Process Equipment Design
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Lecture –43
Design of Packed Column-1

Hello everyone. I welcome you all in this lecture which is 43rd lecture of the course Process Equipment Design and here we are in 9th week of this course. In this lecture, we will start discussion on packed column. So, first of all we will define the packed column and then we will discuss its applications and other factors and after that we will cover design of packed column. So, let us start the discussion on packed column.

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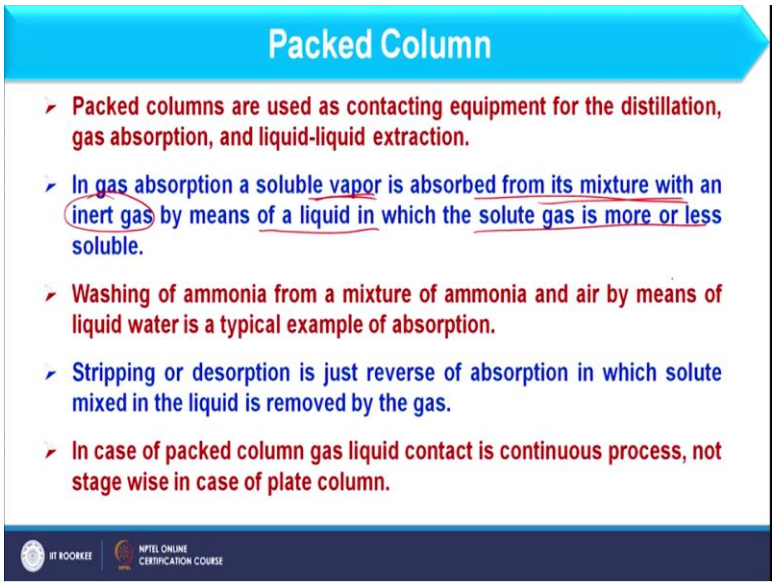

So, as far as packed column is concerned first of all we will see its application in chemical industry and then we will cover few more points about this. So, as far as application is concerned it is considered in different processes such as distillation, gas absorption and liquid-liquid extraction. So, as far as gas absorption is concerned in this a soluble vapour which is absorbed in the gas mixture and that mixture we consider as the inert gas, but component is not inert that can be transfer from gas phase to liquid phase.

So, in this case the solute is basically the gas which is more or less soluble in the solvent. So, solvent is basically the liquid and solute which is available in the gas. So, absorption is taking place from gas phase to liquid phase with the particular component. To give an example if we

need to wash the ammonia and if ammonia is available with the mixture of ammonia and air. So, in that case air works as an inert gas and ammonia is soluble in the water.

So we can consider water as a liquid. So, this is the example of absorption where ammonia is getting absorbed in the liquid and that is water. So, if I consider absorption process where gas solute is transfer from gas phase to liquid phase. If I consider opposite to this it means I am extracting the component which is available in the liquid and that I want to take in the gas form.

So, that is basically the reverse of absorption and we call that as desorption and also we consider that as stripping process. So, in such processes where I am considering absorption or desorption we basically consider packed column and that is not considered in plate column. So, you must have the idea about packed column as well as plate column and after few slides we will discuss in which case which column is better. So, that comparison is also going to discuss in this particular lecture.

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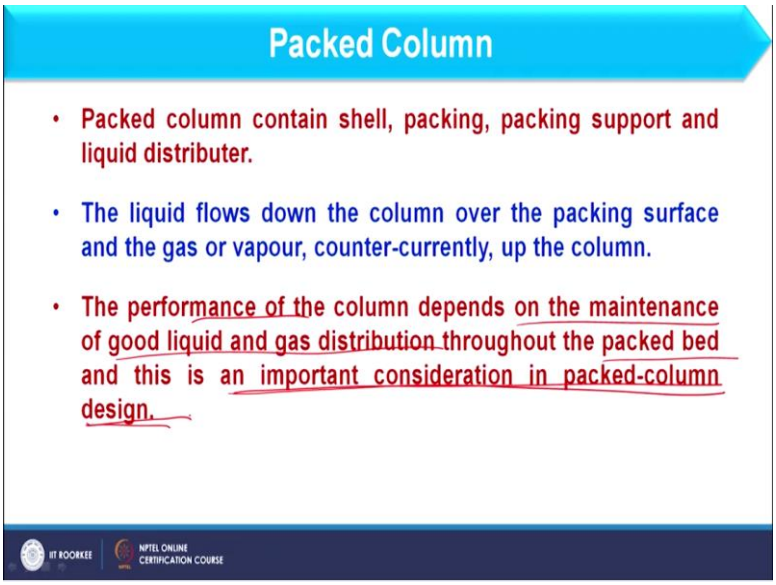

