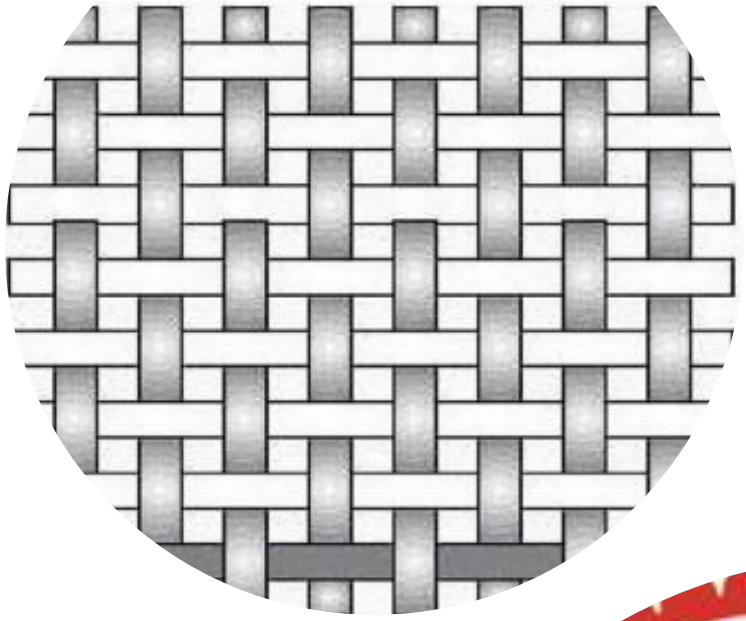
Fabric Manufacturing I (TXL231)



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Sizing: Objectives

The objective of warp sizing is to improve the weaveability of yarns by applying a uniform coating on the yarn surface so that protruding hairs are laid on the yarn surface

Benefits of Sizing

- ❖ It prevents the warp yarn breakage due to abrasion with neighboring yarns or with back rest, heald eye and reed.
- ❖ It improves the yarn strength by 10 to 20%, although it is not the primary objective of sizing process.

Characteristics of Sized Yarn

- ✓ Higher strength
- ✓ Lower elongation
- ✓ Higher bending rigidity
- ✓ Higher abrasion resistance
- ✓ Lower hairiness
- ✓ Lower frictional resistance

Sizing materials

- ❑ Starch
- ❑ PVA

Basic definitions

$$\text{Size concentration (\%)} = \frac{\text{Oven dry mass of size materials}}{\text{Mass of size paste}} \times 100 = \frac{S}{P} \times 100$$

$$\text{Size add on(\%)} = \frac{\text{Oven dry mass of size materials}}{\text{Oven dry mass of unsized yarns}} \times 100 = \frac{S}{Y} \times 100$$

$$\text{Wet Pick up} = \frac{\text{Mass of size paste}}{\text{Oven dry mass of unzized yarns}} = \frac{P}{Y}$$

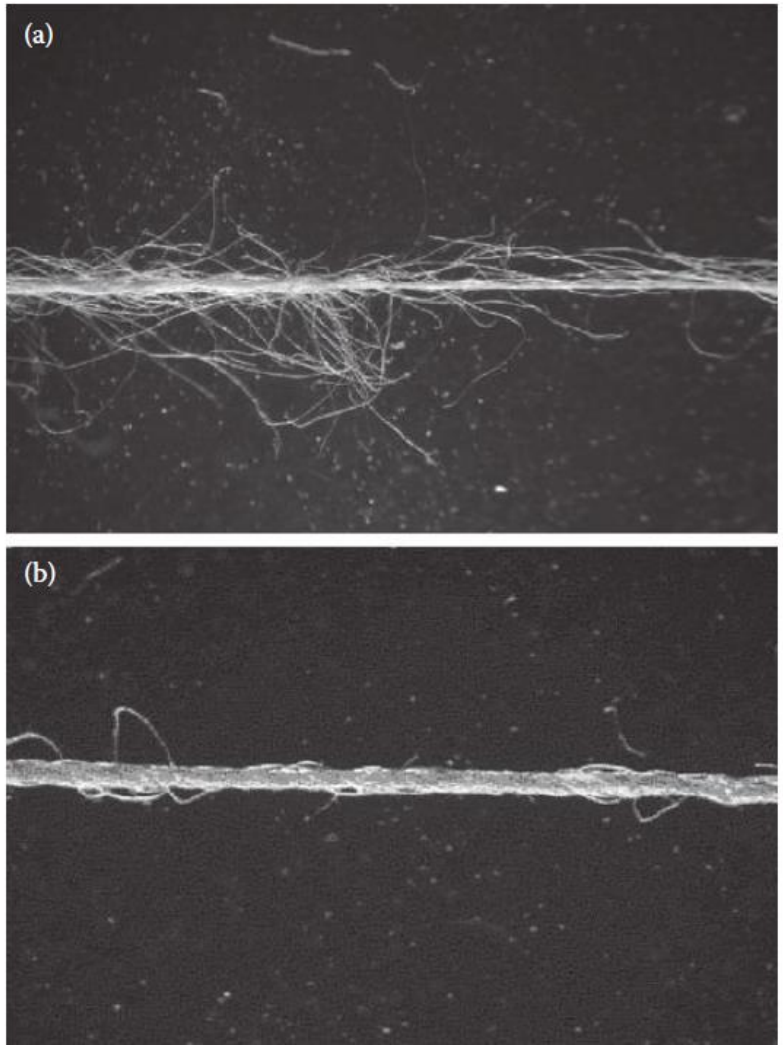
$$= \left(\frac{S}{Y} \times 100\right) \times \left(\frac{P}{S} \times \frac{1}{100}\right)$$

