# Elaslasone fluoro polyethylene polypropylene silk acetate engineering essay

Engineering

Fibre is defined as a thin flexible material with high aspect ratio (> 1000). However to be useful, it should have some other characteristics also like minimum strength &extensibility and minimum levels of dimensional and thermal stability for a particular end purpose. These fibres have repeating long chain molecules (called polymers) arranged axially and have crystalline and amorphous regions. The structural parameters like molecular chain length, molecular weight, the degree and order of arrangement of these chain molecules, crystalline and amorphous regions give rise to different properties to make the fibre suitable for specific end application. Some properties are natural and some can be modified during the fibre manufacture. Few basic properties of some important fibers are given below. DensityMoisture regain at 65%R. HTenacity (gf/tex)Breaking elongation

## (%)

Initial Modulus(gf/tex)TgGlass TransitionTmMelting PointCotton1. 5-1. 557-819-46%5. 6-7. 1400-740Decomposes before softening and meltingWool1. 3 – 1. 3214-1611-1429-43210-310212®C dry; -40®C wet220®CSilk1-34101023-24750162-175®CDecomposes at 280 before meltingViscose1. 46-1. 5411-1320-518-20500-800Decomposes before softening and meltingPET1. 34-1. 380. 425-5412-55600-1200125®C265®CNylon 661-142. 8-532-6516-65200-30050®C static90®C dynamic265®CAcrylic1. 14-1. 171-518-3020-50600-70085-95®C Dry static105-140®C Dynamic64®C Wet static320®CPP0. 90. 04-0. 1035-8015-35225-900-10165®CProperties of fibres are the foundation for the properties of textile structures. Yarn forming and fabric forming methods alone cannot create a new property unless the fibre is found to have the appropriate potential. They can only enhance or

suppress some qualities. Therefore selection of a fibre for a particular end use has to be engineered. We give below some examples of fibre solution for some important uses along with the contributing fibre property and structural features contributing to the fibre property. Property Of FibreDue toFinal property of textile structureSpecific gravityMolecular weightCovering an area with smaller weight, Loftiness, Fullness and lightness. Buoyancy of the fabric. Moisture absorbencyHydroxyl groups. Amorphous regionsDyeability. Water repellency. Static buildup. Comfort and warmth. StrengthMolecular orientation. Crystallinity and degree of polymerization. Durability and mechanical properties of final product. Work of rupture. Toughness. The area under stress-strain curve. Ability to withstand both stress and strain. Molecular arrangementParachute fabricHeat conductivityCross section, crimpWarmthElectrical conductivityPolar groups and chemical structureAbility to conduct chargesLight reflectanceSmoothness, Fibre diameter, cross section shape. LusterElasticityMolecular structure. Side chains and crosslinks. Strong bondsResilience, creepSurface areaLinear density, crimp, twist, cross sectionTo cover a given area at low cost. Sometimes fibres are blended to get the desired properties. Sometimes they are modified during fibre spinning like adding spin finish to reduce friction, texurisation to get bulkiness and crimping to get inter fiber cohesiveness. Some fibres like cotton, wool, Asbestos, silk and spider web are naturally existing for a very long time. They are called natural fibres. Some are manufactured. The manufactured fibres have only 160 year old history. But to-day they dominate the natural fibres. Refer fig 2 fibre production to-day. Fibre

formation requires two steps, Synthesis of the polymer (fibre forming). Spinning the fibre for applications. In the case of regenerated fibres, step 1 is not required. Example: viscose. In the case of synthetic fibres both are required. Example: nylonIn the case of natural fibres both are not required. Example: cotton. The fibre forming methods are: Melt spinningSolution spinning. Electro spinning. Though Electro spinning is also century old process, commercially large quantities are turned out only by 1 & 2. However, 1 & 2 gives only micro level fibres from 50 to 1000microns in diameter. Only electro spun fibres give sub-micron diameter fibres which are having unique properties and applied in a wide range of fields like medicine, health care, water purification, air purification, solar cellsmanufacture, mega capacitors developing industries automobiles and aero space on the shuttles. There is a huge demand for these nano size fibres. Therefore the production technology of these nanofibres is looking for a quantum jump as the case was same w. r. t the manmade fibres a few decades back. Hence we examine here the fibre forming methods and compare them w. r. t the technology to bring about a synergy and convergence. Melt Spinning: The fibre forming material (polymer) is synthesized from the reaction of the required raw materials or melted in an extruder and sent to the spinnerets under constant pressure (2 – 20 Mpa ± 3% depending on the polymer and conditions) exerted by a gear pump after due filtration of unwanted particles (> 15µ). The temperature is maintained by heating coils or hot gases around the extruder at 30*C above the melting point. The polymer melt is thus forced through the fine capillaries of size 50µ to 500µ depending on requirement in the spinneret. The number of holes varies from 2 to 4 for

