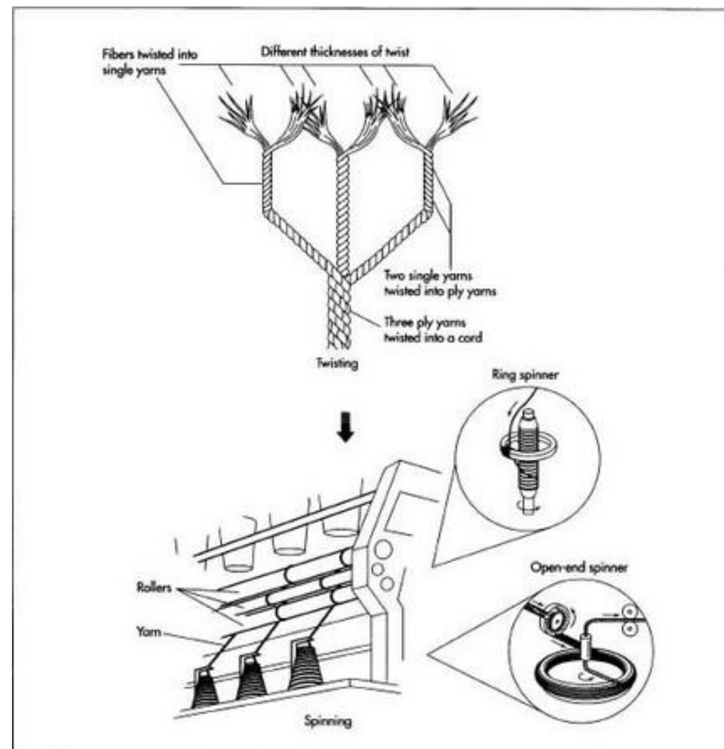
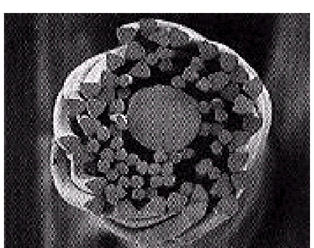
Geometry of Yarns

- ❑ Linear density
- ❑ Twist
- ❑ Unevenness
- ❑ Imperfections
- ❑ Hairiness





Linear density I.

Gravimetric method

$$T = \frac{m}{l} \ [tex]$$

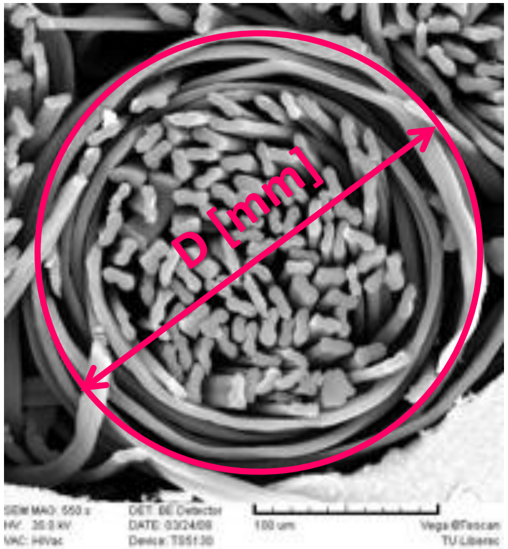
Mass - m [g]

Length - l [km]

Linear density - T [tex]

Packing density μ

$$T = \frac{\pi \cdot D^2}{4} \cdot \rho_{yarn} = \frac{\pi \cdot D^2}{4} \cdot \rho_{fibres} \cdot \mu$$



Linear density II.

Yarns on bobbin:

precise length of yarn

Winding device – perimeter 1 m

Precise weighing of wound yarn

ISO 2060 :1994

Textiles - Yarn from packages - Determination of linear density (mass per unit length) by the skein method

Linear density III.

