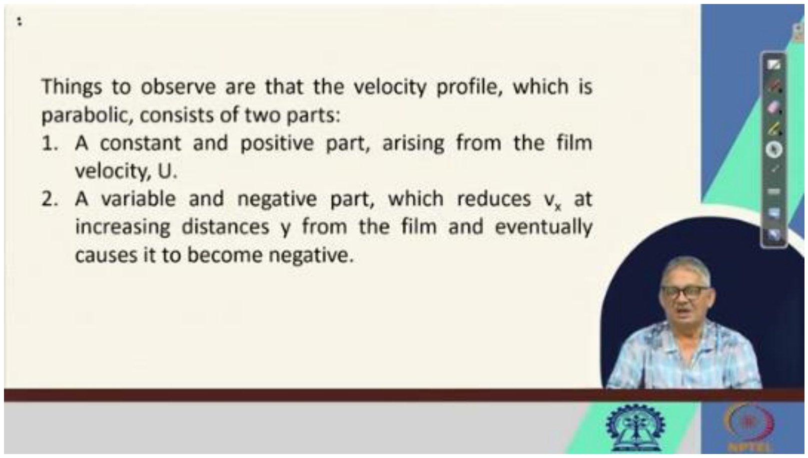
IMPACT OF FLOW OF FLUIDS IN FOOD PROCESSING AND PRESERVATION

Lecture29

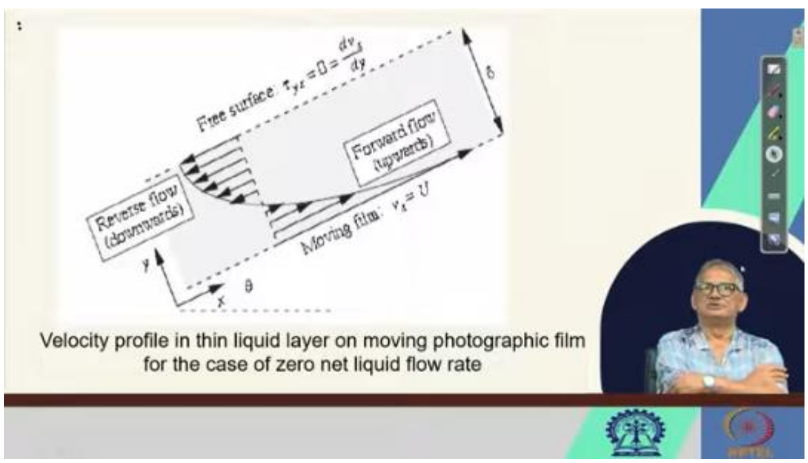
LECTURE 29 : PROBLEMS AND SOLUTIONS OF MOVING SURFACE FLOW TO BE CONTINUED

Good afternoon my dear boys and girls and students and friends. We are handling a unique thing which normally in flow of fluid people do not handle. But since we are coming in this class, so I thought Why can't it be also introduced? So, we are solving a problem in which the surface is also moving.

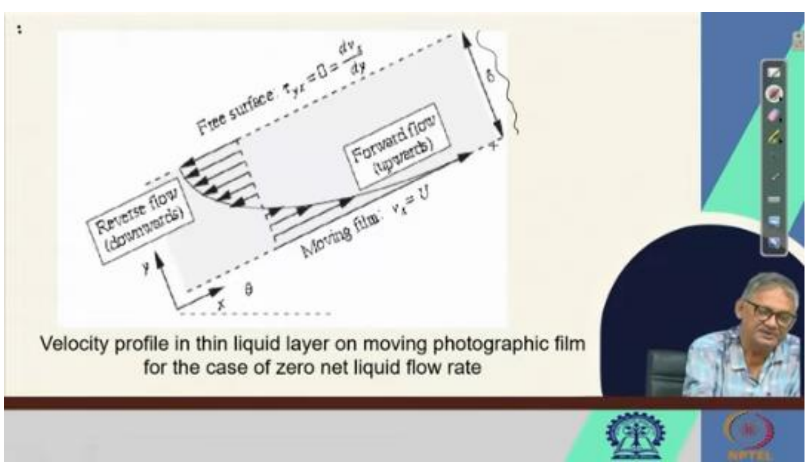
Earlier, we had shown the surface is not moving. But now, we are saying that yes, the surface is also moving. So, with that, we have come to this level that we have found out the velocity distribution, right? And we have explained that this is having similar to the parabolic nature and it has two components.



