Chemical Technology
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Module - 8
Polymer
Lecture - 08
Viscose Rayon and Acetate Rayon

We are discussing the module 8 of the organic chemical technology course, which is about the polymer, elastomere and synthetic fibre and in the previous 3 lectures we discussed about the nylons. We discussed about the nylon 6, nylon 66, polyester and then the acrylic fibre and how the development that has taking place in these sectors and how it has played important role in meeting the synthetic fibre demand of the growing population.

Now today, I will be discussing about the viscose rayon that is acetate rayon and cuprammonium rayon, which is one of the very important sector in case of synthetic fibre and because of its very good quality and the appearance like the silk rayon that has been in use and for only thing that in here the difference because in case of the all the other synthetic fibre, which is we call it the true synthetic fibre or the manmade fibre that is the nylon or the polyester or the acrylic fibre which the raw material major raw material is from the petrochemical fibre, here rayons are based on the cellulose raw material, good quality of cellulose having alpha cellulose, loose semi cellulose and the pentagon. So, these are the some of the basic difference, here we are dependent upon the natural raw material.

So, the coverage of the lecture that will be on the introduction, properties of the viscose rayon, Indian capacity of the viscose rayon, application of the viscose rayon, then the process details of the viscose rayon manufacture. Then we will be discussing about the acetate rayon and the cuprammonium rayon. Although the amount of the total capacity if you see the production wise it is more in case of the, much more, in case of the viscose rayon than the acetate and cuprammonium rayon, but, some of the other raw material definitely that will be from the petrochemical.

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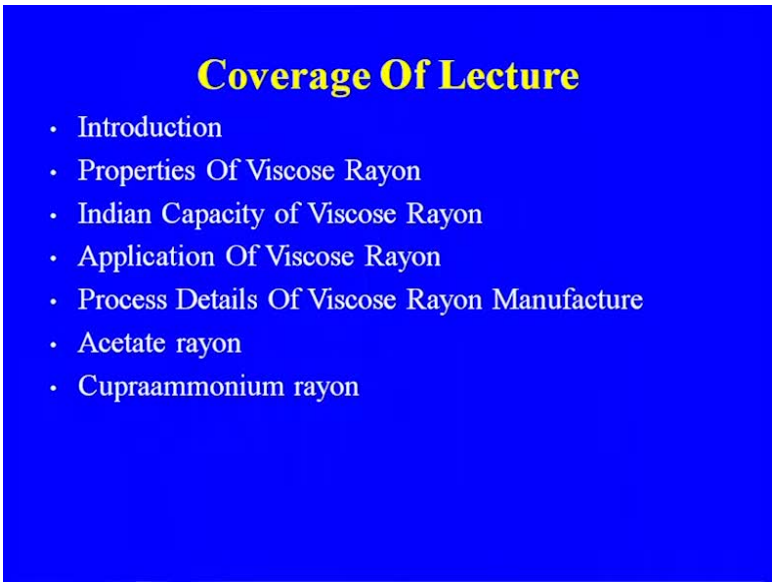

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This is you can see the viscose fibre how it looks like and it is just like woollen material or the acrylic fibre you can say and the brightness you can see the brightness of the fibre also and because of the more and more comfort we are having in case of the viscose now the use of the viscose in the textile that is increasing day by day.

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This is also is the acetate fibre which was, this is also the silk like appearance we are having.

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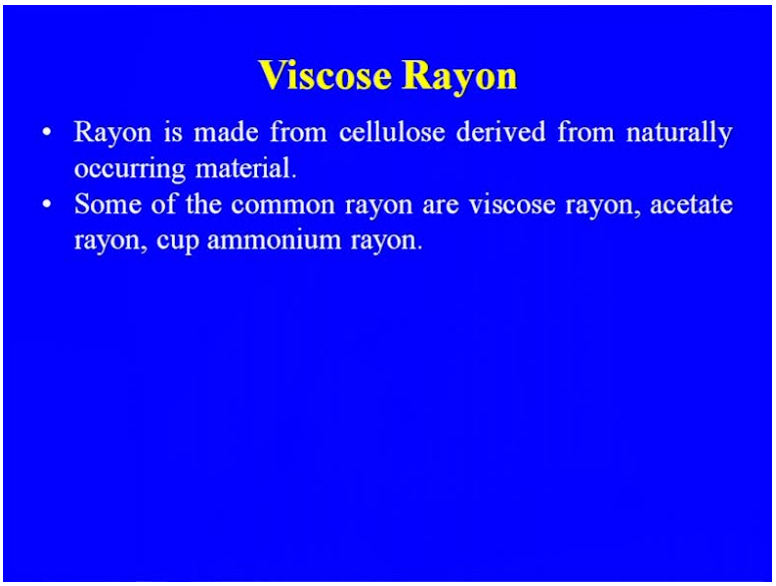

So, the rayon is made from cellulose derived from natural occurring material, especially the wood we are using here, wood pulp we are using in case of the rayon making. Some of the common rayon's are the viscose rayon acetate rayon and the cuprammonium rayon.

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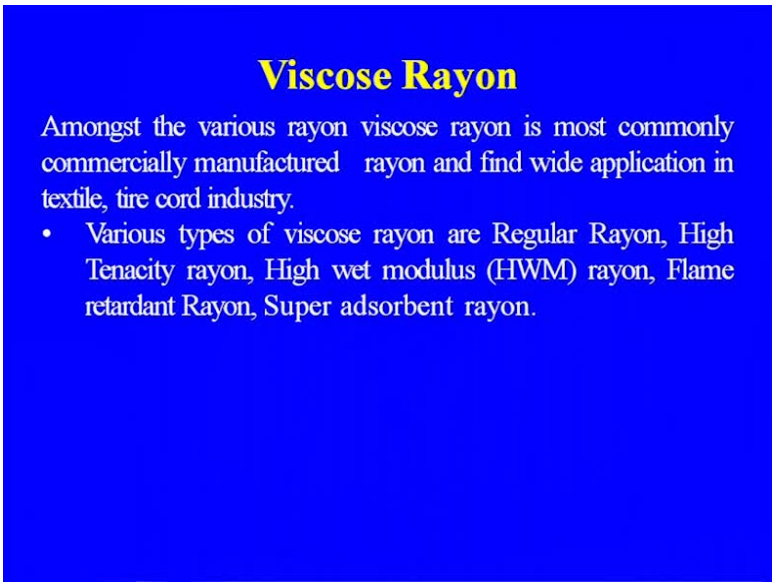

Amongst the various rayon, viscose rayon is the most commonly commercially manufacture rayon and find wide application in textile, tire cord industry, because as I told you earlier also that the tire cord that has been one of the major consumer of the synthetic fibre but, with the coming of the other fibre the petrochemical based synthetic fibre now, more and more polyester or it may be the poly propylene fibre or it may be the nylon that is going in tire cord industry. But, the importance definitely because the viscose that was available earlier than the coming of the your these nylons or it may be the acrylic fibre. So, the importance of the viscose rayon is both in the oven and non oven.

Various type of the viscose rayon and that we are having the regular rayon, high tenacity rayon, high wet modulus rayon, flame retardant rayon, super adsorbent rayon. Viscose rayon has a silk aesthetic with superb drape and the feel and retains its rich brilliant colour, which I showed you in the diagram, the picture of the viscose fibre brilliant colour.

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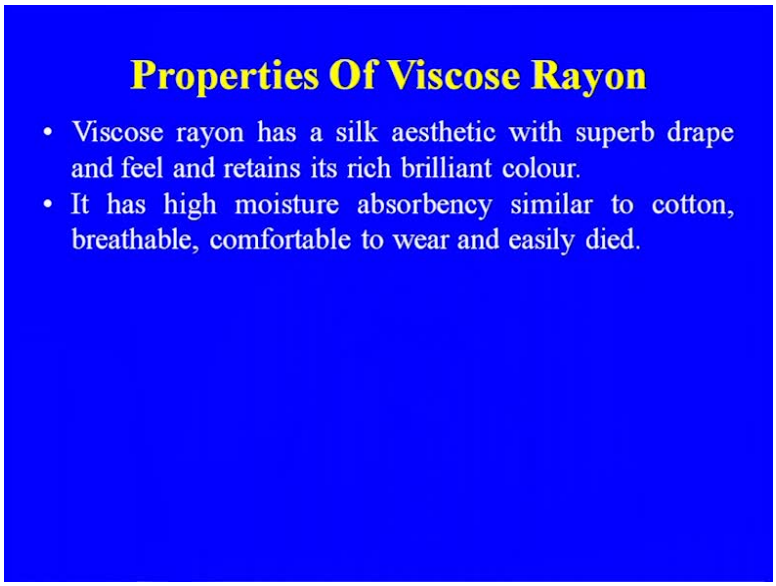

It has high moisture absorbency similar to cotton and this is the reason why we are consuming more and more viscose composition blend along with the it may be the acrylic fibre or it may be the polyester, because the cost of the viscose is less than the cotton, breathable, comfortable to wear and easily dried, because in the earlier stages of the coming of the manmade fibre dying was also a problem for synthetic fibre, especially the polyester and the nylon and the lot of the development that took place in case of the dye manufacture also and so the dying that was the more easier in case of the synthetic fibre with the coming of the new breed of the dye's.

