Rezultati projekta HRZZ IP-2018-01-6363 Razvoj i toplinska svojstva inteligentne odjeće (ThermIC)

Sveučilište u Zagrebu Tekstilno-tehnološki fakultet
University of Zagreb Faculty of Textile Technology

Rezultati projekta
HRZZ IP-2018-01-6363

RAZVOJ I TOPLINSKA SVOJSTVA INTELIGENTNE ODJEĆE (ThermIC)

Project Results
HRZZ IP-2018-01-6363

Development and thermal properties of intelligent clothing (ThermIC)

Zagreb, 2023

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Sadržaj / Content:

01. Osnovne informacije o projekta
Basic project information

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Voditelj / Principal Investigator: Prof. dr. sc. Dubravko Rogale

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02. Predgovor voditelja projekta
Foreword

Znanstveno-istraživački projekt **Razvoj i toplinska svojstva odjeće IP-2018-10-6363 (ThermIC)** odobren i financiran od **Hrvatske zaklade za znanost** je vrlo značajan za razvitak odjevnog inženjerstva. Rezultirao je okupljanjem većeg broja znanstvenika s Tekstilno-tehnološkog fakulteta i Fakulteta elektrotehnike i računarstva, širokim spektrom istraživanja, objavom razmjerno velikog broja kvalitetnih radova, inovacijama i patentnim prijavama, ustrojem novog laboratorija te izradom doktorskih i diplomskih radova. Velika publicistička aktivnost na Projektu, koja je zasigurno doprinijela autorima pri njihovom znanstvenom i nastavnom napredovanju, omogućena je i zbog suvremene istraživačke opreme financirane od strane Hrvatske zaklade za znanost.

Posebno treba napomenuti nabavku stroja za visokofrekventno spajanje polimernih materijala, stroja za koordinatno ravninsko šivanje, mjernog uređaja za mjerenje zrakopropusnosti, te realizaciju termoizolacijske komore za niske temperature kvadrature 4 m^2.

Aktivnosti na projektu provođene su u osam radnih skupina sa sljedećim ciljevima:

1. usavršavanje gradbene arhitekture i provjera uspješnosti reakcija nove generacije IOPATS.
2. uspostava novih mjernih metoda i protokola za mjerenje cjelovitih toplinskih svojstava konvencionalne i inteligentne odjeće.
3. uspostava Laboratorija za termoizolacijska svojstva odjeće u Zavodu za odjevnu tehnologiju u kojem je instaliran unikatni integrirani sustav za cjelovita ispitivanja toplinskih svojstava odjevnih kompozita i odjeće.
4. optimiranje reakcija inteligentne odjeće i određivanje cjelovitih toplinskih svojstava pri promjenjivim uvjetima okoliša u laboratorijskim uvjetima.

U sklopu projekta izrađeno je više mjeriteljskih uređaja i prototipova dijelova odjeće i odjevnih predmeta koji su bili izloženi na domaćim i međunarodnim izložbama inovacija te su nagrađene vrlo prestižnim nagradama prikazanih u 10. poglavlju ove monografije.

Također su Državnom zavodu za intelektualno vlasništvo Republike Hrvatske predane tri patentne prijave, čiji je prijavitelj Tekstilno-tehnološki fakultet.

Razvila se međusobna suradnja i s članovima ostalih HRZZ Projekata. U suradnji s članovima projekta HRZZ IP-2020-02-5041, izv. prof. dr. sc. **Ivanom Salopek Čubrić** i izv. prof. dr. sc. **Goranom Čubrićem** održan je zajednički *Seminar o primjerima dobre prakse istraživačkog rada* te je objavljen jedan znanstveni rad u časopisu Q2.

Izv. prof. dr. sc. **Antonio Petošić** i **Petar Franček**, dipl. ing iz Zavoda za elektroakustiku Fakulteta za elektrotehniku i računarstvo ustupili su, za potrebe istraživanja međuovisnosti tehničkih i tehnoloških parametara ultrazvučnog spajanja polimernih materijala, uređaj za lasersko mjerenje intenziteta amplitude titraja ultrazvučne sonotrode kojeg su nabavili u sklopu HRZZ projekta UIP-11-2013-4996.

Prof. dr. sc. **Tanja Pušić**, voditeljica projekta HRZZ IP-2020-02-7575, doprinijela je svojim velikom iskustvom i savjetima u provođenju Projekta.

Svakako treba napomenuti da su članovi projekta, za vrijeme njegovog trajanja radili i na mnogim drugim projektima, a posebno treba staviti naglasak na sudjelovanje troje članova u pisanju 13 natuknica za Hrvatsku tehničku enciklopediju, od kojih je natuknica *inteligentna odjeća* usko vezana uz ovaj Projekt.

Teme tri doktorska rada vezana su uz istraživanja na ovom Projektu, s time da je jedan doktorat obranjen, drugi je u završnoj fazi, a u sklopu trećeg doktorskog rada načinjen je pregled dosadašnjih istraživanja te je temeljito definirana metodologija istraživanja, izveden dio eksperimentalnih mjerenja i utvrđen dio rezultata.

Na temelju ostvarenih rezultata može se smatrati da je ostvarena znatno bolja znanstvena vidljivost članova projekta, Tekstilno-tehnološkog fakulteta, pa i Hrvatske u dijelu znanstvene zajednice koja se bavi tekstilnom i odjevnom tehnologijom. Oprema i ustroj novog laboratorija zasigurno će doprinijeti budućem razvoju znanstvenog rada u spomenutom području, što je osobito važno za nove naraštaje studenata i mladih znanstvenika.

Provedena znanstvena istraživanja i utvrđeni rezultati na Projektu otvorili su nam nove spoznaje i nove pravce budućih istraživanja u odjevnom inženjerstvu.

Upućujem zahvalu:

- Hrvatskoj zakladi za znanost na financiranju Projekta na čemu izražavam osobnu zahvalu.
- gospođi **Maji Kišić** i gospođi **Magdaleni Butina Kermeci**, Savjetnicama za praćenje provedbe projekata, na ažurnim odgovorima, kao i dr. sc. **Dariu Lečiću**, Savjetniku za praćenje učinka projekata, na korisnim savjetima.
- članovima projekta prof. dr. sc. **Siniši Fajtu**, prof. dr. sc. **Snježani Firšt Rogale**, prof. dr. sc. **Antoneti Tomljenović**, izv. prof. dr. sc. **Željku Kneziću**, izv. prof. dr. sc. **Kristini Krulić Himmelreich**, izv. prof. dr. sc. **Emiliji Zdravevoj**, dr. sc. **Martini Bobovčan Marcelić**, **Nikolini Jukl**, mag. ing. text. techn. i **Danielu Časaru Veličanu**, mag. ing. text. techn. koji su svojim istraživačkim potencijalom doprinijeli izvršenju radnih aktivnosti i ciljeva.
- svim Upravama Tekstilno-tehnološkog fakulteta za vrijeme trajanja Projekta, na čelu s dekanicama prof. dr. sc. **Sandrom Bischof**, prof. dr. sc. **Gordanom Pavlović** i prof. dr. sc. **Anicom Hursom Šajatović**, na podršci.
- prof. dr. sc. **Slavenki Petrak** na potpori i pomoći pri ustrojstvu Laboratorija za termoizolacijska svojstva odjeće te gostoprimstvu u svom laboratoriju kada je naš bio u preuređenju.
- **Miroslavu Horvatiću**, prof., v. pred. i **Agati Knezić Mađarić**, dipl. iur. na ažurnosti i kvalitetnim prijevodima za potrebe Projekta.
- gospođama u Računovodstvu Fakulteta, a posebno gospođi **Milici Rihtarec**, koja je besprijekorno vodila financije Projekta.
- Savezu inovatora Zagreb, posebno **Nevenu Markoviću**, dipl. iur. na podršci i promociji Projekta kroz prezentiranje inovacija nastalih tijekom izvođenja ovog Projekta.
- svim ostalima koji su svojim radom doprinijeli uspješnosti Projekta.

Prof. dr. sc. Dubravko Rogale, voditelj projekta

Foreword

For the advancement of clothing engineering, **the Croatian Science Foundation** has approved and funded the scientific research project **Development and Thermal Properties of Clothing IP-2018-10-6363 (ThermIC)**. It resulted in the gathering of a large number of scientists from the Faculty of Textile Technology and the Faculty of Electrical Engineering and Computing, as well as to a variety of research projects, the publication of a relatively large number of quality articles, innovations and patent applications, the establishment of a new laboratory, and the writing of doctoral and graduate theses. The extensive journalistic activity caused by the project, which undoubtedly aided the writers' scientific and educational advancement, was also made feasible by sophisticated research equipment funded by the Croatian Science Foundation. The acquisition of a machine for high-frequency welding of polymeric materials, a machine for sewing in the coordinate plane, a measuring instrument for measuring air permeability, and the construction of a low-temperature air-conditioning chambers of 4 m^2 are particularly remarkable.

Project activities were carried out in eight working groups with the following objectives:

1. Improving the building architecture and assessing the success of the next generation of IOPATS responses.
2. Development of new measuring methods and protocols for determining the total thermal properties of conventional and intelligent clothing.
3. Establishment of the Laboratory for Thermal Insulation Properties of Clothing at the Department of Clothing Technology, where a special integrated system for extensive testing of the thermal properties of garment composites and garments was installed.
4. Improving the responses of intelligent clothing and determining the total thermal characteristics under various environmental circumstances in the laboratory.

As part of the project, a number of measurement equipment and prototypes of clothes and garments were created. These items were displayed at national and international innovation

exhibitions and honoured with prestigious awards, which are detailed in chapter 10 of this monograph. The Faculty of Textile Technology submitted three patent applications to the State Institute for Intellectual Property of the Republic of Croatia.

Mutual collaboration was established with participants of other Croatian Science Foundation (HRZZ) projects. A collaborative seminar on examples of effective research practice was organized in collaboration with members of HRZZ project IP-2020-02-5041, Assoc. Prof. **Ivana Salopek Čubrić**, Ph.D. and Assoc. Prof. **Goran Čubrić**, Ph.D. and a scientific paper was published in the scientific journal Q2.

Assoc. Prof. **Antonio Petošić**, Ph.D. and **Petar Franček**, B.Sc., from the Department of Electroacoustics of the Faculty of Electrical Engineering and Computing, provided a device for laser measurement of the intensity of vibration of the ultrasonic sonotrode, which they acquired as part of HRZZ project UIP-11-2013-4996, to study the interdependence of technical and technological parameters of ultrasonic bonding of polymer materials.

Prof. **Tanja Pušić**, Ph.D., HRZZ Project Manager IP-2020-02-7575, contributed to the implementation of the project with her extensive experience and advice.

It should be noted that during the course of the project, the participants worked on a variety of other projects. Particular attention should be given to the participation of three members in writing 14 entries for the Croatian Technical Encyclopaedia, of which the entry intelligent clothing is closely related to this Project.

The topics of three doctoral theses are related to the research on this project, with one thesis already defended, the second being in its final stages, and the third thesis giving an overview of the research to date and detailing the research methodology, performed part of the experimental measurements and determined part of the results.

Based on the results achieved, it can be assumed that the scientific visibility of the project members, the Faculty of Textile Technology and even Croatia in the scientific community dealing with textile and clothing technology has been significantly improved. The structure

and technology of the new laboratory will undoubtedly promote further scientific research in the mentioned area, which is especially vital for future generations of students and young scientists.

The scientific research and the identified results of the project opened new insights and new directions for future research in clothing engeneering.

I would like to express my sincere appreciation and gratitude to:

- The **Croatian Science Foundation** for funding the project, on which I express my personal gratitude.
- Ms **Maja Kišić** and Ms **Magdalena Butina Kermeci**, Advisers for monitoring Project implementation for their up-to-date responses, as well as Dr. **Dario Lečić**, Ph.D., Specialist for Monitoring Project Impact, for helpful advice.
- Project members who have contributed their research potential to achieve the activities and work objectives: Prof. **Siniša Fajt**, Ph.D.; Prof. **Snježana Firšt Rogale**, Ph.D.; Prof. **Antoneta Tomljenović**, Ph.D.; Assoc. Prof. **Željko Knezić**, Ph.D.; Assoc. Prof. **Kristina Krulić Himmelreich**, Ph.D.; Assoc. Prof. **Emilija Zdraveva**, Ph.D.; **Martina Bobovčan Marcelić**, Ph.D.; **Nikolina Jukl**, mag. ing. text. techn. and **Daniel Časar Veličan**, mag. ing. text. techn.
- All administrations of the Faculty of Textile Technology for their support throughout the Project, coordinated by the deans: Prof. **Sandra Bischof**, Ph.D.; Prof. **Gordana Pavlović**, Ph.D.; Prof. **Anica Hursa Šajatović**, PhD.
- Prof. PhD. **Slavenka Petrak**, Ph.D. for her support in setting up a new laboratory and for her hospitality in her laboratory when ours was being renovated.
- **Miroslav Horvatić**, senior lecturer and **Agata Knezić Mađarić**, B.Sc. iur., on meeting deadlines and providing high quality translations for the needs of the project

- The ladies of the Accounting Department of the Faculty, in particular Mrs. **Milica Rihtarec**, who carefully managed the project funds.
- Zagreb Inventors Association, especially **Neven Marković**, B.Sc. iur., for supporting and promoting the project by presenting ideas that arose during the implementation of this project.
- All those whose work has contributed to the success of the Project.

Prof. Dubravko Rogale, Ph.D, Project Manager

03. Aktivnosti na projekta
Project activities

Radna skupina	Aktivnosti	Voditelji radnih skupina	Članovi radnih skupina
1	Odabir tekstilnih materijala i folija za izradu vanjskih školjki i ekspandirajućih umetaka za inteligentnu odjeću s adaptivnim termoizolacijskim svojstvima (ThermIC)	Ž. Knezić	D. Rogale, S. Firšt Rogale
2	Ispitivanje svojstava odabranih tekstilnih materijala i folija	A. Tomljenović	D. Rogale, Ž. Knezić, M. Bobovčan Marcelić, Daniel Časar Veličan
3	Izrada vanjskih školjki i ekspandirajućih umetaka za ThermIC	S. Firšt Rogale	D. Rogale, N. Jukl
4	Primjena visokotehnoloških metoda spajanja dijelova ThermIC	S. Fajt	D. Rogale, S. Firšt Rogale, M. Bobovčan Marcelić, Daniel Časar Veličan
5	Optimizacija parametara i poboljšanje postojećih sustava ThermIC	D. Rogale	S. Fajt, S. Firšt Rogale, Ž. Knezić, Daniel Časar Veličan
6	Toplinska svojstva ugradbenih materijala i odjeće	D. Rogale	S. Firšt Rogale, E. Zdraveva, N. Jukl
7	Statistička analiza rezultata	K. Krulić Himmelreich	M. Bobovčan Marcelić, N. Jukl, Daniel Časar Veličan
8	Uspostava novog laboratorija za termoizolaciska svojstva i razvoj inteligentne odjeće	S. Firšt Rogale	D. Rogale, Daniel Časar Veličan

Work package	Activities	Leader of WP	Members of WP
1	Selection of textile materials and foil for the production of outer shells and expanding inserts of intelligent clothing with adaptive thermal insulation properties (ThermIC)	Ž. Knezić	D. Rogale, S. Firšt Rogale
2	Testing the properties of selected textile materials and foils	A. Tomljenović	D. Rogale, Ž. Knezić, M. Bobovčan Marcelić, Daniel Časar Veličan
3	Construction of outer shells and expanding inserts of ThermIC	S. Firšt Rogale	D. Rogale, N. Jukl
4	Application of modern high-tech joining techniques for joining parts of ThermIC	S. Fajt	D. Rogale, S. Firšt Rogale, M. Bobovčan Marcelić, Daniel Časar Veličan
5	Optimization of parameters and improvement of existing ThermIC	D. Rogale	S. Fajt, S. Firšt Rogale, Ž. Knezić, Daniel Časar Veličan
6	Thermal properties of textiles and clothing	D. Rogale	S. Firšt Rogale, E. Zdraveva, N. Jukl
7	Statistical processing of the obtained data	K. Krulić Himmelreich	M. Bobovčan Marcelić, N. Jukl, Daniel Časar Veličan
8	Establishment of a new laboratory for thermal insulation properties and development of intelligent clothing	S. Firšt Rogale	D. Rogale, Ž. Knezić

