

FIBER

Fibers were originally of natural origin and were produced from wool, silk, cotton flax, and similar materials. The first man-made fibers were made by swan in 1883. When he squirted a solution of cellulose nitrate in acetic acid through holes. The first commercial fibers made from cellulose nitrate were produced by chardonnet who patented this process in 1885. The next synthetic fiber was also a cellulose derivative regenerated cellulose or viscose.

The first truly synthetic fiber was nylon introduced in 1940. This was discovered by carothens was commercialized by Dupont. The next fibers that emerged were polyester, acrylics and polyolefines.

PROPERTIES OF FIBERS:

- 1) Length
- 2) Crimp
- 3) Denier

Fibers are either a continuous filament or short fibers, rather uniform in length, spun into the thread. The short fibers i.e. cotton, and wool, are called staple. Continuous filament can be of almost infinite in length and most synthetic fiber, as well as natural silk are of this type. Synthetic staple fibers are prepared by cutting continuous filament to short, uniform length, usually between 3.5 and 15cm.

The curl or weariness, placed in synthetic fibers by chemical or mechanical action is called crimp. Crimps are also introduced in some cases into continuous-filament yarns to alter their appearance and feel. E.g. nylon, carpet yarn, cotton and wool posses natural crimp.

Denier is a measure of the weight of fiber per unit length and is defined as weight in grams of 9000m. Another unit is the tex which is the weight of 1000m.

SYNTHETIC FIBER:-

CLASSIFICATION:-

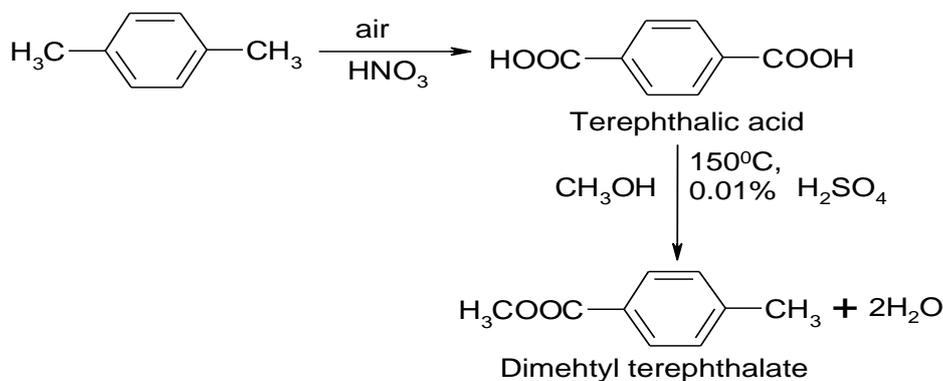
The versatile noncellulosic fibers whose market is rapidly growing are classified chemically and dry the method of spinning. The manufacture of all these synthetic fibers begins with the preparation of a polymer consisting of very long chain like molecules. Two elements imp. In determining the range of the polymer. Mechanical properties are the attractive forces between the molecules and the flexibility and length of the molecular chains.

Spinning procedure is divided into melt, dry and wet.

POLYAMIDES:-

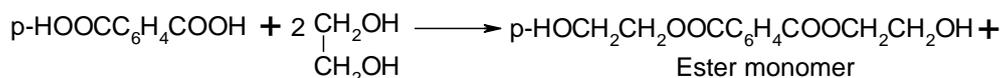
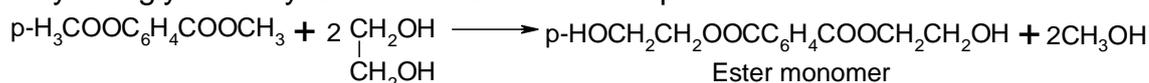
Nylon 6,6 was the first all synthetic fiber made commercially and opened up the entire field. In 1981 the U.S. production was 1.18×10^6 t, of which 59 percent was used for home furnishing mostly carpets. Apparel accounted for 20 percent and these cord for 11 percent.

The product resulting from polymerization reaction of adipic acid and hexamethylene diamine is called nylon 6,6 because of the raw material chains contain six carbon atoms. Nylon 6 is the homo polymer of caprolactum and

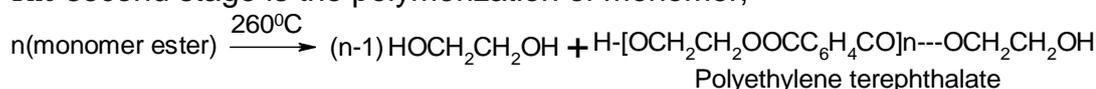


POLYMERISATION AND FIBER PRODUCTION:-

Polymerization is a two stage process in which the monomer is first prepared either by an ester interchange between dimethyl-terphthalate and ethylene glycol or by direct esterification of terphthalic acid.



The second stage is the polymerization of monomer,



iii) ACRYLICS AND MODACRYLICS:-

Poly acrylonitrile (-CH₂CHCN-) is the major component of general industrial textile fibers, but Dupont's Orlon was the first to attain commercial-scale operation. Dye able acrylics are generally co-polymer with modifying constituents.