So, as far as packed column is concerned the complete assembly of packed column includes the shell which is basically the cylindrical section where packing is done and along with shell we have some other accessory such as packing which is basically filled in the shell and if packing is there we provide that with packing support as well as liquid distributor. So, these are some of the accessories which are used in packed column.

So, in that packed column what will happen? Liquid is basically enter from the top and moves downward that is the natural movement of the liquid. So, when the liquid comes down it is passing through the packing surface where it encounters with the gas which is flowing in counter current movement. Counter current movement means when the gas is entering the column from the bottom and moves upwards and that is basically the natural tendency of the gas.

So, in this way counter current movement is occurring in the packed column between gas as well as liquid streams. So, when we discuss the performance of the packed column that performance enhances when I am having better distribution of liquid as well as gas in the packing. So, we can consider that performance of the column depends on maintenance of good liquid and gas distribution throughout the packed bed and this is an important consideration in packaged column design.

So, we will discuss the proper distribution of gas and liquid in the packing so that mass transfer between two streams can be enhanced.

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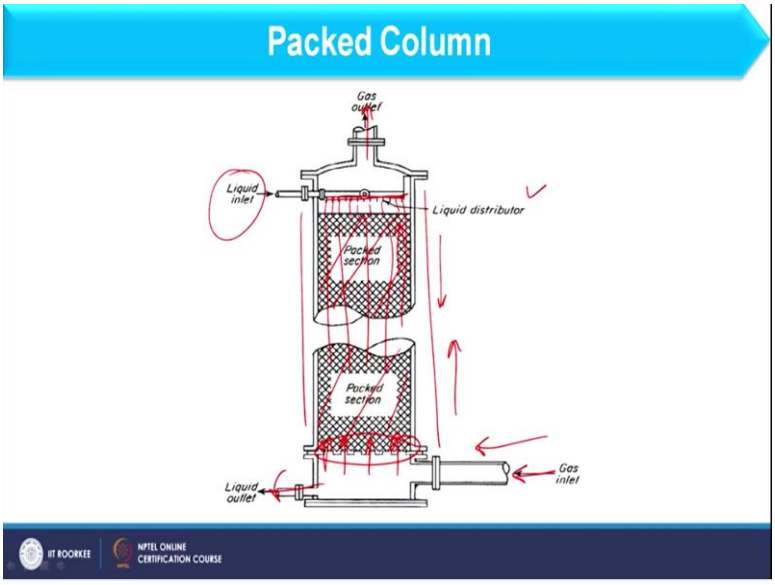

And here I am having the packed column schematic. So, if you see this is basically the shell and that shell has complete packing. So, this we consider as the packed section and as far as liquid movement is concerned we have already discussed that it enters from the top and moves downward and similarly gas enters from the bottom and moves upward. So, liquid enters from here and then it is passing through the distributor where uniformly it is falling over the packing.

And when it is falling over the packing it basically travels the packing along the length and so it is exiting from the bottom covering the complete area where packing is available and gas enters from the bottom and it also enters through the distributor and along with that here we have the section where we consider as the packing support where packing is basically lying. So, gas moves upward and it is exiting from the top at the center.

So, that is basically the schematic of packed column where interaction between liquid and gas is done with counter current manner. Now, we are going to discuss that how we select the packed column or the packing. To select this, we have some points and let us discuss these points one by one.