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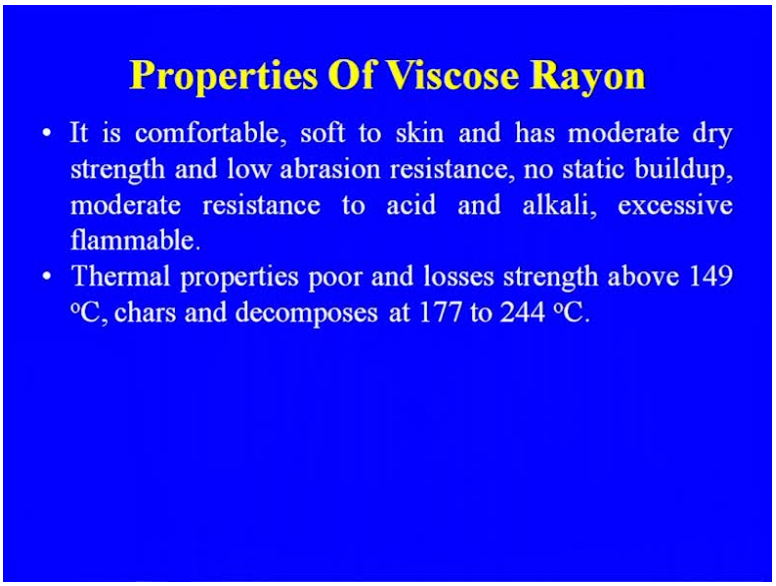

So, the in case of the viscose rayon, it is comfortable soft skin and has moderate, because that was the softness that was your problem in case of the polyester when it came into the market because, most of the textile 100 percent polyester suiting's 100 percent polyester shirts were there and so, that was not comfortable. So, one of the advantage in case of the viscose and now we will see in market the very soft textile materials are there which is because of the viscose rayon, the soft skin and has moderate dry strength and low abrasion resistance and no static build up, as in case of the other polyester and the nylon is there, moderate resistance to acid and alkali, excessive flammable, but, this is the one of the disadvantage.

Thermal property is poor and loses strength about 9 degree chars and decomposes at so the melting point, this was the reason why the from the viscose to nylons or the polyester in the tire cord industry that was because, what we need in case of the tire cord industry higher melting point and that was the reason because in case of the nylon and polyester or the acrylic that is we are having plus 230 melting point or the sticking point. So, that is the one of the disadvantage in case of the viscose rayon that is the low melting point.

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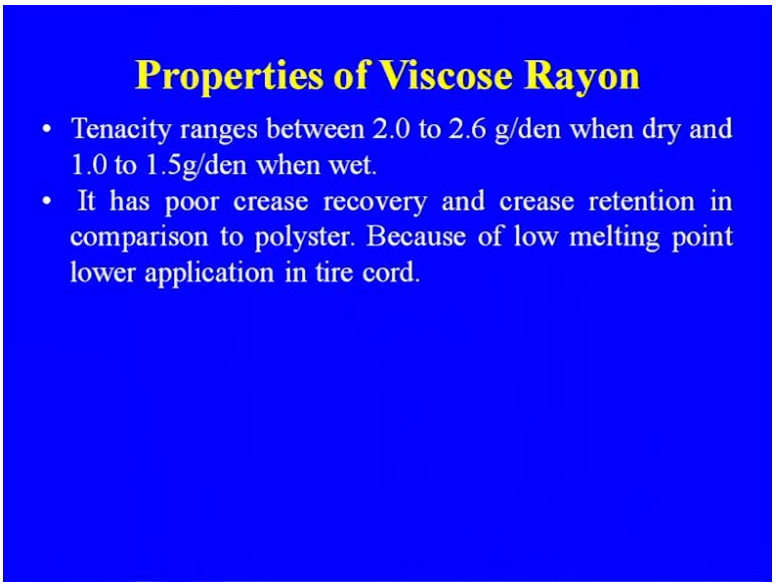

Tenacity ranges between 2 point 0 to 2 point 6 gram per den here and dry and 1 point 0 to 1 point 5 den here when wet. It has poor crease recovery, because this is the 1 of the problem even in case of the cotton but, so far the crease is concerned ironing property is there it is better in case of the polyester or in case of the nylon but, in case of the viscose

and the cotton this the crease problem is there in case when you are using in case of the textile.

So, it has poor crease recovery and crease retention in comparison to the polyester because of the low melting point lower application in the tire cord that is there. But, earlier when it was not available the people were using the viscose rayon also but, the you see the now the speed of the vehicles that is increasing and so, the temperature rise is there and so, we need the more high temperature high melting point material for the tire cord industry and so, that was the shifting from the viscose rayon to your polyester or the nylons.

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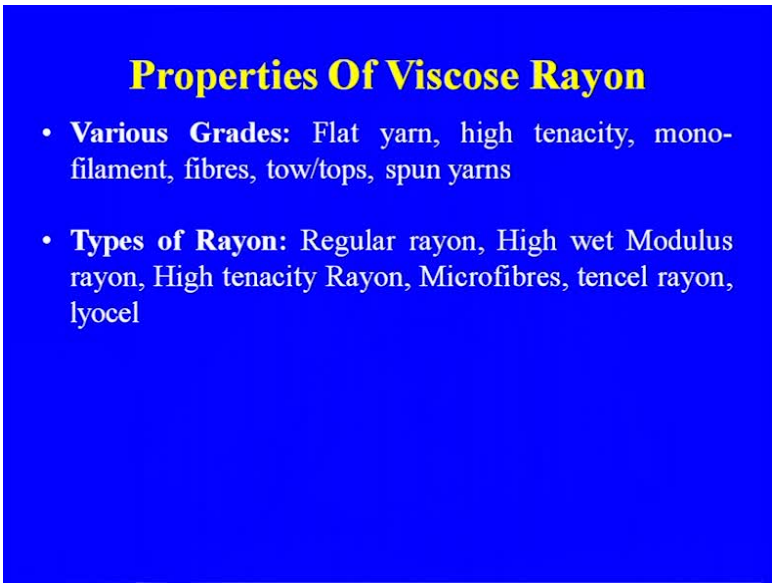

These are the various grades of the viscose rayon types of the rayon: regular high wet modulus, high tenacity, micro fibres, Tencel rayon the lyocell these are the some of the trade name also that is these.

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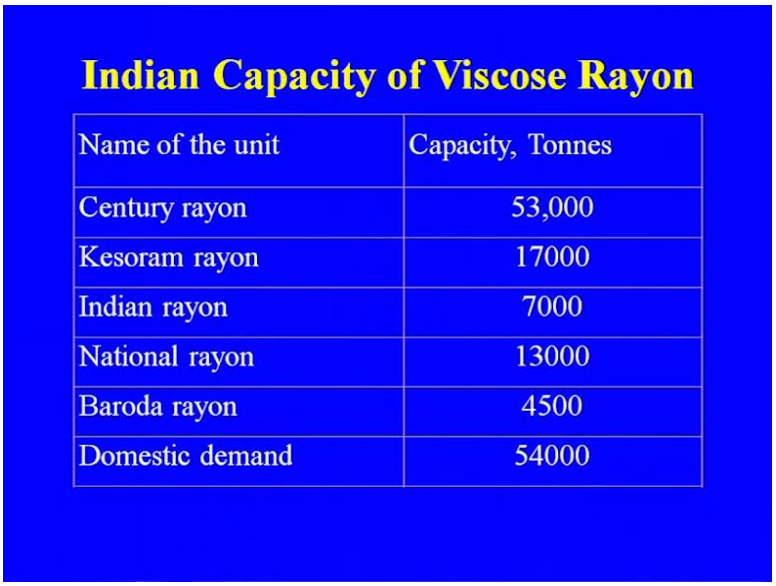

These are the some of the major producers of the rayon. 1 is the century rayon that is because; most of these companies are by the Birla group because they are pioneer in also the paper making. So, century rayon they are having the 1 unit is at Kalyan, another the pulp they are making at the century pulp and paper and that adds Kashipur that they are having 1 plant. Grasim industry they are heavier polyfibre, these are the other which are making the rayon get pulp. Kesoram rayon they are making rayon, Indian rayon, national rayon, Baroda rayon and so this is the domestic demand of the viscose

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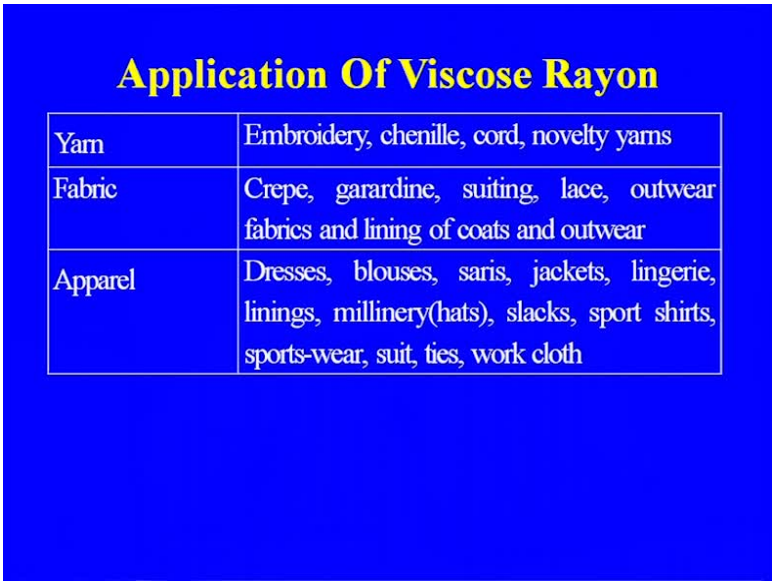

So, the applications of the viscose rayon; yarn, then embroidery, chenille, cord, novelty yarn. The fabric; crepe, garadines, suiting, lace, outwear fabrics and lining of the coats and outwear. So, these are the in case of the fabric we are using even the lining part is there were more your softness that is required.