Orlon is made by polymerizing acrylonitrile. The ivory-white polymer is dissolved in an organic solvent, generally dimethyl-formamide, although it can be dissolved in many concentrated solutions of salts, like lithium bromide or more successfully in other organic solvents such as dimethoxyacetamide and tetramethylene cyclin sulfone. The solution is filtered and dry-spun, utilizing the same spinning technique long used for acetate namely in solution through spinnerets, with the solvent evaporated to furnish the dry fiber. Unlike nylon which is drawn at room temperature acrylics, like polyester are drawn at elevated temperature in a special machine. The acrylic resistance to chemical attack and especially to weathering makes them highly useful in several fields. Other acrylics like Acrilan and Creslan are spun wet into a coagulating bath.

USES:-

- 1) Sweaters, women's coats, men's winter suiting carpets and blankets.
- 2) Blends with wool and other synthetics are common in some end uses.
- 3) Acrylics and also suitable for pile fabrics and filter cloth.

MODACRYLIC FIBERS (Modified fibers)

This is generic name for synthetic fibers in which the fiber-forming substance in any-long chain synthetic fiber polymer composed of less than 85% but at least 35% by weight of acrylonitrile units.

Dynel is the name given by Union-Carbide to their staple copolymer modacrylic fiber made from a resin of 40% acrylonitrile and 60% vinyl chloride. The resin is converted into staple in a continuous wet-spinning process.

The white resin powder is dissolved in acetone, filtered and run through a spinneret where the fibers are formed in an aqueous spinning bath. The fiber is dried, cut and crimped. Dynel is similar to used in many respects and has some superior characteristics.

USES:-

- 1) Used for work clothing, water softner, bags, dye nets, filter cloth, blankets draperies, sweaters, pile fabric etc.

VINYLS AND VINYLIDINES

Saran is the copolymer of vinyl chloride and vinylidene chloride. It is prepared by mixing the two monomer with a catalyst and heating. Colour is added by introducing pigment into the mass. The copolymer is heated extruded at 180°C air-cooled and stretched. Saran is resistant to mildew, bacterial and insect-attack which makes it suitable for insect screens. Its chemical resistance makes it advantageous for filter cloth applications however its widest use has been for automobile seat covers and home upholstery much film is made from Saran.

Vinyon is the trade name given to copolymers of 90% vinyl chloride and 10% vinyl acetate. The copolymer is dissolved in acetone to 22% solids and filtered and the fibers are extruded by the dry spinning technique. After standing the fibers are wet-twisted and stretched. Resistance to acids and alkalis, sunlight and aging makes vinyon useful in heat sealing fabrics work clothing, filter-clothes and other related applications.

POLYOLEFINS:-

Polyolefines fibers are usually made of polyethylene and polypropylene. They excel in special cases such as ropes laundry nets, carpets, blankets and backing for tufted carpets but are difficult to dye and their melting point is low. In 1981 the annual consumption in the United States was 292,000t.

The polymer is spun from a melt at about 100°C above the melting point because the viscosity of the molten polymer at or near the melting point is very high.

FLUOROCARBONS:-

Teflon is polytetrafluoroethylene $[-(C_2F_4)_n-]$ and as fiber or film is non flammable and highly resistant to oxidation and the action of chemicals including strong acids, alkalis, and oxidizing agents. It retains this useful property at high temperatures (230 to 290C) and is strong and tough. A very important property is its low friction, leading with its chemical inertness, to wide use in pump packings and shaft bearings.

GLASS FIBERS:-

Fiberglass wearing materials were prepared as early as 1893 when a dress of fibers about five times the diameter of the present day product was made by Owens. Since that time, however numerous improvements have been discovered until at present continuous fibers as small as 5 mm in diameter are possible. The largest and original manufacture of glass fiber is the Owens-Corning fiber glass Corp. which markets its product under the trade name fiber glass.

CELLULOSIC FIBERS

Rayon and Acetate:-

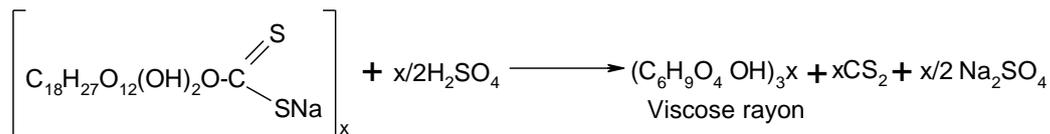
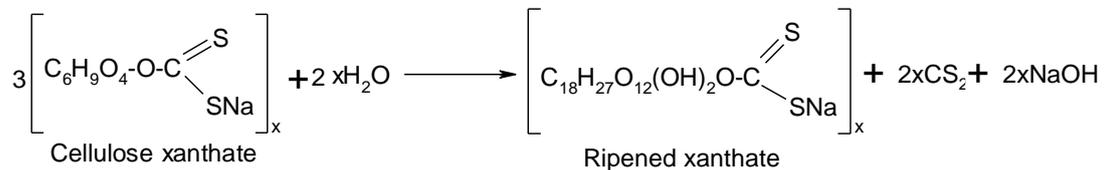
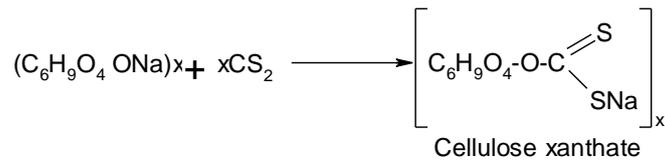
Uses and Economics:-

