Robotics
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Lecture - 07
Introduction to Robots and Robotics (Contd.)

Now, I am going to start with the end effector which is generally used in the Robots.

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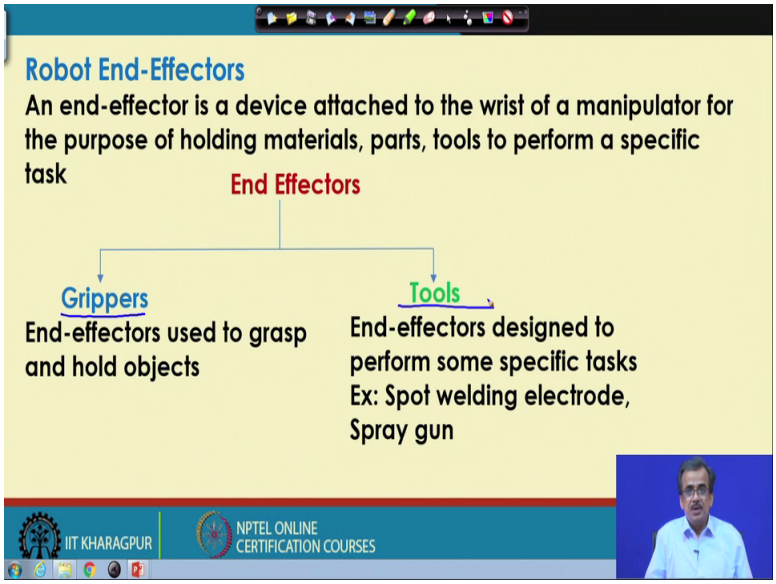

Now, if we see the robots end effector we use generally two types of end effectors which I am going to discuss, but the basic purpose of end effector is to grip or the hold some parts, materials, tools, just to perform some specific task. And this particular end effector are generally attach to the wrist joint that is the last joint. So, there we attach this particular the end effector.

Now, if you see the end effector, this end effector could be of two types. Now, one is called the gripper and another is called some specific tool or the specialized tools. Now, this grippers are known, for example, say we will have to grip some tools like we will have to do some machining, for example, drilling or say grinding or milling. So, we will have to use some special type of gripper so that we can grasp that particular the object. Now, sometimes as we mention the robots are used to perform some specific task for example, say spray painting or say the welding.

Now, if we if we to wants to do the spray pentane the spray gun has to be attached to the wrist joint. Similarly if we to wants to do some set of welding then the welding electrode has to be attached to the wrist joint and that is also an end effector, but this particular end effector is in the form of tools. So, the end effectors could be grippers or it could be some specialized tools.

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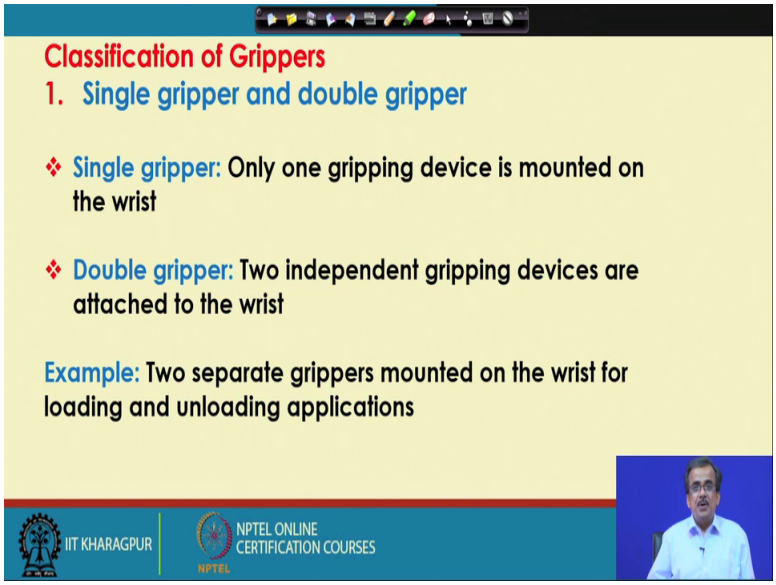

Now, I am just going to see the different types of grippers which we generally used, so I am just going to classify the grippers. Now, this the first classification is your the single gripper and double gripper. Now, as I mentioned that if this is the wrist joint. So here, in this particular wrist joint we connect that particular the gripper. Now, here I can grip I can connect only a one gripper just to serve a specific purpose or depending on the requirement, so I can just attach two independent gripper.

So, if I use two independent gripper so that will become the double gripper and if I use a only a one such gripper gripping device that is called the single gripper. So, this is the difference between single gripper and the double gripper.

