

## Izvirni znanstveni članek *Original Scientific Paper*

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### Vrednotenje toplotnih lastnosti tekstilij in njihovih kombinacij

*Evaluation of Textile Thermal Properties and their Combinations*

V prispevku je predstavljeno vrednotenje toplotnih lastnosti ploskih tekstilij in njihovih kombinacij, namenjenih za poslovna oblačila, ki je potekalo v dveh delih. V prvem delu so bile raziskane toplotne lastnosti ploskih tekstilij ovrednotene na različnih merilnih napravah, ki omogočajo merjenje prehoda toplote in/ali prehoda vodne pare skozi plosko tekstilijo, in sicer s pomočjo toplotne plošče ter merilnih naprav Thermo Labo II in Permetest. V tem delu raziskave so bile raziskane povezave med lastnostmi ploskih tekstilij oziroma odvisnosti med posameznimi parametri toplotnih lastnosti analiziranih ploskih tekstilij, izmerjenimi na različnih merilnih napravah ter odvisnosti med toplotnimi lastnostmi in debelino tekstilije. V drugem delu raziskave so bile raziskane toplotne lastnosti kombinacij posameznih ploskih tekstilij in sicer s pomočjo toplotnega cilindra s simulacijo znojenja, ki omogoča merjenje prehoda toplote in prehoda vodne pare skozi tekstilije ali kombinacijo tekstilij. Za ta namen je bil raziskan vpliv klimatskih razmer in stopnje znojenja na toplotne lastnosti posameznih kombinacij ploskih tekstilij.

Raziskava je pokazala, da med parametri toplotnega upora, izmerjenega s toplotno ploščo, ter merilnima napravama Permetest in Thermo Labo II, obstajajo statistično pomembne korelacije, in da med toplotnim uporom, določenim iz kvocienta debeline in toplotne prevodnosti, dobljene z merilno napravo Thermo Labo II ter toplotnim uporom, dobljenim s toplotno ploščo in z merilno napravo Permetest prav tako obstaja korelacija. Potrjeno je, da se z naraščajočo debelino materiala vrednosti toplotnega upora in upora proti prehodu vodne pare ploskih tekstilij povečujejo. Hkrati je bilo ugotovljeno, da različne klimatske razmere in stopnje znojenja vplivajo na toplotne lastnosti kombinacij ploskih tekstilij. Ugotovljeno je bilo, da so toplotne lastnosti, tj. suhi in evaporativni toplotni tok ter sposobnost prehoda vodne pare odvisne od klimatskih razmer oziroma tempe-

raturenega gradienta med površino cilindra in temperaturo zraka, in da se z različno stopnjo znojenja, vrednosti evaporativnega toplotnega toka, korigiranega toplotnega upora in sposobnosti prehoda vodne pare spremenijo.

**Ključne besede:** ploske tekstilije, toplotne lastnosti, toplotno udobje, toplotna plošča, Thermo Labo II, Permetest, toplotni cilindri s simulacijo znojenja

*The paper presents the evaluation of textile material thermal properties and their combinations as used for business clothing systems, which was conducted through two separate studies. In the first study, an investigation of textile thermal properties was carried out using different measurement systems enabling the measuring of heat and/or moisture transmission through textile materials by using the hot-plate apparatus, the Thermo Labo II and the Permetest measurement systems. This part of the research investigated the correlations between the measured parameters of the textile thermal properties evaluated by using different measurement systems, and correlations between thickness and thermal properties. In the second study, the thermal properties of material combinations were evaluated by using a thermal sweating cylinder enabling the evaluation of heat and moisture transmission through textile materials or material combinations. The influences of different environmental conditions and sweating levels on the thermal properties of material combinations were investigated for this purpose. The results show that statistically significant correlations exist between the parameters of textile thermal resistances evaluated with different measurement systems using the hot-plate apparatus, the Thermo Labo II and the Permetest measurement systems. It is also evident from the results that by increasing textile thicknesses, the values of textile thermal resistances and water vapour resistance increase proportionally. The results of evaluating thermal properties of material combinations under different environmental and sweating conditions showed that different climate conditions and sweating levels influence the heat and moisture transmission properties of material combinations. The results show that dry and evaporative heat loss and water vapour transmission depend on climatic conditions or temperature gradient, respectively, between the cylinder surface and ambient temperature, and that different sweating levels influence the evaporative heat loss, corrected thermal resistance and water vapour transmission values.*

**Keywords:** textiles, thermal properties, thermal comfort, hot plate, Thermo Labo II, Permetest, thermal sweating cylinder

## Izvirni znanstveni članek *Original Scientific Paper*

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### Primerjalna študija fizikalno mehanskih lastnosti tkanin v vezavah keper in atlas *Comparative Analysis of Physical and Mechanical Properties of Fabrics Woven in Twill and Sateen Weaves*

