Fundamentals of Automotive Systems
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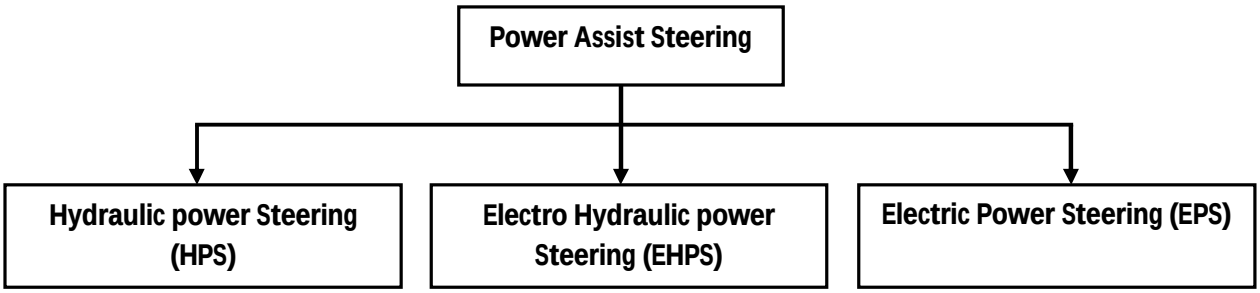
Module No # 11
Lecture No # 61
Power Steering and Kinematic Steering Analysis – Part 01

So greetings welcome to today's class so just a quick recap of where we stopped so we are looking at power steering in the previous class. So the requirement of power steering is motivated from the fact that as vehicle mass and vehicle speeds increased more effort was required to steer the vehicle right. So the question is can some assistance be provided to the driver in order to achieve that steering function.

So that led to the motivation of power steering and as we discussed you know like one could achieve this additional effort by increase in the steer ratio but that is counter productive because increase in the steer ratio will certainly increase the torque magnification but that will be the expense of having higher steering wheel angler displacement for the same steered wheel rotation right. So that is the tradeoff so that is why you know the power assisted steering came into being.

So if we look at broadly the classes of this power assist steering we would look at all these three classes you know first one that we would be looking at is what is called as a hydraulic power steering okay let us abbreviate as HPS okay. The second class will be electrohydraulic power steering EHPS and then third class is going to be electric power steering okay which we will abbreviate as EPS. So broadly these are the 3 categories of power assisted steering that we would be looking at.



CLASSES OF POWERASSIST STEERING

So now if we look at most power assist systems you know like so we have what is called as a speed dependent power assistant that is the assistance provided by this power steering does not remind the same with speed vehicle speed okay. So that is one important attribute why because see typically when would we require them most assist you know like when we want to take tight corners or do for example you know like a parking maneuver you know like parallel parking and so on right.

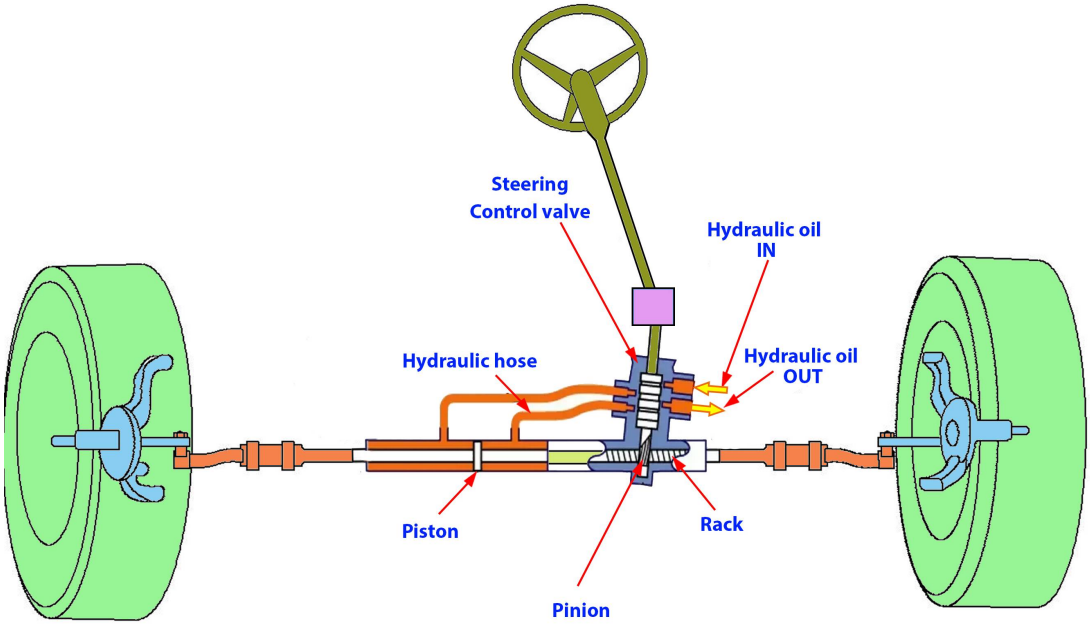
So when we are doing this so called tight steering right so where we want like to achieve very small turning radii alright or essentially we not to go on a very tight path then the effort or the assistance provided to that driver should be higher and a speed increases you know like the assistance provided by the drive is reduced so that there is not too much steering from the power assist system. So that is the concept of this speed assist system.

