SWELLING PROPERTIES OF TEXTILE FIBRES

When textile fibres absorb water, they change in dimensionally (axially & transversely). Swelling occurs in the transverse direction (width-wise) and axial direction (length-wise) of fibre. It may be expressed in terms of the increase in diameter, area, length or volume of a fibre. The changes in dimension due to absorbing moisture or water by any textile fibre are termed as swelling properties.

Swelling phenomenon of textile fibres

The molecular chains are laying roughly parallel to the fibre axis, as a result fibre has lower space between the adjacent chains and swelling will be lower. When the fibres are immersed into water, the water molecules enter into the fibre and occupy the molecular space of fibre and thus push the fibre chains. As a result, there will be a considerable increase in diameter of the fibre but very little increases in length.

Types of Swelling

1) Transverse diameter swelling
The fractional increase in diameter of a fibre after swelling is known as transverse diameter swelling. Transverse diameter swelling of a fibre is denoted by $S_{D.}$

So, $S_D = \Delta D/D$, where ΔD= increase diameter of fibre & D= original diameter of fibre

2) Transverse area swelling
The fractional increase in area of a fibre after swelling is known as transverse area swelling. Transverse area swelling of a fibre is denoted by $S_{A.}$

So, $S_A = \Delta A/A$, where ΔA= increase area of fibre & A= original area of fibre

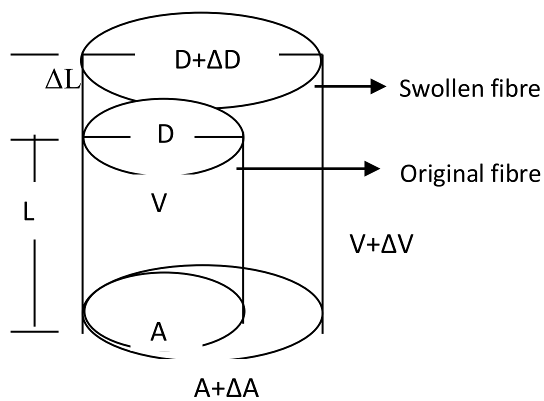

Figure: Before and after swelling of textile fibres

3) Axial swelling
The fractional increase in length of a fibre after swelling is known as axial swelling. Axial swelling of a fibre is denoted by $S_{L.}$

So, $S_L = \Delta L/L$, where ΔL= increase length of fibre & L= original length of fibre

4) Volume swelling
The fractional increase in volume of a fibre after swelling is known as volume swelling. Volume swelling of a fibre is denoted by $S_{V.}$

So, $S_V = \Delta V/V$, where ΔV= increase volume of fibre & V= original volume of fibre

Relationship between S_A & S_D

We know that,
Transverse area swelling, $S_A = \Delta A / A$
Transverse dia. swelling, $S_D = \Delta D / D$

For a circular fiber, area $A = (\pi/4)\ D^2$

For a swollen fiber, we get, $A+\Delta A = (\pi/4)\ (D+\Delta D)^2$

$= (\pi/4)\ (D^2 + 2D.\ \Delta D + \Delta D^2)$

Now, $S_A = \Delta A / A$

$= (A+\Delta A-A) / A$

$= \{(\pi/4)\ (D^2 + 2D.\ \Delta D + \Delta D^2) - (\pi/4)\ D2\} / (\pi/4)\ D2$

$= (\pi/4)\ (D^2 + 2D.\ \Delta D + \Delta D^2 - D^{2)} / (\pi/4)\ D2$

$= (2D.\ \Delta D + \Delta D^2) / D^2$

$= (2D.\ \Delta D / D^2) + (\Delta D^2 / D^2)$

$= 2(\Delta D / D) + (\Delta D^2 / D^2)$

$= 2\ S_D + S_D^2$

So, $S_A = 2\ S_D + S_D^2$.

Relationship between S_A, S_V and S_L

We know that,

Transverse area swelling, $S_A = \Delta A / A$

Volume swelling, $S_V = \Delta V / V$

Axial swelling, $S_L = \Delta L / L$

For a circular fiber, volume, $V=AL$

For a swollen fiber, we get, $V +\Delta V = (A +\Delta A)\ (L +\Delta L)$

$= AL + A\Delta L + \Delta AL + \Delta A\ \Delta L$

Now, $S_V = \Delta V / V$

$= (V+ \Delta V - V) / V$

$= (AL + A\Delta L + \Delta AL + \Delta A\ \Delta L - AL)/AL$

$= \Delta L / L+ \Delta A/ A + \Delta A/ A.\ \Delta L / L$

$= S_L + S_A + S_{L.}\ S_A$

So, $S_V = S_L + S_A + S_{L.}\ S_{A.}$

Factors influencing swelling properties of textile fibres

- ❖ Composition of the material (such as cotton, polyester, acrylic, nylon etc.)
- ❖ Size and form of the sample (such as fiber, yarn, fabric etc.)
- ❖ External condition (temperature, humidity)
- ❖ Chemical content (such as oil, wax and other impurities)

Effects of swelling on textile fibres

- ❖ Swelling improves the absorption of dyes and chemicals in fibre.
- ❖ Due to swelling the pores of closely interlaced woven fabric will be completely blocked and thus it may act as water proof fabric.
- ❖ Swelling changes the dimensional stability of fabric.
- ❖ Swelling changes the electric and tensile properties of fibre.
- ❖ Swelling minimizes static charge formation.

Swelling (%) of different fibres:

Fibre	Transverse diameter swelling % (S_D)	Transverse area swelling % (S_A)	Axial swelling % (S_L)	Volume swelling % (S_V)
Cotton	20	40	-	-

Flax	20	47	0.1	-
Jute	20	40	-	-
Viscose rayon	35	67	3.7	119
Wool	14.8	25	-	37
Silk	16.5	19	1.6	30
Nylon	1.9	1.6	2.7	8.1