INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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NPTEL ONLINE CERTIFICATION COURSE

Unit Operations of Particulate Matter

Lec-01
An Introduction

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I welcome you all in the course unit operations of particulate matter. Today we will start this course and the first lecture of this course that is the introduction. As this course is about unit operation of particulate matter.

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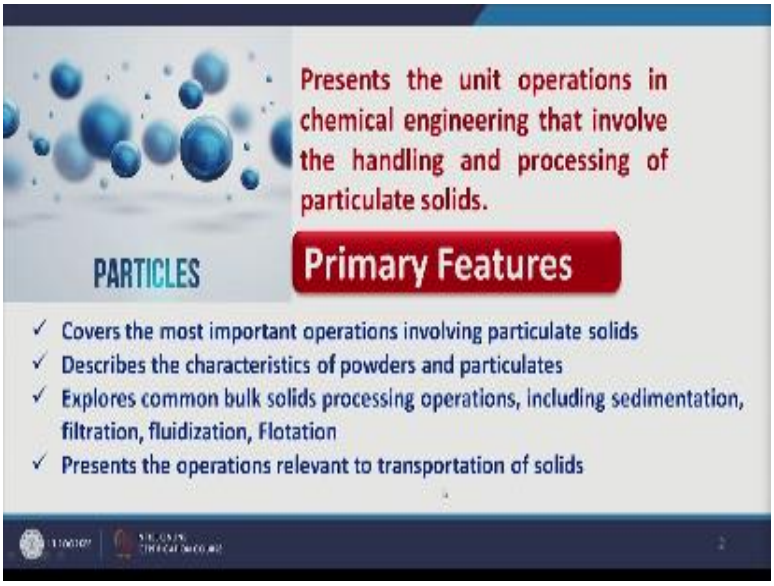

This figure speaks about what we are going to study that is nothing but about the particles. So here I present the unit operations of particulate matters and the unit operation of particulate matter in chemical engineering, it involves the handling and processing of particulate solids. So

here as you have seen that in this particular course we are dealing with the particles, it presents the unit operations in chemical engineering that involves the handling and processing of particulate solids or particulate matter.

Now as far as this particular session or this particular course is concerned the primary features of this course is, it covers the most important operations involving particulate solids. So here basically we will discuss different unit operations which are involved to handle and process of particulate matter. It describes the characteristics of powders and particulates. Now what is the meaning of this characteristics of powders and particulates that is here as far as characteristic is concerned that we can understand in terms of size and shape of the particle as well as its density or etc.

So once we characterize the particle we will define its size, shape, density. Now in this particular course we will see the effect of size, shape and density on the particular operation we are going to discuss. The third feature is explores common bulk solids processing operations, including sedimentation, filtration, fluidization and flotation. So as far as unit operation is concerned we have covered four main unit operation that is sedimentation, filtration, fluidization and flotation.

So this particular course presents the operations relevant to the transportation of solids that is after defining, after discussing these particular unit operation, four unit operations in detail. We will discuss the operation which are involved for transportation or carrying the particle from one place to other place. When we discuss about the particle, I am discussing the bulk of particles that is the total particulate matter.

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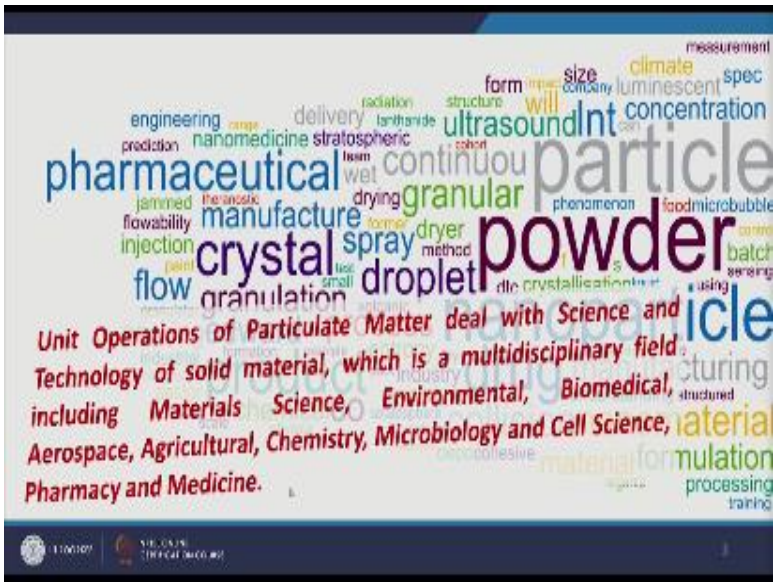

Now if you consider this particular slide, this particular slide shows what, it has different words like pharmaceutical, manufacture, crystal, droplet powder, nanoparticle from this figure you can identify what are the different application of this particular course which involve the handling and processing of particulate matter. So here we can define the unit operations of particulate matter, it deals with science and technology of solid material which is a multidisciplinary field including material science, environmental, biomedical, aerospace, agricultural, chemistry, microbiology and cell science, pharmacy and medicine.

