Lec 9: Equipment for Size Enlargement

Hello everybody. Welcome to this massive open online course on solid-fluid operations. So we are discussing about the size enlargement of the particle or solid. There we are discussing about the mechanism of size enlargement and what are the different types of enlargement methods. Those were actually discussed in the earlier lectures. So in this lecture, in the module of that size enlargement, we will be discussing about the equipment for size enlargement.

So before coming to that equipment, we have to again try to remember what is that size enlargement. Size enlargement is basically that process by which the smaller particles can be brought into a coarser particle just by that the mechanism of intermolecular action by or with the help of some binding agent. And it is associated mainly with the pharmaceutical, agricultural and food industries but also plays an important role in other industries including minerals, metallurgical and ceramic industries and we are also discussing about several methods of size enlargement of the solid material. Those are granulation, compaction, extrusion, sintering, spray drying and filling.

And agglomeration is also another important that enlargement method. Basically that almost that synonymical with that granulation process. The agglomeration is the formation of agglomerates that means granules or aggregates we can say by sticking together of a smaller particles with the help of some binding liquids. And also we have shown a schematic diagram of granulation method where typical agglomeration circuit that is utilized in the processing of pharmaceuticals that involves both granulation and compression techniques. Here you will see that the slides that the feed will be coming from the bin which will be passing through that blender and then it will pass through the granulator.

In the granulator it will be processed just by adding with that solid materials with the binding fluid and this granulator will make you that granules along with that non granules materials where the mixture will be classified or segregated by a classifier and from that classifier the granule material will be passed to a bin from where by a tablet in place the granule will be given a shape of tablet and it will be coming as a product. Whereas non granule materials it will be recycled after milling to the feed again here. So, it will be a continuous process and in the granule maybe at a certain flow rate of that powders with ingredients will be allowed to run and then after making that granules it will be classified and then given a particular shape of tablet or other desired products shape. So, this is the simple schematic granulation process by which you can get that tablet in pharmaceutical industries. There also we have discussed that different mechanism of that granulation process.

One is wet granulation and another is called dry granulation which is broadly classified. Under wet granulation you will see that different steps that we are discussed in the previous lecture that mechanism of granulation process or mechanism of size enlargement there. So,

in the case of wet granulation we will see that some hydrophobic drag and some excipient liquids like binding solvent by which that molecules or particles will be agglomerates making agglomerates just by intermolecular action making by that excipient liquid bridge between that liquid and solid. And it happens based on that different forces acting on that surface of the solid material and also contact angle of that solid material with the binding liquid. And after that you will see that it will be allowed that excipient liquid for the stage of that wetting and nucleation where that excipient liquid will wet that powdered surface and entrained into the powdered beads at a certain rate that we have discussed that what will be the rate of that equation based on which that liquid material will be entraining inside the powdered bead that we have given that equation and what should be the rate of binder addition, how that binder to be added, whether it will be drop wise or not.

After that it will be allowed to growth and consolidate. There during that growth stage you will see that the fine particles will be having layer of that excipient liquid or binding liquid layers and making a bridge and then coalescence and then making a larger one particles and whenever they will form that larger particles you will see that sometimes due to that attrition they will again broken into a finer particles but those particles will be as a granule. So initially at the growth stage you will see that the granules which will be formed in a bigger size then after that it will be broken into a smaller sizes just by attrition or by other mechanism or mixing you can say. So there we are having that mainly this wetting and nucleation stage, growth and consolidation stage, attrition breakage stage all those stage actually how those stages are working or are working that we were discussing in the previous lecture. So I think you have come through that lecture and you try to understand that mechanism of that wet granulation.

Now question here that whenever we are going to make that granule where we have to make, how we have to make there should be certain equipment on which that granule will be made. So here we will be having equipments for that granulation. There are you will see that several different categories of that granulation equipment are there but mostly those are used or those are very common to use for this granulation process are like one is called tumbling granulators, some will be called as mixer granulators, some will be as a fluidized bed granulators, centrifugal granulators, spray granulators and some machine will be as a compressor compaction machine that may be extrusion, roll press, tablet press, molding press, even fillet wheel those are being used for this granulation process. So we are having these different types of granulation equipment. You will see that mixer granulators are mostly used, there you will see that some will be continuous high shear like bass high shear mixing equipment for granulation, some will be paddle mixer, some will be this special name as sugi mixer and also those equipments are generally used based on that product category.

In that case sometimes some granules to be produced very fine, some granules to be produced as a coarser. So according to that the equipment to be selected for fluidized bed granulators you will see that we have to use that to produce very fine granules. There are

different types of bubbling fluidized bed granulators will be there according to the flow pattern of that fluidized bed. One is called bubbling fluidized bed, another is called spouted beds. The bubbling fluidized bed there from the bottom of that bed or a column or that vessel the gas will be supplied from the bottom of its vessel as a disperse phase of bubbles.