In 1981 the U.S. production of rayon and acetate was amounted to 349,000 t. High tenacity viscose yarn is used mainly in cords for tires, hose and belting. The difference in strength between ordinary and high tenacity viscose depends on the amount of orientation imparted to the fiber molecules when they are made. The hydroxyl groups in the cellulose molecules enable the fiber to absorb water, resulting in low wet strength. Hydroxyl group also serves as sites for hydrogen bonding. And thus in the dry state, serve to hold molecules together despite strong bending resulting in fibers which tend to maintain their dry strength well even at high temperatures. The price of rayon and acetate varies according to the size of the filament, process of manufactures and type of finish. Textile rayon and acetate are used primarily in women's apparel, draperies, upholstery, and blends with wool in carpets and rugs.

RAW MATERIAL: - The viscose process is based on sulfite and a little sulfate wood pulp. If sheet cellulose, the form used in viscose manufacture is desired the sulfate pulp, after the bleaching treatment has been completed is blended with several other batches passed successively through a beater and a refiner and formed into sheets on a fourdrinier. Viscose rayon is a major consumer of sulfuric acid, caustic soda and carbon disulfide.

Titanium dioxide is added to deluster the yarn cellulose acetate employs large quantities of acetic anhydride glacial acetic acid, sulfuric acid and acetone to swell the wood pulp.

The process contain the following outline solution of the cellulose through a chemical reaction, ageing as ripening of the solution, filtration and removal of air, spinning of the fiber combining the filaments into yarn, purifying the yarn and finishing.



CARBON-FIBERS

High modulus carbon fibers are prepared from rayon, poly acrylonitrile (PAN) or pitch. Rayon fibers are charred at 200 to 350°C and then carbonized at 1000 to 2000° C. The resulting carbon fibers are then heat treated at 3000°C and stretched during the heat treatment. This is a very costly process as the overall yields are only about 25 percent. These rayon produced fiber are used for manufacturing heat shields for aerospace-vehicles and for air craft brakes.

Fibers can be produced from PAN in a better yield, but the young's modulus is not as high as those prepared from rayon. The PAN is stretched 100 to 500 percent at 100°C, heated at 190 to 280°C for 0.5 to 5 hours, and then carbonized at 1000 to 1300°C. The yield is about 45%. The modulus can be increased by heating above 2500°C.

Coal tar or petroleum pitch is first heated to form a liquid crystal state yarn is spun from the liquid and thermoset in an oxygen atmosphere. When heated to 3000°C the fibers have a high modulus and require no costly stretching.

THREE FORMS OF CARBON:-

- 1) Low Modulus:- This is used as an electrically conducting surface for electrostatic spraying and in injection molding to get electrical conductivity resistance to heat and improved wear (for bearings).
- 2) Medium Modulus: - The fiber can be formed into fabrics.
- 3) High Modulus: - This is the slowest priced high modulus yarn available and is used when stiffness is critical.

USES:-

- 1) Carbon Fibers are used for reinforcing plastics which can be used for sporting goods (fishing rods etc.) and engineering plastics.

FILMS:-

The first successful plastic film was cellulose nitrate. This was soon followed by regenerated cellulose and cellulose acetate. Up until 1950 regenerated cellulose film had the largest share of the market.

Now films are produced from other polyolefines, PVC, acetate, poly styrene, copolymers and poly amides, poly carbonates, acrylics and many other polymers.

VISCOSE AND CELLULOSE ACETATE:-

Transparent viscose film (cellophane) is manufactured from a solution similar to that used for rayon. The solution is extruded through a slit-die into a coagulating bath of buffered sulfuric acid and cast as a sheet upon a rotating drum, the lower side of which is submerged in the bath. The viscose film formed is transferred to succeeding tanks of warm water to remove the acid. It is desulfurised in a basic solution of sodium sulfide and rewashed. The characteristic yellow color is removed by hypochlorite bleach, washed thoroughly and the sheet is then infused with glycerol to impart plasticity to the film. Uncoated cellulose film is not moisture proof and its packaging uses are limited. It does not seal on automatic machinery, it shrinks on getting wet and does not prevent moisture loss. It is used for sausage casings as a base for pressure sensitive tapes and as release agent in molding resins. One great advantage is that it is biodegradable.

Moisture proof cellulose films are prepared by coating one side with nitro-cellulose lacquer or a poly vinylidene-chloride copolymer solution. The coated films can be printed and are still biodegradable although the time required is little larger.

POLYOLEFINES: -

Polyethylene films are made by melting the polymer and extruding it by either slit-die or blow extrusion. The slit die process produces flat sheets of film by extruding the molten polymer through a slit-die into a quenching water bath or onto a chilled roller. It is essential that the films be cooled rapidly to form only small crystals and thus maintain its clarity. Very high outputs of film with superior optical properties can be obtained by this method.

