MARINE ENGINEERING

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Lecture17

Characteristic curves of pumps

Now, a centrifugal pump and a positive distillation pump difference actually flow rate and head, head or pressure, head in meter, let us say flow rate may be meter cube per second. A centrifugal pump will have curve like this, head and flow rate, H versus Q. This is called a head curve. And another curve will be there like this called efficiency curve. Another curve will be there called system curve. efficiency curve, it will have one peak point, it is called best efficiency point, best NCY point.

certain zone you have to run your pump. This zone called operating zone. you have one centrifugal pump. Already I have given you example. This centrifugal pump, it will have characteristic curves.

It is called characteristic curves. All pump companies will give you the curve. I'm showing only one or two lines but pump company when they will give the chart actually they'll give many lines so we'll discuss later that many lines what is that first you understand that head and flow rate relationship like if you are getting more flow rate head will be lower okay you see this curve okay head curve you see if you are giving more getting more flow rate head will be lower and system cost means actually energy consumption consumption curve an efficiency curve means how much efficiency will be there from your pumping system and normally your target will be to run pump at your best efficiency point but is practically not feasible so that is why they will have one operating zone or operating range so within that 10 20 percent of plus-minus of best efficiency point will be okay to get best from your pump if you are running off design condition let us say you are not following any rule like best efficiency point anything then maybe your pump will be cavitating or your energy consumption will be very high or pump will may not work okay so any pump will have one best efficiency point centrifugal pump, especially centrifugal radial or mixed flow pump and you have to try to run your system at best efficiency point

But exactly not possible, so nearby 10-20% plus minus will be okay. And the system curve, like if you see, it is going up and up and up. if you are trying to get more flow rate, your energy consumption also will be higher. And head continuously drawing. You can see this centrifugal pump has limitations of the head.

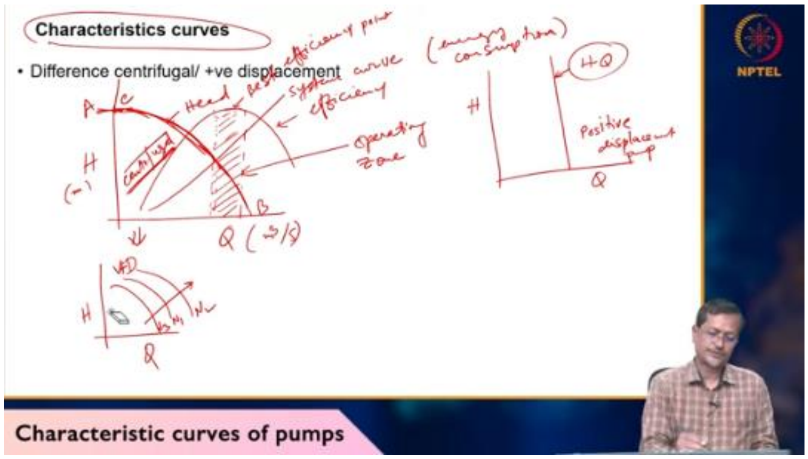
one centrifugal pump will have certain maximum head criteria. it will not give infinity amount of head. One centrifugal pump will have let us say 5 bar head, bar pressure or 10 meter head. if I want to get 100 meter head, so what I will do, I will put series, 1 pump, 2 pump, so 10 pump I will put, so 10 into 10, so 100 meter head I can achieve, but flow rate will not change. Same flow rate I can achieve, a very high head using many pumps in series.

Now, if I use, this is centrifugal pump, this is the centrifugal pump. And if I draw for a positive displacement pump, positive displacement human heart I told, a cycle syringe pump or doctor pushing your medicine injection. So, that positive displacement pump or reciprocating pump, their curve will be like this, HQ, it will be almost vertical. Maybe a little bit slanted towards H, but it will be almost vertical. It will not be touching, HQ curve will not be touching H.

H never okay that implies that you can generate any amount of pressure from your positive displacement pump okay what is positive if I have one reciprocating pump and want to deliver any amount of pressure I can develop in using one single pump but if I have one centrifugal pump I cannot do that because it is having maximum pressure limitation you can see H limit H is limited okay I can put a B so point This curve AB is touching somewhere on H, ABC. At point C, it is touching, you can see. But the HU curve for positive displacement, it is not touch H. That means they can get any amount of pressure and for same flow rate.

