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The Pneumatic Transport of Weak Weft Structures

Abstract

This article presents research work which concerns the loss of weft continuity while being picked with the use of a pneumatic loom. A stand designed and constructed with the aim of investigating the destructive influence of the air stream on the weft is presented, as well as the investigation results. We have stated that dependencies of weft degradation on the effective intensity of the air stream exist. The various characters of these dependencies and the influence of the structure of the transported fibre stream, which additionally changes under the influence of the air stream, were further stated. We found that the differentiation of structure and diameter of the fibre stream intensifies the destruction, whereas the existence of a yarn core inhibits it.

Key words: weft picking, pneumatic picking, weak weft structures, weft degradation, fibre stream, weft destruction.

Introduction

The high weft inserting velocities which can be applied in modern pneumatic looms are decisive for the widespread use of these kind of weaving machines. Construction improvements have mostly been carried out with the aim of achieving better working parameters, and to widen the application range of the pneumatic looms [1,2,4-8]. In contrast, knowledge of the phenomena which occur in the threads processed is at a considerably lower level, especially considering the structure of weft inserted by the use of an air stream. This is why a need has arisen to begin investigation into the durability of a loose weft structure, which should result in the determination of a range of structures which allow pneumatic picking. It is especially important to determine the lower limit of this range's tensile strength boundary.

It is already known that the assortment of threads which can be applied for processing with the use of pneumatic looms decreases with the increase in the loom's working velocity. An analysis of approachable research reports led to the statement that the processing abilities of a pneumatic picking mechanism have not been fully examined, considering the requirements for the minimal weft qual-

ity. The practical aim of our studies has been to determine which boundary weft structures would fulfil the tensile strength requirements of the pneumatic transport. This should enable determination of the technological quality minima, and in turn how to advise what kinds of structures with lowered quality are still suitable for processing into a woven fabric. It should be emphasised that in the available literature we did not find any information about the possibilities of weaving with the use of loose fibrous structures as weft. The work presented in this article, which is part of a more extensive investigation, was carried out with the aim of recognising the general relations connected with this problem, and determine the actual dependencies for one example of a loose, weak roving. To perform this task, it became necessary to build an appropriate measuring stand, and to develop suitable investigation methods.

The key problem of investigation into processing weak wefts into a woven fabric by pneumatic transport is the loss of the weft's continuity during transportation through the shed by the air stream. A research stand (Figure 1) was developed to determine the conditions of the continuity loss, and to make an effort to explain all the causes which can create these conditions. The research stand includes a row of up to 6 pneumatic loom jets arranged along the weft path. The weft is connected into a long loop and continuously conducted through the jets with the use of a drive system (Figure 1). Thanks to the multiplied picking jets arranged in series, the intensified impact of air on the weft can be tested. On the other hand, thanks to the available option of repeatedly passing every point of the weft through the air jet's impact,

the progressive weft degradation can be measured uninterrupted up until the weft's destruction.

Materials and Research Methods

Cotton roving with 125 tex, and with 135 twists per metre, of a loose, weak structure was used as weft. A series of micro-photographs of the same fragment of the transported weft was carried out with the aim of estimating by experiment the effects of air stream impact on the weft surface. This allowed us to compare the condition of the weft before and after the air impact. Next, the determination of the degree of structural changes of the weft as well as the nature of these changes permitted an attempt to describe the phenomena which occur in the loose structure of the linear textile product (the weft) under the influence of an air stream forced by the jet.

The changes of the outer layer, which is a layer containing fibres protruding from the roving and covering the roving's core (and determining its hairiness), as well as changes in the core diameter, could be estimated by means of the above-mentioned photographs [9,10]. The length in the 'raw' state of the segment tested in our investigation was 30 mm. The subsequent degradation stages of the roving were recorded by photographs, beginning with the 'raw' state, over the partial degradation up to the weft destruction. The marked roving segments were photographed after every cycle, and then the images (see Figure 2 a, b, and c) were analysed with the aid of a computer [3]. The analysis results are presented in Figure 3a and 3b; the three lines drawn illustrate three zones on the roving loop.