The blow extrusion process produces tubular film by using air pressure to force the molten polymer around a mandrel. The plastic emerges from the die through a ring shaped opening in the form of a tube bubble. The extrusion is usually upward, but it can be down or even horizontal. Below fig. shows the blown film extrusion process. Poly propylene film cannot be formed by this air cooled method because its rate of cooling is too slow and thus large crystalline aggregates are formed.

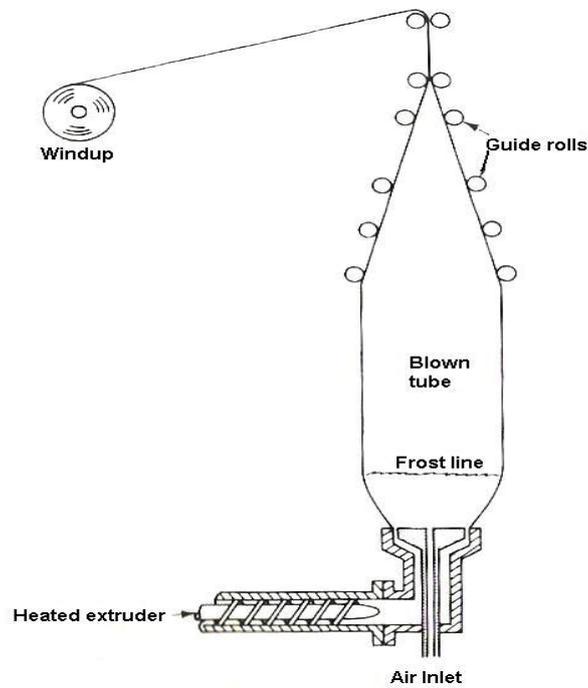


Fig-blown film extrusion process

POLYVINYL CHLORIDE: -

PVC film is prepared by feeding a plastic mix of polymer, stabilizers and plasticizers between two heated rolls where it is squeezed into a film. This process is known as calendaring and is widely used in the rubber industry. Calendaring produces sheets of better uniformity of thickness compared with extruded sheets. PVC requires plasticization because without a plasticizer the film is very brittle. The simple phthalates are most commonly used for this purpose and after in amounts up to 50 parts per hundred parts resin.

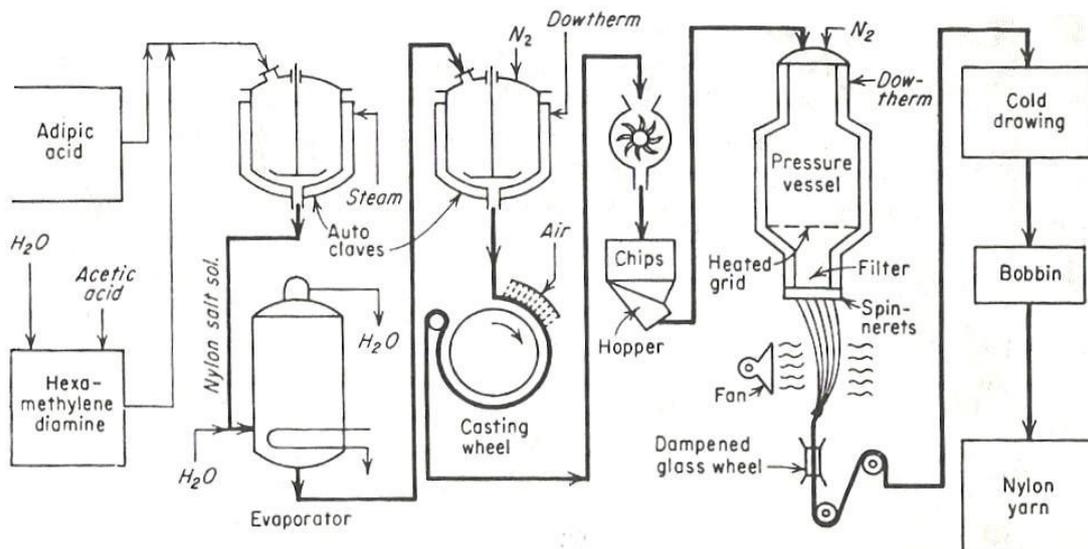
Films for low-temp use are made using aliphatic ester such as di-2-ethylhexyladipate, for plasticizer. Different plasticizer content produces a range of films suitable for different wrapping applications. Meat wraps require very high concentrations to resist moisture and oxygen. PVC films are not biodegradable and give off HCL when burned thus making environmentally acceptable disposal difficult.

OTHER POLYMER:-

Almost any thermoplastic resin can be formed into film by the use of one or the other of the processes described. The choice of process depends largely upon the physical properties of the resin. Polyester and polyamide films are melt extruded.

MANUFACTURING OF NYLON:-

The aqueous nylon salt starts on the top level of the factory and the materials move down by the gravity through the various steps. The hexamethylene diammonium adipate solution is pumped to the top level into evaporators and concentrated. Acetic acid is added to the evaporation charge to stabilize the chain length. After evaporation the salt solution flows into jacketed autoclaves equipped with internal coil and heated by the dowtherm vapor. Rest of water is removed.



Flowchart for Nylon.