mono filament and up to 60000 for staple fibre production. As the melt is extruded into the spinning chamber (A 1. 5m long vertical column of cool air at 18®C - 20®C) is suitable targeted at the melt, the fibre formation takes place. As the melt enters the spinning chamber from the spinneret, it bulges slightly due to release of stored elastic energy. The fiber in process can be processed in two forms. For continuous filament yarn production. For cut staple fibre production which enables blending with other staple fibers like cotton and viscose. In cut filament spinning, the formed fibre is wound on to cheeses. These chesses are then drawn with a draw ratio of 1. 2-2 to orient the chains and get strength and denier. After applying the required spin finish, the final finished filament yarn is wound on to the required bobbins for sale to market. However for producing staple fibers large number of holes (upto 60000) is used in the spinneret. The molten fibre is spun into yarn in the spinning chamber and collected as tows in large cans. These tows are then drawn to the required draw ratio to get the required fibre properties and then taken for post spinning operations -like texturisation where bulkiness is added and then cut into required staples and baled. Solution Spinning: When the fibre melt is not stable at 30®C higher than MPt. i. e when it degrades or decomposes, solution spinning is resorted to. This is done by dissolving the polymer in a selected solvent and then recovering it by solidification either by evaporation of the solvent ( Dry spinning)or by coagulating the polymer by spinning the solution into a bath which contain a fluid non solvent of the polymer which is easily miscible with the solvent(wet spinning). Dry spinning: Dope is first prepared by dissolving the polymer into the solvent. Some solvents are given below for some fibres.

# Polymer

# Solvent

Nylon 6, 66Formic acidPolyacrylonitrileDimethyl FormaldehydePETTrifluoroacetic acid/DimethylPVAWaterPolystyreneDMF/TolueneNylon6 Co plolyamideFormic acidPolybenzamydazoleDimethyl acetaldehydePolyamideSulfuric AcidPolyimidePhenolCellulose acetate, cellulose triacetate, acrylic, spandex (Lycra), PVC, Chlorinated PVC are some polymers spun by the dry spinning methods. While low boiling point is an advantage, there is an accident risk while removing the vapour . The solvent should be relatively volatile, nontoxic, and nonexplosive.. Some agents can be added to the dope for colour etc, some impurities like water can be removed. The concentration of the fluids should be selected to give a uniform and coherent fluid flow. Some concentrations suggested are PAN 25%, PVC 30%, Chlorinated PVC 45%, Cellulose acetate 20%, Cellulose triacetate 25%. The viscosity range is 500 poise to 400 poise at 40®C. After filteration of impurities, the dope is sent through a spinneret made of tantalum, steel , nickel etc, under a pressure of 1-2 Mpa. In some cases higher pressure upto 8 Mpa is used. The thickness of spinneret also varies from 5 mm to 15 mm depending on the solution. The spinneret has a capillary hole of 0. 02 to 0. 03 mm with about 300 holes in a spinneret. The spinning chamber is 10m long and 25 to 45 mm in diameter. The chamber is kept hot by a jacket of hot gasses. The gas flow rate is 1-2 m/s and well directed to evaporate the solution from the dope. The temperature and concentration should not vary to explosive limits. About 90% of the solvent should be removed by drying. After spinning, yarn is

wound at a speed of 250-1500 m/min. After spinning further post spinning operations are drawing, washing, spin finish application, crimping, cutting, heat setting. Dry spinning is used to create some speciality effectsFibres with multilobal cross section. Hollow fibres. Bicomponent fibres. Fibres with pores. Sub micron fibres. Wet Spinnng: The fibre grade polymer is dissolved in a suitable solution with a concentration of 10-30%. The viscosity will be around 500 poises. Polymer solution directly obtained after solution polymerization reaction is sent to spinning directly after adjusting the viscosity and removal of unreacted monomer and other impurities. The polymer solution is metered and pumped through the spinneret which is having 200-600 holes. Low temperatures and pressures are only involved. The diameter of a hole is around 50µ to 250µ. Holes can be very close to each other, if the coagulation bath in which the spinneret is submerged has sufficient anti sticking spacing between the filaments. 200 to 50000 holes per spinneret also can be used. The emerging filaments are coagulated in a precipitating bath which has a non-solvent. The concentration, speed, non-solvent used, temperature of the bath are all critical and conducive for effective coagulation. Counter diffusion of the solvent and non-solvent and phase separation of the polymer takes place in a short time. The fluid is transferred into a rubber like solid as gelation takes place. Optimum conditions have to be maintained at the bath to avoid stretch breakages. The filaments are then washed and drawn to orient the fibres with a stretch of about 30 times. Spin finish is also applied after drying. For staples, the tow after washing is dried, oiled, crimped, heat set and cut into staples and baled. Melt spinningSolution spinningWet spinningDry spinningOperationsSuitable ForPolymers that give stable melts

