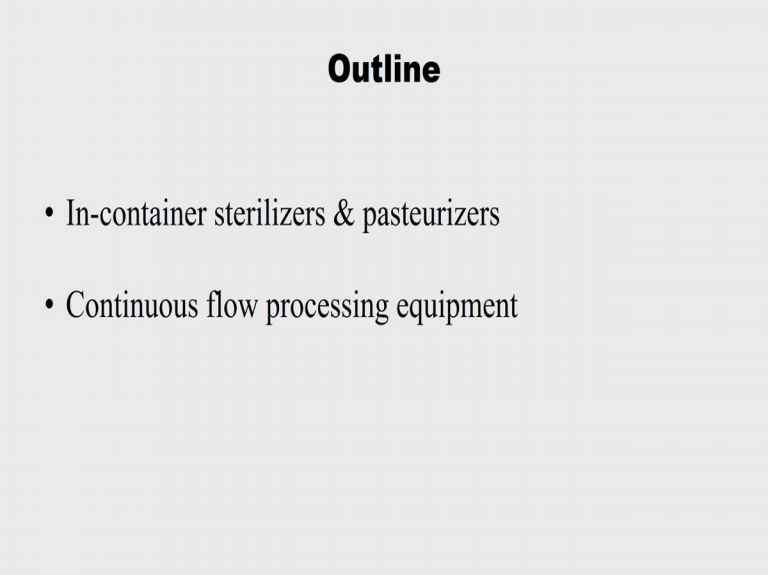
Thermal Processing of Foods
Professor R. Anandalakshmi
Chemical Engineering Department
Indian Institute of Technology, Guwahati
Lecture No. 3
Thermal Processing Equipment

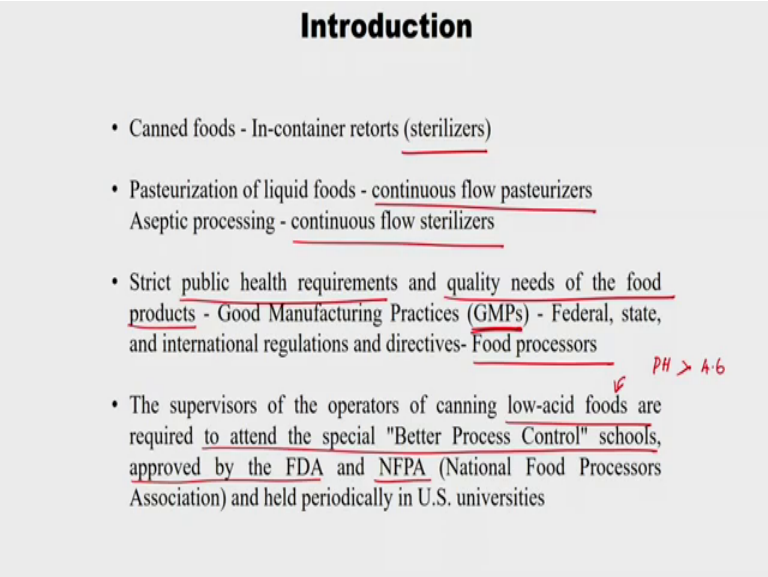
Good afternoon one and all. So today we are going to see about thermal processing equipment. What are all the different equipment used for thermal processing of food.

(Refer Slide Time: 00:43)



The outline goes like this, in-container sterilizers and pasteurizers. Already we have seen the two major thermal processing which happens in the food industries. The pasteurization and the sterilization and the second one is continuous flow processing equipment. The first one batch process and a second one continuous flow processing equipment.

(Refer Slide Time: 01:04)



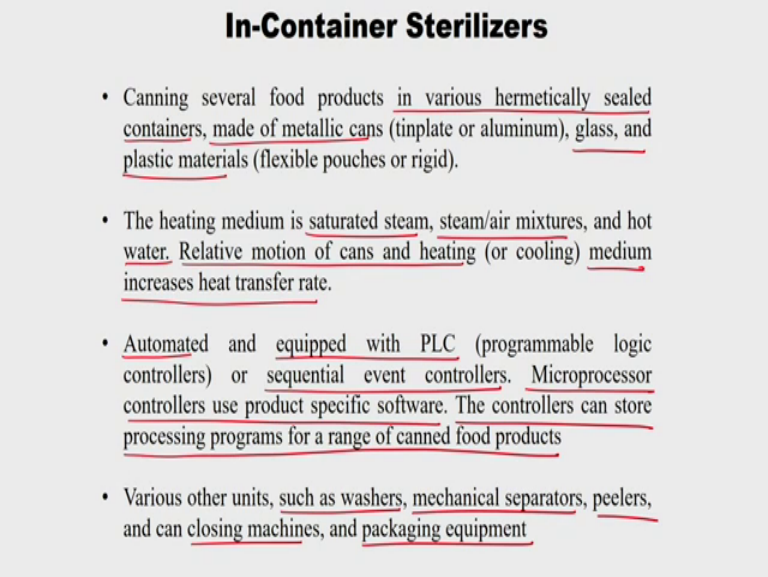
So to introduce in the canned food, it is usually done using retorts which is nothing but a batch process or we call it as a sterilizer as well. And normally the pasteurization of liquid foods happens in the continuous flow pasteurizers and aseptic processing. So which we have already introduced that both food & can is separately sterilized so aseptic processing uses continuous flow sterilizers. Actually when you use either the batch process or continuous process so we need to be very strict about the public health requirements because the cleaning of equipments and equipments use, the pumps, valves and bleeders and all the equipment should come under the regulations of federal state and international.

So, in that aspect we should maintain strict public health requirements and quality needs of the food products. So, they call it as a good manufacturing practices. So, this should be strictly followed and also the federal state and international regulations and directives, also the food processor should be maintaining very strictly and also sometimes, for example, the milk pasteurizations. So earlier days the Mycobacterium tuberculosis was identified as a most heat-resistant microorganism. But now that that slowly changed and Coxiella burnetii is the recent microorganisms. So the heat resistance of the microorganisms also changes based on the environment and the evolution.

So the supervisors of the operators of canning low-acid food, low acid food so this is low acid food we already seen the pH is something greater than 4 point 6. So where this is the favorable

condition for the C.bot to survive. So, the caning low acid food the operators who handles the canning of low acid food should attend the special better process control schools approved by FDA which is nothing but a Food and Drug Administration and also NEPA so National Food Processes Association. So they kept on offering the short term courses and better process control strategies then and there in the periodically in US universities. So, the supervisors are required to attend such short term courses and get to learn about what are all the best practices then and there.

(Refer Slide Time: 3:51)



So in-container sterilizers are used in the canning industry basically. The canning several food products in the various hermetically sealed containers made of metallic cans. We have already understood that the canning does not mean that only metallic canning of aluminium or steel so it also includes glass and plastic materials. So the in container sterilizers are basically hermetically sealed containers. So the heating medium used are either saturated steam or steam air mixtures and hot water based on the requirement.

For example, if if I use glass containers that is of thermal conductivity is very less so in that case which heating medium to be choosed. So based on certain factors we choose which heating medium to be used and relative motion of the cans and heating medium increases heat. Actually sometimes we use agitation to increase the heat transfer rate. So the relative motion of cans and heating medium or cooling medium because the normal processes first heat and hold it for some

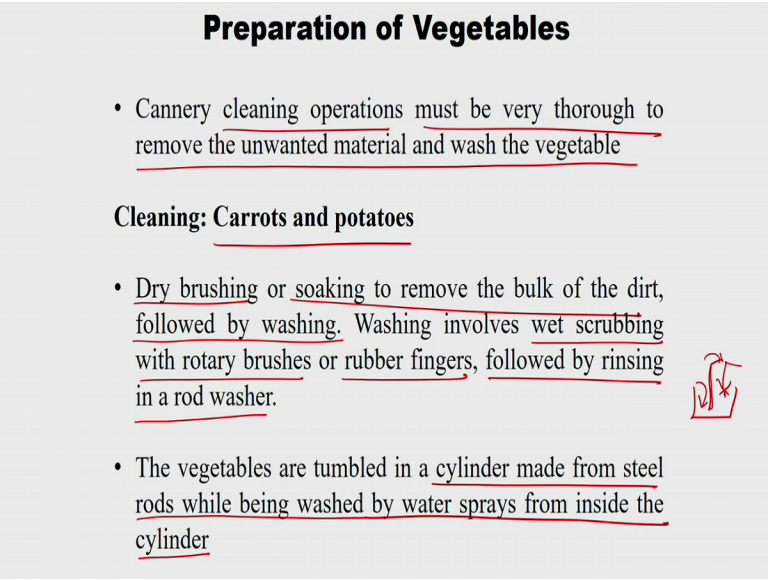
time then cool it to the normal temperature. So their relative motion between them also increases the heat transfer rate.

And nowadays what happens is the automated and equipped with PLC and sequential event controllers. So to control at a particular temperature and to control, to hold the products at, to hold the cans at particular temperature nowadays programmable logic controllers are used and also microprocess controllers use product specific software, okay. For example, if I am processing low-acid food so this much temperature to be maintained at particular time.

So this product specifics software is used in the microprocessor controllers, so that automatically takes care of the temperature control and time control. Also the processing programs for a large canned food product. So this is automatically GUI graphical user interface. First we we have to select the particular food product so it automatically gives what is the time to be maintained and at which temperature it should be processed.

And also various other units such as washers, mechanical separators, peelers and can closing machines and packaging equipment. The moment we say thermal processing equipment it is not only a batch or continuous pasteurizers or sterilizes. Sometimes in the canned preparation first before going into proper thermal sterilization or pasteurization there are food handling units in the canning industry. So these machines also comes under the category of thermal processing equipment. So we are going to see one by one.

(Refer Slide Time: 06:36)

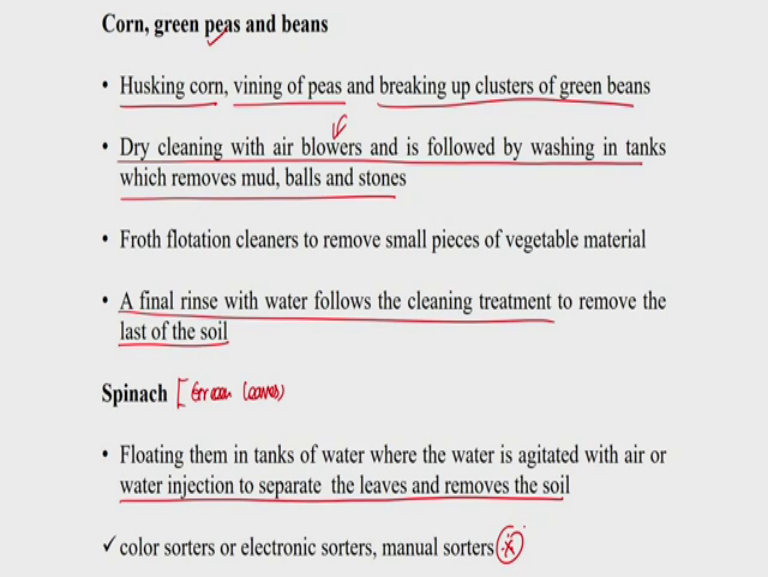


Actually for preparing the vegetables in the can these are all the process to be used to prepare the canned food. Actually in the canning industry the cleaning operations must be thorough to remove all unwanted material and wash the vegetable. Actually if we are not removing the unwanted material, for example, it contains the soil there may be some microorganisms which is thermophilic, which can survive still that heat requirement and it will allow for the further contamination. So it should be washed and the preprocessed thoroughly before going into a sterilization process.