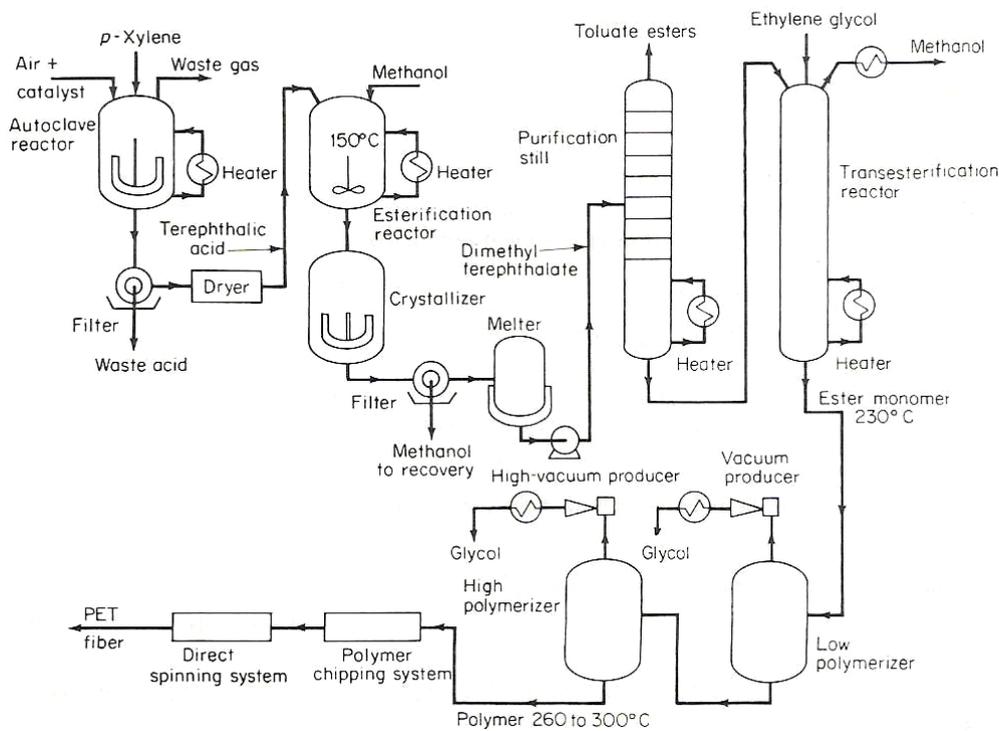
After polymerization is completed the molten viscous polymer is forced out of the bottom onto a casting wheel by specially purified nitrogen at 175 to 375kPa. A ribbon of polymer flows on the casting drum water sprays on the inside cool and harden the underside of the ribbon, the outer is cooled by air and water. The ribbons are cut into small chips or flakes, before being blended. A typical spinning unit is composed of a metal vessel surrounded by a Dowtherm vapour heated jacket which keeps the temp of the vessel above the melting point (263°C) of the nylon. Special precautions are taken to keep the spinning oxygen free. As the nylon-flake enters the vessel it strikes a grid where it melts and flow through the melt chamber below.

The molten polymer passes through the port holes in this chamber to the gear spinning pumps. They deliver it to a sand filter, which is followed by screens and a spinneret plate. The filament are solidified by air in a cooling chimney and passed in a bundle through a steam humidifying chamber, where the moisture content is brought to equilibrium in order to stabilize the length of the spun dryer.

After lubrication on a finish roll, the yarn is stretched or drawn to derived degree by passing it through a differential speed roller system. The nylon filament is then shipped to various manufactures for processing.

POLYESTER FIBER MANUFACTURING

The polymer is extruded from the bottom of the polymerizer through a slot or holes onto the surface of a water-cooled drum. The ribbon is cut to chips and dried before melt spinning in a manner similar to that described for nylon. The polymer chain contains approximately 80 benzene rings. The filaments are stretched with the application of heat to about three to six times their original length. Fig is shown below.



Flowchart for the manufacture of polyester.