04. Životopisi članova projektnog tima
Project Team Member Resume

Prof. dr. sc. Dubravko Rogale

Dubravko Rogale je rođen 1955. godine u Rijeci. Magistarski rad je obranio 1987. godine na Tehnološkom fakultetu Sveučilišta u Zagrebu, a doktorsku disertaciju 1994. godine na Tekstilno-tehnološkom fakultetu Sveučilišta u Zagrebu. Nastavni rad izvodi na Tekstilno-tehnološkom fakultetu u Zagrebu na preddiplomskom studiju Tekstilna tehnologija i inženjerstvo, na diplomskom studiju Tekstilna tehnologija i inženjerstvo te na poslijediplomskom sveučilišnom studiju Tekstilna znanost i tehnologija. Na Fakulteti za strojništvo Univerze v Mariboru kontinuirano je izvodio nastavu od 1984. do 2005. godine. Na Veleučilištu u Karlovcu izradio je dio nastavnih planova i programa dodiplomskog stručnog studija Tekstilne tehnologije te je izvodio nastavu od 1987.-1992. godine i od 2000. do 2012. godine. Bio je mentor studentima koji su do sada dobili šest Rektorovih nagrada Sveučilišta u Zagrebu, a pod njegovim mentorstvom i komentorstvom izrađeno je 202 diplomska i završna rada. Bio je mentor na sedam magistarskih i osam disertacija. Obnašao je dužnosti predsjednika Savjeta Instituta za tekstil i odjeću pri Tehnološkom fakultetu, predstojnika Zavoda za odjevnu tehnologiju (sedam godina), prodekana za nastavu Tekstilno-tehnološkog fakulteta (dva mandata) i dužnost dekana Tekstilno-tehnološkog fakulteta (dva mandata). Kao voditelj znanstveno-istraživačkih i tehnologijskih projekata, voditelj istraživačko-inovacijske skupine te glavni izumitelj i istraživač osmislio je, konstruirao, patentirao, realizirao i umjerio većinu mjeriteljskih sustava u Laboratoriju za procesne parametre Zavoda za odjevnu tehnologiju. Bio je prvi koordinator Tekstilno-tehnološkog fakulteta u sklopu mreže CEEPUS CIII SI-0217 (1997.) Održao je niz seminara i predavanje u svrhu izobrazbe nastavnika srednjih strukovnih škola u sklopu cjeloživotnog učenja. Redoviti je član Akademije tehničkih znanosti Hrvatske. Bio je tajnik Odjela tekstilne tehnologije, glavni tajnik Akademije tehničkih znanosti Hrvatske, te dopredsjednik Akademije tehničkih

znanosti Hrvatske. Član je Tehnologijskog vijeća za gospodarski razvitak Hrvatske pri Hrvatskoj akademiji znanosti i umjetnosti. Član je Skupštine i član Odbora za registraciju Inženjerskih iskaznica Hrvatskog inženjerskog saveza. Predsjednik je Odbora za znanost i obrazovanje pri Hrvatskom inženjerskom savezu tekstilaca. Član je Matičnog odbora za polja kemijskog inženjerstva, rudarstva, nafte i geološkog inženjerstva, metalurgije, tekstilne tehnologije i grafičke tehnologije u trećem mandatu. Sudjelovao je u izradi Tehničkog leksikona Leksikografskog zavoda Miroslav Krleža za kojeg je izradio sve natuknice iz područja odjevne tehnologije i inženjerstva te član Uredničkog vijeća i urednik i autor natuknica za tekstilstvo Hrvatske tehničke enciklopedije. Bio je predsjednik Tehničkog komiteta za normizaciju šivaćih strojeva i dopredsjednik Tehničkog komiteta za normizaciju sustava odjevnih veličina i oznaka pri Državnom zavodu za normizaciju i mjeriteljstvo. Član je Povjerenstva za dodjelu znaka Hrvatska kvaliteta i Izvorno hrvatsko pri Centru za unapređivanje kvalitete Hrvatske gospodarske komore. Koautor je šest sveučilišnih udžbenika, od kojih su neki izdani u nekoliko proširenih izdanja. Također je koautor jednog priručnika u e-obliku te dvije nerecenzirane interne skripte.Izradio je 41 programskih paketa, 65 elaborata projekta, radova i računalskih programa za potrebe privrede i proizvođače opreme za odjevnu industriju od kojih je najveći dio izradio za potrebe tehnoloških procesa odjevne industrije Republike Hrvatske, a dominiraju računalski programi za konstrukcijsku pripremu proizvodnje odjeće i autorizirani programi za tehničku pripremu, izradu tehničke dokumentacije i računalsko praćenje tijeka proizvodnje. Ti su programi izrađeni prema obilježjima i specifičnim potrebama te su posebno namijenjeni hrvatskoj odjevnoj industriji. Instalirani su u dvadesetak tvornica rublja, pletene odjeće, muške i ženske gornje odjeće u Republici Hrvatskoj i predstavljaju značajan stručan doprinos organizaciji i unapređenju rada hrvatske odjevne industrije u cilju zadržavanja njezine konkurentske sposobnosti na stranim tržištima. U transferu tehnologija sudjeluje u kroz strukovna semestralna predavanja za rukovodno - tehničke kadrove u tvornicama odjeće. Odlikovao ga je Predsjednik Republike Hrvatske Redom Danice Hrvatske s likom Ruđera Boškovića za doprinos znanstvenom radu 1997. godine. 2013. dobio je Državnu nagrada tehničke kulture Faust Vrančić (Ministarstvo znanosti, obrazovanja i sporta republike Hrvatske). 2022. godine Akademija tehničkih znanosti dodijelila mu je nagradu za životno djelo Moć znanja. Sveučilište u Zagrebu dodijelilo mu je 2022. godine nagradu za Inovatora godine.

Prof. dr. sc. Dubravko Rogale

Dubravko Rogale was born in Rijeka in 1955. He defended his master's thesis at the Faculty of Textile Technology of the University of Zagreb in 1987. He defended his doctoral thesis at the Faculty of Textile Technology of the University of Zagreb in 1994. He teaches Textile Technology and Engineering at the Faculty of Textile Technology in Zagreb, as well as Textile Technology and Engineering at the graduate level and Textile Science and Technology at the postgraduate level. From 1984 to 2005 he taught at the Faculty of Mechanical Engineering of the University of Maribor. He developed part of the curriculum for the undergraduate textile technology program at the Karlovac University of Applied Sciences, where he taught from 1987 to 1992 and again from 2000 to 2012. He mentored students who earned six awards from the Rector of the University of Zagreb, and 202 diploma and degree theses were prepared under his mentorship and co-mentorship. Seven master's theses and eight dissertations were mentored by him. He was Chairman of the Council of the Institute of Textiles and Clothing at the Faculty of Technology for seven years, Head of the Department of Clothing Technology for seven years, Vice Dean for Teaching at the Faculty of Textile Technology for two mandates, and Dean of the Faculty of Textile Technology for two mandates. He designed, built, patented, implemented, and calibrated the majority of the measuring systems in the Laboratory for Process Parameters of the Department of Clothing Technology in his capacity as the head of scientific research and technology projects, the head of the research and innovation group, and the primary inventor and researcher. He was the first coordinator of the Faculty of Textile Technology within the CEEPUS CIII SI-0217 network (1997). He delivered a series of seminars and lectures on preparing teachers for vocational education in the context of lifelong learning. He is a full member of the Croatian Academy of Engineering. He was secretary of the Department of Textile Technology, general secretary of the Croatian Academy of Engineering, and vice-president of the Croatian Academy of Engineering. He is a member of the Scientific Council for Technological Development of the Croatian Academy of Sciences and Arts. He is a member of the Assembly and a member of the Committee for the

Registration of Engineering Cards of the Croatian Engineering Association. He is the president of the Committee for Science and Education at the Croatian Association of Textile Engineers. He is a member of the Scientific field Committee for Chemical Engineering, Mining, Petroleum and Geological Engineering, Metallurgy, Textile technology and Printing technology in his third mandate. He participated in the creation of the Technical Lexicon of the Miroslav Krleža Institute of Lexicography, for which he created all entries in the field of clothing technology and engineering and a member of the editorial board and editor and author of the entries for textiles in the Croatian Technical Encyclopaedia. He served as vice chairman of the Technical Committee for the Standardization of Clothing Sizes and Markings of the Croatian Standards Institute as well as chairman of the Technical Committee for the Standardization of Sewing Machines. He is a member of the Committee for the Award of the Croatian Quality Label and Original Croatian Trademarks at the Centre for Quality Improvement of the Croatian Chamber of Economy. He is the co-author of six university textbooks, some of which have been published in many expanded versions. He is also a co-author of one electronic handbook and two unreviewed internal scripts. He created 41 software packages, 65 project studies, works, and computer programs for the needs of the economy and manufacturers of clothing industry equipment, the majority of which he created for the needs of the Republic of Croatia's technological processes of clothing production, whereby computer programs for the structural preparation of clothing production and authorized programs dominate for the purposes of technical preparation, creation of technical documentation. These programmes were developed and have been installed in approximately twenty factories of laundry, knitwear, men's and women's outerwear in the Republic of Croatia and represent a significant professional contribution to the organization and improvement of the work of the Croatian clothing industry in order to maintain its competitive ability on foreign markets. He contributes to knowledge transfer through semester lectures for management and technical workers in garment factories. He was awarded the Order of Danica Hrvatska with the image of Ruđer Bošković by the President of the Republic of Croatia for his contribution to scientific work in 1997. In 2013, he received Faust Vrančić - National Award for Technical Culture from the Ministry of Science and Education of the Republic of Croatia. In 2022, the Academy of Engineering honoured him with the Power of Knowledge Award for Lifetime Achievement. He received the Innovator of the Year Award from the University of Zagreb in 2022.

Prof. dr. sc. Siniša Fajt

Prof. dr. sc. Siniša Fajt rođen je 29. kolovoza 1963. godine u Zagrebu. Diplomirao je 1989. godine na Elektrotehničkom fakultetu u Zagrebu, na smjeru Radiokomunikacije i profesionalna elektronika, iz područja digitalne audiotehnike. Magistrirao je 1994. godine na Elektrotehničkom fakultetu u Zagrebu iz područja elektroakustike (s temom magistarskog rada "Predviđanje akustičke kakvoće prostora") za koji je nagrađen Srebrnom plaketom "Josip Lončar", a doktorirao je 2000. godine na Zavodu za elektroakustiku Fakulteta elektrotehnike i računarstva u Zagrebu iz područja elektroakustike (s temom doktorske disertacije "Vrednovanje kvalitete akustički obrađenih prostora"). U poduzeću RIZ-INFOTEHNA zaposlio se 1990. godine, gdje je radio u okviru Servisnog odjela kao voditelj organizacije i praćenja servisne mreže audio i video tehnike. Na Zavodu za elektroakustiku Elektrotehničkog fakulteta u Zagrebu zaposlio se 1992. godine, kao znanstveni novak/zavodski suradnik (mladi istraživač). U suradničko zvanje asistenta, na Zavodu za elektroakustiku Fakulteta elektrotehnike i računarstva u Zagrebu, izabran je 1997. godine na grupi predmeta "Tonfrekvencijska i prijemnička tehnika", a 2000. godine izabran je za višeg asistenta na grupi predmeta "Akustika i elektroakustika" i "Tonfrekvencijska i prijemnička tehnika". U znanstveno-nastavno zvanje znanstvenog suradnika - docenta na Zavodu za elektroakustiku Fakulteta elektrotehnike i računarstva u Zagrebu, izabran je 2003. godine na grupi predmeta "Akustika i elektroakustika". U znanstveno zvanje viši znanstveni suradnik izabran je 2006. U znanstveno-nastavno zvanje izvanrednog profesora u području tehničkih znanosti, polje: elektrotehnika, grana: radiokomunikacije na Fakultetu elektrotehnike i računarstva izabran je 2008., a ponovno izabran 2013. U zvanje redovitog profesora u području tehničkih znanosti, polje: elektrotehnika izabran je 2018. godine na Fakultetu elektrotehnike i računarstva. Na Sveučilištu Sjever radio je od 2015. do 2016. godine kao pročelnik Odjela za elektrotehniku.

Prof. Siniša Fajt, Ph.D.

Prof. Siniša Fajt was born on August 29, 1963 in Zagreb. He is of Croatian nationality and a citizen of the Republic of Croatia. He finished elementary and high school (EOC "Boris Kidrič") in Zagreb. He graduated in 1989 from the Faculty of Electrical Engineering in Zagreb, in the direction of Radiocommunication and Professional Electronics, in the field of digital audio engineering. He received his master's degree in 1994 from the Faculty of Electrical Engineering in Zagreb in the field of electroacoustics (with the thesis "Prediction of acoustic quality of space") for which he was awarded the Silver Plaque "Josip Lončar", and in 2000 he received his PhD at the Department of Electroacoustics of the Faculty of Electrical Engineering and Computing in Zagreb in the field of electroacoustics (with the thesis thesis "Evaluation of the quality of acoustically processed spaces"). In 1990, he worked in the RIZ-INFOTEHNA company, where he worked within the Service Department as a head of organization and monitoring of the service network of audio and video technology. In 1992, he was employed at the Department of Electroacoustics at the Faculty of Electrical Engineering in Zagreb as a junior researchassistant/institute associate (young researcher). He was elected assistant at the Department of Electroacoustics at the Faculty of Electrical Engineering and Computing in Zagreb in 1997 on the subject group "Tonfrequency and Receiving Techniques", and in 2000 he was elected senior assistant in the group of subjects "Acoustics and Electroacoustics" and "Tonfrequency and Radio Technique". In 2003 he was elected to the scientific and teaching title of research associate - assistant professor at the Department of Electroacoustics at the Faculty of Electrical Engineering and Computing in Zagreb, in a group of subjects "Acoustics and Electroacoustics". He was elected a senior research associate in 2006. He was elected in 2008 to the scientific and teaching title of associate professor in the field of technical sciences, field: electrical engineering, branch: radiocommunications at the Faculty of Electrical Engineering and Computing, and re-elected in 2013. He was elected full professor in the field of technical sciences in 2018 at the Faculty of Electrical Engineering and Computing. He worked at the University North from 2015 to 2016 as head of the Department of Electrical Engineering.

Prof. dr. sc. Snježana Firšt Rogale

Prof. dr. sc. Snježana Firšt Rogale bila je zaposlena u tvornicama odjeće kao tehnolog, gdje je stekla iskustvo i temeljita praktična znanja iz tehnoloških procesa industrijske proizvodnje odjeće. Na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu u Zavodu za odjevnu tehnologiju zaposlena je od 1996. godine, gdje je i diplomirala (1994.), magistrirala (2002.) i doktorirala (2007.) 2018. izabrana je u znanstveno zvanje znanstveni savjetnik i u znanstveno-nastavno zvanje redovit profesor. Uključena je u nastavni proces na stručnom, preddiplomskom, diplomskom i doktorskom studiju. Bavi se znanstveno istraživačkom djelatnosti iz područja odjevne tehnologije. Sudjelovala je u više znanstvenih, stručnih i tehnoloških projekata te je bila voditelj jednog bilateralnog projekta. Voditeljica je doktorskog studija Tekstilna znanost i tehnologija (2020.-2023.). Od 2009. do 2013. godine obnašala je u dva mandata dužnost Predstojnice Zavoda za odjevnu tehnologiju. Bila je član Ureda za međunarodnu suradnju Tekstilno-tehnološkog fakulteta (IRO TTF) kao ECTS koordinator (2016.-2018.), te član Povjerenstva za prijelaze i izradu Registra istovrijednosti kolegija Tekstilno-tehnološkog fakulteta (2015.-2019.). Sudjeluje u izradi Standarda kvalifikacija i Standarda zanimanja za preddiplomske studijske programe na Tekstilno-tehnološkom fakultetu. Član je Odbora za znanstveno-istraživački i umjetnički rad (2017.-2023.). Član je u Akademiji tehničkih znanosti Hrvatske u Odjelu tekstilne tehnologije od 2017. godine. Član je Znanstvenog vijeća Akademije tehničkih znanosti Hrvatske (2023.-2027.) te Znanstvenog vijeća za tehnološki razvoj Hrvatske akademije znanosti i umjetnosti (2023.-2027.). Članica je Saveza inovatora Zagreb, Udruge za međunarodnu komercijalizaciju zagrebačkih inovacija te član Skupštine Udruge. Član je uredništva časopisa Tekstil te gostujući urednik dva specijalna izdanja časopisa Materials „Advanced Materials for Clothing and Textile Engineering“ (1. i 2. izdanje). Član je Hrvatskog inženjerskog saveza tekstilaca i Hrvatske udruge bivših studenata i prijatelja Tekstilno-tehnološkog fakulteta.

Prof. Snježana Firšt Rogale, Ph.D.

Professor PhD. Snježana Firšt Rogale worked in garment factories as a technologist, where she gained experience and thorough practical knowledge of the technological processes of industrial garment production. Since 1996, she has been working at the University of Zagreb at the Faculty of Textile Technology at the Department of Clothing Technology, where she also obtained her degree (1994), master's degree (2002) and PhD thesis (2007). In 2018, she was appointed scientific advisor and full professor. She is involved in teaching at the undergraduate professional, undergraduate, graduate, and doctoral study.She is engaged in scientific research in the field of clothing technology. She has participated in several scientific, professional and technological projects and was the leader of a bilateral project. She is the head of the doctoral study Textile Science and Technology (2020-2023). From 2009 to 2013, she was the head of the Department of Clothing Technology (2 mandates). At the Faculty of Textile Technology, she was a member of the International Relations Office as ECTS Coordinator, Commission for Transitions and Development of the Course Equivalence Register, Commission for the development of new study programs of undergraduate studies at the Faculty, and the Committee for Scientific Research and Artistic work. Since 2017, he is a member of the Croatian Academy of Engineering in the Department of Textile Technology, as well as a member of Academy Scientific Council (2023-2027). She is a member of the Scientific Council for Technological Development in the Croatian Academy of Sciences and Arts (2023-2027). She is a member of Zagreb Inventors Association and Association for International commercialization of Zagreb innovations. She is a member of the editorial board of the journal Tekstil and guest editor of two special issues of journal Materials "Advanced materials for clothing and textile engineering" (1st and 2nd Edition). She is a member of the Croatian Association of Textile Engineers and the Croatian Textile Alumni Society and Friends.