So, for example, carrot and potato kind of food, so what are all the cleaning process available. So one is dry brushing and soaking to remove the bulk of the dirt followed by washing. So before going into proper washing when they take it from the soil the root contains the bulk of soil material. So first they they soak it to remove those dirts. Then after that the proper washing will be done. The washing involves wet scrubbing with rotary brushes our rubber fingers followed by rinsing in a rod washer.

So this will be tumble it will be rotated the machine's tumbler. So here you put the vegetables and the rod will be rotating and also here we employ the water then it will be washed thoroughly. And cylinder made from steel rods while being washed by water sprays from the inside of the cylinder. So this is the water spray and this is the rotating element, so it will make the contact between the water and the vegetable properly. So this is the way cleaning can be done in carrots and potatoes those kind of vegetables.

(Refer Slide Time: 8:27)



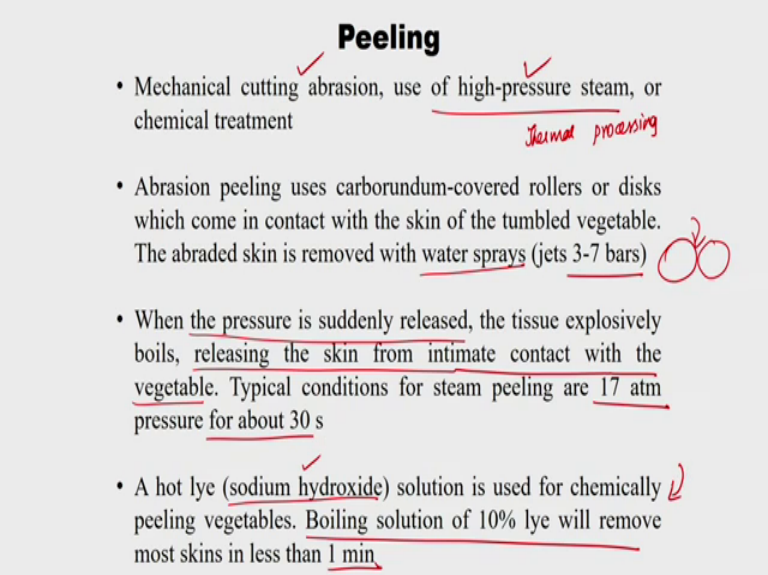
If my vegetables are corn or green peas or beans, so first the husking of the corn should be done in case of corn and vining of peas should be done in in case of green peas and breaking up of clusters of green peas. So these are all to be done before going for washing. And dry cleaning with air blowers and is followed by washing in tanks which removes mud, balls and stones. So before going into proper washing how we have done in carrots and potatoes the dry brushing so here they do it with dry cleaning with air blowers because when we remove the corn by using husking process so there may be some vegetable material kept with the corn itself.

So those will be removed using air blowers in terms of dry cleaning. Then after that the proper washing will be done in the tanks which removes muds, balls and stones. And sometimes what they do is froth flotation, so which also removes pieces of vegetable material and sometimes we we also see the peas which will be very less dense. There will not be any proper inside material so those also will be washed away with while using froth flotation. The final rinse with water follows the cleaning treatment to remove all the lost of them, then one time final rinse with the water which removes the remaining material which is still there after washing.

So that will be removed in the final rinsing. And spinach are greeny vegetables. These are all examples, so this always applicable for all green leaves. Right and floating them in the tanks of water where the water is agitated with the air or water injection to separate the leaves and remove the soil. So when they harvest the spinach or any green leaves so there will be mud associated with that. And also there may be some it is not only the particular green leaves. So for example, with the spinach there are some unwanted green leaves also will be there so those should be sorted it out after the washing.

And so this is usually it is done with the agitated water so that the dirt will be removed from the green leaf vegetables and also it is sorted based on the color and size, shape and everything. For example, I already told in the green peas there are some unwanted material which does not have that core material, right, only the skin will would be there. So those materials will be removed and the proper green peas are proper the spinaches those those will be sorted it out. And sometimes electronics sorters also used nowadays and sometimes still air blower also used to sort it out the required or the best ones. And still the manual sorter is the best one till date. There are some industry which which still uses manual sorters.

(Refer Slide Time: 11:15)



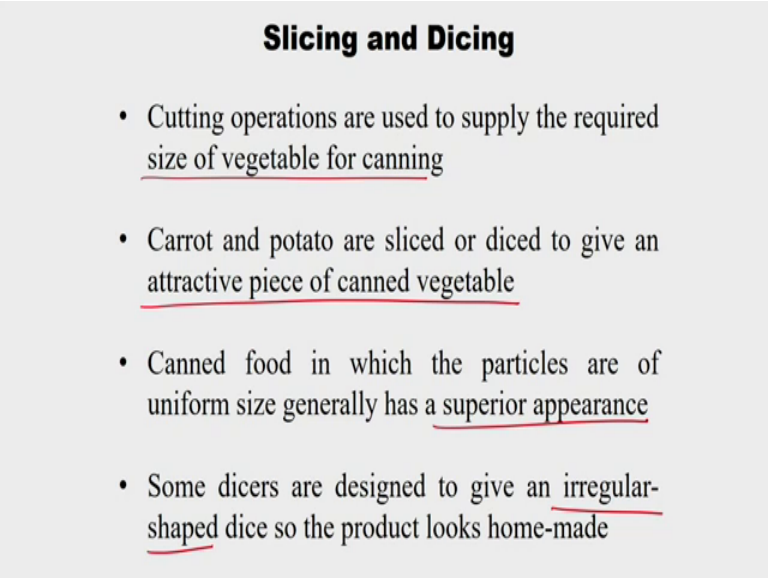
The second operation is peeling. The peeling will be done in three ways either by cutting abrasion and use of high-pressure steam. So this is again a thermal processing thermal processing equipment only. So that is what I told the preparation method itself the preparation for canning the preparation for sterilization itself a thermal processing or chemical treatment. So this is nothing but a two carborundum covered rollers would be there. So the vegetable is put in between the rollers which is in contact with the skin of the vegetable.

So the skin would be removed based on the abrasion phenomena but after that after the skin is removed the water sprays onto the vegetable that remove the skin properly. So that the jets will be of 3 to 7 bars pressure. So what happens in the abrasion it is instead of removing skin there may be some flesh material also goes into that. So in that way compared to high pressure stream peeling, abrasion peeling is less efficient. So in the high pressure steam peeling, what happens is the pressure is suddenly released, so that tissue explosively boils and releasing the above the skin.

When the steam is impinged on on our skin so what happens the skin will be removed. The same phenomena over there as well. The tissue explosively boils releasing the skin from the intimate contact with the vegetable. So here the amount of flesh which is also removed along with the skin is very less. So the typical conditions for steam peeling is 17 atmosphere pressure for about 30 second.

So this is economical and efficient one compared to abrasion and sometimes the chemical treatment which is nothing but a hot lye sodium hydroxide solution is also used to peel the vegetables. So, when you soak it then the skin will be removed very easily. So boiling solution of 10 percentage lye will remove most skins in less than 1 minute and for most of the vegetables. But the problem here is it should be washed thoroughly because we are using a sodium hydroxide chemical and also the washed water you cannot reuse because that is also contaminated water. So in that way this is comparatively less economical than high pressured steam.

(Refer Slide Time: 13:41)



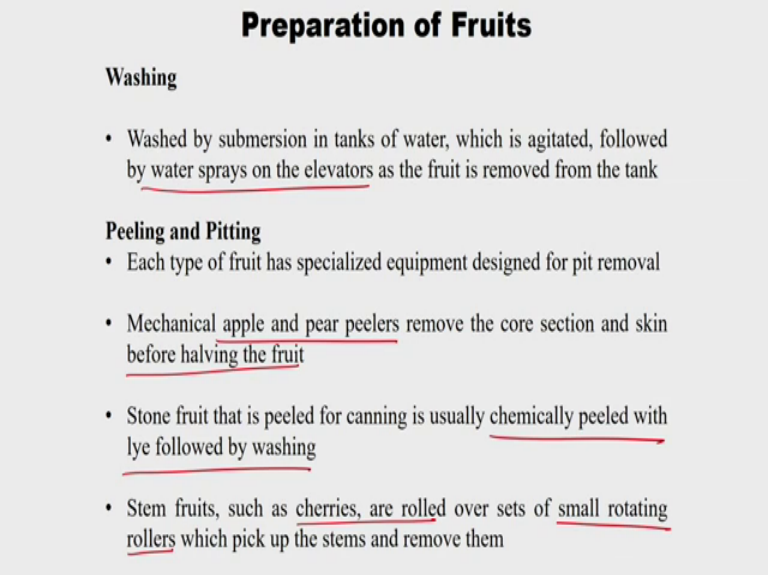
And slicing and dicing will be used, will be done by slices and dices. So the cutting operations used to supply the required size of vegetable for canning, for example, the can sizes are also standardized so there are standard cans. So this much outer diameter and this much length. So in that case my vegetables are whatever the food I am going to sterilize also should be of the required size. So for that purpose the slicing and dicing can be done. And also sometimes it is an attractive piece of canned vegetable.

So I would like to maybe customer would like to see on particular shape and a particular attractive shape in that case also slicing and dicing is required. And also sometimes what happens is like to give superior appearance of a particular shape, for example, I want it in the rounded shape or I wanted it in a cubical shape so based on the appearance also the the slicing and dicing

will be required. And sometimes these they will leave it as a regular shape because in home cutting we would not be able to get the proper size.

For example, if I am cutting it in the round shape so I will not get a round shape of particular diameter throughout all vegetable pieces. So what happens in homemade cutting is some irregular shaped the material will be always there. So sometimes the slicing and dicing also will be done in irregular shapes not only for particular shapes for irregular shape also so they do slicing and dicing.

