Industrial Biotechnology
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Module 4
Lecture No 20
Flow Diagrams, Pumps and Valves used in fermentation Industries

Welcome back to my course that is Industrial biotechnology. Now I am going to discuss very interesting topic that is the flow diagram, pumps and valve used in the fermentation industries.

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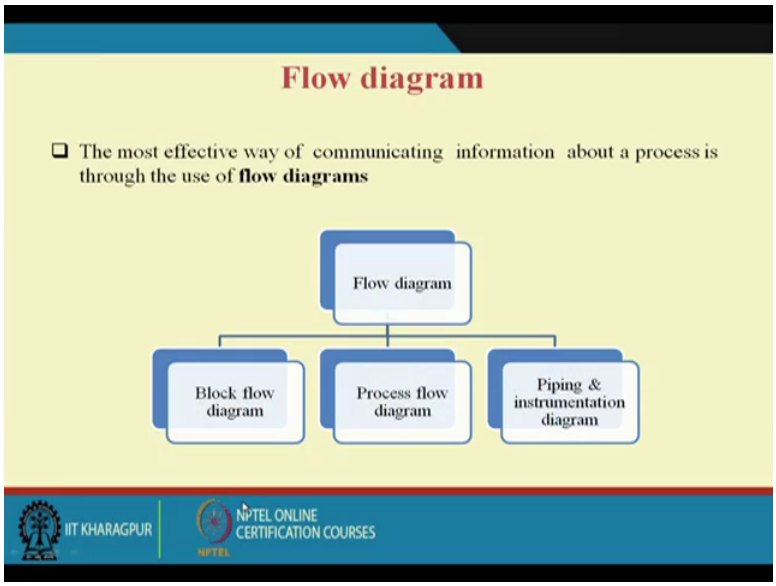

If you look at this flow diagram, the most effective way of communicating the information about a process is through the use of flow diagram. Flow diagram may be a block flow diagram, process flow diagram, piping and instrumentation diagram, let me explain that what is the purpose of the flow diagram. In the industry, biochemical industry, it does not have only the fermenters, it has upstream processes, downstream processes, upstream processes we have pre-treatment of the raw materials then we have we have sterilisation we have medium sterilisation, then you have the fermenter. After fermentation you have to go for the purification of the products, so the different steps are involved for the purification of the product because we should remember that whenever we do market for the marketing of any kind of product, it should be marketing in the purified form.

I can give you I can give you a very simple example, if you look at the catalogue of any chemical catalogue, you will come across to type of chemicals; one is analytical grade and

another is commercial grade. Now commercial grade easily it is about 90 percent 95 percent purity and analytical grade about 99.99 percent purity, so if you see the cost difference between analytical grade and the commercial grade, there is huge difference may be 4 times as compared to commercial grade. So you know purification is a very important part that of the of any chemical and biochemical industry, so main purpose of the flow diagram just to give you the information.

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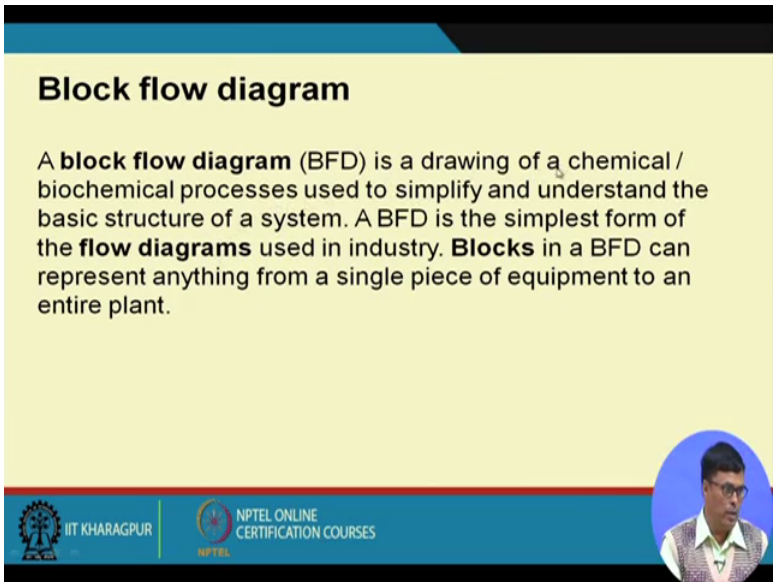

What are the different units involved in this particular process to get the product this can be explained as I told you in 3 ways, one is a block flow diagram, process flow diagram then piping and instrumentation diagram, let us see how we can do that. Now, block flow diagram is the drawing of chemical and biochemical processes used to simplify and understand the basic structure of the system. The block flow diagram is the simplest form of the flow diagrams used in the industry, blocks in a block flow diagram can represent anything from a single piece of equipment to an entire plant. So what does it mean? Every process we we explain as a block because you know in case of block flow diagram.

As for example suppose we consider a sterilisation, there should be a particular block, medium sterilisation there should be a block, so you know fermenter is a block then you have separation of the Micro cell mask from the fermentation block that will be block. So you know all the processes will explain with the help of a block, so it is the simplest way we explain the process that is the what you call block flow diagram.

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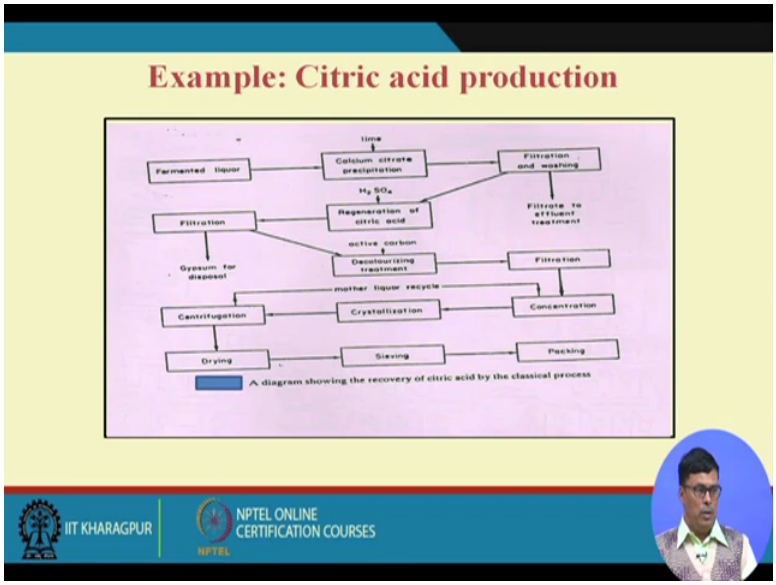

Now here I have taken the example of citric acid production industry, in the citric acid industry you see, after the citric acid production takes place in the fermenters, it pass through the different units can you see it? This is the calcium citrate precipitation unit, filtration and washing then regeneration of citric acid, again filtration, de colouring, again filtration, concentration, crystallisation, centrifugation, drying, sieving and packing. So you know there are so many steps involved before we get the final product and every step we explain with the help of a block like you know this is fermented beaker collected after separation of the microbial cells, we get that filtered and this filtered we treat with lime to precipitate out the citric acid in the form of calcium citrate.

Then this calcium citrate with the insolvent mask that is to be separated with the help of filtration process, then we wash this filtered that is this calcium citrate so that you know the coloured that is partly can be removed then this is hydrolysed in presence of H2SO4. Again then it convert the calcium citrate to citric acid and calcium sulphate, then calcium sulphate is removed in the form this is called Gypsum for disposal and filtered, we have used some kind of de colouring method like activated carbon to remove the colour because if the colour is present in your product then the the it will be very difficult to market the product.

Then you have to do the filtration to remove the activated carbon then you have to concentrate with the help of evaporator then after that you cool it down then you pass through the crystallisation then it forms the crystals of citric acid then you centrifuge this, after

centrifugation you separate the crystals, you try it and sieving it, you get this different size of crystals and packing it, so this is how the whole flow diagram can be explained.