So, this is the difference. So, a positive displacement pump can develop any amount of pressure, but a centrifugal pump, it is having limited pressure or head. Now, if I have, let us say, previously I told that I will have, in my laboratory, I have one VFD, Variable Frequency Drive. Variable Frequency Drive, using that one, I change the speed of my pumping system. in that case, what happens?

If I have QH, VFD I am using, so my HQ curve will be like this. n2 n1 speed pump speed m3 okay so pump is speed increasing my curve also will be changing okay but there will be certain limitation also but normally curve will be like this i have centrifugal pump to run for 1500 company told but i want to run this one 1000 i want to get lower head lower flow rate so using that characteristic curve actually i can decide where to run the pump my efficiency curve will also change my system curve will also change, but the pump characteristic curve will tell where to run the pump so that I will get optimal performance from the pump. if I use VFD, then I will have this type of curve. Now, I am told that characteristic curves are different.



Now, let us see how to draw the curve, how to understand the curve. From that experiment, I will explain. I have shown this picture before from a laboratory and below one also I have shown the schematic diagram. Now, initially assume that all valves are open. there is no restriction in the flow path.

There is no restriction. You switch on the VFD. Pump will start running and fluid will be coming and it will go and it will be going back to my tank. okay so that time there is no restriction okay so if i draw this hq curve what will happen initially there is no restriction so my centrifugal pump will give higher flow rate okay and head or one pressure gauge is here the pressure gauge will be showing very low pressure okay so we are assuming almost zero pressure okay and flow rate will be very high my flow meter here f m and this is pressure gauge pressure gauge.

So, pressure gauge will be showing very low pressure, but flow rate will be very high. So, I got 0.1. Now, I have one restriction here flow control valve, where is that? I should put flow control valve here. let me just wait i have pressure gauge in some other place okay this is pressure gauge this is not pressure gauge pressure gauge is here okay flow meter is here and i have flow control valve is here flow control valve okay flow control valve is here now initially it is completely open now close a little bit flow control valve so what will happen if you close a little bit pressure gauge will be showing a little bit higher pressure and flow rate will be little bit down okay so maybe my flow rate will be little bit down pressure will be showing little bit higher pressure so 0.2 i am getting okay now again little bit closing this flow control valve again my flow rate will be little bit down my pressure will be increasing increasing increasing increasing increasing so slowly if i close the my valve so my pressure gauge will be showing higher pressure flow rate will be down okay Then, I will be reaching maybe up to 10 point, for example. Once we reach near by closing, I will ask the student, do not close completely. Because if you close completely, pressure will be very high, my system can fail. you reach up to 10, then remaining part you just interpolate and extrapolate and draw the line.

If you are closing completely, then my system can fail because of this reason. Now, you got this curve. now if i have reciprocating uh positive displacement pump let's say any reciprocating pump or one positive displacement pump i'll show one positive displacement form so this is actually single screw pump or positive displacement pump okay so this is like this this uh left hand side i have rotor this will be rotating one motor will be there it will be continuously rotating okay it will be And you can see this is stator. This is called stator.

This is having one hole. It will go inside this one. And when it is rotating, actually fluid will be delivered. this is called positive displacement pump. The pump type is called PCP.

or progressive cavity pump. If any student want to know about details about this PCP then they can go to my another NPTEL video called artificial lifting system. So, that course is having more details about this PCP system. cavity pump. So, progressive cavity will be like this.

If you rotate it continuously, so smoothly, this is rotary pump, positive displacement, but rotary, not reciprocating. This is not reciprocating, this is rotary pump. Continuously rotate, so slowly it will be delivering fluid. that fluid when it is delivering, And if I use same experimental setup instead of centrifugal pump, if I use my this pump, replace the centrifugal pump using and put this one, then how this curve will look like.

