Organic Chemical Technology
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Lecture - 10
Carbohydrates Industry – Refined Sugar

Welcome to the MOOCs course organic chemical technology. The title of today's lecture is carbohydrates industry refined sugar. Before going into the details of today's lecture, we will be having a recapitulation of what we have discussed in the previous lecture on carbohydrates industry. Carbohydrates are naturally occurring components. They primarily consist of carbon, hydrogen and oxygen atoms only that also H number of atoms or twice time the O number of atoms like you know in water molecule, right? So, such kind of components are you know carbohydrates. There may be many other organics where other than CHO and other components should also be there but you know we cannot say them as a carbohydrate.

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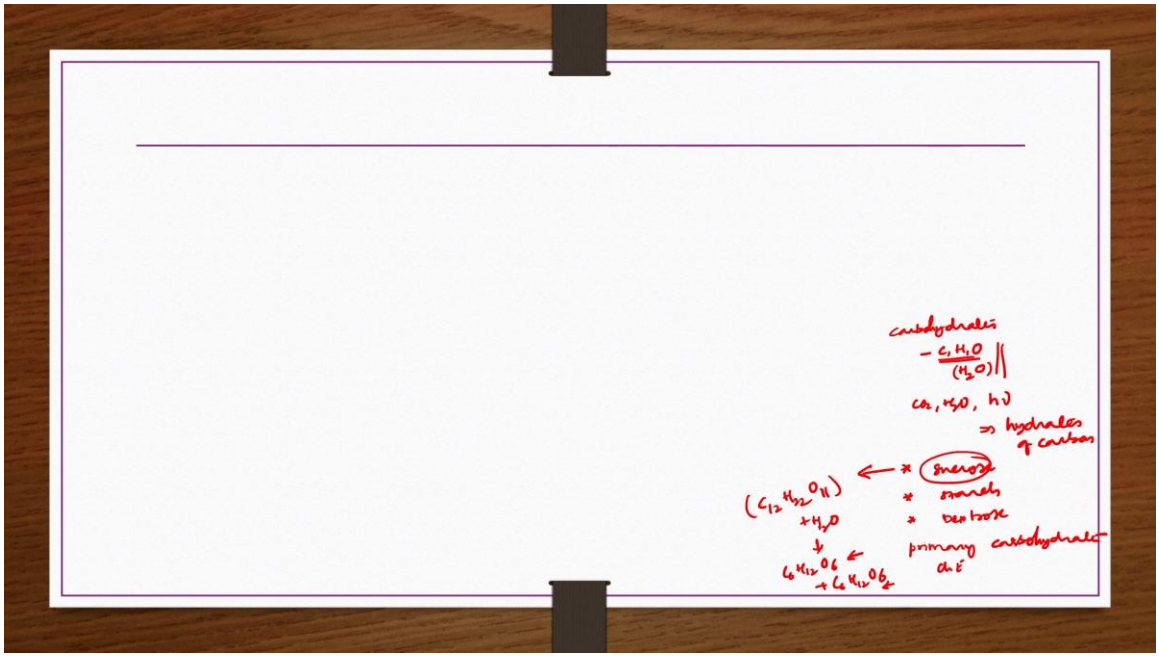

So, carbohydrates they should have only CHO and that also H and O at the ratio of 2 is to 1, okay? Now, these are actually naturally occurring products, natural product industries or carbohydrates comes under natural product industries because whatever the CO2 water is there in the environment, they would be utilized by the plant in the presence of the energy from the sun to produce these hydrates of carbon or carbohydrates, right? So, these are primarily the food stuff primarily for not only for the animals but also for the

human beings, right? So, there are several types of carbohydrates are existing. Some of them include like sucrose which is also known as the sugar in normal terminology and then starch and then dextrose. These are primary carbohydrates which in general chemical engineers are interested about, right? So, then we started about the sucrose production which is having structure of C12H22O11 which is a disaccharide. Sometimes if it is not properly handled then inversion of this one may take place and then it may produce C6H12O6 plus C6H12O6 that is D-glucose, D-fructose formation may also take place in general, right? So, then sugar production or extraction of sugar from the sugarcane is done by the extraction process followed by the decolorization and then crystallization, etc. So, basically the process what it includes is extraction of the sugar juice from the sugarcane and then subsequently concentrating it, decolorizing it and then crystallizing it. So, those are the steps are present in the sugar extraction in general.

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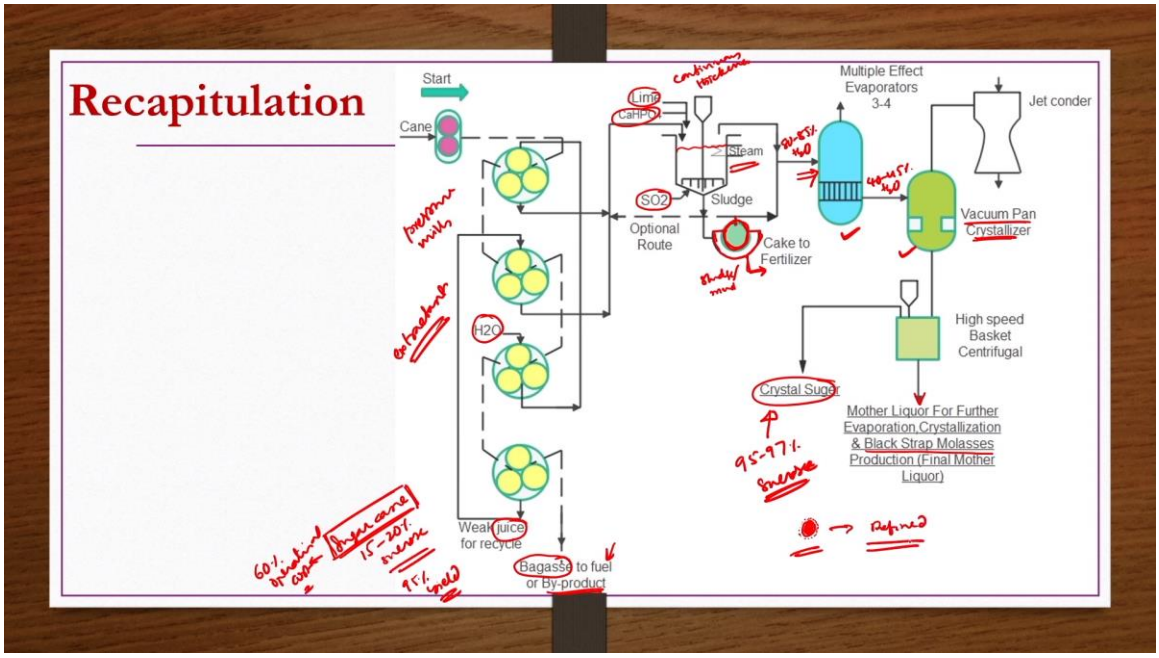

So, however, see the flowchart of the sugar production process at the chemical plants then what you have? This is what we have, this we have discussed but however, it is going to be useful as a continuation to the today's lecture. So, we discuss it once again, okay? So, whatever the cane, sugarcane are there that usually what you do you wash so that to remove mud, debris, etc. Then you shred them then you pass through pressure mills which are having some kind of corrugated surfaces actually three rolls are there.

These three rolls are having corrugated tooth kind of surfaces are there. So, when the shredded cane comes and trap between the rolls that will be crushed and then juice would be extracted, right? Such kind of pressure mills many are possible, right? So, then whatever the juice that you get you check the its concentration because we know that

sugarcane is having only approximately 15, 16 to 20 percent of sucrose only. So, you have to recover as much as possible yield of extraction of the sucrose from the sugarcane has to be very high more than 95 percent yield is required then only it is going to be economically possible, right? Otherwise, you know you have to depend more on the byproducts, right? So, that is the reason this sugarcane is you know taking almost approximately 60 percent of operational cost of a sugar industry that we have seen. So, that juice if it is weak in the sense if it is not having sufficient percentage of sucrose then what you have to do you have to recycle it to the pressure mills along with the water. So, that this weak juice and water act as extractant to extract more juice from the canes that are upcoming, right? So, this is the process.

So, once you have the juice of sufficient quality that you can send it to continuous thickener or settler, okay? Whereas the bagasse whatever is there that you can take it as a fuel, you can dry it and then use it as a fuel to the steam boilers or you can use it for the byproduct productions like you know insulation board and paper making etc. Whereas the juice may be containing the impurities. So, then for that purpose what you do you have to add the lime and then calcium phosphate so that to you know so that to separate those impurities. These impurities would be coming onto the surface if you are using SO2 from the bottom, right? So, then bubbling kind of thing action bubbling action would take place, right? So, because of this bubbling action provided by the SO2 more circulation takes place and then more of the impurities would be floating on surface that you can remove. Actually, to this continuous thickness, a closed heat is also supplied because it operates around at 60 to 70 degrees centigrade.

