TECHNICAL UNIVERSITY OF LIBEREC
Faculty of Textile Engineering

FIBRES AND FIBRE ASSEMBLIES „DEFINITIONS, RELATIONS”

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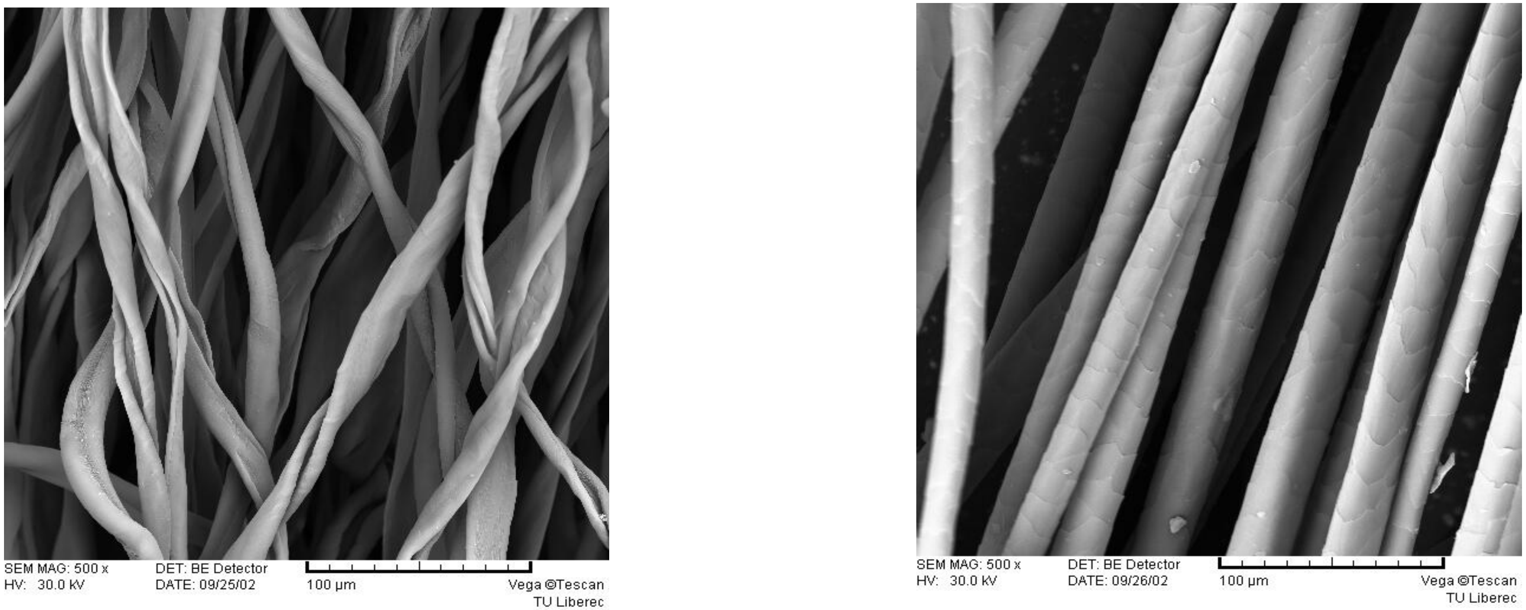


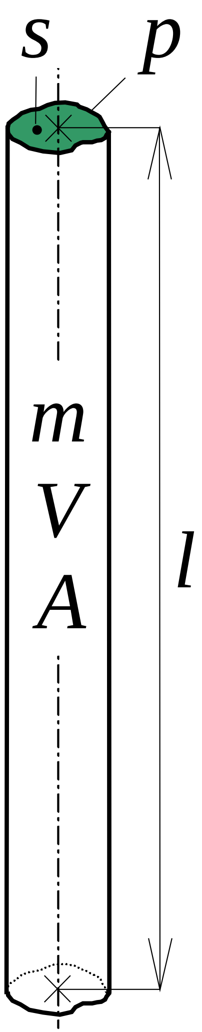
Fig. 2 Examples of fibers longitudinal view a) cotton fibers b) wool fibers

- ✓ basic element of textiles
- ✓ longitudinal textile has $d \ll l$,
- ✓ assumption - approximation to the cylinder shape,
- ✓ basic parameters (fineness, length, other geometrical parameters and very important mechanical parameters).

