

Nové možnosti rozvoje vzdělávání na Technické univerzitě v Liberci

Specifický cíl A2: Rozvoj v oblasti distanční výuky, online výuky a blended learning

NPO_TUL_MSMT-16598/2022



Experimental analysis of structures - internal standards

Ing. Bc Monika Vyšanská, PhD.



Blended yarns - internal structure by image analysis, mechanical properties (repeat, see STR)

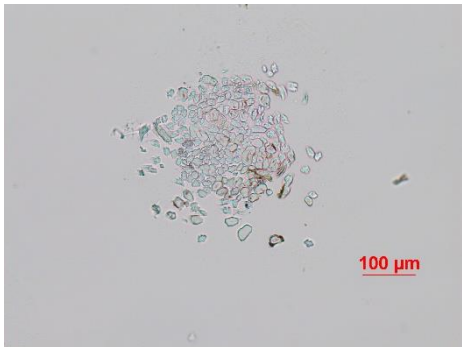
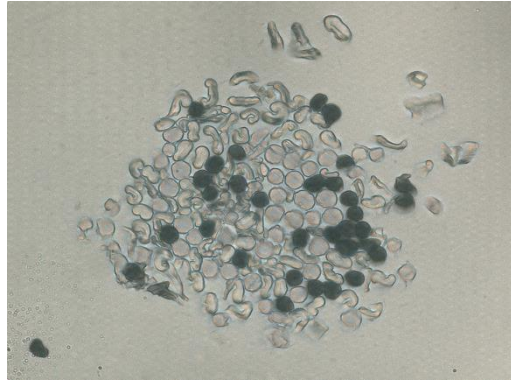
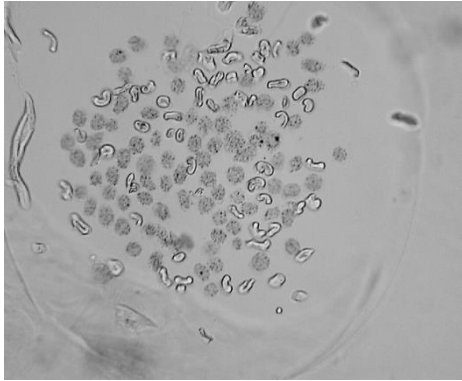
Ing. Monika Vyšanská, PhD.

Blended yarn - internal structure

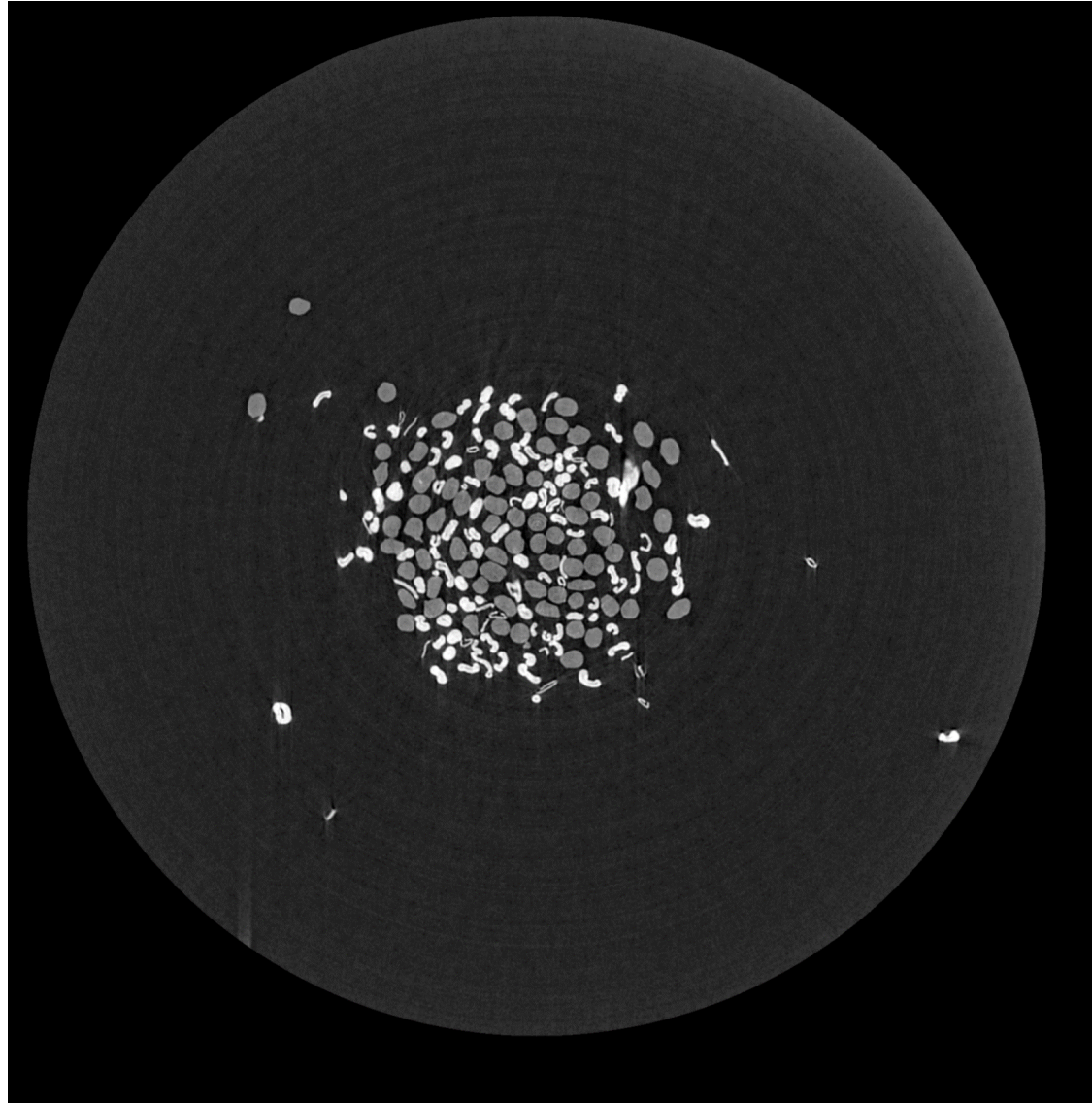
IMAGES:

Cross-sections - optical microscopy

Cross-sections - micro (nano) CT



Blended yarn - internal structure



IMAGES:

Cross-sections - optical microscopy

Cross-sections - micro (nano) CT

Detected parameters, see STR [1] :

$$g_i = \frac{m_i}{m}$$

$$\mu = V/V_c$$

$$\rho = 1 / \sum_{i=1}^n \frac{g_i}{\rho_i}$$

$$v_i = g_i \frac{\rho}{\rho_i}$$

$$t = 1 / \sum_{i=1}^n \frac{g_i}{t_i}$$

$$\lambda_i = g_i \frac{t}{t_i}$$

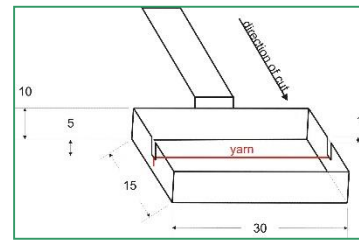
Internal structure of single length fabrics - internal standards (see EXA_01):

- IN 46-108-01/01 Recommended procedure for creating cross sections. Soft and hard cuts
- IN 22-103-01/01 Yarn packing density Direct method and Secant method
- IN 22-103-02/01 Yarn packing density - Direct method

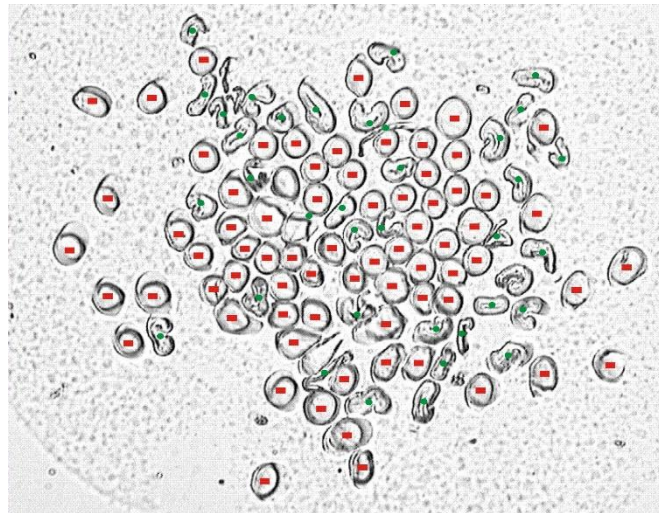
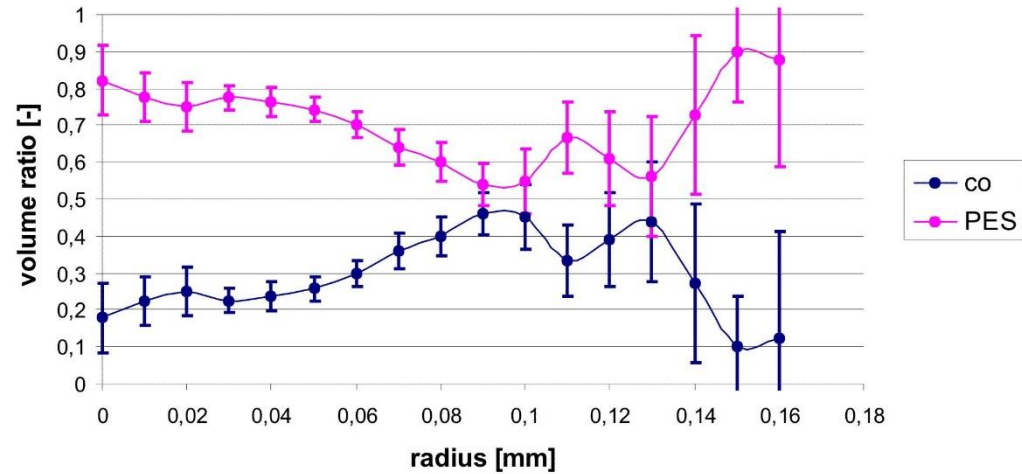
Detected parameters, see STR [1]:

$$g_i = \frac{m_i}{m} = \frac{\rho_i \cdot S_i}{\sum \rho_i \cdot S_i}$$

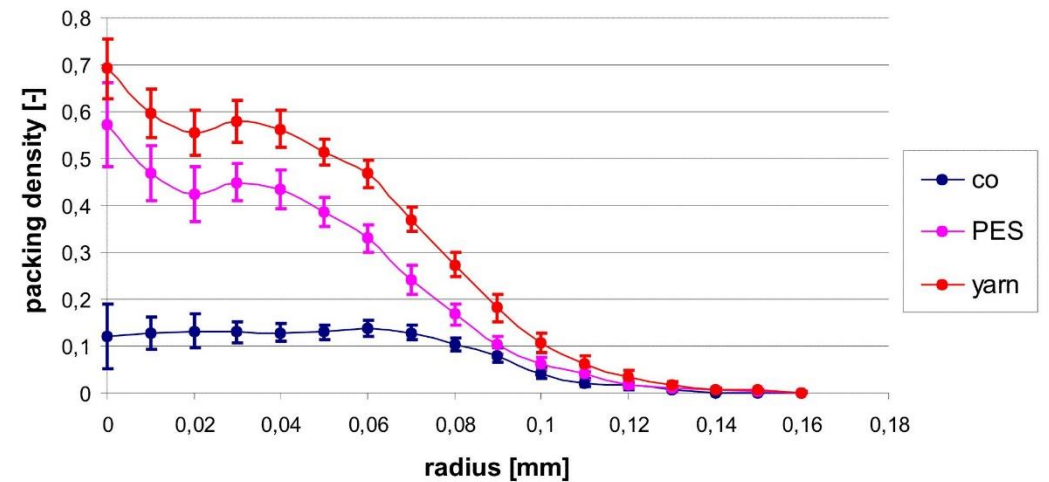
$$v_i = g_i \frac{\rho}{\rho_i} = \frac{S_i}{\sum S_i}$$



