Aspen Plus Simulation Software - a Basic Course for Beginners
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Lecture - 08
Using Model Pallete – Pressure Changers

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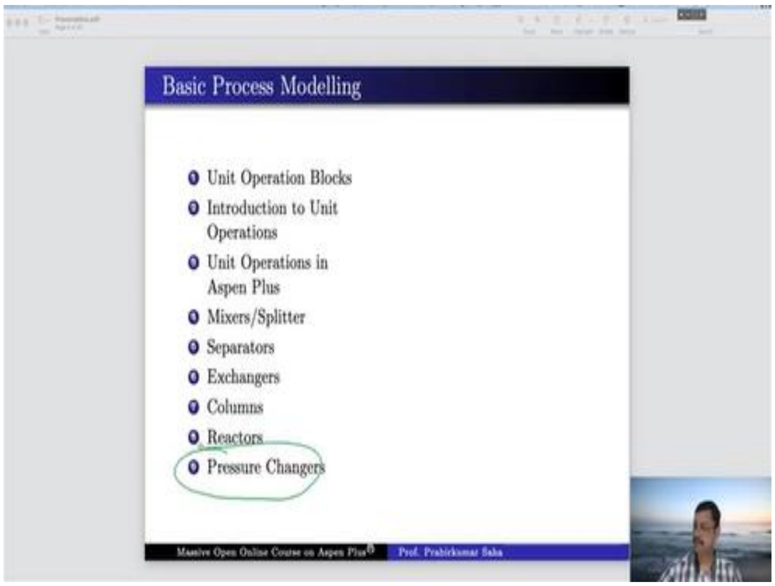

Welcome to the massive open online course on Aspen plus. Today we will cover the final portion of this basic process modelling with pressure changes.

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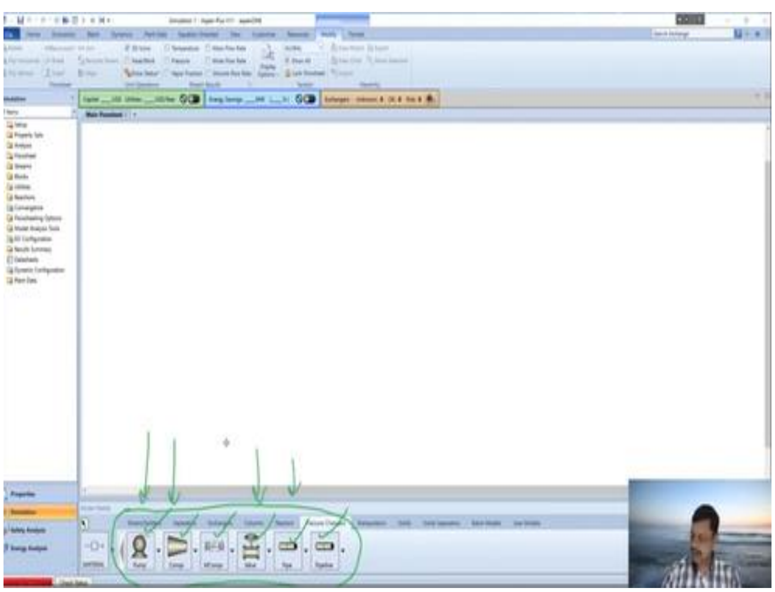

You will find the pressure changers block in Aspen simulation window over here. You have pump, compressor, multi-stage compressor, valve, pipe and pipeline. We will mostly cover this pump and compressor with some help of valve and pipe. Multi-stage compressor and pipeline they are for advanced users, so we will avoid these two in this lecture.