V prispevku je podana študija fizikalno-mehanskih lastnosti tkanin, izdelanih v vezavah štirivezni keper in osemvezni atlas. Namen študije je bil, da omogoči vpogled v omenjene lastnosti tkanin, izdelanih iz enakih materialov, pri enakih pogojih izdelave in bi bila pomoč pri izbiri primernih vezav za dosego tako vizualnih kot fizikalno-mehanskih značilnosti, zahtevanih pri uporabi. Za potrebe raziskav je bilo načrtovanih in izdelanih 12 vzorcev v sedmih vezavah. Vzorci so bili razdeljeni v tri različne skupine, glede na način izdelave in konstrukcijske lastnosti. Vzorci prve in druge skupine so izdelani na industrijskih statvah z nastavljenost gostoto osnove 46 niti/cm in dolžinsko maso osnove  $17 \times 2$  tex, prva skupina je stkana z enako prejo v votku, le da ni škrobljena, in gostoto votka 26 niti/cm, druga skupina pa ima dolžinsko maso votka  $25 \times 2$  tex in gostoto votka 18 niti/cm. Tretja skupina je stkana na laboratorijskih statvah z gostoto osnove 40 niti/cm in gostoto votka 26 votkov/cm z enako prejo v osnovi in votku  $17 \times 2$  tex. V prvi skupini, ki obsega sedem vzorcev, so bili štirje stkani v vezavi keper (votkovni in obojestranski in njegove lomljene izpeljanke v sosledju), trije pa v vezavah osemvezni atlas (osnovni in dve izvedbi ojačenih atlasov). Tkanini druge skupine sta bili stkani v vezavah navadni in lomljeni keper, tkanine tretje skupine pa v vezavah atlas. V raziskavah so bile izvedene preiskave konstrukcijskih, fizikalnih in mehanskih lastnosti stkanih vzorcev. Ugotovljeno je bilo, da izbira vezave ob preostalih enakih konstrukcijskih parametrih in pogojih izdelave v veliki meri vpliva na fizikalno-mehanske lastnosti tkanin. Industrijsko izdelane tkanine v vezavi keper so dosegale v smeri osnove za več kot 100 N večje pretržne sile kot tkanine v vezavah atlas. V smeri votka so industrijsko izdelane tkanine v vezavi keper dosegale le 45 N večjo trdnost kot tkanine v vezavi atlas. Pretržni raztezek v smeri osnove pri tkaninah v vezavah keper je bil dva- do dvainpolkrat večji od pretržnega razteзка v smeri votka. Pri tkaninah v vezavi atlas sta se pretržna raztežka v smeri osnove in votka le malo razlikovala; bili sta enakega reda velikosti. Pogoj tkanja, industrijske in laboratorijske statve ravno tako vplivajo na fizikalno-mehanske lastnosti. Tkanine, izdelane v laboratorijskih, dosegajo boljše mehanske lastnosti kot industrijsko izdelane, kar gre na račun manjših obremenitev in posledično manjših poškodb med tkanjem. Raziskava lahko pomaga oblikovalcem

pri strukturnem vzorčenju (listnih in žakarskih tkanin) izbrati primerne vezave, ki bodo poleg vizualnih značilnosti in efektov omogočile tudi primerne fizikalno-mehanske lastnosti izdelanih tkanin.

**Ključne besede:** tkanina, vezava keper, vezava atlas, fizikalne lastnosti, natezne lastnosti tkanin

*The paper deals with the analysis of physical and mechanical properties of fabrics woven in four-end twill and eight-end sateen weaves from the same materials and under the same weaving conditions. The purpose of the analysis was to give insight into these properties, which might help designers in the selection of appropriate weaves to achieve visual as well as physical and mechanical properties of end products required during the use. For the purposes of the research 12 samples of fabrics in seven weaves were designed and woven. The samples were classified into three groups in dependence of the weaving method and constructional parameters. The samples of the first and second group were made on industrial loom with the preset warp density 46 ends/cm and the linear density of the warp  $17 \times 2$  tex. The samples of the first group were woven with the same yarn in the weft, only that the yarn was not sized, and with the weft density 26 picks/cm, whereas the samples of the second group had the linear density of the weft  $25 \times 2$  tex and the weft density 18 picks/cm. The third group was woven on laboratory loom with the warp density 40 ends/cm and the weft density 26 picks/cm with the same yarn in the warp and weft  $17 \times 2$  tex. In the first group, which comprised seven samples, four of them were woven in twill weave (weft-faced twill and double-faced twill, and its broken variants in the repeat) and three of them in eight-end sateen (weft-faced sateen and two versions of reinforced sateen). The fabrics of the second group were woven in twill and broken twill weaves, and the fabrics of the third group were woven in sateen weaves. The research included investigations of constructional, physical and mechanical properties of woven samples. It has been found that in the case of identical constructional parameters and weaving conditions the selection of weave considerably affects physical and mechanical properties of fabrics. Industrially manufactured fabrics in twill weave achieved for more than 100 N higher breaking forces in the warp direction than the fabrics woven in sateen weave. In the weft direction, industrially manufactured twill fabrics achieved only 45 N higher strength than the fabrics woven in sateen weave. The breaking elongation of fabrics woven in twill weave was two to two and a half times higher in the warp direction than in the weft direction. Breaking elongations of fabrics in sateen weave in the warp and weft direction only slightly differed; they were of the same order of magnitude. Weaving conditions as well as use of industrial or laboratory looms also affected physical and mechanical properties. Fabrics made under laboratory conditions achieved better mechanical properties than industrially manufactured fabrics, which can be attributed to lower stresses and consequently, smaller damages during the weaving process.*