So here you can see the course that is unit operations of particulate matter, its application is not in chemical engineering, but it is used in many other fields also. And that fields are really wide, so this particular course is useful for many fields in which engineers are the person work. Now as far as we will define further what is exactly the unit operation, before we have defined the unit operation of particulate matter it means which deals with the particulate matter. Now here we are defining the unit operation itself.

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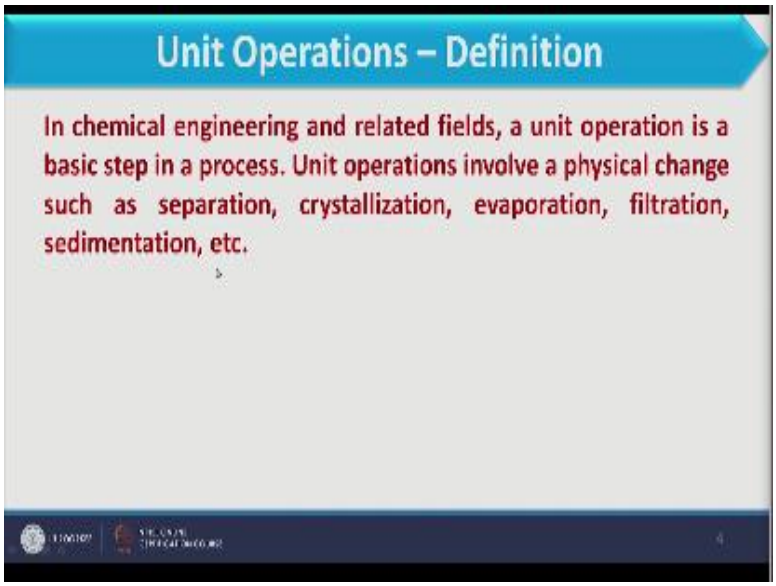

In chemical engineering and related fields, unit operation is a basic step in a process. Unit operations involve a physical change such as separation, crystallization, evaporation, filtration, sedimentation, etc. Now here if you see this statement this speaks about the physical change in the process. So here I have to clarify that unit operations deals with the physical change in the process not the chemical change, chemical change what I mean with the chemical change is when any reaction is carrying out in the process. I am not we are not going to discuss the reaction which is careering out but the physical change.

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When we consider the example of crystallization what happens here is the super saturated solution coverts into the solid particle solid matter what is what happens over there that there we have only the physical form of the component physical form of the content will change initially it was at super saturation liquid at that stage and now it is in the solid state, so that is nothing but the physical change in the process, so that therefore this type of process or this type of operation we called as unit operation.

Where reaction is not involved and similarly in evaporation what happens water vapor water or let us say not only a water the solvent realizes from the slurries the solution so that is nothing but from convergent of from solution state convergent from liquid state to vapor state so that is nothing but the physical change, so all physical changes are involved in chemical engineering and that are clubbed in one section and that section is called unit operations.

So when we consider a particular operation it has many unit operations for examples if I am considering milk processing it as homogenization, pasteurization, chilling and packaging so these are different unit operations which are involved in manufacturing of milk and a process may require many unit operation to obtain the desired product from the raw material.

So you can see in any process there are many unit operations involved however these unit operation does not consider the reaction when we consider the reaction in any process we call as unit process not has unit operation, now that here we have here we have already defined the unit operations now before starting this the details of the unit operation of particulate matter we have to see the history where we are actually identified the unit operations in literature.

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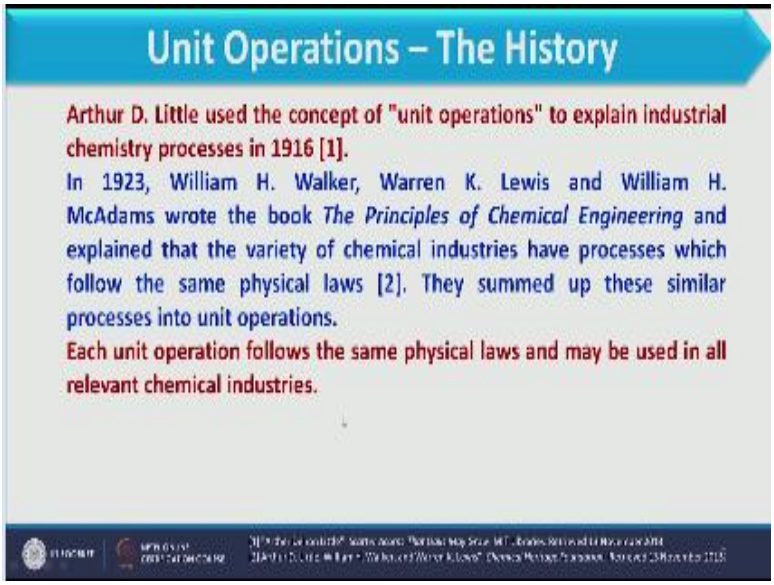

So as far as history is considered Arthur D. Little use the concept of unit operations to explain industrial chemistry processes in 1916 so here you say the first literature about unit operation we have got in 1916 where the unit operation is used at industrial level now further in 1923 William H Walker, Warren K. Lewis and William H McAdams wrote the book the principle of chemical engineering and explain that the variety of chemical industries have processes which follow same physical laws they summed up these similar processes into unit operation.