(Refer Slide Time: 15:14)

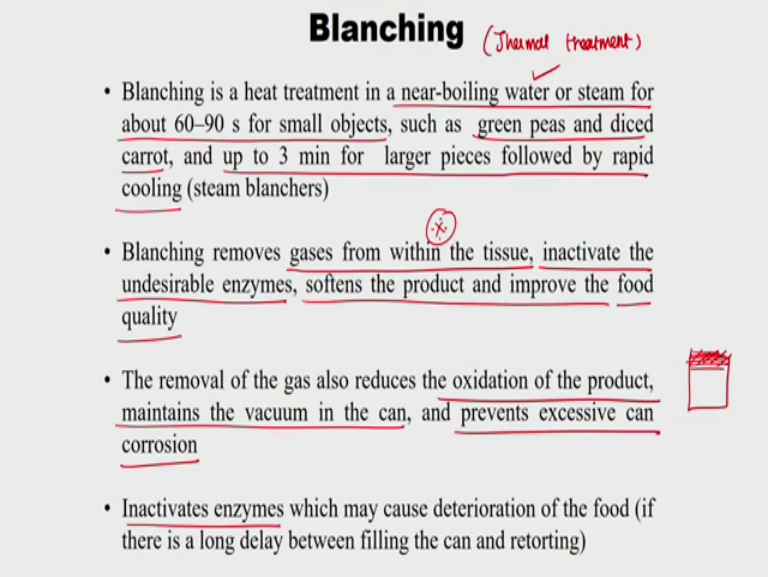


And in terms of fruits the first one is washing. So washing is similar to our vegetable washing so normally it will be washed in the agitated tank and sprays the water to remove the remaining dirt which is not getting washed away by using normal water washing. Then after that peeling and pitting. So there we have seen only peeling. Here pitting in the sense, to remove the pit is nothing but to remove the core part.

For example, in the apple and pear peelers so we need to remove the core section which has that seed. So core section and skin before halving the fruit. Actually each fruit has its own requirement of peeling and pitting. For example, Stone fruit that this peeled for canning is usually chemically peeled with lye we already told it how to peel using the hot lye. So for Stone fruit they use hot lye treatment.

And a stem fruits such as cherries kind of fruits so they rolled over a set of small rotating rollers which pick the stem and remove the stem and you will get the only cherries. When you get the cherry fruit as a raw you will get with the stem also. So then it is sent through the small rotating rollers so where your stem is removed and your cherries are collected.

(Refer Slide Time: 16:36)



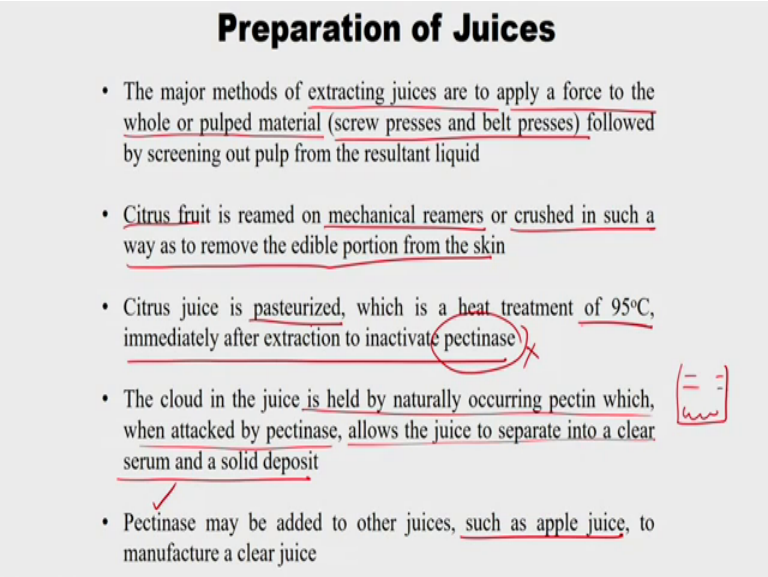
And this is blanching, blanching is also again a thermal treatment. So blanching is a heat treatment in a near boiling water or steam for about 60 to 90 seconds for small objects such as green peas or diced carrot or and up to three-minute for largest pieces followed by rapid cooling. So it is done in the steam blanches. So it is nothing but it is not like up to the sterilizing temperature it is a near boiling water temperature for about 60 to 90 seconds. Why we do that is, it is to remove the gases from within the tissue and one more thing is inactivate the undesirable enzymes and softens the product and improve the food quality.

So for these reasons usually blanching is done. The main reason is to remove the gas from within the tissue because if this gas is still happening to be inside the tissue so it promotes the oxidation of the product and also it prevents the excessive can corrosion. So if we remove the gas then it reduces the oxidation of the product and also maintains vacuum in the can. Vacuum in the can in the sense, in the canning there is a always headspace to be maintained to avoid the damage of the can during processing.

So if we have the gases still inside so this occupies this space. So to our that we need to remove the gas so it maintains vacuum. And also it reduces the oxidation further oxidation of the process

and also it prevents excessive can corrosion. If the gases are left inside then there may be a room for corrosion so that can be avoided using blanching and inactivates enzyme which cause deterioration of the food. If there is a long hour so it also inactivates the enzyme. For example, we fill the can and we will go for retorting but in between the filling of the can and retorting if there is time lag so this this helps in inactivating the enzymes which which spoils the food. So for that purpose also blanching is done.

(Refer Slide Time: 18:51)



And preparation of juices. We have seen preparation of vegetables so what are all the main thermal processing required and what are all the equipments. And after that preparation of the fruits and now preparation of juices. So normally juices are applied to force the whole or pulped material. So the major methods extracting juices are to apply a force to the whole or pulped material. Pulped material in the sense, removed the skin and only the fruit pulp. So this is usually done in screw press or belt press so followed by screening out pulp from the resultant liquid.

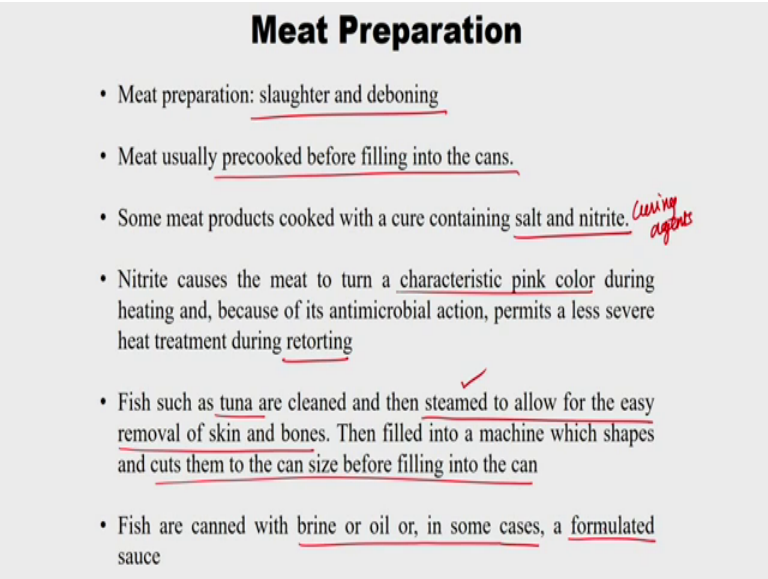
So after that we need to remove pulp from the resultant liquid and usually citrus fruit they are reamed on mechanical reamers. So instead of presses they get the juices from mechanical reamers are crushed in such a way that to remove the edible portion from the skin. As I already told for vegetables or fruits or juices or whatever the preparation methodology we cannot keep every food under the same category and say that okay this particular equipment is used to for these particular category.

For example, preparation of juices we would be using only screw press or belt press. So based on the needs, based on the variety of the food and based on the thermal processing requirement it keeps on changing. And also citrus juices pasteurized so which is heat treatment of 95 degree centigrade immediately after the extraction to inactivate pectinase. So as I told for other juices it may not be required for citrus juice so after the preparation we usually go for pasteurization thermal processing.

Pasteurization processing of at 95 degree for about their required time. So why it is done, is to inactivate pectinase. So this is the enzyme. So what it does is, the cloud in the juice is held by naturally occurring pectin which when attacked by pectinase allows the juice to separate into clear serum and a solid deposit. So what is the function of pectinase is, so it converts the pectin into some other product. So which allows the juice to separate. So your pulp material will be at the bottom you get the clear juice at the top.

So no consumer would be happy to consume such juices. So to avoid the pectin activity, to clarify the juice so we have to inactivate this pectinase product. But it is true for citrus fruit citrus fruit should not be separated as a clear serum and the solid deposit but the same is not true for apple juices. So in kind of apple juices this activity is required to get the clear juice. So there it the activity is required but in the citrus fruit the pectinase activity is not required. So that is the reason we go for pasteurization. So this is another thermal processing so before going for proper sterilization.

(Refer Slide Time: 21:58)

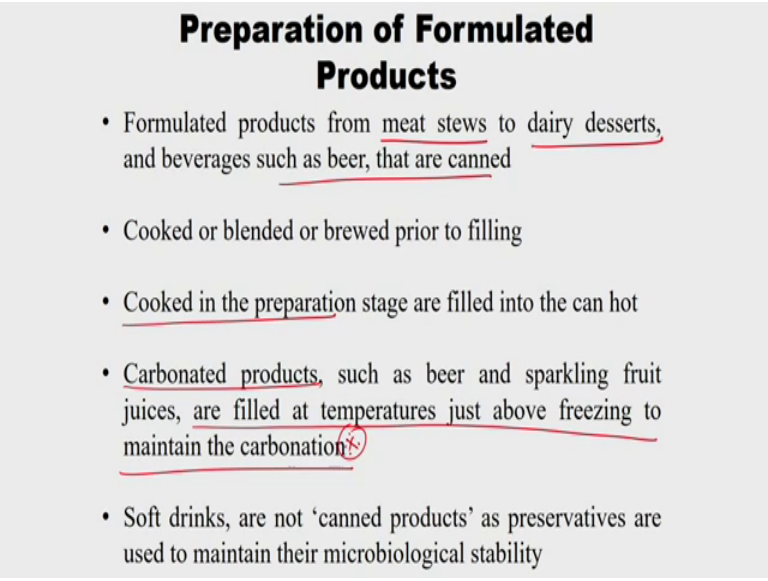


And meat preparation meat preparation normally the first thing would be deboning and slaughtering. Then usually it is precooked before filling into the cans. Meats and meat products cooked with the cure containing salt and nitrate, so this is nothing but a curing agent. So this that also act as a antibacterial activity so nitrate causes the meat to turn a characteristic pink color during heating and because of its antibacterial activation action, so nitrate salt they call it as a salt curing.

