NET-SHAPE KNITTED FABRICS AS CARRYING ELEMENTS IN TECHNICAL COMPOSITE PRODUCTS

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Abstract

This paper presents an experimental investigation aimed at broadening the range of knitwear application on composite products of non-conventional destination carried out at the TRICOTEXTIL Institute of Knitting Technology and Techniques. The research problems of these investigations, as solved by us, included the application of knitted fabrics as abrasive composite products for finishing activities in the building industry, filter materials, and upholstery constructions. An analysis of the structure of net-shaped knitted fabrics as applied for technical composite materials is presented, together with the fabric's parameters. In addition, an estimation of the composites manufactured with the use of net-shaped knitted fabrics also is presented.

Keywords:

knitwear, knitted fabrics, net-shaped fabrics, composites, technical composites, abrasive products, filtration material, upholstery-coverings

Introduction

Between 2001 and 2002, the TRICOTEXTIL Institute of Knitting Technology and Techniques carried out experimental investigations aimed at broadening the range of applying knitting techniques on products of non-conventional destination, especially for use in the chemical, food, automotive and building industries, as well as in furniture manufacture. The target of these investigations was to elaborate products based on net-shaped knitted fabrics of quality which are comparable with, or even of better quality, than imported products, and to introduce them into the domestic market. The research problems of these investigations, which we have solved, included the application of knitted fabrics

- as abrasive composite products which can be helpful in finishing activities in the building industry, and
- in the manufacturing of nonwoven composites destined for filtration products and in upholstery constructions.

Knitted fabrics with open-work stitches manufactured by the wale technique from polyester filament yarns were selected for the investigation, considering the usability requirements by which the above-mentioned technical products should be characterised. The knitted fabrics selected were characterised by the following features:

- optimal chosen net structure,
- high dimensional stability,
- good tensile strength,
- thermal resistivity, and
- possible low area mass.

The structure of net-shaped knitted fabrics which we developed are shown in the photos presented in Figures 1 and 2.

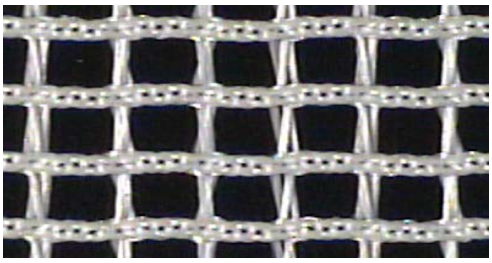

Figure 1. Photo of a knitted net structure before silicon carbide deposition (a selected example)

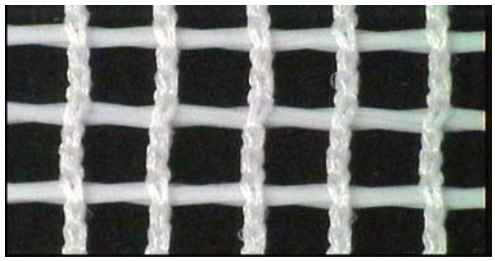

Figure 2. Structure of a knitted fabric destined to strengthen the pile of fibre over the needling process

The basic materials used (a knitting in each case) were joined with the other composite component dependent on the composite's destination by two methods:

- the thermal method, spreading silicon carbide on the knitting surface, and
- the mechanical method, with the use of a pile from synthetic fibres.

The characteristic features of the composite materials we developed, and the research results achieved, are presented in the following chapters.

Abrasive composites

The composites developed have been used as abrasive means for sanding smooth surfaces, such as internal and external building walls (indoors and outdoors). The double-sided granulated composites were obtained by spreading the second component (silicon carbide) on the surface of the knitted fabric. The thermal method used for silicon carbide deposition allowed us to achieve a stable fastening of the carbide to the knitting structure.