So, lining part of the coats we are having the viscose fabric. Apparel are dresses, blouses, saris, jackets, lingerie, linings, hats millinery, slacks, sports shirts, sportswear, suit ties and the work cloth.

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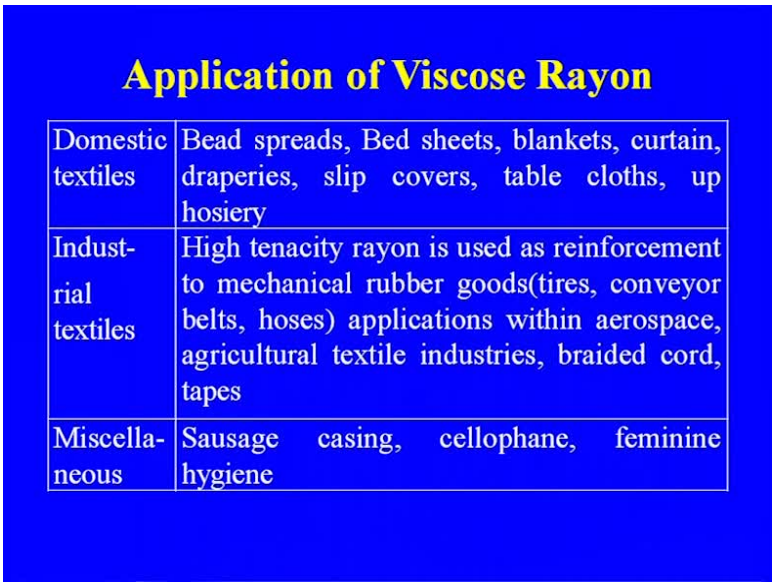

So, these are the some of the apparel that we are making from the domestic textiles bed spreads, bed sheets, blankets, curtains, draperies, slip covers, table clothes and the hosiery. In Industrial textiles, high tenacity rayon is used as reinforcement to mechanical rubber goods, tires, conveyor so, here actually the requirement that is the high tenacity rayon, so the tires, conveyor, belts, hoses, application within the aerospace agriculture textiles industry and then the braided cords and the tapes. Miscellaneous uses; that may be the in the sausage casing, cellophane and then the feminine hygiene.

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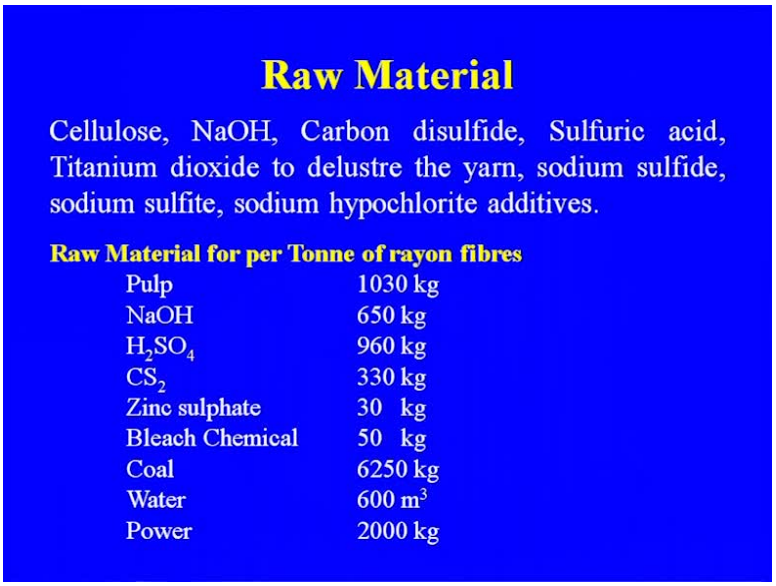

What are the raw materials you see? Here you see the major raw material which we are using for the making of, whether it is viscose rayon or the acetate rayon that is the cellulose. Then the caustic soda, carbon disulphide, sulphuric acid, titanium oxide to delustre the yarn and then the sodium sulphide, sodium sulphite, sodium hypochlorite these are the some of the other actually the raw materials. 1 of the another important raw material that we are using the carbon disulphide in case of the viscose rayon, acid and acetate anhyde in case of the other rayons that we are using.

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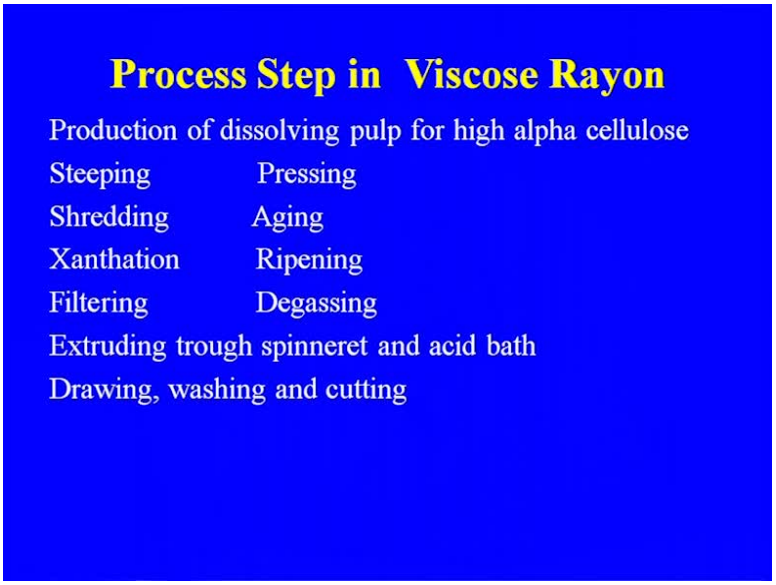

This is the requirement especially in case of per ton of the rayon fibre of the various raw material pulp, NaOH, H2SO4, carbon disulphide, zinc sulphate, because here the spinning so that is the spinning bar that we are doing by the way it is. This is called the regeneration wet spinning that is being done in case of the viscose rayon and other rayons.

These are the various steps involved in case of the viscose rayon that is, the first step that is the production of the dissolving, because the pulp which we are using, because we are using the pulp for making the paper and the news print, here the pulp which we are using for the making of the rayon that we call the dissolving grade pulp for high alpha cellulose because what is happening even where 1 of the process which we are using in case of your treating with the caustic soda, so, alpha cellulose, high alpha cellulose content that is required and so that is the beta and gamma cellulose which present that we are removing.

So, the stripping pressing, shredding aging, xanthation ripening, filtering degassing, extruding through spinneret and acid bath drawing, washing and cutting. So these are the steps.

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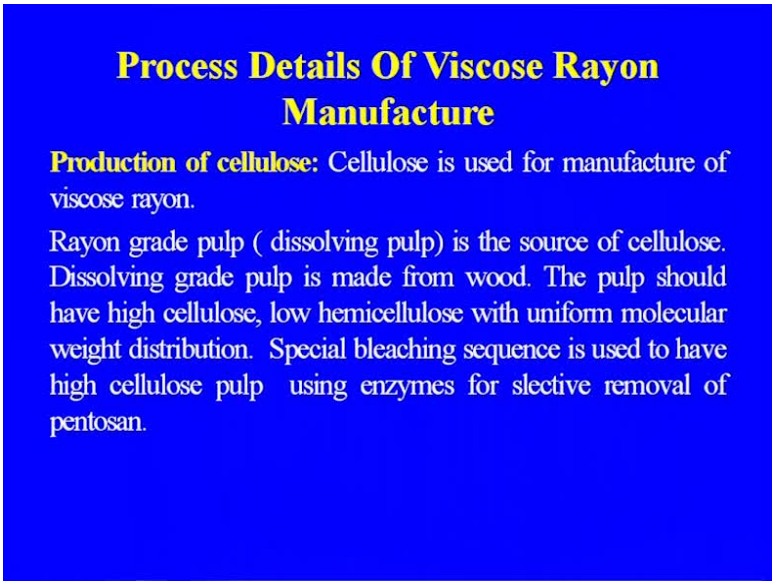

And easy steps we will be discussing in detail because there is importance of the each and every step in the manufacture of the viscose rayon because that will affect the quality of the viscose that we are making. First thing that is the pulp, which we are getting, what

will be the source of the cellulose. Cellulose used for the manufacture of the viscose rayon. So, rayon grade pulp we call it that we are using. So, rayon grade pulp or dissolving pulp is the source of the cellulose. Dissolving grade pulp is made from the wood, mostly it is the wood pulp that is preferred and especially the softwood but, some eucalyptus because eucalyptus having the very good quality of the pulp so that has been also used. So, dissolving grade pulp is made from the wood.