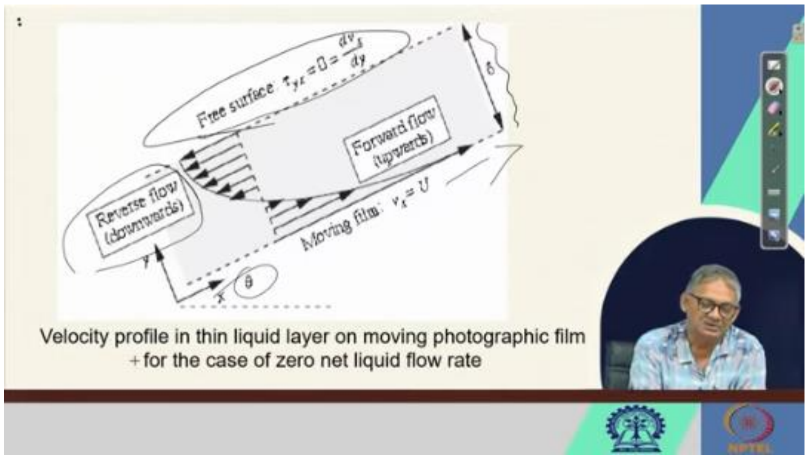
One is positive arising from the film velocity u. and the other one is slightly negative and this reduces v_x at increasing distance of y from the film and eventually causes it to become negative, right? So, this tells like this, okay? If you plot it, you see. This is the delta, ok.



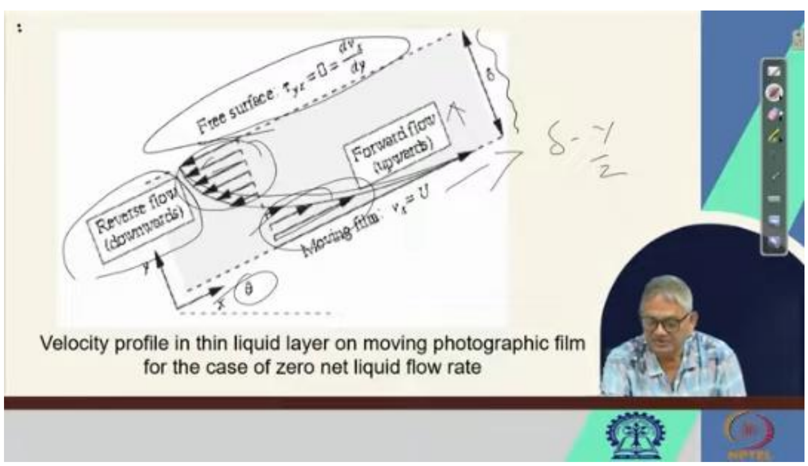
Let us use this. This is the delta, right. That is the film thickness. Free surface is this. That is τ_{yx} is 0.

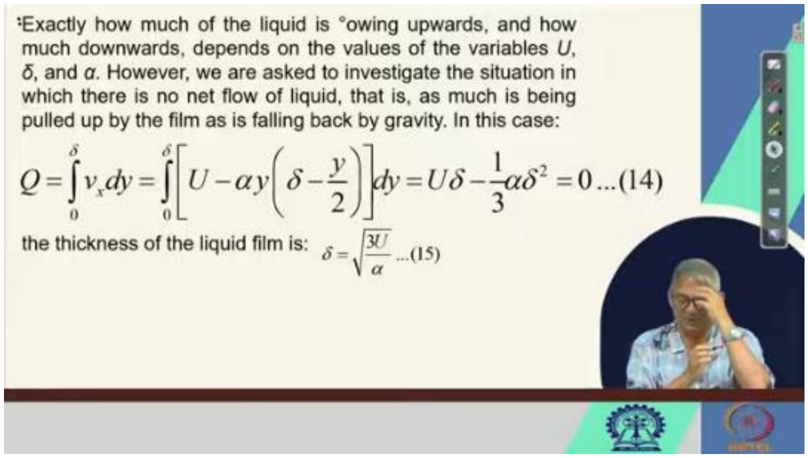


That means dvx / dy is 0, right. And this is reverse flow towards downwards because it is inclined. right flow is moving this way, but this reverse flow is occurring because this is inclined with an angle theta right. So, forward movement is this that is what we are saying it is parabolic in nature, but having a positive part this vx. and the negative part is this that as the y this is the y axis right as y is increasing del minus y by 2 is also increasing right that is what it is appearing here.

