DEVELOPMENT OF FUNCTIONAL HAND PROTECTION AND CUSTOMISED TROUSERS FOR SAFETY AND WELLBEING

Livia Kokas Palicska[1], Fülöp Augusztinovicz [2], Orsolya Nagy Szabó[3], Antonela Curteza[4], Manuela Avadanei[4]
[1] INNOVATEXT Textile Engineering and Testing Institute, Budapest (Hungary)
[2] Budapest University of Technology and Economics, Budapest (Hungary)
[3] Obuda University, Budapest (Hungary)
[4] Gheorghe Asachi Technical University, Iasi (Romania)
E-Mail: kokas@innovatext.hu

Abstract

The aim of the research work was to develop prototypes for hand protection and functional cloth for safety and wellbeing. Theoretical works dealing with adoption of techniques were envisaged, extended by a wide-range of experimental and validation activities. The consortium consitsting of Hungarian and Romanian partners searched for novel structures with functional performance, which protect limbs, are comfortable, have advanced washing resistance, long-lasting performance and can be used in different sectors (industrial, sports, etc.). The Hungarian research concentrates prior on prototypes for new kind of anti-vibration knitted gloves and the Romanian partner on knitted products assuring and maintaining the wearer's health, providing protection in case of accidents caused by the particularities of leisure/recreational activities and sport for active young people.

1. Introduction

Nowadays, what matters the most when wearing protective apparel is its functionality, whereas any aesthetic or wearing properties fall on the second place. Especially challenging is to fulfil all requirements on the field of personal protective equipment (PPE), where special function should be combined with wearing comfort. There are several million workers worldwide suffering daily from vibration exposure of hand-held machines. In case of long-lasting and strong hand-arm vibration exposure even a severe vibration-induced white finger disease can be arisen.
Special functional clothes are required for workers in IT department maintaining the wearer's health and to prevent occupational diseases. Such customized cloth could provide protection also in case of accidents caused by the particularities of leisure/recreational activities and sport. This part of the research focused on the customized trousers for wellbeing.
The aim of this research on one hand was to identify how the the protective level and comfort properties of the knitted multilayer gloves varies when changing their composition and structural parameters, on the other hand to assess the performance and functionality of the proposed structures of the customised trousers for leisure sports.

2. Material and method

2.1 Prototyping anti-vibration gloves

Different Nomex, Dyneetex knitted protective gloves were obtained from the Hungarian partner company. 30 multi-layered composits made of seamless shock-resistance knitted fabrics, space materials and non-textile materials were developed for testing the protective performance. For the measurements special test equipments were built to perform cutting tests according ISO 13997, a test setup for the measurement of vibration isolation according ISO 9052-1 as well as for the determination of the overall vibration isolation of gloves following ISO 10819 (Fig. 1, 2). Tests of protection against mechanical risks and heat were performed. The results were evaluated to create a ranking list according to the mechanical, the heat protection and the comfort characteristics. All selected materials to be used as insertions in vibration isolating gloves were tested according to the international standard ISO 9052-1 performing the measurement of one-degree-of-freedom resonance frequency (Fig.1).

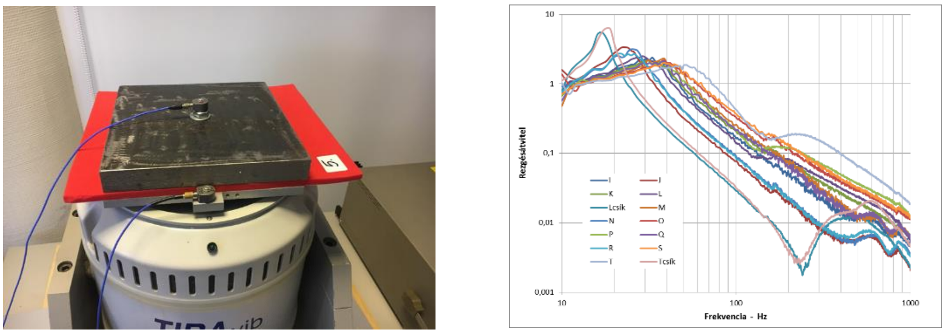

Figure 1 – Test according to ISO 9052-1 and the measured vibration isolation of tested samples