Basic characteristics

- fibres – small letters
- yarns – big letters

s [mm^2] cross sectional area
p [mm] perimeter
l [mm] fibre length
m [g] mass
ρ [kgm^{-3}] density
A [mm^2] surface area
V [m^3] fiber volume



Fiber fineness t [tex]

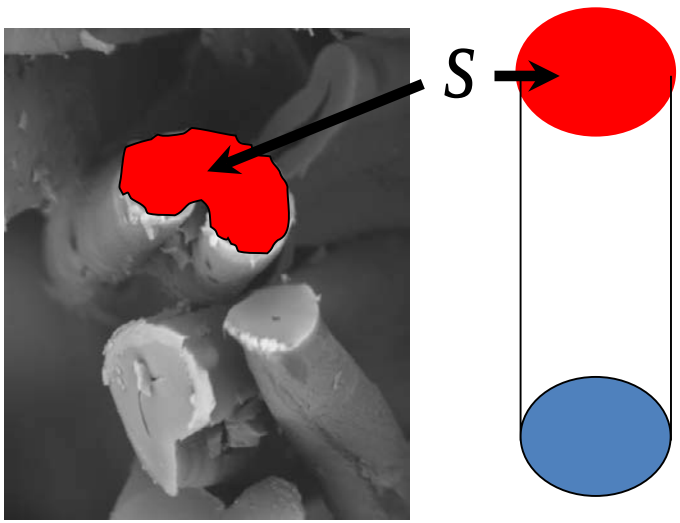
$$t = \frac{m}{l} = s\,\rho$$

Fiber density [kg.m^{-3}]

Type of fibers	Density ρ [kg m^{-3}]
WO (vl) wool	1310
CV (VS) viscose	1500
PP (POP) polypropylen	910
PES polyester	1360
PAN polyacrylonitril	1160
CO cotton	1520

Cross – sectional area s [mm²]

$$s = \frac{V}{l} = \frac{t}{\rho}$$

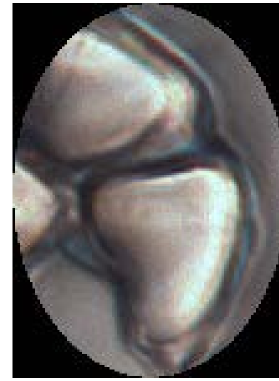


From geometrical standpoint, the fiber “fineness” is characterized by the ratio V/l, but the standard fineness is moreover influenced by fiber density.
Therefore, it is not correct to compare the finenesses of fibers having different densities by the standard fine-ness; it is better to use the ratio t/ρ.

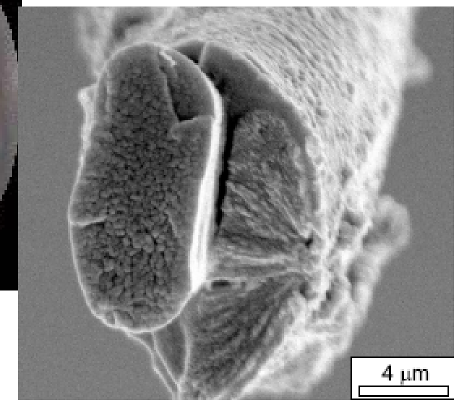
Fineness and density define the cross-sectional area. Cross-sectional area enables to evaluate the equivalent fiber diameter. For cylindrical fibers, the derivation is trivial. For non-cylindrical fibers, the same equation represents the diameter of a ring having the same cross-sectional area.