Prof. dr. sc. Antoneta Tomljenović

Rođena je 1968. Diplomirala je 1995., magistrirala 2002., a 2006. doktorirala na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. 2018. je izabrana u znanstveno-nastavno zvanje redovite profesorice. Na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu je obnašala funkciju predstojnice Zavoda za materijale, vlakna i ispitivanje tekstila i voditeljice Centra za cjeloživotno obrazovanje (2012. - 2014.), predsjednice Povjerenstva za upravljanje kvalitetom (2015. - 2019.) te Prodekanice za nastavu (2018. - 2020.), kao i zamjenice članice Vijeća tehničkog područja Sveučilišta u Zagrebu (2018. - 2020.). Ekspertica je u Hrvatskoj akreditacijskoj agenciji za akreditacijsku shemu: Ispitni laboratoriji prema normi HRN EN ISO/IEC 17025. Bila je članica organizacijskog, programskog i znanstvenog odbora velikog broja međunarodnih skupova. Urednica je znanstveno-stručnog časopisa Koža & Obuća i članica međunarodnog Uredničkog odbora časopisa Tekstilec. Priznati je recenzent eminentnih znanstvenih časopisa. Područje nastavnog rada: Tekstilni materijali. Kvaliteta i ispitivanje tekstila, kože i odjeće. Upravljanje kvalitetom. Tekstil za zaštitu od ultraljubičastog zračenja. Stručna praksa. Područje znanstveno-istraživačkog rada: Materijali, ciljane modifikacije, materijali visoke funkcionalnosti i nano materijali, ispitivanje i ocjena funkcionalnosti i trajnosti, vrijednovanje uporabne kvalitete i gospodarenje materijalima – tekstil, UV zaštitne tekstilije, ribarske mreže, koža, folije, biokompozitni materijali. Pod njezinim mentorstvom obranjena su 33 završna i diplomska rada, mentorirala je tri studentska rada nagrađena Rektorovom nagradom i objavila preko pedeset radova u koautorstvu sa studentom. Studijska je savjetnica dva studenta doktorskoga studija. U posljednjih pet godina sudjeluje na dva HRZZ znanstveno-istraživačka projekta te dva edukacijska projekta financirana sredstvima EU. Njezin znanstveno-istraživački rad rezultirao je objavom više od stotinu različitih publikacija.

Prof. Antoneta Tomljenović, Ph.D.

Antoneta Tomljenović was born on September 10th, 1968. Educated at the University of Zagreb Faculty of Textile Technology: Bachelor of Science 1995, Master of Science 2002 and Doctor of Technical Sciences 2006. In 2018, she elected to research-and-teaching rank of Professor. At the University of Zagreb Faculty of Textile Technology, she was Head of the Department of Materials, Fibres and Textile Testing and Head of the Lifelong Learning Centre (2012 - 2014), President of the Committee for Quality Management (2015 - 2019), Vice-Dean for Education (2018 - 2020), as well as, an alternate member of the Council of the Technical Area of University of Zagreb (2018 - 2020). She is an expert of the Croatian Accreditation Agency for accreditation scheme: testing laboratories according to ISO / IEC 17025. She has been a member of the organizational, program and scientific committees of numerous international conferences. She is the Editor of the scientific - professional Journal Leather & Footwear and a member of the international Editorial board of the journal Tekstilec. She is a recognized reviewer for prestigious scientific journals. Teaching area: Textile Materials. Quality and Testing of Textiles, Leather and Clothes. Quality Management. Textile for Ultraviolet Radiation Protection. Practical Training. Scientific research field: Materials. Targeted modifications. Highly functional materials and nanomaterials. Testing and evaluation of functionality and durability. Evaluation of usage quality and materials management - textiles, UV protective textiles, fishing nets, leather, foils, bio-composites. Under her supervision 33 theses were defended, she supervised three student research works that received Rector's Award, and published over fifty co-authored papers with a student. She is currently the supervisor of two doctoral students. In the last five years, she has participated in two HRZZ scientific projects and two EU-funded educational projects. Her research work has resulted in the publication of more than one hundred different publications.

Izv. prof. dr. sc. Željko Knezić

Željko Knezić rođen je 1958. u Sisku. S odličnim uspjehom završio je osnovnu školu u Sunji i srednju elektrotehničku školu (smjer slabe struje) u Zagrebu. Studirao je i 1983. diplomirao na Tehnološkom fakultetu, tekstilno-mehanički smjer, a usporedno, nadopunom znanja, sudjelovao u nastavi i polagao kolegije pedagoškog sadržaja pri Interfakultetskom studiju PTO Sveučilišta u Zagrebu. Na Tekstilno-tehnološkom fakultetu Sveučilišta u Zagrebu 2010. do 2013. radi kao vanjski suradnik u nastavi, te 2013. zapošljava se na radnom mjestu predavača, od 2017. docenta, a od 2022. izv. profesora. Izradio je programe i uveo dva nova predmeta na preddiplomskom i jedan na diplomskom studiju. U dva mandata bio je predstojnik Stručnog studija u Varaždinu (od 2013. do 2018.). Na osobno izrađenim ručnim tkalačkim stanovima, prema vlastitim programima poduke ručnog tkanja, u suradnji s Međunarodnom federacijom Crvenog križa (od 1991. do 1995.) održavao je radionice ručnog tkanja sa izbjeglicama u izbjegličkim kampovima. Nastavio je suradnju sa šezdesetak udruga i institucija potičući očuvanje tradicijskog ručnog tkanja, te popularizaciji struke kroz zanimljive radionice – skupne igre tkanja s djecom i mladeži. Magistrirao je 2010. i doktorirao 2012. na Tekstilno-tehnološkom fakultetu. Bio je mentor (ili neposredni voditelj) na 18 završnih i diplomskih radova, a u koautorstvu sa studentima objavio je 17 radova. Tijekom rada u industriji je u proizvodne procese uspješno prenosio najsuvremenije znanstvene spoznaje. Svoje bogato znanje uspješno primjenjuje u visokoškolskoj nastavi, znanstvenim i stručnim projektima, te kroz brojne tehničke inovacije, patentne prijave i objavljenih 38 znanstvenih, 23 stručnih radova i mnoga znanstveno popularizacijska predavanja, radove i radionice. Od 2019. je član suradnik Hrvatske akademije tehničkih znanosti. Znanstveno-istraživački rad najvećim je dijelom usmjeren na područje tekstilno-mehaničke tehnologije, mehanike tekstila, CAD/CAM-a u tekstilu, pametnog tekstila, konstrukcije tkanine, tradicionalnog ručnog tkanja, upravljanja procesima.

Assoc. Prof. Željko Knezić, Ph.D.

Željko Knezić was born in 1958 in Sisak. He graduated with honours from elementary school in Sunja and secondary electrical engineering school (weak current major) in Zagreb. He studied and graduated in 1983 at the Faculty of Technology, textile-mechanic study, and in parallel, in addition to his knowledge, he participated in classes and took pedagogical content courses at the Interfaculty Study PTO of the University of Zagreb. From 2010 to 2013, he worked as an external teaching assistant at the Faculty of Textile Technology of the University of Zagreb, and in 2013 he was employed as a lecturer, from 2017 as an assistant professor, and from 2022 as an associate professor. He created programs and introduced two new subjects at the undergraduate and one at the graduate level. In two terms, he was the head of the Study Unit in Varaždin (from 2013 to 2018).He held hand weaving workshops with refugees in refugee camps in cooperation with the International Federation of the Red Cross (from 1991 to 1995) on personally made handlooms, according to his own hand weaving teaching programs. He continued cooperation with about sixty associations and institutions, encouraging the preservation of traditional hand weaving, and the popularization of the profession through interesting workshops - group weaving games with children and youth.He received his master's degree in 2010 and his doctorate in 2012 at the Faculty of Textile Technology. He was a mentor (or direct supervisor) on 18 final and graduate theses, and he published 17 papers as co-author with students. During his work in the textile and clothing industry, he stood out as a scientist who successfully transferred the latest scientific knowledge to production processes by designing industrial plants and innovations in production. He successfully applies his rich knowledge in high education teaching, scientific and professional projects, and through numerous technical innovations, patent applications and published 38 scientific, 23 professional papers and many scientific popularization lectures, papers and workshops. Since 2019, he has been an associate member of the Croatian Academy of Technical Sciences. Scientific-research work is mostly focused on the field of textile mechanical technology, textile mechanics, CAD/CAM in textiles, smart textiles, fabric construction, traditional hand weaving, process management.

Izv. prof. dr. sc. Krulić Himmelreich

Izv. prof. dr. sc Kristina Krulić Himmelreich rođena je 17.11.1982. u Zagrebu. 2001. upisala je Prirodoslovno-matematički fakultet u Zagrebu, Matematički odsjek, smjer profesor matematike i fizike gdje je diplomirala 30. rujna 2005. U svibnju 2010. godine stekla je akademski stupanj doktora znanosti, obranivši disertaciju pod naslovom Generalizations and refinements of Hardy's inequality, pod mentorstvom akademika Josipa Pečarića i profesora Lars-Erika Perrsona, Luleå University, Luleå, Švedska na PMF – MO u Zagrebu. Od prosinca 2006. zaposlena je na Tekstilno-tehnološkom fakultetu Sveučilišta u Zagrebu kao znanstveni novak. U 2010. postala je viši asistent, docent 2013. godine te 2018. izvanredni profesor. Drži nastavu iz kolegija Matematika 1 i Statistika na prediplomskom studiju Tekstilna tehnologija i inženjerstvo, Matematiku na stručnom studiju u Varaždinu te na doktorskom studiju Tekstilna tehnologija i inženjerstvo nastavu iz kolegija Odabrana poglavlja iz matematike.

Do sada je sudjelovala u realizaciji sljedećih 5 znanstvenih projekata: Nejednakosti i primjene (voditelj: akademik J. Pečarić, 2006.), Generalne nejednakosti i primjene (voditelj: akademik J. Pečarić, 2007-2014.), Nejednakosti i primjene (HRZZ, voditelj: akademik J. Pečarić, 2014-2018.), IP-2018-01-6363 Razvoj i toplinska svojstva odjeće - ThermIC (HRZZ, voditelj: prof. dr. sc Dubravko Rogale, 2019 – 2023.), Teaching mathematics in STEM context for STEM students (Erasmus+ projekt, voditeljica: prof. dr. sc. Ana Vukelić 2019-2022.). Recenzirala je 22 znanstvena rada. Od 2011. je urednica u časopisu Journal of Classical Analysis. Članica je Hrvatskog matematičkog društva. Koautorica je 1 znanstvene knjige, 17 radova u CC časopisima, 5 rada u SCIE časopisima, 14 radova u časopisima indeksiranim u Mathematical Reviews. Sudjelovala je na 12 međunarodnih konferencija. Bila je mentor doktorske disertacije Poopćenja i proširenja nejednakosti Opialova tipa, Ane Barbir PMF-MO Sveučilišta u Zagrebu.

Assoc. Prof. Kristina Krulić Himmelreich, Ph.D.

Kristina Krulić Himmelreich, PhD, associate professor, was born on November 17, 1982, in Zagreb, Croatia. In 2001 she enrolled Faculty of Science - Department of Mathematics in Zagreb, where she graduated September 30, 2005 and thus received the Master degree in mathematics and physics education from University of Zagreb. In May 2010 she defended dissertation Generalizations and refinements of Hardy's inequality, under the supervision of academician Josip Pečarić and professor Lars-Erik Perrson, Luleå University, Luleå, Sweden at Faculty of Science - Department of Mathematics in Zagreb. From December 2006, she started to work at the Faculty of Textile Technology in the Section for Mathematics as an assistant. She becomes a senior assistant in 2010, assistant professor in 2013 and associate professor in 2018. She teaches the undergraduate courses Mathematics 1, and Statistics, Mathematics on undergraduate professional study in Varaždin and Selected Topics in Mathematics on postgraduate study Textile Science and Tehnology. She reviewed 22 scientific articles. Since 2011 she is associate editor in Journal of Classical Analysis. She is a member of the Croatian Mathematical Society. Up till now she had published 1 scientific book, 17 papers in CC journals, 5 papers in SCIE journals, 14 papers in journals referred by Mathematical Reviews, and also she has 1professional paper. She has participated on 12 international conferences. She was advisor of the doctoral thesis Generalizations and refinements of Opial type inequalities, Ane Barbir, Faculty of Science - Department of Mathematics, University of Zagreb.

Doc. dr. sc. Emilija Zdraveva

Emilija Zdraveva je docent na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Njezin znanstveno-istraživački interes je usmjeren k elektropredanju, s fokusom na razvoj elektropredenih materijala za pohranu toplinske energije temeljenih na materijalima s promjenom faze i razvoj elektropredenih nosača za in vitro uzgoj stanica. Doktorirala je 2015. na Sveučilištu u Zagrebu, Tekstilno-tehnološkom fakultetu, magistrirala tekstilno inženjerstvo na Sveučilištu u Ghentu, Belgija u 2009. Kao doktorandica radila je na Deakin University, Institute for Frontier Materials u Geelongu, Australija u 2013., 2014. i 2015. Bila je suradnica na projektu HRZZ IP-06-2016-6878, Ciljana izrada prototipa vlaknastog nosača za uzgoj tkivnih stanica kombiniranim elektroispredanjem, COMBOELECTROSPUN (voditelj: prof. dr. sc. B. Mijović) i Hrvatsko-kineski znanstveno-istraživački projekt, sufinanciran od Ministarstva znanosti i obrazovanja Republike Hrvatske, Određivanje biokompatibilnosti i imobilizacijskih svojstava materijala od fibroina svile (glavni istraživači: prof. dr. sc. I. Šlivac i prof. dr. sc. T. Zhang). Bila je urednica 4 zbornika radova/sažetaka te je objavila 3 poglavlja u knjigama, 11 radova u CC časopisima, 2 rada u SCIE časopisima, 10 radova u drugim znanstvenim časopisima i 24 rada u zbornicima međunarodnih i domaćih konferencija. Bila je komentorica/mentorica 14/1 diplomskih radova. Godine 2011. dobila je prvu nagradu Znanstveno-istraživačkog centra za tekstil za najbolji znanstveni rad u kategoriji doktoranada. Članica je Hrvatskog ergonomijskog društva, Hrvatskog društva za kožara i obućara i tematskog savjetodavnog odbora časopisa Journal of Functional Biomaterials te urednica časopisa The Jorunal Leather & Footwear. Bila je članica Organizacijskog odbora 4., 5. i 7. Međunarodnog ergonomijskog kongresa, Međunarodnog kongresa za tekstil AUTEX 2012. i Znanstveno-stručnog savjetovanja TZG u 2011., 2012. i 2019. Također je bila zamjenica voditeljice Ureda za međunarodnu suradnju (IRO) i Erasmus+ koordinatorica Tekstilno-tehnološkog fakulteta od 2017. do 2020. godine.

Assist. Prof. Emilija Zdraveva, Ph.D.

Emilija Zdraveva is assist. prof. at the University of Zagreb, Faculty of Textile Technology. Her research interest concerns electrospinning, with focus on the development of electrospun materials for heat energy storage based on phase change materials and development of electrospun scaffolds for in vitro cells culture. She received her Ph.D. degree in Textile Science and Technology in 2015 at the University of Zagreb, Faculty of Textile Technology, her Master degree in Textile Engineering at Ghent University, Belgium in 2009 and her Bachelor degree in Textile Technology at the University of Zagreb, Faculty of Textile Technology in 2006. As a Ph.D. candidate, she was working at Deakin University, Institute for Frontier Materials in Geelong, Australia in 2013, 2014 and 2015 in the Nanofibers group, Lab of electrospinning. She was/is active associate member of two recent projects, in 2017 to 2021 and 2019 to 2023: 1) the Croatian Science Foundation Project IP-06-2016-6878, Custom Tailored Fibrous Scaffold Prototype for Tissue Cells Culture via Combined Electrospinning, COMBOELECTROSPUN, principal investigator: prof. Budimir Mijović, Ph.D. and 2) the Croatian-Chinese research science project of the Ministry of Science and Education (Croatia), Biocompatibility and cell scaffolding assessment of silk fibroin based materials, principal investigator: prof. Igor Slivac, PhD. and prof. Tonghua Zhang, PhD. She has edited 4 books of proceedings/abstracts and has published: 3 book chapters, 11 papers in CC journals, 2 papers in SCIE journals, 10 papers in other scientific journals and 24 papers in international and domestic conference proceedings. She has co-supervised/supervised 14/1 students' bachelor theses concerning electrospinning and bio-based composite materials. In 2011, she received the Textile Science Research Centre's first award for best research paper in the Ph.D. students' category. She is member of the Croatian Ergonomics Society and the Croatian Society of Leather and Footwear. She is also member of the Topical Advisory Panel of the Journal of Functional Biomaterials and the Editor of the Journal Leather & Footwear. She was the member of the Organizing Committee of the 4th, 5th and 7th International Ergonomics Conference, the World Textile Conference AUTEX 2012 and the Textile Science and Economy Conference in 2011, 2012 and 2019. She was also Deputy Head of the International Relations Office and Erasmus+ coordinator of the Faculty of Textile Technology in 2017 to 2020.

dr. sc. Martina Bobovčan Marcelić

Martina Bobovčan Marcelić, dipl. inž. rođena je 1979. godine u Koprivnici, Hrvatska. Osnovnu i srednju školu završila je u Đurđevcu. Diplomirala je na Sveučilištu u Zagrebu, na Tekstilno-tehnološkom fakultetu 2008. godine. Od 2006. do 2010. godine radila je kao voditeljica razvojnog tima za dizajn kožne galanterije i dio marketing tima u tvrtki Galko d.o.o. Od 2011. do 2021. godine bila je zaposlena kao asistent na Sveučilištu u Zagrebu, Tekstilno-tehnološkom fakultetu na Zavodu za odjevnu tehnologiju. Tijekom 2013., 2014. i 2019. godine boravila je na Univerzi v Mariboru, Fakulteta za strojništvo, u sklopu CEEPUS programa mobilnosti studenata i proučavala rad na KES-FB i FAST mjernom sustavu. 2022. godine osnovala je vlastiti obrt koji se bavi dizajnom i izradom odjeće, organizacijom kreativnih radionica vezanih uz tekstil itd. Doktorsku disertaciju je izradila i obranila pod mentorstvom prof. dr. sc. Dubravko Rogalea. Primarni interesi su joj primjena tehnika spajanja pri izradi zaštitne i inteligentne odjeće s naglaskom na način primjene različitih procesnih parametara tijekom spajanja polimernih materijala i njihov učinak na kvalitetu i svojstva spojeva. Posjeduje relevantne vještine spajanja polimernih materijala pomoću tehnika spajanja, kao što su visokofrekventno, ultrazvučno, toplinsko spajanje kondukcijom i konvekcijom. Također ima relevantno iskustvo u ispitivanju kvalitete gotovih spojeva.