*The research can help designers to select appropriate weaves when designing structural patterns (shaft and jacquard fabrics) which will in addition to visual characteristics and effects impart also appropriate physical and mechanical properties to the manufactured fabrics.*

**Keywords:** fabric, twill weave, sateen weave, physical properties, tensile properties of fabrics

### Strokovni članek *Professional Paper*

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### Recikliranje tekstilnih materialov

*Recycling Textile Materials*

V slovenski industriji vsako leto nastane približno 5000 ton odpadkov v obliki obdelanih ali neobdelanih tekstilnih materialov, ki so razvrščeni v skupino tekstilnih odpadkov. Ti odpadki niso sortirani ali opremljeni s podatki o surovinski sestavi ali o predhodnih obdelavah. Velik del odpadkov konča na odlagališčih. Če bi se odloženi tekstilni odpadki lahko znova uporabili kot vir surovin ali energije, bi to pripomoglo k ohranjanju okolja in surovin.

Avtorici članka želita opomniti na problematiko tekstilnih odpadkov. Želita predstaviti kompleksnost problema, povezanega s proizvodnjo in predvsem z recikliranjem tekstilnih materialov. Poudariti želita, da sta količina ogljikovega dioksida, izpuščenega v okolje (ogljikova stopinja), in posledično onesnaževanje okolja odvisna od proizvajalcev, izdelovalcev kemikalij, trgovcev in dobaviteljev tekstilij in tudi od nas samih.

**Ključne besede:** recikliranje tekstilnih materialov, tekstilni odpadki, ogljikova stopinja

*Slovenian industries produce annually over 5000 tons of waste in the form of treated and untreated textile materials classified as textile waste. They are sorted neither according to the origin nor the chemical structure nor the treatment. A large percentage of this waste finishes on landfills. If this waste could be reused as raw material or as a source of energy, it could be beneficial to the environment.*

*The authors of the paper want to raise awareness of textile waste management and show the vast array of problems associated with the manufacture and recycling of textile materials. They wish to emphasize how the processes of textile materials, the used chemicals, merchandizing and transportation influence the carbon footprint and the environment.*

**Keywords:** recycling textile materials, textile waste, carbon footprint

### Strokovni članek *Professional Paper*

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### Vključenost Slovenije v raziskovalne projekte na področju inteligentnih tekstilij v Evropski uniji, stanje in možnosti

*Slovenian Collaboration in the EU Research Projects on Intelligent Textiles – Survey and Potential*

Inteligentne tekstilije so aktivni tekstilni materiali, ki se odzivajo na spremembe v okolju oziroma se jim prilagajajo. Klasična tekstilija postane aktivna, ko vanjo vgradimo aktivne funkcionalne materiale, inteligentne materiale ali aktivne sisteme. Razvoj inteligentnih tekstilij spada med strateška področja razvoja tekstila v Evropski uniji. Evropska komisija že od leta 1998 vlaga v projekte s področja inteligentnih tekstilij. V petem okvirnem programu je bilo zanje namenjenih okvirno 2,5 milijona evrov, v šestem okvirnem programu že 91,16 milijona evrov. V sedmem okvirnem programu je za obdobje 2007–2013 predvidenih več kot štiri milijarde evrov za financiranje področja naprednih materialov, med katere spadajo tudi inteligentne tekstilije. Članek zajema pregled razvoja inteligentnih tekstilij znotraj evropskih okvirnih programov OP 5, OP 6 in OP 7 ter razvoj tega novega področja v slovenskem raziskovalnem prostoru v zadnjem desetletju. Podan je tudi pregled pomembnih mednarodnih konferenc in simpozijev, specializiranih za področje inteligentnih tekstilij.

**Ključne besede:** inteligentne tekstilije, pametne tekstilije, okvirni raziskovalni programi, OP5, OP6, OP7, tekstilna tehnološka platforma

*Intelligent textiles are active textile materials, which react or adapt to the changes in the environment. A conventional textile becomes active when it contains active functional material, intelligent material or an active system. In the European Union most of intelligent textiles are being developed by strategic textile development sectors. The European Commission has been financially supporting projects in the area of intelligent textiles since 1998. Approximately 2.5 million € were allocated to this area within the Fifth Framework Programme, and 91.16 million € within the Sixth Framework Programme. Within the Seventh Framework Programme, covering the period from 2007 to 2013, even more than 4 billion € are projected for funding in the field of technologically advanced materials, which includes intelligent textiles. An overview of intelligent*

*textiles development in the European Framework Programmes FP 5, FP 6 and FP 7 is presented. Then, development of Slovene research in this new sector is elaborated. The contribution concludes with an outline of most important specialised international conferences and symposia on intelligent textiles.*

*Keywords: intelligent textiles, smart textiles, Research Framework Programmes, FWP5, FWP6, FWP7, textile and technological platform*