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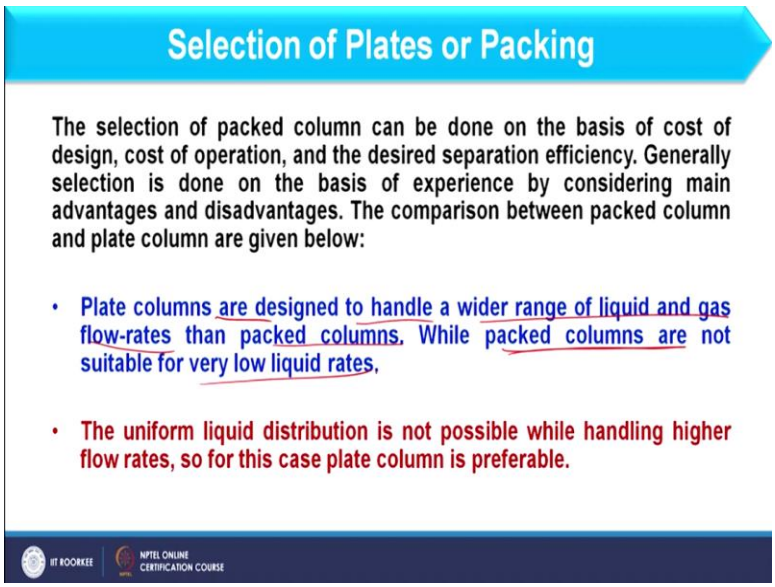

So, as far as selection of packed column is concerned it is basically based on cost of the design and cost of the operation. And after that we consider the separation efficiency which is basically the desired separation efficiency and to choose the proper column we first should consider the advantages and disadvantages of each type. So, when I focus on a plate column these are designed to handle a wide range of liquid and gas flow rates than the packed column.

So, when I am having the wide range of operating data such as the flow rate of the liquid as well as gas we should choose the plate column. And why packed column is not suitable for this case that also we are going to discuss that in packed column. Packed column are

basically not suitable for very low liquid rates because when the liquid flow rate is very low it is not going to distribute properly in the packing.

So, mass transfer will not happen properly on the packing. So, when I am having very less flow rate we have special arrangement in plates, but that is not possible in packing. And what is that arrangement that we will discuss while designing plate column. So, here you should consider that when the flow rate range is very wide we should consider plate column not the packed column. In the same line when I am considering higher flow rate.

So, what will happen in the packing? In the packing usually we have some channeling. So, the flow rate which is available in the packing it passes through the packing without having proper interaction with the gas because some residence time is required. But with high flow, it is passing through the channels which can be formed within the packing. So, high flow rate as well as low flow rate is not suitable for packing in that case we should select the plate column.

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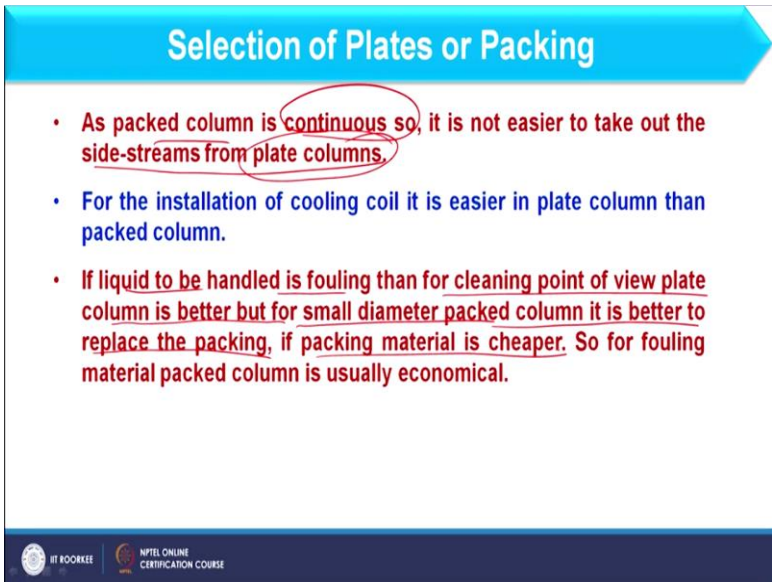

So, we have another point like in packed column because it is continuous we cannot take the side stream from it as we can do in plate column. Side stream means you can get the product at desired boiling point whenever it is occurring on a particular plate. So, that is not possible impact because in between product you cannot take out because packed column is usually continuous.

