keywords: Stitch-bonded fabrics; structural characteristics; tensile strength; elongation

INTRODUCTION

Stitch-bonded fabrics are manufactured on modern automatic warp knitting machines, with compound needles with closed wires. The sewing threads are – like in warp knitting – fed to punching needles which are attached to a laying bar. The threads are processed either by fringe or stockinet-forming process and the choice results in substantial differences of the stitch-bonded product.

When the threads are processed separately, as in a chain stitch seam, and the fibres of the web are thus bound together, the longitudinal

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strength of stitch-bonded fabric is increased considerably, but there is no significant increase in its lateral strength which can be improved by stockinet forming. After the loop has been formed, each thread is taken to its adjacent stitch wale to make a stitch. Each thread makes a stitch in two adjacent wales alternatively. The lateral strength of the fabric is good because the threads make these cross-links. The choice of yarn for the chain of thread has also a great influence on the lateral strength now that both viscose and polyester yarns, for instance, can be used. Filament yarns are preferred to staple fibre yarns because of their good antifrictional properties and desirable performance. The thickness of the yarns depends on the gauge of the machinery.

The stitch-bonded fabric consists of a light grid forming the base (woven or knitted fabric, thread-stitched fabric, film) stitched by a tricot interlacing with a pile loop so that the pile loops are on one side, while on the other side the pile yarn is fixed by the tricot stitch. Among non-wovens for making clothes, the greatest part consists of stitch-and-knitted non-wovens. The structure of knitting depends on the final designation of the non-woven. Single-bar warp knits are mostly used, such as tricot, chain, atlas, charme′ and their combinations. The fabric-stitched non-wovens are dimensionally stable, with low shrinkage and high abrasion resistance.

The breaking force and elongation of a stitch-bonded fabrics with single bar tricot structure varies with density of the fabric.

In the previous studies Petterson and Backer [1] were introduced a study on the properties and the geometric structural arrangement of fibres as they influence the mechanical properties of nonwoven materials.

This paper carried out the influence of density of fabric on strength and extensibility of stitch-bonded fabrics.

THEORETICAL PART

The main structural characteristics for stitched-and-knitted fabrics are:

1. Density of stitching in length and width, which is characterised by the number of courses (c) and the number of wales (w) per 1 cm of fabric.

2. Length of yarn in the loop, (mm)

$$l = \frac{\sum L_i}{\sum n_i} \tag{1}$$

where $\sum L_i$ – is the mass of lengths of stitching threads extracted from the sample, mm, $\sum n_i$ – is the total number of loops from a thread $\sum L_i$ long.

3. Linear density of the stitching thread (tex)

$$T_t = \frac{\sum m_n}{\sum L_i} \tag{2}$$

where $\sum m_n$ – the mass of thread bundle of a length $\sum L_i$, (g).

4. Length of stitching thread for 1 m^2 of web, (m)

$$L_t = 10 \cdot c \cdot w \cdot l \tag{3}$$

5. Surface density of the stitching thread in a web, (gm^{-2})

$$m_t = c \cdot w \cdot l \cdot T_t \cdot 10^{-2} \tag{4}$$

where: l is the length of yarn in the loop of the single bar, (mm).

6. Content of stitching threads in the web (%)

$$C = \frac{m_t}{m_s} 100 \tag{5}$$

where $m_s = m \cdot 10^4 / L \cdot B$, ($gm^{-2}$) is surface density in gm^{-2}, L is length and B is width of sample expressed in cm, *i.e.*, L = 10 cm, B = 10 cm. (*content of stitching threads were* 60% *for sample* S1, 26% *for sample* S2 and 32% *for sample* S3).

7. Volume density, (g/cm^3)

$$\rho_v = \frac{m_s \cdot 10^{-2}}{L \cdot B \cdot t} \tag{6}$$

where: m_s – surface density, (gm^{-2}), ρ_v – volume density, ($g\,cm^{-3}$), L – length, (mm), B – width, (cm) and t is thickness, (mm) (L = 10 cm, B = cm).