So here we again have seen the physical law which are applicable to the process and they are clubbed in one word or one section that we can refer as unit operations so here we have some literature where the unit operation is actually used in actually appear first time now each unit

operation follows same physical law and may be used in all relevant chemical industries for example here we have seen the same physical laws will be applicable to the relevant chemical industries.

Now what is the meaning of this for example if I am going to design a mixture which mixes tow component or may be 3 component together, so when we are designing a mixture whether we design the mixture for a lab scale or for a industry or for 1 process or for other process this design will follow same physical law it means the design equation will be same only scale up.

And the other condition will be applicable mostly the physical law will be same when we are going to design a picture different conditions for different application is should say like when we are going for laboratory when we are going to design this for industry, so in this here we have defined the history which is appear in the literature, now it is basically the reported history now once we see this in our day to day life you can understand that from how long they are using the concept of unit operation in our day to day life to illustrate that I have taken the example.

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Here in this particular slide you can see this figure now this figure a speaks about powder technology in ancient Egypt illustrating the threshing process now if you consider this particular figure here persons are involved in threshing process now what is threshing process, threshing process is basically to remove the edible material from the waste like when we remove the serials from the it is scaly waste that we also called as husk so that we can remove so if you consider this particular figure the person who is standing over here.

He has some screening tools through which the edible serial will be collected and the waste scale material that we also called as husk that is quite lighting comparison to the serials so that can be screened from this and due to the effect of wind it will be collected away from the serial so serial will be collected from one side another side we have the collection of husk so the person which are these two person which are at slightly bending position they are basically collecting the serials as well as husk separately.

So if you consider this particular picture this is taking from this is basically a wall pending in the tomb of Menna. So this is very old picture now this picture is speaks about that it is as old as mankind.

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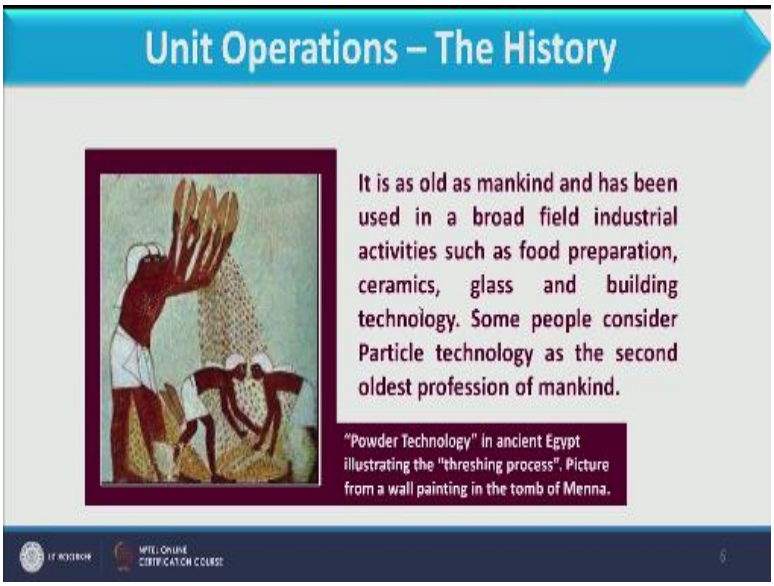

And has been used in a brought field industrial activities such as food preparation ceramics glass and building technology some people consider particle technology as a second oldest profession of the mankind so you can see over here that this particular unit operation is used since very beginning where we were aware with this or not but we were using this concept since many time many years on my decades now here if you see we have use the word order technology and in this particular course we are introducing unit operation.

So that is nothing but the synonyms of unit operation other synonyms are particle technology particulate engineering mechanical operations all these are synonyms of the unit operations so when I speak about particle technology powder technology mechanical operation and doing nothing but I am speaking about unit operation itself. No let us consider few more example from the history if you consider this particular figure that you understand very well.

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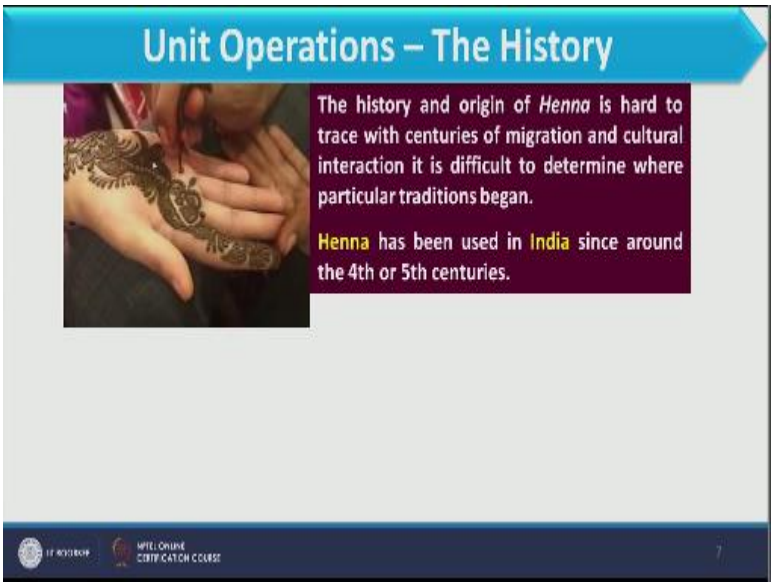

This is nothing the Henna we also call it maybe now if you see this figure here what happens how this ammonia or Henna is prepared if you see this initially we collect the Henna leaves and then that these leaves will be crushed and crush to the very fine size and then it is mixed with the water to make the paste now when we are crushing this so what we are doing basically is we are involving unit operation in this because that is nothing but the physical change that is from higher particle size.