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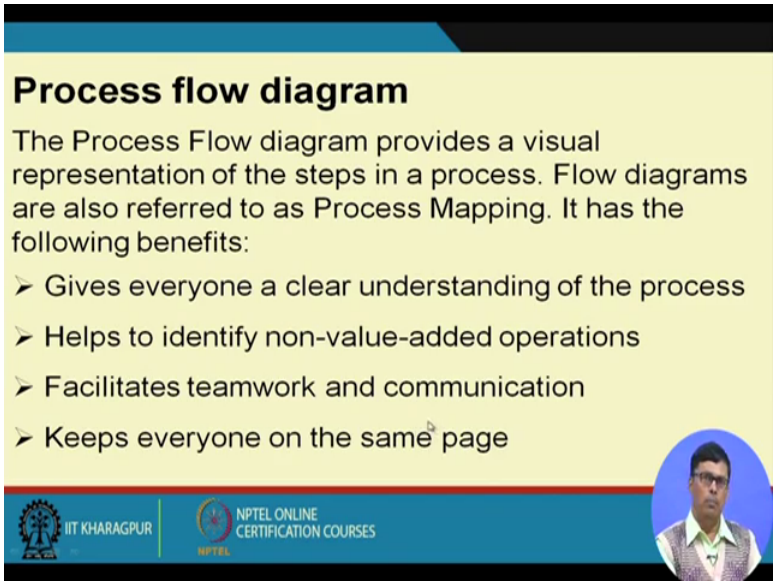

Now, let me tell you something about the process flow diagram. The process flow diagram provides a visual representation of the steps in a process. So you can find a process flow diagram, you can you can visualise what is that process because in a block flow diagram you cannot visualise the process you cannot imagine that how the process looks, but every process has some symbol so you know that that symbol we should have to use in the process flow diagram. The process flow diagram provides a visual representation of the of the steps in a process and flow diagram are also referred to as process mapping, it has the following benefits; gives everyone a clear understanding of the process, helps to identify non-value added operations and facilitates the teamwork and communication and keep everyone on the same page.

So that is what all information we want to keep in the same page that is the very important approach of flow diagram. By by seeing that you can easily find out that what is going on in the in the whole plant you know that is the that is very important as for any kind of industry is concerned.

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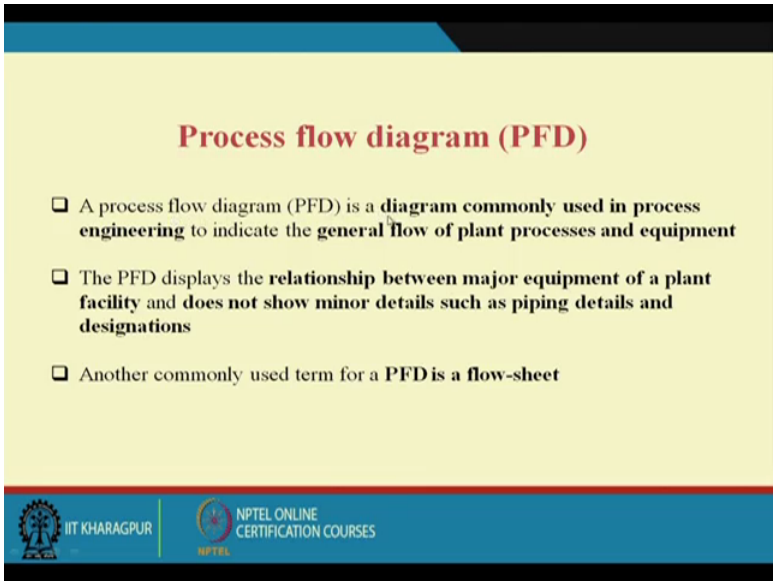

Now, the process flow diagram is the diagram commonly used in process engineering to indicate the general flow of the plant process and equipment, process flow diagram displays the relationship of measure equipments of a plant facility and does not shows minor details such as piping details and designation. It does not give the detail information how the flow different flow is taking place, just we have one flow line that indicate how product how the material flow from one unit to the other unit that is that is exactly what we have. Another common use term of process flow diagram is the flow sheet.

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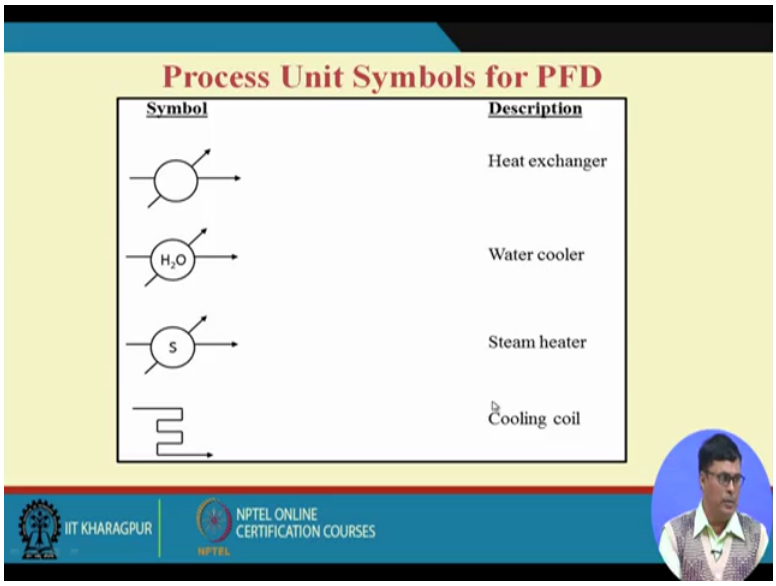

Now, as I told you that the different processes have different units so it has the different symbols actually because we should have to use that then and only then we can easily find

out what is that. As for example, the symbol we consider as the heat exchanger, this symbol is considered as the water cooler, this symbol is considered as steam heater, this type of symbol is considered as the cooling coil.

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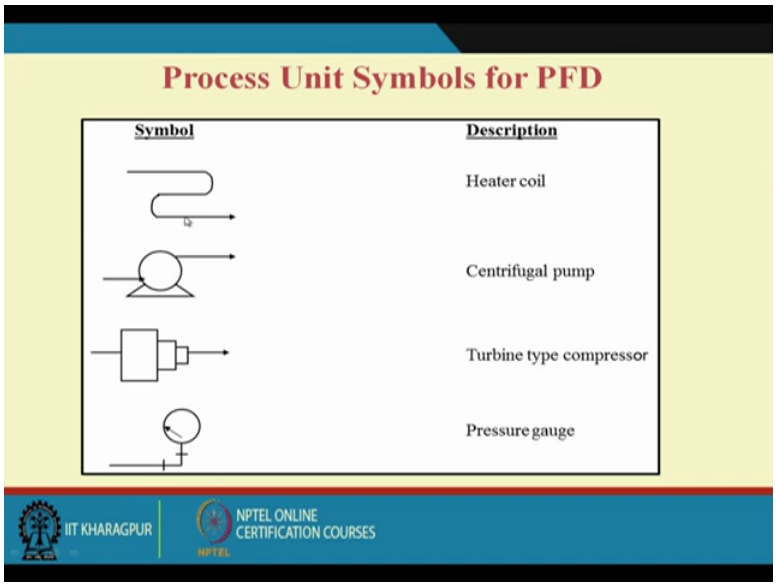

This is considered as the heater coil, this is the centrifugal pump, this is considered as the turbine type compressor, this is considered as a pressure gauge.

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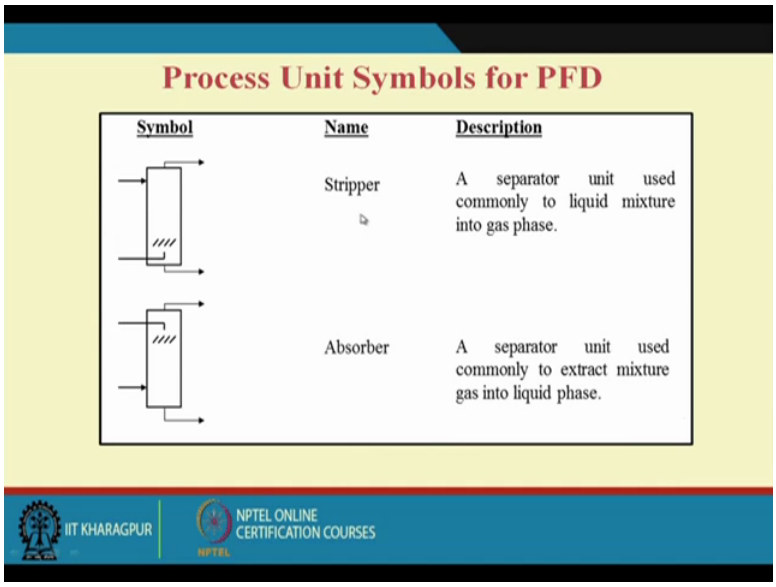

Then this is considered as a stripper is you know there is a separate unit that is commonly used to liquid mixture into the gas phase so you know the stripper that we have. Then we have absorber that can be explained like this come I absorber here then it looks like this and

stripper looks like this, only the difference is that in case of absorber we put the liquid in like this and here in the stripper we put the liquid from the top that is the difference that we have.

