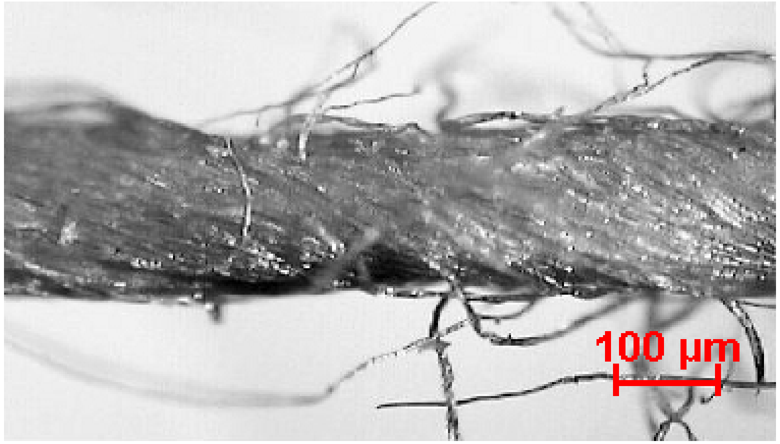
TECHNICAL UNIVERSITY OF LIBEREC
Faculty of Textile Engineering

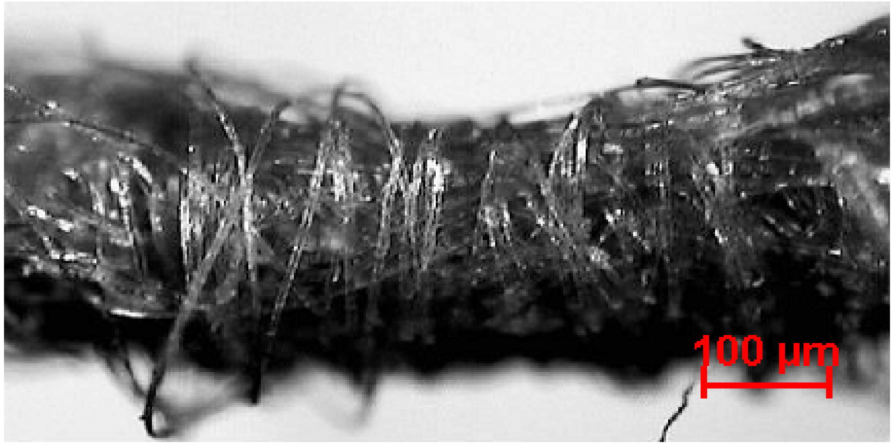
# YARN „DEFINITION, RELATIONSHIPS”

## Basic parameters of yarns

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




**Ring Spun Yarn**




**Rotor Spun Yarn**

## Parameters of yarn description

**T**, **Z**, **D**; **n** (number of fibers in yarn cross-section)

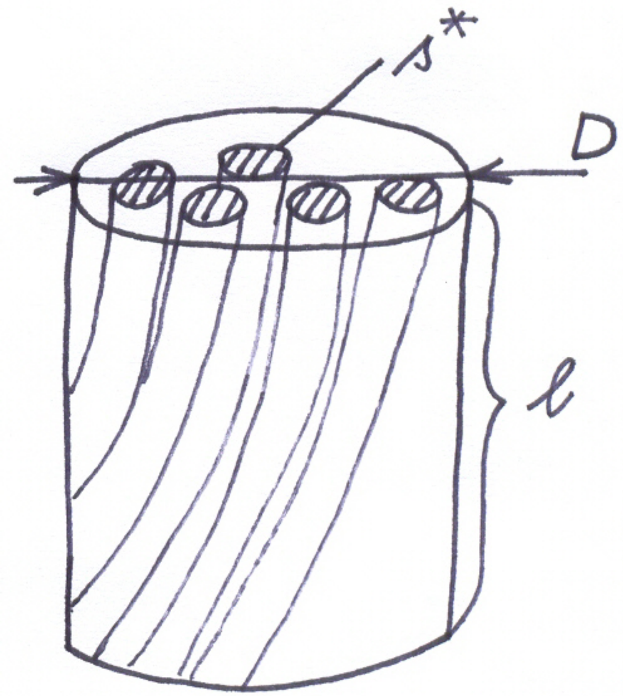
+ **t**, **ρ** ═> expression of further important char.