Volume Ratio of each Component



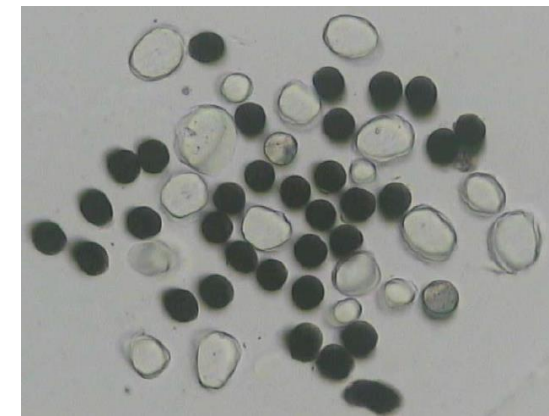
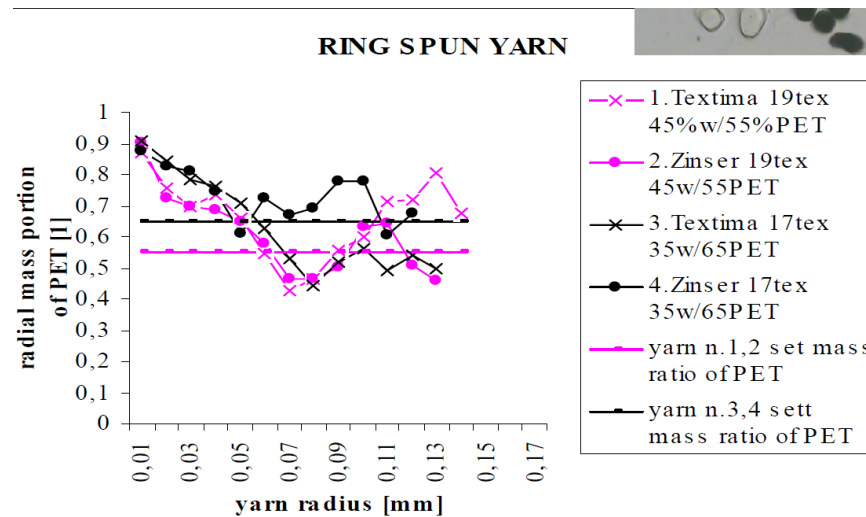
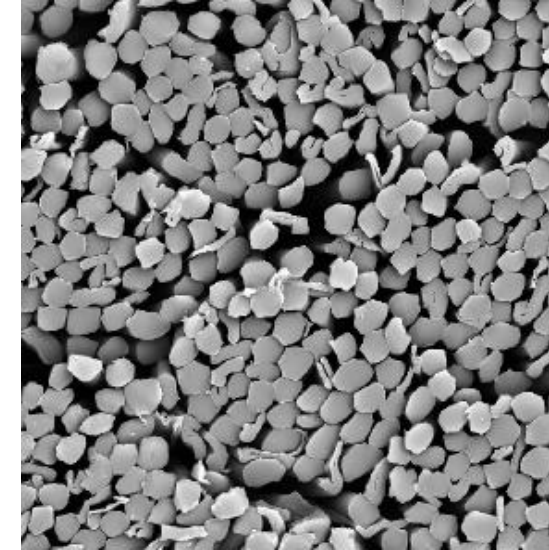
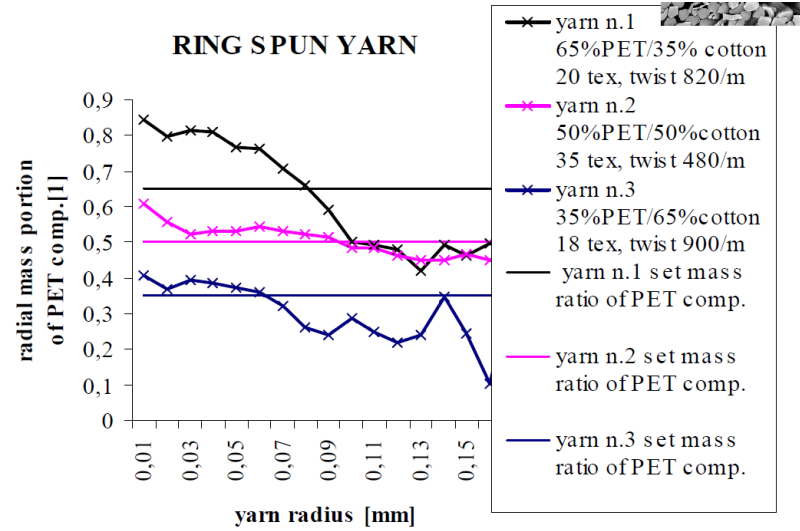
Radial Packing Density of Two Component Yarn (70PES/30co)



Detected parameters, see STR [1]:

$$g_i = \frac{m_i}{m} = \frac{\rho_i \cdot S_i}{\sum \rho_i \cdot S_i}$$

$$v_i = g_i \frac{\rho}{\rho_i} = \frac{S_i}{\sum S_i}$$



Detected parameters:

IBI – Index of blend irregularity [6]

- radial homogeneity - distribution of fibres in the yarn cross-section
- axial homogeneity - variability of mixing of components between cross-sections

$$IBI = \sqrt{\frac{1}{n} \sum \frac{(T_i p - W_i)^2}{T_i p q}} \quad (1)$$

where

T_i = Total number of fibers at a given section

W_i = Number of wool fibers at that section.

p = Average number fraction of wool fiber for all sections.

$q = 1 - p$.

n = Number of sections examined.

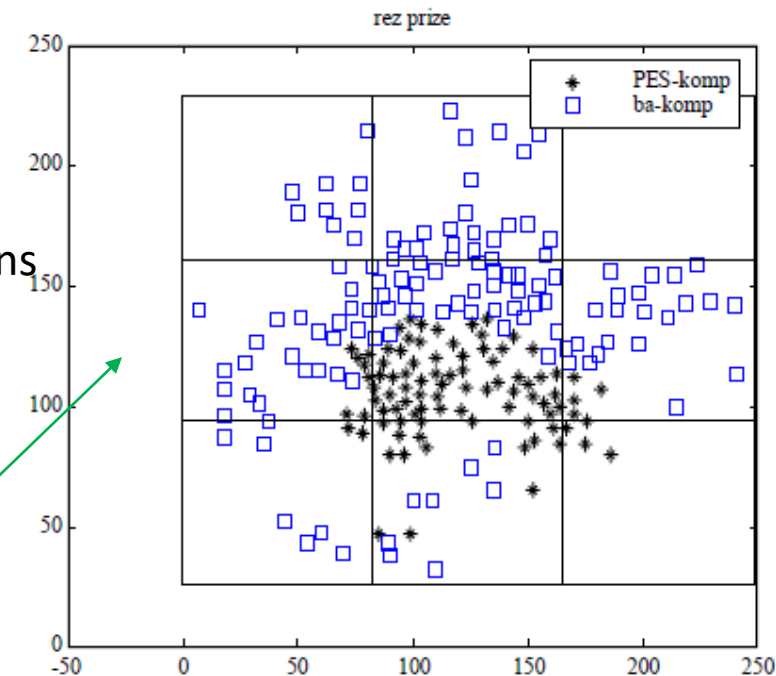
IBI:

0 - perfect arrangement of fibre placement,

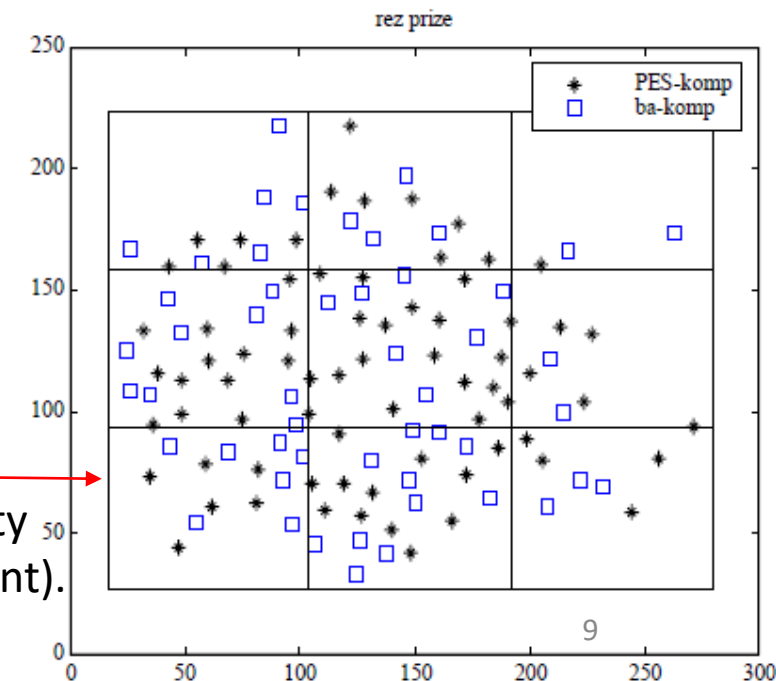
1 - perfect randomness of the distribution of threads,

>1 - (e.g. 1,3 - mixture affected by "causal factors" that increase its inhomogeneity by 30% with respect to the assumed perfect randomness of the fibre arrangement).

EXA_09_10



IBI rather to 0

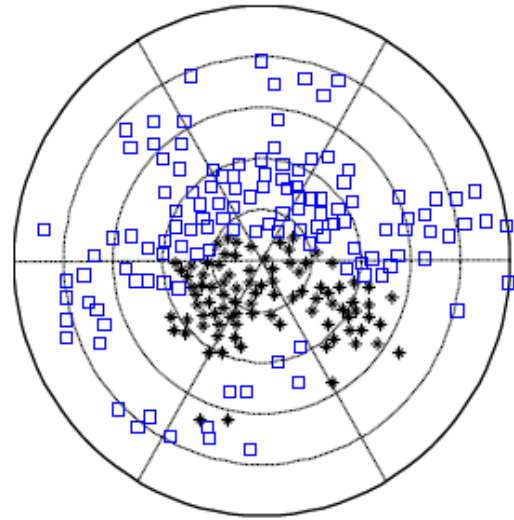


IBI rather to 1

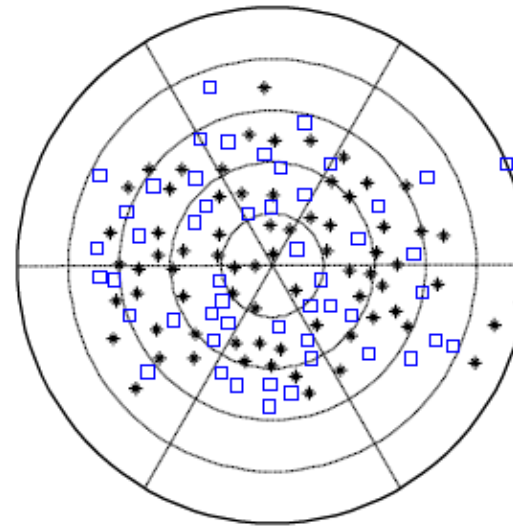
Detected parameters:

IBI – Index of blend irregularity [6]

- radial homogeneity - distribution of fibres in the yarn cross-section
- axial homogeneity - variability of mixing of components between cross-sections



IBI rather to 0



IBI rather to 1

$$IBI = \sqrt{\frac{1}{n} \sum \frac{(T_i p - W_i)^2}{T_i p q}} \quad (1)$$

where

T_i = Total number of fibers at a given section

W_i = Number of wool fibers at that section.