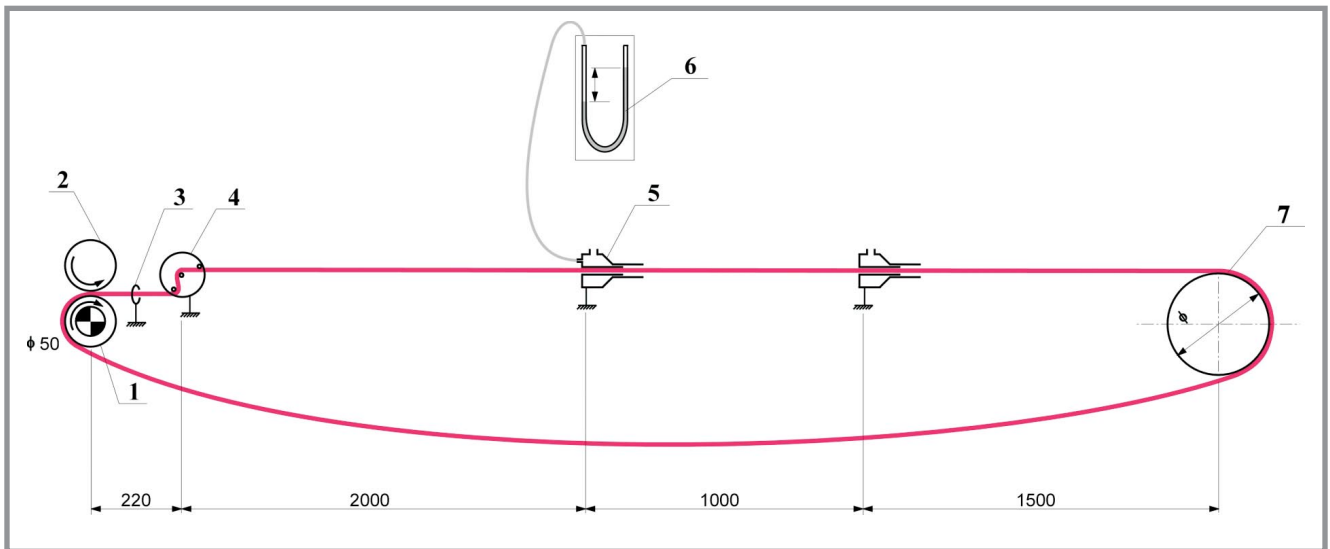


Figure 1. Research stand with doubled pneumatic loom jets for process intensifying; 1 - driving shaft, 2 - top roller, 3 - guide, 4 - thread tension gauge, 5 - jet of a pneumatic loom, 6 - indicator of the air pressure in the jet, 7 - thread transport guiding roller; all dimensions are in mm.