However, plate columns are basically discrete the interaction occurs only on the plate not continuously as it is done in the packed column. So, taking side stream is easier in plate column, but that is not the case with packed column. Further, if we want to install any heating and cooling device. To give an example if I am dealing with let us say reactive distillation. So, what will happen over the plate you can properly insert the cooling coils or the heating coils because plate is there and over that you can make the coiling very easily.

So that coiling is basically sit over the plate, but that is not possible in packed column. So, when I am having reactive condition we should be very careful about the cooling as well as heating requirement because that is not easy in packed column. And so if I consider the cooling as well as heating in the process we should choose plate column. If liquid to be handled is fouling then for cleaning point of view plate column is better because we can simply clean the plate because there is no accessory over the plate.

So, cleaning of the plate becomes easier. However, if I am having smaller diameter packed column it is better to replace the packing if packing material is cheaper. So, if I am having the fouling tendency fluid and the diameter of the packed column is small it means we can have small volume of packing and if the cost of the packing is less we can simply throw the packing instead of cleaning it.

So, in that case complete decision depends on the economy of the plate column or packed column. So, accordingly we should choose, but we can use both options that will depend on the economic.

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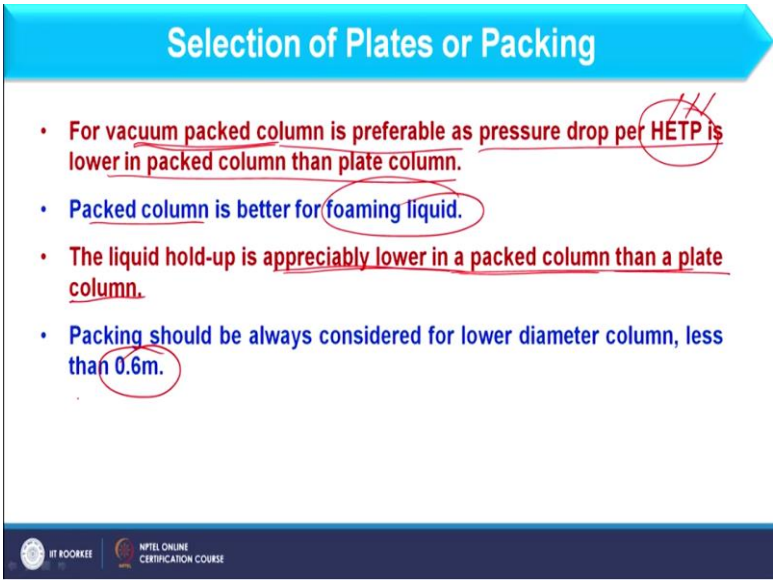

Further, if I consider the vacuum condition packed column is preferable as pressure drop per HETP it means height equivalent to theoretical plate so that is basically HETP and pressure drop per HETP is lower in packed column in comparison to plate column. So, for vacuum condition packed column is better and further we can consider packed column if I am having liquid with foam.

So, if foaming tendency of the liquid is there pack column is better because it has proper distribution of the foam and interaction becomes possible between liquid as well as gas and it will be properly done in packed column. Further, if I consider liquid holdup is appreciably lower in packed column in comparison to plate column. So, accordingly we should choose the proper column in this case.

And usually packed column is preferable when I am having lesser diameter and the guideline is that if diameter is less than 0.6 meter we should choose packed column and that point we will also discuss while designing plate column also. So, based on that you can select proper type of column.