8. Cover factor ($tex^{1/2}\,cm^{-1}$).

An important parameter is cover factor K, which can be expressed as a ratio between the square of the yarn linear density and the knitted loop length l.

$$K = \frac{\sqrt{T_t}}{l} \tag{7}$$

where T_t is the yarn linear density, tex and l is the knitted loop length in mm.

EXPERIMENTAL PART

Sample Preparation

The fabric used was a stitch-bonded fabric, with a mass of 176.8 gm^{-2}, and having a length of yarn in the loop of 6.61 mm. The strips of 5-cm width and 20-cm were cut and clamped length was 10 cm. Five samples along each direction were used for strength and extensibility tests on the fabric. The lower clamp speed was 5 mm min^{-1}. Preliminary the samples are kept for 10 h in premises at a relative humidity of $65 \pm 5\%$ and a temperature of $20 \pm 2°C$. Machine used for manufacturing the stitch-bonded product were automatic warp knitting machine with compound needles and with one laying bar. The sewing thread to form the loops was polyester yarn which tension was = 2.5 cN and stitch-length = 1.8 mm.

Determination of Structural Characteristics

The number of courses and wales is counted with a precision up to half a loop on a strip width of 50 mm. The stitching density of the web in length (c) and in width (w) is determined as the arithmetic mean from five measurements in each direction. The mean value is rounded up to a whole number.

For determining the thread length in the loop five wales are marked and the number of loops over a length of 100 mm is counted on a square sample at a distance of 20 mm from the side edge. The wales are unravelled row after row and the threads are extracted from the web. Pressing one end of the thread to the rule, the zig–zag stitching thread is straigtened along the rule and its length is measured with precision up to 1 mm. The length of the thread in the loop is found from formula (2). The boundle of threads extracted from the web is weighed on torsion scales and the linear density of the stitching thread is determined by formula (3).

The thickness is measured by a caliper at ten points of the web width an accuracy of up to 0.01 mm.

Determination of the Tensile Load and Extensibility at the "Ball Burst" Test

Ball-burst test was carried out on an dynamometer (AVK, Hungary) with a small stainless-steel ball (25.4 mm + 0.025 mm diameter). The diagram of the breaking force and elongation was obtained, where elongation is plotted against load.

Simple Tensile Test

There follows a description of the experiments conducted to measure tensile behaviour of selected stitch-bonded nonwovens over a range of angles to the principal direction. The tensile testing was carried out on an Instron tensile tester at constant rates of strain. When a sample of nonwoven fabric is tensioned at a constant rate and elongated uniformly, the actual stress-strain curve with well defined yield points is obtained.

Based on formulae (3 – 7) the main structural characteristics for stitched-and-knitted fabric were calculated and are shown in Table I. Table I shows calculated values of density of stitching, loop length in the stitch thread, surface density of stitching thread, surface density of the web, thickness of web, cover factor K and volume density for samples $S1$, $S2$ and $S3$.

In determining the mechanical properties of stitch-bonded fabric is made of characteristics obtained at the simple tensile test and the ball burst test, *i.e.*, tensile load and extensibility.

The load-extension curves shown in Figure 1 give a complete and versatile of the fabric characteristic; here, elongation is plotted against load for three different density of stitch (samples $S1$, $S2$ and $S3$). The results are expressed as a breaking load in (N) and

TABLE I Structural characteristics of stitch-bonded fabric, Type Maliwatt®

Samples	*Linear density of yarn* T_t *(tex)*	*Density of stitching* $c\,(cm^{-1})$	$w\,(cm^{-1})$	*Length of the loop* $l\,(mm)$	*Cover factor* $K(tex^{1/2}cm^{-1})$
*S*1	45	6.7	5.6	6.6	10
*S*2	45	4.0	3.0	10.8	6
*S*3	25	6.7	6.0	5.7	8