Properties:-

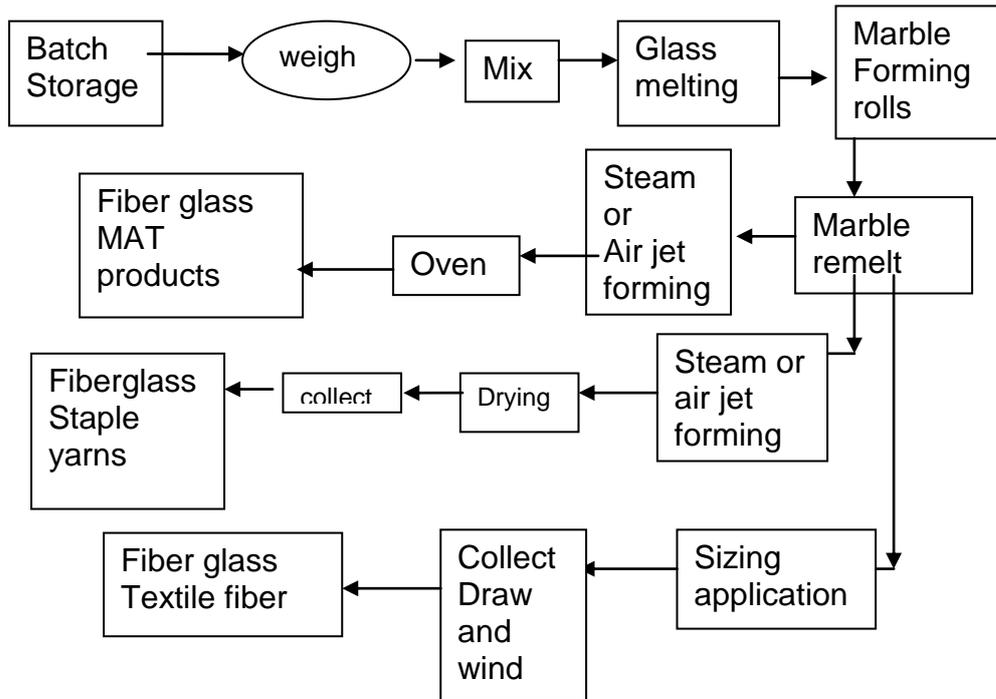
It is particularly well suited for blending wool and cotton to yield good esthetics in woven fabrics, such as men’s summer suits, men’s shirts and women’s dresses and blouses alone in knitted fabrics and some woven fabrics. Because of its strength it is important in the tire-cord and cordage-fields. It is also used for sewing thread fire hose, and v-belts. It is not used for women’s stockings because its elastic modulus is too high and thus it does not recover rapidly after stretching. In staple form it is employed as stuffing for pillows, sleeping bags and comforters.

GLASS FIBER MANUFACTURING:-

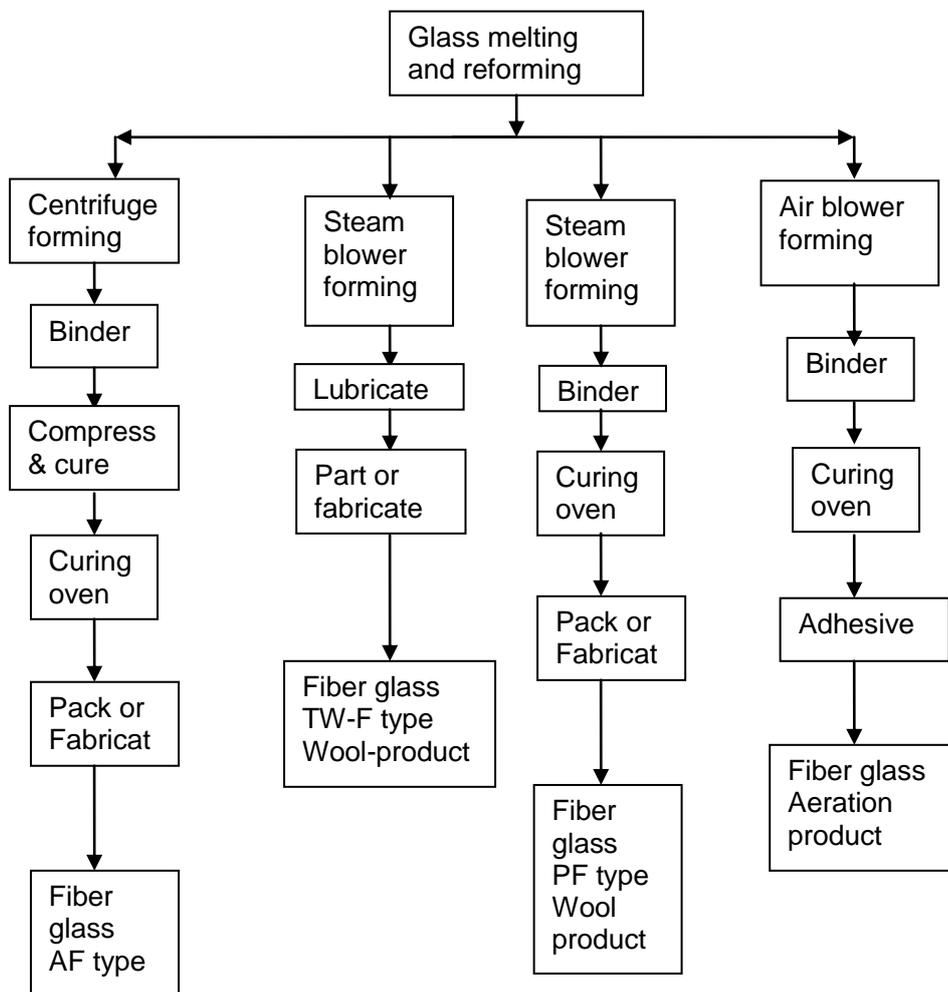
In the continuous filament process specially prepared and inspected glass marbles are melted or a batch of highly purified molten glass is allowed to flow through a set of small holes (usually 102 or 204 in number) in a heated platinum bushing at the bottom of the furnace. The fibers are let through an ‘eye’ and then gathered, lubricated and put on high speed winders, which rotates so much faster than the flow from the bushing that the filaments are drawn down to controlled diameters. The fibers are used for elastical insulation in motor and generators, structural reinforcement for plastic, fire proof wall covering and fire cords.