The selection of the optimum technological parameters connected with the selected structural solutions for the knitting stitches allowed us to achieve a homogeneous distribution of free spaces of the preliminary assumed space-shape and dimensions. A suitable selection of silicon carbide granulation and time-thermal parameters of the spreading process allowed us to obtain the expected abrasive features of the composite, and to protect it against any brittleness and chipping of the abrasive medium.

The developed abrasive nets on the basis of knitted fabrics with open-work stitches achieved tensile strength parameters which approximate the parameters of imported nets of comparable destination which are accessible on the domestic market. We have achieved the following parameters of our products:

- tear resistance in longitudinal direction: minimum 2.3 daN,
- tear resistance in perpendicular direction: minimum 3.0 daN,
- breaking force in longitudinal direction: minimum 25 daN, and
- breaking force in perpendicular direction: minimum 50 daN.

Numerous variants of the knitted samples were prepared for tests, considering the decisive influence of the knitted fabrics' structural properties on their behaviour during practical use as abrasive material. The samples were differentiated by:

- linear density of yarn,
- the yarn length worked-in the loop,
- partial stitches,
- repeat of the yarn draw-in through the needle bars, and
- the dimension and shape of the net 'holes'.

The knitted samples were manufactured with open-work {double-needle, and three-needle stitches} with the use of flat warp-knitting machines and 16E and 28E needle gauges. Polyester yarns with linear densities of 84 dtex f36 and 110 dtex f24 were applied.

The knitted samples were produced with different partial stitches and systems, with the aim of achieving knitted fabrics of appropriate net structure and with limited (as much as possible) deformation ability in both directions. The following stitch systems were applied:

- tricot joined with velvet of increasing link length in the individual variants, and
- pillar stitches together with weft of irregular laps.

An optimal knitting tightness was selected for all sample variants aimed at achieving the demanded dimension stability of the composites. To achieve a regular structure of the open-work knitted fabrics, the optimum relation between the run-in of the individual warps was selected, and then this parameter was maintained exactly during all the tests carried out.

The individual sample variants were thermally stabilised. The stabilisation was carried out according to conditions accepted for common polyester knitted fabrics.

Next, the knitted fabrics finished were metrologically evaluated with the aim of determining the basic technological and strength parameters.

The estimation of the abrasive composites' quality during practical use, including industrial applications, was a confirmation of laboratory tests.

The research results obtained allowed us to state that the knitted fabrics (consisting a component of the abrasive composite) optimally fulfil the usability requirements assumed, if they are characterised by the following parameters:

- area of the net-hole: maximum 4 mm^2,
- dimension changes after washing: maximum 2%,
- breaking resistance in longitudinal direction: minimum 12 daN, and
- breaking resistance in perpendicular direction: minimum 6 daN,

Needled nonwoven composites

Needled nonwoven composites are composite nonwovens manufactured by means of one technological process, by joining a fibre pile with other textile components by the needling method, but without the use of any chemical and physical bonding agents.

The basic raw materials are chemical fibres, especially polyester and polypropylene fibres, which secure the appropriate chemical and biological resistivity of the nonwovens.

Applying components of suitably designed structures, together with the selection of the technique and technological parameters of the needling process, allows us to obtain composites with the use properties demanded.

A broad technological variety which can be applied for needled nonwoven composites and relatively low manufacturing costs, which results from the single-stage manufacturing process, has secured its predominant position in technical application. Nonwoven composites have found application in different economy branches. A broad range of products is manufactured with their use, such as sealings, gaskets, filters and shoe-linings, and upholstery-coverings.

However, there are fields of application which require a search for new assortments of nonwoven composites with improved use properties with the following aims: securing higher durability of the technical products, extension of the exploitation periods, and improving their appearance and aesthetics. Recently, the greatest demand can be observed for such composite applications as filter products in the chemical & food industries, and in medicine. The furniture and automotive industries have also observed an increasing demand for composite materials of decreased specific mass, which at the same time maintain good strength properties. Such materials may be used as upholstery-coverings in furniture and car equipment.