Martina Bobovčan Marcelić, Ph.D.

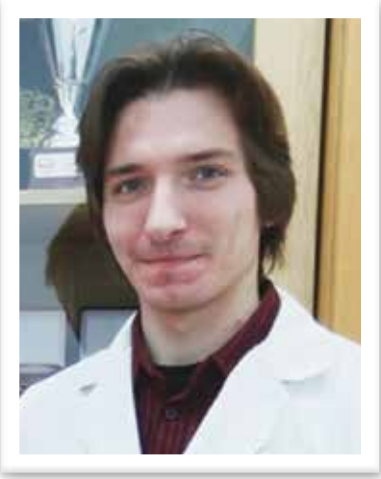
Martina Bobovčan Marcelić, B. Sc. was born in 1979 in Koprivnica, Croatia. She completed primary and secondary school in Đurđevac. She graduated at the University of Zagreb, Faculty of Textile Technology in February 2008. From 2006 till 2010 she worked as head of development team for design of leather accessories and part of marketing team in company Galko d.o.o. From 2011 till 2021 she was employed as an assistant at the University of Zagreb, Faculty of Textile Technology on Department of Clothing Technology. During 2013, 2014 and 2019 she visited University of Maribor the Faculty of Mechanical Engineering under CEEPUS student mobility program and and studied the work on the KES-FB and FAST measuring system. In 2022, she founded his own business, which deals with designing and making clothes, organizes creative workshops related to textiles, etc. She defended her doctoral dissertation under supervision and mentorship of Prof. Ph.D. Dubravko Rogale. Her primary interests are the application of welding techniques in the production of protective and intelligent clothing with an emphasis on the application of different process parameters during the welding of polymeric materials and their effect on the quality and properties of the welded seam. She owns relevant skills for welding of polymer materials using the high tech techniques such as high-frequency, ultrasonic, thermal conduction and thermal conductive materials welding. She also has relevant experience in testing the quality of finished welded seams.

Nikolina Jukl, mag. ing. text. techn.

Nikolina Jukl, mag. ing. techn. text. rođena je 1987. godine u Sv. Nedelji. 2006. godine osvaja 3. mjesto na Državnom natjecanju učenika/ca s programima odjeće, tekstila i dizajna u kategoriji - tehnologija proizvodnja odjeće. Diplomirala je 2013. godine na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Za vrijeme studiranja, a što obuhvaća vremenski period od 2006.-2013. godine, radi kao studentski zaposlenik u tt. Konfeks čija se djelatnost odnosi na proizvodnju radne i zaštitne odjeće, a 2013. godine zaposlena je na mjesto voditeljice proizvodnje. Iste godine upisuje poslijediplomski studij Tekstilna znanost i tehnologija. Od 2022. godine zaposlena je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu, na Zavodu za odjevnu tehnologiju kao asistentica. Istraživački i znanstveni rad mag. ing. techn. text. Nikoline Jukl usmjeren je na tehničku znanost i odjevnu tehnologiju u području ispitivanja termofizioloških svojstava radne i zaštitne odjeće, a istraživačka djelatnost usmjerena je na istraživanje mogućnosti primjene različitih mjernih uređaja i sustava za mjerenje termofizioloških svojstava odjeće u odnosu na konstrukcijske karakteristike odjevnih predmeta i karakteristike materijala od kojih su odjevni predmeti izrađeni. Posjeduje iskustvo iz proizvodnog procesa odjevnih predmeta i organizaciji proizvodnog procesa, što obuhvaća cjelokupan tehnološki proces krojenja, šivanja i dorade. Također posjeduje relevantno iskustvo u području konstrukcije modela odjevnih predmeta (ručna konstrukcija ili računalna konstrukcija) i različitih metoda šivanja i/ili spajanja odjevnih predmeta. Koautor je 3 znanstvena rada objavljena u zborniku rada na međunarodnom skupu i 2 rada objavljenog u časopisu Q2.

Nikolina Jukl, mag. ing. text. techn.

Nikolina Jukl B. Sc. was born in 1987 in St. Nedelja. During high school education she achieved 3rd place at the state competition for high school students studying clothing, textile and design (Clothing days 2006.) in the category – technology of clothing manufacturing. After graduating from the Faculty of Textile Technology in Zagreb (in 2013), she enrolled doctoral study Textile Science and Technology at the University of Zagreb, Faculty of Textile Technology. under the mentorship of . The topic of her doctoral thesis is related to the research of the impact of embedding elements on the overall thermal properties of clothing. She is writing her doctoral thesis under the mentorship of Prof. Snježana Firšt Rogale, Ph.D. Since 2022 she is employed at the University of Zagreb, Faculty of Textile Technology, at the Department of Clothing Technology as an assistant. Her research and scientific work is focused on technical science and clothing technology in the field of testing thermophysiological properties of work and protective clothing, and her research activity is focused on exploring the possibility of using various measuring devices and systems to measure the thermophysiological properties of clothing in relation to the construction characteristics of garments and the properties of the materials from which the garments are made. She has experience in the production process of garments and in the organisation of the production process, which includes the entire technological process of tailoring, sewing and finishing. She also has relevant experience in the field of garment pattern construction (hand construction or computer construction) and various methods of sewing and/or joining garments. Shee is co-author of three scientific papers published in the proceedings of an international conference and two paper published in a second quartile journal (Q2).



Daniel Časar Veličan, mag. ing. text. techn.

Daniel Časar Veličan rođen je u Zagrebu, gdje je završio osnovnu i srednju školu. Pristupnik je 15. rujna 2016. godine na Tekstilno-tehnološkom fakultetu u Zagrebu završio preddiplomski studij Tekstilna tehnologija i inženjerstvo, smjer Odjevno inženjerstvo, koji ukupno traje 6 semestara. Diplomirao je 12. veljače 2019. godine na Tekstilno-tehnološkom fakultetu u Zagrebu na studiju Tekstilna tehnologija i inženjerstvo, smjer Odjevno inženjerstvo, koji ukupno traje 4 semestara te je stekao akademski naziv magistar tekstilne tehnologije i inženjerstva. Tijekom diplomskog studija pristupnik je položio i obavio vježbe na 26 predmeta s prosječnom ocjenom 4,192. Od veljače do travnja 2019. volontirao je na Tekstilno-tehnološkom fakultetu te sudjelovao u radu inovativnog znanstvenog tima prof. dr. sc. Dubravka Rogalea. Od travnja 2019. zaposlen je kao asistent u okviru Istraživačkog projekta financiranog od Hrvatske zaklade za znanost, IP-2018-01-6363 Razvoj i toplinska svojstva inteligentne odjeće voditelja prof. dr. sc. D. Rogalea, a sukladno odobrenom radnom planu projekta razvoja karijera mladih istraživača - izobrazba novih doktora znanosti HRZZ-DOK-2018-09-7933. Završni i diplomski rad obranio je pod mentorstvom prof. dr. sc. Dubravka Rogalea, koji ga je uključio u inovativni rad. Sudjelovao je na realizaciji inovacije Inteligentna odjeća za oboljele od apneje, zajedno s prof. dr. sc. Dubravkom Rogaleom, prof. dr. sc. Sinišom Fajtom, prof. dr. sc. Snježanom Firšt Rogale i izv. prof. dr. sc. Željkom Knezićem. Za vrijeme boravka, u sklopu Erasmus+ programa stručna praksa, sa profesorima sa Tekstilno-tehnološkog fakulteta i Fakultete za strojništvo Univerze v Mariboru (2018.) sudjelovao je na razvoju pametne odjeće za dementne osobe, a koja se razvija u sklopu bilateralne suradnje tih dviju institucija.

Daniel Časar Veličan, mag. ing. text. techn.

Daniel Časar Veličan was born in Zagreb, where he completed primary and secondary school. On September 15, 2016, the applicant completed the undergraduate course in Textile Technology and Engineering, majoring in Clothing Engineering, at the Faculty of Textile Technology in Zagreb, which lasts a total of 6 semesters. On February 12, 2019, he graduated from the Faculty of Textile Technology in Zagreb, studying Textile Technology and Engineering, Department of Clothing Engineering, which lasts 4 semesters in total, and obtained the academic title of Master of Textile Technology and Engineering. During the graduate studies, the applicant passed and completed exercises in 26 subjects with an average grade of 4.192. From February to April 2019, he volunteered at the Faculty of Textile Technology and participated in the work of the innovative scientific team of prof. dr. sc. Dubravko Rogale. Since April 2019, he has been employed as an assistant within the Research Project funded by the Croatian Science Foundation, IP-2018-01-6363 Development and thermal properties of intelligent clothing led by prof. Ph.D. D. Rogale, and in accordance with the approved work plan of the career development project of young researchers - training of new PhDs HRZZ-DOK-2018-09-7933. He defended his final and graduation thesis under the mentorship of prof. Ph.D. Dubravka Rogale, who involved him in innovative work. He participated in the realization of the innovation Intelligent clothing for patients with apnea, together with prof. Ph.D. Dubravko Rogale, prof. Ph.D. Siniša Fajt, prof. Ph.D. Snježana Firšt Rogale and assoc. prof. Ph.D. Željko Knezić. During his stay, as part of the Erasmus+ program of professional practice, with professors from the Faculty of Textile Technology and the Faculty of Mechanical Engineering of the University of Maribor (October 8 - December 8, 2018), he participated in the development of smart clothing for people with dementia, which is being developed as part of bilateral cooperation between these two institutions.

05. Diseminacija
Dissemination

ZNANSTVENI RADOVI U ČASOPISIMA Q1/Q2 / SCIENTIFIC PAPERS IN Q1/Q2 JOURNALS

1. Rogale D., Majstorović G., Firšt Rogale S.: Comparative Analysis of the Thermal Insulation of Multi-Layer Thermal Inserts in a Protective Jacket. Materials 2020, 13(12), 2672, doi:10.3390/ma13122672, https://www.mdpi.com/1996-1944/13/12/2672/htm
2. Rogale D., Firšt Rogale S., Majstorović G., Čubrić G.: Thermal properties of thermal insulation chambers, Textile Research Journal, 91 (9-10), 1-17, https://journals.sagepub.com/doi/abs/10.1177/0040517520966718
3. Čubrić, G.; Salopek Čubrić, I.; Rogale, D.; Firšt Rogale, S. Mechanical and Thermal Properties of Polyurethane Materials and Inflated Insulation Chambers. Materials 2021, 14(6), 1-14, 1541, https://doi.org/10.3390/ma14061541
4. Knezić, Ž.; Penava, Ž.; Penava, D.Š.; Rogale, D. The Impact of Elongation on Change in Electrical Resistance of Electrically Conductive Yarns Woven into Fabric. Materials 2021, 14(12), 1-18, 3390, https://www.mdpi.com/1996-1944/14/12/3390
5. Petrak, S.; Mahnić Naglić, M.; Rogale, D.; Geršak, J. Analysis of Polygonal Computer Model Parameters and Influence on Fabric Drape Simulation. Materials 2021, 14(21), 1-15, 6259, https://doi.org/10.3390/ma14216259
6. Firšt Rogale, S.; Rogale, D.; Knezić, Ž.; Jukl, N. Measurement Method for the Simultaneous Determination of Thermal Resistance and Temperature Gradients in the Determination of Thermal Properties of Textile Material Layers. Materials 2021, 14(22), 6853, https://doi.org/10.3390/ma14226853
7. Rogale, D.; Rogale, S.F.; Knezić, Ž.; Fajt, S. New Method for Determining the Machine-Hand Welding Times Using Ultrasonic Welding Machines with Rotary Sonotrode. Machines 2021, 9(12), 1-18, 330, https://doi.org/10.3390/machines9120330

8. Rogale, D.; Fajt, S.; Firšt Rogale, S.; Knezić, Ž. Interdependence of Technical and Technological Parameters in Polymer Ultrasonic Welding. Machines 2022, 10(10), 1-19, 845, https://doi.org/10.3390/machines10100845
9. Bobovčan Marcelić, M.; Geršak, J.; Rogale, D.; Firšt Rogale, S. Study of the compression properties of welded seams formed using hot wedge, hot air, ultrasonic, and high-frequency welding techniques. Textile Research Journal 2022, 92, 23-24; 4736-4752 https://doi.org/10.1177/0040517522110963
10. Firšt Rogale, S.; Rogale, D. Advanced Materials for Clothing and Textile Engineering. Materials 2023, 16(9), 1-4, 3407, https://doi.org/10.3390/ma16093407
11. Rogale, D.; Firšt Rogale, S.; Knezić, Ž.; Jukl, N.; Majstorović, G. Measurement Methods of the Thermal Resistance of Materials Used in Clothing. Materials 2023, 16(10), 1-19, https://doi.org/10.20944/preprints202305.0270.v1

OSTALI RADOVI U ČASOPISIMA / OTHER JOURNAL PAPERS

12. Firšt Rogale S., Rogale D., Knezić Ž., Fajt S., Časar Veličan D.: Integrirani mjeriteljski sustav u Laboratoriju za termoizolacijska svojstva odjeće, Tekstil 2020, 69(1-3), 11-22, ISSN 0492-5882

1. Knezić Ž., Hrgarek I., Fajt S., Rogale D., Penava Ž., Firšt Rogale S.: Promjena električnih karakteristika elektrovodljive niti zbog djelovanja sile, Tekstil 2022, 71(1) 1-6, ISSN 0492-5882
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3. Jukl N., Firšt Rogale S., Rogale D.: Utjecaj stlačivosti na kontaktnu toplinsku vodljivost toplinsko izolacijskih materijala za namjensku odjeću, Tekstil 2023, 71(1) 1-10 (2023.)

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5. Firšt Rogale S., Rogale D.: Odjevni predmet s adaptivnim mikroklimatskim stanjima, Godišnjak Akademije tehničkih znanosti Hrvatske 2018, Rogale D., Žiljak V. (ur.), Zagreb, Akademija tehničkih znanosti Hrvatske, 2019., 37-40, ISSN 1332-3482
6. Firšt Rogale S. Rogale D.: Univerzalna rebrasta termoizolacijska komora kontinuirano podesive debljine, Godišnjak Akademije tehničkih znanosti Hrvatske 2018, Rogale D., Žiljak V. (ur.), Zagreb, Akademija tehničkih znanosti Hrvatske, 2019., 41-44, ISSN 1332-3482
7. Rogale D., Nikolić G.: Mjerni sustav za određivanje statičkih i dinamičkih toplinskih svojstava kompozita i odjeće, Godišnjak Akademije tehničkih znanosti Hrvatske 2018, Rogale D., Žiljak V. (ur.), Zagreb, Akademija tehničkih znanosti Hrvatske, 2019., 127-132, ISSN 1332-3482
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06. Sažeci Q1/Q2 znanstvenih radova
Abstracts of scientific papers Q1/Q2

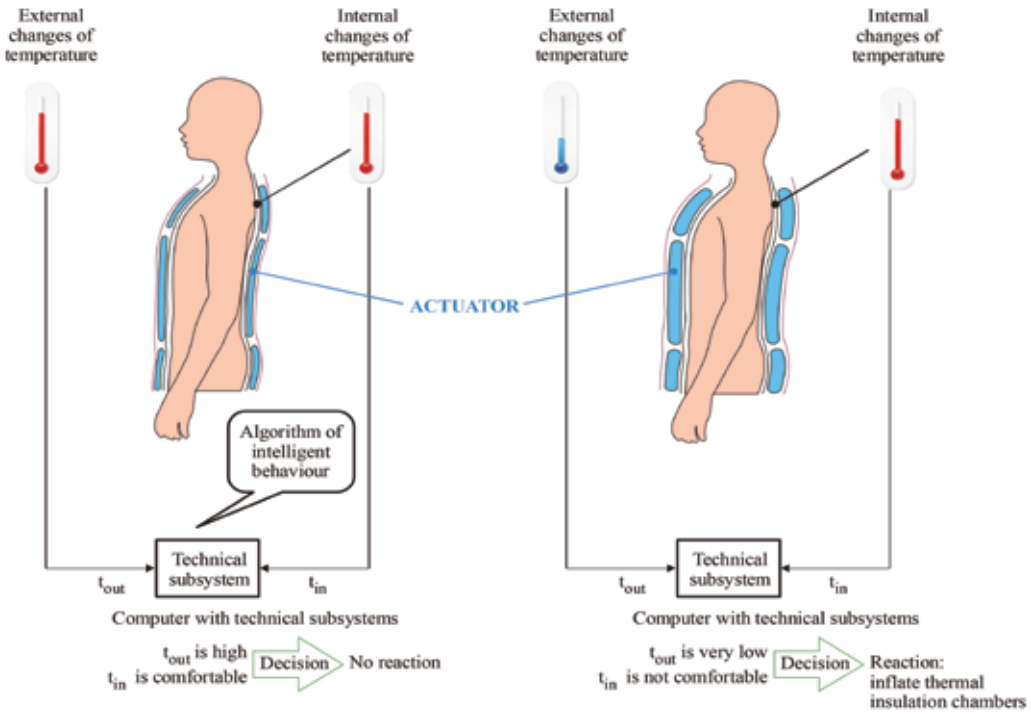
Thermal properties of thermal insulation chambers

Dubravko Rogale, Snježana Firšt Rogale, Goran Majstorović, Goran Čubrić

Abstract: The paper presents the investigation of thermal properties of thermal insulation chambers as an actuator in intelligent clothing, having the property of automatically adjusting thermal protection level. The chambers are designed to vary their thickness based on the pressure of the inflated air in them. The pressure value measured in the thermal insulation chamber gives the microcomputer information on the thickness of the chamber. The paper presents the investigation of the functional dependencies of changes in the thickness of the chambers on the air pressure in them and the thermal resistance depending on the thickness of the thermal insulation chamber. Experimental thermal insulation chambers were made and integrated into an intelligent article of clothing and filled with air of 0-70 mbar, whereby chamber thicknesses of 0-25 mm were measured. Next, thermal resistance of 0.1876-0.5022 m^2 KW-1 was measured on the thermal manikin. It was found out that the ratio of thermal insulation of non-activated to maximally activated chambers was 1:2.7. Research has shown good results for the area where intelligent clothing can automatically adjust its thermal insulation properties. The technical systems described represent a suitable basis for experiments and scientific research during the introduction of intelligent clothing with active thermal protection into human life. The third generation prototype shows very good properties from the aspect of automatic control of thermal protection in intelligent clothing. This forms the basis for further research. Cold protections have always been carried out by wearing garments with higher or lower thermal protection as well as wearing multiple layers of clothing. The conceptual starting point of the development of intelligent clothing is the development of an adaptive insulation layer with changeable thickness in the form of thermal insulation chambers filled with air.