So that is why it is called that bubbling fluidized bed. There will be certain flow rate which is to be maintained to get this bubbling fluidized bed and sometimes you will see that to get that circulatory mixing inside the bed for that powder materials and getting more contact between solid and liquids inside that bed, it is advised to get different types, different patterns of that fluidization. So it is called spouted beds. There you will see that at the center line here if it is a suppose the bed and here the materials are there solid materials along with binding liquids if the gas is supplied from the bottom you will see that gas will be flowing upward through the core region of this fluidized bed. It will be passing as a jet you can say and here one nozzle to be used so that through the nozzle the gas will be passing as a jet.

During that flowing of jet you will see that surrounding this solid liquid material it will be making a circulating cell inside this bed and this circulating cell will give you the better mixing between solid and binding liquid and making that granulation. So this type of provisions to be made at a certain liquid flow rate but it depends on what type of distributor to be used. So if you are having that nozzle type or sometime it is called two-year type distributor. So this distributor will make this type of core flow rate of the gas and because of which there will be a internal circulation inside this and based on which you will get that more intense mixing and making the finer granules. So this is called spouting flow pattern which is happened in this fluidized bed.

So these are fluidized bed granulators. Another one is called centrifugal granulators. So they are centrifugal action there will be the solid materials will be rotating centrifugally and then that the solid materials will be coming in contact with the binding liquids which will be sprayed through a mechanical provision that I will show in the next slides onward. So there it is called centrifugal granulators. Then spray granulators those are basically that binding liquid will be sprayed as a drop on the surface of powdered beds and where you will see that the powdered materials will be getting that wetted with respect to time and when all the powdered bed will be wetted and it will be mixed it will be that sheared so that during that shear action that powdered bed will be coming in granules.

Pressure compaction you will see that extrusion mesh that will give you that fillet forms or you will that small sizes of granules they are just by making or compression of that materials with the binding liquid and it will give you the specific shape of that desired products. Now you will see that those are different type of equipment for that granulation you will see that they will have some special applications and also there will be certain range of capacity and what are the granule density that will be forming based on that equipment category and also what are the size. You will see that if you use the tumbling or

disc drum type tumbling machine or vessels or granulators you can say their product size will be 0.5 to 20 millimeter whereas its density will be moderate not low very and not high. So in that case it depends on what will be the throughput or capacity or flow rate of that excipients there and also what will be the powdered materials flow rate and what is the capacity for that.

Suppose capacity is 0.5 to 800 ton per hour there you will expect that 0.5 to 20 millimeter product size by this tumbling machine and in this case you will see that that granules will be forming almost spherical in size. These are generally used in fertilizers iron ore agricultural even chemical industries and then mixture type that granulators it may be continuous it may be batch or maybe that transient condition. You will see that there may be high shear because their powder materials to be lose from its steel position.

So there whatever granule size will be formed that will be 0.1 to 2 millimeter in range and grain density will be less than 200 kg per batch and your capacity will be less than 50 ton per hour. A small capacity of this machines but it will give you the finer granule size that you can handle it very gently. Main disadvantage is that cleaning of this mixture is very tough. So in that case you can say though the handling is easier but cleaning is not good.

Operation is easier since there is no other mechanical parts which is moving side that mixture. Generally chemicals detergent pharmaceuticals and ceramic industries they are using this type of mixture for granulation process and then fluidized bed this is the special type where you can get again that finer granule size within a range of 0.1 to 2 millimeter but here capacity will be high compared to that mixture and also you can get high densed granular material. Here it is also good for coating and easy to scale up. It is generally used in fertilizer industries to make the detergents even pharmaceutical industries to make that tablets even in agricultural industries you can say that for making that pesticides, herbicides in the granule forms they are using this type of fluidized bed and in fertilizer industry you will see that to make the urea making that granular forms of that urea they are using this fluidized bed granulator.

In the case of centrifugal granulators its product size will be 0.3 to 3.0 in millimeter density moderate to high whereas here capacity will be is equal to up to 200 kg per batch. In this case powder layering and coating applications are feasible pharmaceuticals and agricultural chemicals production they are using this type of centrifugal granulators for their finer products. Then spray granulators here we will see that it will give you the more finer granules it is within a range of 0.

05 millimeter to 0.5 millimeter. So it is a micron size you can say but then it will be very low and in this case you will see that morphology of that spray dried material can vary widely. So this is one advantage it can be used or this feasible to use for making instant foods, dyes, detergents, ceramics even pharmaceutical products. Another important granulator it is called pre-linked granulators where urea and ammonia nitrate production these are very

important. In this case that product size will be point size to 2 millimeter and the granule density is coming around you will see that moderate and it may not be that greater than 200 kg per batch.