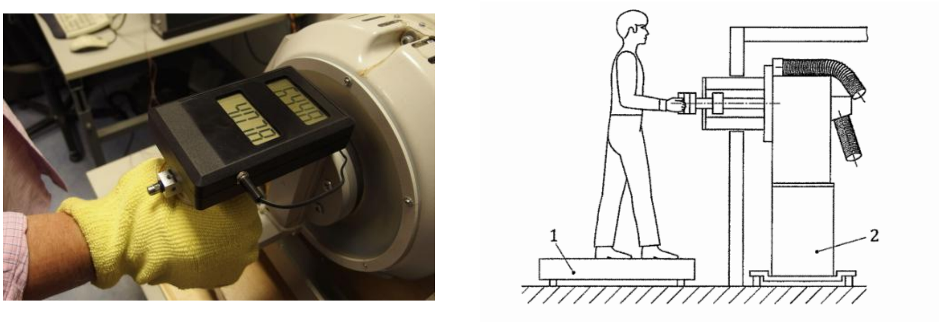

Figure 2 – Test equipment to measure vibration-isolation of gloves according to ISO 10819

To develop prototypes of antivibration gloves, laminating technique was applied to affixe pattern pieces to the surface of the knitted fabric. First stage of the design process was to determine the segmentation of the spacer and other test fabrics. Extent of padding determines dexterity and tactility of the hand. Attaching the fabric without segmentation hinder the movement of hand because it is not able to bend easily. However, maximizing segmentation will reduce the cushioning effect because only small areas are covered with spacer fabric.

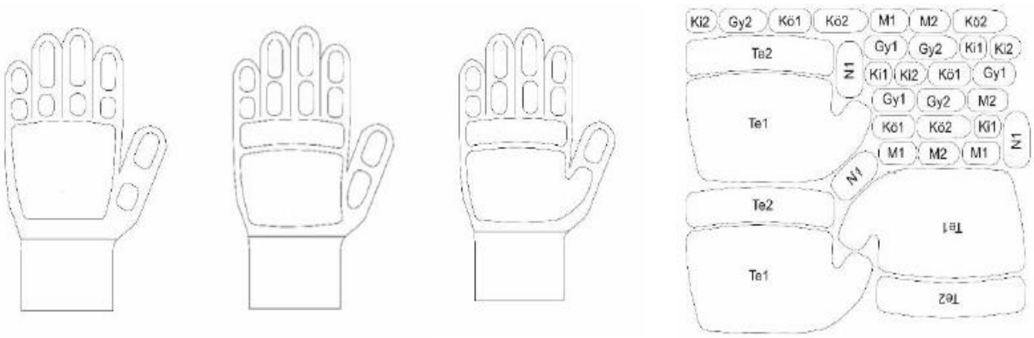

Figure 3 – Pattern for gloves propotypes made by Morgan CAD softver

Fig. 3 shows three of the created patterns designed by the Morgan CAD Garment Manufacturing Preparation Software. It is capable of digitizing existing cut patterns, photo-based editing, creating and modeling new patterns, pattern modification and adjusting. The softver also offers the ability to size grading, and measurements checks. Several other patterns were drawed too. The pieces of space fabrics, three-layers fabrics were laser cutted and glued on using a heating press (120 C ^{o}, 20 sec 1bar) on the inner layer of the knitted Nomex and the Dyneetex protective gloves.

2.2 Prototyping functional trousers for recreational activities targeting children or teenagers

The fabrics used in our study to obtain the functional textile products for those who are exposed to accidents were: 3 base knit materials (interlock, one-sided, and plated jersey) the first two structures comprise cotton and elastomeric yarns, whereas the third structure is made of polyamide and elastomeric yarns; 7 filling fabrics with a layered composition accomplished through various technologies. Corresponding laboratory tests were conducted using the LRX Plus (Lloyd Instruments Ltd -AMETEK-England) equipment which assesses materials when stretched/compressed; the machine had the following functional properties: the loading force is measured with the help of a force transducer (load cell), XLC-500-Al, which allows the measurement of forces up to 5,000N, with a precision of 0.5% according to ASTM E4 and DIN 1221; the speed with which the force is applied can be in the range of 0.01-1,016 mm/min, with a precision of 0.2%; the axial motion (deformation) is measured with the help of the numeric axis of the testing machine, with a precision of 0.001 mm. All the tests were scheduled to take place under identical circumstances (same force, same bradawl movement speed, same loading cycle, and same method of embedding the material). Data acquisition and processing were carried out with the help of integrated software, NEXIGEN Data Analysis, embedded in the LRX Plus testing machine (Figure 4-6). Taking into account the destination of the products, the experiments were conducted in three ways: individually, on each base and filling material; on two-layer combinations (base + filling fabrics); on three-layer combinations (base + filling + base fabrics).