Keywords: intelligent clothing, actuators, thermal expanding insert, thermal insulation properties

Link: https://journals.sagepub.com/doi/abs/10.1177/0040517520966718



Working (action) of the adaptive thermal insulation chambers as an actuator in intelligent clothing when external or internal temperatures changes

Comparative Analysis of the Thermal Insulation of Multi-Layer Thermal Inserts in a Protective Jacket

Dubravko Rogale, Snježana Firšt Rogale, Goran Majstorović

Abstract: This paper presents the measurement results of the thermal insulation of the outer shell, thermal inserts, and clothing systems, as well as a comparative analysis of the thermal insulation of multi-layer thermal inserts in a thermal jacket intended for professional services in cold weather. Detachable thermal inserts are made of double-faced, diamond-shaped quilted lining with different masses per unit area, and together with the jacket, they form clothing systems with different thermal properties. Tests of the thermal properties of clothing were performed on a thermal manikin. They showed that an increase in the mass of thermal insulation textile materials contributes to an increase in the thermal insulation properties of clothing and are insufficient for a complete analysis of the thermal properties of clothing. Therefore, for the first time, three new parameters of integration efficiency of the thermal insert, thermal insulation efficiency parameters, and efficiency parameters of the integration of the textile material integrated into the clothing system were introduced. Based on these parameters, it is possible to perform an effective and accurate comparative analysis of the thermal insulation of multi-layer thermal inserts in clothing. This makes it possible to apply exact scientific methods largely in the technical design of the thermal properties of integrated textile materials, instead of experience-based methods as in the past.

Keywords: textile materials; thermal insulation; clothing system; multi-layer thermal inserts; thermal manikin

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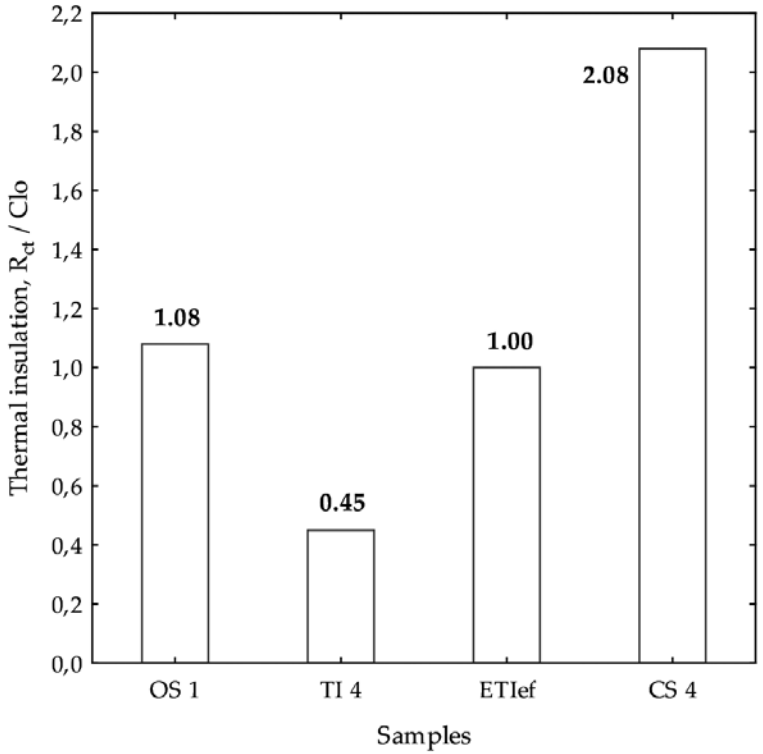

Presentation of the thermal insulation efficiency parameter (ETIef) calculated from the value of the thermal insulations of the clothing system (CS) and the outer shell (OS)

Mechanical and Thermal Properties of Polyurethane Materials and Inflated Insulation Chambers

Goran Čubrić, Ivana Salopek Čubrić, Dubravko Rogale, Snježana Firšt Rogale

Abstract: Evaluating mechanical and thermal characteristics of garment systems or their segments is important in an attempt to provide optimal or at least satisfying levels of comfort and safety, especially in the cold environment. The target groups of users may be athletes engaged in typical sports that are trained in the cold, as well as football players that play matches and train outdoors during the winter season. Previous studies indicated an option to substitute the inner layers of an intelligent garment with polyurethane inflated chambers (PIC) to increase and regulate thermal insulation. In this paper, the authors investigate the mechanical properties of polyurethane material with and without ultrasonic joints. Furthermore, they investigate the potential of designed PICs in terms of efficiency and interdependence of air pressure and heat resistance. The results indicated that an inflated PIC with four diagonal ultrasonic joints has the highest ability to maintain the optimal thermal properties of an intelligent clothing system. The influence of direction and number of ultrasonic joints on the mechanical properties of polyurethane material is confirmed, especially in terms of compression resilience and tensile energy.

Keywords: polyurethane; material; clothing; mechanical properties; heat resistance

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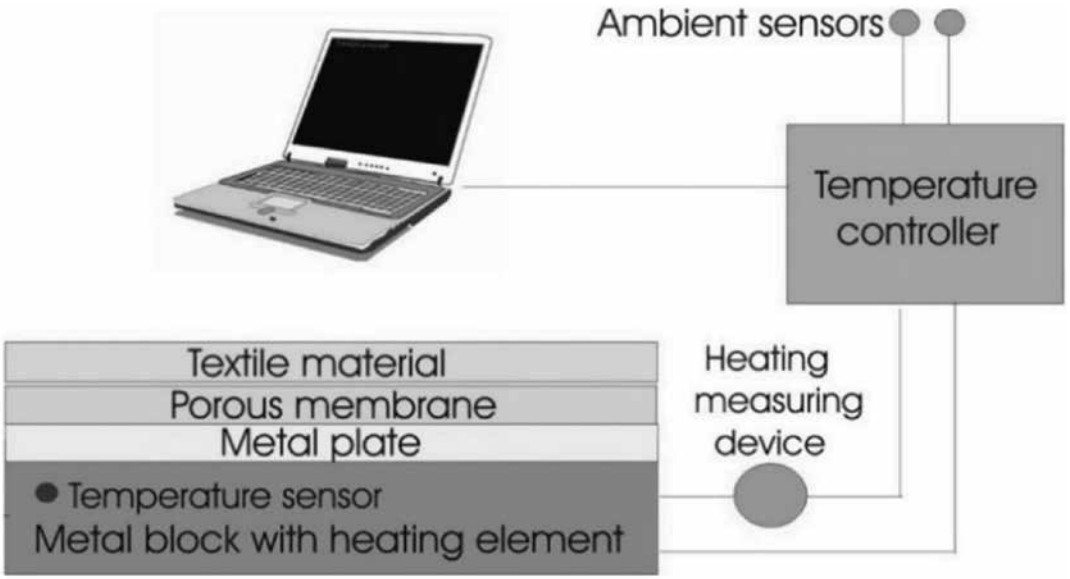

Principle of sweating guarded hotplate (SGHP) device

Measurement Method for the Simultaneous Determination of Thermal Resistance and Temperature Gradients in the Determination of Thermal Properties of Textile Material Layers

Snježana Firšt Rogale, Dubravko Rogale, Željko Knezić, Nikolina Jukl

Abstract: The thermal properties of most clothing products are still not designed according to engineering science due to the lack of simple and acceptable measuring equipment and methods; the type of thermal insulation material, the number of layers of clothing and their thickness are thus chosen empirically. The novelty of this study was the development of a new measuring device and method for simultaneous measurements in the determination of the thermal resistance in one or more textile material layers, such as in multilayer composite clothing. Temperature gradients of textile material layers are presented, as well as the theoretical principles of operation and practical results. Four materials for the production of protective jackets were selected, from which different combinations of composite clothing were constructed and the thermal parameters were measured with a new method and a new device, both individually for the built-in materials and for the composites. Subsequently, five test jackets with the same arrangement of textile material layers as the previously tested composites were produced, and measurements of important thermal parameters were recorded with a thermal mannequin. The determined temperature gradients and measurement results are presented, and based on these it was determined that the total thermal resistance was not equal to the algebraic sum of the resistances of the individual textile material layers in the horizontal position; it was, however, higher, increasing from 30% to 94% due to small air layers caused by crimping and protruding fibres of yarn in the textile fabrics. The same textile material layers built into clothing in the vertical position allowed the formation of significantly wider air layers that increased the thermal resistance by between 2.5 and 9 times.

Keywords: thermal resistance; temperature gradient; textile material layers; composite clothing

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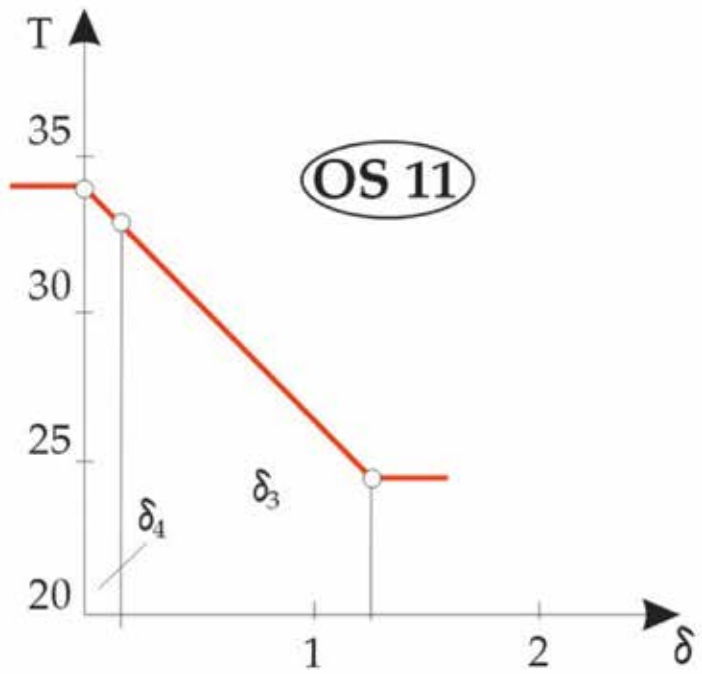


Graphical representation of the temperature gradient for an article of two-layer composite clothing

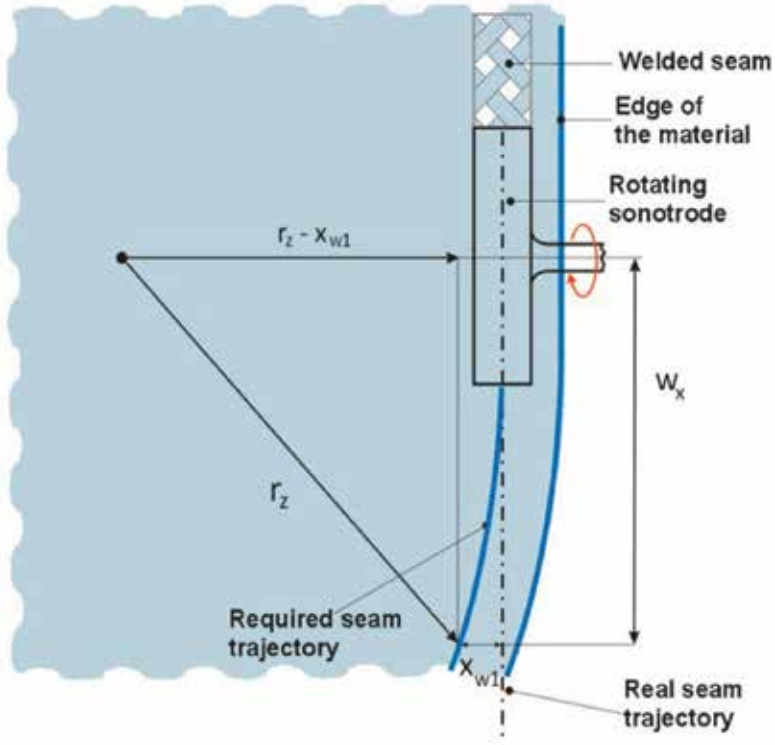
New Method for Determining the Machine-Hand Welding Times Using Ultrasonic Welding Machines with Rotary Sonotrode

Dubravko Rogale, Snježana Firšt Rogale, Željko Knezić, Siniša Fajt

Abstract: The paper presents a new method for determining the machine-hand welding times of synthetic polymer materials using ultrasonic welding machines with rotary sonotrode. The method is based on the claims and observations of W. Möller intended for the clothing industry in the 1990s, according to which there is a spontaneous drop in sewing speed when strongly curved seams are joined, which is due to the possibility of human reactions. The method for determining machine-hand sewing times of curved seams was well accepted in garment production processes. It is used to standardize production time. Using ultrasonic welding machines with rotary sonotrode, the problem of determining the time of ultrasonic joining of curved seams on clothing or technical textiles remained unsolved. That is why is completely new and original model was created, which combines eight technical parameters of ultrasonic welds, eight technological parameters of the production process and seven ergonomic parameters depending on the psychophysical conditions of the workers. The systematic development of the mathematical relationship of all 23 parameters mentioned and the corresponding mathematical expressions for determining and calculating these parameters are presented. These results were also verified by experimental measurements, which show a favourable correlation between the calculated and measured machine hand times. The relationships between the recommended welding speeds, the critical radii of curvature and the number of reactions required according to Möller and the new model are also presented. An analysis of the success in the application of Möller's and the new model was also performed.

Keywords: ultrasonic welding; rotary sonotrode; polymer materials; garment manufacturing; human reaction; machine-hand times; ergonomic parameters

Link: https://www.mdpi.com/2075-1702/9/12/330



Layout of welding two layers of polymer materials with rotary ultrasonic sonotrode together with the specified technological welding parameters

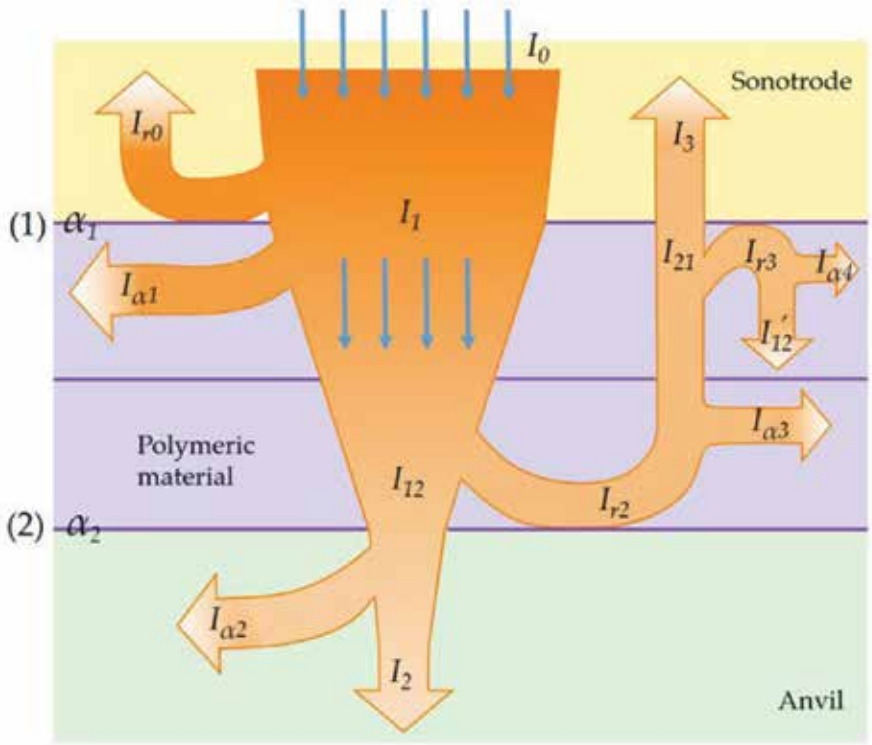
Interdependence of Technical and Technological Parameters in Polymer Ultrasonic Welding

Dubravko Rogale, Siniša Fajt, Snježana Firšt Rogale, Željko Knezić

Abstract: The welding of foils, textiles, and textile composites made of thermoplastic polymer materials using machines with an ultrasonic rotary sonotrode is a high-tech welding technique. Many authors have dealt with only a few parameters in earlier papers, mainly mentioning the speed, i.e., the welding time, and the power of the ultrasonic generator. In this paper, the acoustic model of ultrasonic welding is defined. Based on the model, a group of 44 different parameters important for ultrasonic welding of polymer materials has been summarised, namely 12 parameters of the polymer material, 11 general acoustic and electroacoustic parameters, and 21 technical parameters depending on the ultrasonic machine. Based on this, a comprehensive mathematical derivation was carried out, linking parameter groups with other findings from acoustics, thermodynamics of polymers, and technical and technological parameters of welding polymer materials. The most important parameters are the power of the ultrasonic generator and the welding time, which in practice are adjusted to produce a solid weld. The method of measuring the amplitude of the sonotrode using a photonic sensor is presented in this paper. For 42 groups of welds done at various welding speeds and ultrasonic generator powers, the breaking forces of ultrasonic welds were measured. There are illustrations of power dependence and breaking forces. The accuracy of the mathematical model was confirmed by comparison with the calculation results based on the findings of these measurements.