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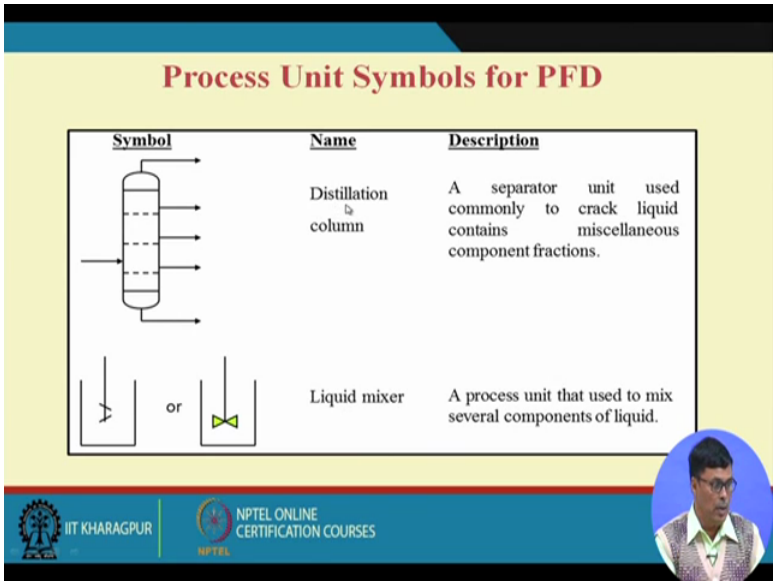

Then this is the distillation column largely used in the alcohol making industry, ethanol fermentation process we use the distillation, so this is the fractional distillation through which at different temperatures you can separate out different fractions. And liquid mixer that tank can be represented by this.

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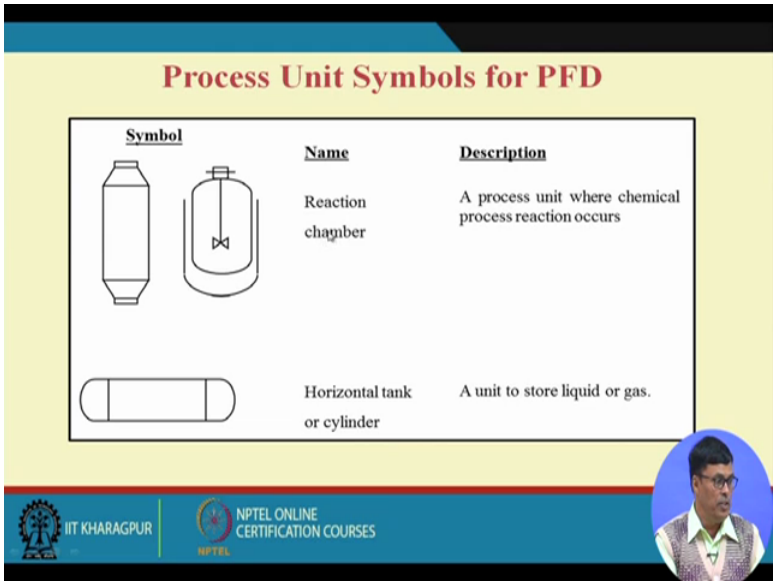

Then this is reaction chambers, reaction chambers can be represented like this, horizontal tank and cylinder can be represented like this.

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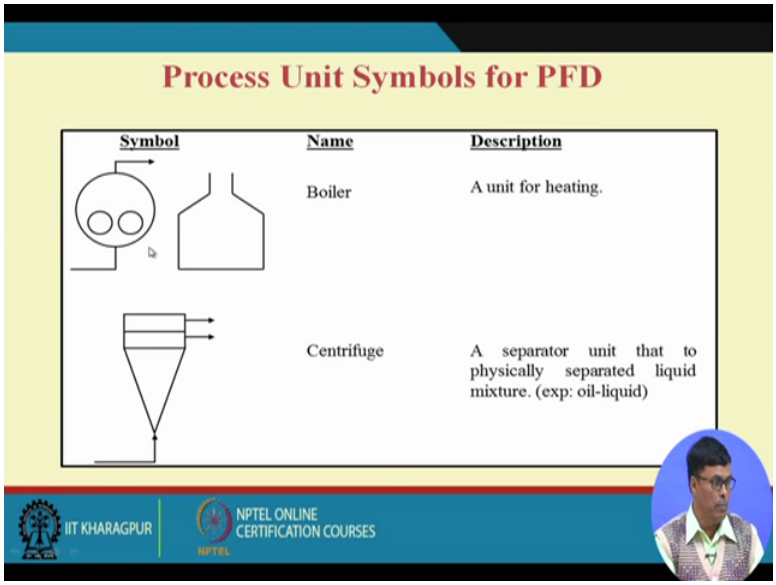

Boilers can be represented by this, centrifuge can be represented like this.

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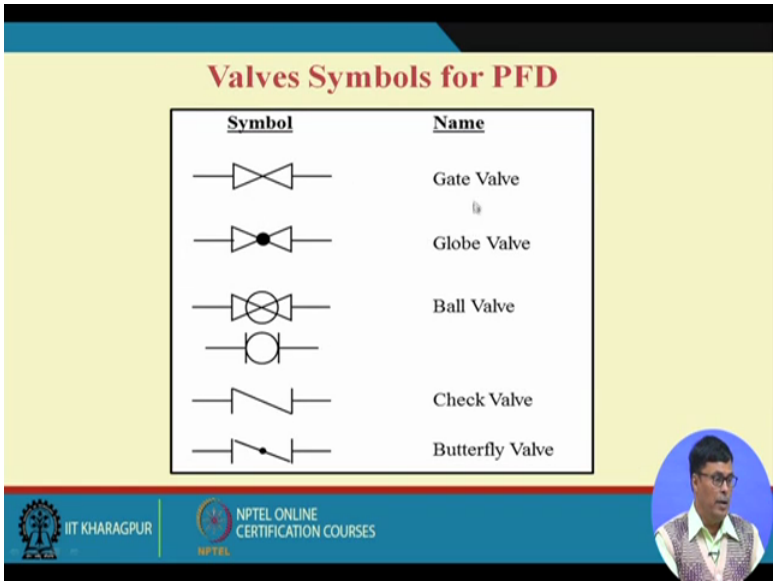

And different valves which is very much required for the operation of the industry, Gate valve, Globe valve, Ball valve, check valve, butterfly valve, but I want to point out here I shall show you the what is the exactly how it looks the ball valve. Ball valve is largely used in the biochemical industry to draw the samples because what is the specialty of the ball valve as compared to Globe valve and gate valve? Gate valve you can it slowly slowly (()) (10:44) you can see in the wash basin the valve that we use is a Globe valve and what is it, we have to slowly slowly open and slowly slowly close. In the industry we cannot do that, in

the fermenter if you open like this and draw the sample and then close it, by the time lot of lot of media or lot of sample can they can they can spread here and there.

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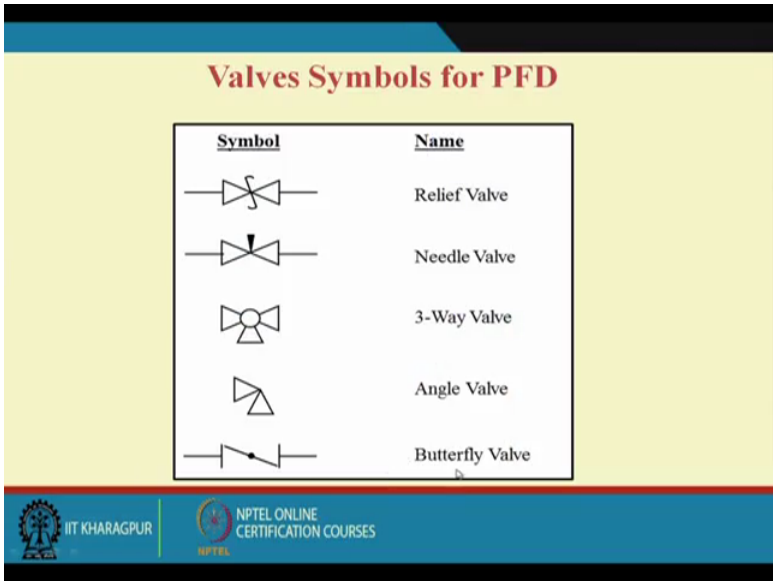

So what do you have to do? Instantaneously you have to open, instantaneously you have to close this valve and for that we find that Ball valve is very good. Ball valve, I will just show you how it operates then Relief valve, Needle valve, 3-way valve and this is the 3-way valve you can see, it can come here, it can go this way and this way, then Angle valve is there, Butterfly valve also lot of use in the industry.