That is in terms of leaf we are converting this into the lower particle size that is a powder so here we have involvement of unit operation now the history and origin of Henna is hard to trace with centuries of migration and cultural interaction it is difficult to determine where particular traditions began so you can understand this from how long we are using Henna that we all we are not aware but Henna has been used.

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India since around the 4th and 5tn centuries so this is a quite old data so you can understand from how long we are using now this particular figure it speaks about different spices so as back as 3000BC India turmeric powder a species powder and Ayurvedic medicine made up powders using particle technology were used so since very beginning we are using this unit operation in our day to day life. Whether we were aware with that or not but we were using it now here you see this particular figure.

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What is this, this I think we all are ware with this, this is nothing but we use this for to prepare the species in our houses even I have seen this in my house since my childhood and you all have seen so this is nothing but we can say an arrangement we can say and equipment which involve unit operation to convert the size higher size particle to lower size so that is nothing but the physical change so we can say that it can be a unit operation.

So here this is basically Indian stone grinder in the second figure in this figure weird the if the shape is quite oval type this is Sudanese stone grinder, so the old traditional method of grinding the grains in India and Africa which was widely used until 20th century was crushing then by stones so here you see 20th century data is available over here and since many time back from this we are using this stones to crush the material.

So here you can say that we are using unit operations since many decades however in 1916 it appears first in the literature as far as industrial application is concerned. So that was about the history of unit operations till now you can understand.

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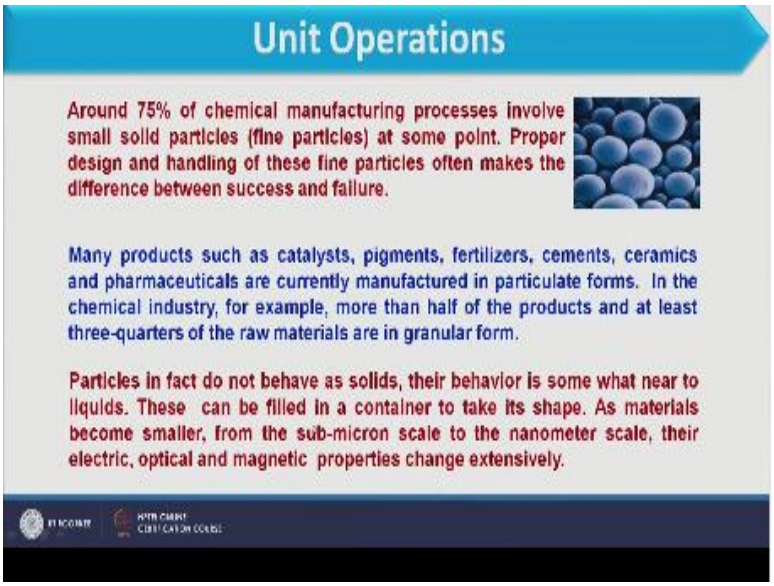

Basic operation is basically the physical change and unit operation basically involved the particle it matter or solid, now why we are defining this course that is unit operation of particle it matter, particle it matter why we are considering because you all are aware that around 75% of chemical manufacturing processes involve a small solid particle at some point, so we have used the particles in our day to day life and as far as chemical processes are concerned they also use this extensively so proper design and handling of these fine particle often makes the difference between success and failure of the product.

Now why I am calling this success and failure of the product depend on the particle size to illustrate that I will give a few examples in subsequent slide. Now as far particle it matter is concerned it prepares different products such as catalyst, pigments, fertilizers, cements, ceramics and pharmaceuticals they are currently manufactured with the particle it forms so in chemical industry for example more than half of the products and atleast three quarters off the raw material are in granular form.

So here you can understand the particular matter they are consider in industrial scales significantly. Now further if we consider the particle that can have a definite shape but we are

considering the number of particles so particles infact do not behave as solids their behavior is somewhat near to liquid, how we can say that because when we consider different when we consider a number of particle size in a glass and when we tilt the glass it will be tilted so it can take the shape of the container and it can change the its property as the property of liquid changes, so therefore we can resemble the behavior of this with the liquid, so as material become smaller from sub micron scale to a nano scale their electric optical and magnetic properties change extensively.

So what is the meaning of this, that when we consider different particle size their property changes and therefore it behaves differently when we consider different particle size and therefore it's the failure and success of the product depends on the particle size because it changes the property of the material. Now far as optimum particle size is concerned.