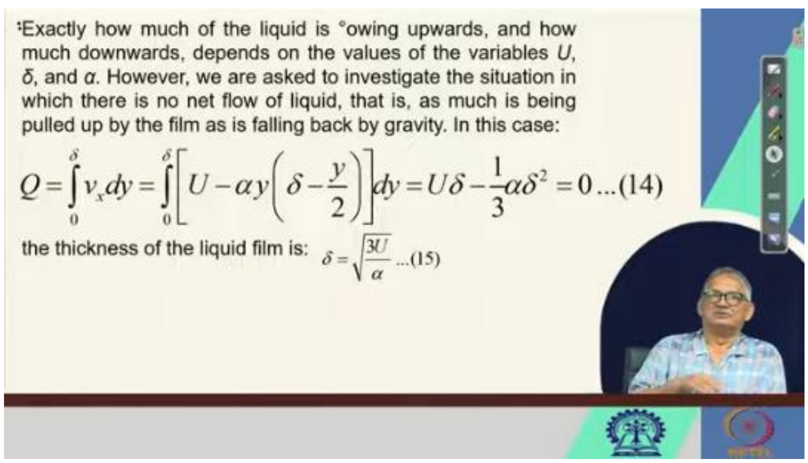


So, with this note let us now proceed for the next. What is that? That this is velocity profile in thin liquid layer on moving photographic film for the case of zero and net liquid flow rate. Now, if we look at exactly how much of the liquid is flowing upwards and how much downwards. We have just seen some liquids are





flowing upward like this and some liquid is flowing downward like this right. Then the question is how much liquid is flowing upward and how much liquid is flowing downwards right. So, this depends on the values of the variables that is u, del and alpha. However, we are asked to investigate the situation in which there is no net flow of liquid that is as much as being pulled up by the film as is falling back by gravity.



Right? So, okay, if you want, we can repeat that what is required that we now need to know the how much liquid is flowing upward and how much liquid is flowing downwards. Obviously, this depends on the variables used, the value of the variables like u del alpha etcetera. However, we are also given a rider.

That is, we are asked to investigate the situation in which there is no net flow of liquid. That is, as much is being pulled down by the film as is falling back by gravity. So, we can write that Q is equal to that is flow rate integral of v_x dy between 0 to del. So, which on simplification we write is between integral of between 0 to del of u minus alpha y into del minus y by 2 into dy. So, this means u del, because our limit is 0 to del, right?

So, u into del minus 1 by 3 alpha del (δ) square, this is equal to 0. Right? Why? You integrate it and put the limit, then it comes like that only. You take the two parts, okay?

One as u and dy is up to del. So, u del. This is one part. And the second part you can easily take.

And that becomes one third alpha del square. Okay. And this is equal to 0. That is what we are given the rider. Right?

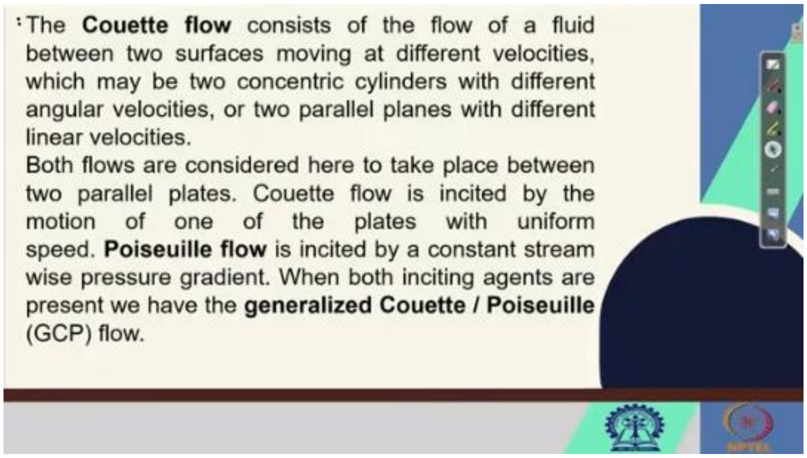
Then we can find out the thickness del liquid film as del equals to under root of 3U by alpha. Under root of 3U by alpha. From this relation of Q is equal to U del del. minus 1 by 3 alpha del square, that is equal to 0. So, from there, we can find out the film thickness, that is del, that is equal to under root of 3 u over alpha, right?

So, things to observe here are like, the velocity profile which is parabolic consists of again two parts. Again a constant and positive part arising from the film, velocity u. A variable negative part which reduces v_x at increasing distance y from the film and eventually causes it to become negative. Right? So, we come to this, that the film thickness that can be obtained as del is equals to 3U under root by alpha.