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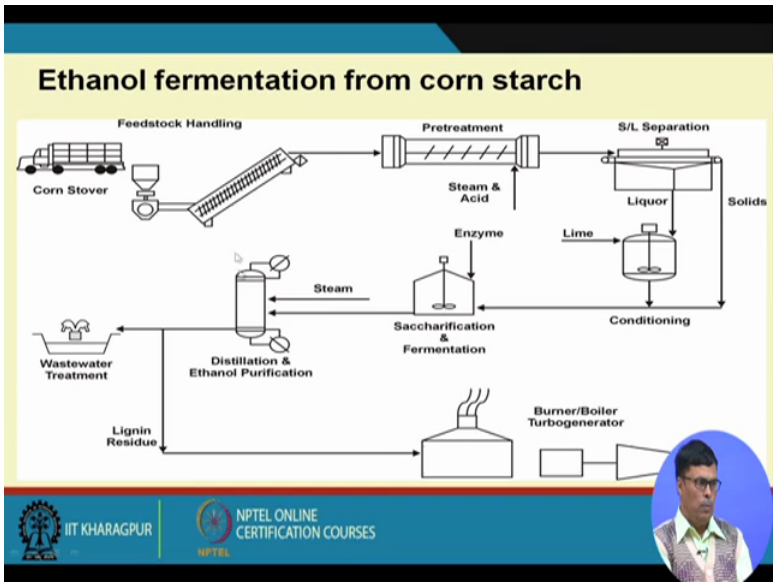

Now let me give the example of one process flow diagram so that your idea will be little bit clear. This is regarding the ethanol fermentation process from cornstarch, so corn corn stover that usually come by track and is unloaded here and after unloading you you take you do the grinding and then this is the conveyor belt, you can see how conveyor belt can be it can be, this is not a block flow diagram this is a process flow diagram. You can see that this is the conveyor belt, and then it passes through the pre-treatment unit that can be here we pass some steam and acid so that some kind of hydrolysis will take place, then solid-liquid separation unit that we have here and take the liquid out with lime, we adjust the page.

Then we take this in the (())(12:30) process for fermentation, we put the enzymes or your microorganisms here to have the ethanol fermentation then we heat it, we pass it we heat it and pass through the distillation column and we finally here the wastewater comes out and this we see that the (())(12:50) process we have surface aerator, you can see that how the surface aerator they are depicted and then alcohol from the top you can separate out the ethanol, ethanol you separate out and and some solid materials you can take it out here and you can use for running the boilers, for heating heating of boilers for steam. So this is the one typical example of process flow diagram how the cornstarch can be converted into ethanol.

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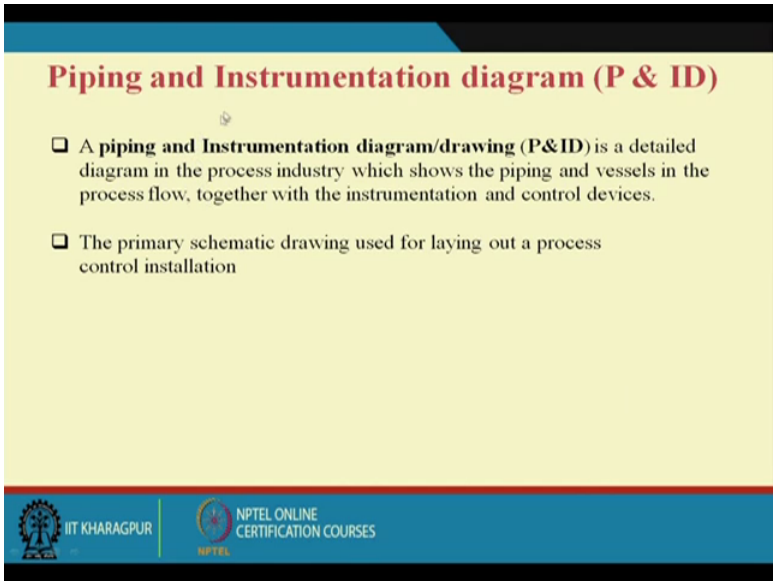

Piping and instrumentation diagram, a piping or instrumentation diagram and drawing is the detailed diagram in the process industry that shows the piping and vessels in the process flow together with the instrumentation and control device. So this this piping and instrumentation diagram that is usually located in the control room of any fermentation industry then you canfind that how the plant is or how the liquid is flowing from one end to other, what are the

different valves is open what are the different forms are functioning, so all this information will be available and this is this is also very what you call P and ID diagram, this is very essential for raving an industry.

Because here I want to point out one thing that in industry we have lots of noise because when you work with the industry, a lot of pumps because I I have given the example that I worked with citric acid industry and and and we had 200 cubic meter rejecter and 200 HP motor is used for running the power, so operating the agitator so tremendous noise is there. So we know that so you know that this is Control Panel PID usually located in the control room so this is you can you can do your analysis very nicely here. The primary schematic drawing used for laying out a process control installation, this is very important.

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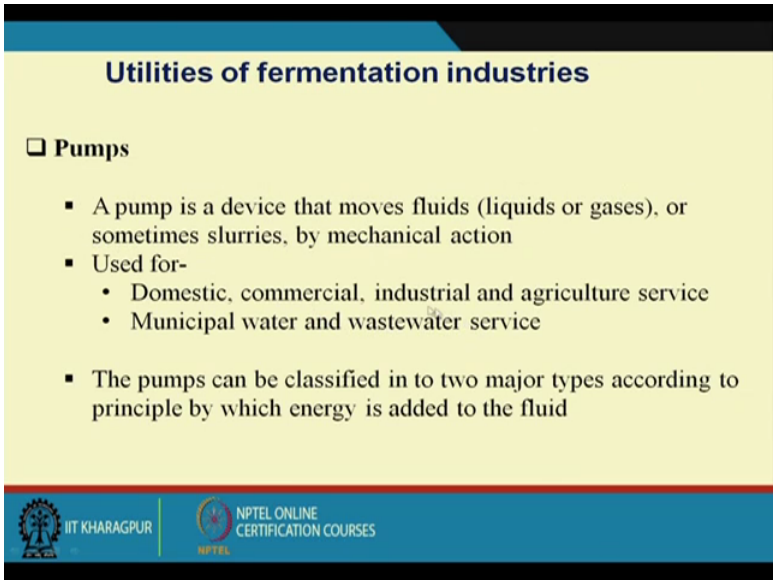

Let me give you some idea that what other utilities of the fermentation industries we have? We have different pumps, a pump is a device that moves the fluids liquid or gas, sometimes slurries by mechanical action. The we use for domestic, commercial, industrial, agricultural service, the municipal water, wastewater service. Pumps can be classified into two major types according to the principles by which the energy is added to the fluid.