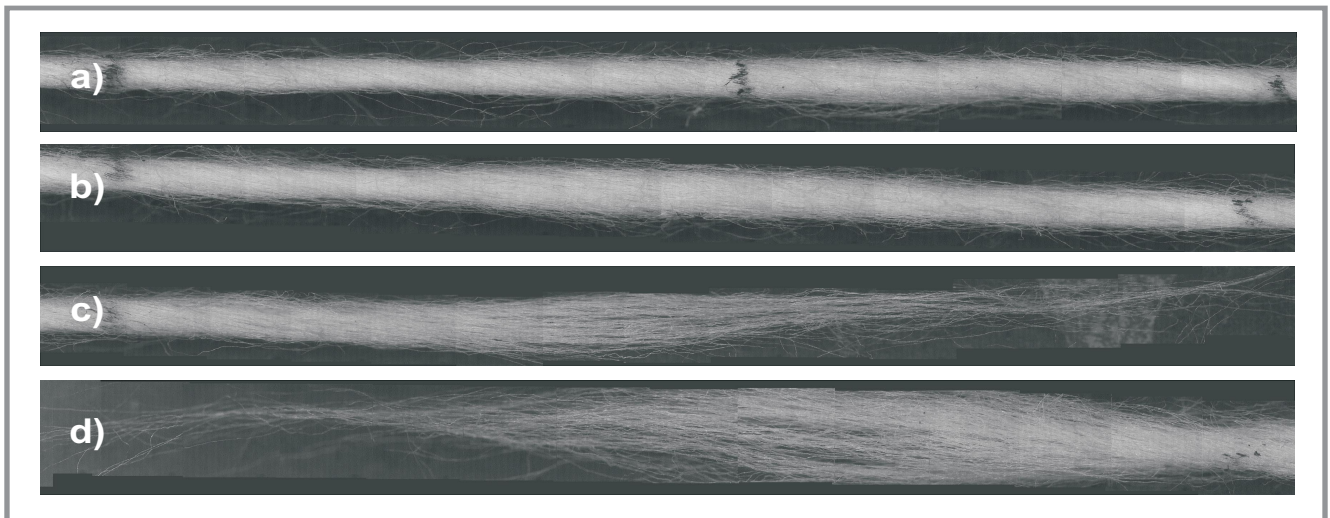


Figure 2. Photographs of 125 tex cotton roving with 135 twist per m; a - before testing, the length of the roving segment between the extreme markers is 30 mm, b - after doublet impact of the air stream, loosening of the structure and elongation of the segment is visible, c, d - loss of the roving's continuity: the separation of the roving's fibres at the place of breakage is visible.

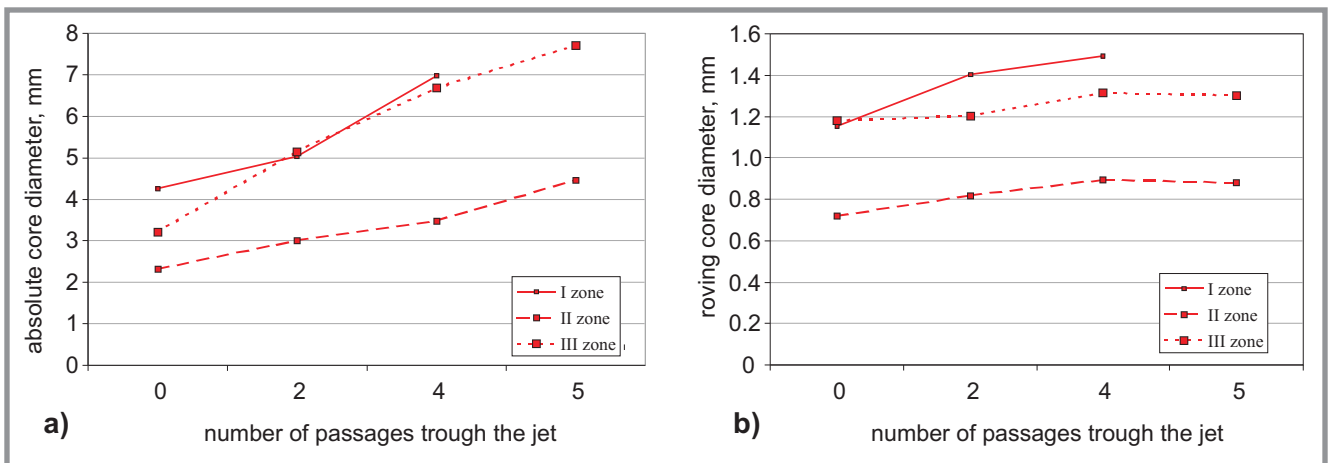


Figure 3. Impact of air stream on the roving expressed by the multiplicity of roving passages through a jet of the pneumatic loom, 'zero' number of passages means the 'raw' state before the test; a - influence on the roving core in three selected zones (I, II, and III); b - influence on the absolute hairiness of the roving.

