INFLUENCE OF BONDING TEMPERATURE ON THE PROPERTIES OF HIGHLOFT FABRICS

O. Jirsak, R. Kotisova and T. Saunders
Technical University of Liberec
Czech Republic

Abstract

Highloft perpendicular-laid nonwovens have gained a favorite position among other bulky textiles.

Highloft perpendicular-laid fabrics made from basic fibers and bicomponent bonding fibers are discussed in this paper and the influence of bonding temperature on the compressional properties of fabrics are studied.

Introduction

Perpendicular-laid fabrics are a new sort of highloft textile materials [1]. Highloft nonwovens are defined as low-density fiber network structures characterized by a high ratio of thickness to weight per unit area [2]. The fibers may be continuous or staple, bonded or unbonded. The highlofts contain less than 10% of mass and thickness is more than 3 mm.

Perpendicular-laid fabrics have been developed to improve the most important characteristics of highloft fabrics – the compressional rigidity and elastic recovery after repeated or long-term loading. Many basic highloft functions such as filling ability, hand, and thermal resistance depend on fabric volume. Therefore, the ability to maintain the volume during and after loading is the basic characteristics of highlofts. Perpendicular-laid fabrics show excellent behavior when compared with typical air-laid and cross-laid fabrics due to predominantly upright positions of fibers. Successful development of various specific perpendicular laid fabrics as well as production machinery resulted in eight installations in the Czech Republic in the last decade, (the first installation was in 1990) and additional eight installations in the United States and England in the last two years (i.e., 1998-2000) [8]. The fabrics have found end-uses as filling materials (in automotive, and in cushioned furniture and mattresses), as thermo-insulting materials (in blankets, quilts, sleeping bags, sports and working apparel) and as air-filters.

Experimental

In the experimental part, the influence of the kind of bonding fibers as well as that of bonding temperatures on the structure and properties of perpendicular-laid nonwovens at the compression and after these compressions is studied.

Series of perpendicular-laid fabrics were produced with different type of bonding fibers. Four types of bonding fibers were used (Table 1.). The bonding fibers were produced for various bonding temperatures. The minimum bonding temperature is 120°C for three types of bonding fibers and 190°C for one type of bonding fibers.

The composition of fiber blend were:

80 weight per cent of basic fibers - polyethyleneterephtalate (PET)
20 weight per cent bi-component bonding fibers – 4 types

Polyethyleneterephtalate fibers 6.7 dtex, 65 mm (PET)
The bi-component bonding fibers core/sheat PET/co-polyester

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:649-652 (2001)
National Cotton Council, Memphis TN

Sample Production Procedures

The fibers were blended by two passes through a laboratory card.

Perpendicular-Laid Materials. Carded web was formed into the batt by a vibrating lapper on the conveyor belt of through-air bonding chamber (Figure 1. and Figure2.).

The scale of the bonding temperatures was chosen in accordance with the melting temperature of the bonding fibers and series of test samples was made (Table 2.).

Area weight and original thickness of the samples had been measured using Edana standards 40.3-89 and 30.4-89.

Compressive rigidity of bulky textile materials is expressed as a dependence of thickness on compression. This was measured by the dynamometer at the deformation rate of 1 mm/sec. In the experiment, the samples 0.1 x 0.1 m were laid so that the total thickness of the assembly was more than 50 mm and placed between two metal plates of dynamometer. Loading tests were then carried out in the load limits of 0 – 4000 Pa and the load vs. thickness curves were (recorded) plotted.

All test samples were submitted to repeated loading, it means that the nonwovens were compressed 25 000 times to 50% their original thickness.

After repeated loading, the compressive rigidity of the materials was measured in the same way as described above.

Figure 3. - Figure 6. The compressional curves of materials at first compression (it means, before dynamic loading). The sample compression is expressed as a relative thickness of samples, the 100 per cent thickness is that of original material at 20 Pa load according to the standard cited.

Figure 7. The influence of dynamic loading to compressive rigidity of materials for bonding fibers of the first type. The compression curves after dynamic loading show materials are softened. It is apparently a result of the partial destruction of bonding sites during repeated.

Figure 8 – Figure 11. Relative size of material's softening due to influence of repeated loading. The rate R is recorded on the Y-axis.

$$R = \frac{Th2}{Th1} * 100[\%]$$

R ……. relative size of material's softening
Th1 ….. the thickness of the sample, which wasn't submitted to repeated loading
Th2 …. the thickness of the sample, which was submitted to repeated loading

Thus, the curves R vs. Load characterize the size of softening (in per cent) due to repeated loading.