So, from this process whatever the clarified liquid is there that you collect from the top, okay? And then check its quality. If its quality is good enough, then you can send it to the subsequent evaporation multi-effect evaporation process otherwise you can recycle back to the continuous thickener again so that more you know purity juice you can get as a clarified liquid, right? Whereas the sludge or mud etc. that is there are collected at the bottom of the continuous thickener that you take to a rotary drum filtration unit so that to extract juice if at all that is present in the sludge or mud, right? So that may be having you know some amount of sucrose content so that you can extract and then you check its quality and then you recycle it back to the continuous thickener whereas the cake that is there that you take it as a fertilizer waste. You can take it as a utility for fertilizer or you can discard it as a waste as well, right? So, the juice that is coming out of the continuous thickener would be having 80 to 85 percent water. So, after passing through this multiple effect evaporator water content reduces to 40 to 45 percent.

Further thickening of the syrup takes place in the vacuum pan crystallizers where crystallization will also take place. These crystals may be containing some amount of syrup also as a test liquid. In order to remove such syrup from the crystals of the sugar you allow that high concentrated you know syrup that is coming from the pan to a

centrifugal basket high speed centrifugal basket. Here you know whatever the crystals sugar crystals are recovered which are almost free from the you know molasses or you know other impurities kind of thing. So, whatever the syrup solution or you know is there that you can collect as a mother liquor for further evaporation depending on its quality you can send it to the evaporation stage here or you can send it to the crystallization section here or if it is not having any sucrose content or very less sucrose content is there then you can take it as molasses for the fertilizer industries.

This is what we have seen and then this crystalline sugar whatever is there that may be having 95 to 97 percent sucrose content. But the crystals if you take this crystal may not be white in color in general. So, it may be slight brownish in color because that molasses whatever is there that may be attached as a layer to the surface of the sugar crystals. For that purpose, this has to be refined. So, that refining of sugar we are going to see otherwise quality wise it is good enough more than 97 percent sucrose content sugar crystals also in general you get but only thing that it may be slightly brown in color.

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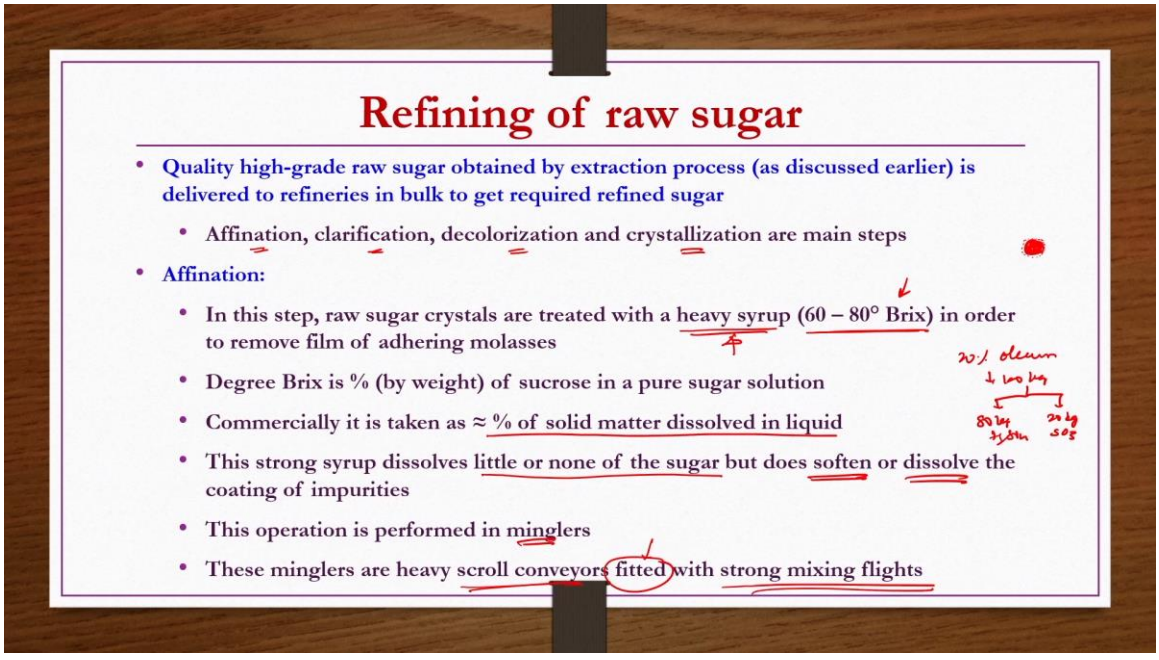

If you want white sugar then it has to be refined as per the process that we are going to discuss now. Refining of raw sugar, a quality high grade raw sugar obtained by extraction process that we just now discussed in the previous slide would be delivered to the refineries in bulk to get refined sugar. In this process or in the refining of this raw sugar there are several steps are there. Those steps may be grouped as affination, clarification, decolorization and crystallization steps. What we do we see each of them along with the flow sheet as well as with respect to description as well.

Let us start with affination. Affination this is the first step in the refining of raw sugar where raw sugar crystals are treated with a heavy syrup which is having 60 to 80 degrees Brix in order to remove film of adhering molasses. As already told whatever the crystals sugar crystals are there, they may be brownish in color because the surface may be covered with impurities or molasses something like that. That layer has to be removed. For that purpose, such crystals are dissolved or mixed with heavy syrup.

It is not dissolved actually. Those crystals will not be dissolved by this process. What will happen when the heavy syrup is added to the raw sugar then that will slightly dissolve the sugar or it will soften or loosen the layer of molasses that are adhering to the crystals so that can be removed. So, that flow chart also we are going to see anyway. So here this Brix whatever is there that is a kind of indication of you know what is the percentage of sugar that is present in the pure sugar solution. It is something like you know 20 percent oleum when we take in H_2SO_4 then what does it mean by out of 100 kg you have 80 kg H_2SO_4 and then 20 kg SO_3 you are having. Like that here also this Brix is one particular kind of unit that is followed that indicates weight percent of sucrose in a pure sugar solution. Commercially it is taken as the percentage of solid matter dissolved in liquid. So, then what happens when this heavy syrup is added to the raw sugar crystals, the strong syrup dissolves little or none of the sugar but does soften or dissolve the coatings of impurities. All this happens in an equipment which is called as a mingler. What is this mingler? This mingler is nothing but heavy scroll conveyors but fitted with strong mixing flights.

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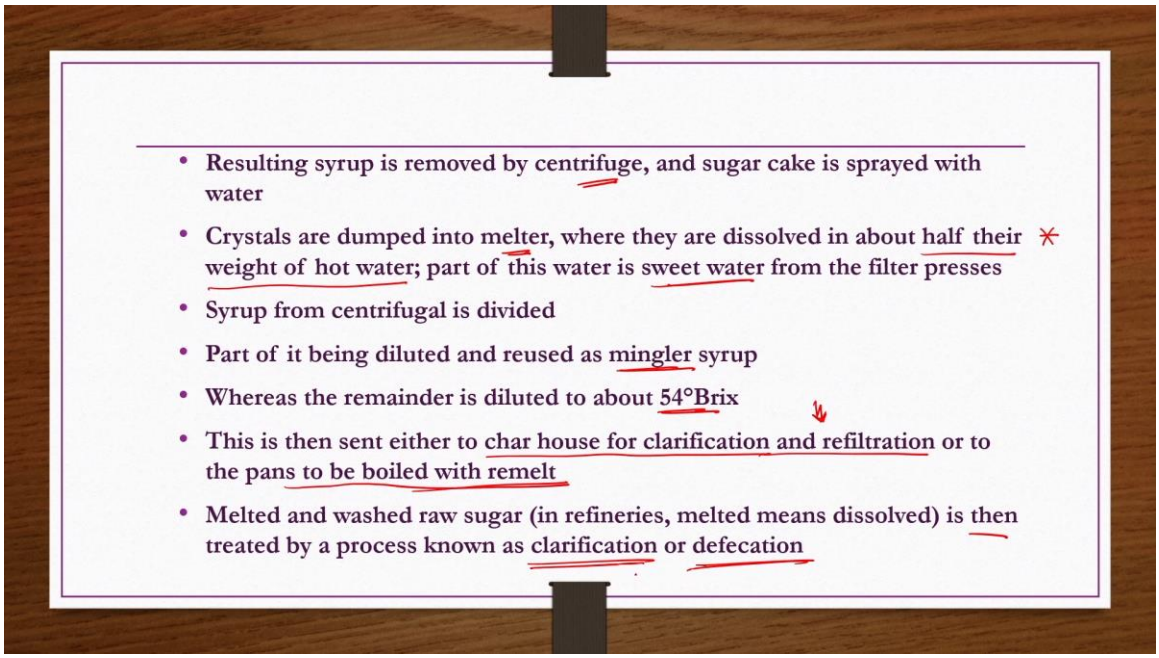