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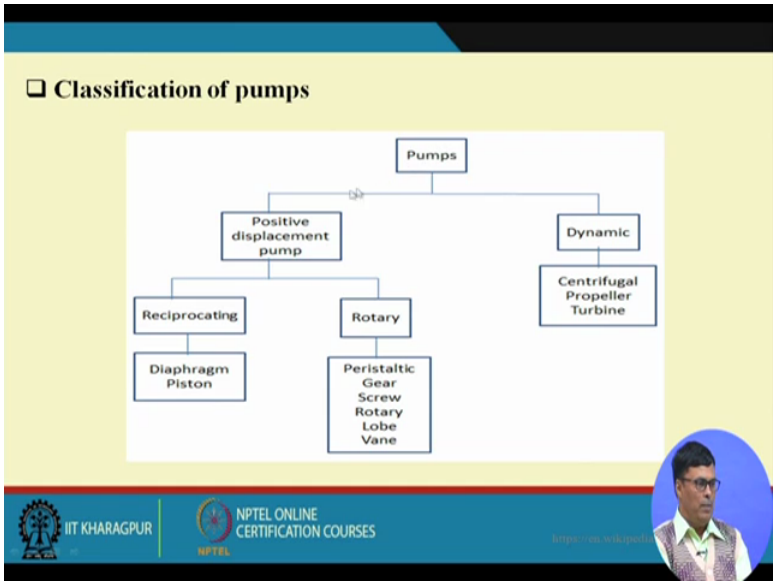

Now pumps may be of 2 types; one is positive displacement pump and dynamic pump and positive displacement pump again divided into 2; the reciprocating pump we have Diaphragm piston I will just show you, then then then rotary pump we have peristaltic pump, gear pump and screw pump, this is rotary pump, lobe pump and Vane. Now Gear pump I I typically I I want to mention here, this Gear pump is largely used for transferring the viscous liquid because particularly, in the in the citric acid, the ethanol making industry we use the molasses and the raw material for the production of ethanol and citric acid and this this molasses this is the viscous liquid, so ordinary pump cannot work, this we use the gear pump for for the transferring the liquid from the molasses storage tank to molasses measuring tank which is located in the fermenter fermentation plant, so the dynamic we have centrifugal pump, propeller and turbine.

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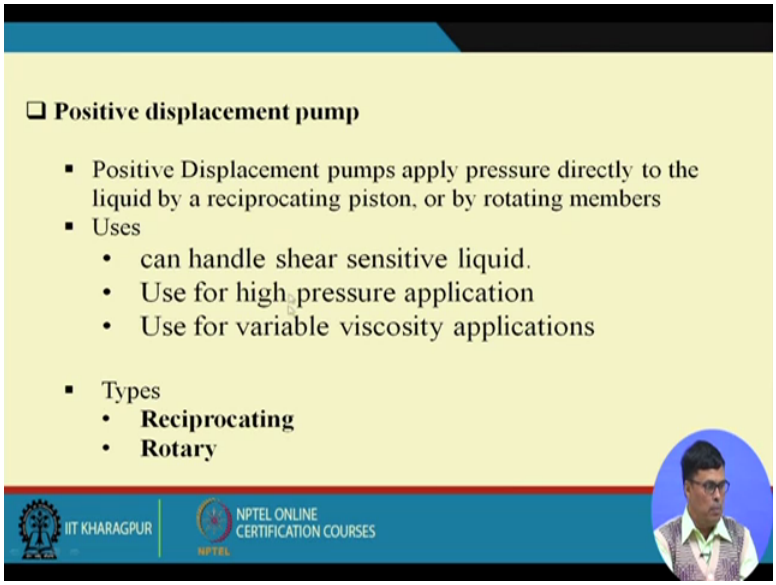

Now, positive displacement pump apply pressure directly to the liquid by reciprocating piston or by rotating the chamber. Uses, can handle the shear sensitive liquid, use high-pressure this is very important, suppose suppose we want to have the high-pressure then we should go for the positive displacement pump, use for variable viscosity applications that can be used, the types are reciprocating and rotary.

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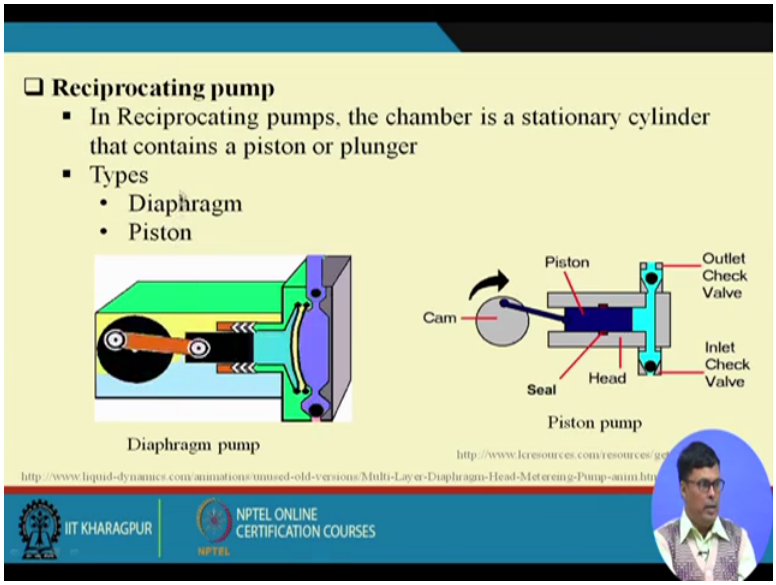

Now here is the reciprocating pump reciprocating pump the chamber is a stationary chamber that contains a pistol or plunger and type of Diaphragm and piston. You can see this is rotating, this is piston is rotating and this is the Diaphragm, this is the diaphragm and this is this is the diaphragm is moving like this than liquid is going like this, the beauty of this is that

you know that your liquid will not in contact with the directly to the pump because there is a membrane which is coming with the this membrane that this diaphragm is contact directly connected with the outside of the piston and other things, this is how it looks, the liquid flow like this.

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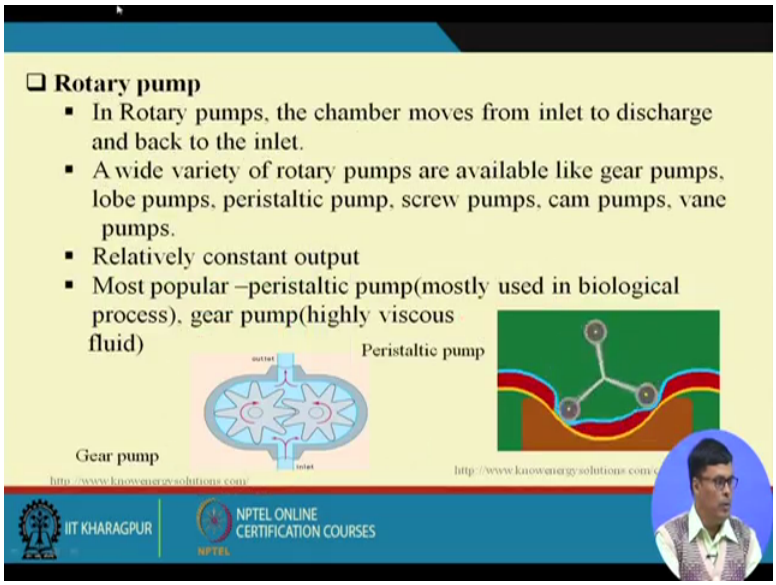

Now this rotary pump is largely used in the biochemical industry, rotary pump with the chamber, moving inlet to discharge and back to the inlet. Now here I can take the typical example of peristaltic pump largely used in the fermentation industry because this is the this is the silicon tube, silicon tube is little bit flexible tube, now you can see that when this sat is rotate like this, this ruler rotates, then it drags the liquid here to this way, can you see that it drags the liquid from one end to other, this is how and you know when it do this, this is all the all the material will remain inside the pipeline inside the tube, so no way the the (())(19:19) will come in contact with this liquid so sterility of this system 100 percent can be maintained.

Now, I was talking of the gear pump for transferring this molasses, this is the gear pump this is we can see this is the gear how it looks and with the help of this inlet and outlet when it moves, then like this then it takes the liquid out there and there is viscous liquid we can use very much.

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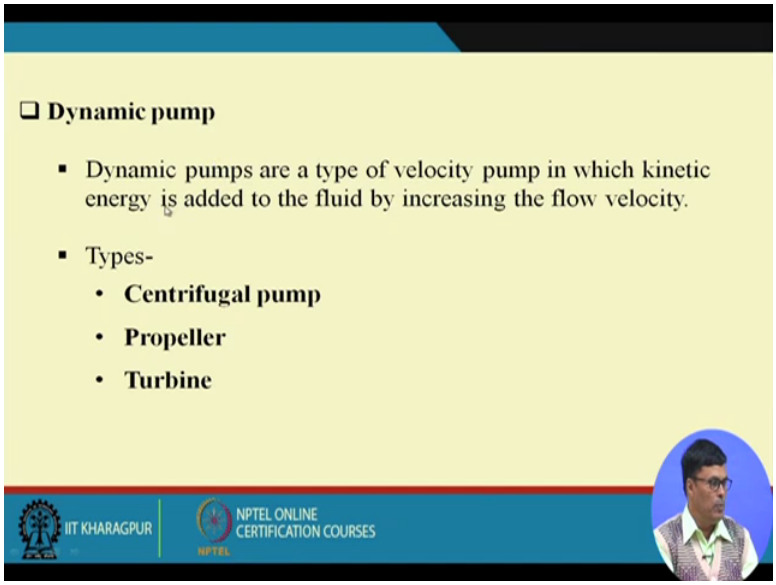

Now dynamic pump, dynamic pumps are the type of velocity pump in which the kinetic energy is added to the fluid by increasing the flow velocity, types are the centrifugal pump, propeller and turbine. Centrifugal pump is largely used in the day-to-day requirement in our household requirement also, in the multi-storey building particularly we have seen that this centrifugal pump is required to drag the water from the ground level to the top load tank to water rank, this is largely used.