So if we look at it at low vehicle speeds the magnitude or the amount of the steering assist is higher to account for let us say tight parking slash slow speed cornering maneuvers right. So what do we mean by tight low radius or high curvature maneuvers right. So that is what is happening at low speeds and as a the speed increases the amount of this power assist is reduced so the amount of assist is reduced as speed is increased okay to avoid too much steering you know like we

do not want the vehicle to be steered too much by high amount of assist at higher speeds.

So that is the concept behind what is called as speed assist right speed dependent power assist. So let us first look at this hydraulic power steering let us see how it functions then we will go to other types of power assist okay. So what happens in this hydraulic power steering?

So let us look at hydraulic power steering okay HPS. So if we look at a hydraulic power steering let us take a look at a simple schematic to just understand the concept okay. So if we look at even typical a rack and pinion is power steering in passenger car so with this power steering. So in the previous class we looked at what is a rack and pinion steering so if you recall you know we have steering wheel then we have a steering column in the traditional rack and pinion steering.



HYDRAULIC POWER STEERING (HPS)

What happen the steering column at the end of the steering column there is a pinion and the pinion essentially meshed with the a rack and any rotation of the steering wheel is converted to a rotation of the pinion and consequently displacement of the rack right that is what happens in the base rack and pinion system. In the rack and pinion system with a hydraulic power assist what we have is that we have a steering control valve which is mounted on the steering column okay.

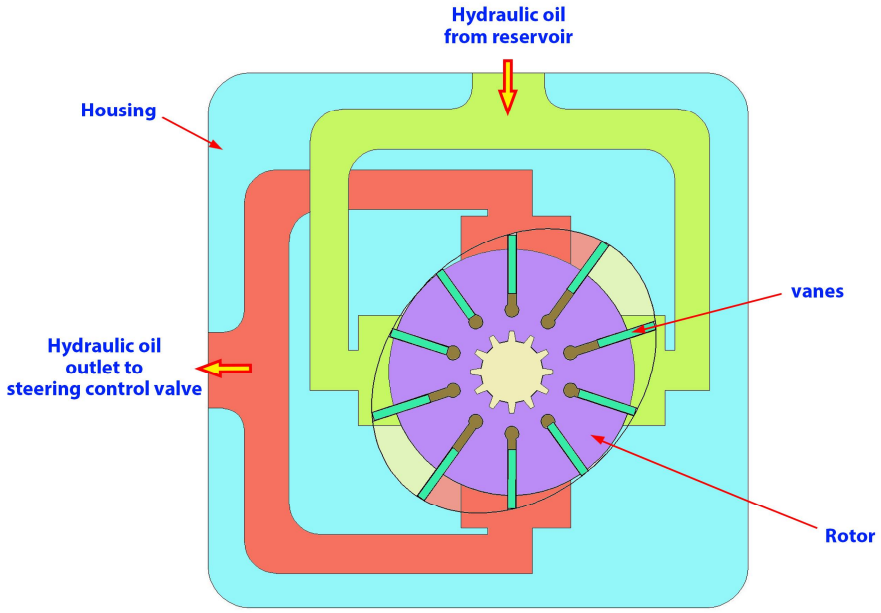
And there is a supply of hydraulic fluid you know at a high pressure okay there is a pump and a storage unit which essentially circulates this hydraulic oil okay at a high pressure. So we will shortly look at this steering control valve in more detail. But what happens is that when the driver turns this oil at high pressure is routed through this control valve to what is called as the power cylinder okay.