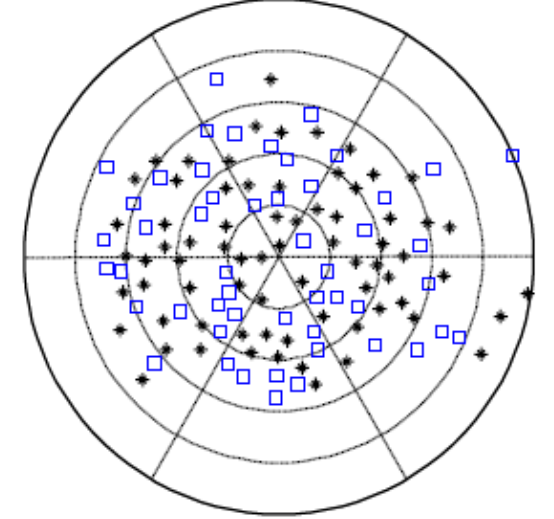
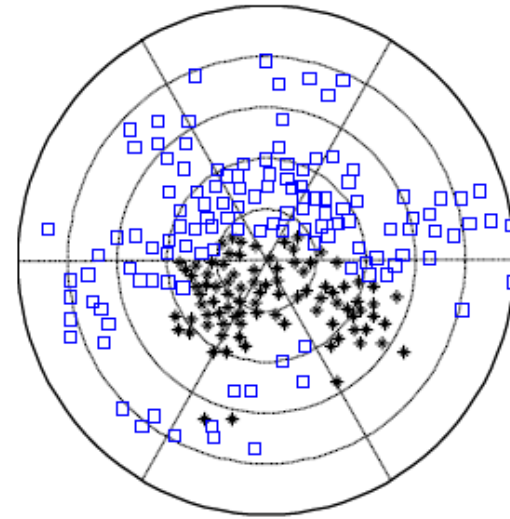
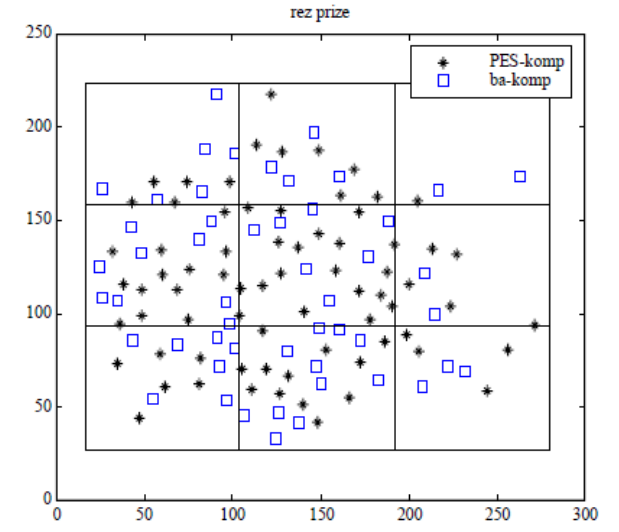
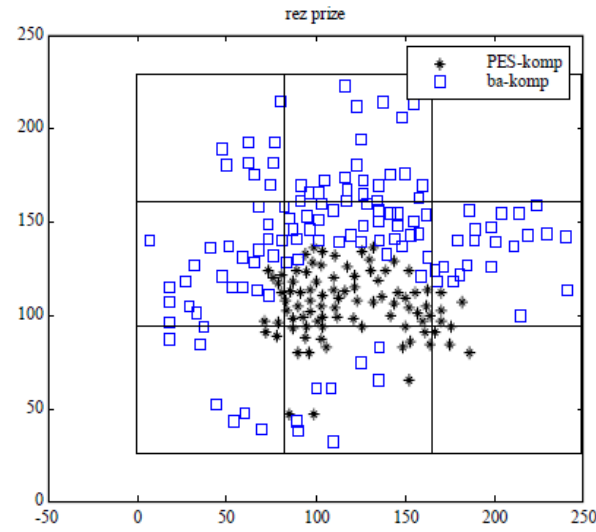
p = Average number fraction of wool fiber for all sections.

$q = 1 - p$.

n = Number of sections examined.

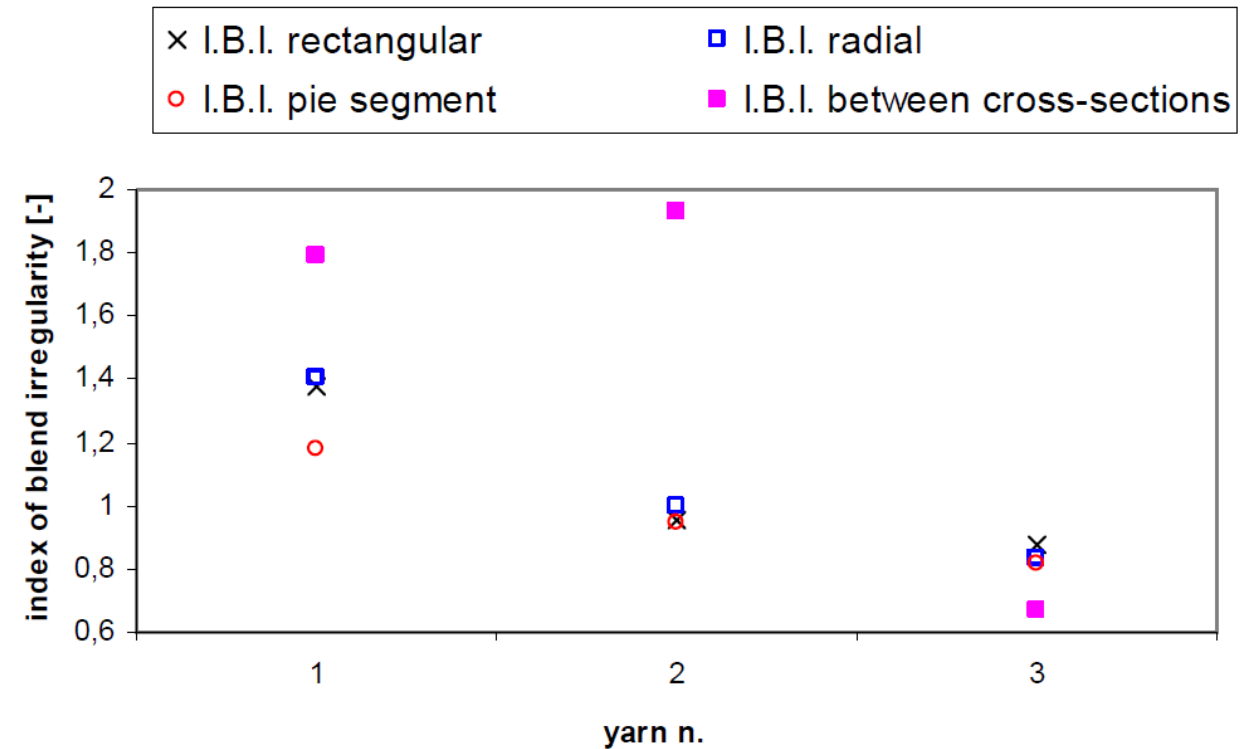
IBI

	65PES/35co "PER1"	Splicer joint "SPOJ4"
Fiber numb. in cross-s. N	123	214
p	0.58	0.42
q	0.42	0.58
I.B.I. rectangular	0.75	2.61
I.B.I. radial	0.93	3.12
I.B.I. pie segments	0.42	3.57