$$= \frac{\text{Add on (\%)}}{\text{Concentration (\%)}}$$

Sizing: Objectives

- The size material should penetrate the body of yarn to such an extent that the size film gets firmly anchored
- However, excess penetration of size not only means an excess material consumption but also reduced yarn flexibility

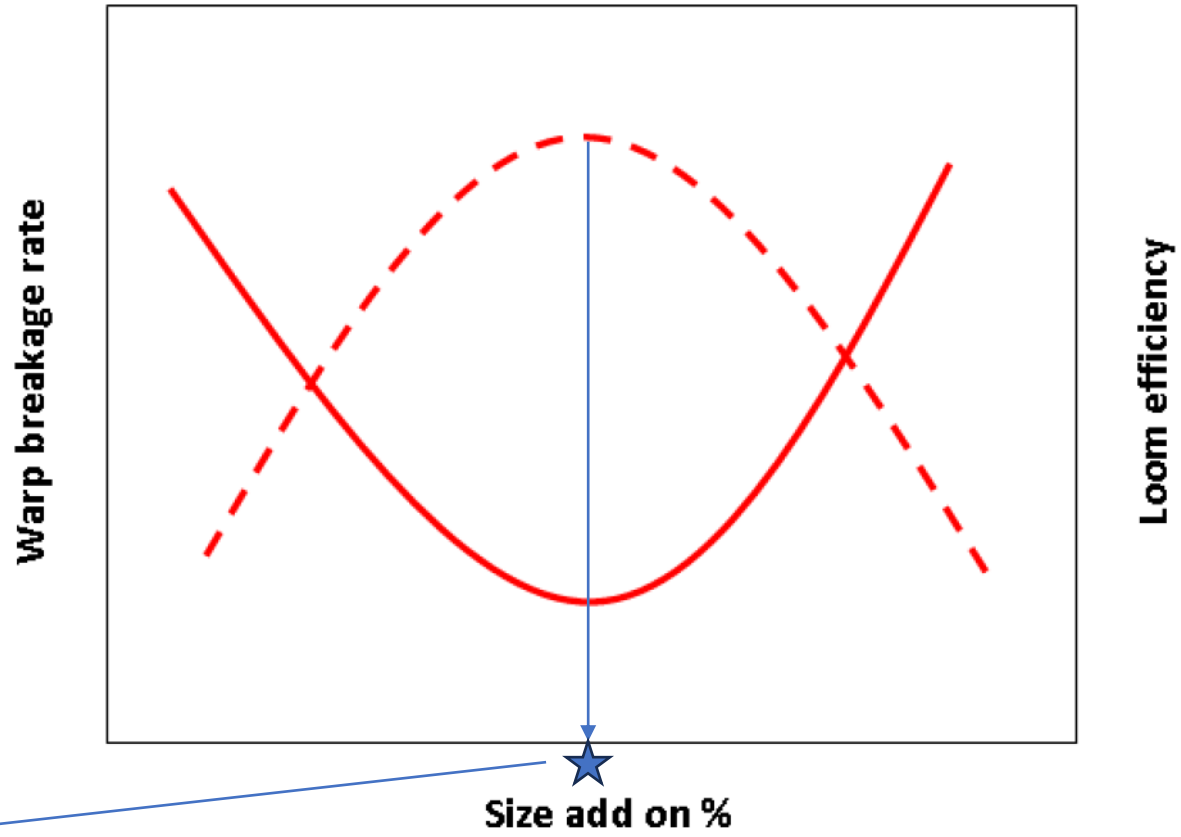
A modern sizing machine can process yarns coming from approximately 25,000 ring spindles and feed 150 projectile looms of 3 m width