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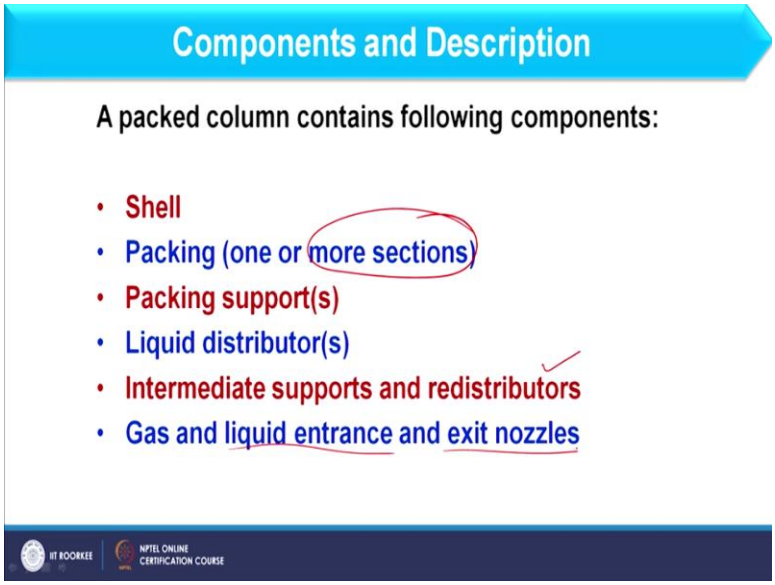

And now we will discuss some components which is available in packed column and these components are shell packing which is having one or more section. So, usually we have the continuous packing, but if height of the column is very large what we can do we can have small sections of packing because distribution of liquid and gas is not proper throughout the length.

So, in that case some height we can fill with the packing, leave some section then again redistribute liquid and vapour and further we are having the packing section. So, packings are basically in different sections along the length and once I am having the packing we should consider packing support also on which packing will lie and in the packed column we should also consider liquid distributors because we have to distribute the liquid properly throughout the packing.

And further we should consider intermediate supports and redistributor and that is basically done when I am considering this section. So, further we should consider gas and liquid entrance and exit nozzles and in this way we can have complete assembly of the packed column and when we will go to design part of this we will consider each part of this one by one. So, as far as different components is concerned let us describe these components little bit.

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So, first of all we will focus on the shell so if you consider the shell this is basically cylindrical. However, sometimes we consider square wooden shell also. It is basically made with the light metal such as steel, alloy or nonferrous material or it can be reinforced with the plastic and which has some addition of liners or we can say the inner layer of rubber or brick. So, in that way we can mix different material and make the reinforced shell.

And selection of material of the shell is done on the basis of properties of the fluid to be handled and the operating conditions. It means we should consider proper material depending upon the fluid because fluid should not be reactive with the shell along with this we should consider the operating condition such as if I focus on the temperature the temperature should not be very high so that it can melt the shell material.

So, that it can melt the shell material. So, if temperature is very high we should choose the ceramic kind of material to prepare the shell. So, all these points we should keep in mind while designing the shell. So, once I am having the shell we should discuss the packing also and packing is basically considered to provide large surface area because when I am having the packing it means liquid and vapour has proper interaction over this packing.

It means we can provide larger surface area and that surface will depend on the type of packing also. So, in that way as we have different variations in packing we can have variations in surface area also. So, if I am having large surface area it means I have more opportunity for liquid and gas to interact. So, packing should have large surface area a high

interfacial area between gas and liquid to have an open structure it should be low resistant to gas flow.

It means it provides the flow of the gas properly along the length through the packing. It promote uniform liquid distribution on the packing surface and to promote uniform vapour gas across the column cross section. So, all these points you have to consider while selecting the proper packing depending upon the operating condition. So, as far as packing is concerned it is basically two type random packing and structure packing. We will discuss about these packing in next lecture.

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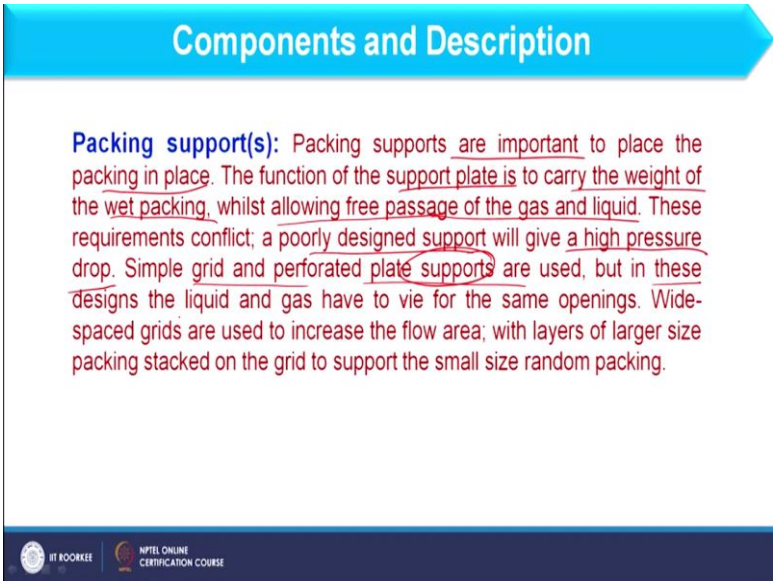