IBI – experimental results

Type	Yarn/fiber fineness [tex]	I.B.I. rectangular	I.B.I. radial	I.B.I. pie segment	I.B.I. between cr.-sect.
Yarn n.1 65PET/ 35co	20/ PET 0,17 co 0,14	1,37 (1,23; 1,51)	1,40 (1,18; 1,62)	1,18 (1,04; 1,31)	1,79
Yarn n.2 50PET/ 50co	35/ PET 0,21 co 0,14	0,95 (0,85; 1,05)	0,99 (0,83; 1,17)	0,95 (0,82; 1,08)	1,93
Yarn n.3 35PET/ 65co	18/ PET 0,16 co 0,17	0,88 (0,79; 0,96)	0,83 (0,72; 0,95)	0,82 (0,71; 0,93)	0,67



Detected parameters:

Mass unevenness - variability in the number of fibres between cross sections

$$(CV)^2 = \frac{100^2}{n} + \frac{(CV_f)^2}{n},$$

where CV = coefficient of variation of weight per unit length of the yarn, n = the average number of fibers in a cross section of the yarn, and CV_f = coefficient of variation of fiber weight per unit length.

and

$$\begin{aligned} (CV_A)^2 &= \frac{100^2}{n_A} + \frac{(CV_{fA})^2}{n_A}, \\ (CV_B)^2 &= \frac{100^2}{n_A} + \frac{(CV_{fB})^2}{n_B}, \end{aligned}$$

Small number - we neglect

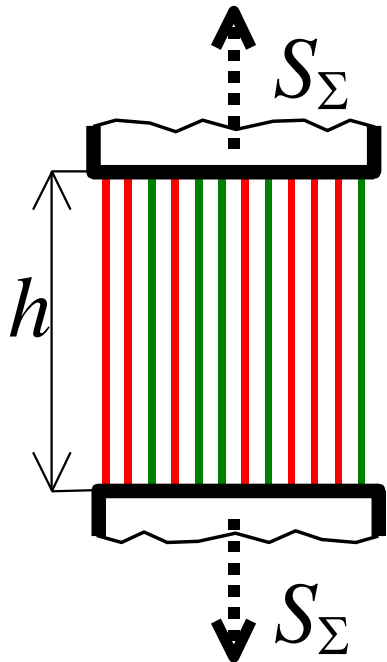
$$CV^2 = (CV_A)^2 + (CV_B)^2 = 100^2 \left(\frac{1}{n_A} + \frac{1}{n_B} \right)$$

Mechanical properties - linear mixing theory (repetition,
for derivations see STR)

"Linear mixing theory" according to W. J. Hamburger

Assumptions:

1. Fiber bundle is a blend (| and |) of 2 types of fibers.
2. All fibers of one type have
 - a) same force-strain curve and
 - b) same strength P and same breaking strain a .



"Linear mixing theory" according to W. J. Hamburgera

Convention:

Fiber of one type having smaller value of breaking strain is denoted as No. 1 (|), other type of fibers is denoted as No. 2. (|). (This numbers are used as subscripts.)

Variables:	Fiber material	
	No. 1	No. 2
Fiber fineness	t_1	t_2
Force-strain relation	$S_1(\varepsilon)$	$S_2(\varepsilon)$
Breaking strain of fiber	$a_1 \leq a_2$	
Fiber strength	$P_1 = S_1(a_1)$	$P_2 = S_2(a_2)$
Number o fibers	n_1	n_2
Total number of fibers	$n = n_1 + n_2$	
Mass of fibers	m_1	m_2
Total mass of fibers	$m = m_1 + m_2$	
Bundle fineness (count)	$T = m/h$	
Mass portion	$g_1 = m_1/m$	$g_2 = m_2/m$
Sum of mass portions	$g_1 + g_2 = 1$	

"Linear mixing theory" according to W. J. Hamburger

It is valid for the fiber No. 1:

$$m_1 = g_1 m, \quad t_1 = m_1 / (n_1 h), \quad n_1 = m_1 / (t_1 h) = (g_1 / t_1) (m / h), \quad n_1 = g_1 (T / t_1) \quad =T$$

For the fiber No. 2, it is valid analogically:

$$n_2 = g_2 (T / t_2)$$

Maximum forces, in a bundle

a) Interval $\varepsilon \leq a_1 \Rightarrow \text{max. at } \varepsilon = a_1$

$$S_{\Sigma}(a_1) = n_1 P_1 + n_2 S_2(a_1)$$

$$S_{\Sigma}(a_1) = T \left[g_1 P_1 / t_1 + g_2 S_2(a_1) / t_2 \right]$$

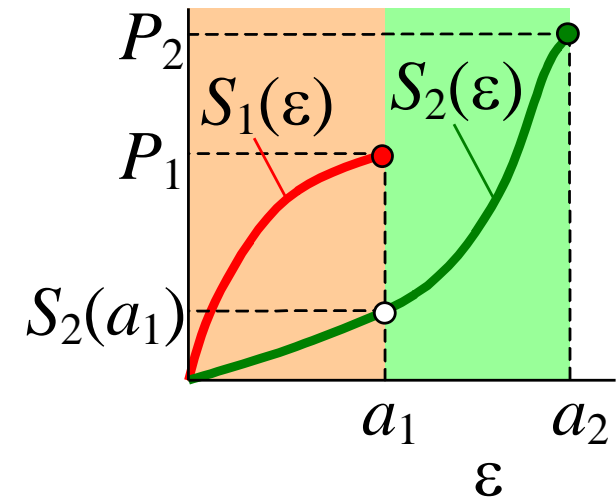
b) Interval $\varepsilon \in (a_1, a_2) \Rightarrow \text{max. at } \varepsilon = a_2$

$$S_{\Sigma}(a_2) = n_1 \cdot 0 + n_2 P_2$$

$$S_{\Sigma}(a_2) = T g_2 P_2 / t_2$$

c) Interval $\varepsilon > a_2 \Rightarrow \text{all fibers are broken, } S_{\Sigma}(\varepsilon > a_2) = 0$

Force-strain curves:



"Linear mixing theory" according to W. J. Hamburger

Strength of bundle

$$P_{\Sigma} = \max \{ S_{\Sigma} (a_1), S_{\Sigma} (a_2) \} = T \max \left\{ \left[g_1 \frac{P_1}{t_1} + g_2 \frac{S_2 (a_1)}{t_2} \right], \left[g_2 \frac{P_2}{t_2} \right] \right\}$$

P_1/t_1 ...tenacity of fiber No. 1 (e.g. N/tex)

P_2/t_2 ...tenacity of fiber No. 2 (e.g. N/tex)