Keywords: ultrasonic welding; rotary sonotrode; process machine parameters; material parameters; acoustic parameters; mathematical model

Link: https://www.mdpi.com/2075-1702/10/10/845



A symbolic author's presentation of the intensity, propagation, reflection and absorption of ultrasonic waves, suitable for production engineering

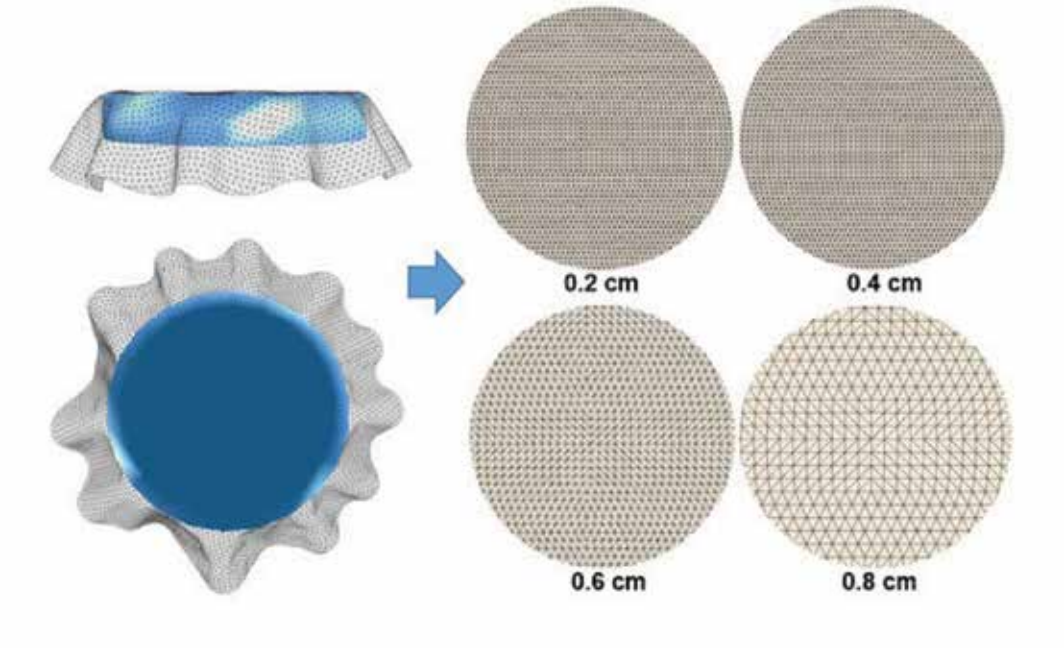
Analysis of Polygonal Computer Model Parameters and Influence on Fabric Drape Simulation

Slavenka Petrak, Maja Mahnić Naglić, Dubravko Rogale, Jelka Geršak

Abstract: Contemporary CAD systems enable 3D clothing simulation for the purpose of predicting the appearance and behavior of conventional and intelligent clothing in real conditions. The physical and mechanical properties of the fabric and the simulation parameters play an important role in this issue. The paper presents an analysis of the parameters of the polygonal computer model that affect fabric drape simulation. Experimental research on physical and mechanical properties were performed for nine fabrics. For this purpose, the values of the parameters for the tensile, bending, shear, and compression properties were determined at low loads, while the complex deformations were analyzed using Cusick drape meter devices. The fabric drape simulations were performed using the 2D/3D CAD system for a computer clothing design on a disk model, corresponding to real testing on the drape tester in order to allow a correlation analysis between the values of drape parameters of the simulated fabrics and the realistically measured values for each fabric. Each fabric was simulated as a polygonal model with a variable related to the side length of the polygon to analyze the influence of the polygon size, i.e., mesh density, on the model behavior in the simulation. Based on the simulated fabric drape shape, the values of the areas within the curves necessary to calculate the drape coefficients of the simulated fabrics were determined in the program for 3D modelling. The results were statistically processed and correlations between the values of the drape coefficients and the optimal parameters for simulating certain physical and mechanical properties of the fabric were determined. The results showed that the mesh density of the polygonal model is an important parameter for the simulation results.

Keywords: fabric; drape; physical and mechanical properties; polygonal model; 3D simulation

Link: https://www.mdpi.com/1996-1944/14/21/6259



Computer circular fabric samples with different polygonal mesh densities, i.e., polygon side lengths

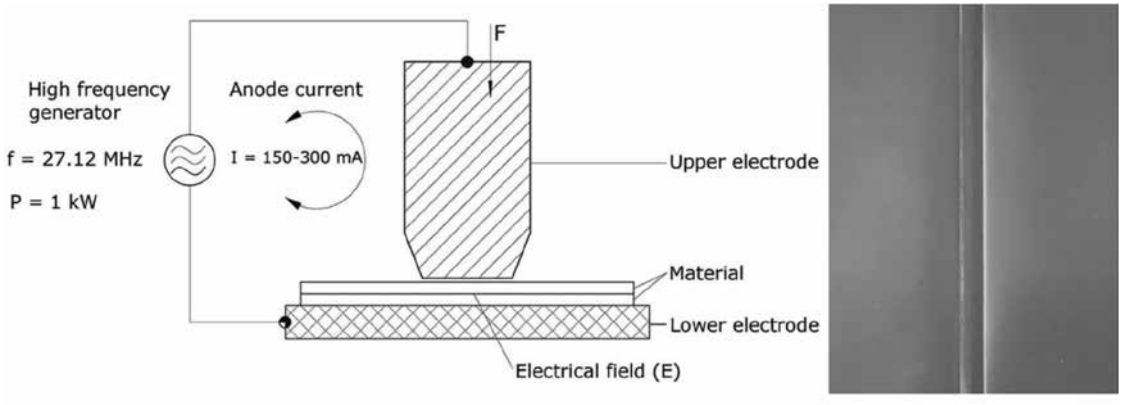
Study of the compression properties of welded seams formed using hot wedge, hot air, ultrasonic, and high-frequency welding techniques

Martina Bobovčan Marcelić, Jelka Geršak, Dubravko Rogale, Snježana Firšt Rogale

Abstract: The compression properties of welded seams depending on welding parameters using the hot wedge and hot air welding technique, ultrasonic welding technique, and high-frequency welding technique were studied. The compression properties, expressed by parameters such as compressional energy WC, compressional resilience RC, linearity LC, and compressibility C, are important information about the welded seam quality in terms of touch, voluminosity, stiffness, and flexibility of the welded seam. KES-FB and FAST measurement systems were used to test the compression properties of the welded seams. Based on the analysis of the results obtained, the influence of the welding parameters on the compression properties of the welded seam was determined. The results of the investigation showed that improperly selected welding parameters, such as the supply or introduction of too much heat into the material to be welded or too long exposure of the material in the weld zone to heat, result in welded seams with expressive extrusion edges, which affects the quality of the welded seams. These welded seams have very low values of compressional resilience RC and very high values of compressional energy WC and compressibility C.

Keywords: welding, welding parameters, compression properties, hot wedge welding, hot air welding, ultrasonic welding, high-frequency welding

Link: https://journals.sagepub.com/doi/abs/10.1177/00405175221109637



High-frequency welding of thermoplastic polymer material: (a) schematic presentation of high-frequency welding and (b) appearance of the welded seams

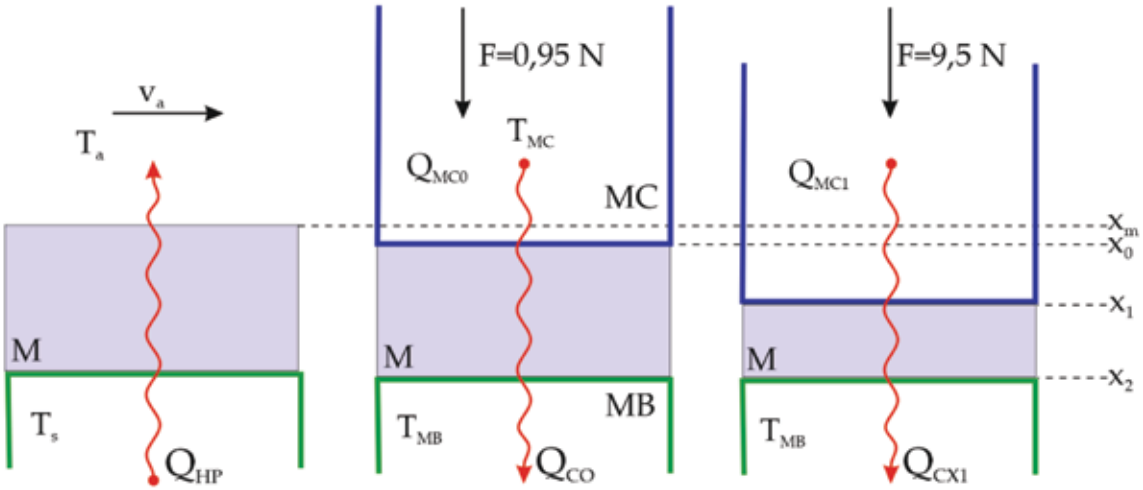
Measurement Methods of the Thermal Resistance of Materials Used in Clothing

Dubravko Rogale, Snježana Firšt Rogale, Željko Knezić, Nikolina Jukl, Goran Majstorović

Abstract: This paper describes methods for evaluating the thermal properties of textile materials, clothing composites, and clothing using an integrated measurement system that includes a hot plate, a multi-purpose differential conductometer, a thermal manikin, a temperature gradient measurement device, and a device for measuring the physiological parameters of the human body during the exact evaluation of garment thermal comfort. In practice, measurements were taken on four types of materials widely used in the production of conventional and protective clothing. The measurements were carried out using a hot plate and a multi-purpose differential conductometer, determining the thermal resistances of the material in its uncompressed form and a force that was ten times greater than that needed to determine its thickness. Using a hot plate and a multi-purpose differential conductometer, thermal resistances of textile materials were assessed at different levels of material compression. On hot plates, both conduction and convection had an impact on thermal resistance, but in multi-purpose differential conductometer, only conduction did. Moreover, the reduction of thermal resistance was observed while compressing textile materials.

Keywords: textiles; clothing; thermal resistance; hot plate; multi-purpose differential conductometer

Link: https://www.preprints.org/manuscript/202305.0270/v1



Measurement of characteristic parameters on hot plate and multi-purpose differential conductometer

07. Disertacije
Dissertation

dr. sc. Martina Bobovčan Marcelić

Naziv disertacije: Procesni parametri visokotehnoloških metoda spajanja i svojstva spojeva na zaštitnoj i inteligentnoj odjeći

Mentor: prof. dr. sc. Dubravko Rogale

Povjerenstvo za ocjenu i obranu doktorskog rada: prof. dr. sc. Siniša Fajt, prof. dr. sc. Dubravko Rogale, izv. prof. dr. sc. Željko Knezić

Datum obrane: 10. svibnja 2023.

Sažetak: U doktorskom istražena su svojstva spojeva koji su nastali spajanjem nekoliko vrsta termoplastičnih polimernih materija primjenom visokotehnoloških metoda spajanja dijelova odjeće. Metoda spajanja uključuje osim tehnike spajanja i rukovanje strojem i detaljnu analizu procesnih parametara. Tehnike spajanja koje su se koristile za izradu uzoraka spojeva koji su ispitani u doktorskom radu su ultrazvučna tehnika spajanja, visokofrekventna tehnika spajanja, spajanje toplinskom kondukcijom, spajanje toplinskom konvekcijom i kombinacija šivanja i toplinske konvekcije, spajanje adhezivne trake po šavu. Spojevi spajani visokotehnološkim tehnikama spajanja mogu imati, ovisno o uzorku materijala i načinu projektiranja spoja, svojstvo zrakonepropusnosti i/ili vodonepropusnosti. Takvi spojevi koriste se kod spajanja dijelova odjeće specifičnih namjena kao što su zaštitna i inteligentna odjeća.

Za spajanje termoplastičnih polimernih materijala definirani su parametri spajanja, primijenjeni pri spajanju uzoraka termoplastičnih materijala. Vrednovanje kvalitete spojeva na temelju vizualnog izgleda spoja, ocjenjivano je u dvije faze. U prvoj fazi ocjenjivanja, pozitivnom ocjenom ocjenjeni su oni uzorci spojeva kod kojih je spoj ostvaren, a svi oni uzorci spojeva koji su slabo spojeni ili je prilikom spajanja došlo do oštećenja u zoni spoja i/ili okolnog područja, ocjenjeni su negativnom ocjenom. U drugoj fazi ocjenjivanja uzorcima spojeva dodijeljena je ocjena od 1 (loš spoj) do 5 (dobar spoj), na temelju kriterija oštećenja ili nabiranja materijala u spoju ili uz spoj. Na

uzorcima spojeva koji su ocjenjeni dobrom ocjenom vizualne kvalitete, provedena su ispitivanja svojstva spojeva.

U radu su prikazana ispitivanja vlačnih, smičnih, savojnih i kompresijskih svojstva spojeva na KES-FB mjernim uređajima. Na temelju analize mjernih rezultata ispitivanih svojstava spojeva, čije vrijednosti se mijenjaju u ovisnosti o primijenjenim procesnim parametrima spajanja, utvrĎen je odnos utjecaja procesnih parametara spajanja na navedena svojstva spojeva, estetski izgled i na kvalitetu spojeva. Na kvalitetu spojeva osim nabrojenih svojstava spojeva utječe i čvrstoća spoja čije su vrijednosti ispitane i također je analiziran odnos utjecaja parametara spajanja na čvrstoću spojeva.

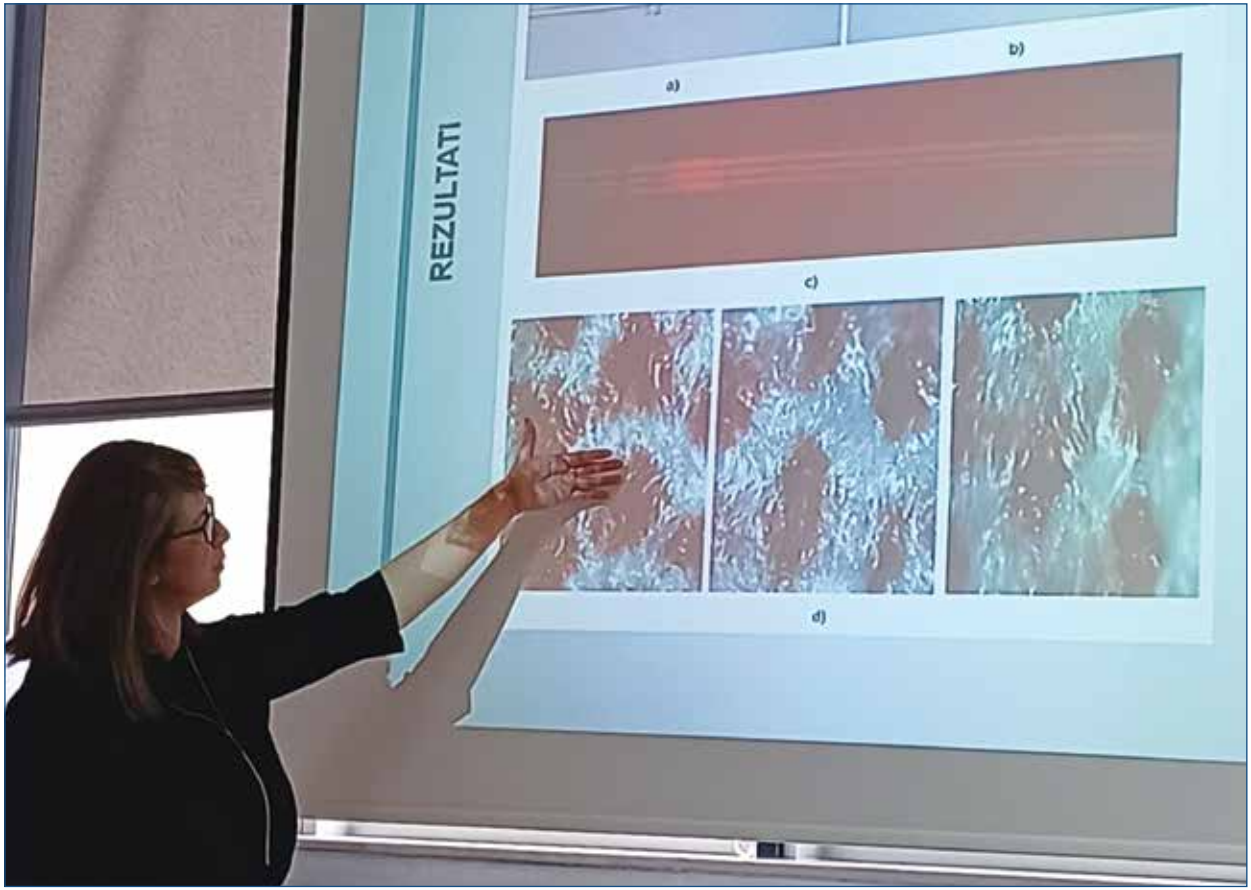
Proučavanjem odnosa utjecaja parametara spajanja na vrijednosti izmjerenih parametara kompresijskih svojstava, uočeno je da vrlo bitan faktor koji utječe na vrijednosti svih proučavanih svojstava spojeva je debljina istisnutih rubova. Manje vrijednosti debljine istisnutih rubova ukazuju da spoj ima blago istisnute rubove, a veće izmjerene vrijednosti upućuju na jači intenzitet istisnutih rubova. Vrlo naglašeni istisnuti rubovi su deformacije koje nastaju kod dovođenja i/ili iniciranja prevelike količine topline u zoni spajanja. Omekšani materijal se iz područja zahvaćenog djelovanju topline, djelovanjem pritisne sile, istiskuje u rubove spoja.