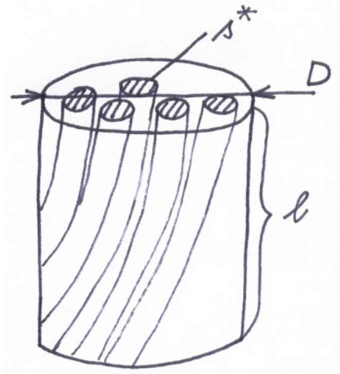
## *Assumptions:*

Yarn is totally even.

Yarn is cylinder with diameter Ø *D.*

The hairiness of the yarn is neglected.






# Substance area S

$$S = \sum_{i=1}^{n} s_i^*$$

$s_i^*$ *... area of i-th fiber cross-section*

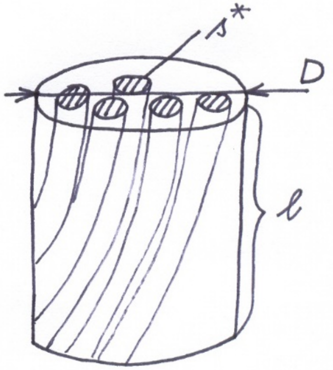
# Mean fiber cross-sectional area of fiber

$$\overline{s^*} = \frac{S}{n}$$

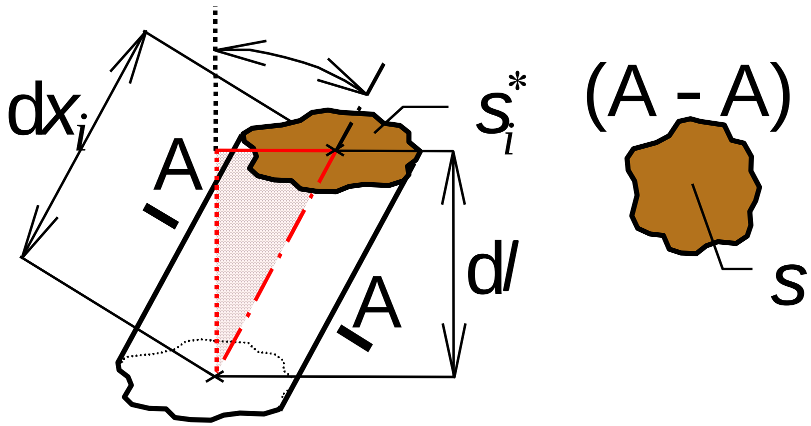
# Yarn count T

$$T = \frac{m}{l} = \frac{V\ \rho}{l} = \frac{S\ l\ \rho}{l}$$

$$\boxed{T = S\rho}$$




$T$ [tex]; $S$ [mm$^2$]; $\rho$ [kg/m$^3$]




$$\cos \beta_i = \frac{dl}{dx_i}$$

$$dV_{vl} = dx_i \, s = s_i^* \, dl \Rightarrow s_i^* = \frac{s}{\cos \beta_i}$$

## Coefficient of sloping rate of fibers in a yarn $k_n$

$$k_n = \frac{s}{s^*}$$

$s_i^*$ … area of sloping fiber cross-section

$s$….area of parallel fiber cross-section

# Substance diameter $D_S$

*imagination:*

Yarn compression → push away the air → removing of inter-fiber spaces → yarn cross-section with area of *S* = substance cross-sectional area → Ø of yarn $D_S$

$$S = \frac{\pi D_S^{\,2}}{4} \Rightarrow$$

$$D_S = \sqrt{\frac{4S}{\pi}} = \sqrt{\frac{4T}{\pi \rho}}$$

$D_S$ [mm]; $T$ [tex]; $\rho$ [kg/m$^3$]