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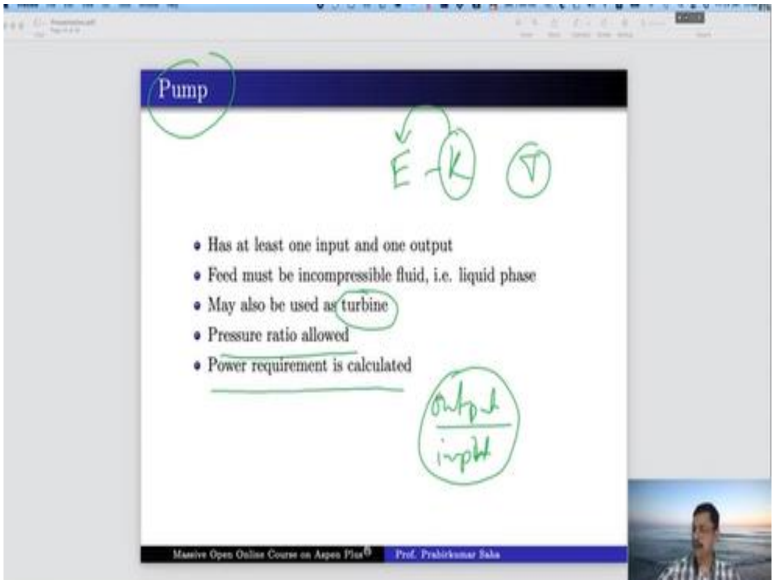

So, we begin with the pump block. A pump block has at least one input and one output, in pump the feed must be incompressible fluid that is it should be in liquid phase and pump model can be used as a pump or as a turbine. So, you know the difference between pump and turbine. In pump the electrical energy is converted into kinetic energy that drives the fluid through the pump whereas, in turbine the kinetic energy of fluid is converted into the electrical energy.

So, we can model both pump and turbine through this pump block. In this block pressure ratio is allowed as an input to this pump block. Pressure ratio means the discharge pressure in the output by inlet fluid pressure. So, this is the ratio of pressure and this can be taken as an input to the pump block and here power requirement can be calculated through this pump model.

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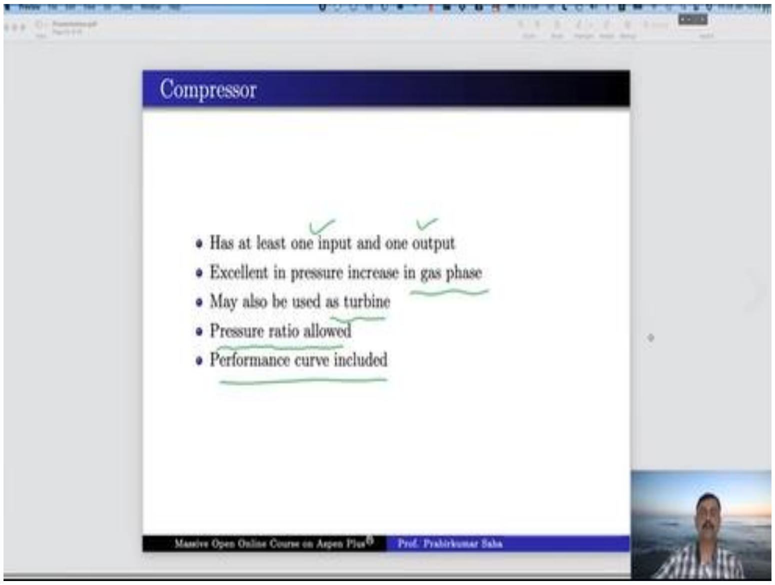

On the other hand, compressor also has at least one input and one output, and it is an excellent model in pressure increase for gas phase. It also may be used as a turbine. We will take an example to show how and then here also the pressure ratio can be used as an input to the block. And performance curve can be used for simulating this compressor block.