In the production of staple fiber glass is automatically fed at regular intervals to a small electrically heated furnace. The molten glass discharges continuously through a spinneret directly below the orifice plate in a jet discharging high pressure air or steam in such a manner as to seize the molten filaments and drag them downward, decreasing their diameter. The resulting web of fibers on the drum is drawn off through guides and wound on tubes and after drafting and twisting to form yarns sent to weaving and textile fabrication.

Textile process and products



Wool-type process and products

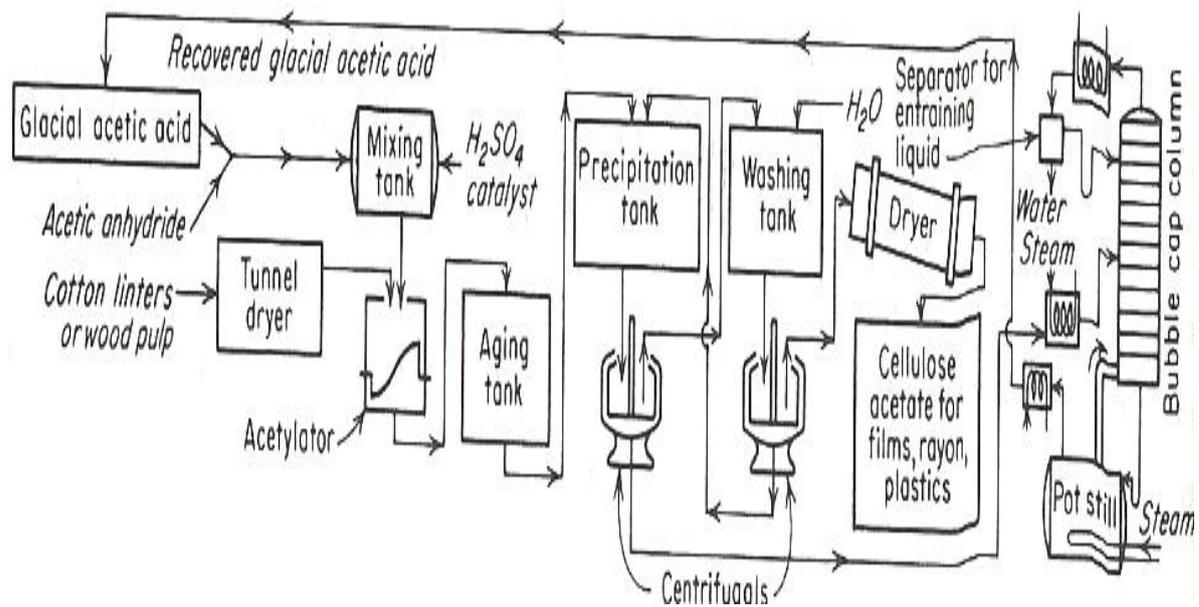


Flowchart for fiberglass production.

CELLULOSE ACETATE MANUFACTURING

PROCESS:-

Cellulose acetate and its homologs are esters of cellulose and are not regenerated cellulose. The raw material for the spinning solution is prepared by changing acetic anhydride, glacial acetic acid and a small quantity of sulfuric acid as a catalyst to a jacketed glass lined agitated cast iron acetylator. The mixture is cooled to 7°C and the wood pulp is added slowly. The acetylation required 5 to 8 hours and temperature maintain below 50°C. Viscous fluid is diluted with concentrated acetic acid and 10% sulfuric acid and allowed to age for 15 h at 38° C. The desired material is usually about half way between triacetate and diacetate.



Flowchart for cellulose acetate manufacturing.

The hydration is stopped by running the mixture into a large volume of water and precipitating the secondary acetate. The secondary acetate is centrifuged to separate it from the still strong acetic acid which is recovered concentrated, and used over.