Discussion

The influence of various types of bonding fibers on the compressional rigidity of perpendicular-laid fabrics was studied and the results are shown in Figure 3.-6..

- Figure 3 - the best result is for the bonding temperature T+10°C=200°C
- Figure 4 - the best result is for the bonding temperature T+80°C=200°C
- Figure 5 - the best result is for the bonding temperature T+80°C=200°C
- Figure 6 - the best result is for the bonding temperature T+80°C=200°C

The behavior in the repeated loading was measured and compared in the second part of our experiment. The Figure 7. show the compressional curves for the samples with the content of the first type of bonding fibers before and after dynamic loading. The samples before dynamic loading show higher compressional resistance at the various bonding temperatures.

The best result is for the temperature T+10°C=200°C

- Figure 8 - for the first type of bonding fibers; the best result is for the bonding temperature T+10°C=200°C
- Figure 9 - for the second type of bonding fibers; the best result is for the bonding temperature T+40°C=160°C
- Figure 9 - for the third type of bonding fibers; the best result is for the bonding temperature T+40°C=160°C
- Figure 9 - for the fourth type of bonding fibers; the best result is for the bonding temperature T+20°C=140°C

Summary

The vertically oriented fiber segments in perpendicular laid textiles contribute significantly to the compressive rigidity as well as to the elastic recovery of fabrics. The results of compressional resistance before dynamic stress are better for all samples. Generally, the influence of various bonding fibers and bonding temperatures is not negligible. This paper resolves to optimization of fiber blends for the end uses.

Table 1. Different types of bonding fibers and their properties.

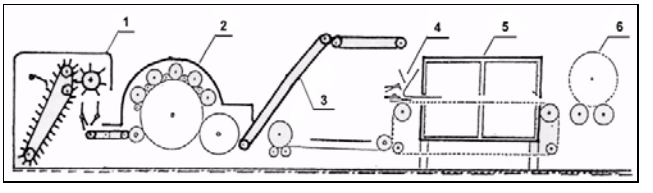
BF	Fineness[dtex]	Lenght[mm]	T[°C]
1	3,4	76	190
2	4	50	120
3	4,4	45	120
4	4,4	51	120

BF = the kind of the bonding fiber
T = the melting temperature = the minimum bonding temperature

Table 2. The composition and properties of the various blend samples.

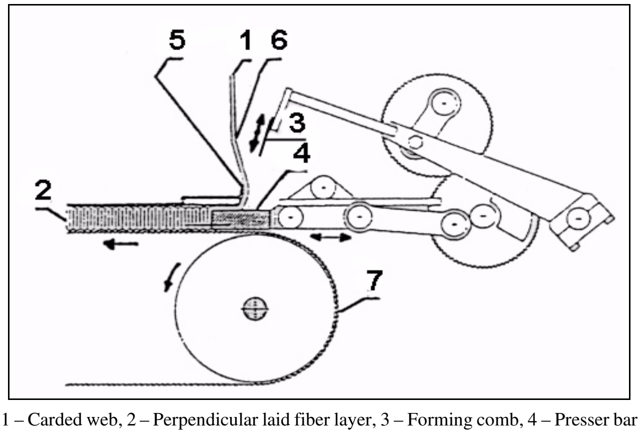
Samples	BF	Th.[mm]	Den.[kg.m^{-3}]	T[°C]	T+x[°C]
S1T1	1	25,67	10,32	190	190
S1T2	1	25,33	10,46	190	200
S1T3	1	27,44	9,66	190	210
S2T1	2	28,22	9,39	120	120
S2T2	2	28,33	9,35	120	140
S2T3	2	28,45	9,31	120	160
S2T4	2	27,11	9,95	120	180
S2T5	2	27,89	9,50	120	200
S3T1	3	28,00	9,29	120	120
S3T2	3	30,17	8,62	120	140
S3T3	3	28,11	9,25	120	160
S3T4	3	27,55	9,44	120	180
S3T5	3	26,00	10,00	120	200
S4T1	4	29,00	8,79	120	120
S4T2	4	28,56	8,93	120	140
S4T3	4	28,00	9,11	120	160
S4T4	4	27,33	9,33	120	180
S4T5	4	26,78	9,52	120	200

Th. = thickness
Den. = density
T = the melting temperature = the minimum bonding temperature
T+x = the bonding temperature



1 - Feeder, 2 – Carding machine, 3 – Output belt, 4 – Perpendicular lapper, 5 – Through – air bonding chamber, 6 – Take – up mechanism

Figure 1. A typical continuous production line for perpendicular laid textiles.