Okay? Now, this problem we started in the previous class. Because of the time constraint, we could not finish. But, yeah, now it got over. So, we can move to some other topic because

We have enough time in this class and that is why we are not saying it to be thank you. Right? So, we go to the next class. Now, you see, since we have enough time in this class, let us bring some other problem and solutions also. So, in particular now we are looking for problems and solutions on Poiseuille and Couette flows in polymer processing.

So, it is not only food, but also food is also polymer, biopolymer. So, natural or biopolymer, in that processing, some problem and solution using Poiseuille equation and the Couette flow in polymer processing. So, what is Couette flow? That first we must know. That Couette flow, it consists of the flow of a fluid between two surfaces moving at different velocities, which may be the concentric cylinders with different angular velocities or two parallel planes with different linear velocities.



Both flows are considered here to take place between two parallel plates. Couette flow is incited by the motion of the one of the plates with uniform speed. Poiseuille flow is incited by constant stream wise pressure gradient. When both inciting agents are present, we have the generalized Couette / Poiseuille, that is, GCP flow. Right?

So, I think this Couette flow, many of us have not understood. come across. Poiseuille flow we know, we have seen, right? That Hagen-Poiseuille equation also we have derived. So, that is easy.

I am not saying easy, okay, that is not, which we have not heard of. But Couette flow, we have not, many, I am not saying we, many of us have not So, first let us understand what is that. It is saying that it consists of the flow of a fluid between two surfaces moving at different velocities. Two surfaces moving

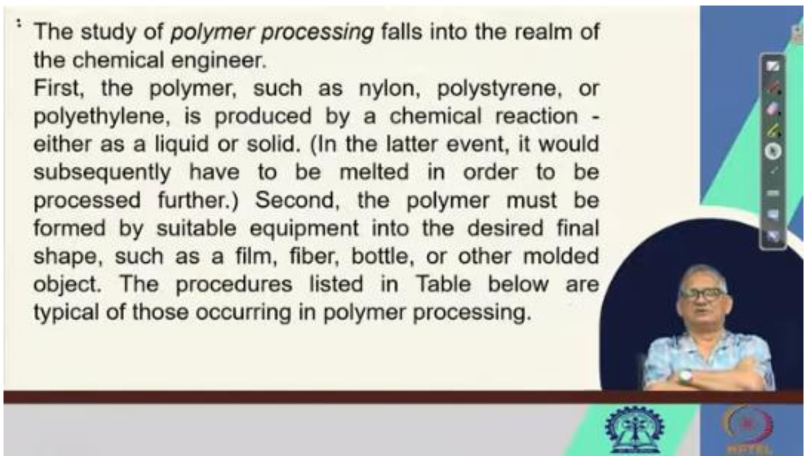
moving at different velocities, may be same like this, okay? Or it is going like this, or this way, okay? It should be different. So, one is different than the other, okay? So, this should be also like this, like this, like this, okay?

Whatever be. That means, we can draw it in better way that this is a plate, this is another plate, velocity of this is say more, right, higher than velocity of this, right. So, that is why after some time you will see this plate has become this and this plate has become this. right that is what we are saying that needs to be taught in cute flow ok. So, it consists of the flow of a fluid between two surfaces moving at different velocities which may be two concentric

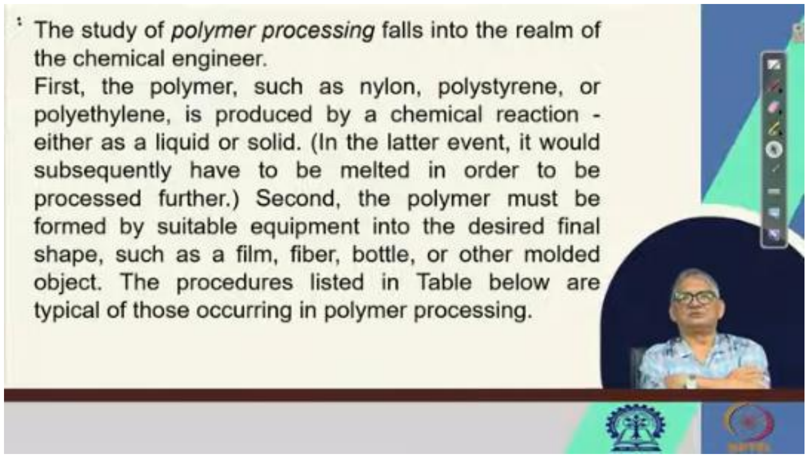
with different angular velocities. It can be. We have one cylinder, another cylinder, both are moving, maybe in the same direction, but this has one angular velocity and this has another angular velocity. Or two parallel planes with different linear velocities as just now as I drawn and shown you. So, both flows are considered here to take place between two parallel plates.