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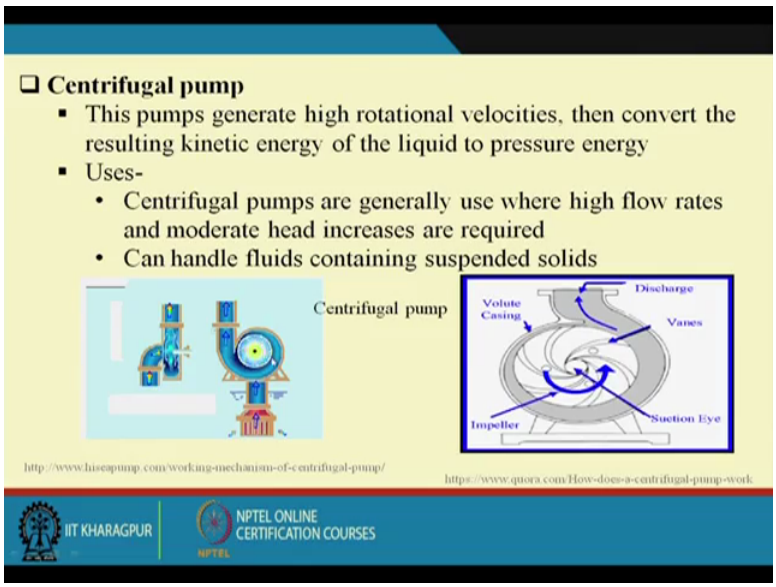

So as I show you this is the operation of the centrifugal pump you can see, how the liquid pumping this drags the liquid out and is going like this, the pump generates the rotational velocity that converts the resulting kinetic energy of the liquid to pressure energy. So uses the

centrifugal pump generally use where the high flow rates or moderate head is required moderate head increases are required, can handle the fluids containing suspended solids, this is how it looks.

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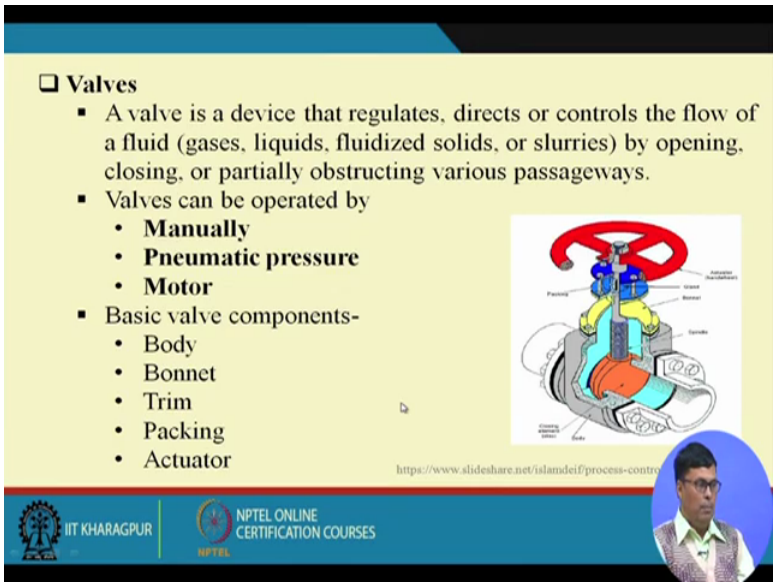

Now besides that there are different valves we use in the fermentation industry that is very important, the valve is a device that regulate or direct or control the flow of the fluid, the gas, liquid, the fluidised solids or slurries by opening or closing or partially obstructing the various passageways. The balance can be operated manually, pneumatic pneumatic pressure and the motor. Based on the valve components, body, Bonnet, trim, packing and actuator that you know that different portions that has been showing here that you know it looks like this.

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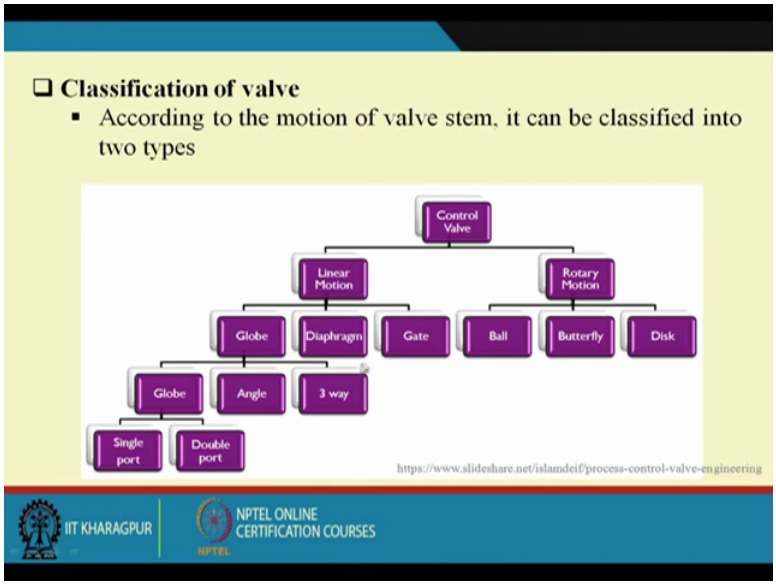

Now the how the what is the classification of pump according to the motion of the valve stem, it can be classified into 2 types control valves, you have linear motion and the rotary motion. Now in case of linear motion we have globe valve we have we have diaphragm valve, we have Gate valve. Now a globe valve we have this is again 2 types, so we have single port double port and again we have angle and 3 ways. But when you come to the rotary motion, we have ball valve, we have butterfly valve and Disk, this is largely used in the biochemical industry for drawing the sample, and Gate valve is largely used for the harvesting purpose, after the fermentation is over the whole fermentation valve we take it out through this opening the gate valve.

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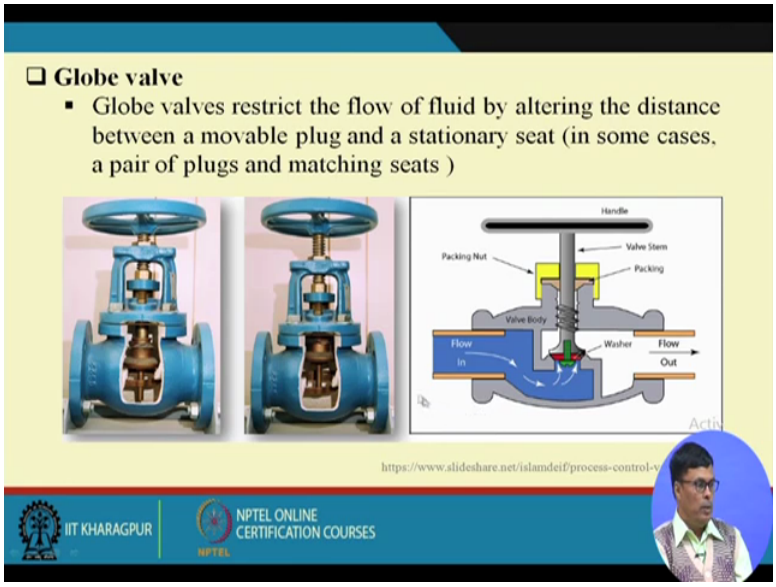

Now the globe valve how it looks, let me show you that, globe valve restrict the flow of liquid by altering the distance between a movable plug and a stationary seat. So you can see this is the liquid is coming and passing through this and is going like this. So when you open this, this side will go up, the liquid will flow like this. And when you close it, then slowly slowly it will close this so your no water will flow take place, this is how globe valve this is used in our house in particularly in the water basin we use this because for controlling the flow rate of the water.