So just a cylinder which is mounted on the rack okay in line with the rack and that has a piston So we can see that there are 2 sides to the piston so essentially depending on the direction of rotation by the driver the pressurized fluid is given to the appropriate side end of the piston to create a an assist force okay that is the concept behind this hydraulic power steering okay. So let us look closely at this steering system the hydraulic power steering system okay.

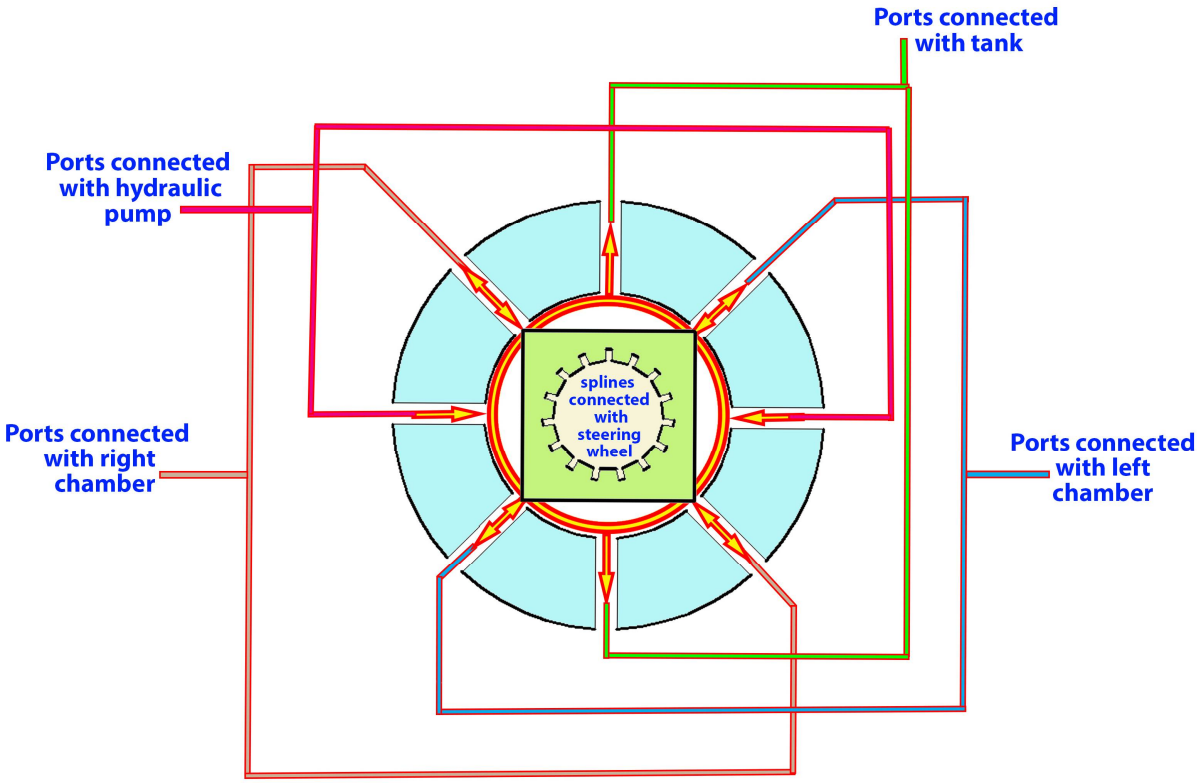
So, essentially as we just discussed it uses hydraulic fluid pressure to assist to the steering process okay. Then if we look at the main components of the hydraulic power steering system we have a reservoir for the steering power steering fluid then we have a pump we have the corresponding hoses we have the control valve which routes the fluid in the correct path right.

Then we have what are called pressure relief valves, which ensures that the peak system pressure is limited. So that it protects the system components then we have this hydraulic cylinder or what is called as a power cylinder right. So in the rack, so those are the main components of this hydraulic power steering system okay. So the control valve is typically mounted at the end of the steering column okay and it directs the fluid flow to the appropriate side of the power cylinder system okay.