The salt used is sodium nitrite. So this causes the the characteristic pink color to the meat and also this allows before going for heat treatment during retorting. So this this process is done so the meat is cooked with the either salt or nitrate. So this lessens the time required for the proper heat treatment during retorting. And fishes such as tuna are cleaned and then steamed to allow further easy removal of skins and bones.

So this is another thermal processing which is done in the steamers. So they are cleaned and then steamed to allow for easy removal of skins and bones. Then they filled into a machine which shapes and cuts them into cans ice the cutting and slicing and dicing. So the fishes are canned with brine or oil or in some cases some formulated sauce also will be used in can itself the fish can itself.

(Refer Slide Time: 23:31)



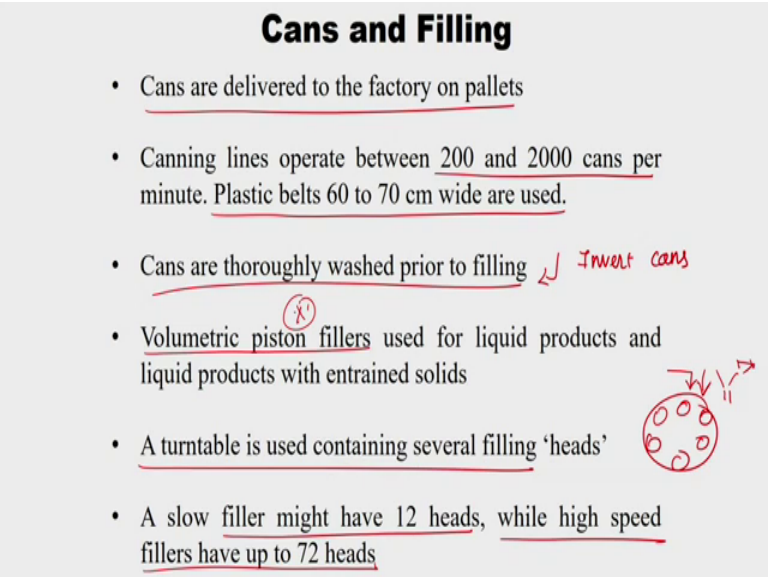
And formulated products it varies from meat stews, dairy desserts and beer every product is a formulated product. Usually they cooked or blended or brewed before filling into the can. The cooked in the preparation stage or filled into the can hot. So if you are doing cooking process

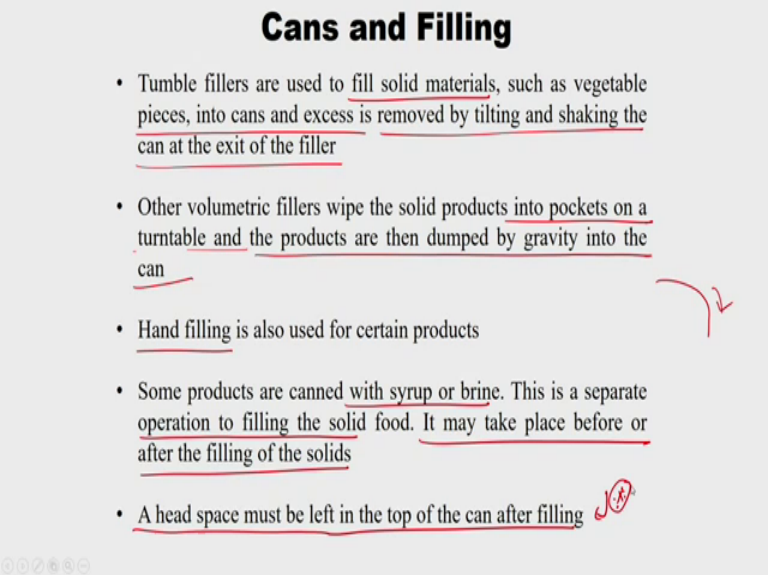
cooking process we have seen for the meat as well so they cook it with the salt or nitrate and fish also steamed to remove the bones. So if that kind of cooking is done then it should be filled in the can with the hot stage itself.

So normally the carbonated products are filled at temperatures just above the freezing to maintain the carbonation. So this is important so they should be filled at temperatures just above the freezing. And usually the soft drinks which are not canned products we will see in the canning operations why it is not called canned products because they use preservatives to maintain the microbiological stability. And we do not go for any particular sterilization process for these kind of canned products. So then finally so these are all the preprocessing before going for canning.

One is washing proper washing and peeling. And if there are any certain fruits if they need pitting then pitting will be done. Then after that slicing and dicing and then finally it two cans for fill. So as I told earlier not all the vegetables, not all the fruits, not all the formulated products will have the same protocol to to prepare for the canning. Because it is based on the product and the size, shape, color and in what process you would like to employ. So everything based on the product size, shape and and the process requirement so we cannot generalize, okay, this is the flowchart to be followed before canning.

(Refer Slide Time: 25:30)





So usually cans are delivered to the factory on pallets. So can lines operate between 200 to 2000 cans per minute. So usually plastic belts will be of 60 to 70 centimeter wide to transfer the cans. So cans are thoroughly washed before prior to filling it is not only the food to be washed cans also to be washed. And also they use invert they they usually invert cans to remove all the water before filling. And usually volumetric piston fillers are used to fill the liquid products and liquid products with entrained solid so volumetric piston fillers will be used.

And there is a turntable so which has, for example, here my cans are there. So above which there there there is a header. So which which fills the product. Whether if it is a liquid product you will use volumetric piston fillers or if it is a solid product there will be a hooper. So this size for example based on the cans size there will be a programmable controller. So which takes care of how much volume to be filled in each can. So usually slow filler might have 12 such heads and while high speed fillers will have up to 72 heads.

Actually, what happens in the cans is, why we are doing canning processes is, canning operations is, for particular season any vegetable or fruits or the leafy vegetables you will get it at particular season only. So the canning is done for even in the half off season how do I get the same product. But to do that so I should be handling large amount of volumes. Each particular season I should be harvesting large amount of volume and I should be canning it for the off season. So all the equipment should be able to had large volume.

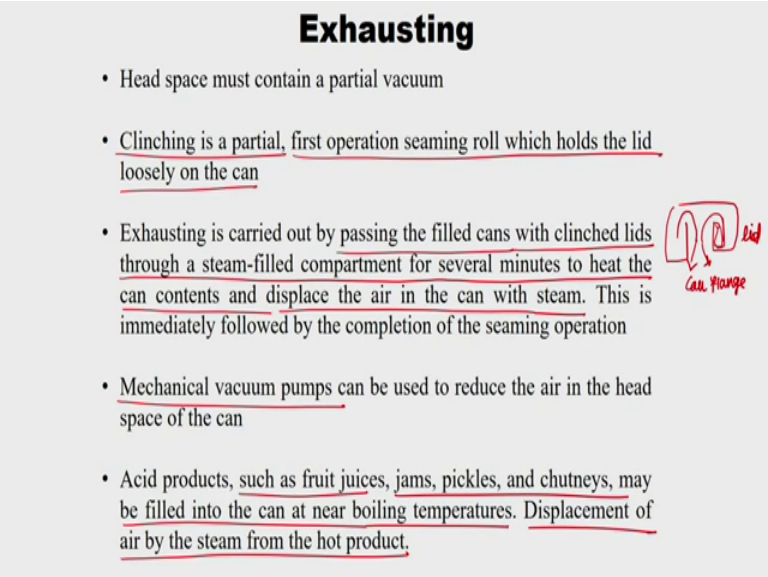
So that is the way so from 12 heads to almost 72 heads nowadays industries are using. Usually tumble fillers are used to fill the solid materials and also sometimes the hoopers such as

vegetable pieces, into the cans excess is removed by tilting and shaking the can at the exit of the filler. So if you shake or tilt then the materials which happen to be there in the lid then they will be removed. And other volumetric fillers wipe the solid products into the packets on the turntable and the products are then dumped by gravity into the can.

So when the can moves so normally these products will be removed due to gravity action. And still as I said there are hand sorters here hand filling is also there. And some products are canned with syrup and or brine. So we already told the fish will be packed with the oil. So there is a separate operation for filling the solid food. It may takes place before or after filling of the solids.

So normally if the solid to be canned with a syrup or brine so normally they do they fill separately. But it is a good practice to fill the syrup first then go for the solid material because it will remove the unnecessary air packets between the solid material. So the head space must be left in the top of the can after filling so this is very much important I already told otherwise it will damage the can.

(Refer Slide Time: 28:56)



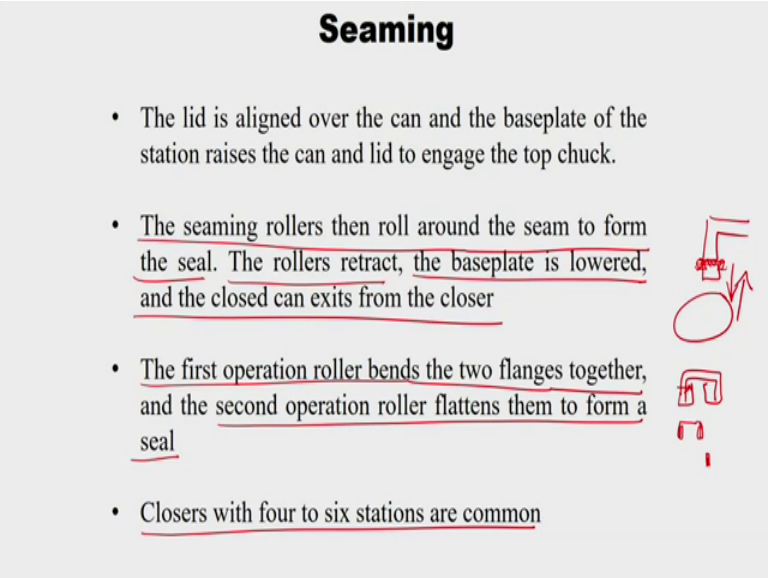
So this process is called exhausting. So exhausting is nothing but to keep the headspace in the vacuum condition and the clinching is the operation. So what they do is we are going to see in the canning operations there is something called a seaming. Double seaming, they call it as. So this is my canning flange so they put the lid of something of this kind, so this is nothing but my can flange. So this is the lid, so the clinching is nothing but so the lid will be loosely kept in the

can. So the first operation seaming roll which holds the lid loosely on the can they just kept it and they did not seal, okay.

So the exhausting is carried out by passing this filled cans which is at a clinching operation. Now with the clinched lids through the steam filled compartment for several minutes to heat the can contents and displace the air air in the can with the steam. So normally this loosely clinched lids contained cans would be processed in the steam filled compartment to remove the air inside the can and to fill with the steam. Then after this is done, then they seam the lid with the can flange. Sometimes mechanical vacuum pumps also used to remove the air bubbles in the headspace.