Couette flow is incited by the motion of one of the plates with uniform speed. Poiseuille flow is incited by a constant stream. And this streamwise pressure gradient, when both inciting agents are present, we can say or we have the generalized Couette / Poiseuille GCP flow. Right? Now,

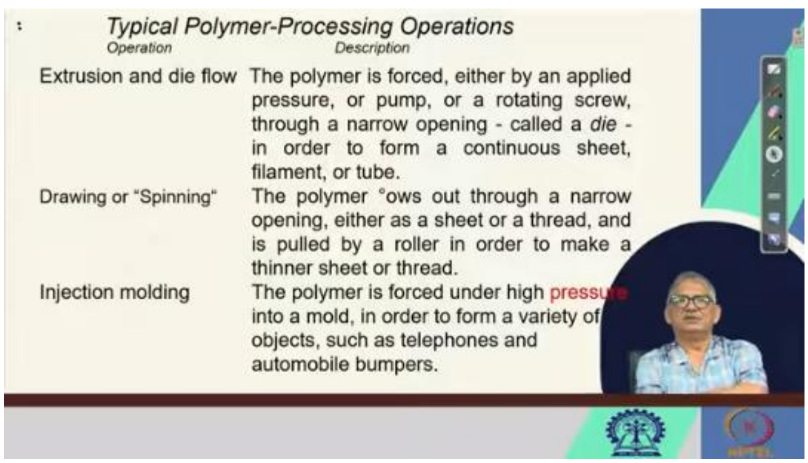
For the study of the polymer, whatever it is, whether it is chemical polymer or ceramic polymer or biopolymer, the study of polymer processing falls in the realm of the chemical engineering if it is chemical. But food is also biopolymer that also falls under chemical engineering. Earlier, maybe several decades back, it was under the umbrella of chemical only. First, the polymer such as nylon, polystyrene or polyethylene is produced by a chemical reaction either as a liquid or solid. in the latter that is solid in the latter event it would subsequently have to be melted in order to be processed further.

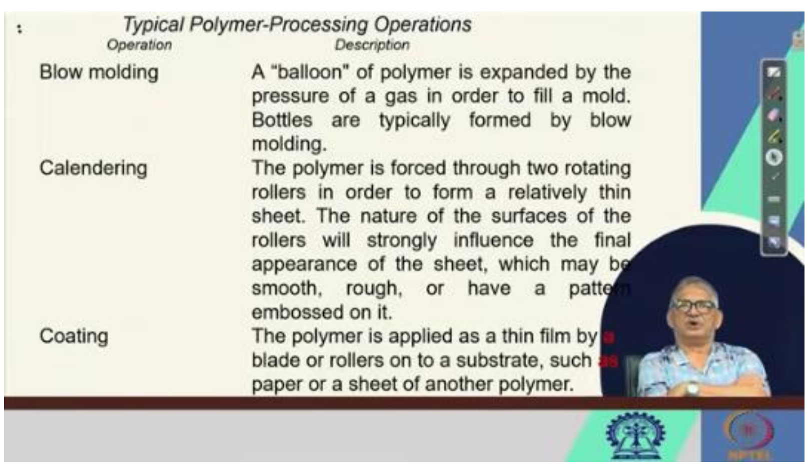


Yes, if it is if it becomes solidified then further processing cannot be done. So, it has to be definitely liquefied or melted Second, the polymer must be formed by suitable equipment into the desired final shape, such as film fibre, bottle or other moulded object. The procedures listed in table below are typical of those occurring in polymer processing like