Iz rezultata ispitivanja čvrstoće spojeva i utjecaja različitih parametara spajanja može se zaključiti da na čvrstoću spojeva značajan utjecaj imaju parametri spajanja ali i raspored slojeva materijala. Najveće vrijednosti čvrstoće spojeva izmjerene su kod spojeva spajanih pri nižim brzinama spajanja (što odgovara dužem vremenu djelovanja energije na materijal) i većim vrijednostima snage/ jakosti anodne struje. Spojevi koji imaju više vrijednosti debljine istisnutih rubova, imaju veću čvrstoću spoja.

Da bi se utvrdila količina energije kojom se djeluje na materijal prilikom spajanja, provedeni su izračuni te je na temelju ulaznih parametara spajanja izračunata vrijednosti gustoće energije po volumenu. Usporedbom vrijednosti dobiveni su podaci o količini energije koju je potrebno utrošiti za postizanje kvalitetnog spoja za svaki od uzoraka materijala.

Analizom je utvrđeno da spojevi kod kojih je izračunom dobiveno da iniciraju veću gustoću energije po volumenu imaju i veću čvrstoću i veću debljinu istisnutog ruba.

Ključne riječi: Spajanje termoplastičnih materijala, ultrazvučno spajanje, visokofrekventno spajanje, spajanje toplinskom kondukcijom, spajanje toplinskom konvekcijom, svojstva spojeva, čvrstoća spoja, gustoća energije po volumenu.



Martina Bobovčan Marcelić, PhD.

Title of dissertation: Process parameters of high-tech welding methods and properties of welds on protective and intelligent clothing

Mentor: Prof. PhD. Dubravko Rogale

Committee for the evaluation and defense of the doctoral thesis: Prof. PhD. Siniša Fajt, Prof. PhD. Dubravko Rogale, Assoc. Prof. PhD. Željko Knezić

Date of defence: May the 3rd 2023.

Abstract: In the doctoral thesis, the properties of welded seams created by welding several types of thermoplastic polymer materials using high-tech methods of welding clothing parts were investigated. The welding method includes, in addition to the welding technique, machine handling, and a detailed analysis of welding process parameters. The welding techniques that were used to make the welded seam samples that were examined in the doctoral thesis are the ultrasonic welding technique, high-frequency welding technique, thermal welding by conduction, thermal welding by convection and a combination of sewing and thermal welding by convection, joining adhesive tape by sewing seam. Welded seams joined by high-tech welding techniques can have, depending on the material sample and the way the welded seam is designed, the property of air tightness and/or water tightness. Such welded seams are used when joining parts of clothing for specific purposes, such as protective and intelligent clothing.

For the welding of thermoplastic polymer materials, the welding parameters are defined, applied for welding samples of thermoplastic materials. Evaluation of the quality of welded seam based on the visual appearance of the welded seam was evaluated in two phases. In the first evaluation phase, those welded seam samples where the weld was achieved were given a positive grade, and all those welded seam samples that were weakly weld or during welding, were damaged in

the weld zone and/or the surrounding area were given a negative grade. In the second evaluation phase, the welded seam samples were assigned a grade from 1 (bad welded seam) to 5 (good welded seam), based on the criteria of damage or wrinkling of material in the weld zone or next to the weld. Tests of the properties of the welded seams were carried out on the samples of weld that were evaluated with a good visual quality rating.

The paper presents the results of properties measurement on KES-FB (Kawabata Evaluation System) measuring devices: tensile, shear, bending, and compression properties of welded seams. Based on the analysis of the measurement results of the examined welded seams properties, the values of which change depending on the applied welding process parameters, the relationship between the influence of the welding process parameters on the specified welded seam properties, the aesthetic appearance and the quality of the welded seam was determined. In addition to the listed properties of the welded seams, the quality of the weld is also affected by the strength of the welded seam, the values of which were tested and the relationship between the influences of the welding parameters on the strength of the welded seam was also analysed.

By studying the relationship between the influence of the welding parameters on the values of the measured parameters of the compression properties of welded seams, it wasobserved that a very important factor that affects the values of all studied properties of the welded seams is the thickness of the extruded edges. Lower values of the thickness of extruded edges indicate that the welded seam has slightly extruded edges, and higher measured values indicate a higher intensity of extruded edges. The highly accentuated extruded edges are deformations that occur when a large amount of heat is introduced and/or initiated in the welding zone. The softened material is pushed out of the area affected by the heat, by the action of pressure force, into the edges of the welding seam.

From the results of testing the strength of the welded seams and the influence of different welding parameters, it can be concluded that the strength of the welded seams is significantly influenced by the welding parameters as well as the number of the material layers and their position.

The highest values of welded seam strength were measured for welded seams, welded at lower values of the welding speed (which corresponds to a longer time of energy action on the material) and higher values of the strength anode current/ultrasonic power. Welded seams that have higher values of the thickness of the extruded edges have a higher strength.

In order to determine the amount of energy exerted on the material during welding, calculations were carried out based on the input welding parameters; energy density values per volume were calculated. By comparing the values, data was obtained on the amount of energy that needs to be used to achieve a quality-welded seam for each of the material samples.

The analysis determined that the welded seams where it was calculated that they initiate a higher energy density per volume have higher values of the welded seams strength and a higher values of the thickness of the extruded edge.

Keywords: Welding of thermoplastic polymer materials, ultrasonic welding, high-frequency welding, thermal welding by conduction, thermal welding by convection, welded seam properties, strength of welded seam, energy density per volume.

Nikolina Jukl, mag. ing. techn. text.

Naziv disertacije: Utjecaj vrste ugradbenih materijala i konstrukcije odjevnih kompozita na zbirna toplinska svojstva odjeće

Mentor: prof. dr. sc. Snježana Firšt Rogale

Povjerenstvo za prijavu i ocjenu teme doktorskog rada: prof. dr. sc. Igor Sutlović, prof. dr. sc. Snježana Firšt Rogale, izv. prof. dr. sc. Željko Knezić

Datum javnog izlaganja o očekivanom izvornom znanstvenom doprinosu doktorskog rada: 18. prosinca 2019.

Očekivani datum obrane: rujan 2023.

Sažetak: Pri tehničkom projektiranju svojstava odjeće nedovoljno je istražen utjecaj različitih vrsta ugradbenih materijala, redoslijeda ugradnje i tvorbe odjevnih kompozita na toplinska i paropropusna svojstva projektiranog odjevnog predmeta. Skorašnjom pojavom cjelovitog mjernog sustava s više karakterističnih instrumenata moguća je uspostava nove metodologije pri projektiranju i konstruiranju odjeće temeljene na istraživanjima i novim spoznajama, uz primjenu mjernih rezultata utvrđenih laboratorijskim mjerenjima. Pri tome se misli na primjenu nove originalne i patentirane istraživačke opreme u vidu mjernog sustava za ispitivanje statičkih i dinamičkih svojstava kompozita i odjeće, višenamjenskog diferencijalnog toplinskog konduktometra za odjevne kompozite, uređaja za ispitivanje otpora prolazu vodene pare te uređaja za mjerenje diferencijalnih temperatura između pojedinih slojeva odjevnih kompozita, kao i na uspostavu nove metodologije toplinskog projektiranja svojstava odjeće.

Ključne riječi: ugradbeni materijali, odjeća, zborna toplinska svojstva

Nikolina Jukl, mag. ing. techn. text.

Title of dissertation: Influence of the type of embedded materials and construction of clothing composites on the overall thermal properties of clothing

Mentor: Prof. PhD. Snježana Firšt Rogale

Committee for approval of the dissertation topic: Prof. PhD. Igor Sutlović, Prof. PhD. Snježana Firšt Rogale, Prof. PhD. Antoneta Tomljenović

Date of public presentation on the expected original scientific contribution of the dissertation: December the 18th 2019

Expected date of defence: September 2023

Abstract: Influence of different types of embedded materials, order of their incorporation in clothing and composition of clothing composites on the thermal and vapor permeability properties of the designed garment is insufficiently explored through the process of technical engineering (design) of clothing properties. Recent introduction of an integrated measuring system with more characteristic instruments made it possible to establish a new methodology for designing and constructing clothing based on the conducted research and new knowledge, and also by using the measurement results determined by laboratory measurements.This refers to the application of new, original and patented research equipment in the form of a measuring system for testing the static and dynamic properties of composites and clothes, the multi-purpose differential thermal conductometer for textile composites and clothing, the measuring device for testing water vapor resistance and the device for measuring differential temperatures between the individual layers of clothing composites, as well as the establishment of a new methodology for thermal design/engineering of clothing properties.

Keywords: eembedded materials, clothing, overall thermal properties

Daniel Časar Veličan, mag. ing. techn. text.

Naziv disertacije: Procesni parametri visokofrekventnog spajanja dijelova namjenske odjeće

Mentor: prof. dr. sc. Dubravko Rogale

Povjerenstvo za prijavu i ocjenu teme doktorskog rada: prof. dr. sc. Siniša Fajt, prof. dr. sc. Dubravko Rogale, izv. prof. dr. sc. Željko Knezić

Datum javnog izlaganja o očekivanom izvornom znanstvenom doprinosu doktorskog rada: 24. travnja 2023.

Očekivani datum obrane: rujan 2024.

Sažetak: U sklopu doktorskog rada istražit će se svi relevantni procesni parametri visokofrekventnog (VF) spajanja dijelova namjenske odjeće spram električnih (relativna dielektrična konstanta i faktor dielektričnih gubitaka), fizikalnih (debljina materijala i specifična gustoća) i toplinskih svojstva termoplastičnih polimernih materijala (specifična toplina, latentna toplina, točka omekšavanja), te procesnih parametara stroja za VF spajanje (anodna struja, vrijeme djelovanja VF električnog polja, frekvencija, kondenzatorski kapacitet, sila pritiska i površina spojne elektrode). Optimiranje procesnih parametara, osobito anodne struje i vremena djelovanja VF električnog polja na spajani polimerni materijal, izvodit će se u širokom rasponu vrijednosti, a optimum će se utvrđivati spram postignute čvrstoće spoja. Izvest će se i usporedba teorijskog matematičkog modela utjecajnih procesnih parametara materijala i VF stroja na tehnološko vrijeme spajanja dijelova namjenske odjeće utvrđeno u eksperimentalnom dijelu rada.

Ključne riječi: visokofrekventno spajanje, termoplastični polimerni materijali, namjenska odjeća

Daniel Časar Veličan, mag. ing. techn. text.

Title of dissertation: Process parameters of high-frequency welding of special purpose clothing parts

Mentor: Prof. PhD. Dubravko Rogale

Committee for approval of the dissertation topic: Prof. PhD. Siniša Fajt, Prof. PhD. Dubravko Rogale, Assoc. Prof. PhD. Željko Knezić

Date of public presentation on the expected original scientific contribution of the dissertation: April the 24th 2023

Expected date of defence: September 2024

Abstract: All relevant process parameters of high-frequency (HF) welding of special purpose clothing parts will be investigated against electrical (relative dielectric constant and dielectric loss factor), physical (material thickness and specific density) and thermal properties of thermoplastic polymer materials (specific heat, latent heat, softening point), and the process parameters of the HF welding machine (anode current, treatment time in the HF electric field, pressure force of the connecting electrodes, frequency, capacitor capacity and surface of the connecting electrode). Optimizing the process parameters, especially the anode current and the treatment time of the welded polymer material, will be performed in a wide range of values and the optimum will be determined according to the achieved strength of the weld. A comparison of the theoretical mathematical model of the influencing process parameters of the material and the HF machine on the technological time of welding the parts of special purpose clothing determined in the experimental part of the work will be performed.

Keywords: embedded materials, clothing, overall thermal properties

08.

Laboratorij za termoizolacijska svojstva odjeće

Laboratory for thermal insulation properties of clothing

Na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu u Zavodu za odjevnu tehnologiju ustrojen je 1996. godine Laboratorij za procesne parametre. U laboratoriju su, pod vodstvom prof. dr. sc. Dubravka Rogalea, kroz istraživačke, stručne i nastavne djelatnosti provođena istraživanja procesnih parametar odjevnog inženjerstva. 2007. godine znanstveno-inovativni tim, pod vodstvom voditelja prof. dr. sc. D. Rogalea, počeo je razvijati inteligentnu odjeću s adaptivnim termoizolacijskim svojstvima. Bila su to prva istraživanja na području razvoja inteligentne odjeće u Hrvatskoj, ali i u svijetu. Razvojem inteligentne odjeće s adaptivnim termoizolacijskim svojstvima javila se potreba za opremom za ispitivanje termoizolacijskih svojstava odjevnih kompozita i odjeće, čiji je razvoj, realizacija, umjeravanje i patentiranje financiran kroz znanstveni projekt Ministarstva znanosti i tehnologije Republike Hrvatske Inteligentna odjeća i okruženje (2007.-2011.), tehnologijski projekt financiran od Hrvatskog instituta za tehnologije Odjeća sa adaptivnim termoizolacijskim svojstvima (2009.-2011.), PoC6_1_189 Diferencijalni toplinski konduktometar za tekstilne kompozite i odjeću financiran od Svjetske banke kroz HAMAG BICRO, a nastavljen u sklopu istraživačkog projekta IP-2018-01-6363 Hrvatske zaklade za znanost Razvoj i toplinska svojstva odjeće, te kroz Kratkoročne financijske potpora istraživanju Sveučilišta u Zagrebu. S obzirom da je oprema nadmašila i prostorno i namjenom Laboratorij za procesne parametre javila se opravdana potreba za razdvajanjem i smještanjem opreme u dva laboratorija.

Fakultetsko vijeće Sveučilišta u Zagrebu Tekstilno-tehnološkog fakulteta je na 8. redovitoj sjednici u akad. god. 2020./2021., održanoj 24. svibnja 2021. godine donijelo odluku o osnivanju i ustrojstvu Laboratorija za termoizolacijska svojstva odjeće, što je bila jedna od aktivnosti projekta Hrvatske zaklade za znanost IP-2018-01-6363 Razvoj i toplinska svojstva odjeće.

U Laboratoriju za termoizolacijska svojstva odjeće, integriran je mjeriteljski sustav za cjelovita ispitivanja termoizolacijskih svojstava odjevnih kompozita i odjeće koji se sastoji od mjernog sustava za određivanje statičkih i dinamičkih toplinskih svojstava kompozita i odjeće (vruće ploče i termalnog manekena) smještenih u termoizolacijsku komoru. Uspostavljeni integrirani mjerni sustav za cjelovita mjerenja toplinskih svojstava odjeće koji se sastoji od pet mjernih metoda i uređaja (vruća ploča, višenamjenski diferencijalni konduktometar, toplinski maneken, uređaj

za mjerenje temperaturnih gradijenata, uređaj za mjerenja fizioloških parametara ljudskog tijela pri egzaktnom vrednovanju toplinske udobnosti odjeće) koje su razvili i umjerili, patentirali i/ili koristili autori na ovom radu. Kao dio ovog sustava su i Uređaja za nedestruktivno mjerenje otpora prolazu topline i propusnosti vodene pare i otpora prolazu vode (Permetest), uređaji tt. Pfaff za ispitivanje zrakonepropusnosti te za ispitivanje vodonepropusnosti, kao i mjerni uređaj za mjerenje zrakopropusnosti TF164B, tvrtke Testex kupljen sa sredstava projekta IP-2018-01-6363.

U sklopu projekta a za potrebe mjerenja toplinske udobnosti odjeće, višenamjenskog diferencijalnog konduktometra za tekstilne kompozite i odjeću konstruirana je i izgrađena termoizolacijska komora za niske temperature površine 4 m^2, koja je također financirana iz sredstava Projekta.

Termoizolacijske komore inteligentne odjeće izrađene su od hermetički zatvorene visokoelastične poliuretanske folije. Načini spajanja komada odjeće šivaćim radovima nisu prihvatljivi zbog zahtijevanih hermetičkih svojstava. Zbog toga su za spajanje termoizolacijskih komora korištene visokotehnološke metode spajanja: ultrazvučna metoda, toplinska metoda uz primjenu konvekcijskih i provodnih učinaka te metoda spajanja s visokofrekventnim elektromagnetskim poljima. U tu svrhu nabavljen je stroj za visokofrekventno spajanje. Povezivanje tehničkih podsustava inteligentne odjeće izvedeno je elektrovodljivim koncem. Za te potrebe kupljen je stroj za koordinatno ravninsko šivanja.

The Laboratory of Process Parameters was established at University of Zagreb Faculty of Textile Technology in the Department of Clothing Technology. U laboratoriju su, pod vodstvom prof. dr. sc. In the laboratory, under the direction of Professor Dr. sc. Dubravko Rogale, through research, professional and teaching activities, researched the process parameters of clothing engineering. In 2007, a scientific and innovative team under his leadership began developing intelligent clothing with adaptive thermal insulation properties. This was the first research in the field of intelligent clothing development in Croatia and in the world. The development of intelligent clothing with adaptive thermal insulation properties required new equipment for testing the thermal insulation properties of clothing composites and clothing. Therefore, the team started to develop, realize, calibrate and patent new scientific devices, which were financed through a scientific project Intelligent Clothing and Environment, funded by the Ministry of Science and Technology of the Republic of Croatia (2007-2011), Technology Project Clothing with Adaptive Thermal Insulation Properties, funded by the Croatian Institute of Technology (2009-2011), PoC6_1_189 Differential Thermal Conductometer for Textile Composites and Clothing, funded by the World Bank through HAMAG BICRO, Research Project IP-2018-01-6363 Development and Thermal Properties of Clothing, funded by the Croatian Science Foundation, and short-term financial support for research, funded by the University of Zagreb. Since the equipment exceeded both the space and the purpose of the Laboratory for process parameters, there was a justified need to separate the equipment and place it in two laboratories.