Wool

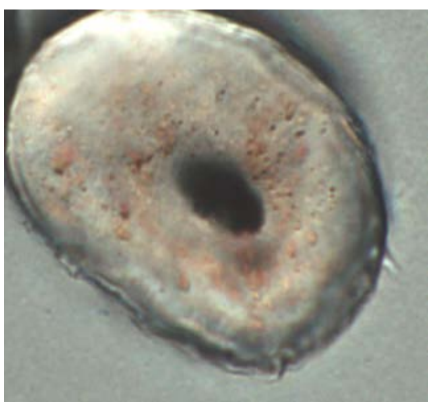
Rabbit hair



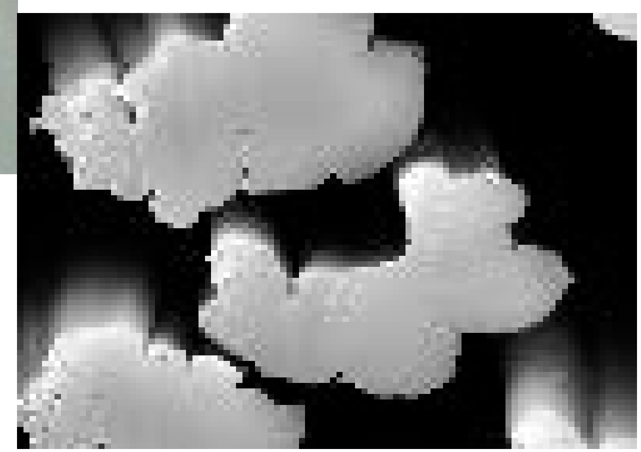
Natural silk



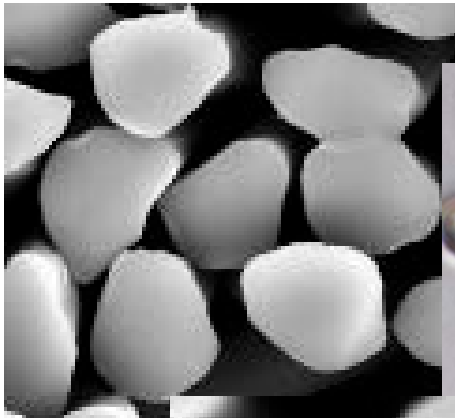
Camel hair

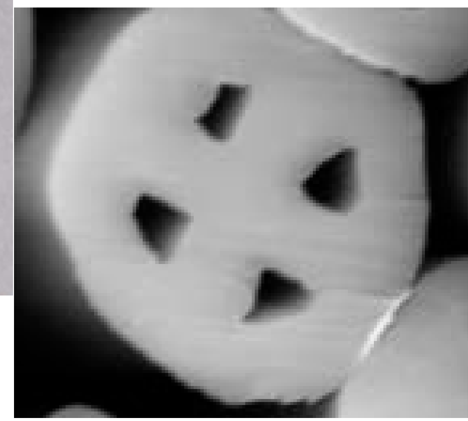


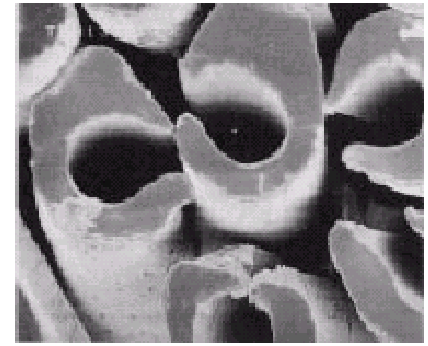
Viscose



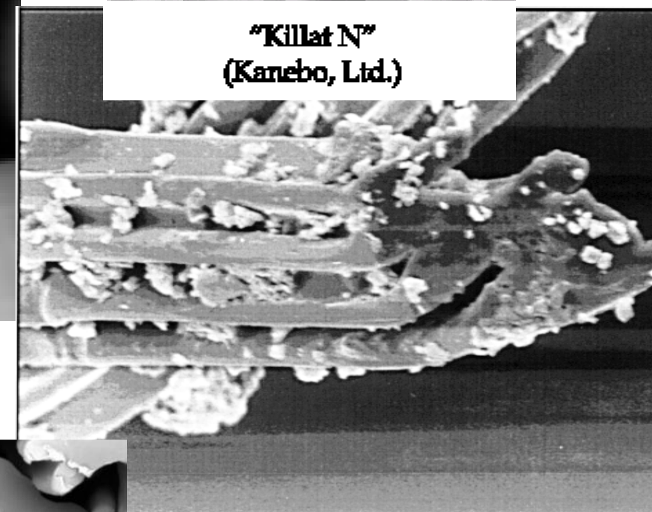
Modified viscose

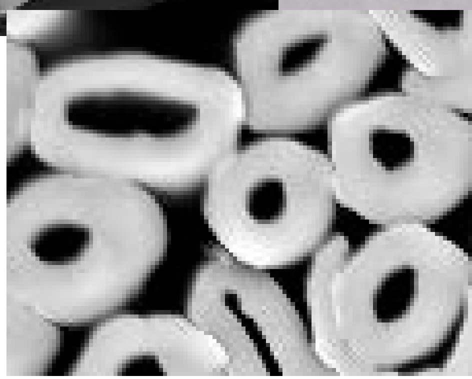




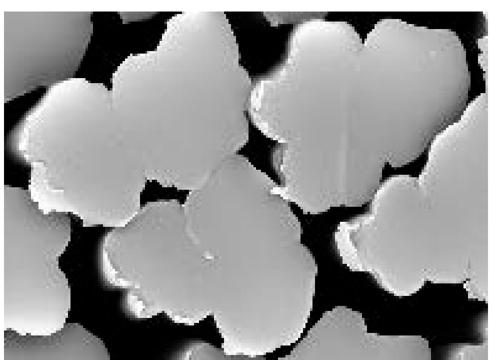


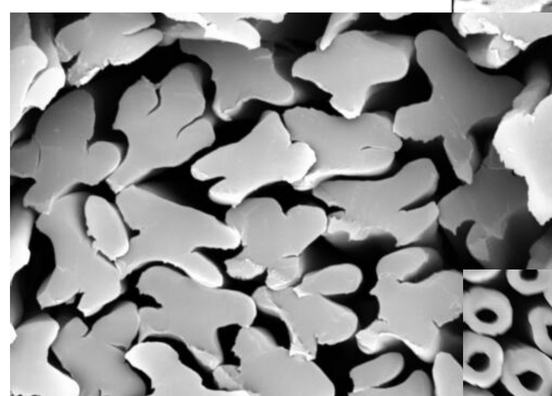
"Killat N"
(Kanebo, Ltd.)

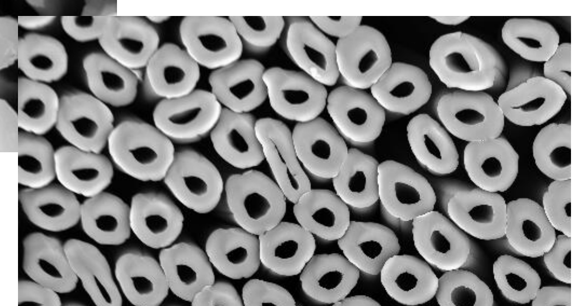




Acetate fibres