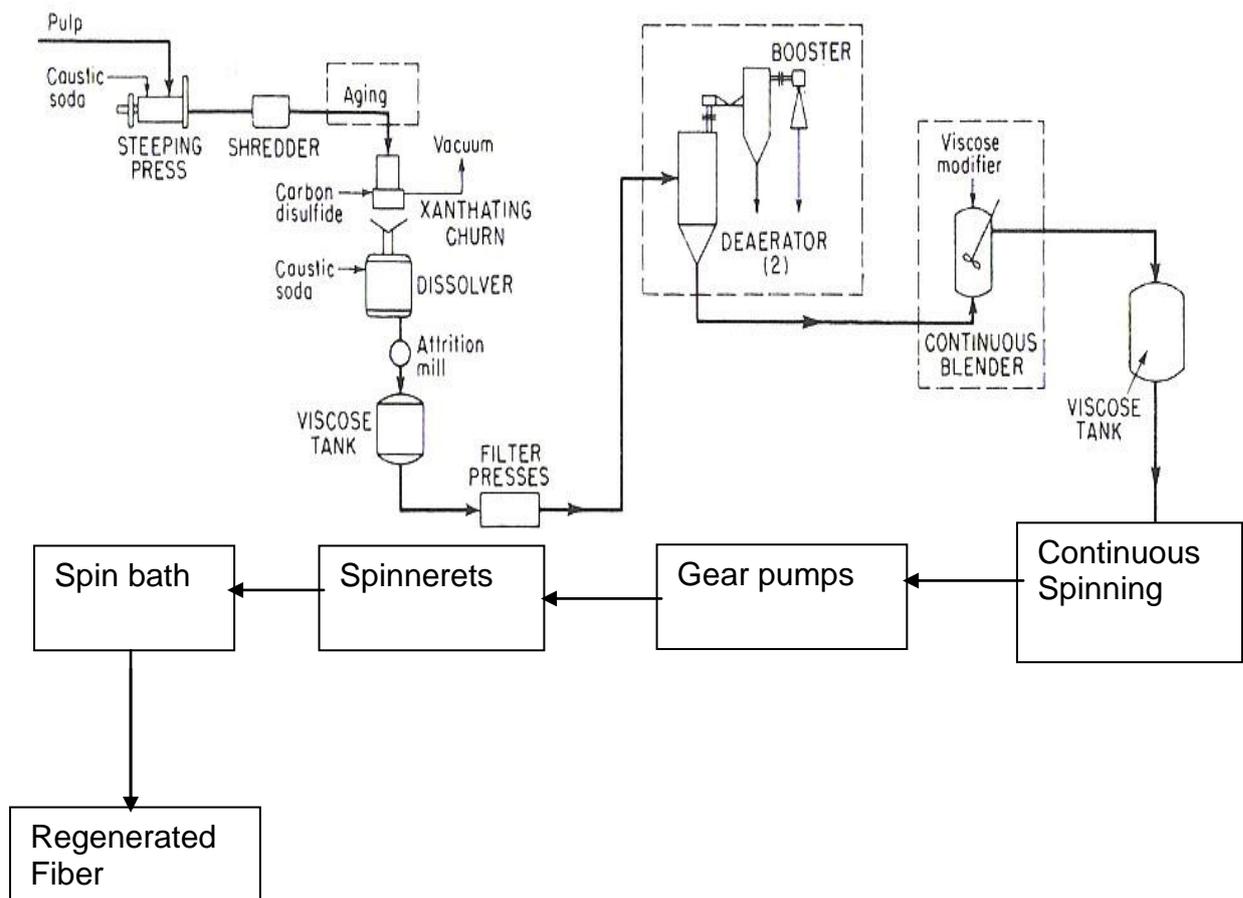
The flakes are washed several times by decantation and dissolved in acetone in a closed agitated mixture. A delustering pigment is added. Several batches are blended filtered and sent to the spinning machine. The solution is forced through spinnerets into a current of warm, moist air. The acetone evaporates and is recovered, leaving a filament of cellulose acetate.

VISCOSE MANUFACTURING:-

The cellulosic raw material is changed to a steeping press containing vertical perforated steel plates and is steeped either batch wise or continuously in a caustic soda solution for about 1 h at 13 to 17°C to dissolve the cellulose. The excess liquor is drained off, removing impurities such as cellulose degradation products. The soft sheets of alkali cellulose are reduced

to small crumbs in a shredder. This requires 2 to 3 hours and the temperature is maintained at 18 to 20°C.

The crumbs of alkali cellulose are aged either batch wise as continuously for 24 to 48 hr at 24°C in large steel cans. The aged crumbs are dropped into large cylindrical xanthating churns. Carbon disulfide weighing between 30 to 40% of the dry recoverable cellulose is slowly added under carefully controlled temperature and reduced pressure during 2h of churning during which time the crumbs gradually turn yellow and finally deep orange and coagulate into small balls. Still in batch form, the cellulose xanthate balls are dropped into a jacketed dissolver containing dilute sodium hydroxide. The xanthate particles dissolves in caustic soda and the final product viscose solution contains 6 to 8% cellulose xanthate and 6 to 7% sodium hydroxide. The result is a viscous golden brown liquid.



Flowchart for viscose rayon production

During the ripening the proportion of combined sulfur decreases and the ease of coagulation increases. In a series of tanks the reaction proceeds under deaeration and continuous blending with modifier that control neutralization and regeneration rates. Finally in two continuous vacuum-flash boiling deaerators small air bubbles are removed that would either weaken the final yarn or cause breaks during spinning.

In spinning, viscose is forced by gear pumps through thimble like spinnerets of noble metal, each with from 750 to 2000 holes. The fine streams thus formed are injected into the spin bath where they coagulate and the cellulose is regenerated to form fiber. Sulfuric acid in the spinning bath neutralizes free NaOH and decomposes xanthate and various viscous by-products containing sulfur, thus liberating CS₂, H₂S, CO₂ and S.

Three separate continuous spinning and treating procedures are following:-

- 1) Textile yarns are twisted into continuous yarn as the filament leave the spinneret. They are dyed and sent to coning and warping.
- 2) Tire yarns are stretched to impart strength over a series of thread advancing row where wash and other treatments are applied such as deacidifying, desulfurizing and bleaching.
- 3) Staple yarns are spun on the machine by combining filament from many spinnerets without twisting and cutting them into uniform lengths.