$D_S < D$ ⇒ $D_S$ is the smallest diameter

# Yarn packing density μ

**a)** $\mu = \frac{\gamma}{\rho}$ $\gamma \langle \rho$ (air spaces)

**b)** $\mu = \frac{V}{V_C}; \quad V = S\,l; \quad V_C = \frac{\pi \cdot D^2}{4} \cdot l$

$$\mu = \ldots = \frac{4T}{\pi D^2 \rho}$$

Substance diameter of yarn

$$\mu = \ldots = \left(\frac{D_S}{D}\right)^2$$

Real diameter of yarn

# Relative fineness

$D_S$ ..substance diameter of yarn

$$\tau = \frac{T}{t} = \ldots = \left( \frac{D_S}{d} \right)^2$$

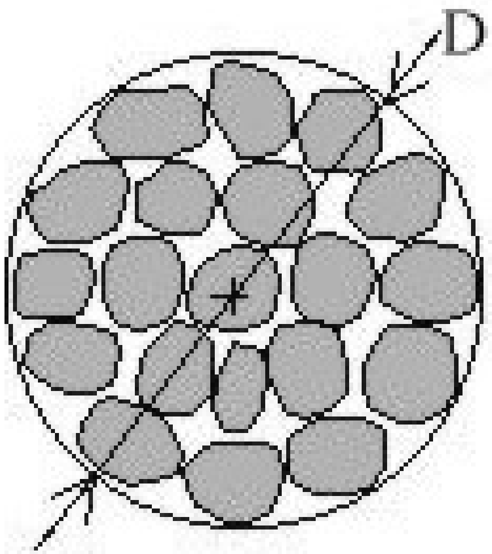
*d* … equivalent diameter of fiber

# Number of fibers n in cross-section of yarn

$$k_n = \frac{s}{\overline{s^*}} = \frac{s\ n}{S} = \frac{s\,\rho\, n}{S\,\rho} = \frac{1}{\tau} n \Rightarrow n = k_n\, \tau$$

# Yarn diameter D

$$D = \sqrt{\frac{4S}{\pi \mu}} = \sqrt{\frac{4T}{\pi \mu \rho}}$$




Areal multiplier $K_S$ Common multiplier $K$

$$= \frac{2}{\sqrt{\pi \mu}} \sqrt{S} = \frac{2}{\sqrt{\pi \mu \rho}} \sqrt{T}$$

Relation between multipliers

$$K = \frac{K_S}{\sqrt{\rho}}$$

# Twist Z[m$^{-1}$]

- number of turns *N* in yarn per second and with using of withdrawing speed

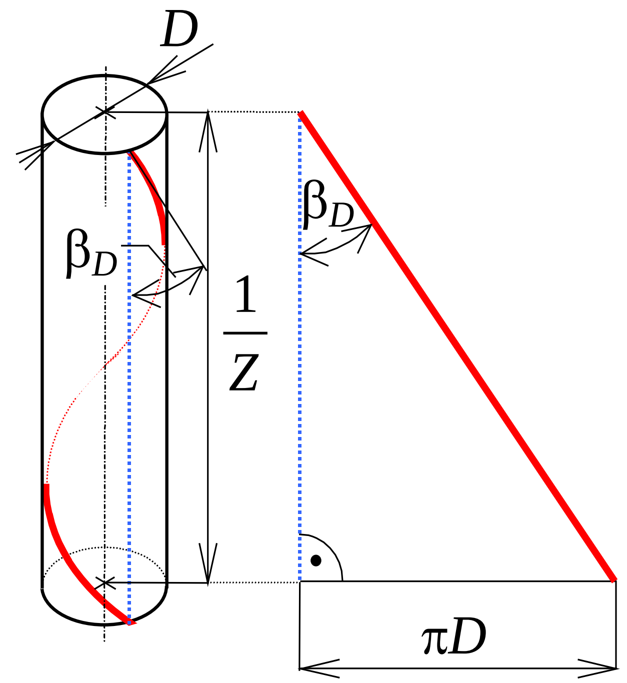
$$Z = \frac{N}{\vec{v}}$$

→ from point of view of technology: number of turns per unit length

→ from point of view of structure: number of twists per unit length

# Twist intensity κ[-]

$$\kappa = \pi D Z$$




$$tg\beta_D = \frac{\pi D}{1/Z} = \pi D Z \Rightarrow$$

$$tg\beta_D = \kappa$$

$\beta_D$ ...slope angle of surface fibers

→ characterizes rate of yarn twist

→ tangent of surface fibers slope angle

# Koechlin's twist coefficients

## q = ½ (twist exponent)

a) Koechlin's common

$$\alpha = Z\sqrt{T} = Z\sqrt{S\rho} = \ldots = \frac{\kappa}{2\sqrt{\pi}}\sqrt{\mu\rho}$$