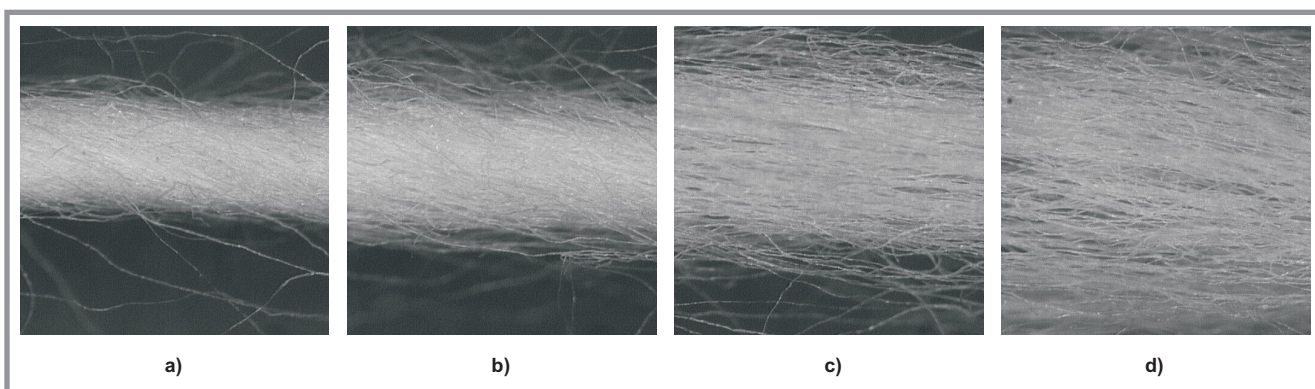


Figure 4. Photographs of roving at different stages of the air stream impact; a - before air impact, b - after two passages through the jet, c - after four passages through the jet, d - roving destruction.

Research Results and Discussion

An analysis of the subsequent photos taken in the individual zones, beginning with the 'raw' state, and up to the loss of continuity, enable us to state that changes in the roving's surface and in its interior can be noted which take place as the impact effect of the air stream. Enlarged fragments of the photographed roving segments are shown in Figure 4 (a, b, c, and d). The 'raw' state of the roving is a structure with a distinctly visible core, twist, and hairy outer layer (Figure 4a). The influence of air causes a gradual blurring of the boundary outlines between the core and the outer layer (Figures 4b and 4c). The image recorded during the last stage (Figure 4d) shows just loose fibres spread in one direction more uniformly than before, and more parallel to each other. The number and the length of the protruding fibre segments forming the outer layer increase, which means that the hairiness of the roving also increases. The structure proves to be bulkier, which results in the fibres being distributed in a greater volume. For this reason, the distances between the individual fibres of the stream also increase. There is no doubt that if even small longitudinal forces occur in the weft, such a structure is conducive to mutual translocations of the fibres. This is because the adhesion forces disappear on great fibre surfaces, as do those forces which originate in the interactions normal to the fibre surfaces, such as friction and hooking-up of the fibres' ends and bends. The above-mentioned phenomena fully explain the loss of continuity of the tested weft (Figure 4d).

With the use of computer-aided analysis of the future breakage spots it became possible to establish that, in the major-

ity of the events analysed, these weft spots are characterised by diameter differentiation (thickness irregularity) within short segments. The reason for this coincidence can be established on the basis of the following consideration: as is already known, different twist intensity characterises the weft segments with differentiated thickness. The close packing of the fibres in the spots with higher twist protect the structure (i.e. the spaces between fibres) against penetration by air, which loosens the weft structure. The owing air of the transporting stream can penetrate the thicker weft segments more easily, firstly as here it is faced with canals of greater cross-sections existing between the fibres, and secondly as thicker places cause higher aerodynamic thrust. In such a situation, the formation of bulky thick places, with fibres arranged more parallel to the thread axis as in thin places, causes the reduction of adhesion, friction, and hooking forces between the fibres, and leads to continuity loss of the fibre stream. Within the weft segments, which are characterised by regular thickness, the twist pressing the fibres together is greater than at the thicker places, and as a result the penetration of the air stream is smaller. This means that the weft fibre's tendency to mutual separation is smaller, and that the breaks occur more rarely. However, within these segments a certain weakening of the weft structure can also be observed, but it is of the same intensity along the whole weft segment length, and smaller than in the thick places.

In addition, in places where the weft is thinner, the stronger pressure (created by greater twist) which presses the fibres together protects the fibres against mutual translocations. But in turn, this phenomenon intensifies the tendency of the

bulked weft structure's fibres to separate in the thickened places, and causes a loss of continuity under the action of longitudinal forces without greater resistance.

During the degradation tests of pneumatically transported weft, the following experiment was carried out. The cotton roving was submitted in four tests to pass the jet: 4, 8, 12, and 16 times. The 16 passages caused the continuity loss of the structure. After every test, the correspondingly fatigued roving was divided into 25 segments, and their tensile strength was measured. The minimum value stands for the tensile strength of the weakest segment, and the maximum value for that of the strongest; the average value is related to 25 measurements.