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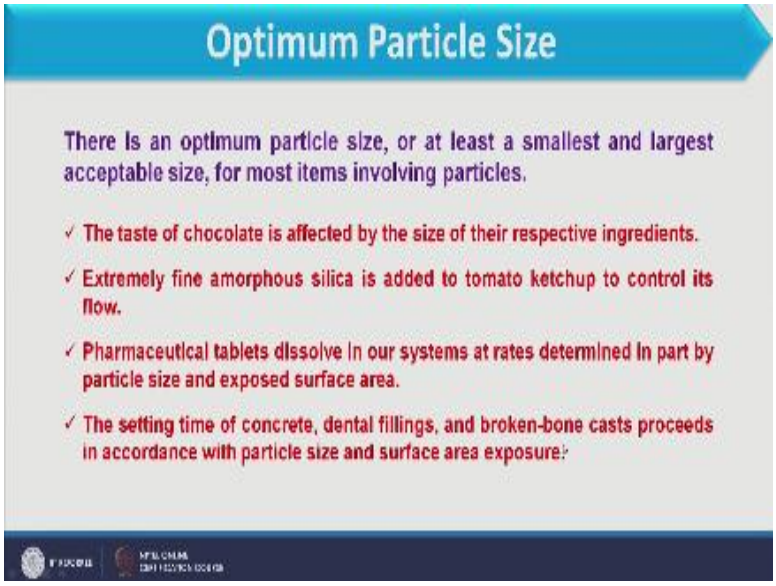

There is an optimum particle size or atleast a smallest and largest acceptable size for most items involving particles, a few example I am considering over here the first is the taste of chocolate is affected by the size of their respective ingredient to illustrate that I will speak about the particle size of chocolate in a subsequent slide so you can have the idea how the taste changes, secondly

extremely fine amorphous silica is added to tomato ketchup to control its flow, so here you can understand the extremely fine silica we add.

So that is nothing but the a very small particle size or that optimum particle size which controls the flow of the ketchup and similarly pharmaceuticals tablets dissolve in our system at rates determined in part by particle size and exposed surface area. Now to give an example of this if we purchase the crosin that is very common tablet if we purchase the crosin and consume this even I have experience this many a time that some time the crosin reduces the temperature and some time it does not affect.

So what is the reason of this because composition of crosin is same, company same so what is the difference, difference is the particle size they are considering, they consider not the optimum particle size which considers which takes the optimum time or which takes minimum time to react, so here we can see the effect of particle size even the tablets which I think most of us consume and finally we have the settling time of concrete, dental filling and broken bone casts proceeds in accordance with the particle size and surface area exposure. So this will depend upon the particle size optimum particle size basically.

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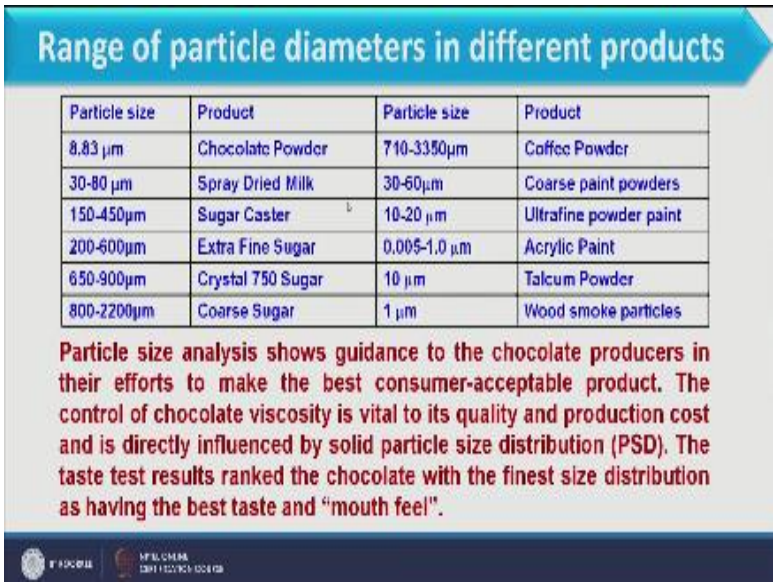

So here if we consider in this slide there we have the range of particle diameters in different product like if we consider the chocolate powder the optimum particle size is 8.83 micrometer and similarly for other material. Now if you consider the particle size of chocolate powder what we have this like optimum particle size the taste of chocolate is affected by the particle size as we have seen in the last slide.

Now why we are saying that because when we consider a smaller particle size it basically controls the viscosity when it you can understand when it we are considering very fine particle size it behaves as a liquid, so when the particle size is very small it is a viscosity is controlled in such a way so that it is spreads in the mouth and give the mouth feel. So based on that we can say that the chocolate is having a mouth feel or not and accordingly we have different taste.

If to give an example, if we consider the chocolate of very fine particle size and we have the mouth feel these days we have experienced mouth feel in different biscuits also. For example, if I take the biscuit that very famous biscuit and that we call as dark fantasy if you consider that biscuit and when we break this when we have this then it has liquor inside this, so that liquor is basically the very fine particle size chocolate.

And when we consume this it gives the mouth feel the coating of the biscuit will not give the mouth feel only the chocolate which is inside so that is, that has a particular optimum size and that optimum size gives the mouth feel so therefore the particle size will be depending upon whether the product is acceptable by the consumers or not. For example, dark fantasy if we consider that we like a lot because of the mouth feel and similarly the chocolate when we consider it also has the mouth feel and sometimes we have seen in TV the advertisement like chocolate come in thumb bomb we call at.