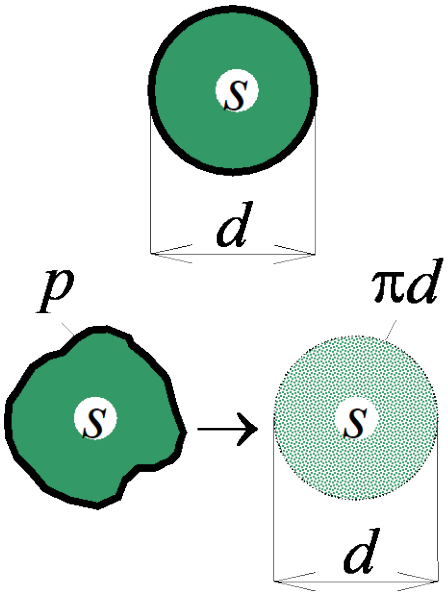


polyester fibres

Equivalent fiber diameter d [mm]

Cylindrical fibre

Non cylindrical fibre



$$s = \frac{\pi d^2}{4} \ldots d = \sqrt{\frac{4s}{\pi}} = \sqrt{\frac{4t}{\pi \rho}}$$

Shape factor Mrs. Malinowska q [-]

Fiber shape factor *q* [-] – comparison of fibre perimeters, the fibre with circular shape has *q*=0, the more fragmented the shape of the fiber, the larger the *q*

$$q = \frac{p_{original\ fibre\ shape}}{p_{circle\ with\ the\ same\ area}} - 1 = \left(\frac{p}{\pi d} \right) - 1 \geq 0$$