(a) unsized and (b) sized yarn

Sizing: Sizing-weaving Curve

The solid line represents the warp breakage rate whereas the broken line implies loom efficiency.

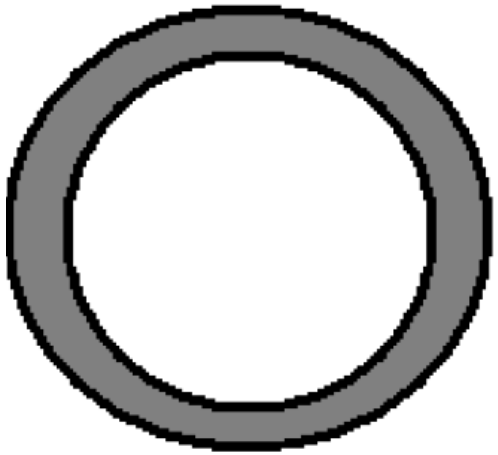


The optimum level of size add-on will depend on the following factors

- Type of fibre
- Type of size materials
- Yarn spinning technology
- Yarn count and twist
- Level of hairiness in the yarn
- Loom type and loom speed

Sizing: Sizing-weaving Curve

Although add-on primarily influences the weaving performance, it is possible to have different weaving performances even at the same level of size add-on, mainly due to differences in Size penetration and Size coating



Size coating

- Uniform coating
- No hairiness problem
- Lower adhesion
- Stiff coating
- Chances of shedding of sizing material

size penetration

- No outer coating
- No abrasion protection
- Too deep penetration
- Less binding

optimum coating and penetration

- Thin but uniform coating
- Appreciable penetration and binding
- Penetration distance about 15-20% of radius

Sizing: Sizing Materials

What are the desirable and essential properties of sizing material?

Film forming	Controllable viscosity
Adhesion	Easy removal and recyclability
Optimum penetration	Neutral pH
Film flexibility and elasticity	Non-polluting
Lubrication	Cheap
Bacterial resistance	

Adhesion is the most critical component

- ❑ The adhesive part is responsible for forming the film and adhering with the fibres
- ❑ Softening agent makes the film flexible so that the film can bend easily without forming cracks
- ❑ Antimicrobial agents are added to thwart the mildew to grow on the size film

Sizing: Desirable Nature of Bonds between Adhesives and Fiber Material

In order to hold down protruding fibers onto the yarn body, the number of bonding sites between the sizing material and the fibers constituting the yarn must be sufficiently high. However, a sizing material should ideally have a low bond strength as it has to be disposed of after sized yarns have been woven into a fabric.

What kind of forces we can expect?

- ❑ van der Waals interaction → van der Waals forces are weak forces of attraction. They arise due to momentary dipoles occurring due to uneven electron distribution and/or The weak residual attraction of the nuclei in one molecule for the electrons in a neighboring molecule
- ❑ Hydrogen bonds → Hydrogen bonds occur between molecules that have a permanent net dipole resulting from hydrogen being covalently bonded to fluorine, oxygen, or nitrogen
- ❑ Dipole-dipole interaction → Dipole-dipole interactions are intermolecular forces that are stronger than van der Waals forces. They develop between molecules that have permanent net dipoles as found in polar molecules

Sizing: Desirable Nature of Bonds between Adhesives and Fiber Material

What kind of forces we can expect?