And acid products such as fruit juices jams pickles and chutneys may be filled with the can at the near boiling temperatures so displacement of air by steam in the hot product itself. So one way to do exhausting is you prepare the canned products and put the lid loosely and send it through the steam filled compartment and fill the steam or otherwise you use a mechanical vacuum pumps to remove the air or sometimes when you fill the product with the near boiling temperature so that creates the steam so that removes the air in the head space and when condensation happens so that become vacuum that headspace become vacant.

(Refer Slide Time: 30:58)

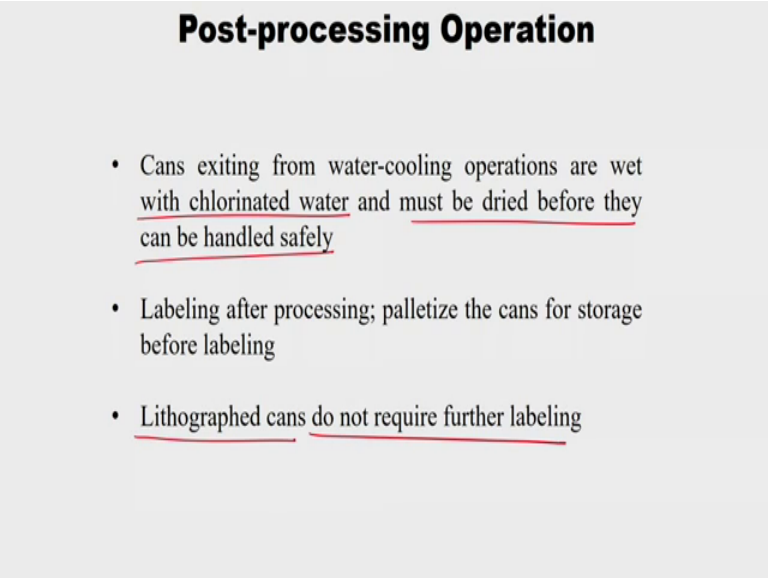


So the (scea) seaming I as I already told then after once it is done, once the removing of air in the head space is done then finally seaming will be done. The seaming rollers then roll around the seam to form the seal. The rollers retract the base plate is lowered. And then actually normally what happens is this is the seamer equipment so normally this base plate will go here so then the

reamer will act on the can and it it seems it does the seaming process. Seaming process is nothing but closing the can air tight.

Then after that this will become lower, the baseplate will become lowered then the closed can exist from the closer. The first operation roller bends the two flanges together as I told. So this is the late and this is the can flange so this becomes so final would be something like this so in between to this thing, your can flange will be held, so it is a full seaming operation. The second operation roller flattens them to form a seal. So flattens in the sense so you cannot differentiate between the can flange and the lid. So closest with four to six stations are common the the closing operations also can be done in six or more stations.

(Refer Slide Time: 32:24)

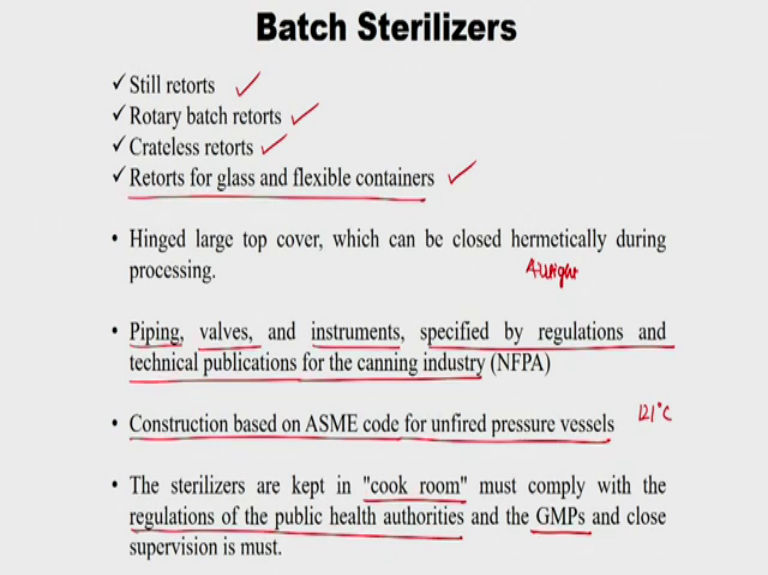


So the post processing operations is, after finishing everything so they are wet with the chlorinated water and must be dried before they are handled safely. And labeling would be done after the canning process and sometimes what happens the can itself lithographed the already before processing itself, so they do not require the labeling. So after that it will go to market or the further operation.

So these are all the operations normally held before sterilization or pasteurization. So all these process also contains some of the thermal processing so that is what we have done. The major thermal processing are one is the steam filled compartment we do exhausting so that is there and another one is blanching. Blanching operations also thermal processing and during peeling we

use the high stream operation to peel the vegetable that is also another thermal processing operations.

(Refer Slide Time: 33:19)



So the major thermal processing equipment are batch sterilizes. So they are further divided into still retorts, rotary batch retorts, crateless retorts and retorts with glass and flexible containers, so this is special case. Usually they have a one hinged large top cover which can be closed hermetically that is airtight during processing. So this is a batch sterilizer so you need to put it and forget it, means the batch process no continuous flow is happening.

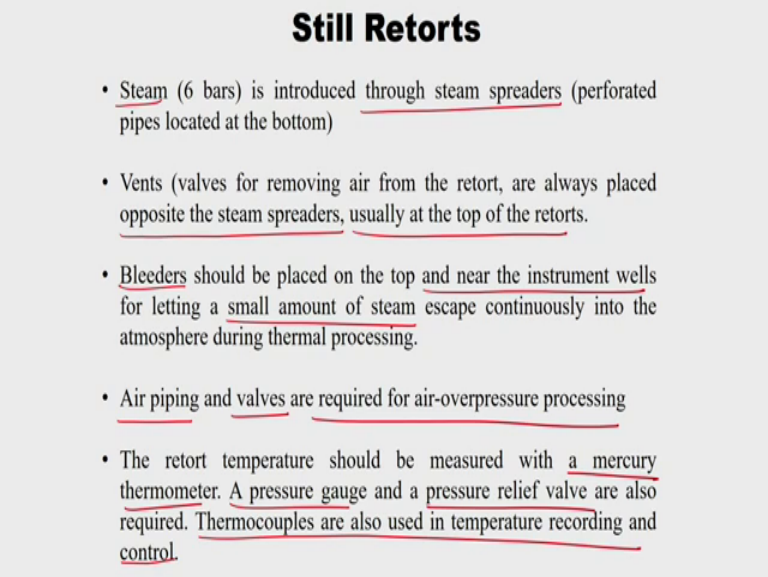
So as we told already the piping, valves, instruments specified by regulations and technical publications for the canning industry which is formulated by NFPA so that is National Food Processors Association and construction based on ASME code American Society of Mechanical Engineers code. So that should be followed in unfired pressure vessels.

So we can say that batch process in the sense even just to one jacketed vessel is enough to sterilize, no it is not like that. So whatever the equipment you use so that should be based on the regulations and standards and also for pressure vessels because in sterilization you use 121 degree and particular temperature and higher pressure so in that case the pressure vessels also should follow the ASME code.

The sterilizes are kept in “cook room”. There is a special room in the in every industry and must comply with the regulations of the public health authorities. It cannot be just like that kept and

also when we do the sterilization process it is basically for killing of microorganisms. Right so finally when the food is checked for its microbial activity also it should be done on the organism which is not toxic enough. So in that way, so all the regulations of the public health authority should be taken into account and good manufacturing practices GMPs always should be followed and close supervision is must.

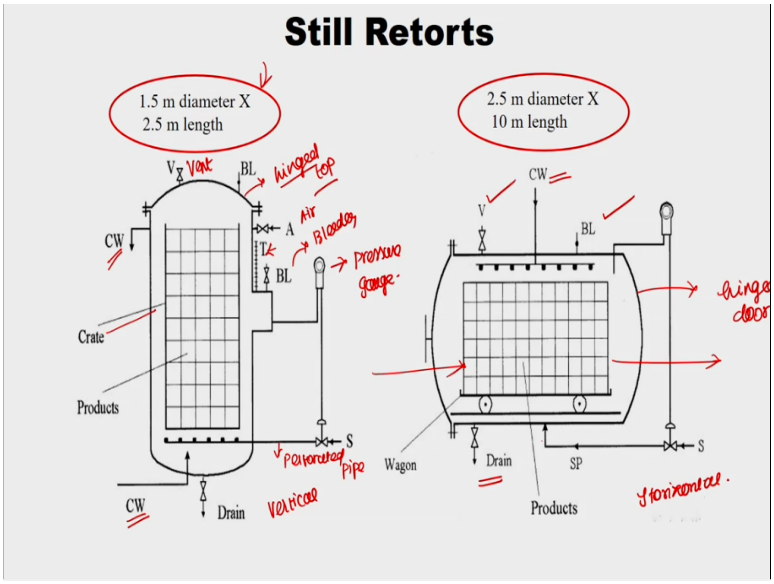
(Refer Slide Time: 35:25)



And still retorts normally use steam of six bars is introduced to the steam spreaders which is perforated pipes located in the bottom. And vents which are the valves for removing air from the retort and always placed opposite to the steam spreader anyway we are going to see how it looks like usually at the top of the retorts. And bleeders, bleeders are just for the steam to escape. So they should be placed on the top and near the instrument wells for letting small amount of steam to escape continuously to the atmosphere during thermal processing.

And air piping valving are also required for air over pressure processing and retort temperature should be measured with the mercury thermometer a pressure gauge and a pressure relief valve also should be required. And thermocouples are also used in temperature recording and control. So these are all the parts of the Still retorts we need to be a bit careful about and it should comply with all the standards.

(Refer Slide Time: 36:25)



So this this is how the still retorts looks like so this is vertical retort. So this is horizontal retort. So there is no standard but still it is of 1 point 5-meter diameter and 2 point 5 meter length and the horizontal retort is of 2 point 5 meter diameter and 10 meter length. So this is the hinged top. So once the can is kept inside so this is the crate, right. So this is this is crate and these are all the products kept in the crates. And this is steam so which is nothing but a perforated pipe so through which steam is employed. And once they keep the can then the this top will be hermetically sealed.