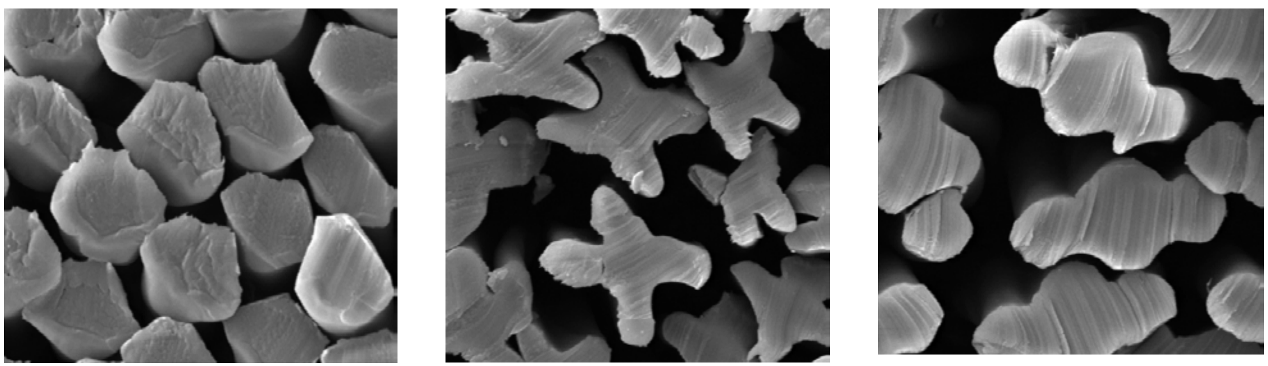
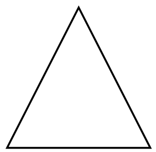
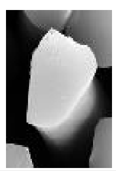
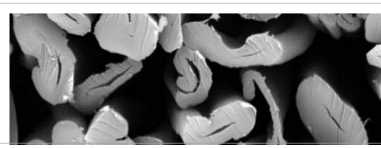
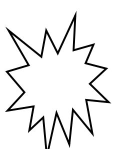
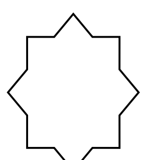


Fig. 4 Examples of fibers with various shape of cross-section

Perimeter p [mm]

$$p = \pi d \left(1 + q \right)$$

Orientation Values of Shape factor

Shape of fibre cross section	**Fibre (picture)**	**Shape Factor *q* [-]**
„Circle“ (e.g. hollow PES fibres)	 	0-0,07
Ideal triangle		0,29
Real triangle (e.g. natural silk)		0,09-0,12
Cotton (middle maturity		0,45-0,50
Irregular shape - viscose	 	0,50-0,60

Specific surface area a [m²/kg]

$$a = \frac{fibre \quad surface}{fibre \quad mass} = \frac{p\,l}{m} = \ldots = \frac{4(1+q)}{\rho d} = \frac{2(1+q)\sqrt{\pi}}{\sqrt{\rho\, t}}$$

Fiber aspect ratio Λ [-]

$$\Lambda = \frac{l}{d}$$

Fiber	Aspect ratio
Cotton	1500
Wool	3000
Flax	1250
Ramie	3000

Mechanical properties of fibres

Mechanical properties of textile fibres – the responses to applied forces and deformations. The mechanical properties of textile fibers include tensile, torsion, bending, pressure and frictional properties.

These types of loading are occur in combination.

During mechanical loading it become to change of fiber shape – deformation. This deformation depends on type of loading, loading speed and time.