- van der Waals interaction
- Hydrogen bonds
- Dipole-dipole interaction

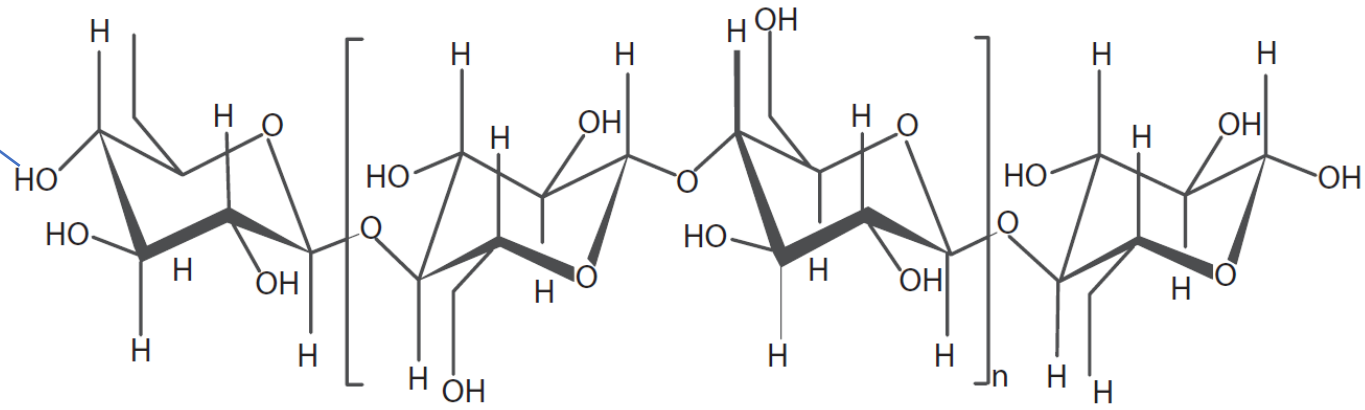
Strength of Different Types of Bonds

Type of Bond	Bond Strength (kJ mol^{-1})
van der Waal's forces	<<50
Dipole–dipole interactions	~50
Hydrogen bond	~100
Single covalent bond	~300

Sizing Material: Starch

Cotton yarns, in general, are sized by the starch which forms the adhesive component of the size mix. The reasons are-

- Starch is chemically same with cotton and rayon and thus the adhesion is very good.
- Desizing is easy
- Relatively cheap
- Properties can be tuned to cope with the need



Organization of chemical groups in a cellulose molecule of cotton

(*Large number of –OH groups in starch*)

Sizing Material: Starch

- Starches are available from the seed, root or pith of plants. Corn, rice and wheat are the examples of seed starch. Potato and Tapioca starches are obtained from roots. Sago starch is obtained from pith.

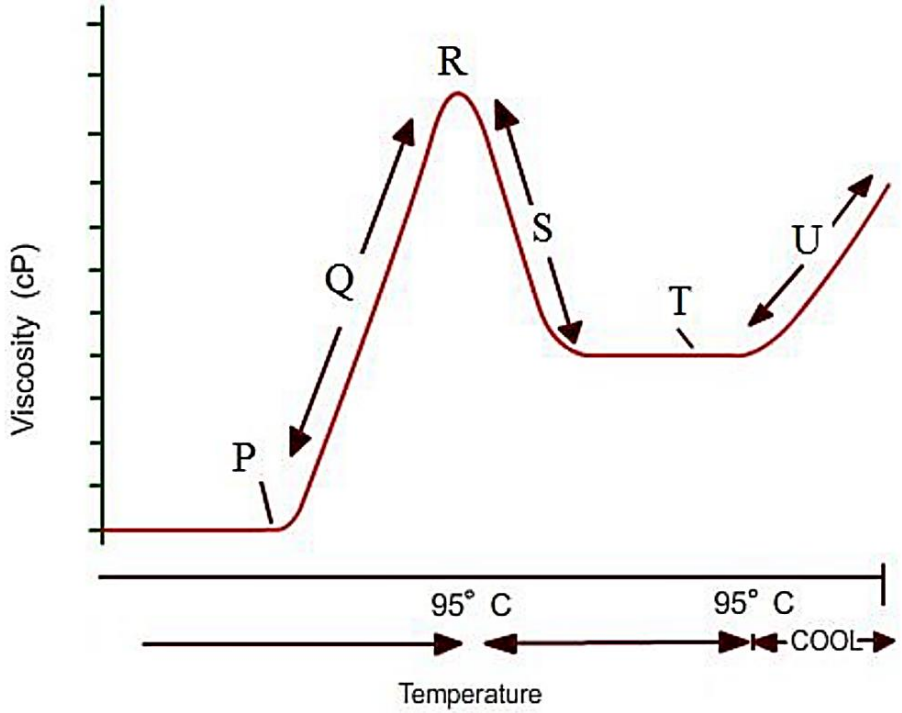
- Starch is usually composed of two components, a straight chain polysaccharide of glucose, called Amylose (low mol. wt) and a branched chain polysaccharide of glucose, called Amylopectin (high mol. wt)