And next we have the packing support. So as far as this support is concerned it is important to place the packing in place otherwise packing will not be proper. So, the function of the support plate is to carry the weight of wet packing while allowing free passage of gas as well as liquid because when we consider the packing support its role is basically to hold all weight.

So, all weights means weight of the packing, weight of the liquid. However, gas does not have proper weight, but liquid and packing should be properly supported by this support. So, we should select the proper support according to the operation. So, when we will not consider proper support in design of packed column it gives high pressure drop which is not required for the proper operation.

So, simple grid or perforated plate support are used, however, when we consider the plate support we should keep in mind that from that support liquid as well as gas will move from the same hole. So, that kind of arrangement we should do like we should consider wide space support. It means support must have wide holes so that liquid and gas both should pass through this.

And over that we put some large size packing and above that we put some small size packing because if I put the small size packing over the wide spaced support packing will simply drop from that and it will not stay in the column for the mass transfer operation. So, that we can consider while selecting the packing support.

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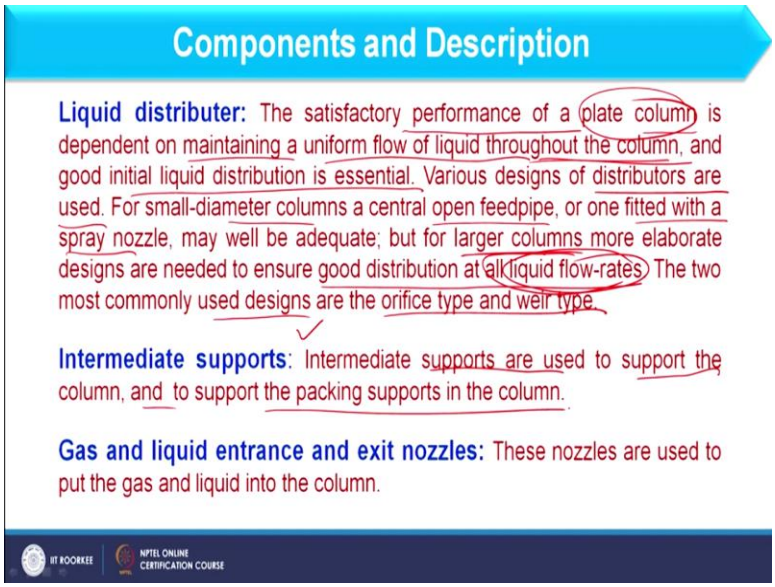

And then we have the liquid distributor when I consider that the satisfactory performance of the plate column is dependent on maintain a uniform flow liquid throughout the column. And good initial liquid distribution is essential. So, in this case this should be basically the packed column not the plate column. So, as far as various designs of distributors are considered these are included in packed column while selecting proper distributor and what designs are available that also we will consider.

So, for small diameter column a center open feed pipe can be considered or one fitted with spray nozzle. So, that can be done with the small diameter. So, from that spray nozzle droplets of liquid can be fall and that can cover or that can distribute throughout the area of the column. So, however if I consider the large column it should be required proper liquid distribution which can consider all liquid flow rates.

So, that distribution should be done properly and for that two most commonly used designs are orifice type and weir type. So, these design we will discuss in subsequent lectures and then we have the intermediate support so that intermediate support are used to support the column and to support packing in the column. So, intermediate support means when I am having the larger height of the column then one support will not work.