1 – Carded web, 2 – Perpendicular laid fiber layer, 3 – Forming comb, 4 – Presser bar with needles, 5 – Wire grid, 6 – Guide board, 7 – Conveyor belt of thermo-bonding chamber

Figure 2. Vibrating perpendicular lapper.

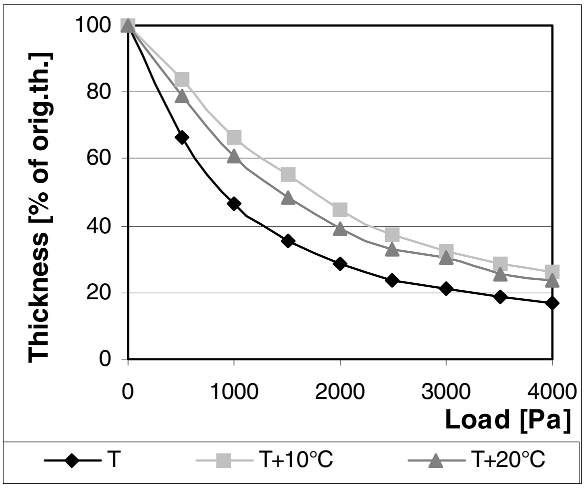


Figure 3. The first type of bonding fibers.

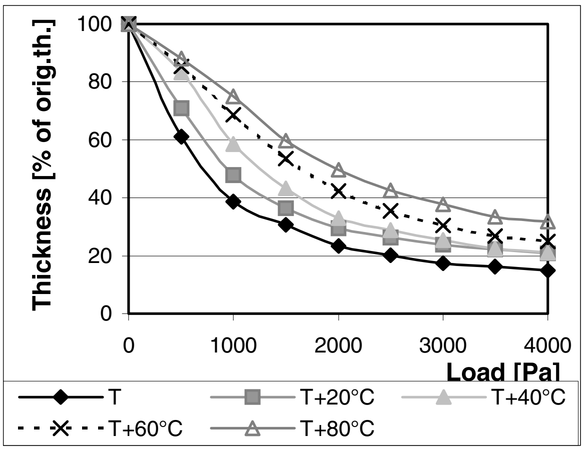


Figure 4. The second type of bonding fibers.

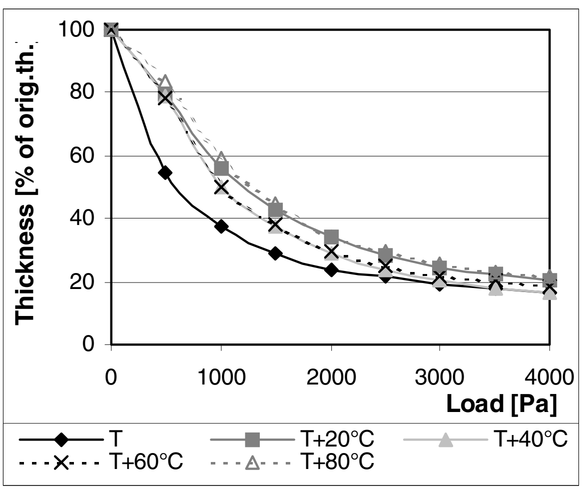


Figure 5. The third type of bonding fibers.

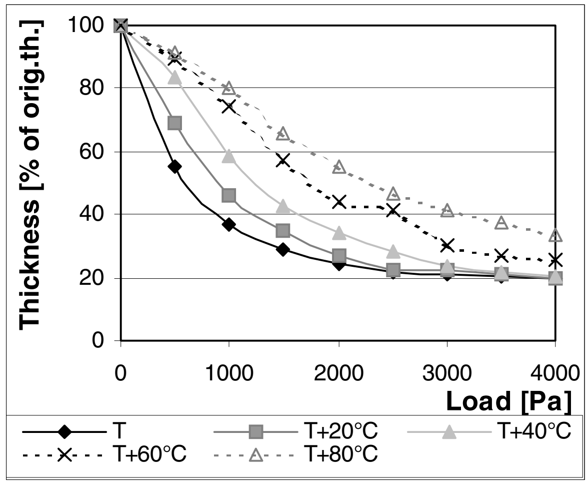


Figure 6. The fourth type of bonding fibers.