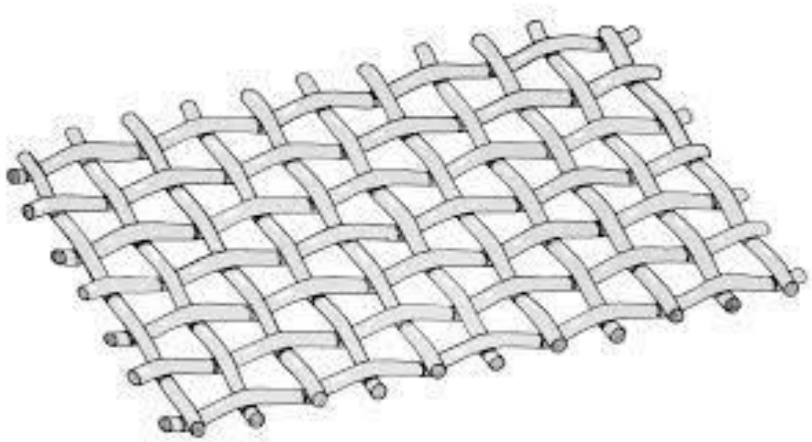
Linear density of yarns from fabric

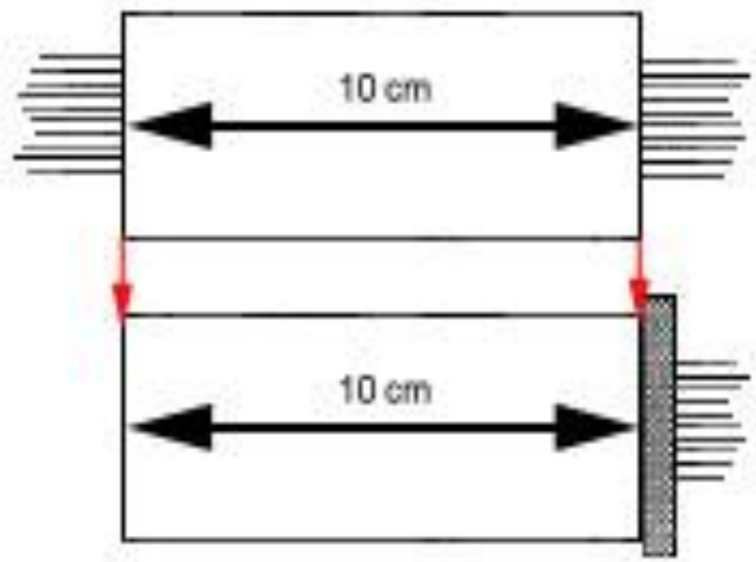
WOVEN

min. 10 warp a 10 weft yarns

Warp - equidistant sampling from whole width of fabric

Weft - selected distance mass include yarn from different windings



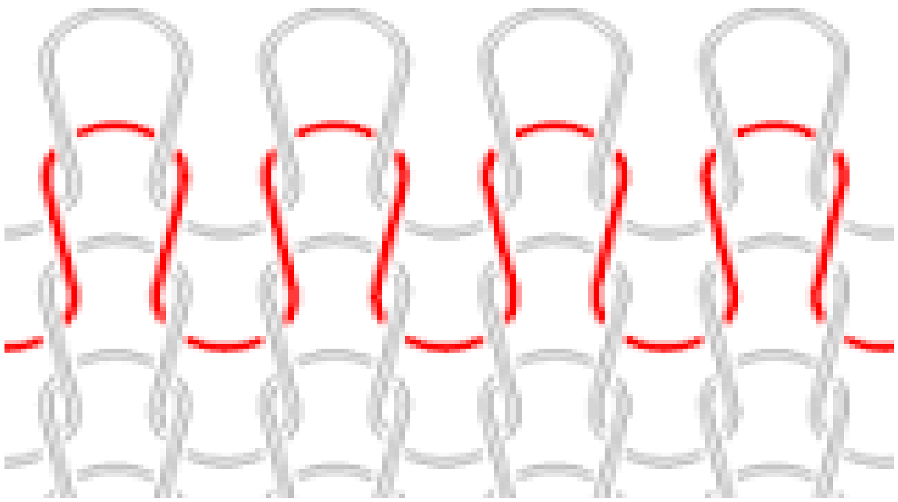


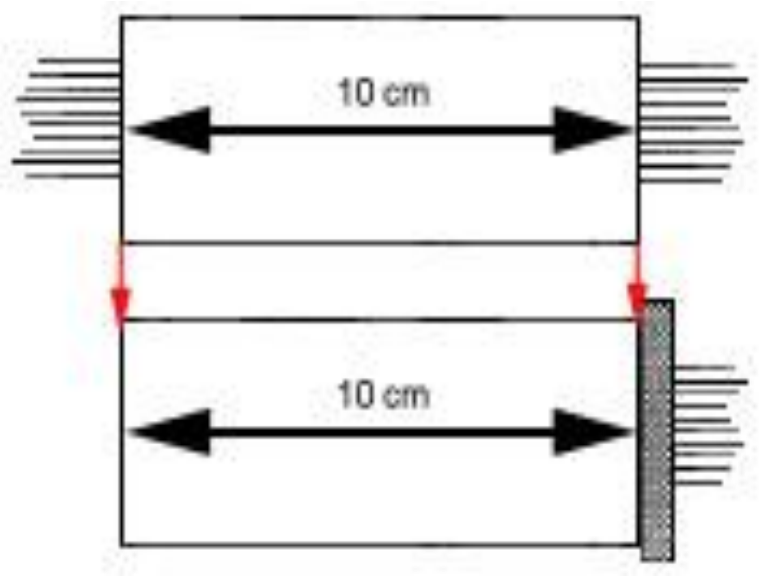
Linear density IV.

Linear density of yarn from fabric

Knitted fabric

Ripping of min. 10 threads to obtain yarns from different bobbins



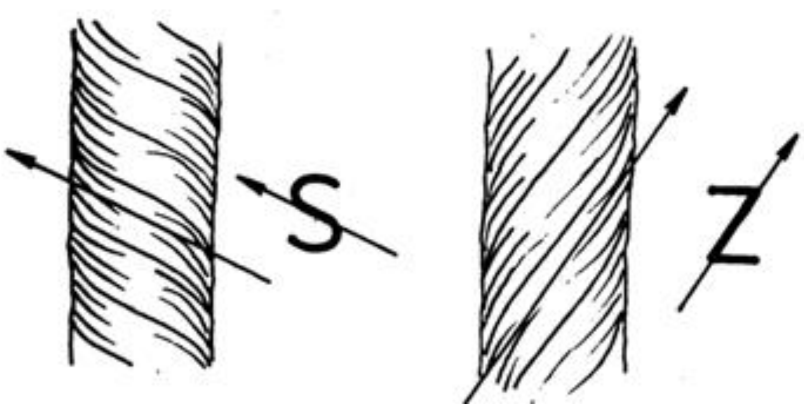


Twist I.

Twist principle

Rotation of fiber bundle $\Rightarrow$ fiber compression
increase of fiber friction (increase of yarn strength)

Each rotation of winding device
(spindle, wing, rotor) = 1 twist

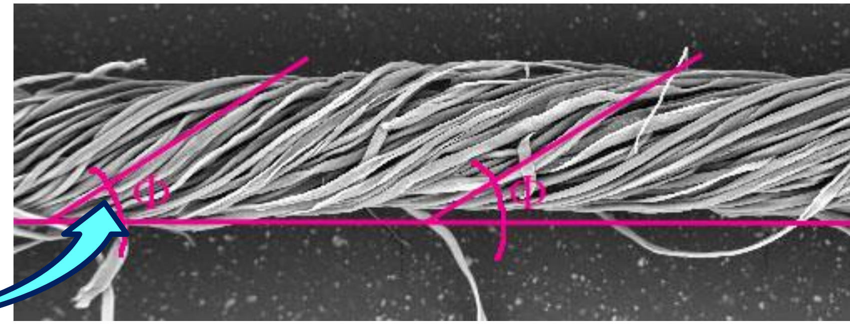


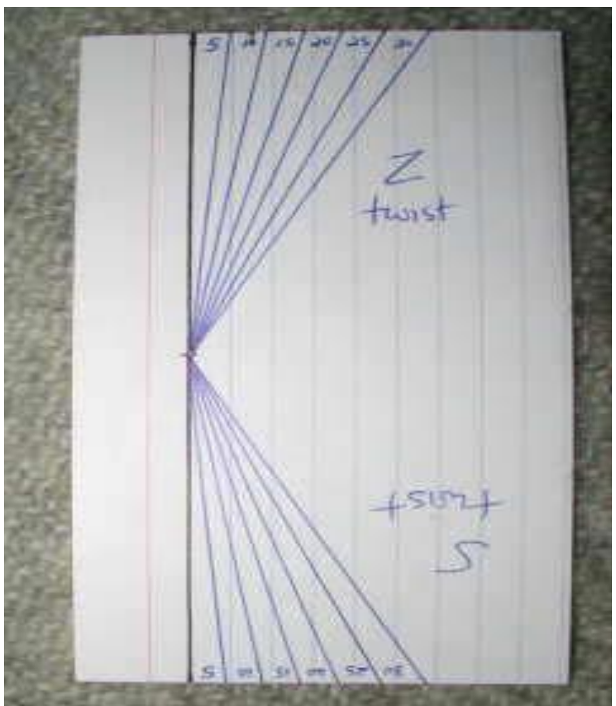
Twist measurement

Untwisting and counting
of twists (z $\Rightarrow$ *twists per meter*)