The pulp should have high cellulose low hemicellulose with the uniform molecular weight distribution. Special bleaching sequence, because you see the lot of the detoriation in the quality and the strength of the pulp is there during the bleaching when we are using the conventional bleaching of the chlorine or chlorine dioxide or the hypo chloride bleaching. Here, we need this some of the other modified bleaching sequences for the making of the rayon grade pulp and 1 of them is the enzymatic bleaching. Also, the oxygen chlorine dioxide or the oxygen delignification that may be there or it may be polysulphide pulping. So, different type of the pulping processes also there but, bleaching we will have take care so, that the minimum damage is there and at the same time the selective removal of the pentagon is also there when you are using the enzymes.

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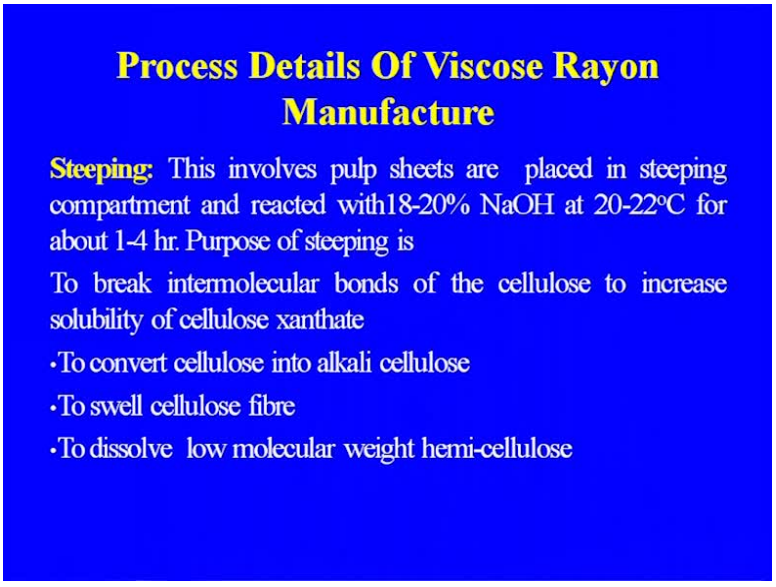

So, this is the basic requirement in case of the your rayon grade pulp and you see the different, it is not the similar process which you are making from the broad process is same which we are making the pulp for the paper making but, here the special quality of

the rayon grade pulp that will be required for making with the high alpha cellulose hemicelluloses pentagon all those that should be minimal.

So, the first step in case of the manufacture of the viscose rayon is the steeping process. This involve the pulp sheets are placed in steeping compartment and reacted with 18 to 20 percent NaOH at 20 to 22 degree centigrade for about 1 to 4 hour, because you see the purpose why if you see the definition of the alpha cellulose beta and gamma cellulose, so, the alpha beta and gamma cellulose when we are treating with the 17 point 5 percent of the NaOH, so, alpha cellulose that remains as such and the beta and gamma cellulose they dissolve. So, that is the reason of the keeping the 18 to 20 percent NaOH.

Then what is the purpose? This is 1 purpose to break the intermolecular bonds of the cellulose to increase the solubility of the cellulose xanthate because finally, we are treating with the carbon disulphide for xanthation. So, to convert the cellulose into alkali cellulose because, this alkali cellulose that further we are using. The swell cellulose fibre, because the swelling of the fibre and so, the better actually your reaction of the carbon disulphide that will be there, to dissolve the low molecular weight hemi cellulose.

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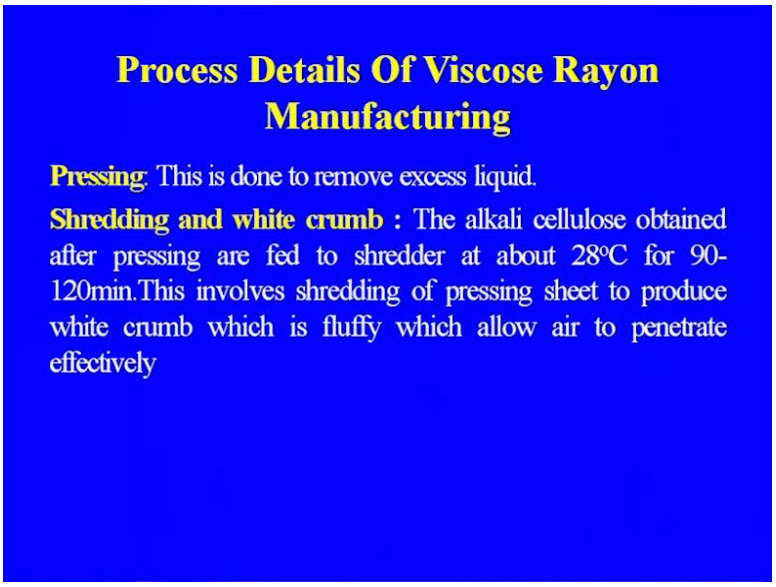

Then, the next step in case of the viscose rayon manufacture is the pressing part. This is done to remove the excess liquid which is there and so, finally, after the pressing the your cellulose that will go to the shading and the white crumb that we will be getting, the alkali cellulose obtained after pressing are lead to shredder at about 20 degree centigrade

for 90 to 120 minutes. This involves shredding of the pressing sheet, which we are getting from the previous step, to produce white crumb, which is fluffy which allow air to penetrate effectively inside.

So, because if you are taking as such the pulp if it is not fluffy then the reaction of, xanthation reaction which we are using in the substance stages that will be not effective. So, this was shredding and the making of the white crumb that is also very important step in case of the viscose rayon manufacture.

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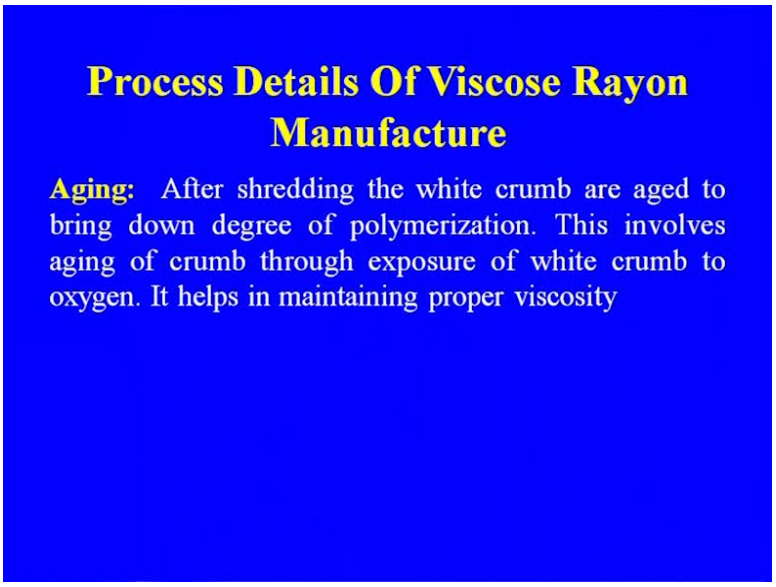

Then it comes the aging. After shredding the white crumb are aged to bring down degree of the polymerization. This involves aging of the crumb through exposure of the white crumb to oxygen. It helps in maintaining the proper viscosity. This is the next step after your shredding. This is the main reaction which is taking place in case of the viscose rayon and that is one of the very important reactions that is xanthation where the we are reacting with the carbon disulphide after aging.

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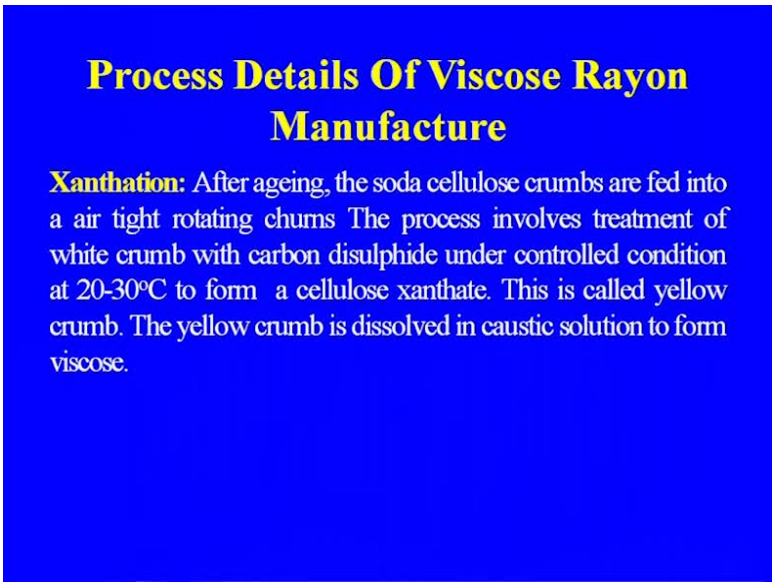

The soda cellulose crumbs are fed into air tight rotating churns, these are also churning process. The process involves treatment of the white crumb with carbon disulphide under controlled condition at 20 to 30 degree centigrade to form a cellulose xanthate. This is called the yellow crumb, which we are getting and this is going for the further processing to get the viscose rayon. The yellow crumb is dissolved in caustic soda to form viscose.