So, intermediate support we usually provide in that case. So, further we have gas liquid entrance and exit nozzles and these should be properly selected as far as gas and liquid input is concerned in the column.

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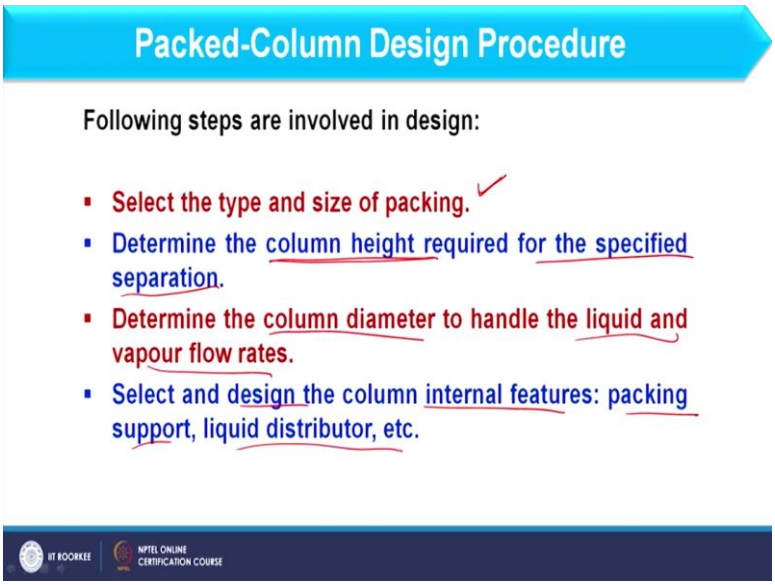

And now we will focus on packed column design procedure. So, the steps are first of all we will choose proper packing, its size and after that we will calculate the column height which is required for specified separation and further we can calculate the column diameter to handle the liquid and vapour flow rates. So, all these points we will discuss while considering detailed packed column design.

And after that we should select and design the column internals such as packing support, liquid distributor and redistributor etcetera.

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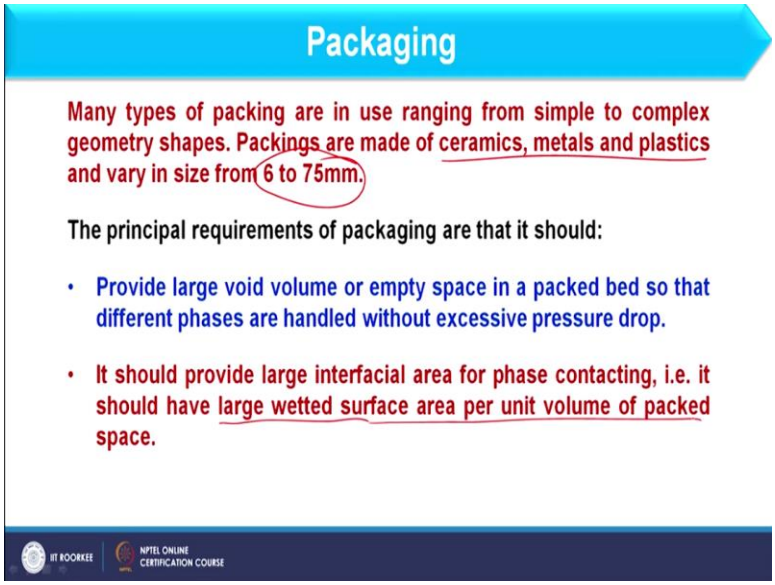

So, now we will have some points about the packing. So, as far as packing is concerned that you can select considering some guidelines and as far as complete size of the packing is concerned it basically varies from 6 to 75 mm. And material we consider as ceramic metal plastic etcetera. So, as far as packing is concerned the proper requirement of the packing should be it should provide large void volume or the empty space in the pack column.

So that liquid and vapour can interact properly without having very large pressure drop. It should have large interfacial area for face contacting that is it should have large wetted surface area per unit volume of the packed space. So, that we should consider while selecting the packing.