when heated up to 30*c -60*C higher than the melting point. PolymerMpt•CSpgTemp •CPET250285-290PP165230-250Nylon66265290-295Polymers that can be dissolved in a non volatile solvent, which is miscible with another fluid, a Non-solvent of the polymer. PolymerSolventCoagulantViscoseAqueous of sodium salt and xanthate esterDilute H2SO4+Na2SO4+ZnSO4AcrylicDimethyl-acetamide (DMA)50% Aqueous Dimethyl AcetamidePVADMF (Dimethyle Formide), Water30% Aqueous DMFSpandexDMA30% Aqueous DMAPolymers that can be dissolved in a relatively volatile, but nontoxic & non explosive solvent in a predetermined concentration. PolymerSolventBPt •CAcetateAcetone56TriacetateEthylAlcohol78. 4Chlorinated PVCAcetone56PVAWater100SpandexDMF153PolyacrylonitrileDMF153Fiber FormingMechanismMolten polymer is drawn and cooled in a quenching chamber by directing cold air at 18-20*C. The solidified fiber is further drawn to orient the chain molecules. Counter diffusion between the solvent and the coagulant in the spin bath leads to phase separation of the polymer as the polymer is precipitated.. The polymer is dissolved and the solvent is removed from fluid filament by varpourisation with hot inert gas. Spinning zoneOnly heat transferHeat transfer and two way mass transferHeat transfer and one way mass transferSpinnability limitationFibers which are thermally not stable at above melting point temperatures cannot be spun. Very high molecular weight Polymers cannot be spun because the limits of viscosity at zero shear and thus the spinning pressure increase proportionally. Further washing and drying is requiredFinal product is exposed to heat. Strict requirements of the solvent. Solvent handling and disposal. Selection and availability at

reasonable costCOST /TONSpinning SpeedHighYarn: 6000-7000m/min FDYTow: 1000-1500m/minLowYarn: <200 m/minTow: 5-40 m/minMediumYarn: up to 1200m/minTow: 200-600 m/minRunning CostLow( only cooling is required)Removal &Recovering of solventCost of drying and cost of disposal of effluents. Investment reqdLowLowHighAdvantagesHigh speed (1000 to 1500mts/min)for tow 6000 mts/min for spin drawNo solvent neededNo purification. Large tows can be handledDrawing, cutting and crimping can be combined. No purification is requiredDisadvantagesSeparate drawing stepSlow (60-150 mts/min)Washing to remove impuritiesSolvent and chemical recoveryFlammable solvent hazardSolvent recoverySlower (200-400 mts/min)Operating ConditionsPolymer mass viscosityHighMediumMediumHeat inputHighVery LowVery HighOperating TempHighVery LowHighPressure10-30MPaHighUp to 2MPaLow2-4MPaLowSpinneretSteelThickness 5mm-15mmHoleDia 0. 15 to . 5 mmSteel/glass/noble metalsThickness2-5mmHole Dia: 0. 025-0. 25mmSteel, glass, and other noble metalsThickness5-15mmSensitive Process parametersMechanical & Thermal factors like spineline tension, stress, velocity fields, Rate of cooling. For example, 1% variation in extrusion Temp results in 10% variation in spinline stress, which causes a higher cv of resulting fiber diameter. The fiber properties are not decided by thermal or mechanical process parameters; but by coagulating conditions, intensity of mass transfer between the spin line and the surrounding medium and all kinds of concentration related transitions phase separation, gelation etc. The concentration and viscosity of the solution-is important. Dripping condition to be avoided. Fibre propertiesFiber Cross-sectionFollows the profile of the

spinneret*Pictures adapted from [3]DeformedDeformedFiber structureCompact structure with smooth surfaceMicro porous with rough surfaceMicroporous with compact surface. As-spun fibers are not oriented, Crystallisation forms during cooling. But fibers have more uniform cross section, from center core to outer. Highly oriented because of the hydraulic drag and highly crystalline because of low temp fiber forming but low crystal orientationSkin core effect, voids and cracks on the outer surfaceHigh degree of crystallinity, low crystal orientation, skin- core effect because of differentially drying and diffusion from centre to outer , voids and cracks during removal of residual solventSolidificationBy CoolingBy CoagulationBy EvapourationSolventNo Solvent is requiredOrganic , not stringent requirementsOnly organic, non toxic, non-explosive, should be selectedHealth Hazard/ToxicityNon toxicToxicToxic & Accident RiskyEnvironment HazardNo solvent disposal. Solvent Recovery and disposalSolvent Recovery and DisposalDryjet wet spinning: It is a modified version of wet spinning in which the spinneret is 3 -5 mm outside the coagulation bath. The dope is extruded as a dry jet and then taken to the coagulation bath in which wet spinning takes place. This is to combine the advantages of dry spinning and wet spinning. Some are, The voids in the as spun fibres are eliminated. The higher speeds of dry spinning are made possible. The thread line stresses created by the drag forces of the wet spinning are not transmitted back to the spinneret. The high stretch of dry spinning is present but fibre formation takes place in the wet bath and all other parameters are controlled by the coagulation bath. Explosion risk is avoided. Spinning sub-micro fibres is possible (< 1denier). The fibres are

uniform and less oriented, as the air gap relaxes the orientation produced in the spinneret. Hence they can be drawn and stronger fibres can be produced.