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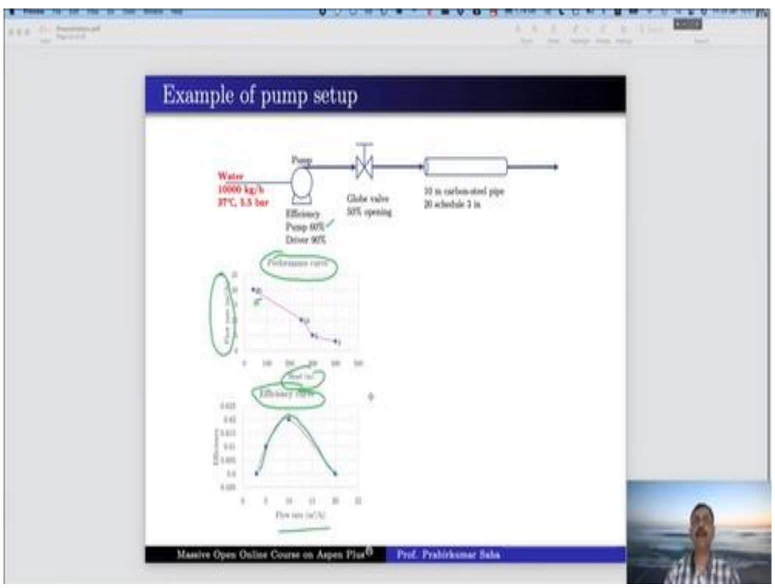

We will take a small example of this pump setup. Here we have a pump whose efficiency is given 60%, its driver efficiency is given as 90%, water at a flow rate of 10,000 kg/hour is passed through this pump whose temperature and pressure have been given. In the downstream of the pump there is a globe valve with 50% opening and at the downstream of global we have a 10-meter-long carbon steel pipe whose, specification is also given.

So, we shall simulate this pump setup whereby, we can understand how a pump works? How a valve model works and how a pipe model works? First, we begin with the pump this information is given, we have the performance curve of this pump. Here we find a graph where x axis is the head and y axis, we have flow rate of the pump output. Now obviously when the head goes higher and higher flow rate decreases.

That means if the pump has to lift the water to a higher elevation, then obviously the flow rate of the pump output will be reduced, and the figures are given over here. And the second curve is efficiency curve. Here we have taken an efficiency of 60% but suppose if we want to simulate a block where efficiency of the pump is not constant then we can use this efficiency curve where the efficiency of the pump varies and it varies with the flow rate.

So, we have been given different flow rates and their corresponding efficiencies. So, we can also use this information for the pump block. In order to simulate this, let us go to the Aspen plus simulation window.

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First, we must select the component, here we have only one component that is water and we have to use the correct property method. We shall use this IAPWS 95 formulation, which is ideal for thermodynamic properties of water. This is the current standard of international association for the properties of water and steam. So, we shall use this method, run it and we shall go to the simulation go to pressure changers bring in this pump.

First let us simulate pump and see the result we shall add the valve and pipe later. Let us connect the material streams. This is the first material stream, and this is the second material stream, rename them. This is our feed, and this is our pump output press next it is asking for the inputs for feed material. Now the temperature and pressures are given it is 37 degree centigrade and 5.5 bar so 37, 5.5 and water flow rate is 10000 kg/hour.

Press next here; we have the option to use this model as a pump or as a turbine. For this model let us use as a pump. And the pump outlet specification can be given here; we can specify either the discharge pressure or the pressure increase. What is the difference between the outlet pressure and the inlet pressure? We can give the pressure ratio or we can give the power required that is the horsepower of the pump that also we can give as an input or else we can use the performance curve to determine the discharge condition.

For this problem, let us use the performance curve because we have the data already. Now efficiencies we know the efficiencies are 60% and 90% so we write 0.6 and 0.9 over here. Press next, now it will ask for the curve setup as we have chosen the performance curve. So, we must give tabular data. Now we have this information head versus flow rate head in meter and flow rate in m3/hr.

So, head and flow variable volumetric flow rate and we have only single curve at the operating speed. Next, we must give the data for this curve the unit of head is in meter and flow rate is in m3/hr. So, we must add in these values. So, we have heads at 40, 250, 300 and 400. So, we have 40, 250, 300 and 400. The corresponding data are 20, 10, 5 and 3 so 20, 10, 5 and 3.

So, we have given it in tabular form. Now, it is ready to run. Let us run the simulation of the pump. So, results are available go to the results all the information are available. We have the net positive suction head in meters, you can have 55.8184 meters net positive suction head is available. We have the network required that is 12.5684 kilowatt. So, that much of power should be required for running the pump and in m3/hr the volumetric flow rate already we have specified and the same will be observed over here and just see what the outlet pressure is.