So now what happens the resulting syrup whatever is there that is coming out of the mingler that would be you know passed through a centrifuge centrifugation unit where the syrup is removed and then sugar cake whatever is there that is sprayed with water. These crystals are dumped into melter from the centrifuge where they are dissolved in about half their weight of hot water. These are the optimum conditions actually these conditions like you know how much of water should be there at what flow rate all those things optimized one and they are plant to plant they may be varying slightly. So approximately half their weight of hot water is added in the melter. Let us say you have 100 kgs of crystals in the melter. So, approximately 50 kgs of water hot water you may be adding. Part of this water is sweet water from the filter press. In this process flow chart you are going to see that so many filter presses are there both plate and frame type filter presses as well as the rotary drum filter presses kind of things are there. So, from here whatever the sweet water is there so that must be containing some amount of sucrose so that should not be going waste.So, then that is that water is reused wherever is required either in mingler or either in melter sometimes in centrifuge also they are used. Those details we are going to see in the flow chart anyway. So, syrup from centrifugal is actually divided part of it is diluted and reused as a mingler syrup. Initially we use high concentrated syrup now after certain operation whatever the things are the clarified liquid that is coming from the centrifuge that syrup is you know diluted and then reused as a mingler syrup only part of it is used for that whereas the remaining one is diluted about 54 degrees Brix. This is then sent to either char house for clarification and refiltration. Actually, after this whatever the sugar is there or whatever the syrup is there that color removal has to be done. So, for that purpose either that would be sent to char house for clarification and refiltration or if the color is already sufficiently white enough then it can be directly sent to the pans to be boiled with remelt. Melted and washed raw sugar is then treated by a process known as clarification or defecation. So, this can be mechanical or chemical that process we see. So, in the industry in the sugar refining industries melted means dissolved.

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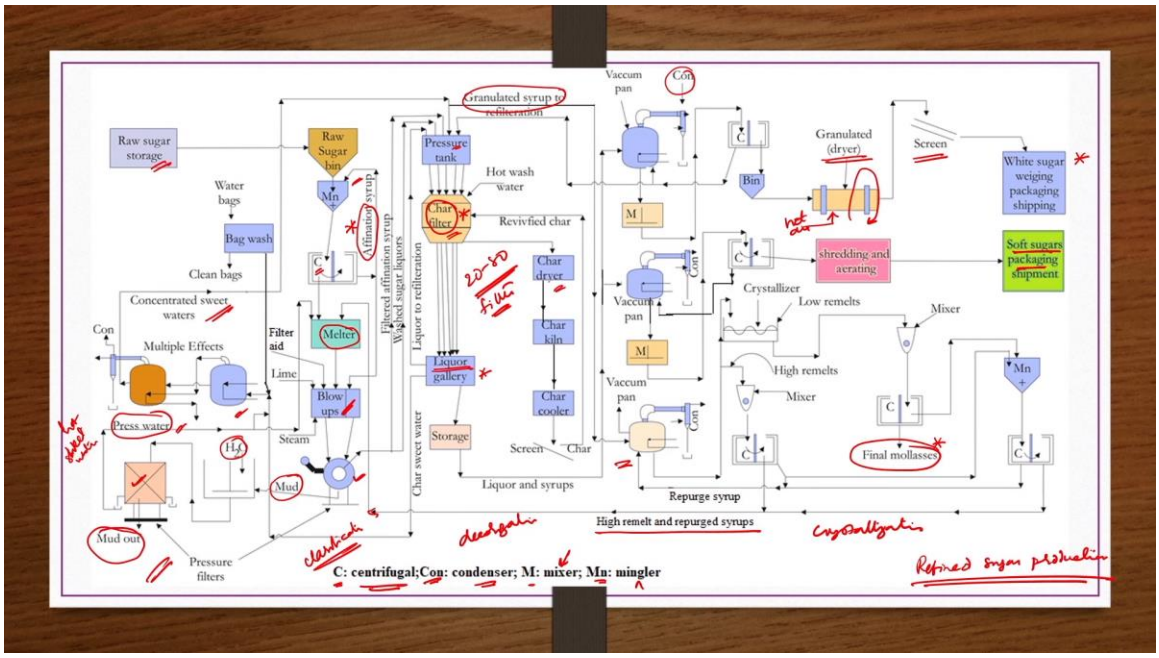

Now if you see the flow chart for the refining of the sugar so you can realize all those 4 steps affination step then clarification step then decolorization step then you know crystallization steps you can see. All of them are connected one after other and some kind of recycling streams are also there all those things we are going to discuss here in this flow chart. So raw sugar whatever is there from the storage it is taken to the bins that are present in the plant and then that sugar is taken to the minglers actually terminology here in the flow chart something like Mn, M, Conc are there C stands for the centrifugation operations Con stands for the condenser M stands for the mixer and then Mn stands for the mingler. So that raw sugar from the bin is taken to the mingler where affination syrup is added up so that you know slightly dissolving of sugar may take place because of that one softening and then loosening of the molasses the impurities that are attached to the crystalline because of which there is brownish color is there so that will take place. So once it is loosened so that can be removed easily.

So, from the mingler the mixture is taken to a centrifuge where you know by the centrifugal operation, centrifugal operation means this rotating ball would be there in that ball this material will be taken. When it is rotating at high speed the high density material will be thrown towards the wall whereas the low density material would be clustered towards the center. So the liquid whatever is there so that syrup rather liquid syrup so that syrup from the centrifugation that you take and then you can recycle to the mingler partially and then remaining one you can send for the subsequent clarification steps and then further what you can do after the centrifugation whatever the crystals are there which are slightly dissolved in the syrup or maybe now coated with the syrup they will be taken to a melter. To this melter what are you trying to do you are adding water, press water or hot water, sweet water also being added which is in general hot in condition.

From where it is coming? It is coming from the you know different types of presses plate and frame filter press or rotary drum filter press they are used.

So, from there the water is coming so that water is containing sucrose so that is used for this melter purpose. So now from here to this melter some amount of high remelt and repurge syrup is also being added up from the crystallization unit that is also coming here. In the melter required mixing of these things will take place then that mixture is taken to the blow up section where either mechanical or chemical clarification takes place. Here lime is added for the chemical process so that to remove if any impurities etc. are there. What this lime etc. will do that will try to precipitate out the impurities mixture whatever is there that is taken to a rotary drum filtration unit here. In this rotary drum whatever the filtrate is there that you can take it to the pressure tank or filtered affiliation syrup whatever is there that also you can take it here as a fraction or washed sugar liquors also you can take here to the pressure tanks. Whereas the mud or the sludge or cake etc. that is there in the rotary drum filter that would be taken and then it is expected that you know this mud may be having some sucrose contents. So, this mud would be washed with water then it will be filtered in a plate and frame filter press here.

So that only mud is separated out with whereas the sweet water filtrate whatever is there that is nothing but sweet water which would be at some pressure that will be recycled back to the melter. Now from this pressure tanks what is happening the material is taken to char filter actually by this blow up section itself some amount of you know so called color has been removed actually. So that is the advantage of clarification whether it is mechanical or chemical clarification that you do. So then still some kind of impurities may be there most of the impurities are removed here by this you know mingler melt centrifugation, melter and blow up processes, centrifugation and then rotary drum filtration processes etc. All these will removing the insoluble impurities but if at all some soluble impurities are there those soluble impurities would be removed in this char filter.

Along with the soluble impurities it will also remove some kind of you know colors which are not desired for the sugar crystal. So, the char filter is actually you know some kind of adsorption tower where bone char etc are used or activated carbons are also used and then powdered carbon is also used several times depends on the you know size of the plant and applications. So here what will happen this whatever the beds are there char filter beds are there they will remove the colors and insoluble impurities then clear liquor pure and clear liquor would be collected and then stored in a gallery. Now this liquor only steps are required to do next is to do the concentrating by multiple effect evaporator or vacuum pan evaporation followed by the crystallization only you need to do then you can get the crystals. But this char filter whatever the filtration medium activated carbon or char etc. are there they will be deactivated after 1 or 2 hours of operation. So, what you have to do you have to collect them and then wash with water then you dry them in dry air why do you need to wash you because when the absorption is taking place this

activated char carbon may also be you know adsorbing some amount of sucrose. So those things would be removed by washing and then you dry the char and then heat it in kiln and then cool it and then refit to the char filter. Continuous processes are also possible some plants are having batch operations where every one hour they clean this such kind of filters or they use 20 to 80 filters for 1 hour they may be using certain set of the filters after another hour they may be using the other filters and then meanwhile they clear the or purify the previous set of the filters like that they can manage. So, whatever the clear liquor is there that now you take to vacuum pan evaporator here.