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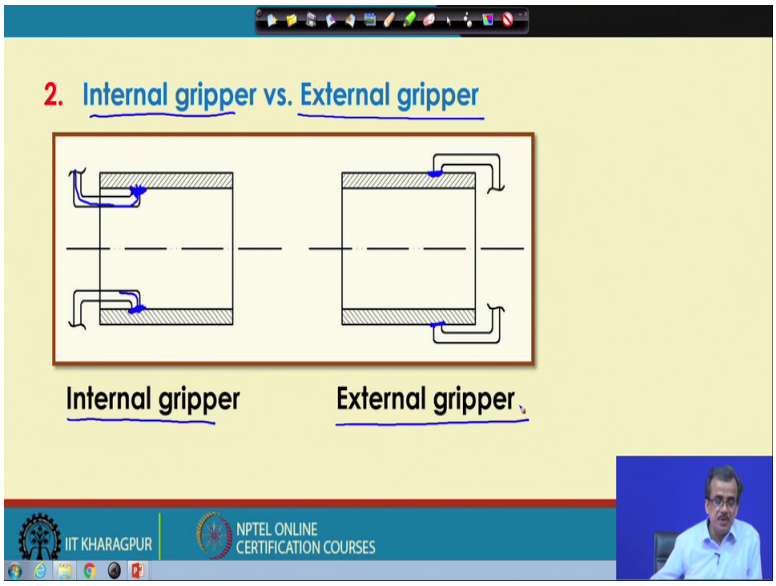

Now, then comes your the concept of the internal gripper and the external gripper. Now, let me take one example. Supposing that I have got a steel pipe for example, say water pipe or the oil pipe, ok, now, this particular this pipe I want to grip.

Now, there are two possible ways with the help of which I can grip this particular pipe, so I can follow this type of gripper. So, this type of gripping pad, so gripping pad or gripper, so I can use a one gripper like this, I can use another gripper. So, one gripper is here another gripper is here and this is a hollow pipe so I can grip with the help of these two finger or these two gripper so this hollow pipe or there is another possibility the same pipe I can grip here externally. So, I can put a one gripping pad here and another gripping pad here and I can grip this particular the hollow pipe.

So, if I use this type of gripper that is called the internal gripper, if I use this type of two fingers. So, that is called the external gripper. So, this is the difference between your internal gripper and the external gripper.

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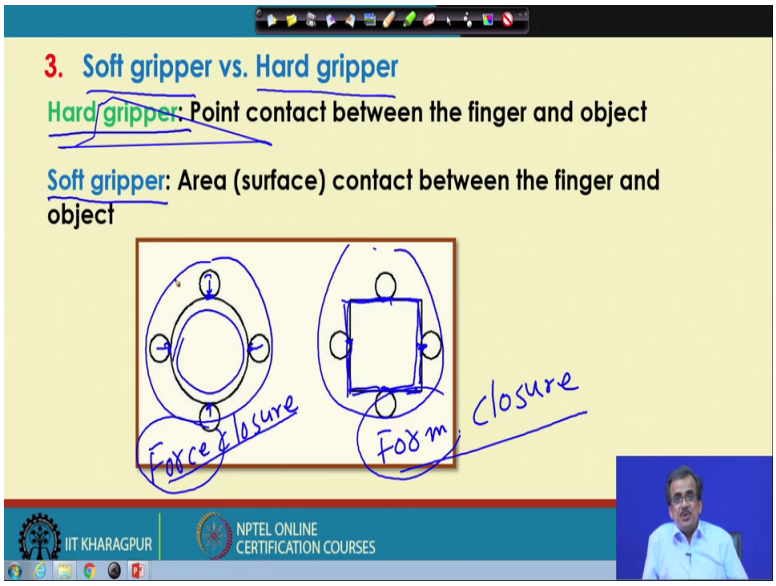

The next classification is the soft gripper versus the hard gripper, soft gripper and hard gripper. Now, let me take one example. Supposing that, this particular the marker say if I just grip it like this. So, there is a possibility that I can grip it with the help of these two fingers and although this is not the perfect point contact, so might be it is almost similar to the point contact and with the help of these two finger, so I can grip it.

And there is another way of gripping, so I can also grip it like this. Now, if I grip it like this, this is nothing but the perfect area gripper, ok. So, if I use the point gripper like this so that is nothing but the hard gripper, that is actually the hard gripper and if I use this type of the area contact and that is called the soft gripper. So, for the hard gripper we maintain the point contact just to grip that particular object and for the soft gripper we consider the area contact just to grip that particular the object.