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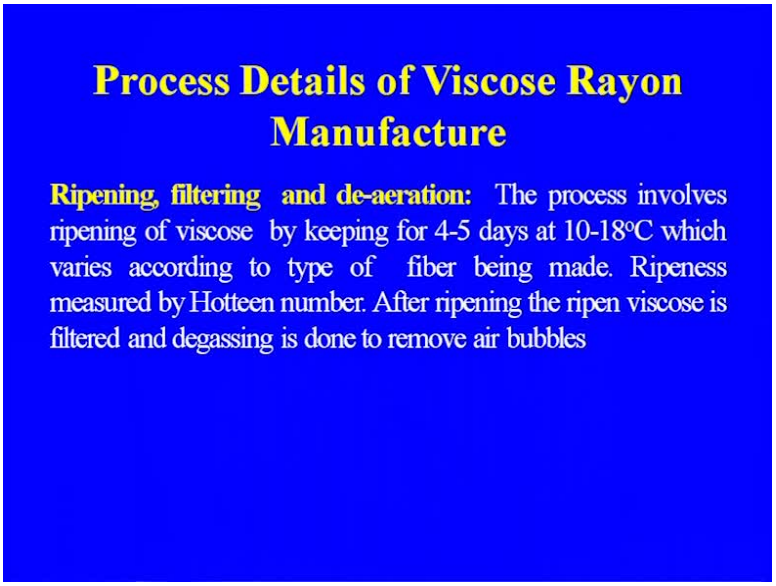

Then the next step in case of the viscose rayon is the ripening, filtering and de-aeration. The process involves ripening of the viscose by keeping it for 4 to 5 days, because here

the low temperature is there and so, that is also 1 of the important requirement in case of the viscose manufacture, by keeping this various types of the fibres being made.

Ripeness measured by the Hotteen number, that is 1 of the number of the ripeness is there. After ripening the ripen viscose is filtered and degassing, degassing is another step there to remove the air bubbles which is there.

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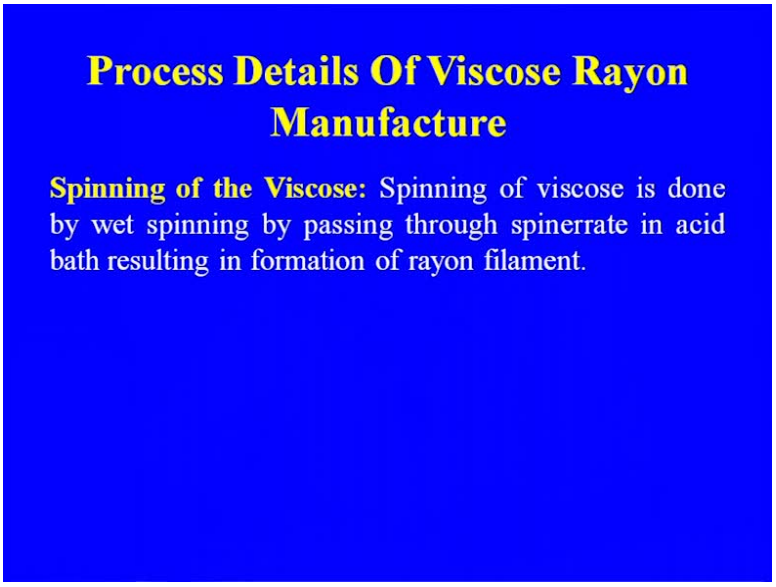

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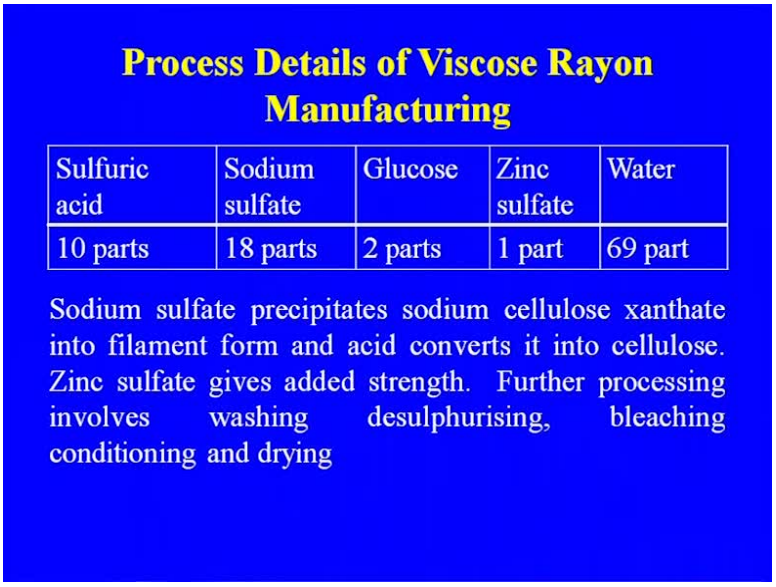

Now the let us discuss the spinning of the viscose, because as I told you earlier here what are doing? We are doing this bed spinning and this is also called the regenerated cell. So,

spinning of the viscose is done by wet spinning by passing through spinnerette in acid in acid bath resulting in formation of rayon filament.

This is your bath composition. Sulphuric acid, sodium sulphate, glucose, zinc sulphate and water. This is the composition of your bath in case of the spinning bath which we called it the sodium sulphate precipitates sodium cellulose xanthate into filament form. This is why sodium sulphate that has been added and acid converts it into cellulose. Zinc sulphate gives added strength. Further processing involves, after this rayon is formed or the yarn is formed so, what is the next step? Further process involved washing, desulphurising, bleaching, conditioning and drying.

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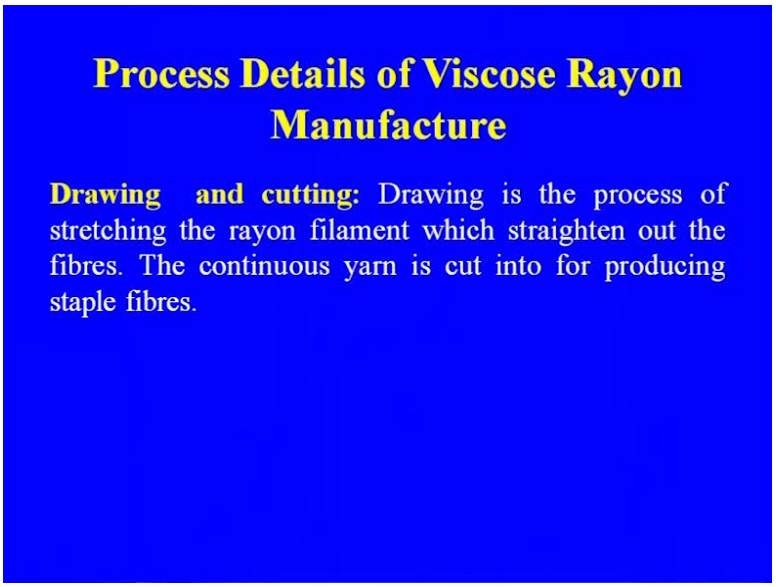

Drawing And cutting; Drawing is the process of stretching the rayon filament which is straighten out the fibres, because this is 1 of the very drawing in all the cases of the fibre drawing is very important in to give strength to the yarn. The continuous yarn is cut into for producing staple fibres. What are the various variables involved in case of the viscose rayon? The spinning process, temperature and composition of the bath, speed of the coagulation, length of the immersion, speed of the spinning, stretch imparted to the filament, because the that is as I told you the stretch imparted to the filament that is also very important. So these are the some of the parameters which are affecting your spinning process.

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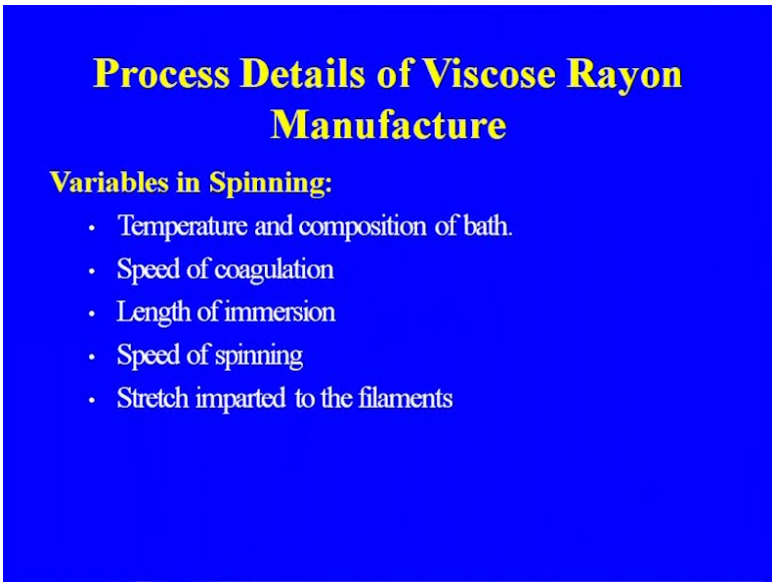