Description of mechanical (tensile) properties using so called **ultimate characteristics**

- Breaking force, Strength **F** [N]
- Stress **σ** [Pa]
- Breaking elongation **Δl** [mm]
- Breaking strain **ε** [-] (Extension **ε** [%])
- Tenacity (Specific strength) **f** [N/ tex], [cN / dtex]

Tensile stress

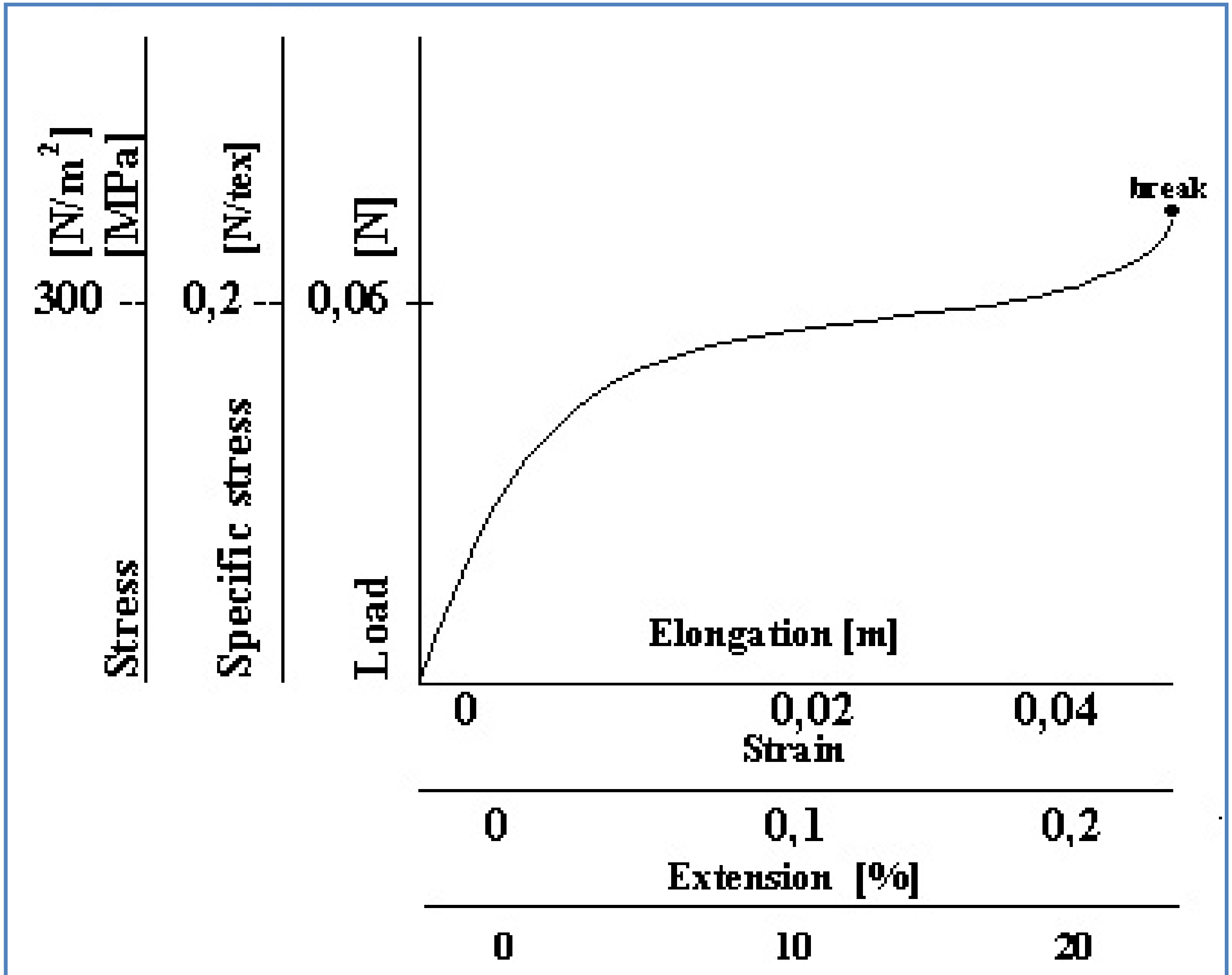
$$\tau = \frac{F}{s} \quad [\mathrm{Pa}]$$

Mechanical stress

$$\sigma = \frac{F}{t} \quad [\mathrm{N/tex}]$$

Textile stress (specific stress)