So here what is happening primarily in the vacuum pan evaporator so concentration of the syrup is taking place whatever the water vapors etc. are there they would be condensed and then collected as water depending on its sucrose content that water may be fed back to melters or you know centrifugation units or minglers as per the requirement. If it is not having any sucrose content then it may be discarded. So then after the vacuum pan crystallization if at all any mixing is required that mixing is done so that to make the syrup uniform and then send it to the centrifugation chamber or centrifugation unit where by the rotations centrifugation forces will be pushing the heavier medium towards the wall and then lighter medium towards the center of the ball. So here the sugars whatever are there they are collected as a been concentrated sugars they will be passed through granulated dryers. This granulated dryers in the sense they are something like rotary drum dryers only there is a drum like shown here and then that would be rotating in a particular direction like this the material when it comes here so this rotation takes place. So then to this drum what you do in general you supply hot air or you know some kind of gas which is not interacting chemically with the material. So, this hot air or steam will dry up the sugar crystals and then those crystals would be taken to the screens to check the size of the crystals. If the size of the sugar crystals are sufficient enough they would be taken to the packaging otherwise they would be sent back to the you know so called you know vacuum pan mixer and centrifugation unit back for the resizing purpose. Some part of the liquor is taken to the other vacuum pan where the similar processes takes place but here you know the conditions operating conditions are maintained such a way that here you may be targeting soft sugar packaging soft sugars and its packaging. So, then this whatever the granulated syrup is there so which is being you know recovered from this filtration process here. So actually, whatever the hot water or you know press water or hot sweet water is there that would be passed through some multiple effect evaporators if the sucrose content of that filtrate is higher. So then here it will be concentrated and then concentrated sweet waters. These concentrated sweet waters may be taken back to the pressure tanks right some of which may be taken as a granulated syrup for the refiltration this would be done here in the third vacuum pan filtration unit here. So, from here whatever the high concentrated syrup is there that would be passed through a crystallizer to get the required size of the sugar crystals whereas the final liquor whatever is there which is not having much sugar content or which cannot be recovered by any of the

process that would be taken as a final molasses that can be taken to the fermentation industries for the production of ethanol etc. So this is the flow chart about refined sugar production looks bigger and clumsy but you know simpler if you take it step by step as we have discussed here. Now for this flow chart up to the affination process text description part we have already seen. So, the remaining clarification and then decolorization and then crystallization steps we are going to see the description of the process as well.

Clarification can be mechanical or chemical in the mechanical clarification you may require addition of diatomaceous earth or similar inert material. pH is then adjusted and then mixture filtered in a press. This system gives an absolutely clear solution of slightly improved color this is very important that means inherently it is doing a part of a decoloration job also and it is a batch process.

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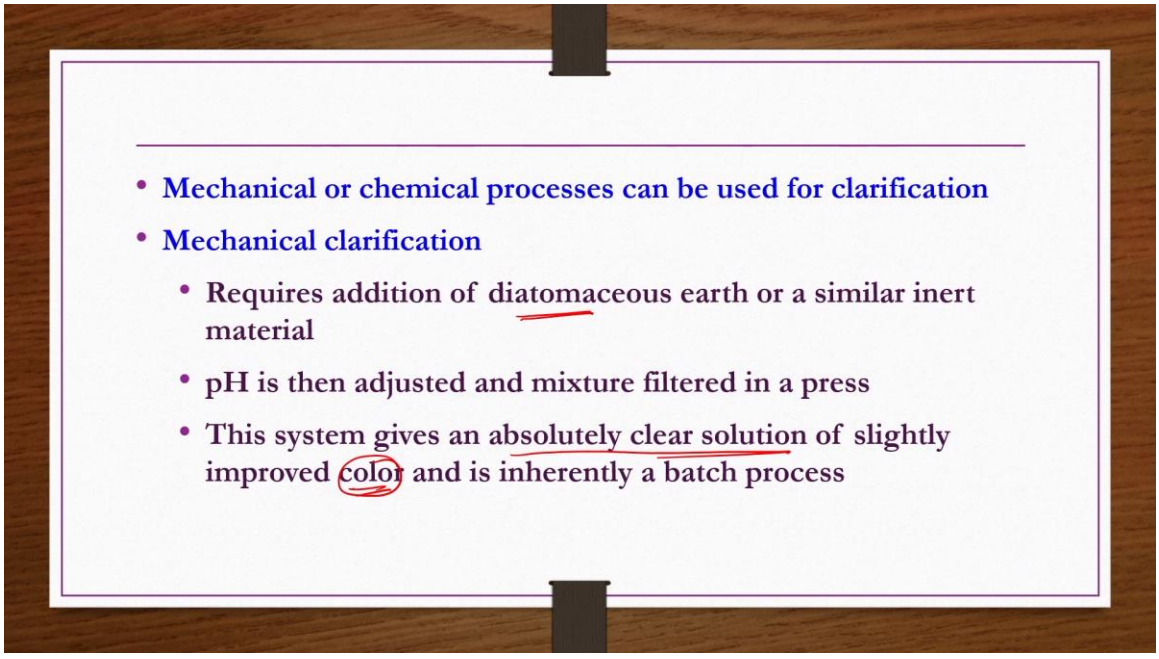

Next is chemical clarification or defecation process it uses either a frothing or clarifier or a carbonation system or you know when you do the clarification using chemical methods what you do you take the you know syrup that is coming from the mixture from the mixture whatever is there that you take in a container to this container you try to provide the aeration or you know you provide CO2 because carbonation system carbonation is also improved and then this is actually some frothing agents also you can give frothing agents.

Then what happens you know flocculation or froth formation takes place and this froth formation would be improved by the CO2 provided and then it also adds to adjust the pH and then other things as well. So what will happen so now impurities whatever are there they may be suspending on the surface along with the froth and that can be taken as a wastage or that would be further you know washed if at all sucrose content is more in the froth that would be washed and then filtered to get the sweet water and then sweet water as per its sucrose content it can be used as a hot water for the mixer or mingler or other ways it may be concentrated if it is more concentrated sucrose is there further it can be concentrated and can be used as a affination syrup as well. This froth flotation etc. how it operates etc. those things are part of mechanical unit operation course. So, this course is also available in NPTEL we have already done in the one of the previous semester so you can check them or you can check their YouTube videos as well. Liquor treated for frothing containing entrapped air bubbles enters the clarifier at about 65 degrees centigrade in the clarifier it is heated causing a froth to form which rises to surface. This froth carrying gelatinous tricalcium phosphate impurities and entrapped impurities as well so they would be taken away along the froth. Clarified liquor is filtered and sent to decolorization.

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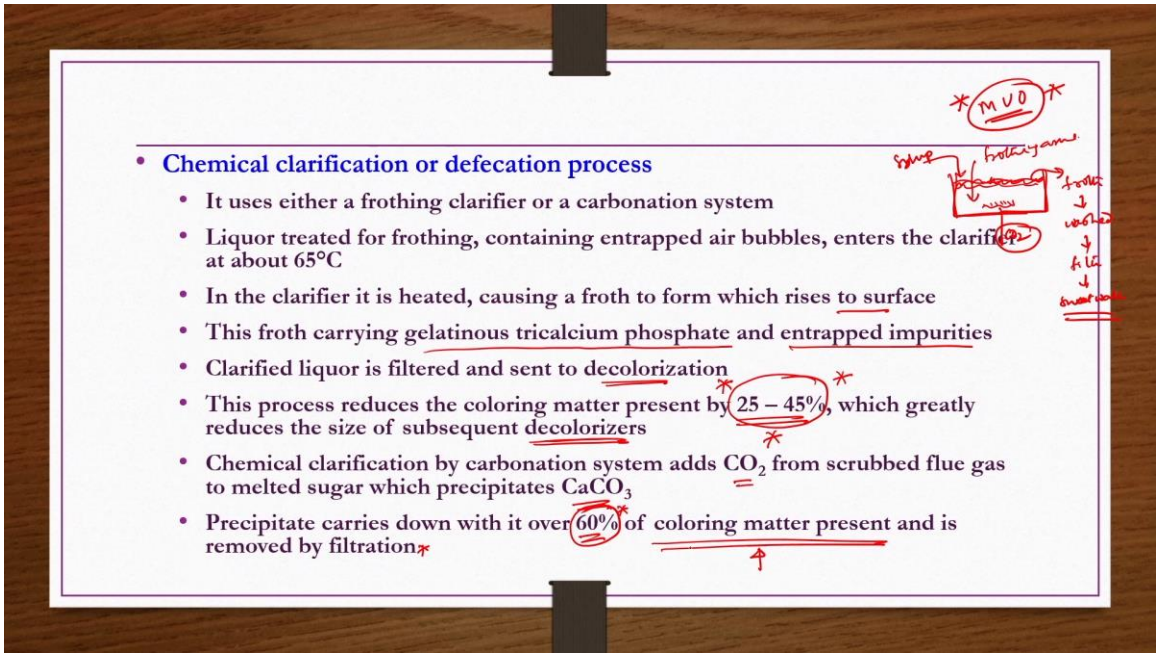

This process reduces the coloring matter present by 25 to 45 percent that is a very good number that much color reduction is taken place that means up to 45 percent of the job whatever you know decolorization unit supposed to do that job has already been done by this chemical clarification method by froth flotation. So, because of that one what will happen the size of the decolorizer units whatever is there that is going to be substantially

decreasing if it is a new plant. If it is existing plant so then its duty may be reduced. Chemical clarification by carbonation system adds CO2 from scrubbed flue gas to melted sugar which precipitate calcium carbonate. Precipitate carries down with it over 60 percent of coloring matter even better here if you are using CO2. If you are using air bubbles then only 25 to 45 percent color removal is taking place whereas if you are using CO2 along with the impurities 60 percent of the color containing matters or constituents are removed and is removed by filtration whatever that coloring matter that is there 60 percent that is removed by filtration simple filtration. So, such is the important one clarification in this process because it not only removes the impurities but also reduces the color to more than 50 percent. If it is a chemical clarification method more than 50 percent of the color is being removed in the clarification process itself so that your subsequent load on you know decolorization is there that will decrease.