And then you will get pressure compactors there are different types of pressure compactors like extrusion, roll press, tablet press, molding press, even fillet mill. And all that extrusion, roll press and tablet press you will see that their product granule size will be no greater than 0.5 even 1 and 10 like this respectively. Here granule density will be high to very high and but capacity is very low up to 5 ton per hour only. In this case whatever products you will get you will get very fine size products and almost all the granule will be uniform in size that is why there will be a narrow size distribution of this product.

And also these are very front to powder flow and material properties that is why we are getting that very high granule density and also size will be very small. But in this case capacity will be less because of that material characteristics. And these are being used in pharmaceuticals even to make the catalyst inorganic and organic chemicals preparation and plastic preforms even metal parts, ceramics, clays, minerals and animal feeds to make all those products these machines are being used. Here one picture is shown about that tumbling granulator. This tumbling granulator you will see that it is imparted to the particles in an inclined cylinder generally called drum granulators or you can say it is called a pan sometimes it is called disk granulators.

In this case solid and liquids are fed continuously to the granulator and there will be a tumbling action that will be rotating you will see that which gives rise to the rotational movement of that solid particles. And you will see that during that tumbling action there will be a natural classification of the contents according to that size. So that is why it is advantageous parallelly that formation of granules and separation. So here you can get that narrow size distribution of the product. Whereas mixer granulator you will see that here as shown in the picture the motion of the particles is brought about by some form of agitator that will be rotating at a low or high speed on a vertical or horizontal axis.

And in this case rotation speeds may vary from 50 revolutions per minute in the case of horizontal mixers generally used in fertilizer industries for fertilizer granulation and its RPM will be increased up to 3000 in the case of vertical Shugi high shear continuous granulator which is generally used for making detergent and agricultural chemicals. And for vertical axis mixer you will see that is used by that pharmaceutical industry in that case impeller speeds the main important point here. So impeller speeds to be varied from 500 to 1500 RPM for mixer less than 30 centimeter in diameter. If the mixer is less than 30 centimeter in diameter then only this rotational speed will be considered 500 to 1500 RPM. Whereas if your mixer size will be larger than 1 meter in diameter in that case you have to control that RPM or you can say that rotational speed should be within a range of 50 to 200 RPM.

So this you have to remember and the in general you can say that the agitator speed decreases as the mixer scale increases in order to maintain either constant maximum velocity at the blade tip of that mixer or constant mixing pattern inside the mixer. And also that constant mixer patterns to be depending on that Froude number that to be controlled as per design. Then fluidized bed granulator is shown in the picture from the bottom the air or some other gas which will be non-reacting with the binding liquids will be supplied through a distributor where that it will be distributed as a dispersed phase of bubbles or through a rotameter as a jet also you can say which will be broken into a finer jet. So in that case it will be allowed that solid and fluid materials inside that fluidized bed as a circulatory motion and there will be internal circulation of that solid and binding liquid and there will be intense mixing and based on which that granulators will be acting as a fluidized bed you can say here and make the granules. The advantage over others include that good heat and mass transfer will be having here because of that intense mixing and also there will be mechanical simplicity ability to combine the drying stage with the granulation stage and ability to produce small granules from powder pits.

In this case that liquid binders and wetting agents are sprayed in the fluidized bed from the some location from that periphery either from top or from that bottom side of that fluidized bed from the nozzle which will be giving that atomized form of that binding liquid that will be above or within that bed. So particles are set in motion by that fluidizing air this is the main mechanism based on which that granules will be formed. So here see that how that liquid binder will be supplied from that top you will see that there are different way that will be supplied and it will be sprayed and over that solid material or can the powder bed and from the bottom there will be fluidizing air which will be fluidizing here and this is your basically what is that a spouting bed here from that core regions the jet will be here and that you know particles will be again going downward and it will be making a circulation over here and then getting the solid materials with that binding materials mixed and then continuously with respect to time whenever that granules will be formed it will be taken out from that fluidized bed. And whereas if fine particles which is coming out from that air it will be you know separated again by that cyclone separator and then particles again can be reused here in the fluidized bed. So here see that how that solid material should be getting that circulation inside that bed here.

So this is the main mechanism by which you can get that fluidized bed granulators and based on which that you can get the granules. So here the different stage or different mechanism or pattern by which you can get that efficiency of that fluidized bed granulator for making that granules. So it depends on flow pattern okay flow rate, particle characteristics even that binding a liquid concentration as well as you can say that the distributor of this fluidized bed to which that gas will be supplied to make that flow pattern inside the bed. Then centrifugal granulators you will see that in the picture here you will see that hot air is blown upward okay between turntable and granulation area. This is turntable we have shown and this is the granulated area.