As can be seen from Table 1 and Figure 5, the breaking strength of the tested segments decreased as the result of air impact. The dispersion of the average value significantly increased. These symptoms mean that the degradation of the places with higher tensile strength is smaller than that of the weaker places. The minimum value of the breaking force decreased by over 14 times, whereas the maximum value only by slightly over 2 times. It should be emphasised that the reason for the degradation of the objects tested was not based on plucking out the fibres by air. After the test with the weft passing the jets 16 times, only 3% loss of the total mass could be determined. The interpretation of the destruction mechanism of the loose weft structures presented above finds its proof in the latter statement. The structural instability of the tested weft is intensified by the air impact: the local thick places, which as weak elements are conducive to fibre separation, are significantly further

Table 1. Values of the tensile force which causes the loss of continuity before the test (zero), and after the 4th, 8th, 12th, and 16th passage through the pneumatic loom jet under established air velocity conditions.

Breaking strength, cN	Multiplicity of passages through jet				
	0	4	8	12	16 (break)
Average value	250.31	171.95	116.15	122.65	57.21
Minimum value	59.92	33.22	19.64	13.95	4.24
Maximum value	477.30	384.80	251.20	365.40	207.90
Standard deviation	125.725	81.981	72.258	117.581	49.42
Coefficient of variation, %	50.229	47.678	62.214	95.867	86.384

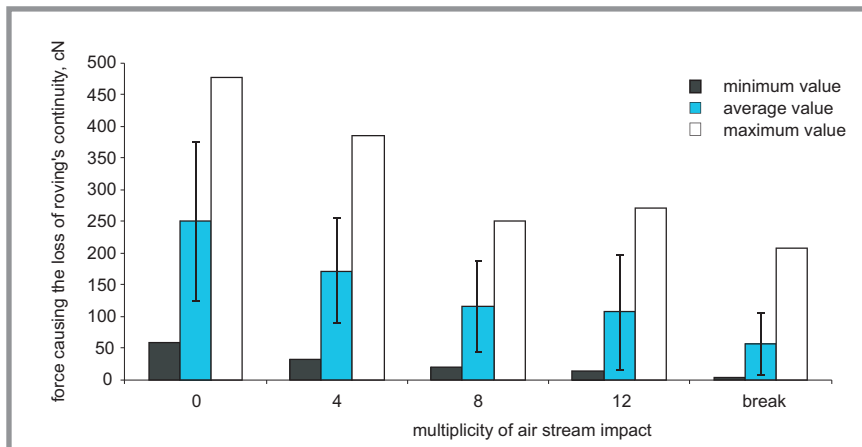


Figure 5. Influence of the multiplicity of air stream impact on the tensile force value, which causes the loss of the roving's continuity; the dispersions for the average values are also presented.

weakened, whereas the local thin places with higher strength are considerably less weakened.

Conclusions

- The research stand which we designed and built, which simulates the conditions of fibrous loose linear structures translocated by means of a pneumatic transport in the loom, allows the observation of these structures, as well as measurement of their degradation and destruction.
- Investigation of the influence of loose fibrous structures on the destructive impact of the transporting air stream allows us to determine the degradation degree of these structures in dependence on the intensity of the air impact. The degradation degree can be measured by the increase in weft and core diameter and by the increase in hairiness. All changes increase monotonically with the air impact intensity.
- An analysis of the microscopic images of the weft structures proves that an intensive degradation of the loose linear fibrous object takes place in weft segments of differentiated thickness.

- The explanation of the phenomenon pointed out in the 3rd conclusion is possible by means of a microscopic analysis of the weft images and of the tensile strength tests.
- Distinctly differentiated conditions exist which determine the degradation of loose weft structures which are pneumatically transported and subjected to the impact of the air stream forced by jets:
 - A smaller degradation of the weft was noted if the degradation was caused by numerous air streams than if fewer streams with the same draught force had acted on the weft.
 - The impact of the aerodynamic force causes an increase in the diameter, the diameter of core, and hairiness of the loose linear textile product. The tensile strength decreases, whereas its dispersion along the textile product increases. The boundaries between the core and the outer layer are blurred, the weft becomes more bulky, and migration of fibres from the core to the outer layer is visible, as is its arrangement in this layer.

- The existence of a fibrous core in the structure of the loose textile product inhibits its degradation by the transporting air stream (the hairiness, the elongation of weft segments, and the diameter increase more slowly, compared with a structure without a core).

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