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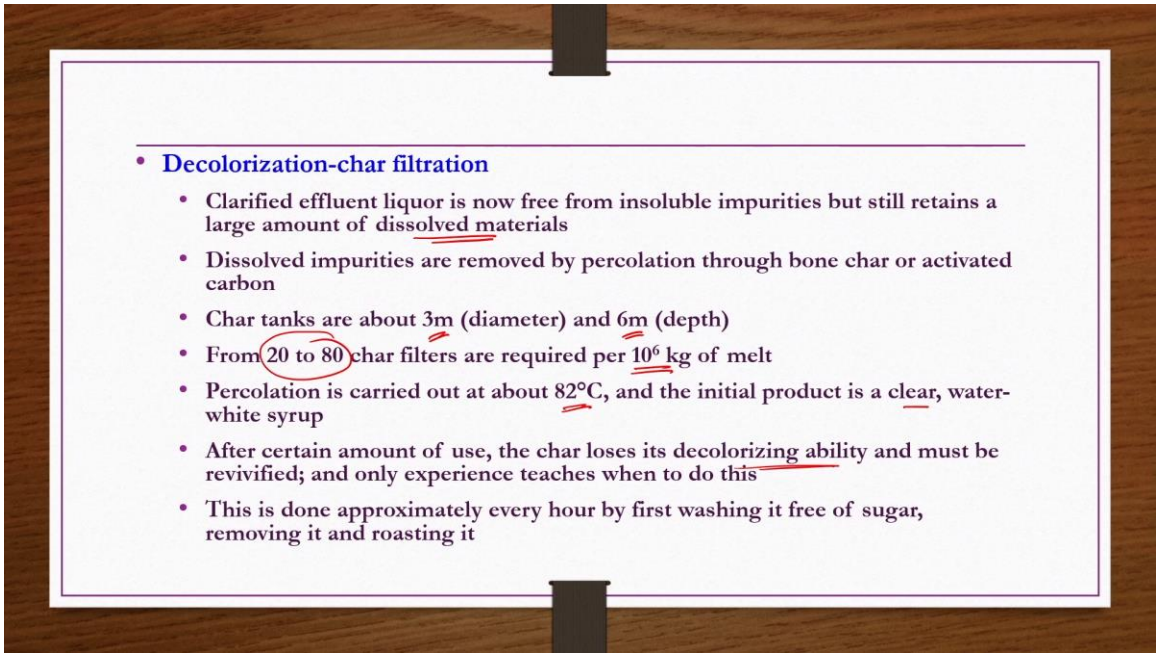

Next step is the decolorization char filtration. Clarified effluent liquor is now free from insoluble impurities but still retains a large amount of dissolved materials. Dissolved impurities are removed by percolation through bone char or activated carbon. Char tanks are about 3 meters in diameter and 6 meters depth. For treating 10 power 6 kg of melt approximately 20 to 80 char filters are used. They are not used at a time if it is a batch process they are used periodically. The set may be 10 filters or 20 filters as one set first used and then remaining 10 or 20 filters when are being used. Previous 10 or 20 filters

which are already you know deactivated because of sufficient duty has been taken by them. They will be purified by washing, drying and then you know repacking purpose as explained while discussing the flow chart in couple of slides previously. Percolation is carried out at about 82 degrees centigrade and the initial product is clear water white syrup. After decoloration almost you know water white clear syrup you are getting. After certain amount of use char loses its decolorizing ability. So, it has to undergo desorption process so that to remove the adsorbed species from the char and then that char must be washed and dried for the subsequent uses. And when to do such kind of recharging or you know washing of the char, desorption of char and washing and then drying and then recharging the filtration with the reactivated char that depends you know on the experience of the professional or engineer working in the plant. Often if it is a batch process every hourly it has to be done. Continuous decoloration processes are also used in general.

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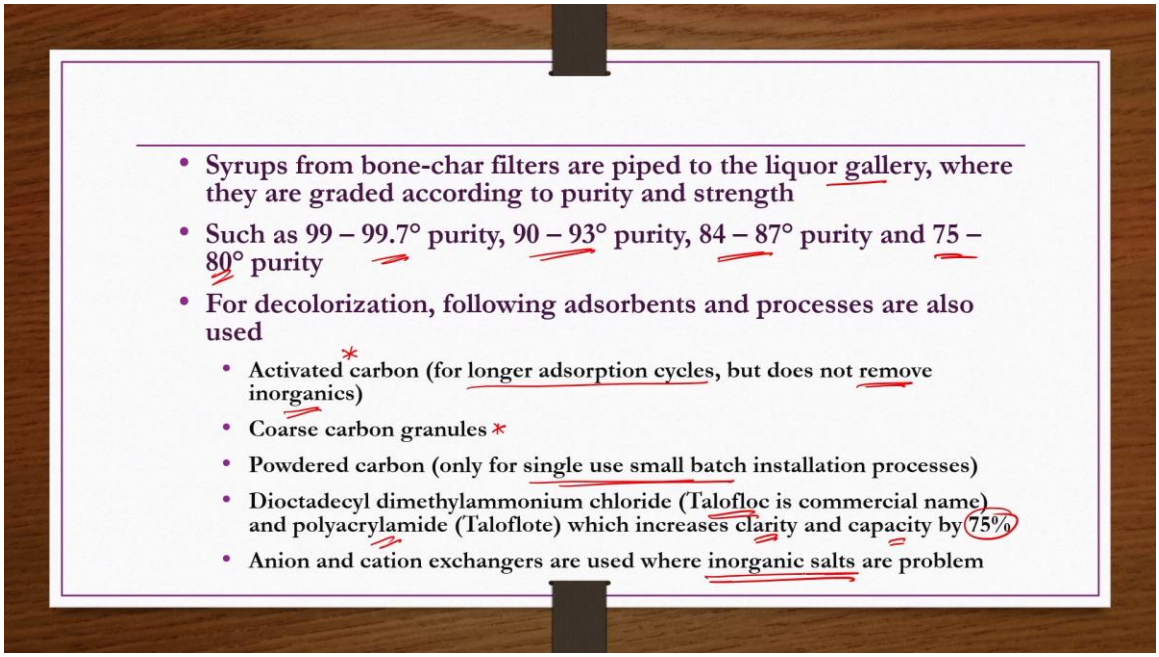

Syrups from bone char filters are piped to liquor gallery where they are graded according to purity and strength something like 99 to 99.7 degrees of Brix purity, 90 to 93 degrees Brix purity, 84 to 87 degrees Brix purity or even 75 to 80 degrees Brix purity as per the you know consumers requirement.

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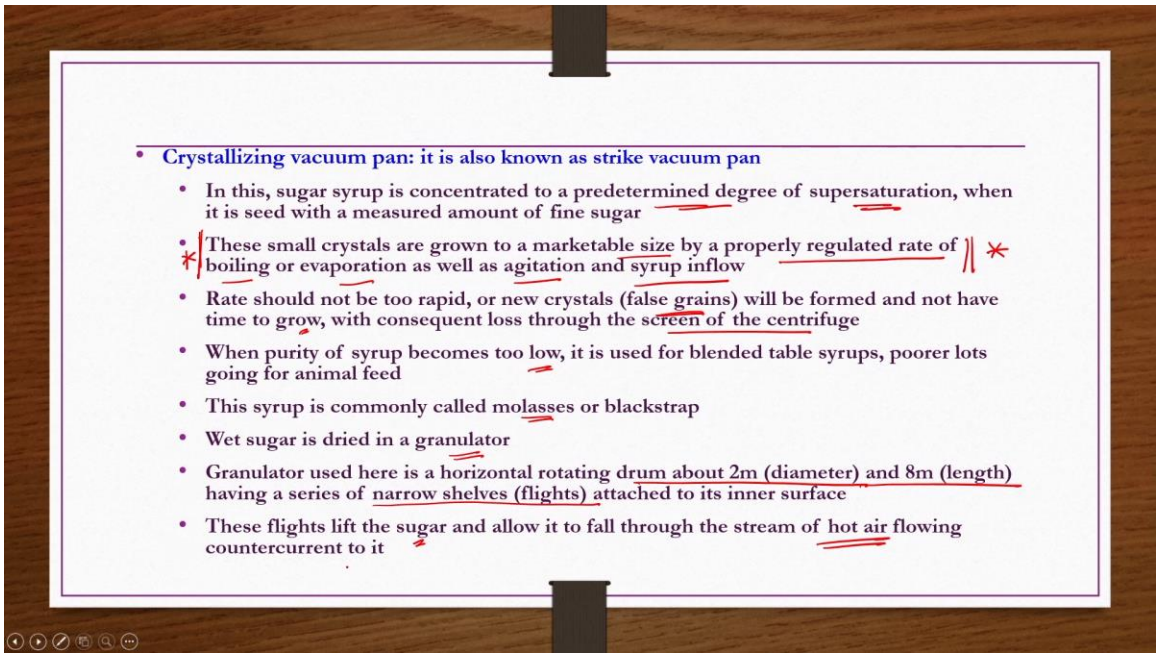