So that bomb is nothing but when we have the mouth feel of chocolate and that we can find through very fine particle size. So here you can say the particle size will depend upon whether product is acceptable by the consumers or not or in other word whether the product is successful or not. So the previous slide statement if you remember that we have seen the particle size affects the success and failure of the product and this one example of that.

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Now another example here we are considering the wheat we all consume wheat, now if you consider this particular figure here this figure shows the wheat the raw wheat or we call it at the

serials. Now if consider one particle size this particle size maybe of length by 5mm, 6mm or sometime 4mm also when we consider this when we consume this wheat it will not be easily digestible because of its size, in this figure we have another product from the same source that is the wheat we called this as the dahlia that is nothing this dahlia is nothing but the small smaller size of this wheat and you can understand that when we have this smaller size wheat it is healthy food because of this particle size because it considers the fibers protein etc.

This also considers fibers, protein but due it size it cannot be it cannot be taken directly so we reduce this size of the particle wheat to make the dahlia. Another product of the wheat is semolina we also call it shoji so that you can understand that is nothing but the product of the wheat of different it has a smaller particle size than dahlia it will be used in making pastas etc, and that is also very healthy food.

Now further when we consider the product of wheat that is we all are aware with this that is nothing but the Atta that we use in our daily life and that is also contains fiber protein carbohydrate etc so that is again the healthy food and finally we have the product that we called as Maida, so that is very fine particle but it is developed it is prepare with the wheat itself, so it is basically just a carbohydrate content of the wheat and it is free from vitamin, fiber and protein.

So you see this even we consider this Maida it has very less particles size so that fiber vitamin all are remove from this only carbohydrate is remaining. So therefore this is not healthy food as for as our consumption is concerned but we have this in different product so you can understand that from this wheat we have derived four different products that is dahlia shoji Atta and Maida. So all three are healthy but Maida is not healthy so that depend on the particle size of a particular product of a particular material in which particle size we are consuming so that it can help us.

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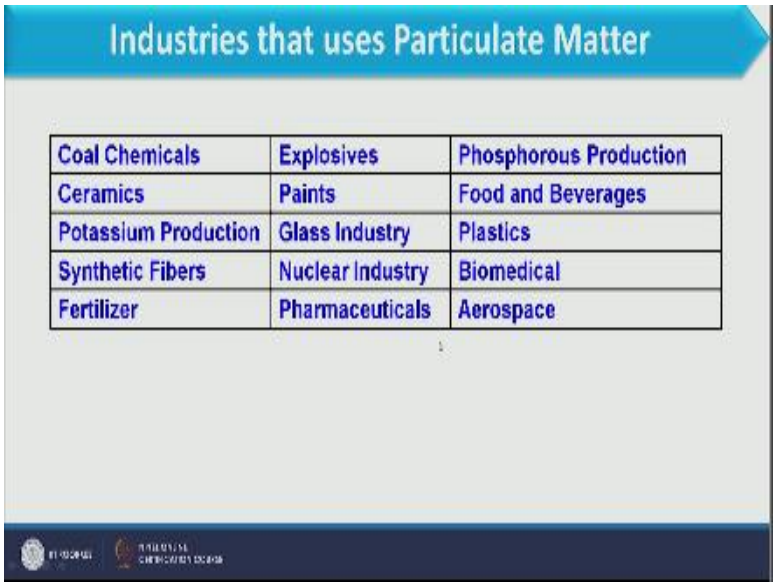

And here we have different industries which are using particulate matter, so these are coal chemicals, ceramic, potassium production, synthetic fibers, fertilizers, explosives, paints, glass industry, and many more. So you can understand this particular course is applicable to many industries. Now further we consider the unit operations.

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What are the different unit operations available, so in chemical engineering chemical unit operation consist total five categories or five classes the first class is the fluid flow processes it include fluid transportations, filtration, and solid fluidization. Second class is the heat transfer processes it involves evaporation and heat exchange. Third category mass transfer processes it considers absorption, distillation, extraction, adsorption and drying these are different unit operation which are involve in the mass transfer processes.

Now forth category we have is the thermo dynamic processes it includes gas liquefaction and refrigeration the fifth category is the mechanical processes which consider solid transportation, crushing and pulverization and screening. Now among this five category in this particular course we will speak about the fluid flow processes as for as well as the mechanical processes, in fluid flow processes we consider filtration fluidization sedimentation and flotation that is the fluid flow processes.

And in mechanical processes we will discuss the solid transportation, so this two unit operations are involved in this particular course. Now for this particular course the target audience would be the under graduate students.