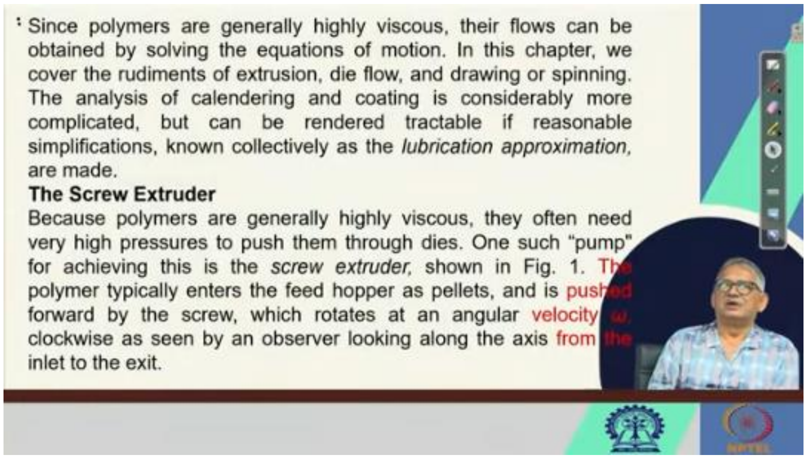
This extrusion and die flow in food also there are many extrusion and die flow. The polymer is forced either by an applied pressure of a gas in order to fill a mold. Bottles are typically formed by blow molding. Then calendering that is another processing that is the polymer is forced through two rotating rollers in order to form a relatively thin sheet. The nature of the surfaces of the rollers





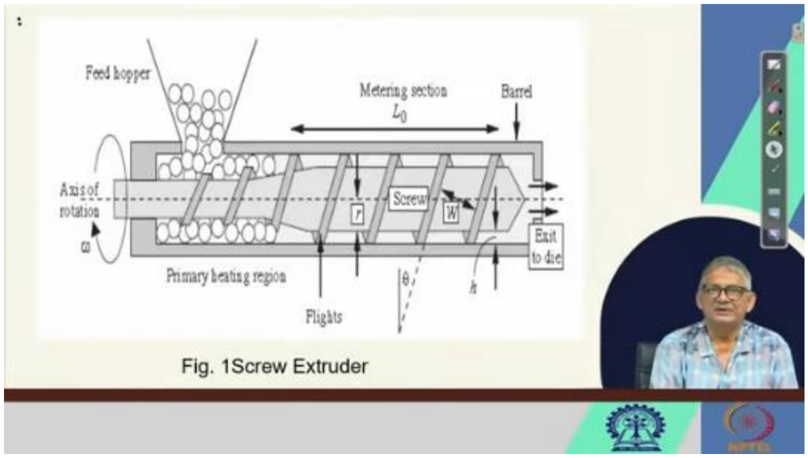
will strongly influence the final appearance of the sheet, which may be smooth, rough or have a pattern imposed on it. The polymer is applied, the coating, the polymer is applied as a thin by a blade or rollers onto the substrate to which as paper which such a paper rather or a sheet of another polymer. Now, since polymers are generally highly viscous, their flows can be obtained by solving the equations of motion.

So, in this typical aspect we can say that we cover the let us cover the rudiments of extrusion, die, flow and drawing or spinning. Many exudate products are available in food, right? The analysis of calendaring and coating is considerably more complicated, but can be rendered tractable if reasonable simplifications known collectively as the lubrication approximation are made, right.



If we look into that screw extruder, yeah there could be single screw, there could be twin screw like that many. So, because the polymers are generally highly viscous, they often need very high pressure to push. them through dies. One such pump for achieving this is the screw extruder. This is shown as in the next figure.

Okay. This is a screw extruder. We will come back. Right? We will come back.



The polymer typically enters the feed hopper as plates and is pushed forward by the screw which rotates at an angular velocity omega. Clockwise it is seen by an observer. along the axis from the inlet to the exit. Yeah, why I am giving so much emphasis on this because this is also telling a process. Yeah, which obviously is related to the flow of the fluid, but keep in mind

that only the flow of the fluid, if we look at, then that becomes a mathematical class. So we have to bring some filler so that it becomes a concrete class. Right? So Since this class timing is also is getting over, before going to the figure again, we will go to the figure next.

But let us look into what the screw extruder says. Because this screw extruder is used both in food industry, in polymer industry, in many, many other industries. Right? So, as I am saying that food is also a biopolymer and chemical polymers are also there.

Rubber is also a polymer. So, because polymers are generally highly viscous, they often need very high pressures to push through dies very high pressure so that your viscosity becomes very high. One such pump for achieving this is the screw extruder right. This we will discuss in the next class because time is almost over.

But before it is we say the polymer typically enters the feed hopper as pellets and is pushed forward by the screw which rotates at an angular velocity omega. and is clockwise as it is seen from the figure by an observer looking along the axis from inlet to the exit right. We have come to the end of this class. I hope you are finding interesting because this is a new topic which normally is not covered unless it is explicitly required by that section. But I have introduced it because, yeah,

instead of only having stationary object, let us also look into the moving object, how it is happening, what is happening there, right. So, with this we conclude the class. Thank you.

Thank you for listening. Yes.