Outlet pressure is 29.7749. We have given the input pressure as 5.5 bar but the outlet it is 29.7749 so there is an increase of 24.2749 bar. So, if you add 5.5 with it you will get this figure. So, this information is available, and these are all calculated values by the pump block. Now in the pump let us use variable efficiency. In this case we have fixed efficiency at 60%, let us say we do not have fixed efficiency we have variable efficiency and we do have the information for that. So, this is the efficiency curve flow rate against efficiency.

So, we shall use this information to run the simulation. For that, we just deleted this pump and driver efficiencies and we have gone to the performance curve and here, we have the efficiency information flow rate in terms of cubic meter/hour. So, we have efficiencies at these points 0.6, 0.61, 0.62 and 0.6 again. So, we give this information over here 0.6, 0.61, 0.62 and 0.6 again.

So, for lower flow rate the efficiency is low for higher flow rate again efficiency comes down. There is an optimum point of flow rate at 10-m3/hr we have the highest efficiency. Anyway, so the flow rates are 3, 5,10 and 20. So, we give these values over 3, 5, 10 and 20. Now we can run with these variable efficiencies and we have these results available again. Now, here you can see the net positive suction head available in meter it is 55.8184 meter and there is no change in this NPSH.

So, whatever you have got the value of net positive suction head before you are getting the same value over here. Now power required in this case is 10.9467. Network or power required has been reduced and obviously, if you remember the previous figure, it was higher. In this case power required has been reduced why? Because the pump efficiency has been increased it has been increased to 0.619999 or it can you can say 0.62.

So, as the pump efficiency has been increased so, the network or the power required has been decreased, if you want to see this figure in terms of horsepower that also you can see it is 14.6798 horsepower. Now, let us attach a globe valve at the downstream of the pump and re-simulate the system. So just add in this valve over here, attach the material streams reconnect this P out with the inlet to the valve.

Rename the valve output as V out simulate next here you have three options for calculation type. Adiabatic flash for specified outlet pressure, calculate valve coefficient for specified outlet pressure and finally calculate outlet pressure for specified valve this is ready. Let us use the third option. So, the moment you choose the third option it is asking for the valve operating specification. So, you must specify either percent opening or the flow coefficient.

Now one of this information you must provide. We have this information provided to us which is percentage opening it is 50% opening. So, we just give 50% opening and flow coefficient will be calculated by this valve model. Go to next asking for valve parameters. Now here we have three types of valve ball, butterfly, and globe ours is a globe valve it is looking for manufacturer at this moment Aspen gives only one manufacturer that is nails and James Berry.

So, you select it has several series and styles. Now, we can select suppose we select this v 810 equal percentage flow valve and we must give the size also let us use three in size. The moment we choose them the valve parameters tables are available to us. It has been given by the manufacturer you do not have to provide any more data. So, now it is ready to run, run the simulation and see the results.

See the results over here now here choking status of the valve it is said valve is not choked, we are safe the Aspen plus is assuring us that valve is not choked. And what is the outlet pressure? Outlet pressure is 29.4011. So, there is a reduction in the pressure. So, there is a pressure drop obviously if there is a valve some pressure drop is inevitable and chopped outlet pressure is 2.3905 and our outlet pressure is much above that.

The valve flow coefficient it has calculated as 19. Next, we shall add a pipe to this line. So, just bring in the pipe over here so attach this V out with this material out from here to here, press next. Here we have the option for fluid flow and solids conveying obviously it is a fluid flow for us no solid so, pipe length must be given. We already have the information it is 10-meter carbon steel pipe.

So, it is 10 meter and inner diameter it is 3 inches so, you can give the information in inch or you can use the information of pipe schedule. We do have these information 20 schedules 3 inch. So, we can use pipe schedule of material carbon steel schedule 20 and nominal diameter 3 inch. The moment you give this information the inner diameter is 3.164, it is a standard diameter of this pipe schedule it has been taken automatically.