So, initially all the valves are open. Now, you got certain flow rate and your head is lower. Now, you close your flow control valve again. So in that case, what happens if RPM is fixed, rotational speed is fixed, it will be delivering constant amount of fluid. okay pressure gauge will be showing higher pressure but flow meter will be showing same flow rate okay so same flow rate will be showing again you close you get same flow rate pressure increasing same flow rate pressure increasing same same same okay so continuously you get line and you get completely vertical line okay this is the beauty of progressive cavity pump or any positive displacement pump positive displacement pump can deliver any amount of fluid

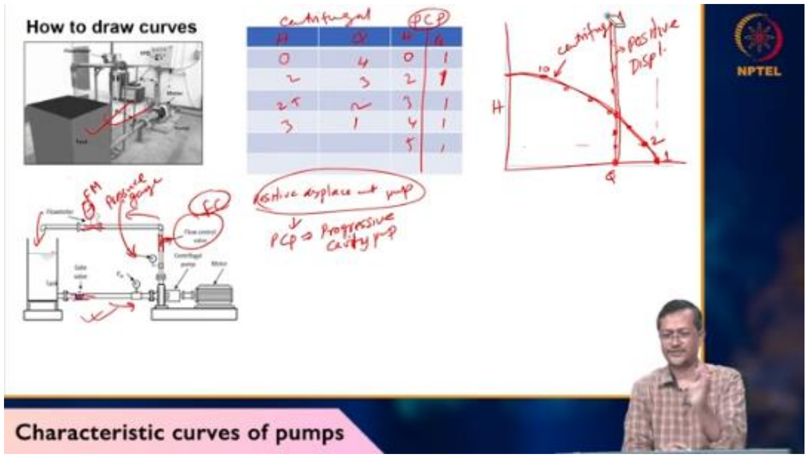
Even your heart is positive displacement pump, if there is any blockage, you get palpitation or pain because heart is trying to deliver. Any amount of fluid, fixed amount of fluid it will be delivering, but you are restricting. but it will try to deliver the same fluid, but higher pressure. positive displacement pump, my progressive cavity pump, it will be delivering same amount of fluid at fixed RPM, but at any pressure. So, wherever you would be required, for example, fuel injection in your engine systems or your refrigeration systems, many other applications, you can use positive dissipation pump for very high pressure application.

For if you need moderate flow rate also and pressure also, then normally you will go for centrifugal type pump. But very high, small amount of fluid, very high pressure you need, like say very high thick fluid is there. For example, grease, and toothpaste. a centrifugal pump will not be able to handle okay so centrifugal pump will be good for low viscosity fluid but high viscosity fluid to paste grease any food processing processed food or anything you want a fixed amount of fluid you want to deliver so centrifugal positive displacement pump or rotary type of positive displacement pump is very good for that okay you got difference between positive displacement form, positive displacement, this is positive displacement, positive displacement, this is centrifugal.

Now, if I give an example, let us say I am doing experiment, initially H Q HQ for centrifugal HQ for PCP whatever my experimental system is there. centrifugal pump if I say initially all valves are open. So initially head may be 0 flow rate may be 4 then you close the valve head can be 2 maybe, it will be 3 maybe, 2.5, 2, 3, 1.

in that way, you can draw the curve like this. The curve will be like this. But if I go for positive displacement type, then head 0 maybe, flow rate 1, head 2, flow rate 3. flow rate may be 1, 3, 4, 5, 1, 1, 1. flow rate will not change.

flow rate will be completely vertical. in exam I can ask, I can give you data and I can ask you identify your pump. in that case actually you can see the flow rate and head relationship or you can draw a curve little bit roughly and you can guess it will be centrifugal pump or it will be a positive displacement type pump. whenever you are talking about pumping system fluid flow so normally we use one term called specific speed so specific speed formula is that n s equals n q h power 3 by 4 okay n is specific speed and the small n is your rpm or revolution per minute speed the q is flow rate h 3 by 4. here when we talk about specific speed it is unit dependent okay it is not non-dimensional number okay so whenever you are talking about si unit or other events si unit value will be something different other unit will be value will be something different because if you calculate



the dimensions so there will be some existing dimensions because of that this difference will be coming okay so this is radial this is uh axial okay so if you see radial your specific should be like 500 and maybe 15 000 okay 1 000 maybe 2 000 okay uh so one example ns equals rpm gpm flow rate gallon per minute and meter for three by four okay uh so i can give one example also for that so if n or small n is 1400 rpm and q equals 1 gpm h equals 1 meter Can you calculate NS? I am leaving this problem for you. You solve.

Now, what is the unit? You just try to solve it. So, normally NS will be 500 to 42,000 for a centrifugal radial type pump. NS will be 4,200 to 9,000 for mixed flow pump. and it will be 500 to 4200 for radial, radial flow pump and more than 9000 will be axial pump, 500, 1000, 2000 that is better.