For decoloration following adsorbents and processes are also used in general. Activated carbon if you are using for longer adsorption cycles activated carbon is a better option, but it cannot remove in organics. Coarse carbon granules can also be used. Powder carbon can also be used if you are using or using for single small batch installation process. And then dioctadecyl dimethylammonium chloride commercially known as Talofloc can also be used. Polyacrylamide can also be used. This will increase the clarity and capacity by 75 percent. And then if there are some kind of inorganic salts then ion exchangers can also be used appropriately. Crystallizing vacuum pan it is also known as strike vacuum pan. In this sugar syrup is concentrated to a predetermined degree of super saturation when it is seed with a measured amount of fine sugar. These small crystals are grown to marketable size by properly regulated rate of boiling, evaporation as well as agitation and syrup inflow. These are very much important parameters to decide the crystal size. So, such kind of optimization is important and that has to be done within the plant by the experienced engineers working in the plant. Rate should not be too rapid or new crystals or false grains will be formed and not have time to grow with consequent loss through the screen of the centrifuge. If they are small so they will be lost through the screen of the centrifuge anyway. When purity of syrup becomes too low it is used for blended table syrup's purpose. This syrup is commonly called molasses or black strap. Wet sugar is dried in a granulator as explained. Granulator used here is a horizontal rotating drum about 2 meters diameter and 8 meters length having a series of narrow shells or flights attached to its inner surface. These flights lift the sugar and allow it to fall through the stream of hot air flowing counter current to it so that drying of the crystals takes place as I explained already in the flow chart.

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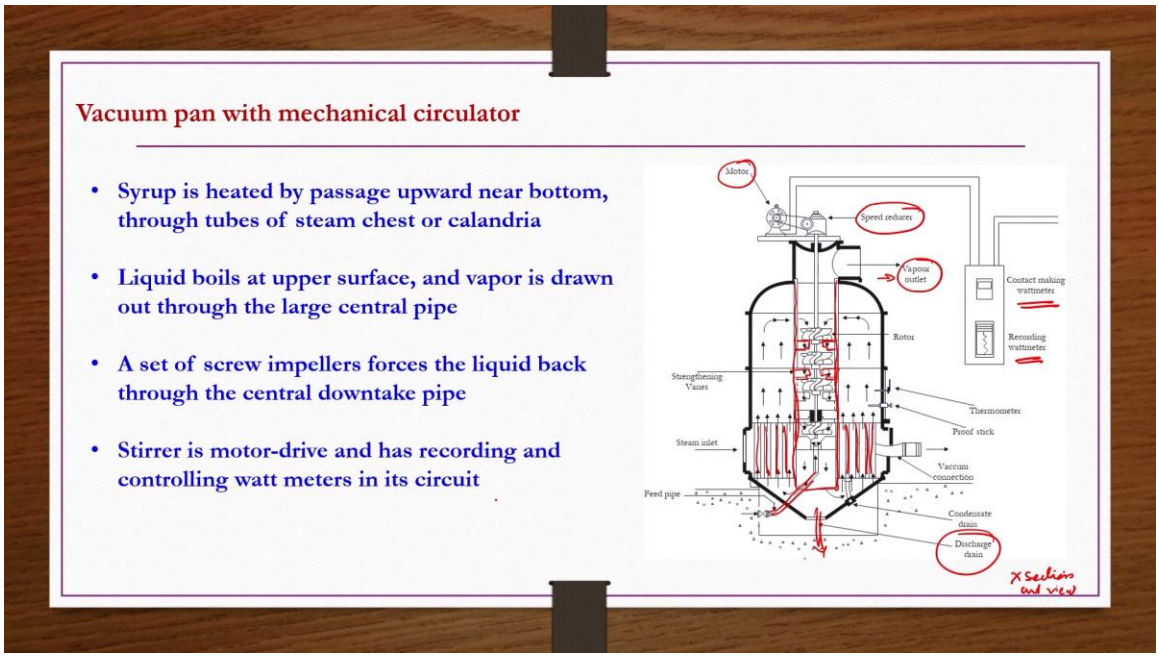

Now, here vacuum pan is there in the process how does it operate or how does it look like that we are going to see here now. This is the cross section or cut view of the vacuum pan. So, here there is a central tube here that you can see to which from the bottom we are allowing the syrup to pass feed pipe. So, this is the feed pipe from here we are allowing the syrup to pass and then this tube whatever is there so that is actually you know when the material comes in that is being heated by the calendria or you know steam chest different tubes are there provided here. So, they are nothing but the steam tubes are known as the steam chest are also known as the calendria. So, when the material comes here that would be heated up and then the evaporation or boiling of the syrup will take place at the upper surface here and then whatever the vapors are there those vapors are collected from the top. This is rotating also there is a possibility for this one this section for the rotation that is driven by the motor speed controller is also there. This motor is controlled by you know control panel which is having recording the wattmeter etcetera also there. So, this section there are also baffles kind of things are provided so that whatever the liquid is there that liquid should fall back. You do not want the concentrated syrup to go out along the evaporator only moisture water which is lighter in weight that you want to go out. Concentrated syrup that you want to fell down so far that can be aided by these baffles that are provided here. Once the required concentration of the syrup is achieved that can be taken or discharged from here through discharge drain. Syrup is heated by passage upward near bottom through tubes of steam chest or calendria. Liquid boils at upper surface and vapor is drawn out through the large central pipe. A set of screw impellers forces the liquid back through the central down take pipe. Stirrer is motor driven and has recording and controlling wattmeters in its circuit.

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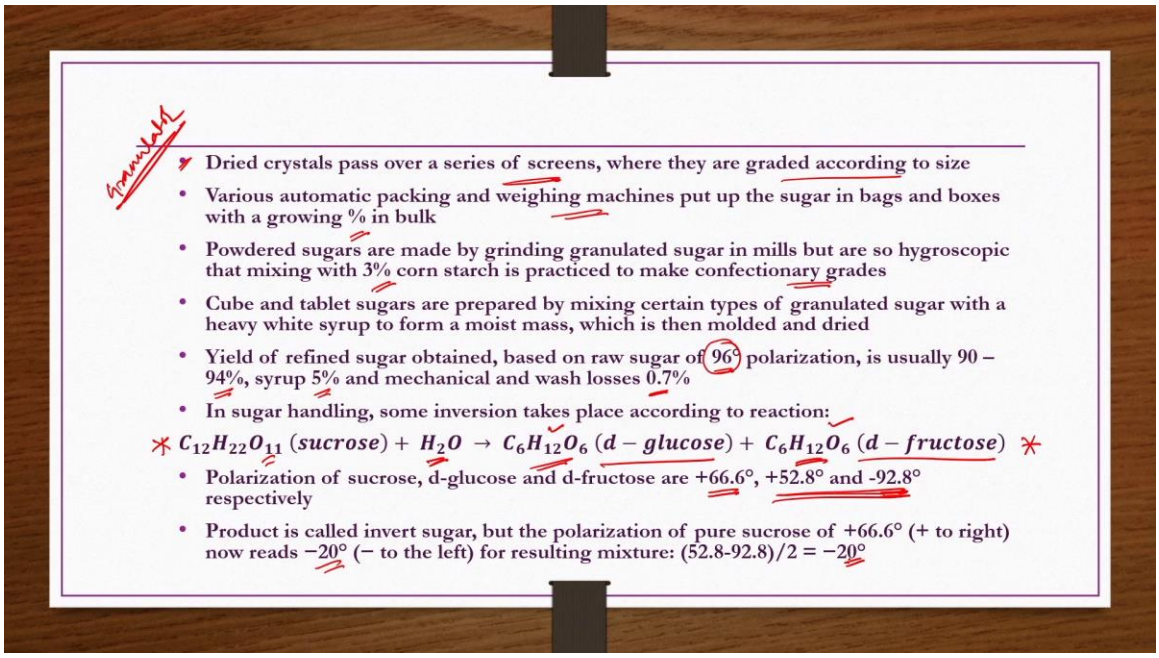