Samples	*Length of stitching thread for* 1 m^2 *of the web* $L_t(mm)$	*Surface density of stitching thread* $m_t(gm^{-2})$	*Surface density of the web* $m_s(gm^{-2})$	*Thickness of the web* $t\,(mm)$	*Volume density* $\rho(g\,cm^{-3})$
*S*1	2476	113.9	188.7	0.09	0.210
*S*2	1296	58.32	227.0	0.11	0.206
*S*3	2291	57.3	178.5	0.11	0.162

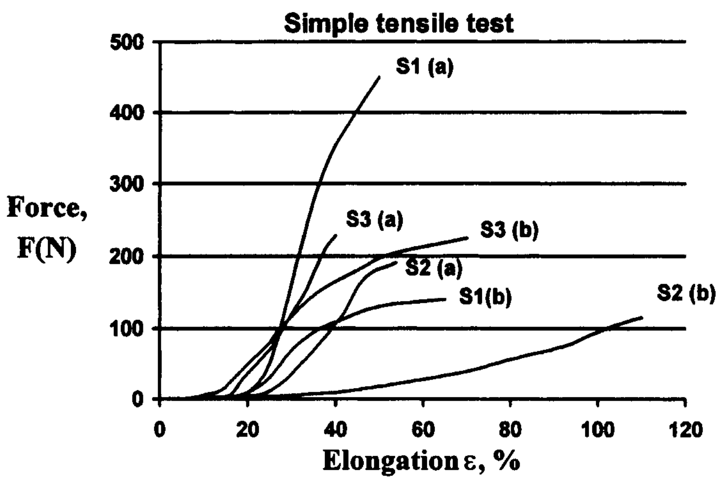

FIGURE 1 Diagram recorded in the tensile tester obtained in principal directions for *S*1, *S*2 and *S*3 samples of stitch-and-knitted non-wovens: *a* – in length direction (α = 90°), *b* – in weft direction (α = 180°).

elongation in (%). The curve shows the geometrical disposition of points characterizing variation in load and deformation at a single extension to breakage.

The diagram of breaking force and elongation obtained at the ball burst test for sample *S*1 is illustratively shown in Figure 2. Actual

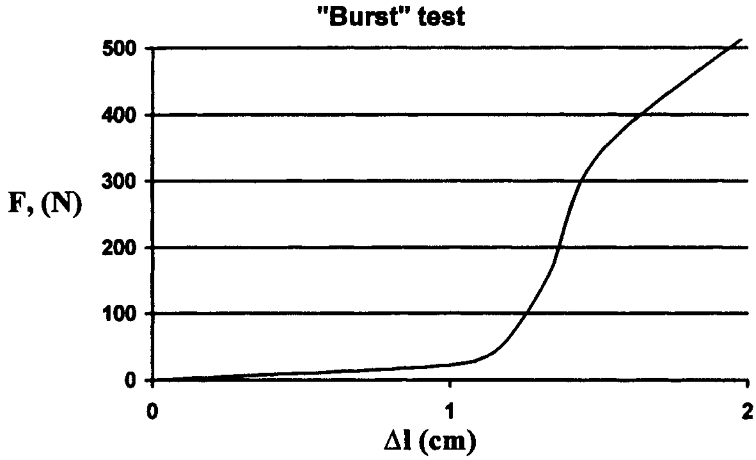

FIGURE 2 Diagram recorded in the tensile tester obtained at the ball burst test for samples of stitch-and-knitted non-woven *S*1.

stress σ was calculated based on the cross-sectional area of sample. This calculation involving the assumption of no change in volume.

CONCLUSION

On the base of the results the stitch-bonded sample with yarn of 45 tex and the smallest density of stitching is having the best mechanical properties in the warp direction and un weft direction it is case for the stitch-bonded sample with 25 tex.

From the view of the extension, the best sample is the one which is stitch-bonded by the yarn with linear density of 45 tex and with smaller loop length.

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