Amylose	Amylopectin
Provides strength	Prevents rapid gelling
Water soluble	Water insoluble
Low molecular weight	Relatively high molecular weight
20-30%	70-80%

- Corn starch is generally preferred for the sizing of coarse and medium count yarns
- Potato starch is preferred for sizing finer yarns

Sizing Material: Cooking of Starch

Starch alone suspended in cold water cannot act as an adhesive because it is tightly bound in granular form. The granules consist of crystalline regions of straight chain molecules and straight chain section of aligned branched chain molecules. The crystalline regions are linked together by more amorphous areas in which the molecules are not aligned. Hence, the granules must be **opened**.



P- gelatinization temperature (crystal structure broken ~60 deg C)

Q- Increase in viscosity due to swelling

R- Maximum viscosity (also aided by stirring), starch granules break

S- The chai molecules of amylose and amylopection come out within the solution causing reduction in viscosity

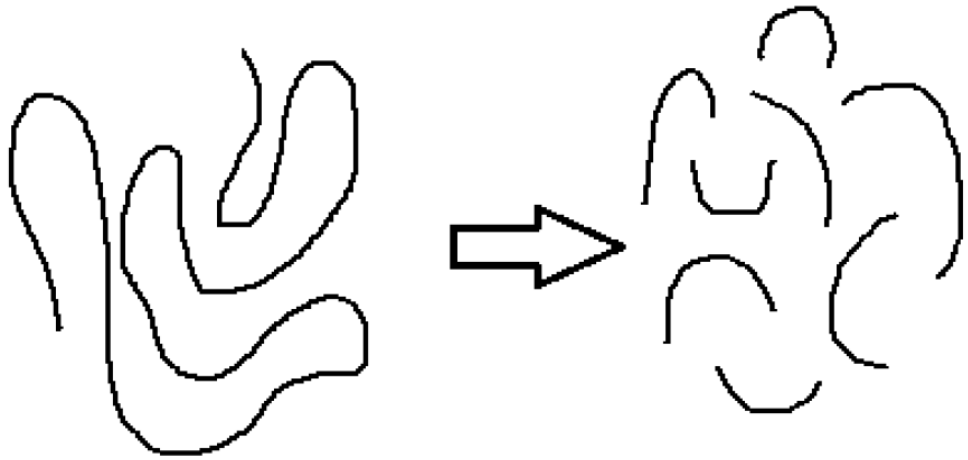
T- When all the granules have burst, the viscosity stabilizes or levels off

U-When the solution is cooled, the starch gels due to the formation of a rigid interlocked micelle-like structure having hydrogen bonding (ready for coating) (retrogradation of starch)

Sizing Material: Acid Treatment (Thin Boiling Starch)

- The viscosity of the sizing paste influences the wet pick-up and resultant add-on %. The viscosity is influenced by the concentration of starch (solid content) and molecular chain length of starch
- Aqueous solution of starch is treated with hydrochloric acids at specified temperature and duration. The acid cleaves the polymer at the glycoside linkage and thus the length of the polymer chain is reduced

Thin boiling starch-the viscosity is reduced and the fluidity increases



Acid treatment of starch to reduce the molecular chain length

Sizing Material: Alkali Treatment

- Strong bases activate starch-the degree of granule swelling depends upon the nature of the starch; the nature of the alkali; the relative amounts of starch, alkali, and water; the temperature, and the presence or absence of neutral salts.
- Increase in reactivity of starch in aqueous alkali is obtained by addition of neutral salts, especially sodium sulfate

Sizing Material: Oxidation of Starch

Starch granules are oxidized with sodium hypochlorite, which converts some hydroxyls into −COOH groups breaking the ring at that point. Sodium bisulfite is added to destroy excess hypochlorite. The granular structure is retained, and films from oxidized starch are better than those formed from thin boiling starch.

Sizing Material: Starch actual behavior