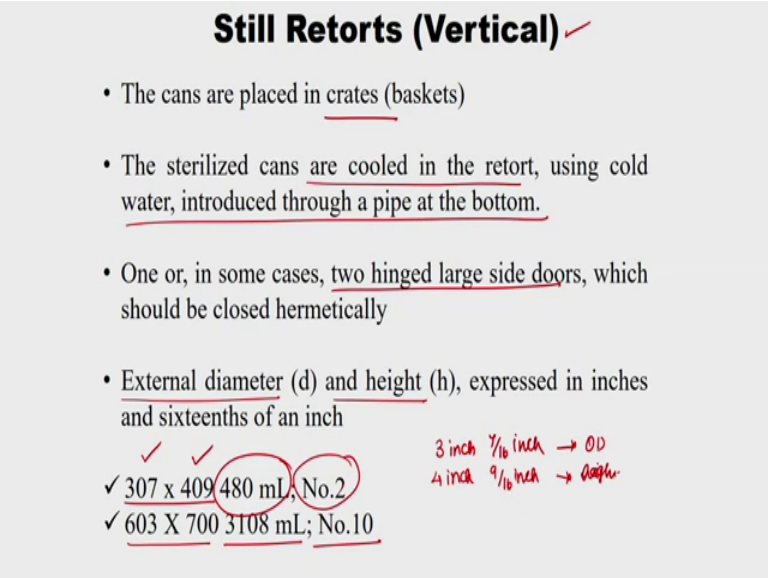
Then this is the bottom perforated place through which steam is employing inside the retort and this is the steam bleeder. So this is air for over pressure, for example, you do sterilization at 121 degree centigrade and higher pressure, right. So immediately the product to be cooled to normal temperature of around 38 degree centigrade. But why we do so is because to avoid any thermophilic bacterias to survive. So when when you cool the product which is at high temperature and high pressure there may be internal stresses caused due to pressure so your outside pressure should be balanced.

So that is nothing but overpressure riding. So that for that purpose air is also employed here. And so this is nothing but temperature control the thermocouple. T is thermocouple, BL is bleeder and A is air and after the sterilization at particular temperature is done particular temperature for particular time is done then cooling water, CW is cooling water. This is employed by bottom and

it is removed and the top. And this is the vent, this is a again bleeder yeah that is all. So this is the pressure catch to check the pressure.

And here everything is similar in the horizontal so here it is your steam which is employed and sometimes what happens is this door is this also will have a hinge top door. It is not hinged, hinged dried door right it is not top any way hinged door there is another door here. So they they keep inside the can and the can will be removed for further operation. So that kind of design is also available. The same way this is the drain this is the drain, this is cooling water inside and this is the drain and this is the steam so this is bleeder this is vent again yeah that is all. So this is a two type of retorts batch retorts.

(Refer Slide Time: 39:32)

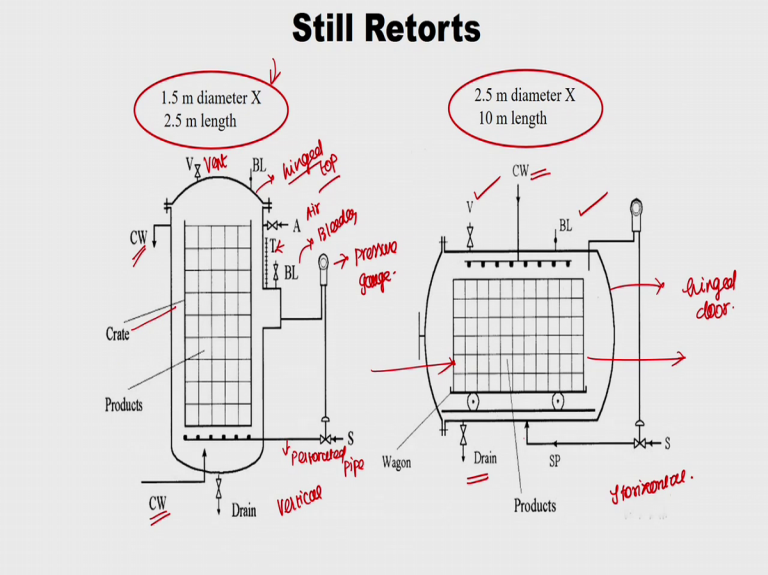


So creates so we have already discussed and the sterilized cans are cooled in the retort using cold water which is introduced through the pipe at the bottom when it is vertical retort. Two hinged doors also used which should be closed hermetically. Normally the number of cans how do they decide or number of or the diameter and length of the retorts how do they decide it is based on the can size.

So this is nothing but external diameter and height so this is external diameter this is height so normally it is 3 inch and a 16th of an inch so 3 inch 7 upon 16 inch so that is nothing but 307, 40 minus 4 inch and 9 upon 16 inch, so that is the this is diameter, external diameter, outer diameter so this is nothing but a height.

So this holds 480 ml so normally because this size is standardized they call this as a number 2 can. Number 2 can means which has 3 and 7 upon 16-inch OD and 49 upon 16 inch height can which has the 480 ml volume. And the same way 6 not 3 and 700 which holds 3108 ml and this is called number 10 can. So based on the sizes of the can we can decide how many cans can be kept inside the retort.

(Refer Slide Time: 40:57)

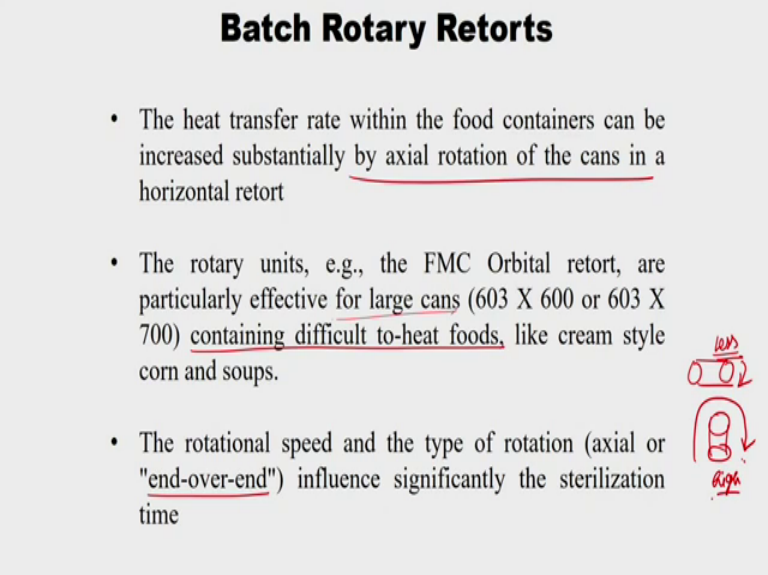


So horizontal retort we already have seen the placed in trucks or trolleys which are loading into the retorts moving on special tracks. So if you see here so this is what they talk about. And the steam is introduced into the retort through the long perforated pipe which is at the bottom. And venting and bleeding valves are also located on the top, cooling water is introduced normally from the top and removed from the bottom in the horizontal retorts.

And the cooling of large and flat cans with water records overriding off the air pressure to prevent the bulging. I already told if you are processing the pouch or the glass cans then there may be a chance of bulging and the lid will be thrown out and if it is a pouch and there is a large possibility for the pouches to break.

So to balance the pressure or to avoid the mechanical distortion the excessive internal or to avoid the excessive internal pressure particularly during initial stage of cooling. I already told it is at high pressure and high temperature when the start of cooling. So we need to take care of the pressure balance between the inside and the outside of the can. So for that normally overriding air pressure this is done that is way that air valves are used.

(Refer Slide Time: 42:15)

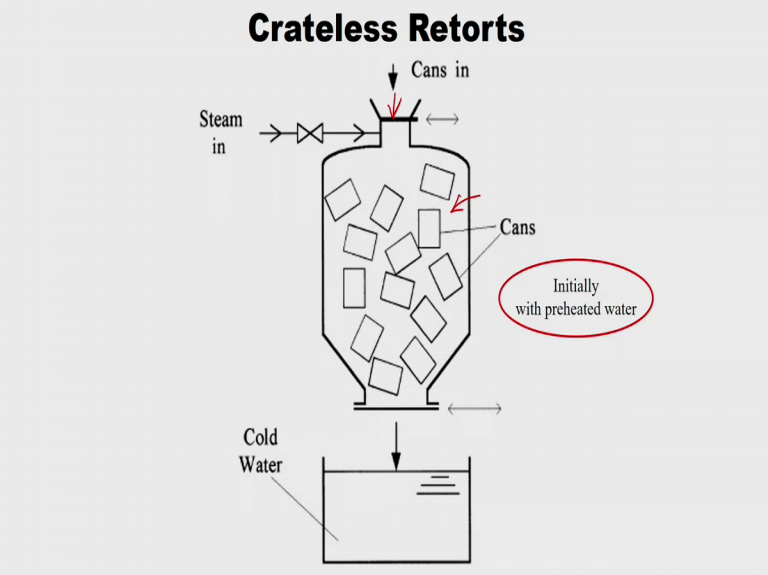


So next one is the batch rotary retorts I have already told the rotary action is done just to increase the heat transfer rate by axial rotation and there are certain categories. For example, this is my can and so you do axial rotation and also can can be rotated in this way also. So normally this has less comparatively this is high.

The heat transfer it is still high in the one-on-one rotation. So this is axial rotation so comparative to that this is this is having less heat transfer rate. The rotary units usually particularly effective for larger cans which contains the difficult to heat food. Difficult to heat food in the sense cream-style corns or soup.

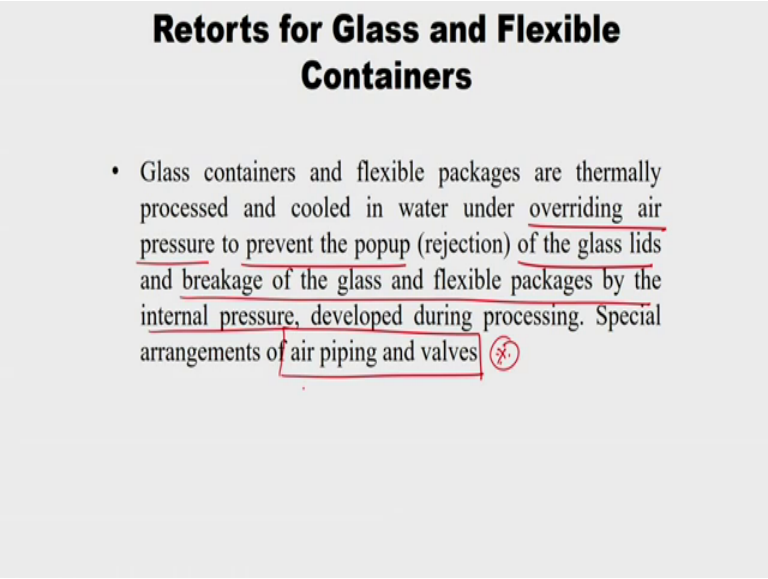
So they their viscosity is high so normally the heat transfer coefficient would be less to increase that, then normally the agitation is done. It improves the mixing and also it increases the heat transfer rate. So end-over-end is this this one. So this is comparatively high compared to axial rotation.