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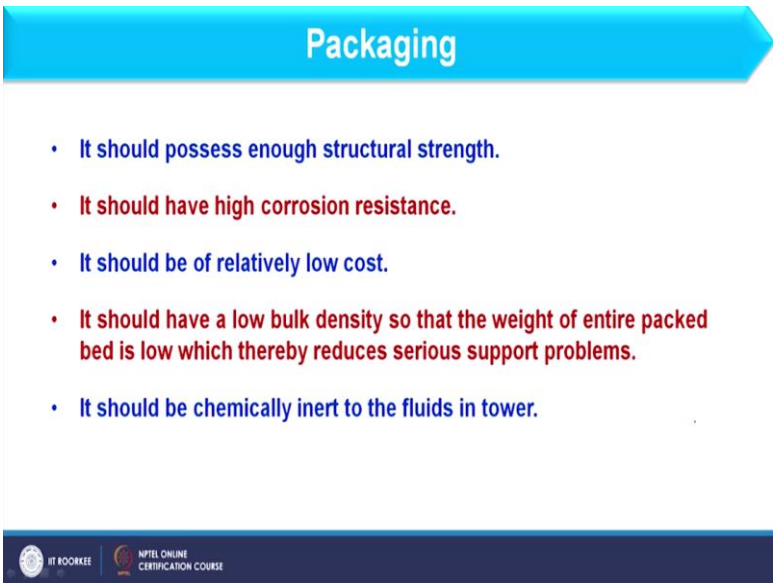

It should posses enough strength it means when the process is going on the rupturing should not occur in the packing and further it should be non corrosive. So, it should have non corrosive nature it means the material of the packing should be selected in such a way so that corrosion will not occur when it will react with the fluid. First of all it should not react with the fluid and so corrosion should not occur in the packing.

As far as cost is concerned the cost should be low because economic decision is very important when I select the proper packing and after that we should consider very important point that it should have less density because that will give extra load on the packing support. So, we should consider packing which is lighter in nature. And as we have discussed that it should be corrosive resistance it means it should not react with the fluid so that should be inert with the fluid which we are handling in the packed column.

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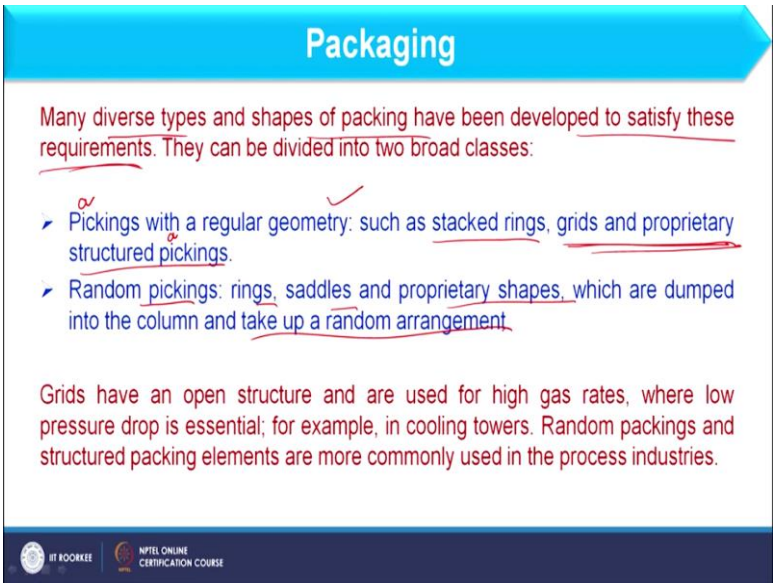

And we have some more points about this like as far as packing is concerned many diverse types and shapes of the packing have been developed to satisfy these requirements which we have just discussed. So, we can broadly classify the packing as packing with the regular geometry here you can consider packing such as stacked rings, grids and proprietary structured packing.

So, please consider here packing not the picking. First I am having the random packing, next I am having the random packing such as rings, saddles and proprietary shape which are dumped into the column and take up the random arrangement. So, this point we will further discuss that how the packing is done in the packed column using these two class. So, in this

way you can consider different points about the packing and based on that you can select proper packing.

However, the size of the packing its interfacial area, its packing factor all those points we will consider in design of the packed column. So, that is all for now. Thank you.