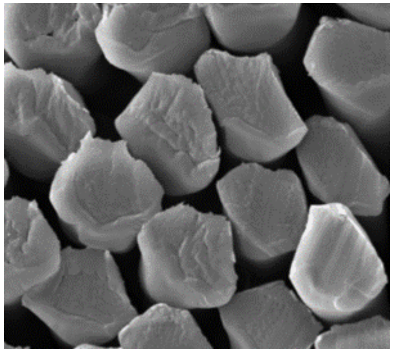
Tensile curve

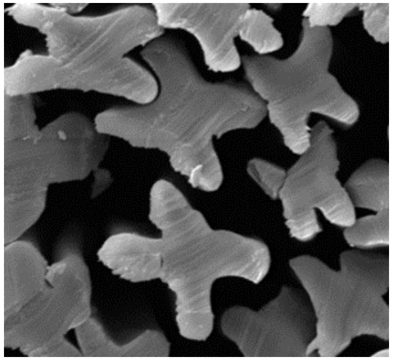


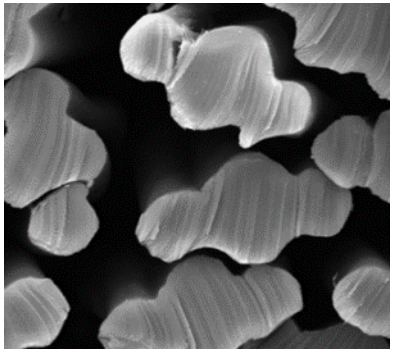
Stress strain curves, of various fibres tested at 65% humidity, 20°C, 90gf/tex/min

Calculations for training I

Calculate basic parameters of three types modified PET fibers (fill in the table)


Fiber type B


Fiber type E


Fiber type G

PET fiber density =1360 kgm^{-3}

Type	Fineness [tex]	Cross section area [mm^2]	Equivalent diameter [mm]	Shape factor [-]	Specific surface area [m^2kg^{-1}]
B	0,19			0,02	
E	0,28			0,4	
G	0,46			0,2	

Calculations for training II

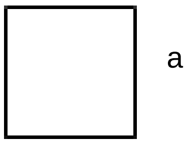
Calculate basic parameters of different fibers (fill in the table):

Material	Fineness [tex]	Fiber density [kgm^{-3}]	Cross section area [mm^2]	Equivalent diameter [mm]
Cotton	0,2	1520		
Wool	0,2	1310		
Viscose	0,2	1500		
Polyester	0,2	1360		
Polypropylene	0,2	910		
Polyacrylonitrile	0,2	1160		

Remark:
From geometrical standpoint, the fiber “fineness” is characterized by the ratio V/l, but the standard fineness is moreover influenced by fiber density. Therefore, it is not correct to compare the fineness of fibers having different densities by the standard fineness; it is better to use the ratio t/ρ.

Calculations for training III

Calculate shape factor q of ideal fiber with square profile: square with side equal to a.



d [m] diameter, *l* [m] length.

Calculations for training IV

	CO	WO	VI	PES	PAN
q [-]	0,47	0,20	0,60	0,05	0,05
σ [$Ntex^{-1}$]	0,28	0,16	0,18	0,45	0,22
t [tex]	0,16	1	0,16	0,17	0,17
ρ [kgm^{-3}]	1520	1310	1500	1360	1160
l [mm]	28,6	80	36	40	40
s [mm^2]					
d [mm]					
p [mm]					
a [m^2kg^{-1}]					
λ [-]					
τ [MPa]					

Calculations for training IV - results

	CO	WO	VI	PES	PAN
q [-]	0,47	0,20	0,60	0,05	0,05
σ [$Ntex^{-1}$]	0,28	0,16	0,18	0,45	0,22
t [tex]	0,16	1	0,16	0,17	0,17
ρ [kgm^{-3}]	1520	1310	1500	1360	1160
l [mm]	28,6	80	36	40	40
s [mm^2]	$1,05*10^{-4}$	$7,63*10^{-4}$	$1,06*10^{-4}$	$1,25*10^{-4}$	$1,46*10^{-4}$
d [mm]	0,0116	0,0312	0,0116	0,0126	0,0137
p [mm]	0,0535	0,1175	0,0586	0,0416	0,0451
a [m^2kg^{-1}]	334,1	117,5	366,1	244,8	265,1
λ [-]	2470	2566	3089	3171	2928
τ [MPa]	425,6	209,6	270,0	612	255,2