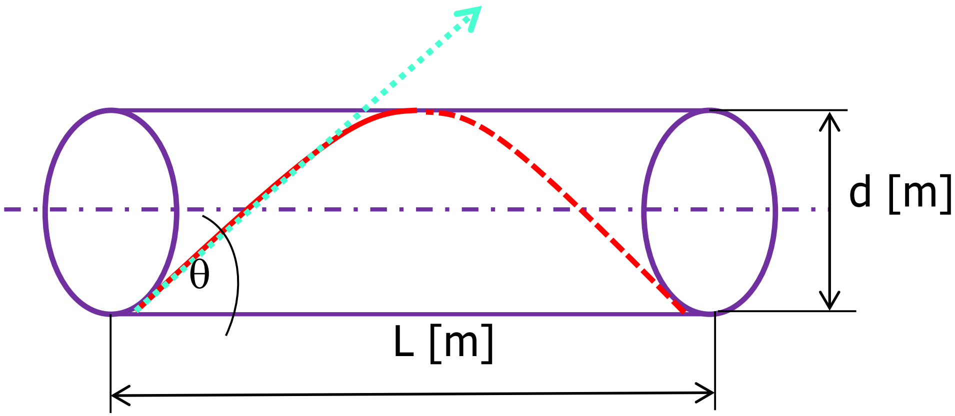
Helix inclination angle

$$\tan\theta = \pi d z$$





Twist factor α



$$z = \frac{1}{L}; \qquad \tan\theta = \frac{\pi d}{L} = \pi d z$$

$$T = \frac{\pi \cdot d^2}{4} \cdot \rho \cdot 10^6; d = \sqrt{\frac{4T}{\pi\rho 10^6}}$$

$$z = \frac{\tan\theta}{\pi d} = \frac{\tan\theta}{\pi\sqrt{\frac{4T}{\pi\rho 10^6}}} = \frac{\tan\theta}{\sqrt{\frac{\pi^2 4T}{\pi\rho 10^6}}} = \frac{\tan\theta}{\sqrt{\frac{\pi 4T}{\rho 10^6}}} = \frac{\tan\theta\sqrt{10^6\rho}}{\sqrt{4\pi T}} = \frac{\tan\theta \cdot 10^3\sqrt{\rho}}{2\sqrt{\pi}\cdot\sqrt{T}}$$

$$K = 0,5\tan\theta \cdot 10^3\sqrt{\frac{\rho}{\pi}}$$

Twist factor II.

Units of twist factor α

Köchlin's relation* (*T >10 tex*)

$$Z = \frac{\alpha}{\sqrt{T}} \quad [m^{-1}]$$

α [m^-1 . ktex ^1/2]

Phrix's relation** (*T < 10 tex*)

$$Z = \frac{a_m}{\sqrt[3]{T^2}} \quad [m^{-1}]$$

a_m [m^{-1} . ktex $^{2/3}$]

*Koechlin's equation is the oldest and forms the basis for the derivation of all other equations developed by various scientists. When calculating the yarn twist, Koechlin's equation assumes that the yarn forms the shape of a cylinder. The twist angle (helix angle) is an important parameter of the filaments, which determines the degree and shape of deformations that occur along their length. Koechlin's equation was first proposed by Mr. Koechlin in 1828 and represents an objective method for determining the twist level in yarn.

**The basic supposition of objective validity of Koechlin's yarn twist factor is functional dependence of packing density on yarn twist factor, otherwise assumptation, that yarns twisted with the same intensity, have same packing density. In accordance with this model, packing density increases and yarn diameter is reduced. The basic assumptation of objective validity of Phrix's yarn twist factor is functional dependence of packing density on yarn fineness. In accordance with this model of twisting, the packing density is constant, independent of on twists and in consequence of this, yarn diameter is constant.

Twist of Yarn II.

Twisting leads to shortening of yarn

$$\varepsilon_s = \frac{\Delta l}{l_0} \cdot 10^2 \ [\%]$$

Presumption: both left and right twist leads to same shortening

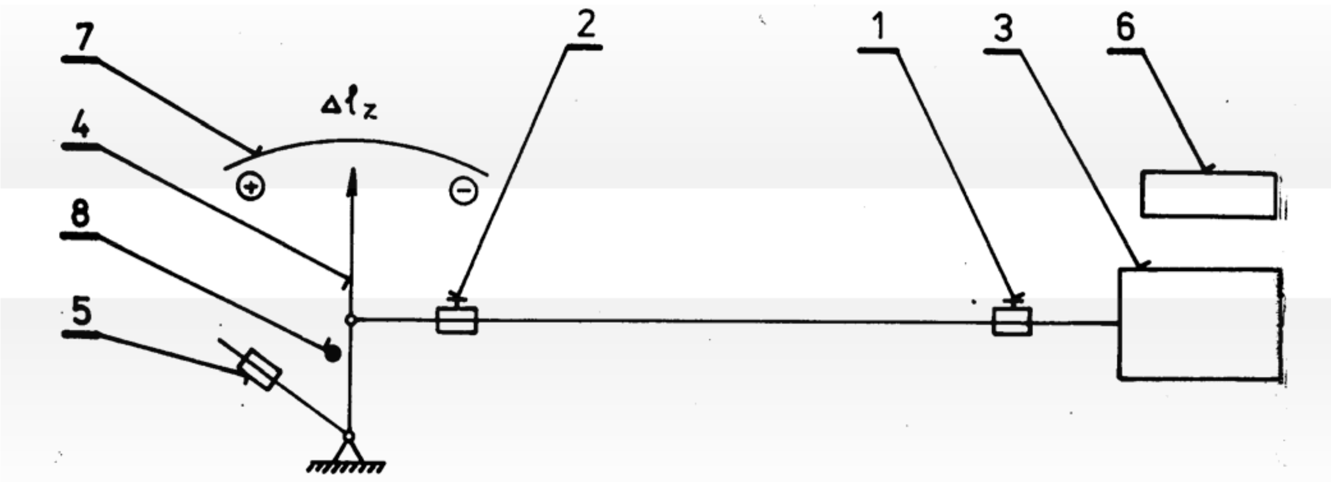
Testing methods - **Twist tester**

Direct counting method for folded yarn

Untwist-twist method for spun yarn

Untwist-twist method for multifilaments

Schema of twist tester I.