Now dried crystals from the granulator whatever are there they pass over a series of screens where they are graded according to size. Various automatic packing and then weighing machines put up the sugar in bags and boxes with growing percentage in bulk. So, these steps are followed after the granulation. After granulating the sugar crystals then these steps are followed. Powdered sugars are made by grinding granulated sugar in mills but are so hygroscopic that mixing with 3 percent corn starch is practiced to make confectionery grades. Cubes and tablet sugars are prepared by mixing certain types of granulated sugar with a heavy white syrup to form a moist mass which is then molded and dried. Yield of refined sugar obtained based on raw sugar of 96 degree polarization actually polarizability is the property of material. So, raw sugar is having 96 degrees polarization that plus 96 degrees that is towards the right is usually 90 to 94 percent yield is there syrup 5 percent and mechanical and wash losses would be approximately 0.7 percent. In sugar handling some inversion takes place according to reaction as already mentioned in the previous lecture where sucrose interact with water to form D-glucose and D-fructose. Chemically they are similar, their polarizability are different. Polarizability is property that the chemical structure wise they are different. So, now polarization of sucrose this one D-glucose this one and then D-fructose this one are in a respectively 66.6 degrees 52.8 degrees and minus 92.8 degrees plus in the sense towards the right and then minus in the sense towards the left. Product is called invert sugar this reaction whatever is there this is known as the inversion reaction or sugar inversion reaction. So, product is called invert sugar but the polarization of pure sucrose of plus 66.6 degrees to right now reads as minus 20 degrees to the left for resulting mixture because whatever this D-glucose and D-fructose their polarizability is there polarization

angle is there. If you add them together and divide by 2 because 2 components it is decomposing then you get minus 20 degrees polarization.

Now, bagasse this is the byproduct wastage that is coming out from the sugar industries how to utilize it because sometimes its yield is more than the yield of the sucrose in refined sugar plant. So, that much quantity of bagasse is there you cannot feed only to the cattles all of them cannot be consumed by the cattles. You cannot use them only as a kind of fertilizer in the field. So, there should be some kind of chemical ways to handle it so that you can get some byproducts so that to make the overall plant more economical. So, insulation boards or papers are made by using such bagases. So, how it is that is what we are going to discuss now. In general, in sugar industry amount of bagasse available is more than sugar yield. On burning 70 percent of the total bagasse enough steam for the power heat to run the mill can be produced and then after that still 30 percent is remaining that can be used for the byproducts. In the previous lecture we have already discussed that bagasse quantity is so much high that you know whatever the power requirements are there for the steam boiler etc. That can be generated by burning these bagasses after drying you can burn them in the steam boilers and then use it as a required power within the system and then use it as a required power within the mill itself that we have seen.

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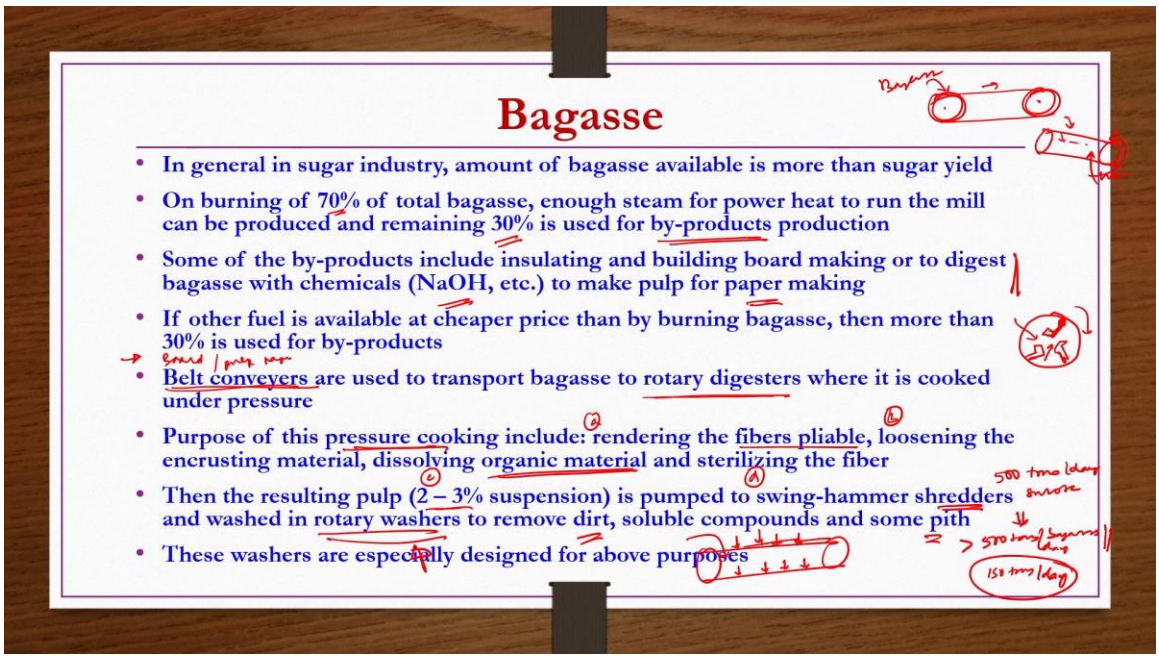

But now what happens remaining 30 percent it is still high if your plant capacity is 500 tons sucrose then approximately 500 tons or more bagasse would be there per day this is per day. Out of which 70 percent has been used for a power requirement within the mill. What about the remaining 150 tons per day which is a huge quantity. So, for that purpose

you know you can look over how to utilize for the byproducts. Some of the byproducts include insulating and building board making or to digest with chemicals like sodium hydroxide etc. to make pulp for paper making. So, these are the industrial applications. Fertilizer purpose these are being used but you know they are not as good as you know mixed chemical fertilizers that are produced you know by fertilizer plants. They may not be providing all required nutrients if you are using them as a fertilizer. So, appropriate modification is required there also. So, better you go for such kind of products which are industrially producible within the plant and then make money out of it. Not only this 30 percent if the fuel to run the mill is available at cheaper cost compared to how are you producing within the plant then you know you can go for the cheaper fuel. So, if other fuel is available at cheaper price than by burning bagasse then more than 30 percent can be used for byproducts. Belt conveyors are in general used to transport bagasse to rotary digesters where it is cooked under pressure. Now this process whatever here we are going to study is now board making, insulation board making or you know pulp for the paper. This bagasse what you do you transport using belt conveyors. Belt conveyors you know two rotating rolls would be there and then that would be covered by a belt, endless belt. So the material that is coming port taken here or the material that is to be transported that would be taken here if this rotating in this direction and then by the if the material is to be collected this location so the belt distance has to be maintained such a way that you get the material discharge here. So, by the belt conveyors this bagasse is taken to rotary digesters. Rotary digesters how are they? They are something like this. Drums which are rotating in one particular direction to this rotary dryer from the top bagasse is coming and then from the bottom you may be spraying some hot water or something like that at high pressure so that too you know cooking can take place. So, they are interacting counter currently. The rotation is taking place because of that one mixing is taking place and then the bagasse and then hot water are interacting in a opposite direction in a counter current direction. Purpose of this pressure cooking include many other one is that rendering the fibers pliable then second one is the loosening the encrusting material if at all impurities or some inorganic etc. and then some of the organic materials which may not be suitable to make insulation board. So, then they has to be removed so that dissolving of organic material will also taking place by this cooking under pressure and then finally most important sterilizing the fiber will also take place. These many purposes are there in this high pressure cooking of bagasse. Then the resulting pulp which is 2 to 3 percent suspension is pumped to swing hammer. How this swing hammers would be there? Let us say so swing hammers let us say you have a surface to which you know the swings hammers are being attached like this. Some hammers are attached like this. They when it is rotating this hammers also rotating in a different angle in different direction but they may not be interacting with each other but whatever the material that is being coming here and that would be hammered by this swinging hammers. These hammers also swing as per the rotation angle. So, when this hammering action takes place by the swimming

hammer shredding will take place and then further washing would be done in the rotary washers. After passing through this in a swinging hammer whatever the material is coming that you take to rotary washers which are you know having a drum to which this material shredded material is coming and then this drum is rotating here and then to this one water is sprayed. So that our water is supplied to the interior of this drum where the washing of this one takes place so that dirt and insoluble compounds and pith etc. are also being removed by this rotary washers. These washers are especially designed for above purpose but they are more or less like you know rotary drum granulators only.

Then from washers pulp enters half stock chest where sizing is added. This sizing is nothing but usually paper makers, rosin and alum etc. Further this mass stayed with powerful agitators to remove any irregularities are there in order to make the pulp more uniform that would be that mass whatever is there that would be processed through agitators powerful agitators strong agitators would be there. So, then you know uniformity would be brought by processing that suspension in these agitators. Finally, fibers are refined in conical refiners to give optimum fiber size.