You can give the information about the pipe rise or pipe angle. Suppose the pipe is at an elevation so, you must give this information because if the pipe is in elevated state, then there will be some pressure drop extra that can be calculated. And the roughness option this has been already given by the pipe schedule and the manufacturer of the pipe. So, no more information must be given over here it is ready to run so please run, and the results are available, and you can find that some warning message is observed over here.

There is a sign of this. So, there is some warning message. So, let us see what the warning message is. Go there and check the status. It says thermal option is required for single component model unless n phase is equal to 1 is specified. It is a single component model because, we have only 1 component that is water but we have not specified whether it is n phase is equal to 1 or 2. Let us check what we have given.

So, go to the setup of pipe go to flash option, here we have done a mistake. Here it has been said valid phases vapour and liquid. Now, we must give either vapour or liquid. So, let us say it is liquid only so only 1 phase there are no 2 phases. Re-run with the updated information so, all those problems have done, and you have got the result. So, this is the total pressure drop across the pipe is a frictional pressure drop and heat duty in terms of what we find only 1.017 watt of heat duty is required for this pipe flow.

So, in this simulation example we have learned how to use pump valve and pipe. Now we shall take an example where we will learn the simulation of a compressor. Now this compressor again this model compressor model can be used both as a compressor and as a turbine. Now, we shall take an example where the compressor model can be used as a turbine.

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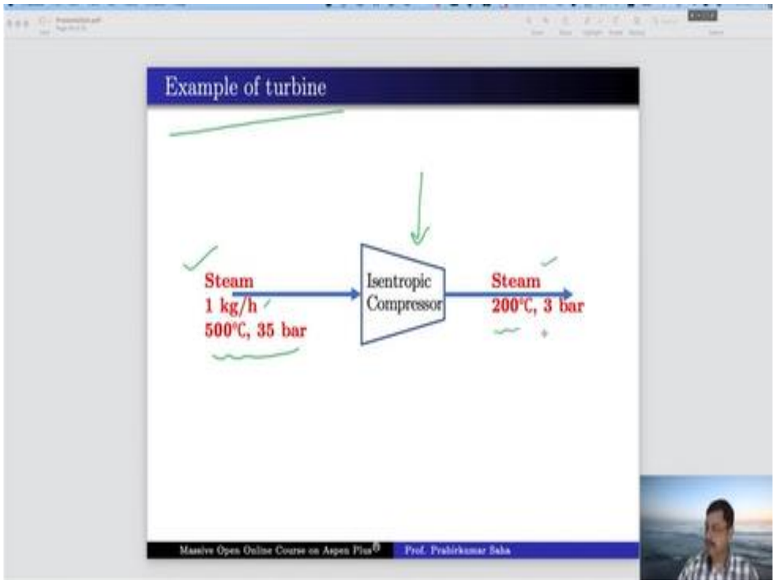

Now, we will take this example of turbine where the isentropic compressor model will be used as a turbine. The inlet to the turbine is steam flow rate 1 kg/hour and temperature 500-degree centigrade pressure is 35 bar. The outlet of the turbine is against steam with 200 degree centigrade and 3 bar pressure. So, the entire thermal energy will be converted into electrical energy and power will be generated through this turbine. So, we shall model this system.

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For that let us go back to our simulation. Now, the water property has already been set through the previous example. We do not have to redo it. So, bring in this compressor over here we have one material in and one material out. Now this is steam in this is steam out, press next. It is asking for the input specification. So input is 500-degree centigrade and 35 bar pressure and flow rate is 1 kg/hour.

Press next, so it will ask for the compressor inputs. So, again here you find model and type you can use it either as a compressor or a turbine. So, let us use as a turbine type isentropic. Let us take a discharge pressure of 3 bar. In the previous example we had used the performance curves to determine discharge condition. In this example let us not go to that complication we will use discharge pressure which is 3 bar.