1 – rotating jaw**, 2 –** movable jaw

3 – motor with speed control

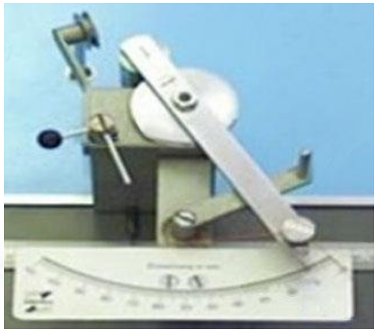
4 – movable arm connected to jaw 2

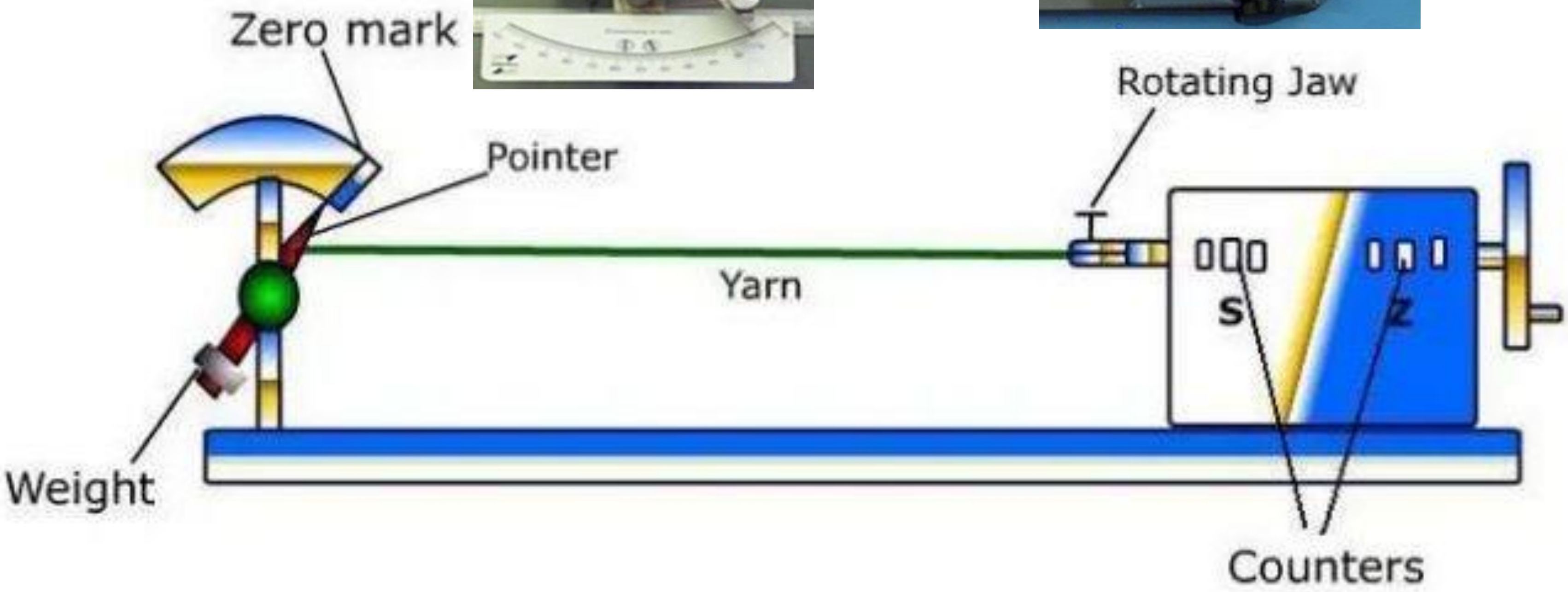
5 - pre-tension**, 6 –** screen

7 – yarn length control

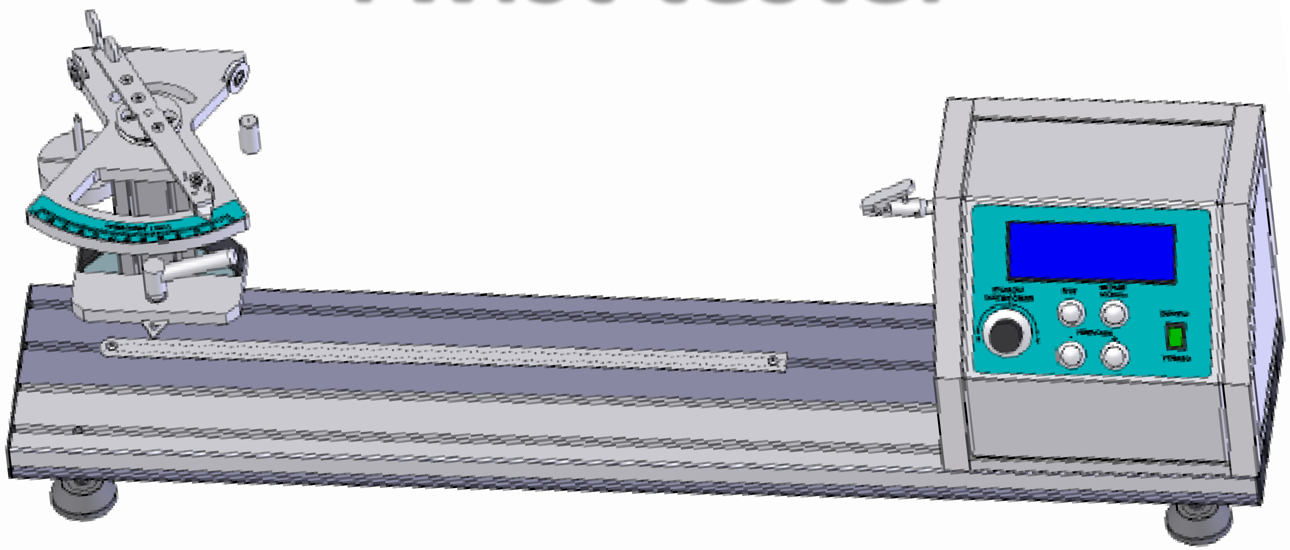
8 – stop for movable arm – limiter

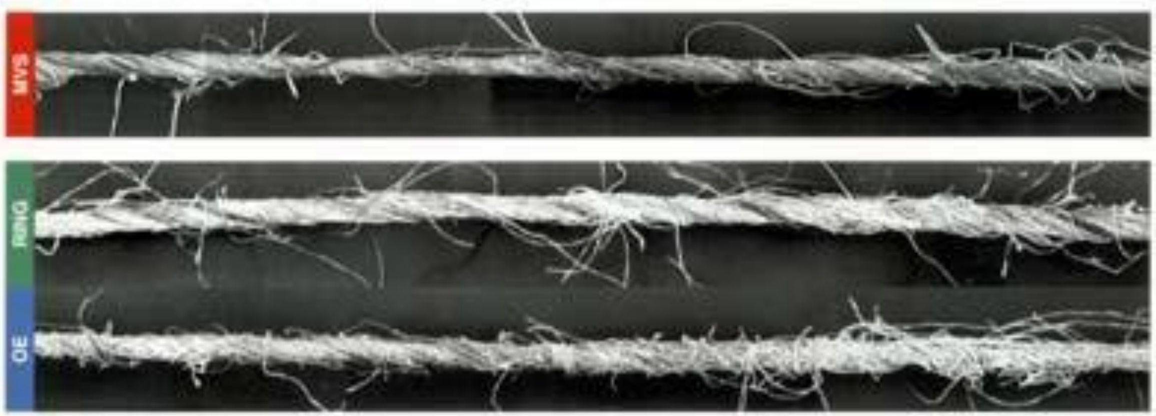
Schema of twist tester II.