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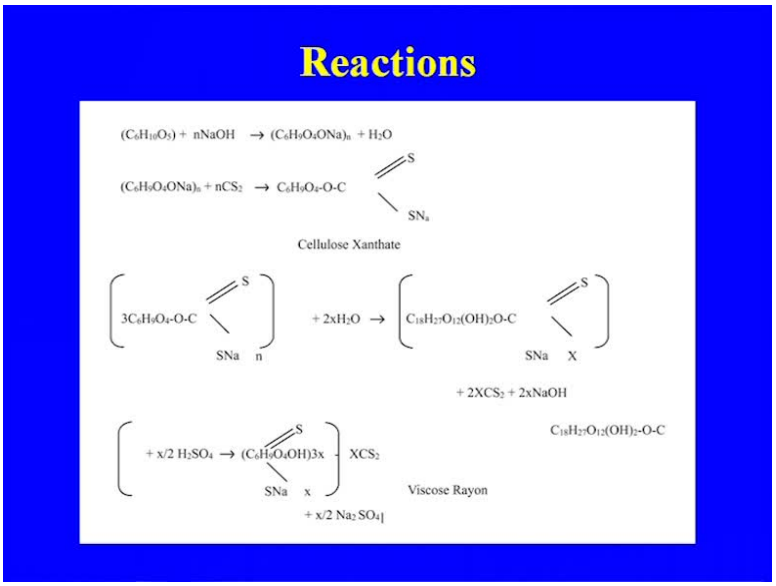

This is the reaction that is taking place and the cellulose with NaOH. Then it is the sodium cellulose that you are getting and after reacting with the carbon disulphide, cellulose xanthate and this cellulose xanthate again we are getting the regenerated cellulose and in the form of the yarn.

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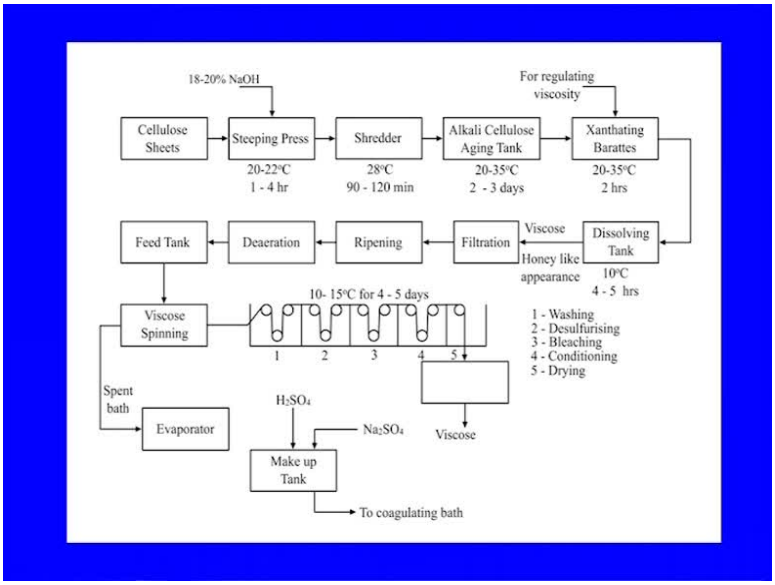

So, this is the process which I discussed about the manufacture of the viscose rayon. This cellulose sheets in the form of the sheets we are getting the pulp and that sheet or the pulp sheet or cellulose sheet, whatever you say it, this is going to the steeping and press section.

Then the shredder alkali cellulose aging tank, xanthation reaction where the for regulating the dissolving tank filtration, ripening, de-aeration, that is removal of the air bubble and then the viscose spinning. These were the actually the steps which you discussed in detail earlier and so, this is the process flow diagram and then the viscose spinning that will go to spinning bath where the viscose fibre that will be getting. This is about your, it is going to the coagulating bath that is the makeup tank where H2SO4 and Na2SO4 that we are adding. So, this is the washing, desulphurisation, the bleaching and the conditioning and drawing. These are the some of the other steps that are involved.

Now let us come to this. This was about the viscose rayon. You see, the viscose rayon, as I told you, that is 1 of the very important part of synthetic fibre which we are using in our daily life. Another type of the rayon which was produced earlier that was the acetate rayon and this is the just appearance silk like appearance. It is just like the synthetic silk we used to call it and we are calling the acetate rayon.

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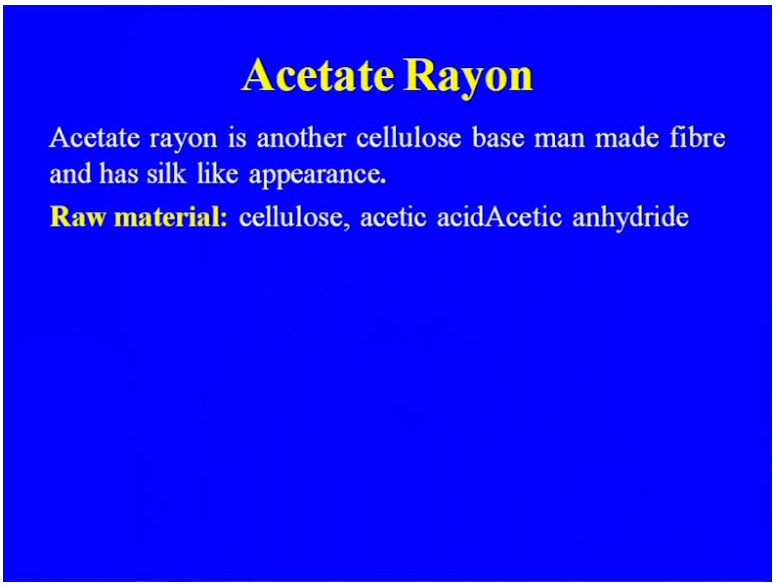

Acetate rayon is the other cellulose based manmade fibre and has silk like appearance. The raw material is cellulose, acetic acid, acetic anhydride. Again the acetic acid or acetic anhydride can be from the alcohol route or it may be from the petrochemical route.

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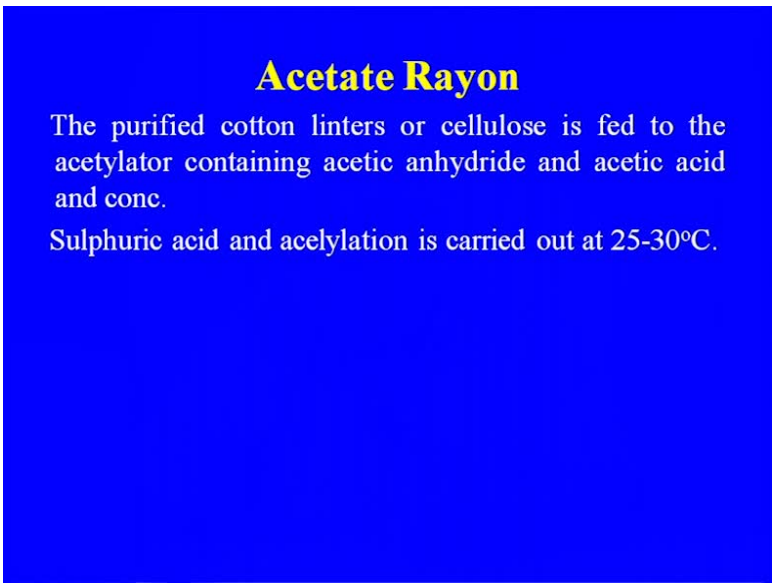

Here, the purified cotton linters, where the cotton linters or cellulosic is a cellulose, cellulosic material both the cotton linters that is the fibre is more stronger than the cellulose, is fed to the acetylator containing acetic anhydride and acetic acid and concentrated sulphuric acetylation is carried out at 25 to 30 degree centigrade.

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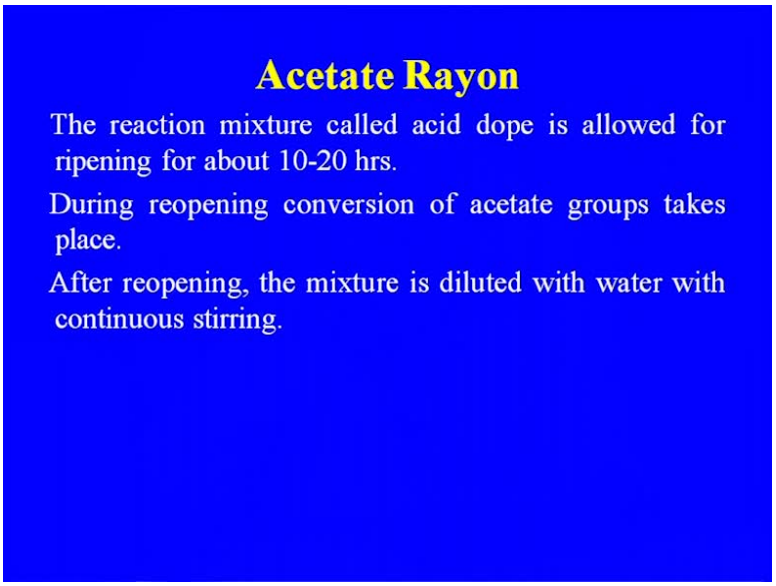

This is the reaction mixture called the acid dope is allowed for ripening for about 10 to 20 hours. During ripening that is the conversion of the acetate groups takes place. After this, the mixture is diluted with water with continuous stirring.