$S_2(a_1)/t_2$...specific stress of fiber No. 2 (e.g. N/tex) at $\varepsilon = a_1$

Bundle tenacity P_{Σ}/T

$$\frac{P_{\Sigma}}{T} = \max \left\{ \left[g_1 \frac{P_1}{t_1} + g_2 \frac{S_2 (a_1)}{t_2} \right], \left[g_2 \frac{P_2}{t_2} \right] \right\}$$

Breaking strain of bundle

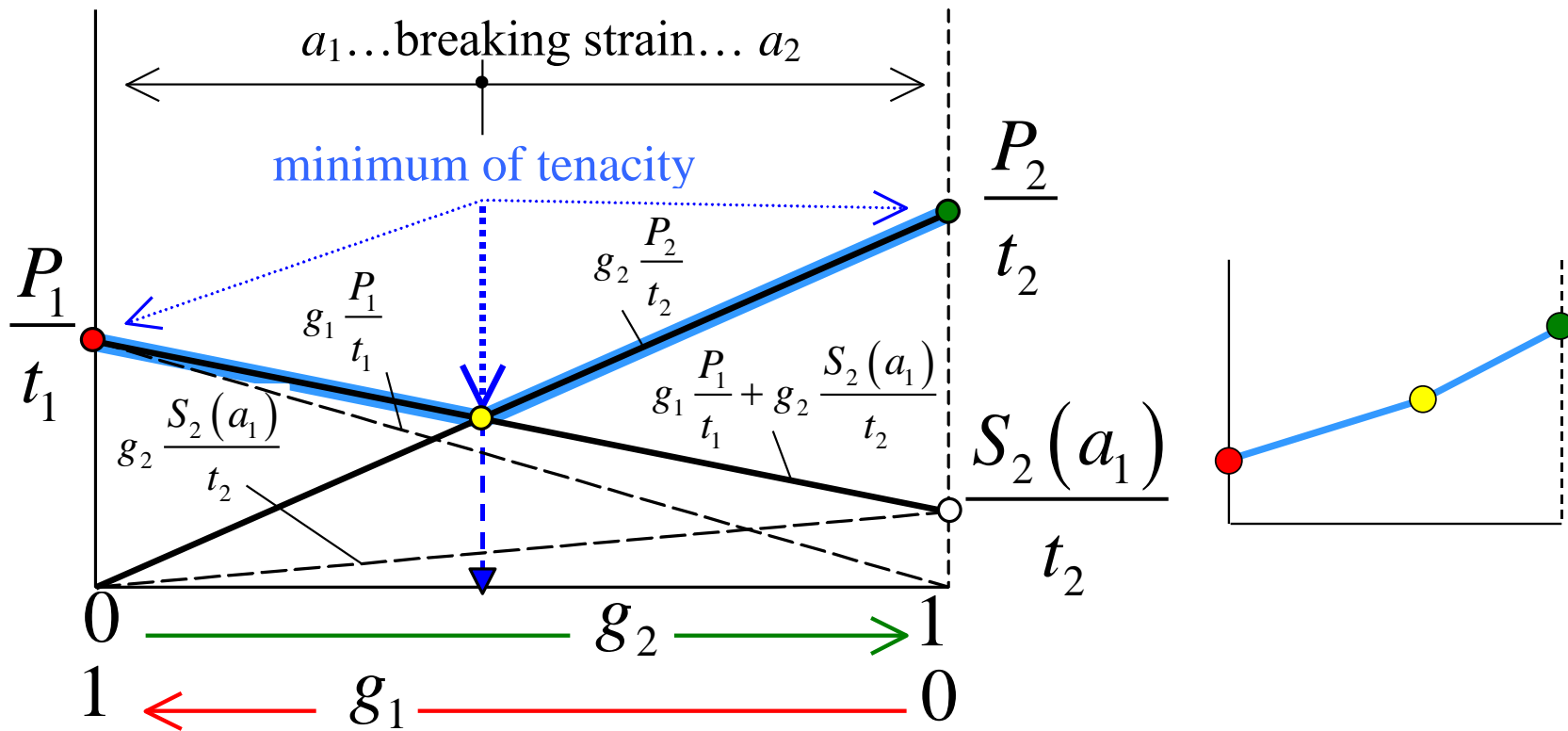
a) $a_{\Sigma} = a_1$ $P_{\Sigma}/T = g_1 P_1/t_1 + g_2 S_2(a_1)/t_2$

b) $a_{\Sigma} = a_2$ $P_{\Sigma}/T = g_2 P_2/t_2$

"Linear mixing theory" according to W. J. Hamburger

Graphical representation of resulting equation

$$P_{\Sigma}/T = \max \left\{ \left[g_1 P_1/t_1 + g_2 S_2(a_1)/t_2 \right], \left[g_2 P_2/t_2 \right] \right\}$$



"Linear mixing theory" according to W. J. Hamburger

Minimum bundle tenacity – two possibilities:

a) $g_2 = 0$ (●) and then $P_{\Sigma}/T = P_1/t_1$

b) By point of intersection (○) of two lines, it is

$=1-g_2$

$$g_1 P_1/t_1 + g_2 S_2(a_1)/t_2 = g_2 P_2/t_2,$$

$$P_1/t_1 = g_2 P_1/t_1 + g_2 P_2/t_2 - g_2 S_2(a_1)/t_2,$$

$$g_2 = \frac{P_1/t_1}{P_1/t_1 + P_2/t_2 - S_2(a_1)/t_2}$$

$$P_{\Sigma}/T = g_2 P_2/t_2$$

and using this value we get

Now, the minimum bundle tenacity is the **minimum of three calculated values** P_{Σ}/T

Note: After addition of fibers having higher tenacity, the tenacity of resulting bundle can **decrease!**