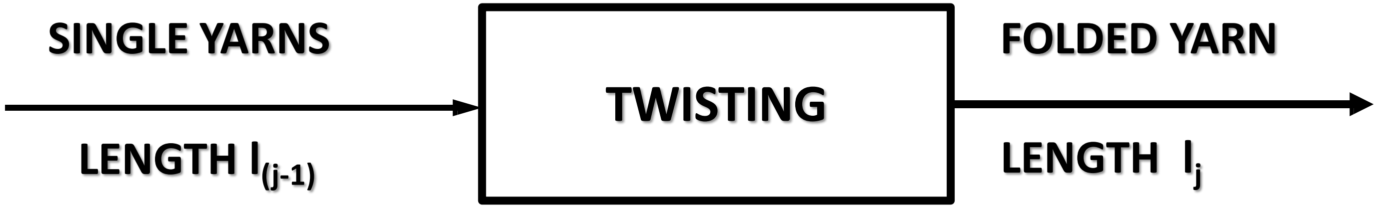
Twist tester

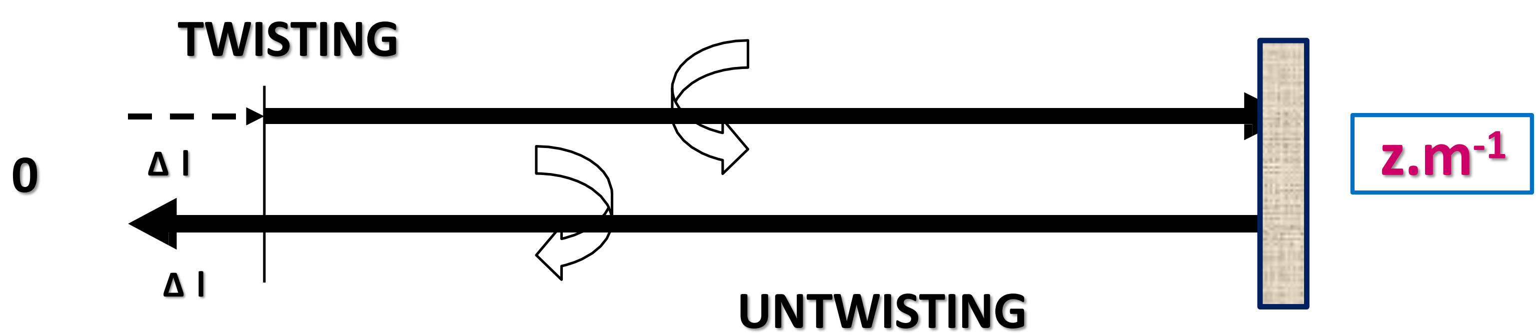




Direct counting method

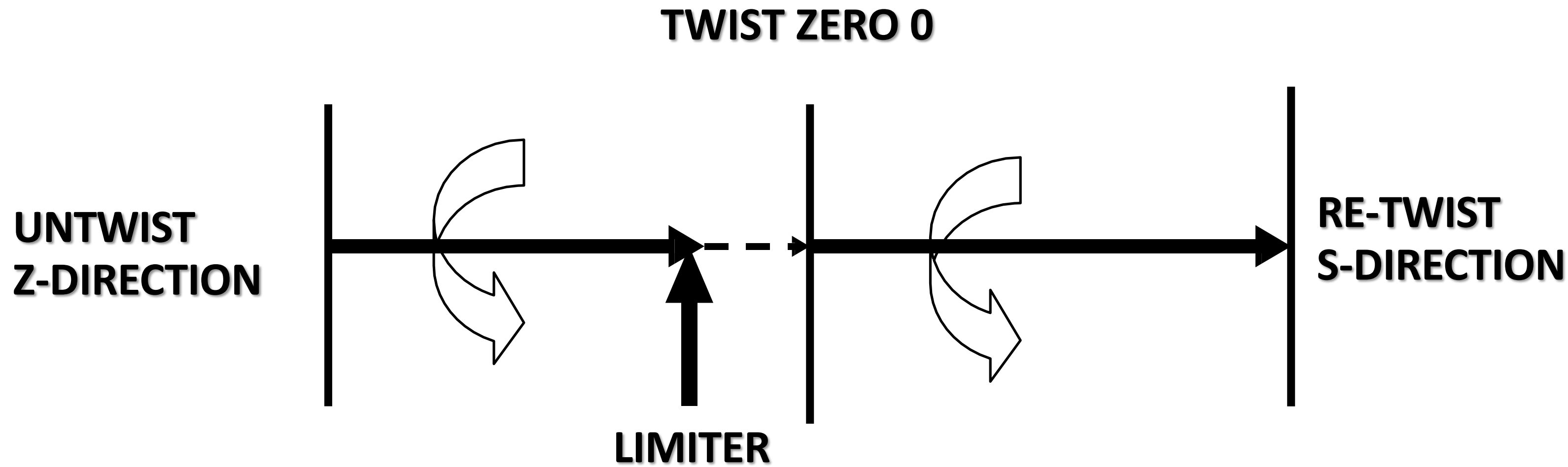
Untwist till zero twists





Initial length 0,25 m ⇒ recalculate to z/m !

Untwist - twist method (single yarn)

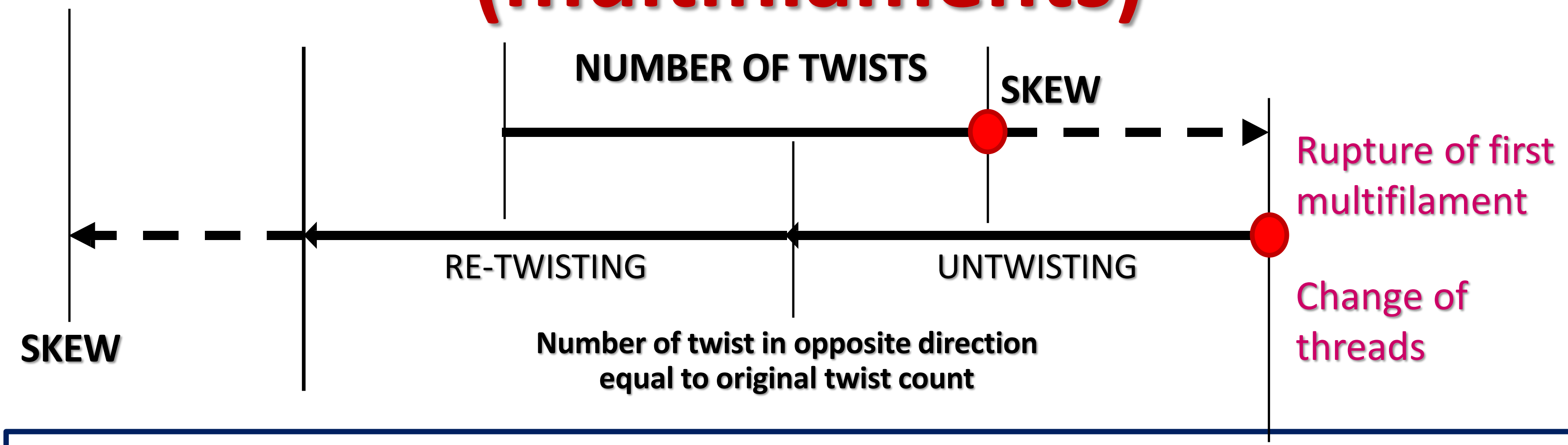


Initial length 0,25 m x 2

Recalculate to z/m !

Pre-tension - defined by standard

Untwist - twist method (multifilaments)



Two multifilaments

First is twisted until **rupture in scew**

CHANGE OF THREAD

Second is untwisted and re-twisted to opposite direction until rupture in scew

Counter shows number of twist per twice initial length (0,25x2 m)
Pre-tension - defined by standards

Unevenness

Describes the variation of material in percentage
= coefficient of variation!!!