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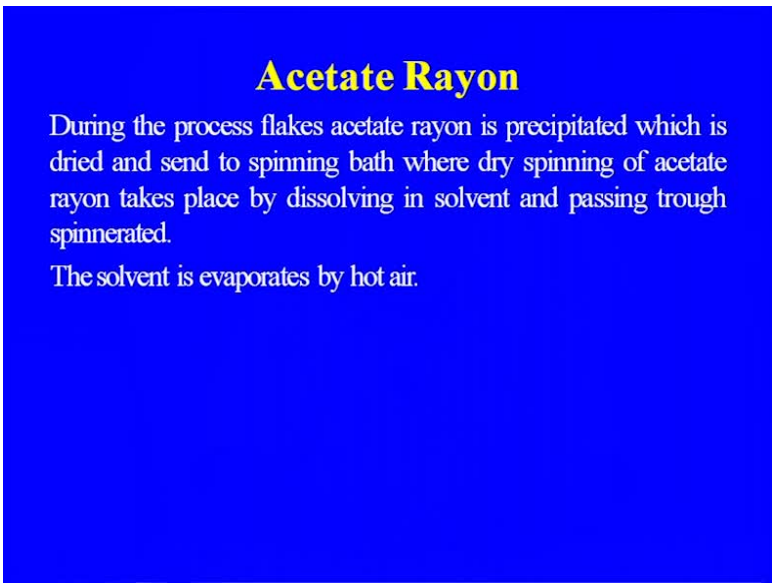

During the process flakes acetate rayon is precipitated which is dried and sent to the spinning bath where dry spinning of the acetate rayon takes place by dissolving in the solvent and passing through spinneretted.

So, that is not the degenerated as in case of the viscose rayon we are doing the wet spinning. Here, in case of the acetate rayon where we are having dry spinning also. The solvent is evaporated by hot air during this spinning process, where the because the it will pass through the number of folds are there in spinnerette and the continuous rayon that will be getting and the drying of the removal of the your solvent that will be there.

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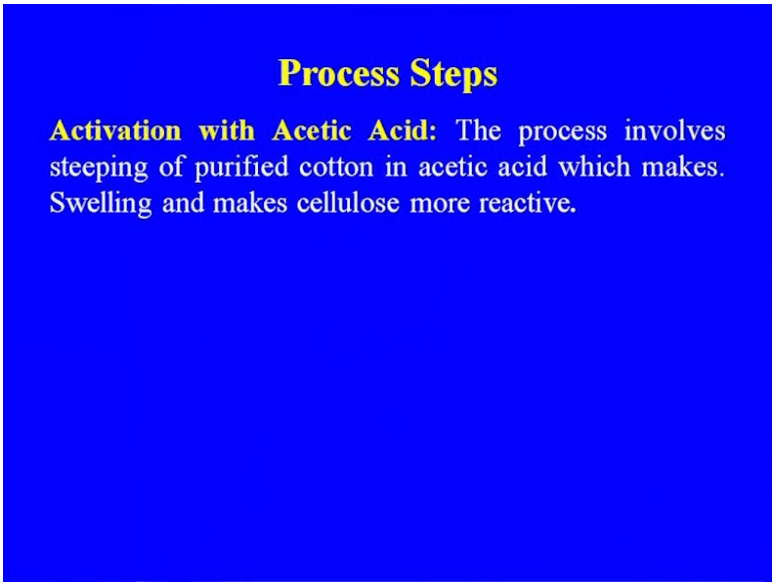

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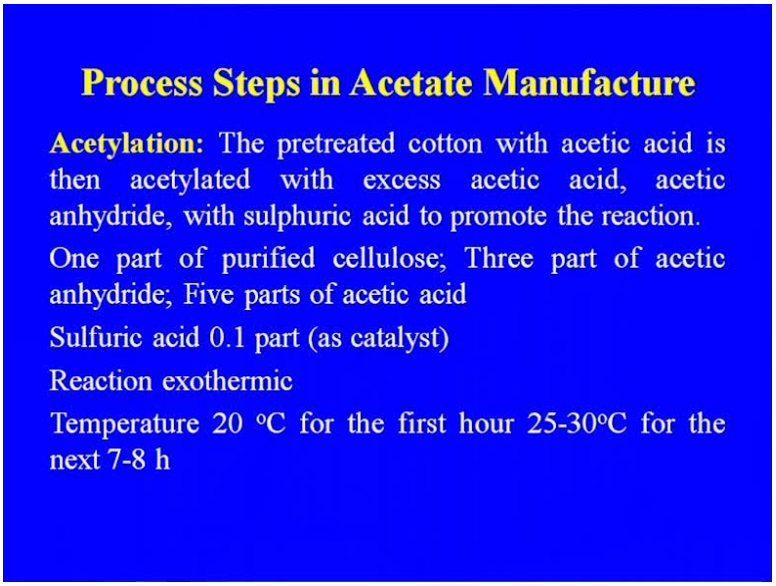

Activation with the acetic acid; the process involves steeping of the purified cotton acetic acid which makes swelling and makes the cellulose more reactive. So, that was the purpose of the activation with the acetic acid acetylation, already we discussed this part.

The pre-treated cotton and the acetic acid is then acetated with the excess acetic acid, acetic anhydride, with sulphuric acid to promote the reaction. So, 1 part of the purified cellulose, 3 part of the acetic anhydride and 5 part of the acetic acid, that is the combination. Sulphuric acids as catalyst 0 point 1 part, reaction is exothermic, the temperature is around 20 degree centigrade for first hour and 25 to 30 degree centigrade for the next 7 to 8 hours.

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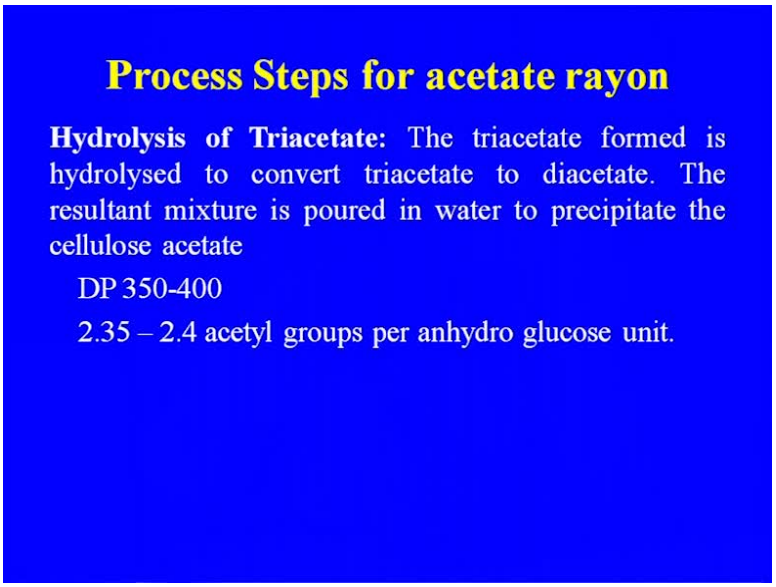

Then the hydrolysis of the triacetate; the triacetate form is hydrolysed to convert triacetate to diacetate. The resultant mixture is poured in water to precipitate the cellulose acetate fibre with the degree of polymerization 350 to 400. Properties of the acetate rayon; tenacity 1 point 4 gram per denser, melting point 230 degree centigrade and decompose when melted readily, soluble in acetone methyl, ethyl ketone, methyl acetate, ethyl acetone, chloroform and the ethylene chloride

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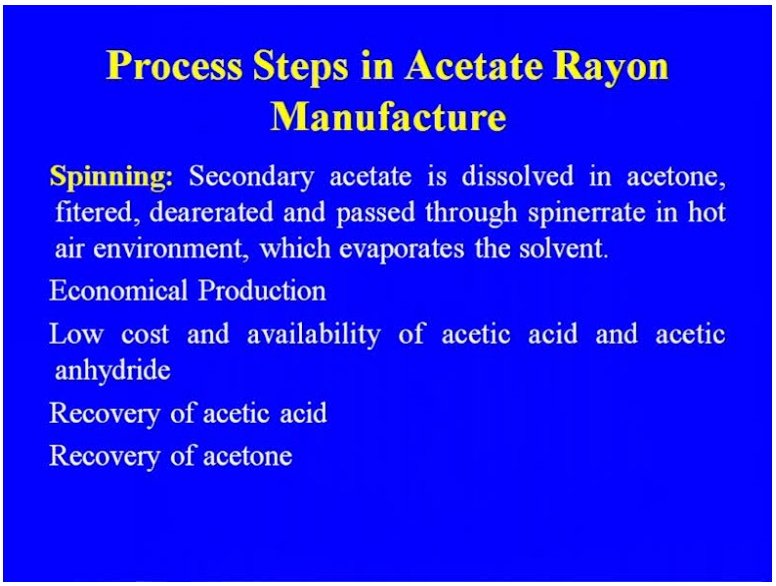

So, this is the spinning, already I told you this spinning is dissolved in the acetone that we are using as a solvent and then the filter de-aerated and passed through the spinnerette in hot air environment, which evaporates the solvent. So, that is the spinning process dry spinning process that we are using. So, low cost and availability here actually as we are using huge amount of the acetic acid and Acetic anhydride, so, the some of the economical production that will depend upon the low cost and availability of the acetic acid and acetic anhydride recovery of the acetic acid. That is very important in case of the polyester, also, recovery of the acetic acid that is very important. Here the recovery of the acetone that we are using for the spinning that is that has to be recovered effectively and economically.

