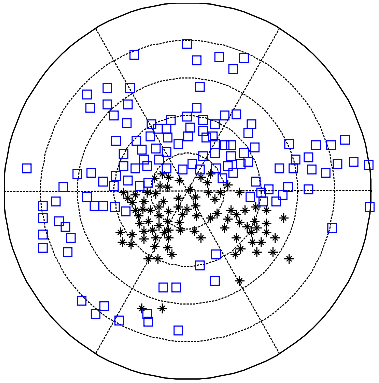
TECHNICAL UNIVERSITY OF LIBEREC
Faculty of Textile Engineering

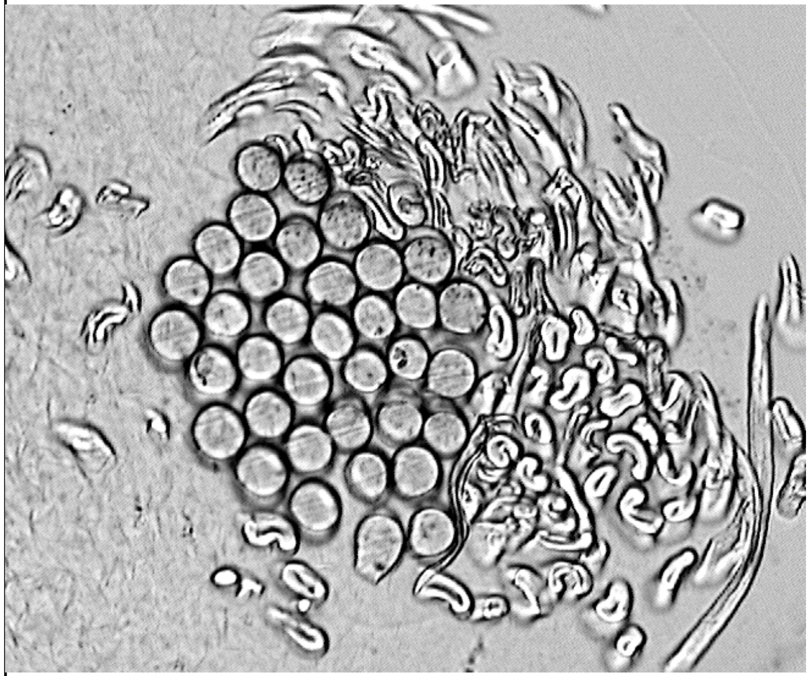
MULTI-COMPONENT TEXTILE FIBROUS FORMATIONS (MFF)

„CHARACTERISTICS OF FIBER BLEND“



Ing. Iva Mertová, Ph.D. / Department of technologies and structures

Cross section of blended yarns

Cross section of ring spun yarn 20 tex, 65% PES/35% WO	Cross section of rotor spun yarn 30 tex, 70% PES/30% cotton
	

Fibrous formation

- Fibrous formation = fibrous assembly, fibers are in direct (mutual) contact

- Division of MFF from point of view of:

  Geometrical properties (linear, areal, 3D)

  Hierarchy of structure (simple – yarn, web

  composite – knitted, woven fabrics)

- Types of fibers

  one-component (one type of fibres)

  multi-component (mixed assemblies)

Multi-fiber blend - input parameters:

n number of components, i = 1, 2, 3, …, n

Mass of i-th component m_i [kg]

$$\sum_i m_i = m, \quad m_i \leq m$$

Total mass of fibers (blend) … m

Mass fraction of i-th component g_i [1]

$$g_i = m_i / m$$

$$\sum_i g_i = 1$$

Density of i-th component ρ_i [kg/m^3]

Fineness of fiber of i-th component t_i [tex]

Average fibre length of i-th component l_i [mm]

In the mass unit of blend we define:

Volume of i-th component V_i [m^3.kg^{-1}]

$$V_i = \frac{g_i}{\rho_i}$$

Total volume of the blend

$$V = \sum_{i=1}^{n} V_i = \sum_{i=1}^{n} \left(m \frac{g_i}{\rho_i} \right) = m \sum_{i=1}^{n} \frac{g_i}{\rho_i}$$

Mean fiber density of the blend ρ[kg.m^{-3}]

… weighted harmonic mean value

$$1/\rho = \sum_{i=1}^{n} \left(g_i / \rho_i \right)$$

Volume fraction of i-th component of the blend v_i [1]

$$v_i = \frac{V_i}{V} = \frac{V_i}{\sum V_i} = \frac{g_i / \rho_i}{\sum_{i=1}^{n} \left(g_i / \rho_i \right)} = \frac{g_i}{\rho_i} \rho = g_i \frac{\rho}{\rho_i}$$