(Refer Slide Time: 43:20)



And there is something called crateless retorts. The crateless retorts what what happens is initially it is filled with the pre heated water then after that cans are just to put inside through the top opening. Then slowly the steam is employed, the steam replaces the pre heated water then once the sterilization is done for a particular time then cooling water is employed then cooling water is removed here then cans are sterilized.

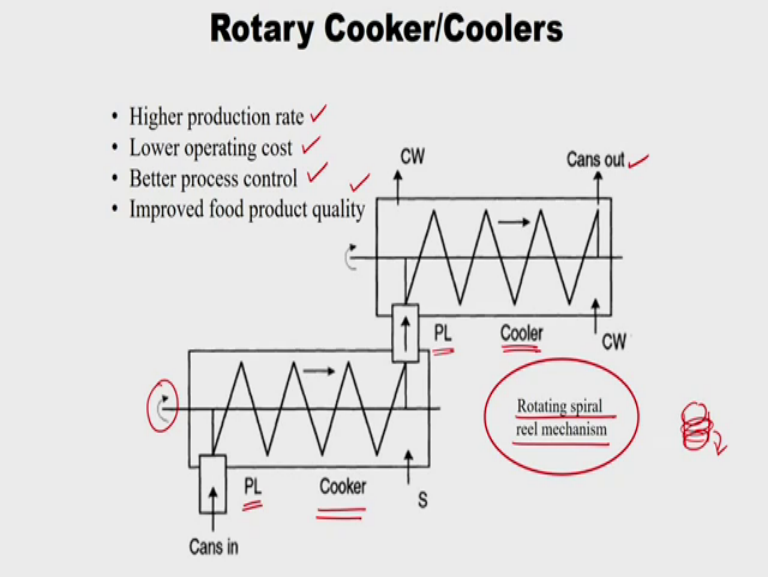
(Refer Slide Time: 43:47)



Usually gas and flexible containers, I have already told when you do thermal processing there may be a overriding air pressure to prevent the pop up or rejection of the class lids or breakage of

the glass or flexible packages by the internal pressure developed during processing. So special arrangements of air piping and valves are done these kind of there is nothing like we have special kind of retorts for these kind of cans of glass or flexible back pouches and only thing we need to take care of take is overriding of pressure that is done in extra air piping and valves.

(Refer Slide Time: 44:30)



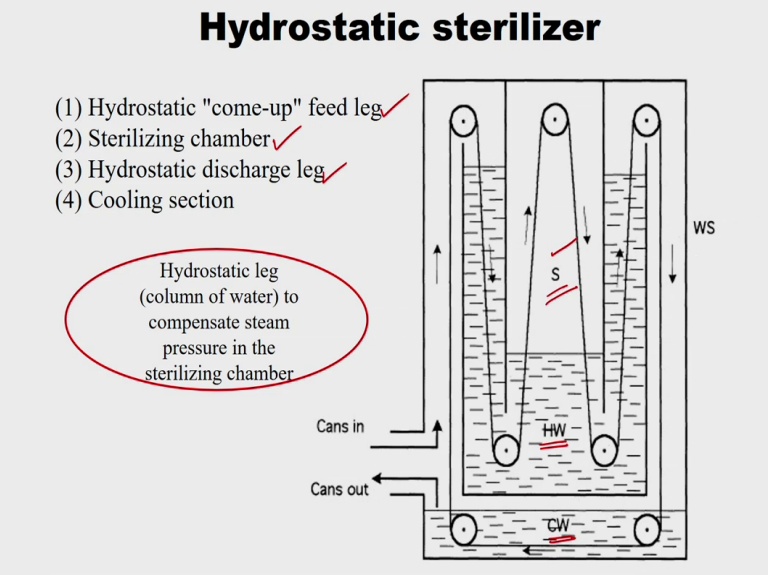
Apart from that the industry adopts the new range of retorts so which is nothing but a rotary cooker or coolers. So this is done for high production rate, lower operating cost, better process control, improved food quality. So all all this purpose instead of doing it in the batch process you do it in a better manner. So here there are two separate retorts so one is cooker another one is cooler. The cooker we have a rotating spiral reel mechanism. So this is the mechanism followed the ream ream is nothing but what you take it out, your thread, right.

So this is wounded and and we take it out, right. So this kind of rotating reel mechanism is used inside. So the cans are in here. So this is nothing but a pressure lockers which is used to move the can through the spiral reel mechanism till the end and the same pressure lockers are used to it transfer the cans from the cooker section to the cooler section, so where cooler section cooling water is employed to cool the cans, then the cans out here.

So this is done for high production rate so instead of putting 30 cans inside the batch retorts and wait for 30 minutes and this is the continuous process and also it takes care of lower operating cost. Lower operating cost in the sense we can process more cans in at the same time and also it gives the better process control and improved food product quality because when you are

rotating here so I we already told the heat transfer rate is improved and also the mixing is for a proper you will not get more cold spots compared to non-rotating one.

(Refer Slide Time: 46:08)

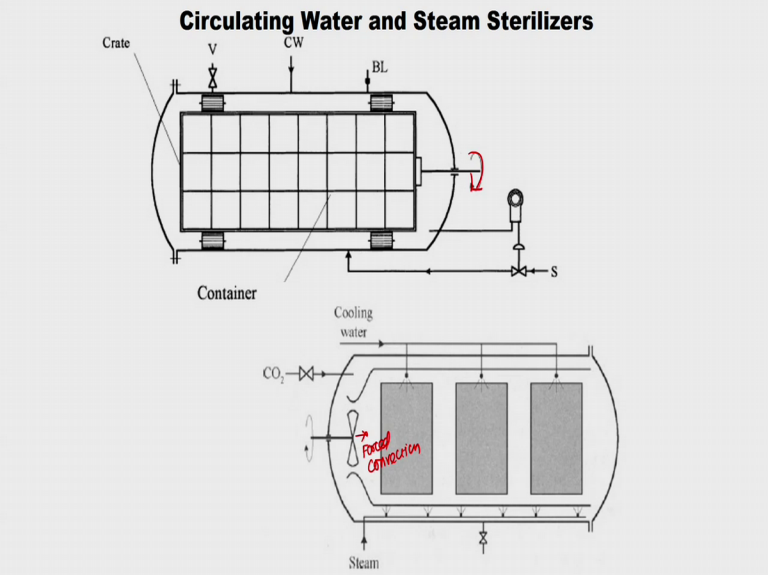


And there is something called hydrostatic sterilizer this is also new version. So here what happens is the different regions are there. One is hydrostatic come up feed leg. So this is come up in the sense here the hot water is there, here it is cold water, so before going to steam sterilizing so it is preheated in the hot water so that is nothing but a come up feed leg. Then sterilizing chamber which is nothing but this one and hydrostatic discharge like this is again coming into hot water then after that it is going to cooling section.

So it is not like you are not transferring from the high temperature high pressure to sudden cooling. So before doing that you it is processing through hot water again. So usually these kind of hydrostatic sterilizer, we already told the when you are doing the sterilization it is a high temperature high pressure process to counterbalance the pressure the hydrostatic in the sense rho gh.

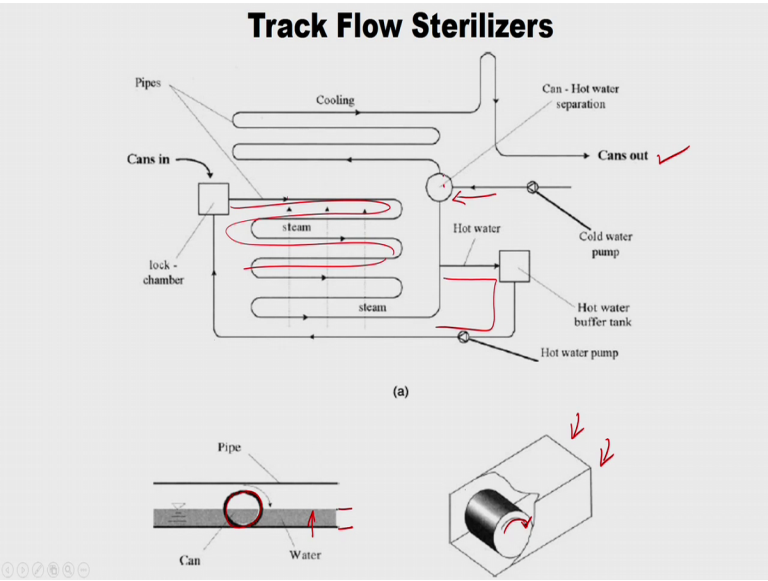
So your height should be so high to maintain at high pressure so in that case the height of this unit would be around around 12-meter length. So it should be kept outside the industry unit and it is not completely outside the industry unit. So you need to find the proper place because 12-meter height of this unit it is we cannot accommodate in the normal plant. So this kind of sterilizers also available.

(Refer Slide Time: 47:32)



And another is circulating water and steam sterilizers. So this is what we have seen the same container sterilizer. So this is the crate and this is the bleeder and steam and everything is there but here the crates is kept rotating. And here another mechanism where your fan is used to forced convection. Forced convection, fan is used to for forced convection so when the steam is applied through the perforated plates so the fan is used to distribute the steam evenly within the sterilizer. So these are all special types of thermal processing sterilizers.

(Refer Slide Time: 48:16)

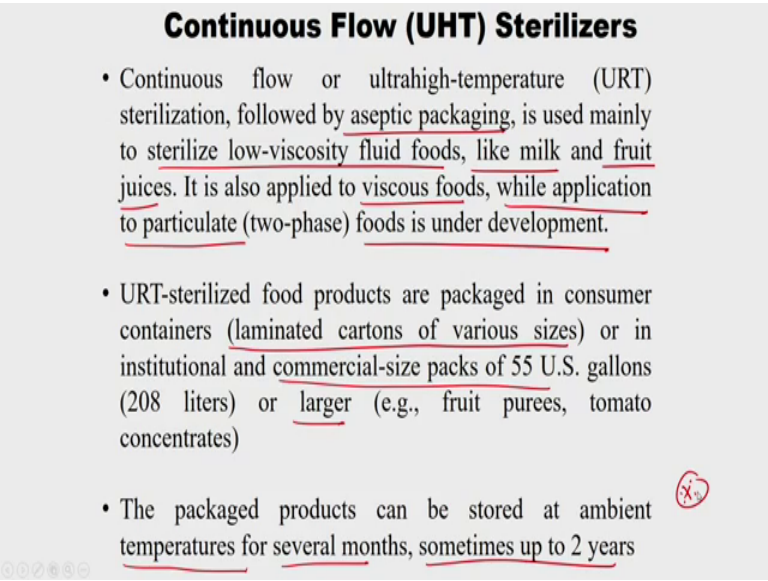


And another is nothing but track flow sterilizer. So here you have a serpentine piping. So this is the proper line, so this serpentine pipe is nothing but this. So which has the rectangular cross section so your can is kept inside. So when it goes and the rotation happens in this way, so here you have a lock chamber which takes care of the pressure differences when cans are in it is employed through the serpentine pipe, so where your hot water is employed.