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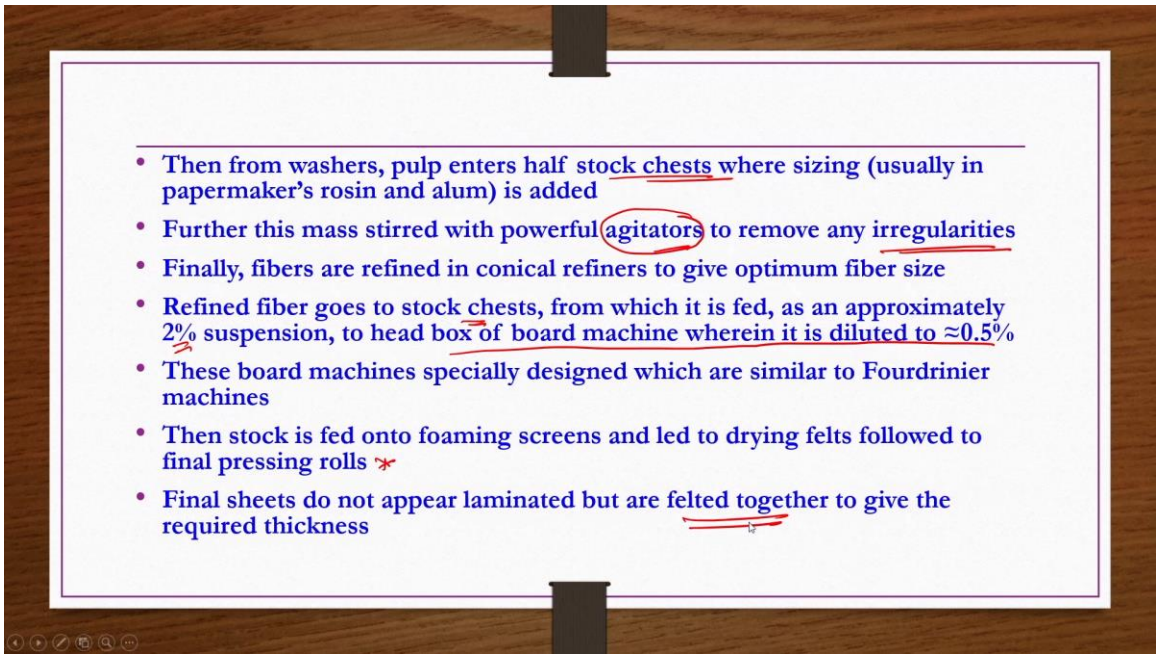

Refined fiber goes to stock chest from which it is fed and an approximately 2 percent of the suspension to head box or board machine where it is diluted to 0.5 percent. These board machines especially designed which are similar to Fourdrinier machines. Then stock is fed on to foaming screens and lead to drying felts followed to final pressing rules. Final sheets do not appear laminated but are felted together to give the required thickness as discussed here.

Boards from these machines are usually 4 meters wide and then contains 50 to 55 percent water and is produced at a rate of 50 meters of board per minute such you know lengthier ones are being produced which are having 4 meters wide. Such boards are then dried in a continuous sheet at temperature of 150 to 230 degrees centigrade in a gas or steam heated dryer which is approximately 250 to 300 meters long. Product must be sprayed with water as it leaves the dryer in order to bring it up to its normal water content of approximately 8 percent. Board is then cut and fabricated. Bagasse products also include acoustic and structural wall board, agricultural mulch and litter, plastic filler, furfural, paper and plastic reinforcing fibers for these purposes also it is used. In addition, when you do all these processes it is possible that you get high quality wax. In oils and fats industry we have seen that wax is very important component different types of waxes are there. So, one particular type of high quality wax may be produced when you do the processing of the bagasse that is coming from the sugarcane in the production of sugar in the sugar industry.

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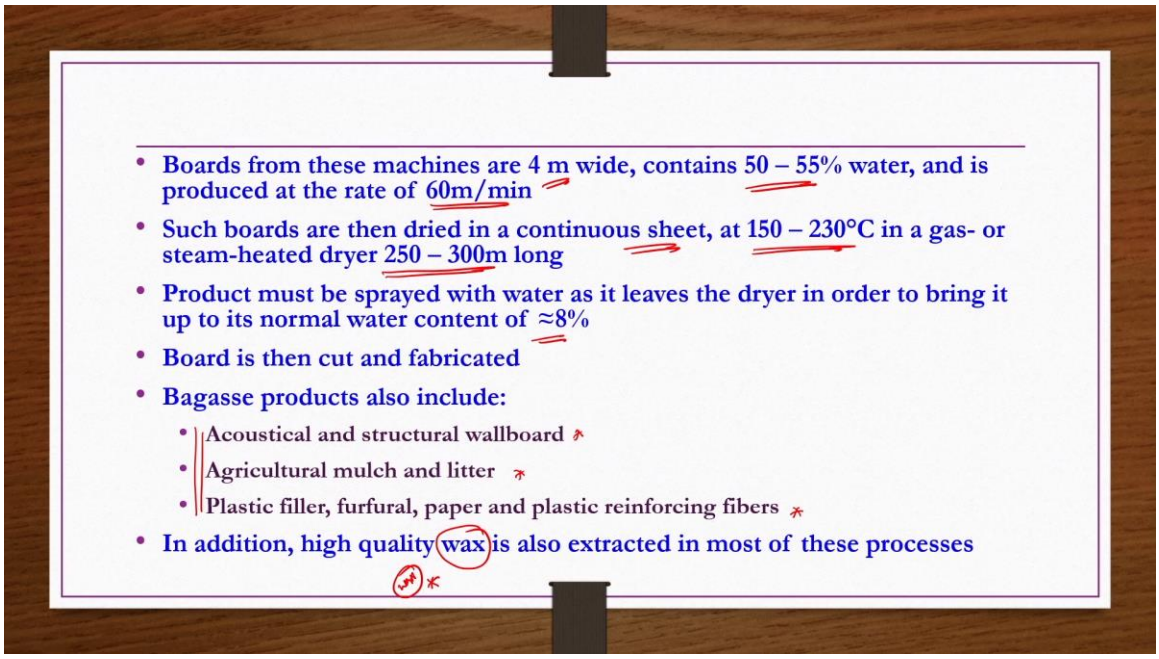

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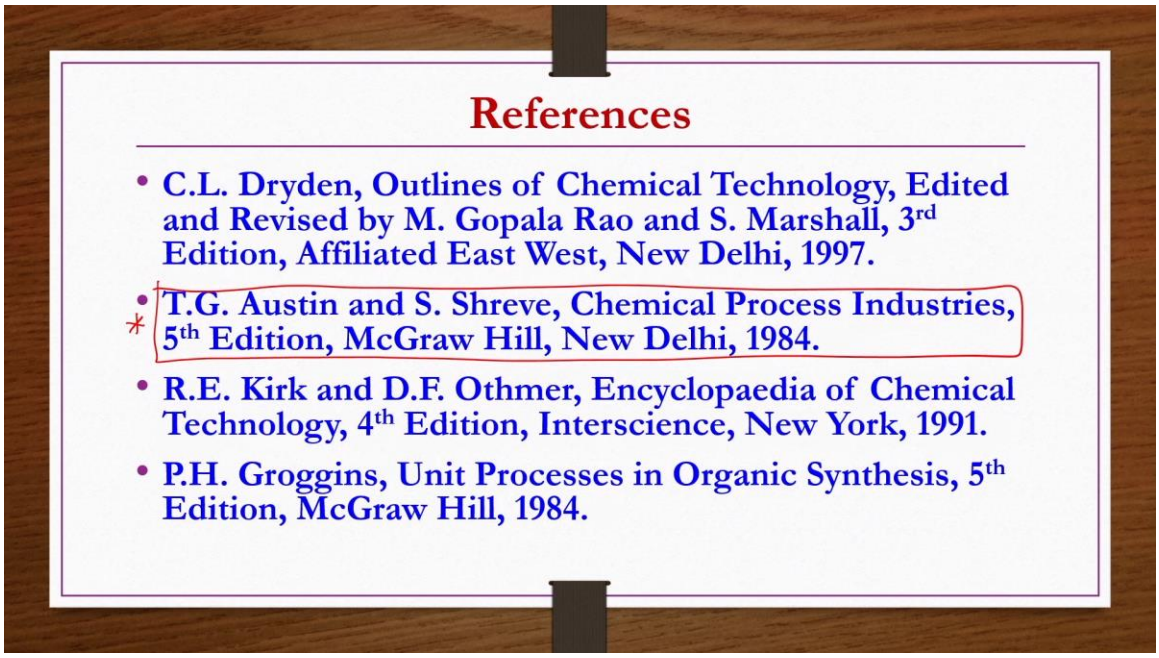

References for today's lecture are provided here. Outlines of Chemical Technology by Dryden edited and revised by Gopalrao and Marshall third edition. Chemical Process Industries by Austin and Shrive fifth edition. Encyclopedia of Chemical Technology by Kirchner and Ottmer fourth edition and then Unit Processes in Organic Synthesis by Grogin fifth edition. But however, most of the lecture is prepared from this particular reference book. Thank you.