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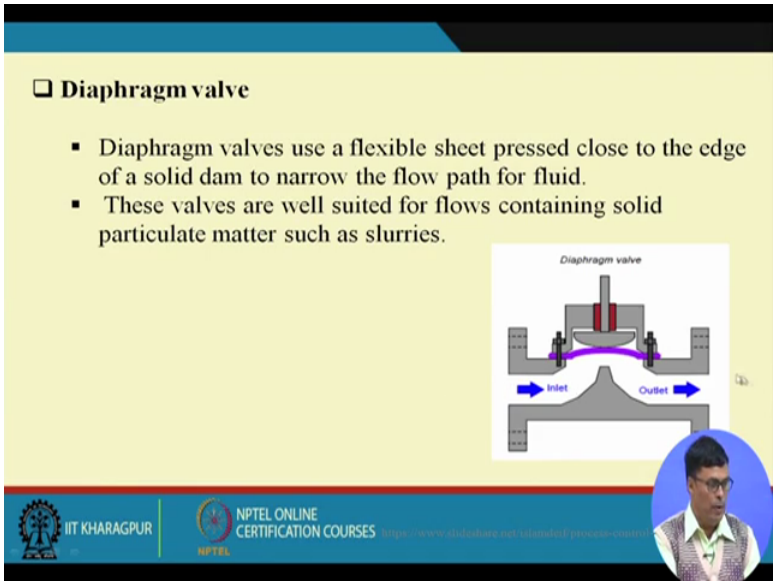

Now diaphragm valve is like this, this is a diaphragm this is so when it comes, it touches this here so the flow rate will be arrested. The diaphragm valve is a flexible, this is a flexible sheet, it is available type of material and pressed close to the edge of a solid dam to narrow the flow path of the fluid. And this is perfectly this is used to have the leakage proof because you know since it is flexible, it does not have much of leakage inside the system. This valve is well-suited for flows containing the solid particulate matter such as slurries, it is largely used for that.

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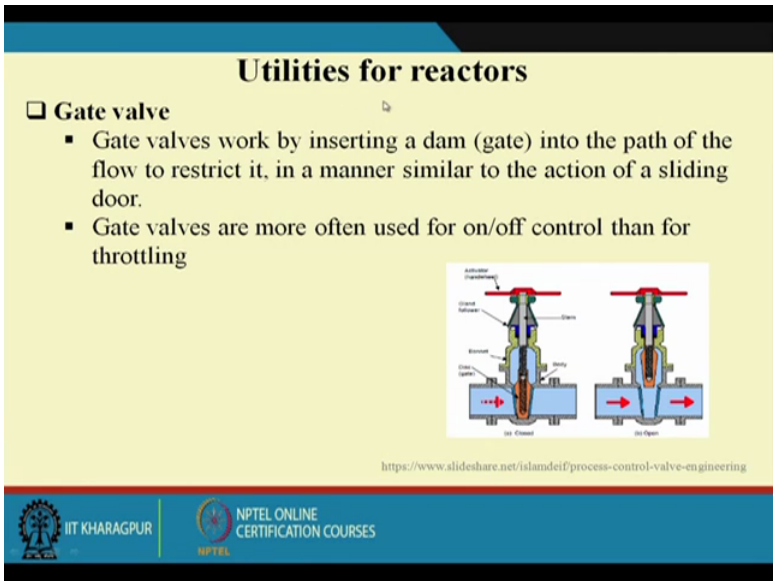

The utilities of the reactor is gate valve I told, this is used for for in the harvesting line, the gate valve works by inserting a dam gate into the path of the flow to restrict in a manner

similar to the action of the sliding door. It is just like a sliding door, what is happening in the sliding door that if you open it, everything is open and close is everything is open, so here in this valve also you can see it is coming down, it is totally closed and when it is open, it is open properly so that when the liquid is flowing, there will not be any kind of hindrance to the flow of the liquid, no friction, no hindrance will be there, all liquid will go out like this. Gate valves are more often used for on and off control than throttling. This is this cannot be used for throttling this is just on and off, it automatically goes out like there should not be any friction that takes place here.

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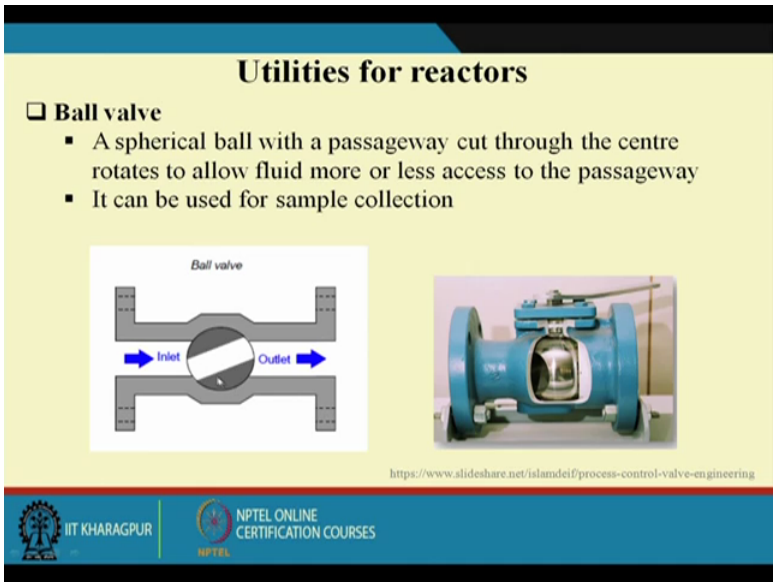

Now Ball valve I was talking of the ball valve for using for handling purpose, the spherical ball with a passageway cut through the centre rotates to allow the fluid more or less access to the passageway. It can be used for sample collection, let me explain that. You can see this is the valve, this is the this is ball you know this is circular thing so when you rotate, it will close this whole this is the handle, if you do it like this then it will close. This is the opening you can see this is the something inside this is the opening that we have and okay and this is the ball that we have, so when it comes to the pipeline the liquid will flow, when this side will go in this pipeline then the flow will be arrested. So this can be instantaneously you can close instantaneously can open, this is used for handling purpose.

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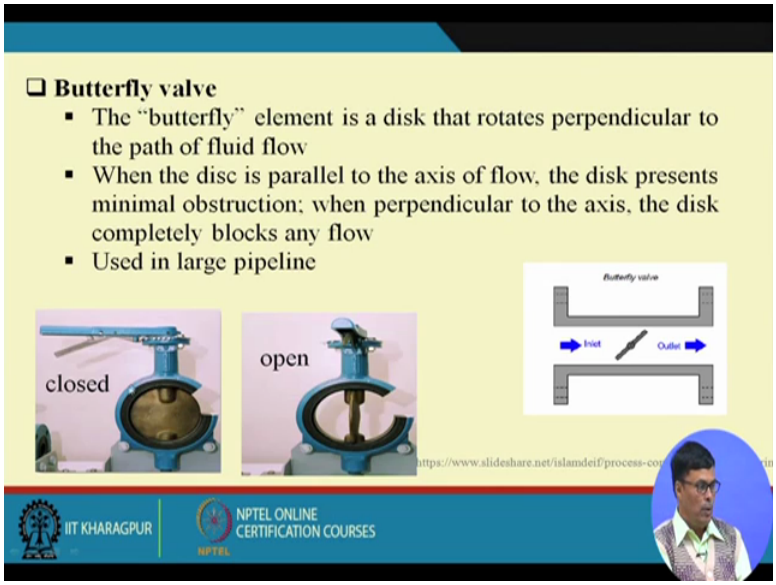

Same this is for Butterfly valve, you can see that you can instantaneously open, instantaneously close that can be used.