So, these are the some of the issues involved in case of the 1 of the major problem that has been in case of the all the rayons, because we are using the forest raw material, means the wood for making of the pulp. So, that is from the environment point of view and the deforestation point of view.

So, this is the process which I told you the acetic anhydride H_2SO_4, acetic acid and the pulp and the here acetylator. That is the cotton linter or the wood pulp that is going to the acetylation and then the it is going aging, precipitation, centrifuging and cellulose acetate for spinning that is going when we are doing the dry spinning we are doing.

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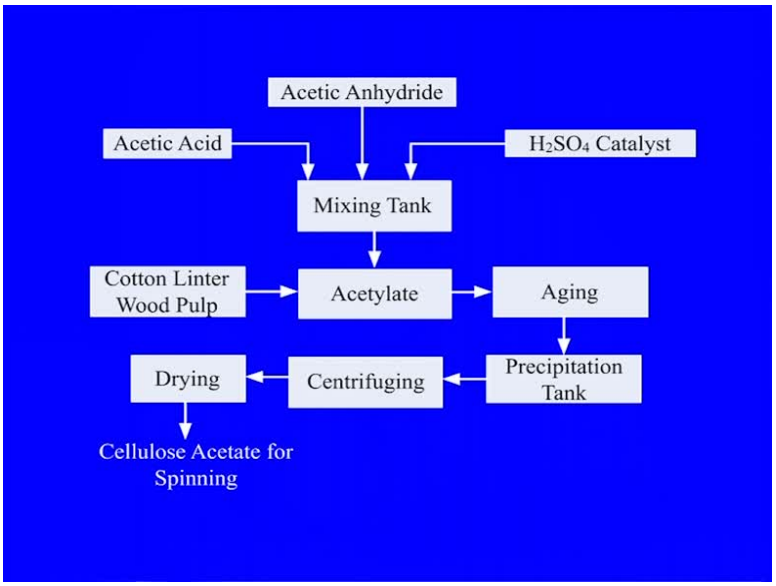

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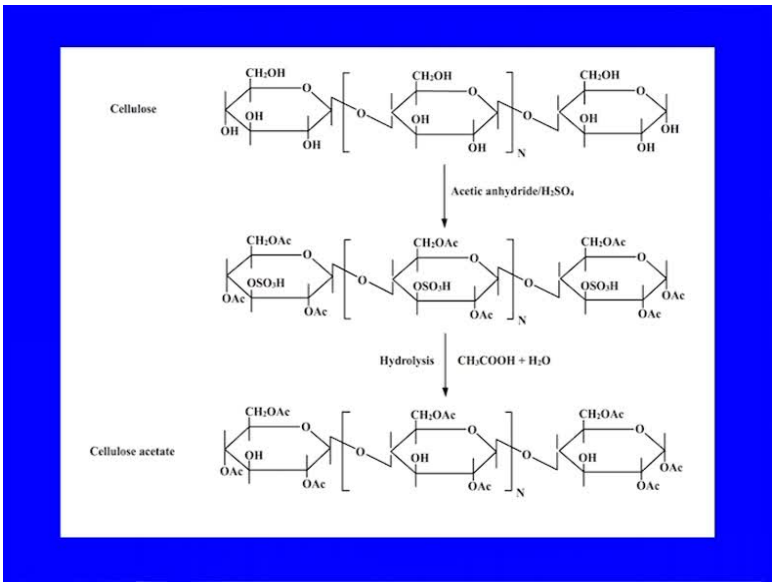

This is the reaction that is taking place during the acetylation. Now, let us come to another important class of the cellulosic base rayon that is the cuprammonium rayon. Although the amount of acetate and cuprammonium is much less than what you have in case of the viscose rayon but, these are the apart of this rayon some other rayons are also there which are made from the natural fibre, that is just a galvinate fibre, soyabeen fibre so, all those things are also there. Let us discuss now the cuprammonium rayon.

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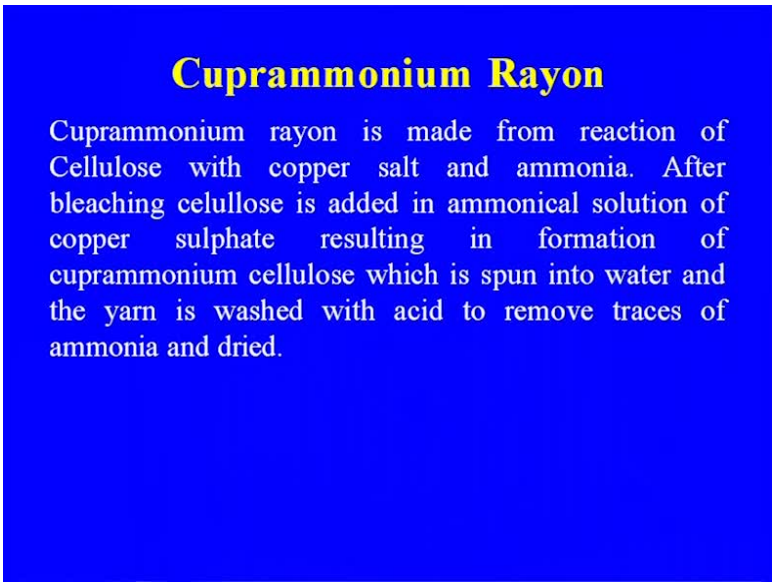

Cuprammonium is made from reaction of cellulose with copper salt and ammonia. After bleaching cellulose is added to the ammonia solution of copper sulphate resulting in formation of cuprammonium cellulose, which is spun into water and the yarn is washed with acid to remove the traces of the ammonia and dried.

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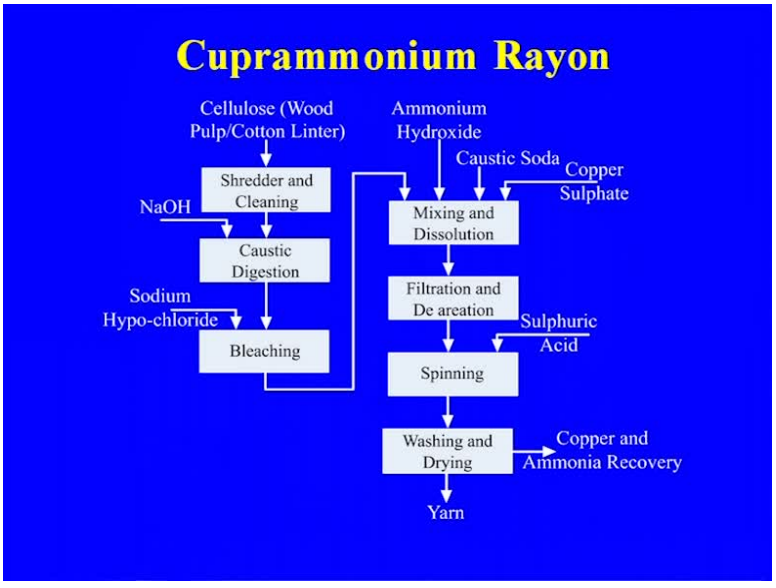

So, this is the method which we are using for the and if you see the here also the shredding and cleaning, caustic digestion, sodium hypo chloride for bleaching that we are adding and in case of this is the wood pulp the cotton linter that is going. So, this is

after the shredding because the more effective reactions may be there and so, the caustic digestion after the shredding that is been done. Mixing and resolution, filtration, spinning, washing and drying, so, this is the process that we are using in case of the cuprammonium.

So, this was the actually about the various rayons and that we are manufacturing and as I told you in the beginning also the viscose rayon that has played very important role in meeting the demand of the textile industry. And again now we are finding the trend in the market is to use the more viscose rayon and the various blends of the polyester or the acro nitrate, because the cost point of view and at the same time more comfort is there when you are having the viscose rayon.

So, the one of the actually major issue that has been in case of your viscose rayon plants, all the viscose rayon plants, because here which I forgot tell you, we are using huge amount of the caustic soda and that caustic soda now most of the viscose rayon manufacturing they are having their own caustic chlorine plant and earlier as you see, before coming of the membrane process, it was only the mercury cell process that was being used in the making of the caustic chlorine.

So, in case of the all the plants one of the another issue that has been there, where to go? Where will be chlorine? So, chlorine handling that has been 1 of the major because that has to be supplied somewhere because during the manufacture of the caustic. So, this was the 1 of the issue. Another issue in case of the viscose rayon, the your environment point of view because you see in case of the carbon disulphide that is highly toxic and the smell of the carbon disulphide that is there in the plant. So, 1 of the major issue that has been in case of the viscose rayon is the chemical part of the chemical manufacturing unit of the viscose rayon, because normally they are having the in case of the any viscose rayon that will be 1 of the carbon disulphide unit, caustic chlorine plant and then the finally, the viscose rayon manufacturing.

So, just like you take the case of that they are having the membranes also most of now the caustic chlorine plant they have been converted to membrane caustic chlorine plant but, the issue of the this chlorine that there. So, this is 1 of the factor which is affecting the cost of the viscose also.