The Faculty Council of the University of Zagreb Faculty of Textile Technology, at its 8th regular meeting on May 24, 2021, decided to establish and organise a Laboratory for thermal insulation properties of clothing, which was one of the activities of the Croatian Science Foundation project IP-2018-01-6363 Development and thermal properties of clothing. In the Laboratory of thermal insulating properties of clothing, an integrated measuring system for thorough evaluations of the thermal properties of clothing composites and clothing, consisting of five measuring methods and devices (hot plate, multipurpose differential conductometer, thermal manikin, device for measuring temperature gradients, device for measuring physiological parameters of the human body in the precise evaluation of the thermal comfort of clothing) developed and calibrated, patented and / or used by the members of this Project. This system includes devices for non-

destructive determination of water-vapour and thermal resistance or permeability of textile fabrics (Permetest), Pfaff waterproofing testing device, Pfaff airtight testing device, and the Air Permeability Tester TF164B, Testex purchased under IP-2018-01-6363. As part of the project, a low-temperature air-conditioning chamber with an area of 4 m^2 was constructed to measure the thermal properties of clothing, which was also financed from the project funds. Thermal insulation chambers, as a part of intelligent clothing, intelligent clothing were made from airtight high-elastic polyurethane foil. Methods of joining clothing pieces using sewing is not acceptable because of required airtight properties. For this reason, to join thermal insulation chambers, high-tech joining methods have be used: the ultrasonic method, the thermal method with the use of convection and conduction effects and the joining method with high-frequency electromagnetic fields. For this purpose, it was purchased Wedge welding machine.

The technical subsystems of the intelligent clothing are connected via an electrically conductive thread. A coordinate plane sewing machine was purchased for this purpose.

09. Znanstvena oprema
Scientific equipment

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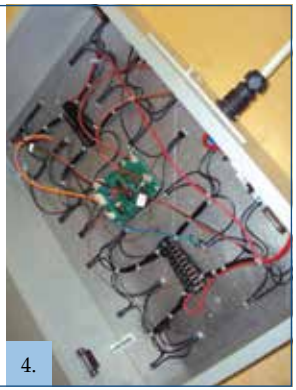
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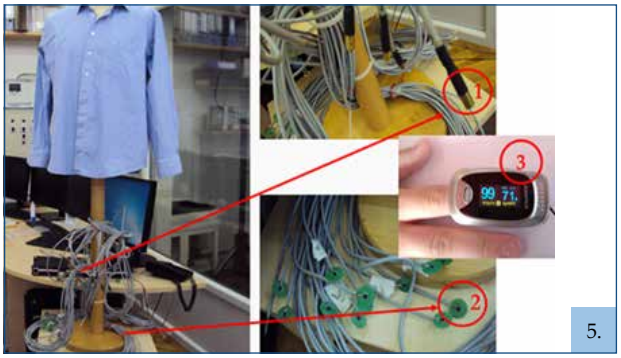

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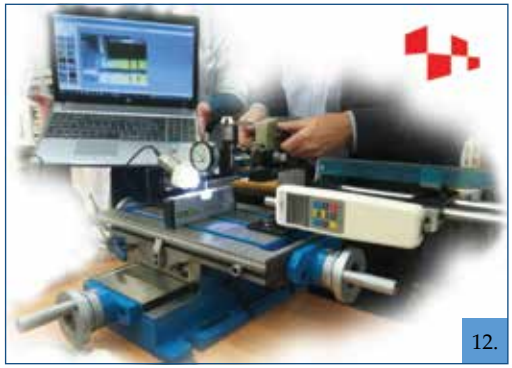
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Popis mjerne opreme / List of measuring equipment		
1.	Termalni maneken	Thermal mannequin
2.	Unutrašnjost termalnog manekena	Interior of thermal mannequin
3.	Višenamjenski diferencijalni konduktometar	Multi-purpose differential conductometer
4.	Vruća ploča	Hot plate

5.	Mjerni sustav za mjerenja fizioloških parametara ljudskog tijela pri egzaktnom vrednovanju toplinske udobnosti odjeće	Measurement system and method for assessing the physiological properties of the human body by accurately evaluating the thermal comfort
6.	Klima komora za niske temperature	Low-temperature air-conditioning chambers
7.	Uređaj za mjerenje temperaturnih gradijenata u odjevnim kompozitima i odjeći	Device for measuring temperature gradients on clothing composites and clothing
8.	Uređaji za ispitivanje vodonepropusnosti, Pfaff	Pfaff waterproofing testing device
9.	Uređaji za ispitivanje zrakonepropusnosti, Pfaff	Pfaff airtight testing device
10.	Uređaja za nedestruktivno mjerenje otpora prolazu topline i propusnosti vodene pare i otpora prolazu vode Permetest	Permetest for non-destructive determination of water-vapour and thermal resistance or permeability of textile fabrics
11.	Uređaj za mjerenje zrakopropusnosti TF164B, Testex	Air Permeability Tester
12.	Uređaj za testiranje ultrazvučnih spojeva dijelova odjeće	Device for testing the caracteristics of ultrasonic welding
13.	Miroskop LCD MICRO 40x-1600, Bresser	Micoscope LCD MICRO 40x-1600, Bresser
14.	Dinamonetar THM500N, Sauter	Dynamometer THM500N, Sauter

15.	Dinamometar TVM5000N240, Sauter	Dynamometer TVM5000N240, Sauter
16.	Stroj za koordinatno ravninsko šivanja, Ricoma	Coordinate plane sewing machine, Ricoma
17.	Uređaj za ultrazvučno iskrojavanje polimernih materijala	Device for for ultrasonic cutting of polymeric materials
18.	Ultrazvučni generator ELM 40, Sonic	Ultrasonic generator ELM 40, Sonic
19.	Stroj za ultrazvučno spajanje umjetnih polimernih materijala, Seamsonic 8310-003, Pfaff	Programmable ultrasonic welding machine with sonotrode, Seamsonic 8310-003, Pfaff
20.	Stroj za toplotno spajanje umjetnih polimerni materijala pomoću kondukcije i konvekcije, Weldchampion 8304-020, Pfaff	Fabric Welder Heat Sealing Machine, Weldchampion 8304-020, Pfaff
21.	Stroj za visokofrekventno spajanje polimernih materijala, Siatem	High frequency welding machine for polymeric materials, Siatem
22.	Stroj za visokofrekventno spajanje umjetnih polimernih materijala Depta, Zemat	Wedge welding machine, Depta, Zemat
23.	Mjerni sustav za određivanje kuta gubitaka (tg δ)	Measuring system for determiningthe angle of the loss tangent (tg δ)

10. Patentne prijave, inovacije i nagrade
Patent applications, innovation and awards

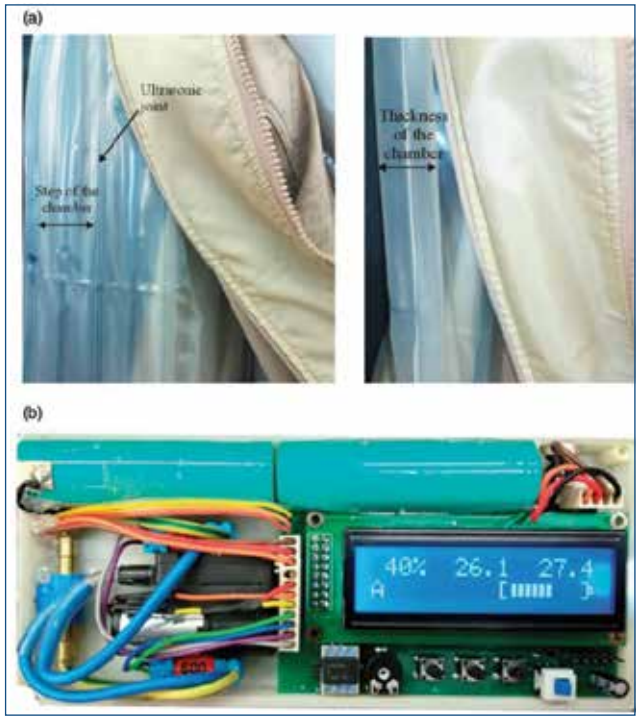
Patentne prijave

1. Rogale D., Firšt Rogale S., Knezić Ž.: Mjerni uređaj i metoda za simultana mjerenja otpora prolazu topline i temperaturnih gradijenata slojeva kompozita odjeće, Državni zavod za intelektualno vlasništvo Republike Hrvatske, P20211208A
2. Rogale D., Knezić Ž.: Uređaj i metoda za ispitivanje karakteristika spojeva nastalih visokotehnološkim tehnikama spajanja polimernih materijala, Državni zavod za intelektualno vlasništvo Republike Hrvatske, P20211094A
3. Knezić Ž., Rogale D.: Tekstilni koso tkani senzor sile i istezanja, Državni zavod za intelektualno vlasništvo Republike Hrvatske, P20211027A

Patent application

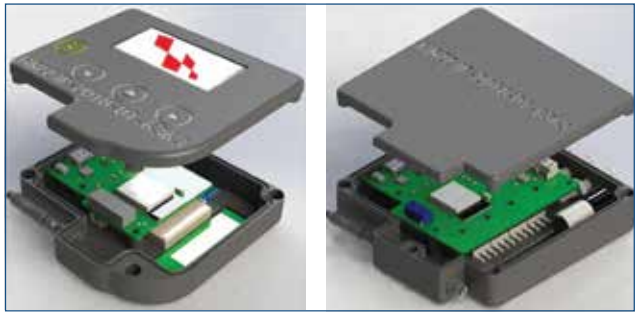
1. Rogale D., Firšt Rogale S., Knezić Ž.: Measuring device and method for simultaneous measurement of thermal resistance temperature gradients of layers of clothing composites, State Intellectual property Office of the Republic of Croatia, P20211208A
2. Rogale D., Knezić Ž.: Device and method for testing the properties of compounds produced by high technology processes for welding polymeric materials, State Intellectual property Office of the Republic of Croatia, P20211094A
3. Knezić Ž., Rogale D.: Narrow hand loom with four sheets and direct warping, State Intellectual property Office of the Republic of Croatia, P20211027A

Inteligentna odjeća / Intelligent clothing



Inteligentna odjeća s adaptivnim svojstvima toplinske izolacije: (a) termoizolacijske komore između vanjske školjke i podstave; između vanjske ovojnice i obloge; (b) elektroničke i pneumatske komponente smještene u posebnoj vodootpornoj kutiji

Intelligent clothing with adaptive thermal insulation properties: (a) expanding thermal insulation chambers located between the outer shell and the lining; (b) electronic and pneumatic components situated in a special waterproof box



Master i slave izgled sklopa

Master and slave assembly layout

Nagrade / Awards

Rogale D., Firšt Rogale S., Knezić Ž., Bobovčan Marcelić M.: Uređaj za određivanje karakteristika spojeva stvorenih tehnikom spajanja ultrazvukom / Devices for determining the characteristics of compounds created by ultrasound welding technique

1. Excellence Innovation Award for achieving excellency in innovation through dedication and the consistent wish to push the boarders of what can be obtained through science and technology, Rector University Politehnica of Bucharest professor Mihnea Costoiu, EUROINVENT 2019, Iasi, Romania
2. Silver medal, EUROINVENT 2019, Iasi, Romania
3. WIIPA Grand Award, World Invention Intellectual Property Associations, INTARG 2019, Katowice, Poland
4. Platinum Award INTARG 2019, Katowice, Poland
5. Diploma on account of winning Platinum Medal at INTARG 2019, Ministry of Investment and Economic Development, INTARG 2019, Katowice, Poland
6. Award for best Innovation in Science, INOVA 2019, Zagreb,
7. Gold medal, INOVA 2019, Zagreb, Croatia

Rogale D., Firšt Rogale S., Knezić Ž., Fajt S.: Uređaj za mjerenja temperaturnih gradijenata u odjevnim kompozitima / Measuring device and method for simultaneous measurement of thermal resistance temperature gradients of layers of clothing composites

8. Grand Prix Nikola Tesla for best Croatian Innovation, INOVA 2020, Zagreb, Croatia
9. Gold medal, INOVA 2020, Zagreb, Croatia
10. Silver medal, Archimedes 2021, Moscow, Russia
11. Gold award, International Invention and Trade Expo, ITE EXPO 2021, London, UK
12. Gold medal, National Research Council of Thailand, 2021 Bangkok International Intellectual Property, Invention, IPITEx 2021, Bangkok, Tajland

13. Gold medal, World Invention Intelectual Property Associations, KIDE 2021, Kaohsiung, Tajvanu.
14. Gold medal, The VIth International Fair of Innovation and Creative Education for Youth, Ștefan cel Mare University of Suceava, Romanian Inventors Forum, Romanian General Association of Engineers i Romanian Ministry of Education and Research, EUROINVENT 2022, Iasi, Romania
15. Gold medal, EUROINVENT 2022, Iasi, Romania
16. Special Award, High Innovative Unique Foundation in the Kingdom of Saudi Arabia, EUROINVENT 2022, Iasi
17. Gold award, E-NNOVATE 2022, Bydgoszcz, Poland
18. Grand prize, E-NNOVATE 2022, Bydgoszcz, Poland
19. Golden medal, KIDE 2022, Kaohsiung, Taiwan
20. Special award with plaque who presents this outstanding service and dedicated innovation management, International Invention and Trade Expo, ITE EXPO 2022, London, UK
21. Special award, Norton University, Cambodia, INOVA 2022, Osijek, Hrvatska

Rogale D., Knezić Ž., Fajt S., Firšt Rogale S.: Tradicijski tkana vrpca promjenjivog električnog otpora / Traditionally woven band/ribbon of variable electrical resistance

22. Silver medal, INOVA 2019, Zagreb, Croatia

Knezić Ž., Rogale D., Penava Ž.: Uski ručni tkalački stan s četiri lista i direktnim snovanjem / Narrow hand loom with four sheets and direct warping

23. Silver medal, INOVA 2019, Zagreb, Croatia

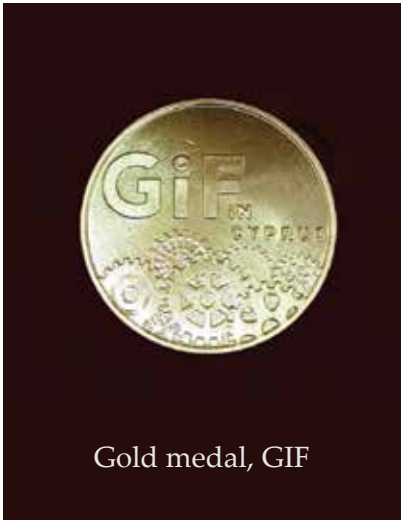
Željko K., Rogale D., Matašić R.: Izvor električne energije temeljen na gibanju ekstremiteta / Power source based on movement of extremities

24. Gold medal, INOVA 2022, Osijek, Croatia
25. Grand prix 2nd INOVA 2022 Award, INOVA 2022, Osijek, Croatia
26. Gold medal, EUROINVENT 2023

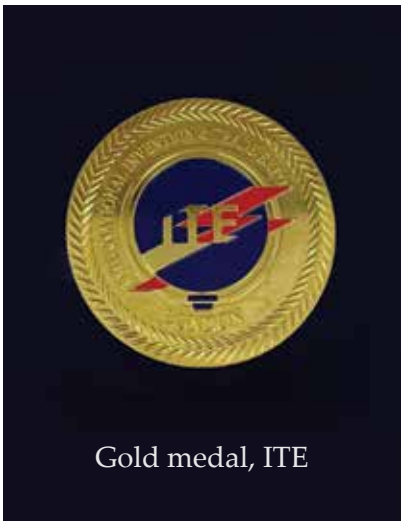
Dubravko Rogale

27. Moć znanja, nagradu za životno djelo, Akademija tehničkih znanosti Hrvatske, 2022. / Power of Knowledge Award for Lifetime Achievement, Academy of Engineering 2022
28. Inovator Godine, Sveučilište u Zagrebu, 2022 / Innovator of the Year Award, University of Zagreb in 2022
29. Gold medal as head of the team for research on temperature gradients in clothing composites, GIF 2021, Limassol, Cyprus

Gold medal, KIDE



Gold medal, GIF



Gold medal, ITE

Silver medal, WIIPA

Power of Knowledge Award for Lifetime Achievement, Academy of Engineering

Gold medal, INOVA

Innovator of the Year Award, University of Zagreb

Platinum award, INTARG

Award for best Innovation in Science, INOVA

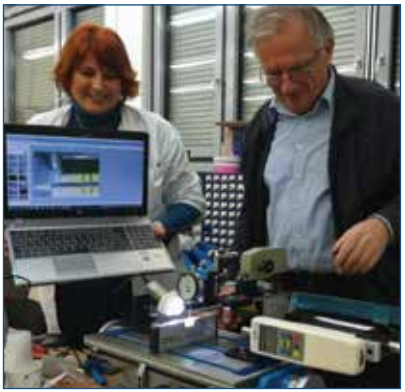
Grand prix 2nd,
INOVA

Gold medal,
EUROINVENT

Grand Prix
Nikola Tesla
for best Croatian
Innovation,
INOVA

11. Galerija
Gallery

















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