Suppose we are running it as 100% efficiency and then see the result. The outlet temperature is 166.292 degree centigrade. But we need a temperature of 200-degree centigrade on the outlet. So, this does not serve our purpose. Although the outlet pressure is 3 bar, but the temperature is much lower so, we need a higher temperature. So, maybe a fully efficient isentropic turbine may not be useful for our case.

Now, the question is what should be the efficiency of this isentropic turbine which will lead us to an outlet temperature of 200 degree centigrade?

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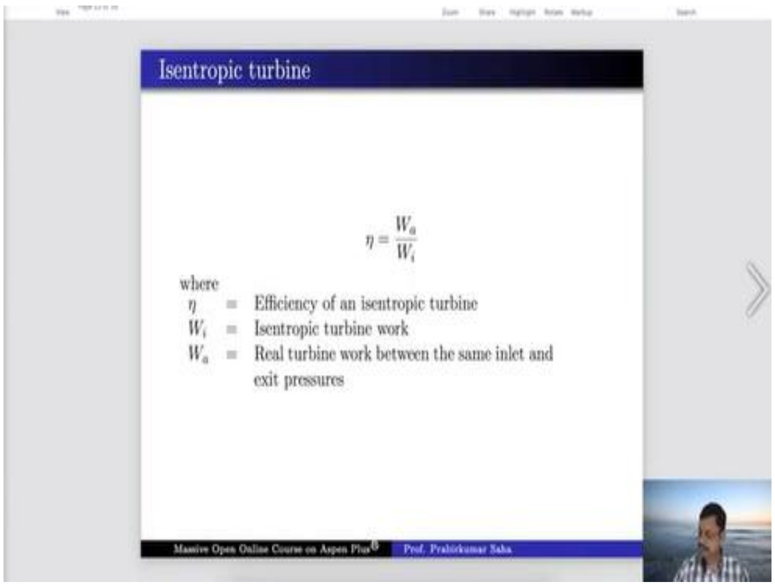

Now, for that we have to use an equation that is the efficiency of an Isentropic turbine is the ratio between real turbine work between the same inlet and exit pressures and the isentropic turbine work. So, we have to calculate them from the mass enthalpy and from there we have to find the efficiency.

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Let us go to stream results and see the mass enthalpy. So, here we have mass enthalpy. Let us use mega joule/kg this unit is good. So, we have the mass enthalpy/kg for steam in and steam out they are minus 12.5193 and minus 13.175 isentropic.

$$work\ done = (-12.5193) - (-13.175) = 0.6557$$

work done is minus 12.5193 minus, minus 13.175. So, this is equal to point 0.6557. So, in the efficiency calculation this is the denominator, it is 0.6557.

So, we must find out real turbine work between the same inlet and exit pressures. Now we shall use the input for the time being let us change it to 200 and 3 bars. As if the steam at 200 degrees centigrade and 3 bar pressure is going inside the isentropic turbine the steam at 200 degrees centigrade and 3 bar pressure is coming out. That is real turbine work and we will get some warning messages over here.

At this moment, please disregard this warning message because we need only the information nothing else. So, we need this information which is steam in and steam out both are at 200 degree centigrade and we take this information in mega joule/kg it is 13.105.

$$work\ done = (-12.5193) - (-13.105) = 0.5857$$

Work done in this case will be minus 12.5193 minus, minus 13.105. So, this is the figure that we have got from our earlier simulation this is the new figure, so this is equal to 0.5857.

So, our efficiency is the numerator by the denominator that we have calculated just few minutes back it is 0.6557, and the result is 0.8932.

$$efficiciency = \frac{0.5857}{0.6557} = 0.8932$$

So, we need an 89.32% efficient isentropic turbine. So, let us give this information 0.8932 in our simulation and see what happens. So, go back 500, 35 and the setup let us use 0.8932 and rerun the simulation. Yes, now the results are available. You can check yes, so the outlet pressure is 3 bar and outlet temperature are 200 degree centigrade.

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So, that is how by tweaking the efficiency of that isentropic turbine you can get the desired output condition for your turbine output. So, we end our lecture at this point today. Thank you.