So that is what happens in this control valve and if we look at this power cylinder the power cylinder is mounted in line with the rack and the power cylinder directly acts we should be say the power cylinder or the piston right in the power cylinder directly acts on the rack right to create that assist function. So that is how this hydraulic power steering works so if we look this power steering let us look at a few components so the most common type of pump which is used in this power cylinder is a Vane type pump okay.



VANE TYPE PUMP



STEERING CONTROL VALVE

So what is this Vane type pump let us look at that so with the simple schematic so this is what is called as a Vane pump okay. So it is most commonly used in hydraulic power steering systems so what is this Vane pump? You know we have a rotor you know and in this rotor we can see that you know there are slots okay which are in which these vanes are fitted so this vanes can move radially in these slots okay.

And then we have this a cavity which is in the shape of a cam so it is not a sorry it is in the shape of ellipse okay it is not essentially in the a circular cavity but it is the shape of an ellipse so what happens is that when this rotor rotates these vanes are going to be thrown out due to centrifugal force right. So the top ends of the vanes are going to slide on the inner surface of this elliptical cavity.

So what happens when hydraulic oil comes from the reservoir let us say the vane type pump the rotor is rotating in this direction right. So when the what to say rotor is rotating what happen is that the oil is sucked into the cavity between the two vanes okay from the reservoir and as this rotor rotates the oil which is taken in is compressed and then the pressurized oil is released to the outlet port of the from the coming out of the vane okay so that is how this vane type pump operates okay.

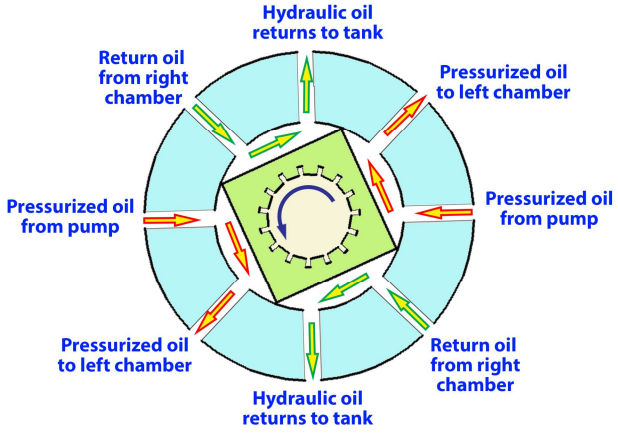
So essentially the idea is to what to say taken the oil or suck the oil from the reservoir as essentially the vane keeps on rotating pressurize it and then deliver it through the outlet port of the pump okay. So this vane type pump you know like which essentially delivers this pressurized oil and the oil or the fluid comes to this steering control valve. So let us look at how this steering control works?

So essentially what happens in this steering control valve is the following so I just adjust the size alright. So what happens is that this steering control valve is mounted on the steering column so we can see this central part right so which where we have this splines that are connected to the steering column. So any rotation of the steering wheel by the driver is going to rotate this spool okay which is mounted at the center.

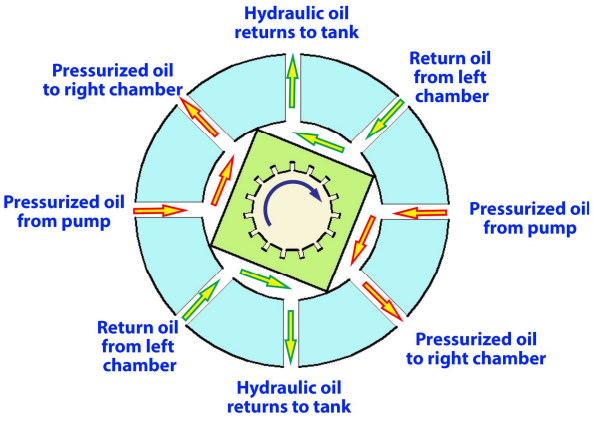
Now we can see several ports which are either connected with the tank okay or connected with the right chamber of the power cylinder or the left chamber or the hydraulic pump outlet. So what happens is that when the steering wheel is centered this fluid from the hydraulic pump enters through this port okay and it circulated through the entire fluid circuit right so some of it goes to the right side of the power cylinder some goes to the left side some goes to the reservoir okay.