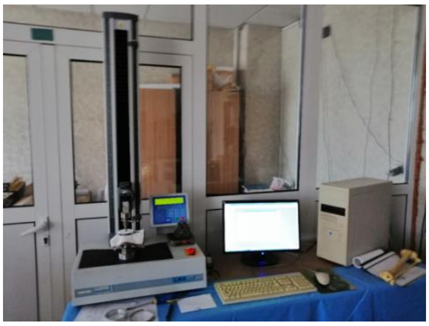

Figure 4 - Overview of the testing installation

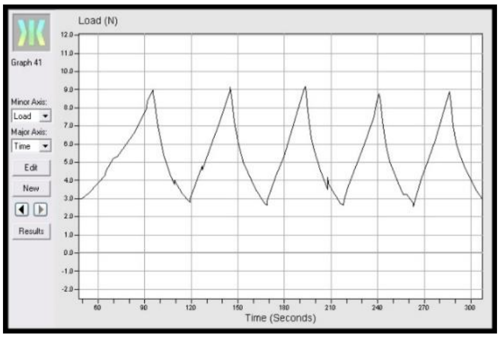

Figure 5 – Example of experimental results obtained

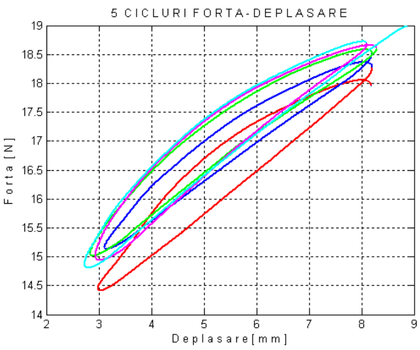

Figure 6 – Force-motion testing loads (5 cycles) for the filling fabric, namely the three-dimensional knitted textile support (sandwich-type) made of polyamide yarns

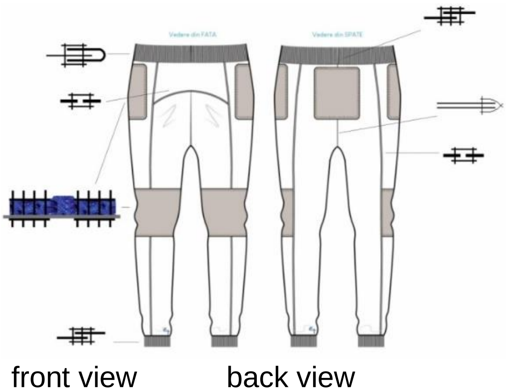

Figure 7- Functional trousers model – technological map

3. Results and discussion

The cut resistance of the tested knitted samples was level 5 and 4 (from rate 1-5), and B according to the TDM-100 method, while all other physical performance factors such as abrasion, tear and puncture resistance were level 1. Samples including silicon and space fabrics have shown significant anti-vibration characteristics in frequencies 10-200 Hz. The transmissibility value (y) decreased rapidly at frequency range of 50 – 130 Hz, the vibration was reduced by one to two orders of magnitude (corresponding to 20 to 40 dB damping). Space fabric instead of silica in three-layer composition increased the dexterity and hand feel comfort of the gloves. Further research should be continued on the structure of the glove protoptypes, investigating how to bond the layers together and how to fix the selected anti-vibration elements on the knitted surface. After the final tests of the gloves prototypes and the wearing trials the results will be evaluated.

The tests of the specimens for functional functional trousers for recreational activities targeting children or teenagers were evaluated. As for the ability to resist external mechanical actions and to dampen shocks, respectively, the best results were obtained in the case of the three-layered variant corresponding to the following knitting structures: plated jersey + three-dimensional knitted textile support + plated jersey. Using this best variant, a functional trousers model was designed and obtained with the help of the manufacturing technology (Figure 7).

4. Summary

The development of new anti-vibration gloves and textile apparels (functional models) is the result of applying new design concepts that entail, from the very start, specific planning and execution methods based on the use of high-performing textile products. Thus, it can be ensured a balance between function, shape and structure. The technical-scientific activity was focused not only on the application of new/innovative techniques and solutions so as to design and implement such products, but it also included experimental and result validation activities.

5. Acknowledgements

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Literature

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2. ISO 10819:2013 Measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand
3. Helga E. Laszlo, Michael J. Griffin, The transmission of vibration through gloves: effects of push force, vibration magnitude and inter-subject variability; Ergonomics. 54, 5, p. 488-496 ,(2011)
4. L.Kokas, Palicska ; F., Augusztinovicz ; A., Szemeredy ; L., Szucs,Development and test of new kinds of anti-vibration knitted hand protection, AUTEX2019 – 19th World Textile Conference on Textiles at the Crossroads, p. & , 3 p.Ghent, Belgium, (2019)

PROTEXSAFE

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Aim

To protect workers working with percussion drills, road-breakers, chainsaw and similar, special PPEs are requested. The developed prototype for anti-vibration gloves aims to prevent severe vibration-induced white finger disease. Customized knitted cloth could provide protection in case of accidents caused by the particularities of leisure/recreational activities and sport.