The composite nonwovens which have so far been manufactured are in general processed on the basis of joining the pile with a woven fabric component.

Existing knowledge concerned with the question discussed has confirmed the TRICOTEXTIL research staff's advisable and proper decision to commence experimental investigations aimed at determining the ability to use knitted structures destined for new-generation nonwoven composites manufactured by means of the needling technique. Such investigations were commenced at the TRICOTEXTIL Institute of Knitting Technology and Techniques in 2001. It was assumed that the experimental tested knitted fabrics which should be used for reinforcing the fibrous pile must have a net structure. This solution should secure a possible low area mass while at the same time maintaining a good level of the strength parameters.

The following components were selected for tests:

- polyester knitted fabric with net structure,
- polypropylene fibre pile, and
- pile of waste synthetic fibres.

During the laboratory needling tests carried out, the net knitted fabrics were joined with the fibre pile without any additional thermal or chemical processing.

Two variants of needled nonwoven composites were developed:

– the **first variant** consisted in manufacturing a composite nonwoven destined for products applied in gas, dye, and oil filtration. The knitted net-shaped fabric was joined with a polypropylene fibre pile.

– the **second variant** included manufacturing of composites destined for upholstery coverings. The pile from synthetic fibre wastes was reinforced by a net-shaped knitted fabric.

Appropriate parameters of the technological process were chosen to secure good cohesion between the components joined. The needling density and depth were selected. In addition, the selection of the tension values maintaining these values on a constant level along the components' guiding-way during their manufacture, and the high dimension stability of the knitted fabric, all protected the fabric from forming durable crinkles in the structure of the composite nonwovens.

No defects in the net structure could be noted during the needling process, which confirms that the knitted fabric had been correctly designed considering the selection of the open-work stitch and of the technological parameters of the process.

The nonwovens manufactured were estimated as being of good quality, considering their good voluminous cover, the soft, pleasant handle, the good elasticity features, and the good drape ability.

The technical and technological parameters of the compounds used for manufacturing the samples of the needled nonwovens are presented in Table 1.

Table 1. Technical and technological parameters of the compounds used for sample manufacturing of the needled nonwovens.

Components	Sample 1	Sample 2
Fleece:		
materials	PP fibres	waste synthetic fibres
weight [g/m^2]	240	270
Knitwear:		
type	wrap knit net	wrap knit net
materials	PET yarn, 167 dtex	PET yarn, 167 dtex
weight [g/m^2]	110	110

Selected physico-mechanical parameters of the composite samples obtained as determined in laboratory tests are listed in Table 2.

Table 2. Physico-mechanical parameters of the composites obtained, destined for filtration materials (test no. 1) and upholstery-coverings

Name of parameter	Sample 1	Sample 2	Method of investigation
weight [g/m^2]	352	380	PN-EN 29073-1:1994
thickness [mm]	3.81	3.57	PN-EN ISO 5084:1999
breaking resistance in longitudinal direction [N]	205	124	PN-EN ISO 9073-4:2002
breaking resistance in perpendicular direction [N]	377	114	PN-EN ISO 9073-4:2002
tensile strength in longitudinal direction [N]	671	333	PN-EN 29073-3:1994
tensile strength in perpendicular direction [N]	986	385	PN-EN 29073-3:1994
elongation at break in longitudinal direction [%]	155	149	PN-EN 29073-3:1994
elongation at break in perpendicular direction [%]	84.0	63.9	PN-EN 29073-3:1994

Conclusions

The analysis and the estimation of test results carried out allowed us to state that the nonwoven composites developed, manufactured on the basis of net-shape knitted fabrics, have (considering their destination) very good strength features, a relatively low area mass and high air permeability.

At present, the nonwovens developed are being tested by experimental use in order to confirm the laboratory test results.

The usage opinion achieved will serve as an indicator for further investigation into net-shaped knitted fabrics.

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