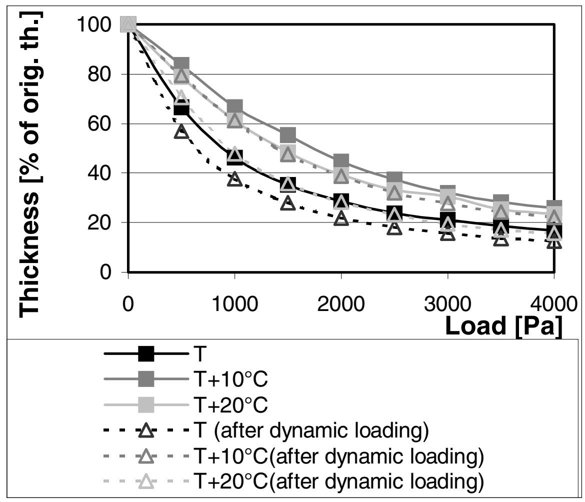


Figure 7. The first type of bonding fibers before and after dynamic Loading.

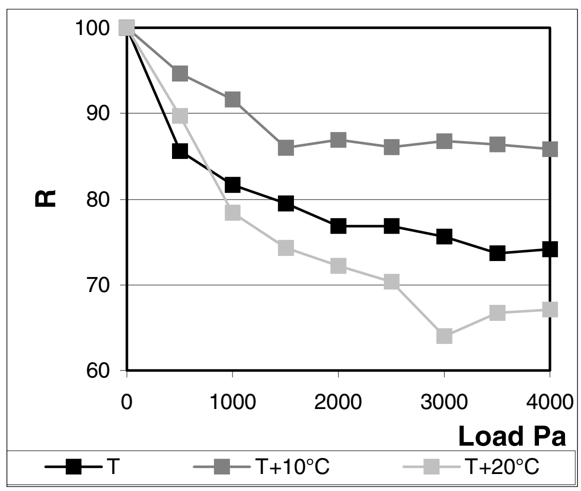


Figure 8. The first type of bonding fibers.

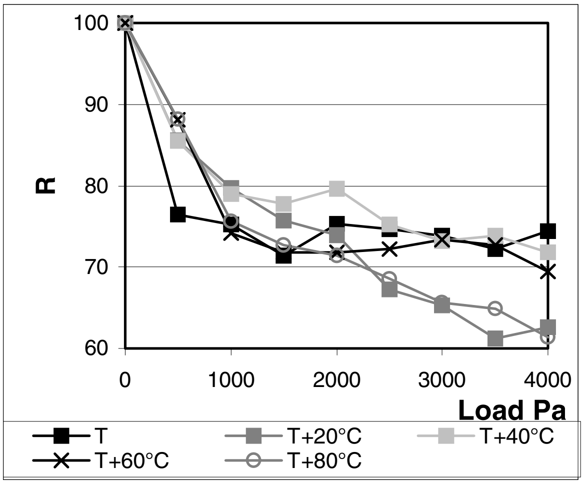


Figure 9. The second type of bonding fibers.

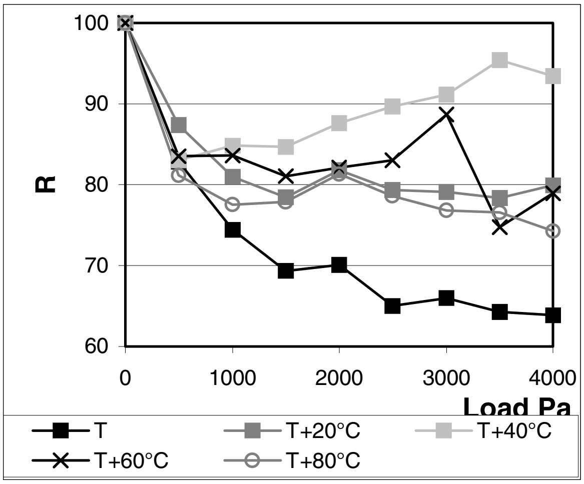


Figure 10. The third type of bonding fibers.

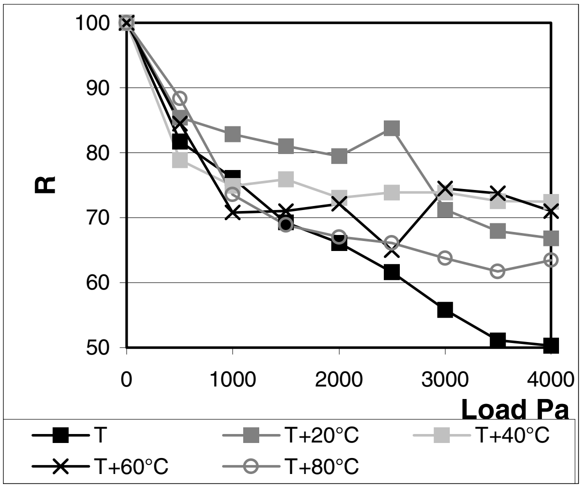


Figure 11. The fourth type of bonding fibers