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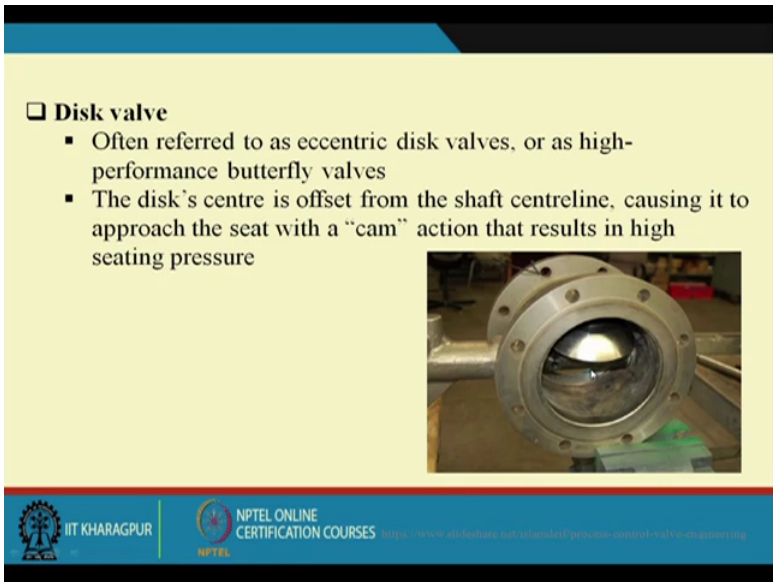

Then we have Disk valve this is also same nature.

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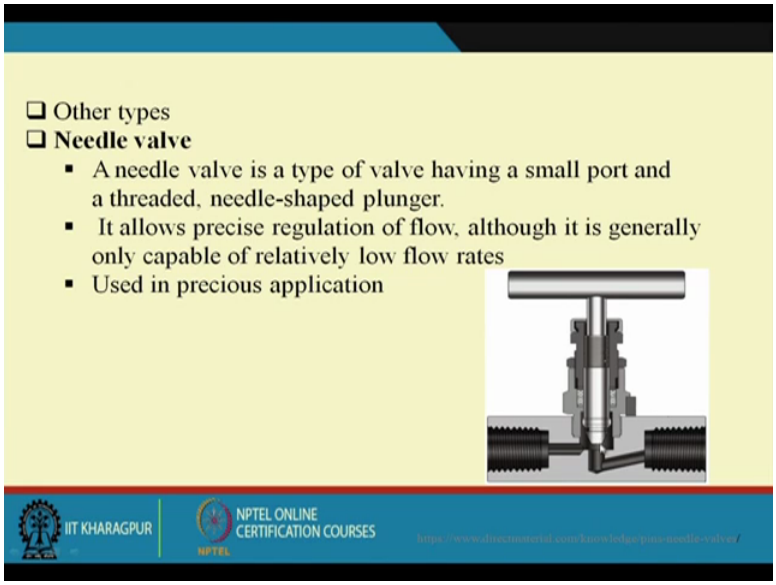

Then needle while you can also see that we put a needle here, this is for minute control use, this valve.

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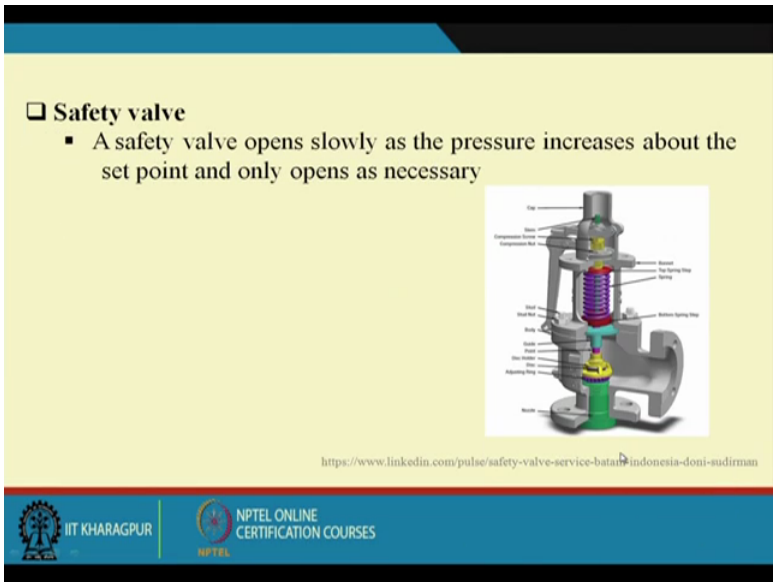

Then safety valve that you know I told you that safety valve this spring you can see there is a spring that keeps the pressure here. As the pressure increases, it has it can withstands certain pressure, if it is above this pressure than it will the spring will go up and pressure will be released. Safety valve opens slowly as the pressure increases above the set point and only opens as necessary, so this is how the safety valve looks.

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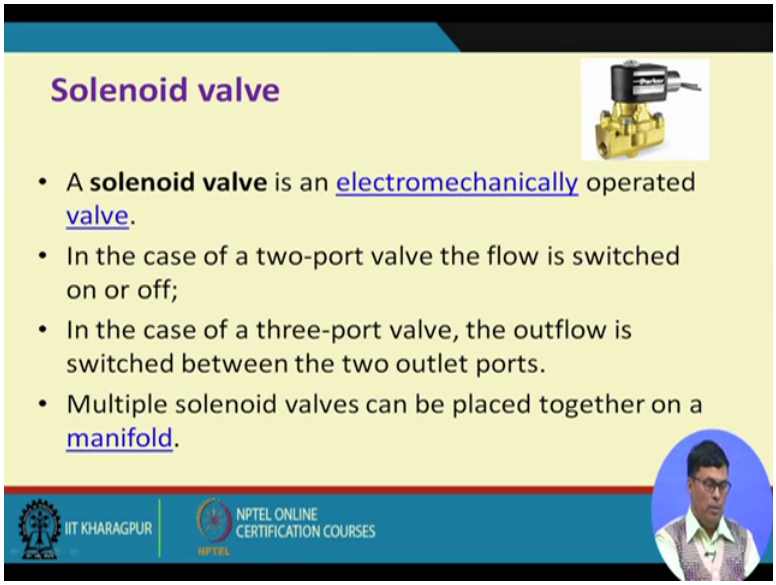

Besides that 2 other pumps, I want to point out that is largely used in the chemical and biochemical industry, this one is the solenoid valve. Solenoid valve is an electromechanically operated valve because it is electrically operated so if we want to control the things by electrically with the help of some kind of device control device, then we have to use the solenoid valve, Manual valve cannot operate electrically so solenoid valve that is why is largely used by the industry. As for example, you want to monitor the air flow rate or suppose I told you that in the industry that that as anti-foam sensor is there, as soon as the foam touch this then energises the it will connect with this your baby pump your valve is connected so that your it is open and it will draw the liquid inside the fermenter. So you know that automatically control it is largely used in case of 3 ports, it can have 2 ports, it can have 3 ports as per the, it can have many ports also, so it has a defined purpose.

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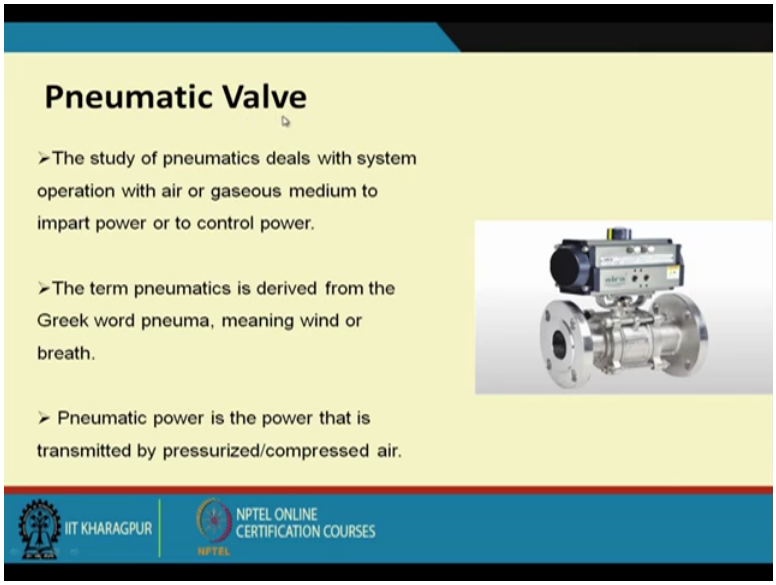

And another is the pneumatic valve, pneumatic valve is controlled with the help of pressure. The study of pneumatic deals with system operate with air and gaseous medium to impact power or control power. The term pneumatic is derived from Greek word “pneuma” meaning the wind or breath. Pneumatic power is the power that is transmitted to pressurise the compressed air, so you know that on the basis of pressure you can regulate the valve. If we decrease the pressure, increased the pressure, we can close the valve and open the valve like this with the help of pneumatic valve. So this is all about the different flow diagrams and the utilities that it will be used in the fermentation industries, in the next class we are going to discuss about the upstream processes of the fermentation industry, thank you very much.