Mass unevenness of Yarn [%]:

variation of linear density in whole length of yarn

influence on fabric appearance

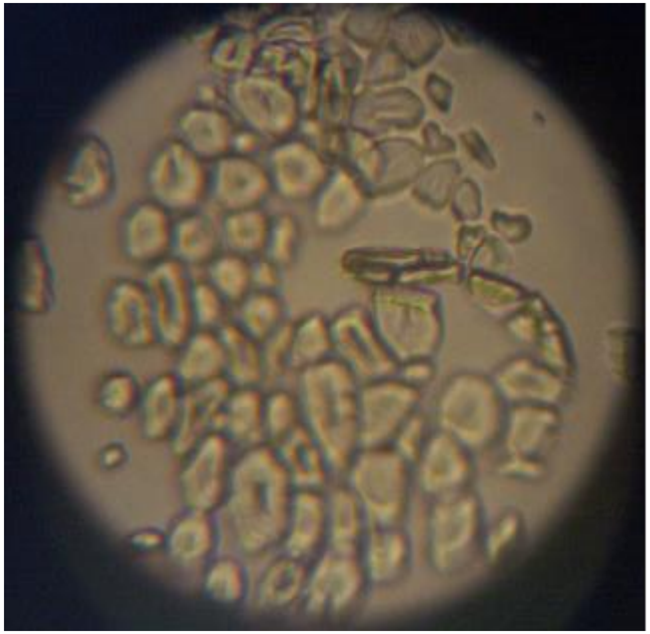
regular repeating of unevenness leads to e.g. moire (moare) effect on fabric, next influences other parameters as twist, strength etc.

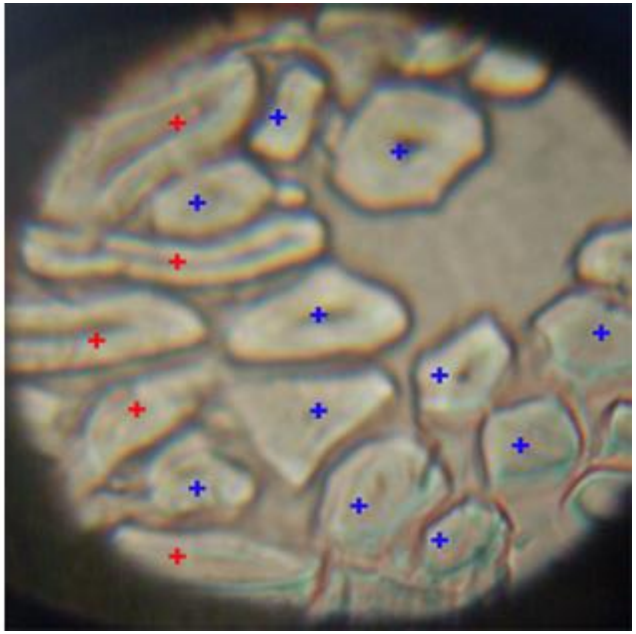
Imperfections – yarn purity

Analysis of yarn composition

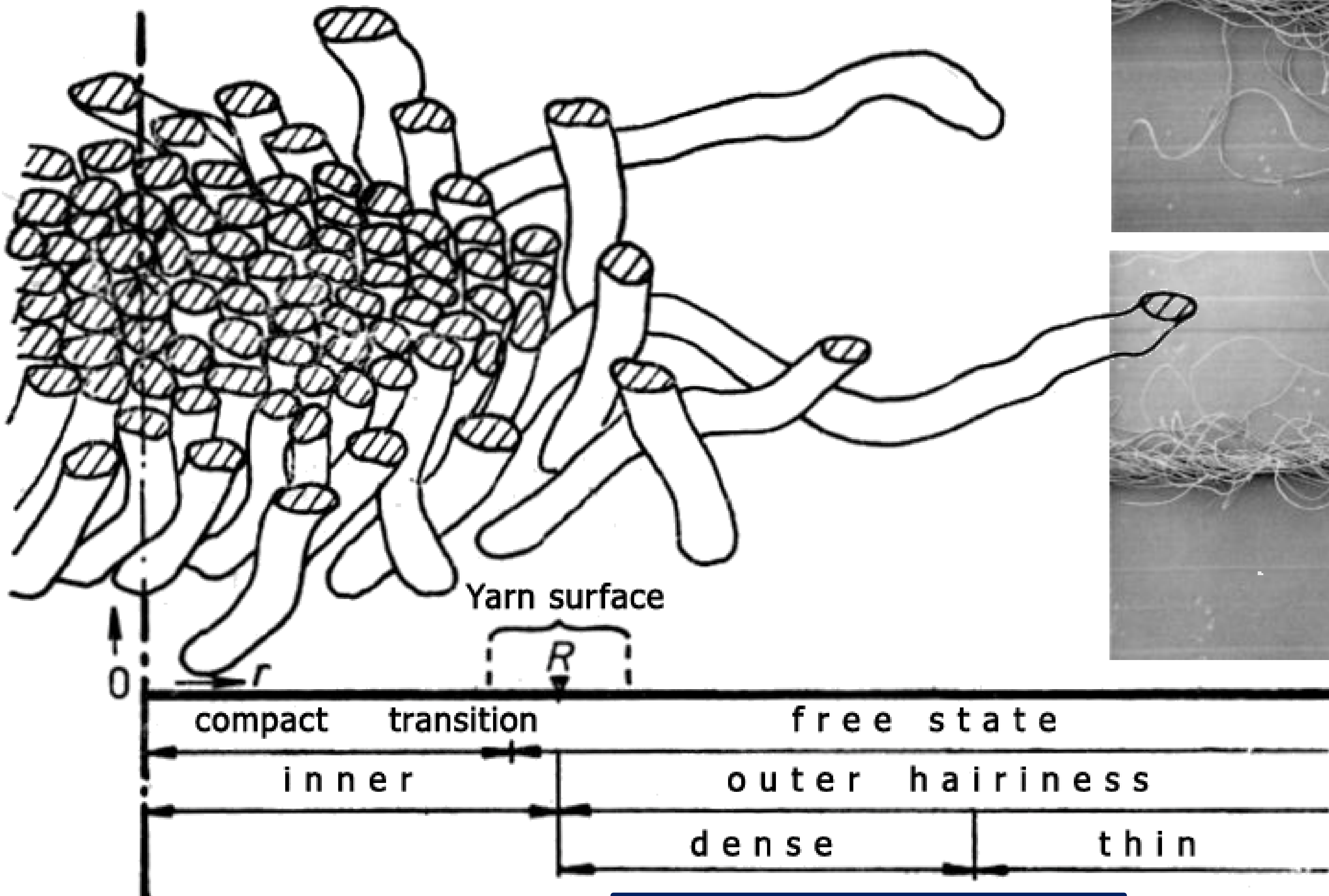
material analysis
ratio of fiber mixture