Now, here in this particular sketch in fact, I am just going to give information of another concept. Now, that concept is also very important from the gripper design point of view and that is nothing but the concept between or the difference between the force closure. So, this is actually the force closure and this is nothing but the form closure form closure. So, the concept of this force closure and the form closure is a very important.

Now, let me take one very simple example. Supposing that say I am just going to write something on the board with the help of say a white chock. So, the chock is having circular cross section. Now, to grip that particular chock so that I can write in a very nice

way, so what I will have to do is with the help of my finger. So, I will have to put some force here I will have to put some force here then only I can grip this particular your the chock, because the chock is having the circular cross section and if I do not grip it properly if I do not put force there is a possibility that I will not be able to write or draw the picture which I am planning to write.

The same is true if I do not grip it properly, so I will not be able to write anything here are you getting my point. Now, this is another example. Supposing that the object is having the cross section which is nothing but a square in place of a circular in place of circular now, this object is having the square. Now, if it is a square and if I just trying to grip it. So, here gripping will be much easier compared to this particular object because here, so I have got a one finger here, another finger here, another finger here, another finger here. And this particular geometry this particular geometry or the corner this geometry or the corner is going to help us in gripping which is a absent here.

So, supposing that both the chocks are having the same mass same weight and I have got chock having circular cross section, I am having chock having the square cross section. So, handling the chock having square cross section will be much easier, and that is why in fact, in some of the universities they follow the square chock a particularly in foreign universities they take the help of square chock.

But here actually we take the help of this type of circular cross section chock. So, the difference between the concept of force closure and form closure is a as follows. Here to grip this particular object. So, we will have to take the help of some force and here this particular geometry is going to help us in gripping this particular the object. So, this is the concept of your the form closure and this is the concept of the force closure

So, if we want to design and develop some sort of gripper. So, we will have to see the nature of the object, the cross section of the object which I am going to grip. And accordingly, depending on the requirement, I will have to design that particular the gripper. So, this is the concept of the force closure and form closure.

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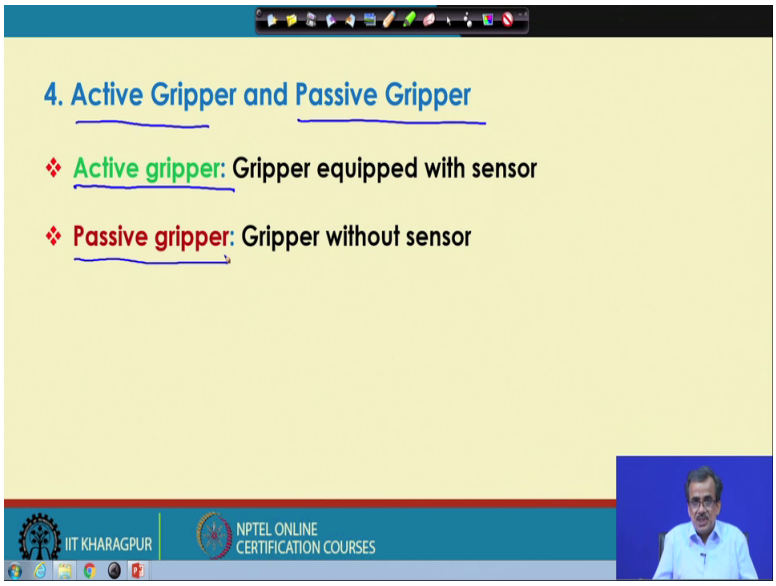

Now, another classification is actually the active gripper versus the passive gripper. Now, by active gripper we means the gripper is having some sensor and by passive gripper we mean it is a gripper without sensor.

Now, let me take that the example of our gripper. So, if I just consider our gripper. So, for example, say with the help of this finger. So, I am just going to grip it. Now, for gripping definitely I will have to put some force, but at the same time so this particular the skin which I have on the finger that is going to help us little bit and this particular sensor the skin is a touch sensor which I will be discussing in details after sometime. So, this particular skin that is the touch sensor is going to help me in a gripping also besides that particular the force which I am putting and that is nothing but a example and example of active gripper. On the other hand we have got the concept of passive gripper where we do not use any such sensor.

Now, I will be discussing the working principle of passive gripper in much more details after sometime.