„Lineární teorie mísení“ dle W. J. Hamburgera

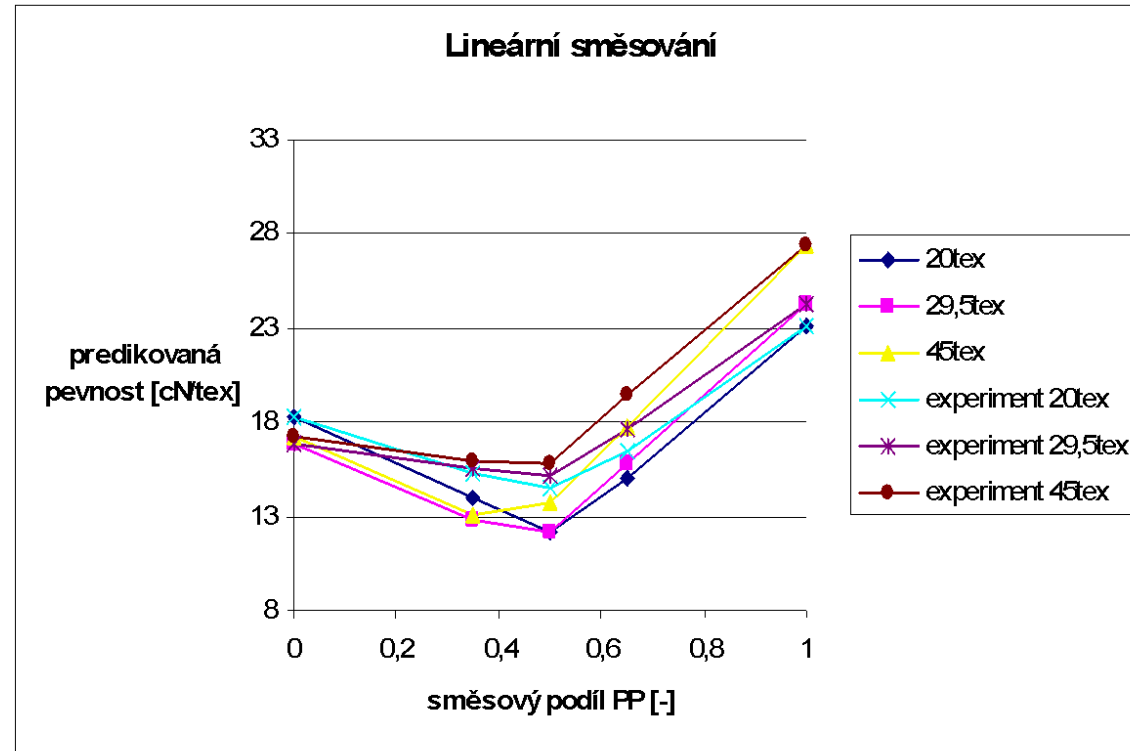
EMPIRICKÉ POUŽITÍ VÝSLEDKŮ PRO PŘÍZE

Místo parametrů vláken se užijí obdobné parametry jednokomponentních a směsových přízí

<i>Veličina</i>	<i>místo VLÁKEN a SVAZKU</i>	<i>užijeme hodnoty PŘÍZÍ</i>
p_1	Poměrná pevnost vlákna s nižší tažností	Poměrná pevnost jednokomponentní příze s nižší tažností
p_2	Poměrná pevnost vlákna s vyšší tažností	Poměrná pevnost jednokomponentní příze s vyšší tažností
a_1	Tažnost vlákna komponenty s nižší tažností	Tažnost jednokomponentní příze s nižší tažností
a_2	Tažnost vlákna komponenty s vyšší tažností	Tažnost jednokomponentní příze s vyšší tažností
$\sigma_2(a_1)$	Specifické napětí ve vlákně s vyšší tažností při poměrném prodloužení $\varepsilon = a_1$	Specifické napětí v jednokomponentní přízi s vyšší tažností při poměrném prodloužení $\varepsilon = a_1$
g_1, g_2	Hmotnostní podíly vláken s nižší a vyšší tažností ve svazku	Hmotnostní podíly vláken jednokomponentních přízí s nižší a vyšší tažností ve směsové přízi
p_Σ	Poměrná pevnost svazku ze dvou komponent	Poměrná pevnost směsové příze ze dvou komponent
a_Σ	Tažnost svazku ze dvou komponent	Tažnost směsové příze ze dvou komponent

Experiment - strength of blended yarns [9]

jemnost příze [tex]	zákrut příze [m ⁻¹]	hmotnostní směšový podíl PP vláken [-]	řezy - efektivní zaplnění příze [-]	95%-ní interval spolehlivosti efektivního zaplnění příze - řezy[-]
20	828 <817;838>	0	0,427	<0,410 ; 0,444>
	823 <812;835>	0,35	0,352	<0,339 ; 0,365>
	796 <790;803>	0,50	0,414	<0,391 ; 0,438>
	825 <817;833>	0,65	0,417	<0,381 ; 0,453>
	787 <776;799>	1	0,544	<0,523 ; 0,565>
29,5	625 <616;633>	0	0,467	<0,449 ; 0,485>
	632 <624;639>	0,35	0,403	<0,390 ; 0,416>
	621 <615;626>	0,50	0,468	<0,449 ; 0,487>
	643 <637;648>	0,65	0,417	<0,401 ; 0,433>
	601 <593;610>	1	0,517	<0,496 ; 0,537>
45	467 <461;473>	0	0,449	<0,437 ; 0,462>
	478 <473;484>	0,35	0,399	<0,386 ; 0,412>
	470 <464;476>	0,50	0,461	<0,449 ; 0,474>
	470 <462;477>	0,65	0,424	<0,410 ; 0,438>
	489 <482;495>	1	0,495	<0,476 ; 0,513>



References used:

1. Neckář, B.: VLÁKNA A VLÁKENNÉ ÚTVARY 1 – DEFINICE, SOUVISLOSTI, TU Liberec, KTT, power point prezentace pro předmět STR
2. Neckář, B.: VLÁKNA A VLÁKENNÉ ÚTVARY 3 – MECHANIKA VLÁKENNÝCH ÚTVARŮ, TU Liberec, KTT, power point prezentace pro předmět STR
3. Neckář, B.: Příze – struktura, vlastnosti, výroba, SNTL, Praha, 1991
4. Výběr interních norem KTT – viz text prezentace
5. CEITEC – výsledky vyhodnocení textilií pomocí nanoCT
6. Výběr publikací a zpráv autorky, práce vedené autorkou
7. Coplan, Myron J., Bloch, Manfred G.: A Study of Blended Woolen Structures, Part II: Blend Distribution in Some Wool-Nylon and Wool-Viscose Yarns, TRJ, 1955
8. Křemenáková, D.: Přednášky předmětu EAS, Liberec, TUL, 2004
9. Hryzová, L.: Pevnost směsových přízí, Diplomová práce, TUL, Liberec, 2006