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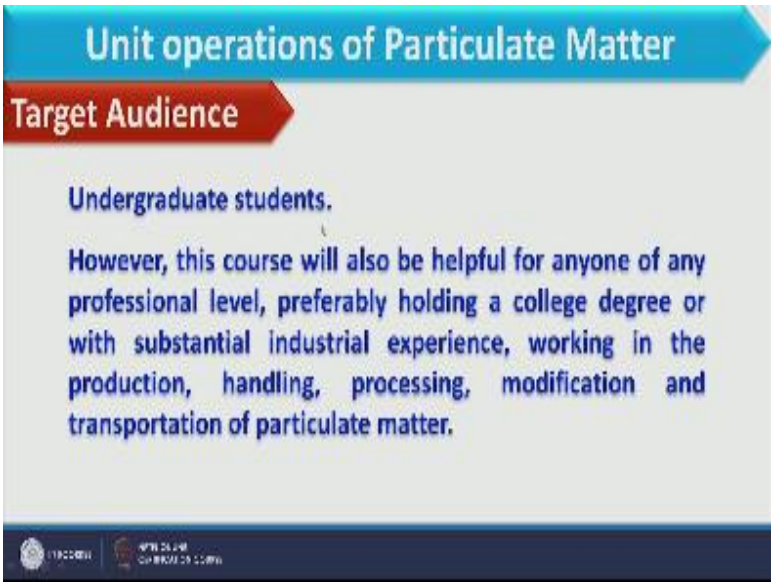

However this course will also be helpful for anyone of any professional level, preferably he or she should have the college degree or substantial experience industrial experience who can work or who can has already work in the production handling processing modification and transportation of particulate matter. So all persons who are involved in this they can join this course.

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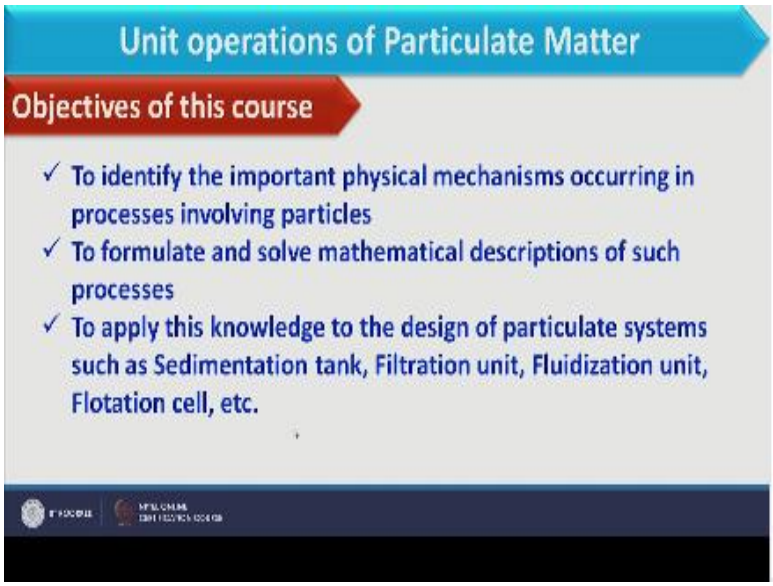

Objective of this course is to identify the important physical mechanism occurring in the processes involving particles to formulate and solve mathematical descriptions of such processes. To apply this knowledge to the design of particular systems such as sedimentation tank, filtration unit, floatation cell, etc. so these are the different objectives of this particular course. Now this particular course basically covers sedimentation you can see

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From this diagram if we need to collect the thick sledge as well as the clarified liquid and clarified solvent so we can go for the sedimentation process.

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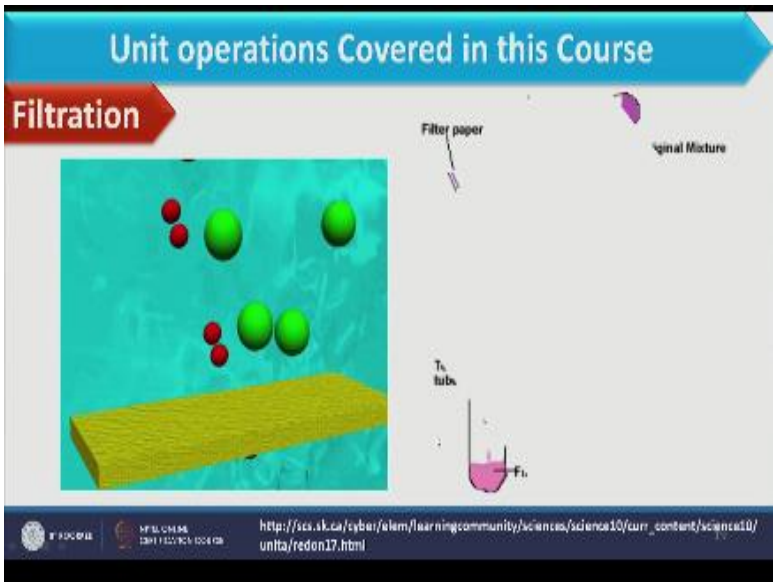

Second is the sedimentation process is the filtration we all are aware with that we have the filter media and the particles which are falling in this if it has he larger particles size then the opening it will be blocked otherwise the next rest will be passed through the media so that is nothing but the filtration. We all have use the filtration in our labs when we have the funnel, when we have the filter paper when we have the test tube. So here this particular figure shows the filtration at laboratory scale.