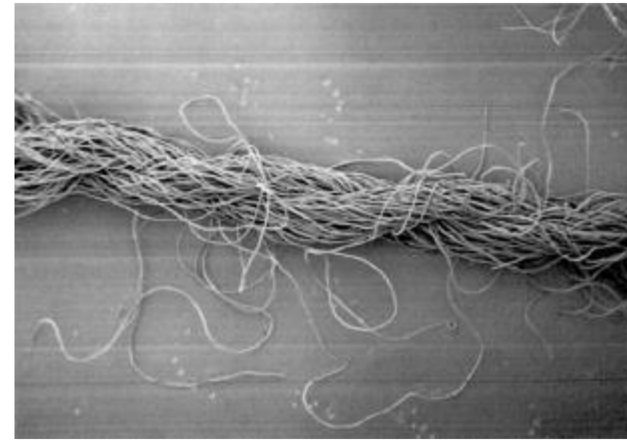
ratio of undesirable
impurities, lenth of fibers

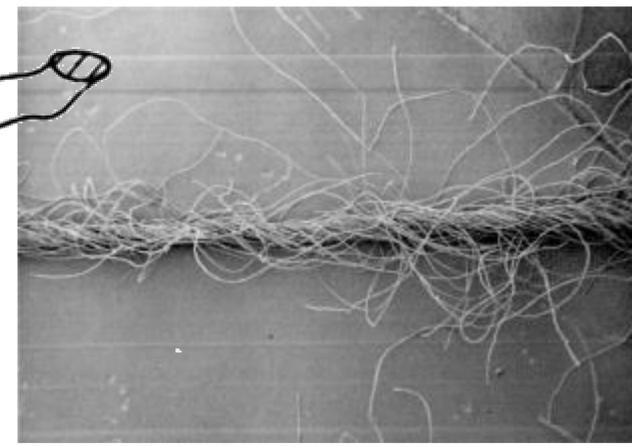




Hairiness

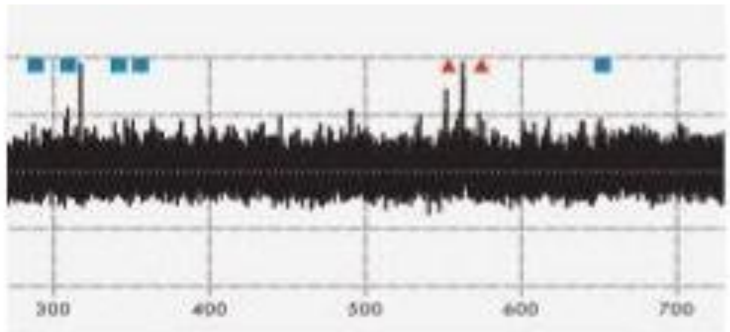


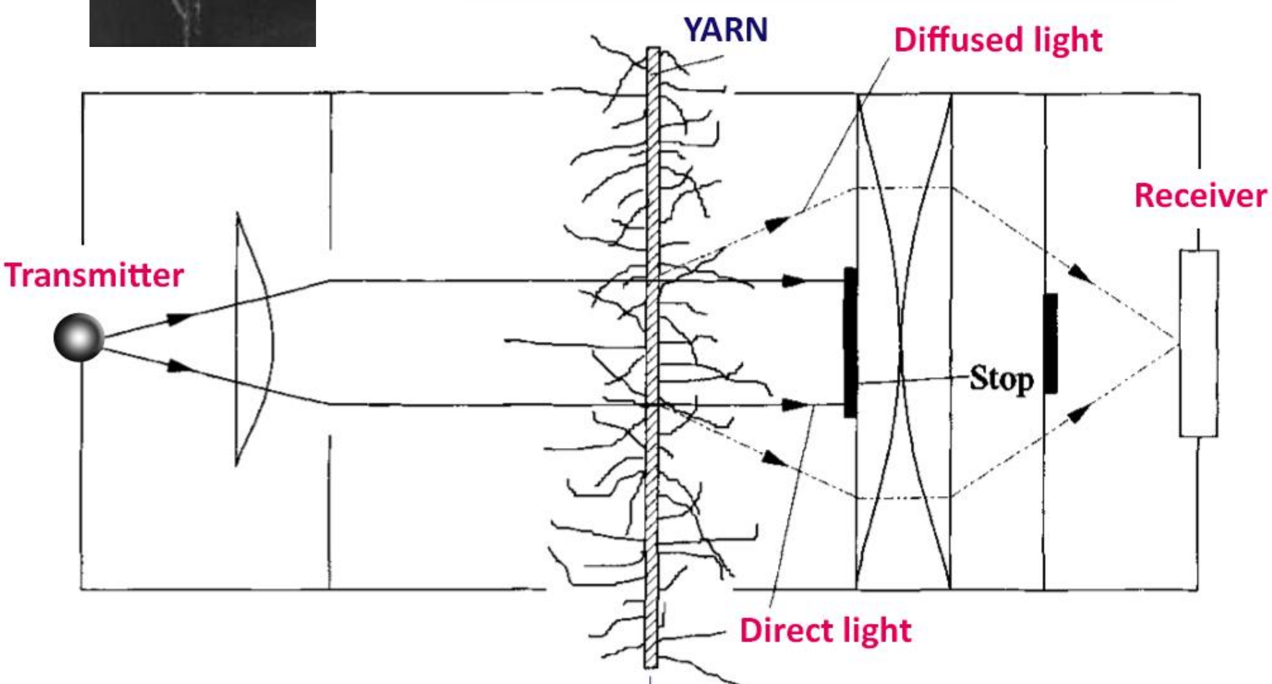


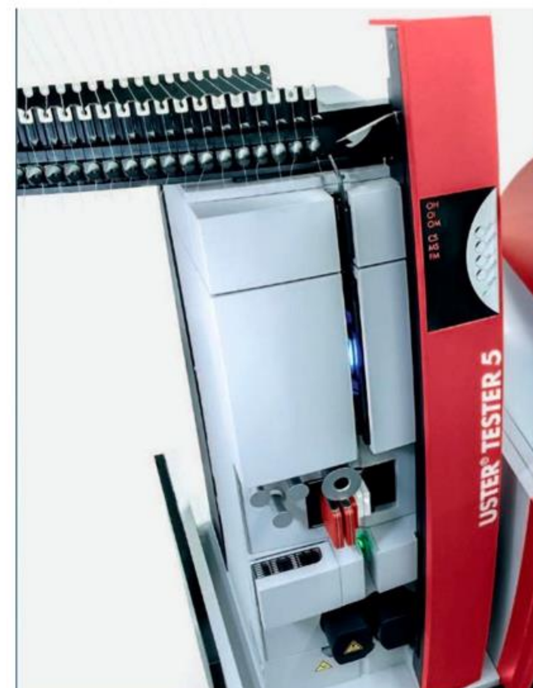


Body of yarn

Uster Tester 4