The mostly used formation:

$$\alpha\left[m^{-1}ktex^{1/2}\right] = \frac{Z\left[m^{-1}\right]\sqrt{T\left[tex\right]}}{10^{3/2}}$$

## b) Koechlin's areal

$$\alpha_S = Z\sqrt{S} = \dots = \frac{\kappa}{2\sqrt{\pi}}\sqrt{\mu}$$

The mostly used formation:

$$\alpha_S[1] = \frac{Z[\mathrm{m}^{-1}]\sqrt{S[\mathrm{mm}^2]}}{10^3}$$

# Phrix's twist coefficients

## q = 2/3 (twist exponent)

a) Phrix's common

$$a = Z T^{2/3}$$

The mostly used formation:

$$a\left[m^{-1}ktex^{2/3}\right] = \frac{Z\left[m^{-1}\right]T\left[tex\right]^{2/3}}{10^2}$$

b) Phrix's areal

$$a_S = Z S^{2/3}$$

The mostly used formation:

$$a_S\left[m^{1/3}\right] = \frac{Z\left[m^{-1}\right]S\left[mm^2\right]^{2/3}}{10^4}$$

# Task 1

Define mutual relation among

*a* [m$^{-1}$ktex$^{2/3}$], *α* [m$^{-1}$ktex$^{1/2}$] and *T* [tex].

$$\alpha = \frac{Z T^{1/2}}{10^{3/2}} \Rightarrow Z = \alpha T^{-1/2} 10^{3/2}$$

$$a\left[m^{-1} ktex^{\frac{2}{3}}\right] = \frac{Z T^{2/3}}{10^2} = \frac{\alpha T^{-1/2} T^{2/3} 10^{3/2}}{10^2} = \alpha\left[m^{-1} ktex^{\frac{1}{2}}\right]\left(T\left[tex\right]\right)^{1/6} 10^{-1/2}$$

$$\boxed{a = \frac{\alpha T^{1/6}}{\sqrt{10}}}$$

# Task 2

Calculate basic parameters of three cotton yarns with different yarn count (fill in the table):

| $T$ [tex] | $\rho$ [$kgm^{-3}$] | $t$ [tex] | $S$ [$mm^2$] | $D_S$ [mm] | $\tau$ [1] |
|---|---|---|---|---|---|
| 16 | 1520 | 0.16 | 0.0105 | 0.116 | 100 |
| 29.5 | 1520 | 0.16 | 0.0194 | 0.157 | 184 |
| 50 | 1520 | 0.16 | 0.0329 | 0.205 | 312 |

| $\mu$ [-] | $Z$ [$m^{-1}$] | $D$[mm] | $\kappa$ [-] | $a$ [$m^{-1}ktex^{2/3}$] | $\alpha$ [$m^{-1}ktex^{1/2}$] |
|---|---|---|---|---|---|
| 0.573 | 1055 | 0.153 | 0.507 | 67 | 133.4 |
| 0.467 | 702 | 0.230 | 0.507 | 67 | 120.6 |
| 0.392 | 494 | 0.327 | 0.507 | 67 | 110.5 |

# Task 3

The fineness of cotton yarn is 29,5 tex. Calculate fineness of:

a) polypropylene,

b) polyester

if volume and length will be the same like by cotton one.

The same volume *V*, length *l*:

CO – 1520 $kgm^{-3}$, 29,5 tex

PES – 1380 $kgm^{-3}$, 26,8 tex

PP – 900 $kgm^{-3}$, 17,5 tex

Remark:

Yarn fineness is moreover influenced by fiber mass density. Therefore, it is not possible to compare the yarns from different fibers using yarn "count" (e.g. cotton and polyester yarns). In this case, we can compare only ratios yarn count to fiber mass density, as shown due this example.

$$\frac{T}{\rho} = \frac{V}{l}$$