Total length of fibers of i-th component $\boldsymbol{L_i}$ [tex^{-1}]

$$L_i = \frac{g_i}{t_i}$$

Total length of all fibers in blend *L* [tex^{-1}]

$$L = \sum_i^n L_i$$

Mean fiber fineness in blend *t* [tex]

$$1/t = \sum_{i=1}^{n} \left(\frac{g_i}{t_i} \right)$$

… weighted harmonic mean

Fiber length fraction of i-th component λ_i [1]

$$\lambda_i = L_i / L = L_i \Big/ \sum_i L_i = \frac{g_i}{t_i} \Big/ \sum_i \frac{g_i}{t_i} = \frac{g_i}{t_i} t = g_i \frac{t}{t_i}$$

Number of fibers of i-th component n_i [g^{-1}]

$$n_i = \frac{L_i}{l_i} = \frac{\lambda_i \sum_i L_i}{l_i} = \frac{\lambda_i}{l_i} \sum_i L_i$$

Total number of fibers in the blend n [g^{-1}]

$$n = \sum_i n_i = \sum_i \left[\frac{\lambda_i}{l_i} \sum_i L_i \right] = \left(\sum_i L_i \right) \left(\sum_i \frac{\lambda_i}{l_i} \right)$$

Mean fiber length in the blend *l* [mm]

$$l = \frac{L}{n} = \frac{\sum_i L_i}{\sum_i L_i \sum_i \left(\frac{\lambda_i}{l_i} \right)} = 1 \Big/ \sum_i \left(\frac{\lambda_i}{l_i} \right)$$

$$\frac{1}{l} = \sum_i \left(\frac{\lambda_i}{l_i} \right)$$

… weighted harmonic mean

Relative frequency of i-th component v_i [1]

$$v_i = \frac{n_i}{n} = \frac{\frac{\lambda_i}{l_i} \sum_i L_i}{\sum_i L_i \sum_i \frac{\lambda_i}{l_i}} = \frac{\frac{\lambda_i}{l_i}}{\sum_i \frac{\lambda_i}{l_i}} = \lambda_i \frac{l}{l_i}$$

Total fiber surface of i-th component A_i [m^2.kg^{-1}]

$$A_i = L_i p_i = \frac{g_i}{t_i}\left[\pi d_i\left(1+q_i\right)\right] = \frac{g_i \pi d_i\left(1+q_i\right)}{s_i \rho_i} = g_i \frac{4\left(1+q_i\right)}{d_i \rho_i} = g_i a_i$$

Specific surface of fiber of i-th component a_i [m^2.kg^{-1}]

$$a_i = \frac{4\left(1+q_i\right)}{d_i \rho_i}$$

$$a_i = \frac{2000\sqrt{\pi}\left(1+q_i\right)}{\sqrt{\rho_i t_i}}$$

Mean specific surface area of the blend a [$m^{-2}.kg^{-1}$]

$$a = \frac{A}{m} = \frac{m\sum_{i=1}^{n}(g_i a_i)}{m}, \quad a = \sum_{i=1}^{n}(g_i a_i)$$

… weighted arithmetical mean

Fiber surface area fraction α_i [1]

$$\alpha_i = \frac{A_i}{\sum_{i=1}^{n} A_i} = \frac{g_i a_i}{\sum_{i=1}^{n}(g_i a_i)} = g_i \frac{a_i}{a}$$

TECHNICA
Faculty of Te

Task 1

Blend 70%PES / 30%cotton		
g_i [1]	0,70	0,30
t_i [tex]	0,16	0,12
ρ_i [kgm^{-3}]	1360	1520
l_i [mm]	40	25
q_i [1]	0,05	0,47
ρ [kgm^{-3}]	1404	
v_i [1]	0,723	0,277
t [tex]	0,145	
λ_i [1]	0,637	0,363
L_i [kmg^{-1}]	4,375	2,5
L [kmg^{-1}]	6,875	
n_i [g^{-1}]	109 375	100 000
n [g^{-1}]	209 375	
l [mm]	32,8	
A_i [m^2kg^{-1}]	179,99	116,54
a [m^2kg^{-1}]	296,53	
α_i [1]	0,61	0,38

Task 2

For blended yarn 45wool/55PES evaluate:

a) Mean density of fiber
b) Mean fineness of fiber
c) Length portions of components

Equivalent diameter of woollen fiber is 22μm, fineness of PES fiber is 5,2dtex.

ρ wool= 1310kg/m^3
ρ PES=1360kg/m^3

Task 3

Blend 65%cotton/ 35%polypropylene		
g_i [1]	0,65	0,35
t_i [tex]	0,17	0,188
ρ_i [kgm^{-3}]	1520	910
l_i [mm]	26,5	38,8
q_i [1]	0,47	0,07
ρ [kgm^{-3}]	1231	
v_i [1]	0,53	0,47
t [tex]	0,176	
λ_i [1]	0,67	0,33
L_i [kmg^{-1}]	3,82	1,86
L [kmg^{-1}]	5,68	
n_i [g^{-1}]	144 284	47 982
n [g^{-1}]	192 266	
l [mm]	29,6	
A_i [m^{2}kg^{-1}]	210,7	101,5
a [m^{2}kg^{-1}]	312,2	
α_i [1]	0,67	0,33