But the consequence is that when it is centered the net the pressure in the right chamber and the left chamber of the power cylinder is the same right. So consequently there is no assist okay so that is what we want when the steering wheel is center alright. So that is the mechanism so now let us look at what happens if the driver turns the steering wheels to the left or the right okay. And how does this steering control valve then respond.

So let me introduce to a simple schematics right that show what happens when the steering wheel is either turn to the right or to the left okay. So let us first consider the scenario where the steering wheel is turned to the right okay.



STEERING CONTROL VALVE - RIGHT



STEERING CONTROL VALVE - LEFT

So this is the scenario where the steering wheel is turned to the right so then what happens is that immediately observe that this spool is rotated because it is connected to this steering column now you can see something interesting right the pressurized oil from the pump which enters through this port is directed through this path into the right chamber of the power cylinder okay. So that is how the control valve is designed so on the other hand as the piston is moving fluid is displaced from the left chamber is not it?

So consider a cylinder and piston assembly so the piston is shifted to the right then in the left chamber or the pressure is increased in the right chamber so the piston is going to move towards the left so in the whatever fluid is displaced in the left chamber as to be let out somewhere right. So you can immediately see that the return oil which is coming from the left chamber is connected to the tank or the reservoir alright.

So you can see that there are 2 paths by which the pressurized oil is taken to the right chamber and two paths by which the return oil comes from the left chamber and returns to the tank. So what is the consequence? This implies that there is a net assist force in the power cylinder to support a right turn right. Because that is the intention of the driver right is it not? So that is what happens when the steering wheel is turned towards the right.

The reverse sequence of operation happens when the steering wheel is turned to the left so this schematic tells us what happens when the steering wheel is rotated to the left right. What happens if the steering wheel is rotated to the left we can immediately see that the pressurized oil from the pump now goes to the left chamber alright the ports are connected in that manner and then we can immediately observe that the return oil from the right chamber goes to the reservoir or the tank okay so that is how this have a what to say control valve works okay.

But there are some although you know like the operating principle is what pretty simple there are some limitation associated with this hydraulic power steering what are they? So please note that in a hydraulic power steering this hydraulic fluid is pumped or circulated in the circuit all the time continuously so does not matter whether the driver is steering or not the fluid is pumped through the circuit and that

results in loss of energy right because ultimately the energy which is required to drive the pump as to come from the engine is it not.

So engine drives the pump and the pump is operated continuously so that is the critical limitation of this hydraulic power steering. So essentially we have the first limitation is that we have a continuously running pump which results in significant energy loss right it is a waste of energy right when the driver is not steering the steering when the driver is not rotating the steering. And secondly it will not work if the engine is stalled alright so due to some reason if the engine is not working or it is stalled right so then we lose this functionality right as far as the hydraulic power assist is concerned.

Of course if the hydraulic power assist fails let us say there is a severe leakage in the mainline right and the pressure drops and there is no fluid pressure generated then please note that the driver will be able to maintain basic steering capability because the steering column is still connected the pinion mechanically. So there is always a failsafe you know like please remember this hydraulic power steering is only augmenting the steering torque it is not completely replacing the rack and pinion at the edge okay. So that is the, those are the main features okay of this hydraulic power steering.

So in order to address a few limitations of this hydraulic power steering you know the electro hydraulic power steering has been developed and also is finding use. So this is let us abbreviated as EHPS so what is this electro hydraulic power steering? So the main limitation of this hydraulic power steering is that the engine has to keep on operating the pump continuously so what happens is the electro

hydraulic power steering as the name indicates we have a motor pump unit what is abbreviated as MPU that pressurizes the fluid right.

And where the pump is driven by an electric motor okay so consequently the pump need not be operated continuously right so, whenever there is a requirement the electric motor can operate the pump okay. So it compared to a hydraulic power steering okay it is saves energy since the hydraulic pump can be operated when required okay and independent of the engine right. So of course now we need an energy source for driving the motor right.

So let us say the motor will require it is own energy source may be from a battery and the associated electronic circuits to provide the input energy to the motor right so that is a complexity which is added but one more advantage when compared to an hydraulic power steering is that we can have an electronic control unit regulating this motor right so at least some active control you know like it can be obtained from this electro hydraulic power steering okay when compared to hydraulic power steering okay.

So an electronic control unit or ECU is used to control the motor okay the motor pump unit so those are all pump features of electro hydraulic power steering.