- Anti-vibration gloves are aimed at
  - ensuring improved comfort
  - avoiding health impairment
  - ensuring resistance to cutting and fire
- Issues to be decided upon:
  - Composition
  - Fabrication technologies
  - Materials

- Knitted sport trousers for youngsters
  - assuring and maintaining the wearer's health,
  - providing protection in case of accidents
- Issues to be decided upon:
  - Raw material,
  - Design and knitted structures
  - Production technologies

Experimental

- Specimens in sandwich construction:
  - upper: 100% Kevlar or Dynetex
  - inner: space fabric, PUR
  - underlining: 100% cotton fabric
- Prototypes :
  - Anti-vibration parts were laser cutted and glued on the knitted fabrics
- Measurements and tests:
  - Vibration isolation measurements
  - Coup test
  - Heat resistance test

- Specimens were interlock, one-sided and plated jersey made of
  - cotton/elastomeric yarns
  - polyamide/elastomeric yarns
  - 7 filling fabrics
- Prototypes:
  - Trousers with a layered composition
- Measurements and tests:
  - stress/elongations by LRX Plus (Lloyd Instruments Ltd-AMETEK)

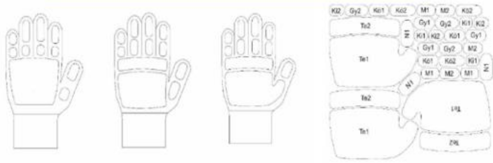

Fig. 1 Pattern for gloves prototypes made by Morgan CAD software

Measurements of vibration isolation

- **according to ISO 10846 : 2013, to proof the degree of protection against vibration at frequencies from 100 Hz up to 600 Hz.**
- **according to ISO 10819 : 2013 Measurement of the vibration transmissibility of gloves at the palm of the hand**

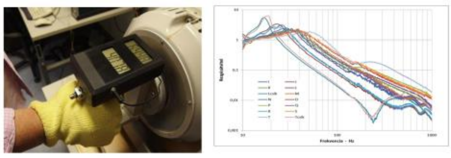

Fig. 2 Vibration isolation test and results according to measurements in the laboratory of BME

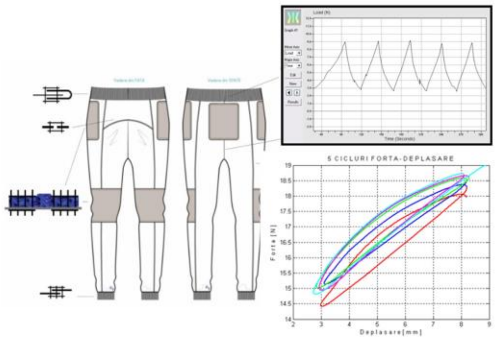

Fig. 3. Model for functional trousers – technological map and result of measurements

Results and discussion

New testing devices to measure hand-arm vibration and cut resistance according to the relevant standards were developed and validated. 30 multi-layered composits made of seamless shock-resistance knitted fabrics, space materials and non-textile materials were produced and tested. Cut resistance of the tested knitted specimens acc. to EN 388 were 5 and 4 (from rating 1-5), and B according to the TDM-100 method, while abrasion, tear and puncture resistance reached level 1. Samples including silicone gel and space fabric show significant anti-vibration characteristics in frequencies 10-200 Hz. The transmissibility value (y) decreases rapidly at frequency range of 50 – 130 Hz, the vibration was reduced by one to two orders of magnitude (corresponding to 20 to 40 dB damping) (Fig. 2).

As for the ability to resist external mechanical actions and to dampen shocks, respectively, the best results for trousers were obtained in the case of the three-layered variant corresponding to the following knitting structures: plated jersey + three-dimensional knitted textile support + plated jersey. Using this best variant, a functional trousers model was designed and obtained with the help of the manufacturing technology (Fig. 3).

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Contact

INNOVATEXT Textile Testing and Engineering Institute Co.
H-1103 Budapest, Gyömrői út 86.
Dr. Livia Kokas Palicska, e-mail: kokas@innovatext.hu
www.protexsafe.hu

AACHEN DRESDEN DENKENDORF INTERNATIONAL TEXTILE CONFERENCE
INNOVATEXT
GLOVITA
MŰEGYETEM 1782
NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE HUNGARY
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