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Another topic is fluidization where the solid particles are fluidized wit help of air and liquid. Fluidized means they will be considering the flowing they will be transported flowing state from the static state. Further we will consider the flotation this particular figure I have only shown to give you

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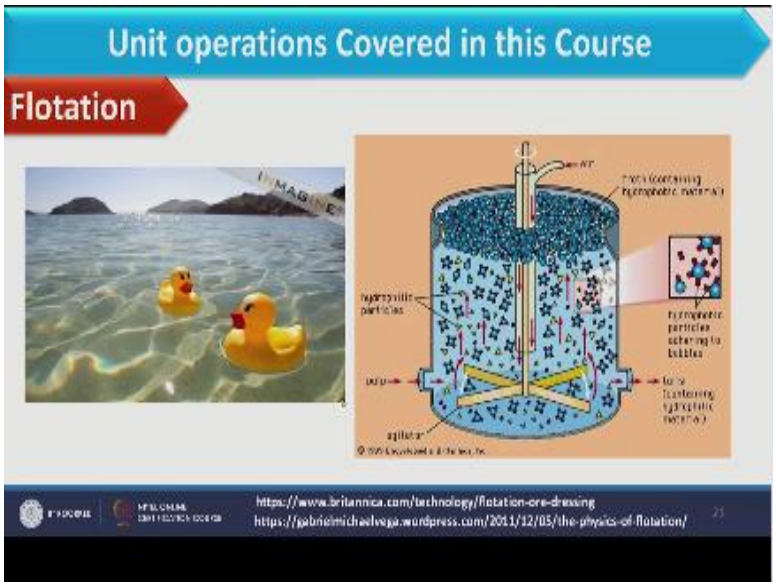

The idea what is flotation that when material floats over the surface that will call has floatation? Now this second figure speaks about the particular operation as far the chemical engineering is concern. So we will concede the flotation.

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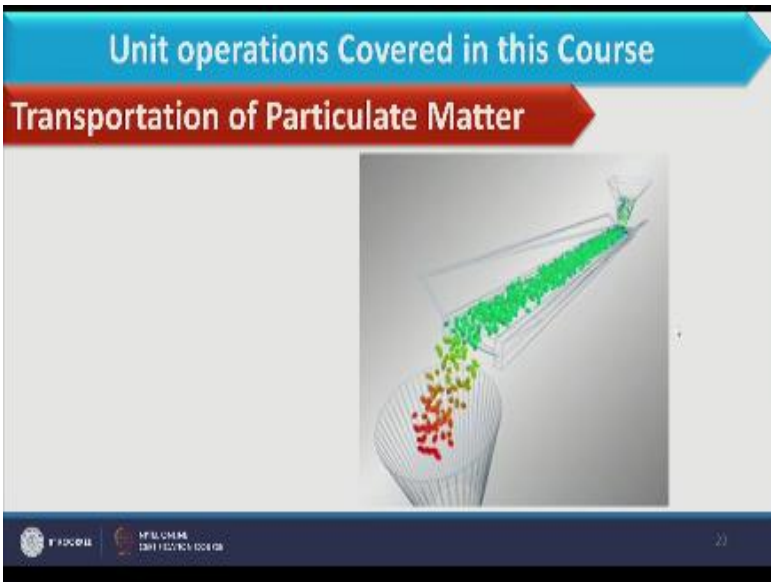

And then we will finally consider the transportation of particulate matter that is how that the solid material is transported from one part to another part in plant as well as away from the plant also.

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Here we have some of the references which we references in terms of books the books which we are going to refer this particular course these are 5 books other thing we have also considered some web page at sectors so that I will when speak it will appear in that time. I will speak about that so these are the few references.

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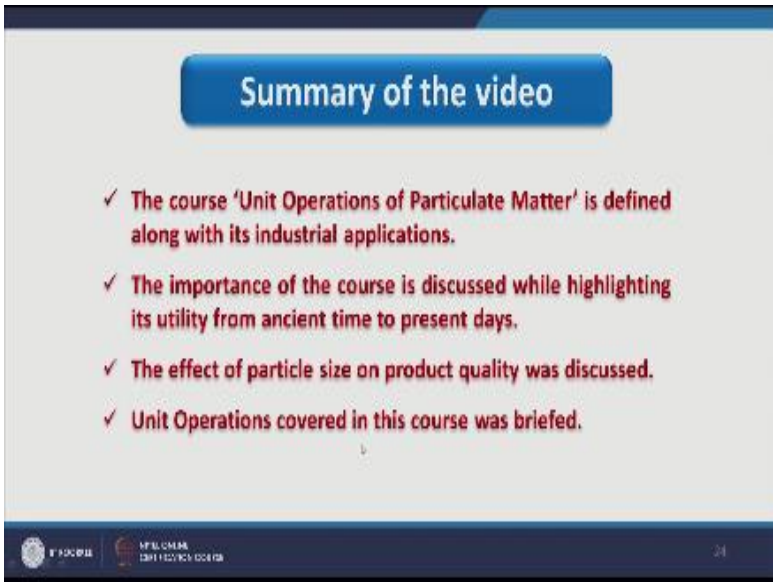

So here we have the video the course unit operation of particulate matter is defined along with it is industrial applications. The importance of the course is discussed while highlighting it is utility from ancient time to present days. The effect of particle size on product quality was discussed. Unit operations covered in this course was briefed.

So here this is the first lecture where you have idea what unit operation particulate matter what is is it is application what was it is history and what is it utility in our day to life. So I think you have enough idea this introductory class that why are you going to study this course. It has utility to day to day life at industrial scale also. So that is all from now. Thank you.

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