So the hot water if you see here, the hot water as well as cans, so both are going inside the pipe of rectangular cross section here. So if you see this is my can and this is the hot water field. So here your steam is passing, so the steam is heating the hot water here so that is the way the cans are beings sterilized.

This is the hot water loop and this the cans are in so when they are passing through the serpentine piping so the steam is employed here and that is the way your water gets heated and the cans are sterilized. Then after that it is removed here and the cold water pump employs the cold water. The same thing happening in the cooling loop then finally your cans are out and can and hot water separations is done here. So this is nothing but track flow sterilizer.

(Refer Slide Time: 49:43)

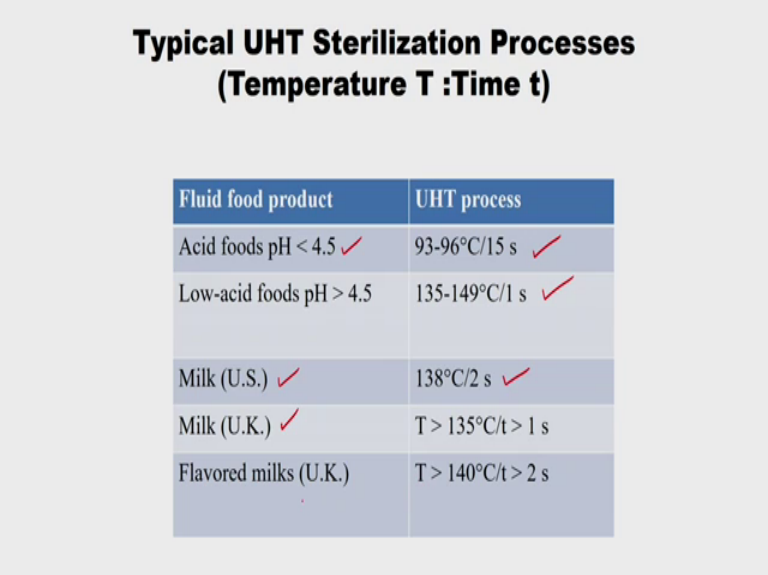


And continuous flow sterilizers normally we are going to see anyway the milk pasteurization so there you will see the thermal processing equipment used to for UHT. So UHT is employed for the aseptic packaging which is mainly used to sterilize low viscosity fluid foods like milk or fruit juices. It is also applied to viscous food, while application to particulate foods is under development.

Usually the pure milk, pure liquid products it is well developed UHT process, but particulate foods which are in two phase which are in suspension in the liquid, the solid materials are suspended in the liquid so this is under development. Usually this URT sterilized food are packaged in consumer containers usually the laminated cartons of various sizes so there are seven layers of packaging. Usually the commercial size of packaging of 55 US gallons that is nothing but 208 liters or larger is also available.

The packaged products can be stored up in ambient temperature for several months and sometimes up to 2 years so this is the beauty of UHT. So normal pasteurization you cannot keep it in the atmosphere temperature you should be refrigerating it to avoid further contamination but in UHT so you can store it in the normal temperature up to several months to up to 2 years. So based on the time temperature relation you apply for sterilization.

(Refer Slide Time: 51:15)

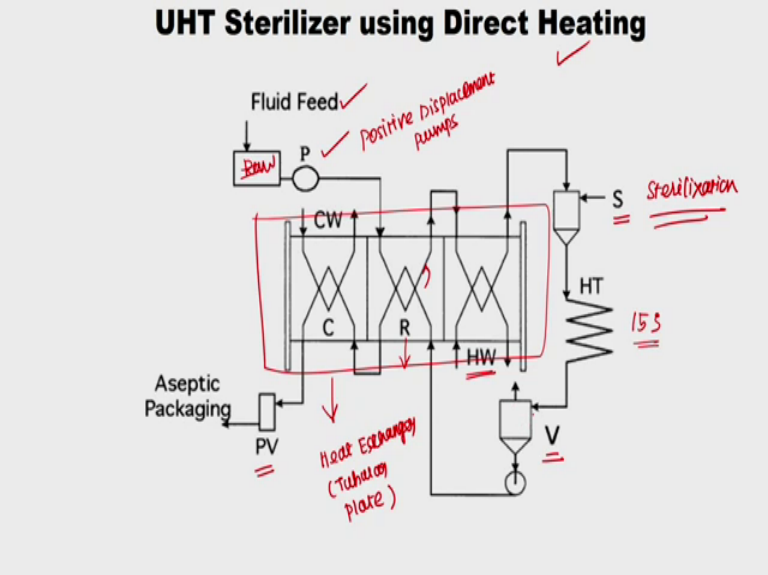


So this is one such table which talks about temperature and time relation. So in UHT process if it is acid food of less than 4 point 5, so you use 93 to 96 degree for 15 seconds and if it is a low acid food pH of greater than 4 point 5 we use 130 to 149 degrees centigrade about 1, 1 second. So milk US, UK so this why we are telling US, UK is.

What is the difference is, that we are going to see in milk pasteurization lecture because US and UK use different regulations to kill the microorganisms at particular time temperature relation. So that is what that is why this is US, UK. So US standard says 138 degree centigrade and 2 second is enough but UK regulation the T should be greater than 135 degree, time should be

greater than 1 second because they take care of to keep good enzymes as well at the same time inactivating the enzymes which spoils the milk. And for flavored milks UK Standard says greater than 140 degrees centigrade and about 2 seconds.

(Refer Slide Time: 52:26)



So this is common UHT sterilizer which is going to used by direct heating. Direct heating in the sense your steam is employed in the product itself. So this is the fluid feed so which is pumped, so normally they use positive displacement pump, so because irrespective of the pressure it takes care of the particular speed of the material so that is why plus positive displacement pumps are preferred over centrifugal pumps. And there are certain industry which uses centrifugal pumps as well.

The fluid feed is pumped through and it is going to regeneration section. So this whole unit is nothing but heat exchanger. So this is the heat exchanger either it can be a tubular or it will be a plate heat exchanger there is other variety of heat exchangers also there. So this is the fluid which is pumped and it is going through the regeneration section then after that it comes to heat this is the hot water so this is proper heating then it goes to steam section where steam is employed here only your sterilization happens.

It is raised to 121 degree or whatever, for example, if you are processing acid food, so it is heated to 93 to 96 degree and it is holding in the holding tube around 15 second. Then after that it comes to flush tank where excess water is removed. Why we are removing the excess water, I will be

telling. So then again it goes to regeneration section to exchange its high heat with the raw feed. This is the raw feed so it exchanges the heat with the raw feed.

So then it goes to cooling water section where cooling water is employed to cool the product. Then again it goes to through the pressure valve back pressure valve for the further aseptic packaging. So your raw feed is come pumped and coming to the regeneration section then heated using hot water then goes to sterilization where steam is employed to reach their required temperature and holding it for particular seconds to maintain that temperature then comes to flash tank where the excess water is removed.

Then goes to regeneration section to exchange heat with the raw feed then go to cooling section by using cooling water, the product gets cooled. Then go to through pressure valve it goes for aseptic packaging. So here you are saying direct heating so the steam is employed to heat the product directly. So when condensation happens there may be some water which is also present in the product so that can be separated in the flush tank. So that is why we use flush tank here.

(Refer Slide Time: 55:24)

Pasteurization Processes for Liquid Food Products

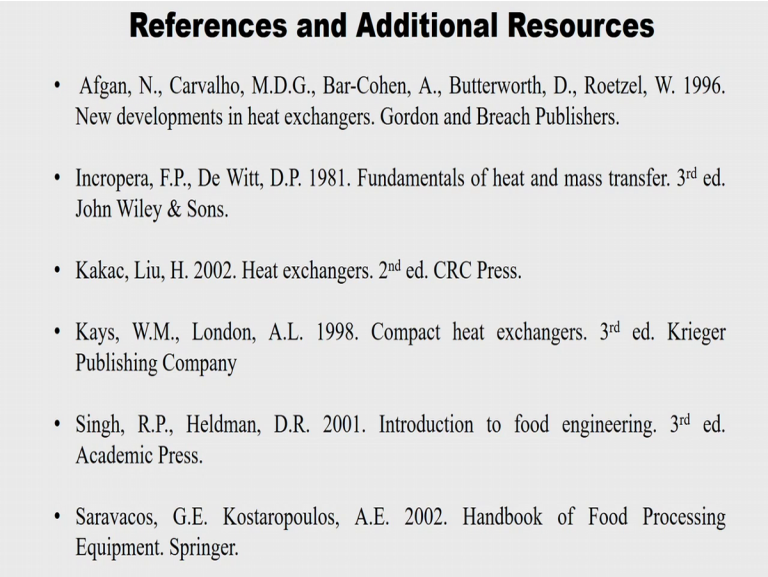
Food product	Temperature, °C/time
Milk grade A (U.S.)	63/30 min, 77/15 s
Milk (U.K.)	63/30 min, 72/15 s
Fruit juices	85/15 s
Liquid eggs (U.S.)	60/3.5 min
Liquid eggs (UK)	64.4/2.5 min
Beer	65/20 min

So then pasteurization process for liquid food if it is a mill grade of A then 63 at 30 minute or 77 degree at 15 seconds. If it is some will I already told the milk standard of UK 63 at 30 minute or 72 at 15 second this is low temperature high time this is high temperature low time. Fruit juices normally 85 degree and 15 seconds. Liquid eggs 60 degree 3 point 5 minute, liquid eggs off UK standard 64 point 4 in 2 point 5 minute.

For beer 65 degree and 20 minute. So this is setting time temperature combinations for the food based on different countries. Apart from that we have told the direct heating, indirect heating only the heat exchanger comes. The heat exchanger I already told plate type heat exchangers are mostly used, tubular heat exchangers used to for a high viscous food or particularly if we have solids in the liquid.

And apart from recent sterilizer I have forgot to mention the flame sterilizer. So flame sterilizer normally used for the food which has high viscosity because the flame sterilizers uses almost 2000 to 1400 degree 1400 degree centigrade gases which comes out of the combustion to heat the product instead of the steam. And there are many recent versions of the sterilizer so you may refer some other books to get to know the recent sterilizes which are used in the industry.

(Refer Slide Time: 56:53)



I have discussed only a few thermal processing equipment as we have seen already there are large varieties of thermal processing equipment based on the needs and the safety concerns to be followed in the particular thermal processing. So here are the references and additional resources. So I prefer more books for different heat exchanges and other thermal processing equipments. Thank you.