Zweigle G656 hairiness tester

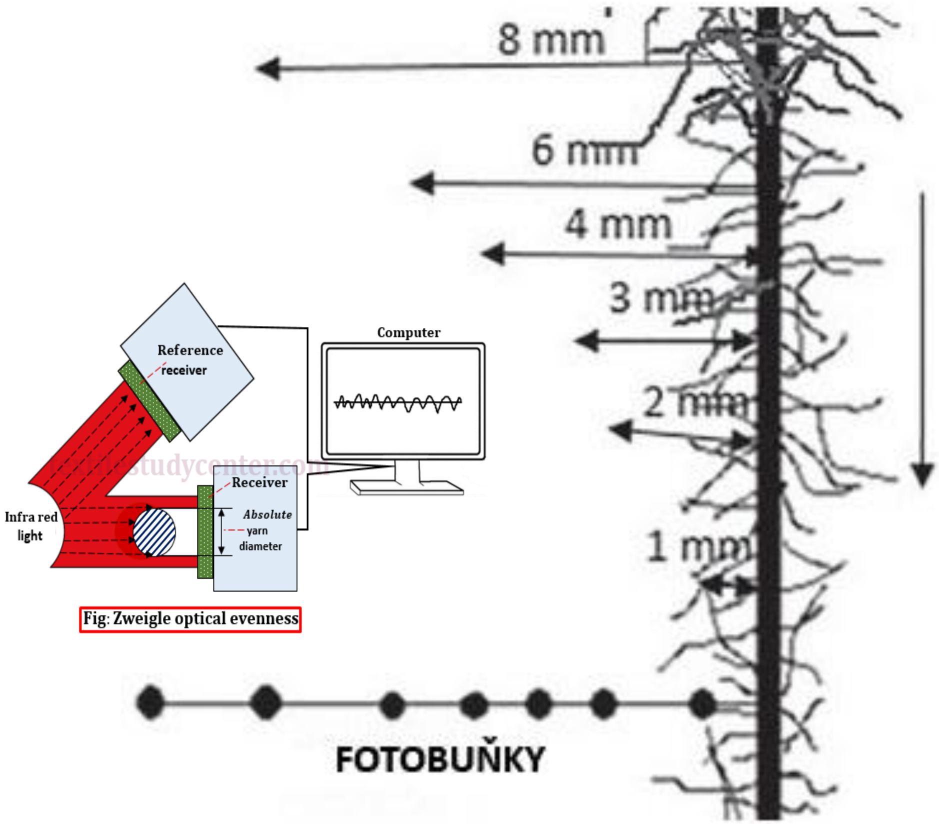
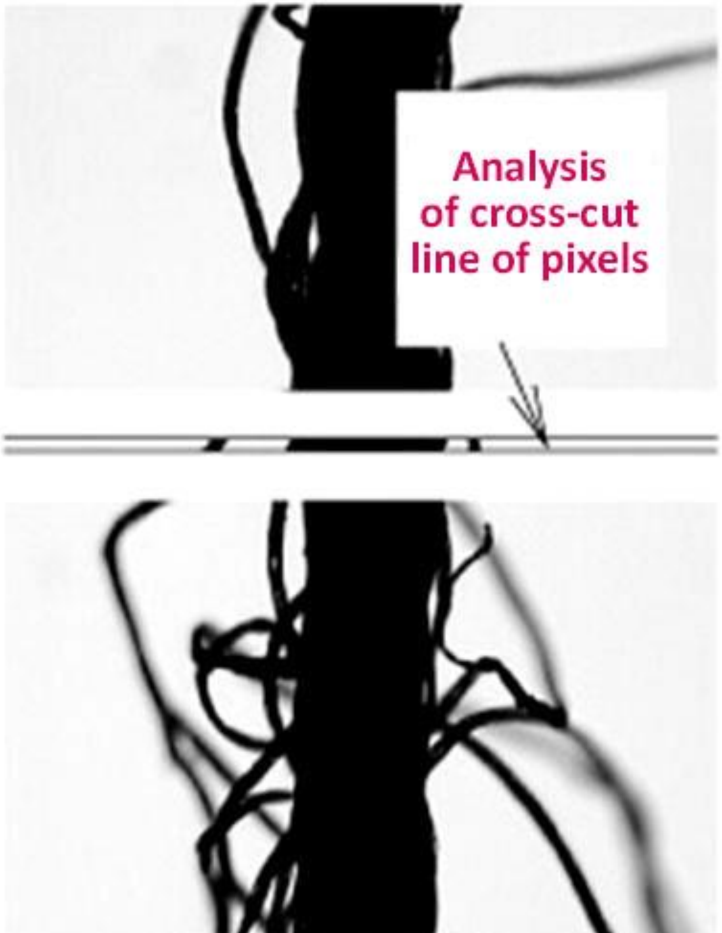
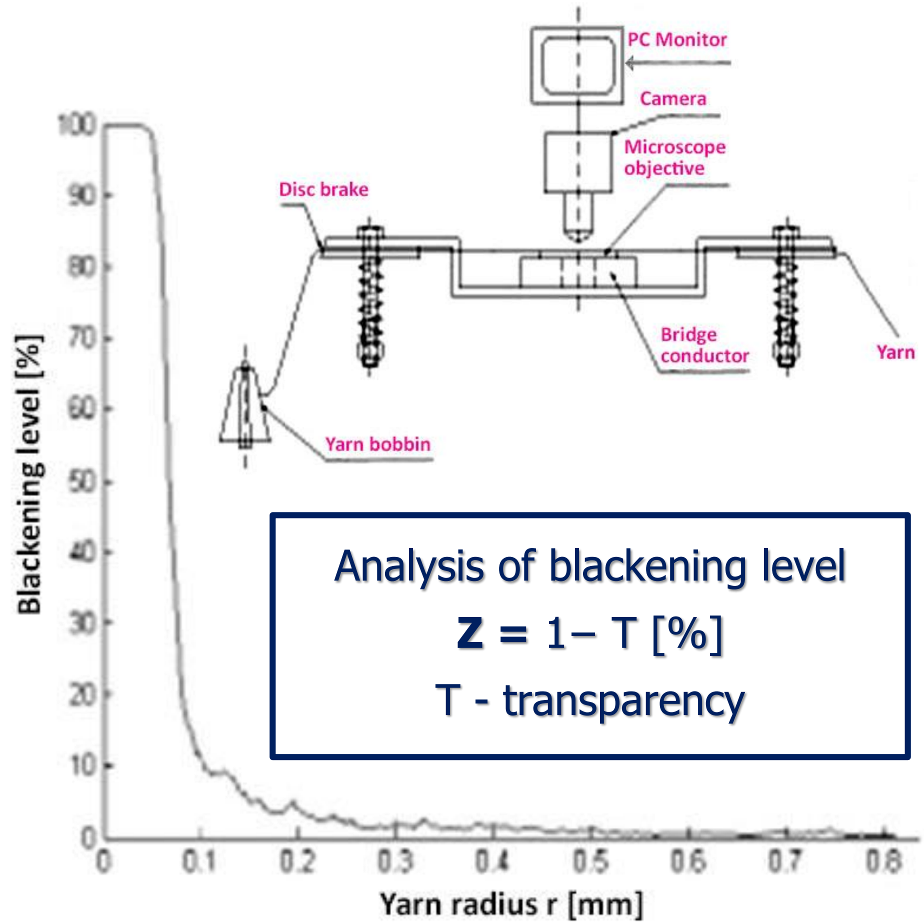


Fig: Zweigle optical evenness

Image analysis



Imaginary yarn cross-cut



Analysis of blackening level

$$\mathbf{Z} = 1 - T\ [\%]$$

T - transparency

Experimental hairiness function