You will see that the air here which will be coming to that turntable it will be spraying or it will be sprayed inside that granulator which will cause that course to roll the binder solution then is sprayed on the rolling course through the pump and spray gun. So here you will see that the air will cause the course to roll here. The binder solution is a sprayed here this is the mechanism the spraying mechanism on the rolling course here this is the rolling course through the pump that binder liquid will be supplied and spray gun to be used to spray here and then rolling core will be spraying this way. So during that rolling of that materials just by spraying that or spreading that binding liquid by that circulating motion of that air you will see that the solid materials will come into contact with that spraying liquid and whenever it will come then of course it will form a core and after that you will see that there will be a drying operation. The drying operation will be happened simultaneously here and if powder coating is required the fixed volume of powder is to be sprayed at a certain time whenever that continuously moving that gas inside the granulator and you will see that the solution whenever come in contact with that solid material during that movement the solution will coat the powder on the course and it will produce the pellet and get coating and drying simultaneously.

Now this type of granulator will be very promising due to its advantage of simple and compact structure controlling of this equipment is very easy energy consumption is low and also you will see that fine slag particles and desired glassy phase also will be forming during that granulation process which may be used again for that recirculating granulator. Now there are different types of this type of granulators can be used in industry for making this granules to get that enlarged size of particles. Now main point here that to make these granulators you need that excipients that means binding acids some additives some other chemicals which will give you some coating some stabilizers which will stabilize that granulator PS modifiers even you will see that some colors that you have to give. So what are those that excipients so we can classify that excipients in a bulking agents functional additives and others like this. Bulking agents or as fillers we can say that will start to form the core or structure of a dose form.

Bulking agents generally are inert materials that are relatively inexpensive and also you will see that functional additives which include the binders disintegrants lubricants colorants even stabilizing some agents that will be used and the size of that excipients depends on the number of factors like drug what type of drug that will be used the process involved the formulators and the cost of excipient these are the factors. And what are those bulking agents you can say that very common filler or bulking agents are sugar lactose dicalcium phosphate stars microcrystalline cell loss etc. Functional additives very common functional additives are binders disintegrates lubricants stabilizing agents and colorants. Now in this case question is that what is the difference between that functional additives and bulking agents. To see that functional additives will react with that materials whereas bulking agents will not react with that man solid materials.

Binders there are different types of binders are generally used some will be polymers some

will be that sugars, sugars may be sucrose glucose and sorbitol whereas polymers some will be natural some will be semi synthetic material as a polymers semi synthetic polymers some will be synthetic polymers. Some natural you will see sometimes it is called biopolymers also like acacia, allogeneic acid, sodium allogeneate even kia gum these are biomaterials even you will see that some other seed gum you will see gill and gum and their combination also different types of gums they are used as a natural polymers we can say. Semi synthetic polymers like ethyl cellulose, sodium, carboxymethyl cellulose, methyl cellulose even hydroxy profile cellulose etc. even hydroxy profile methyl cellulose also used as a semi synthetic polymers which is used as binders and then synthetic like polyvinyl, pyrolidone and polyethylene glycol those are being used as a binders. And what is the role of that binders? So the binders will provide the cohesiveness which is essential for the bonding of the solid particles under the compaction to form tablet and also it will promote the size enlargement to produce granules and thus improve the flowability of that blend.

Also you see that this binders are often used as a filers and impart compressibility of the powder blend. Also it is used to age in durability and enhance the elegance of the granules. Sometimes the disintegrants also being used for this granulation process to increase the hydrostatic pressure in the formulation when it comes in contact with the water. So there you have to increase sometimes that hydrostatic pressure. So it is responsible for ensuring the breakup of the tablet matrix upon ingestion.

So what is that disintegrants? Like some will be that cross caramelose sodium, some will be sodium starch glycolate, even some will be low substituted hydroxypropyl cellulose, even some will be called as cross povidone like this. These are the different types of disintegrates to be used for the granulation process. And sometimes to increase the flowability by reducing the friction between the tablet and the dye materials you will see that sometimes you need to reduce that friction. So for that you have to use some lubricants. What are those? Sometimes starch, talc powder, hydrogenated vegetable oil, stearic acid wax, even calcium stearate are being used as lubricants but mostly used as magnesium stearate in industry as a lubricant.

So I think you have learned something about that what are the different types of equipments are generally used in industry for making granules and also what are the different types of binding liquids are being used for that granulation process along with other lubricants, even other disintegrants all those things. So please go through the slides again to know better and you can follow other books which is given for your reference. I think you will be able to gain more knowledge on this subject. So this is basically that undergraduate level.

So these are the portion that will be covered. So that is why I think this much is enough for you. And in the next lecture, we will try to follow the next module that will be flow past immersed bodies. In the next lecture, we will try to understand what is the flow phenomena whenever it will be flowing over the cylinder or spherical particle and

successively we will also discuss more about flow past of the solid materials. So thank you. Have a nice day.