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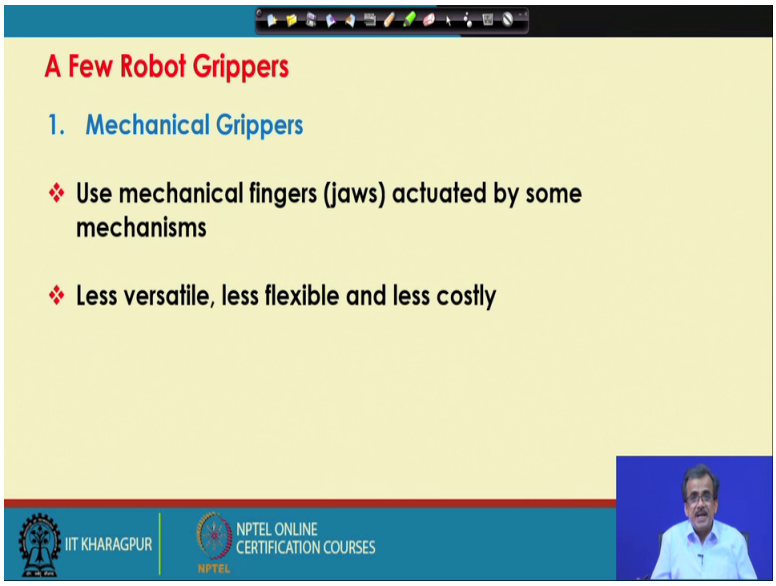

Now, I am just going to discuss the working principle of a very of a few very simple mechanical gripper which are very easy to understand. So, in mechanical gripper actually what we do is we try to design some finger and we operate those finger with the help of some mechanism. And these are purely mechanical, so I am just going to design and this particular grippers are very simple very simple to design and these are less costly and less versatile. So, I am just going to discuss a few available very simple mechanical design for this particular the gripper.

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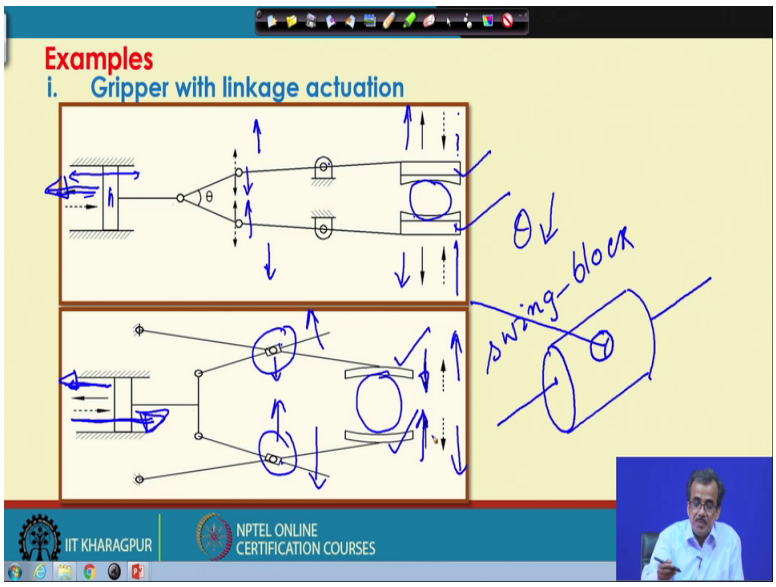

For example say the first one is a gripper with linkage actuation. So, let us try to understand the working principle of this particular very simple gripper.

So, here we have got two gripping pad. So, these two are the gripping pad or the gripping jaws. So, with the help of this gripping pad, so I am just going to grip some object here. So, might be the object here. So, I am just going to grip with the help of these two gripping jaws or gripping pad. Now, I will have to grip, I will have to un-grip also how to do it. Now, the mechanism is very simple. So, what we do is here we have got one piston cylinder arrangement, so this particular piston, so this can slide inside this particular the cylinder.

Now, the moment this particular the piston moves towards this solid arrow; that means, in this particular direction, ok. So, here I have got a joint the rotary joint. So, what will happen is the moment it is sliding in this particular direction so this angle theta is going to be reduced and as theta decreases. So, these two points is going to come closure to each other and here we have got the support and due to that. So, these two gripper are going to move away from each other and it is going to un-grip.

On the other hand, if this particular piston is moving towards this particular arrow this dotted one, this dotted arrow, what will happen is theta is going to increase and these two points are going to move away from each other and consequently. So, these two gripping jaws are going to coming closure to each other and it is going to grip this particular the object. So, this is such a simple the gripper with the help of designed with the help of the linkage or the mechanism, ok.

Now, I am just going to discuss the working principle of another very simple gripper. Now, here once again, this is the gripping pad or the gripping jaw with the help of which I am just going to grip this particular object the object is here say. Now, what we do is, so here once again we use the principle of the cylinder piston mechanism. So, this part particular piston can slide.

Now, supposing that it is slide it is sliding towards this particular direction shown as the solid arrow. Now, if it moves towards that. So, here we have got one mechanism that is called the swing block mechanism. So, swing block mechanism, swing block mechanism it is a very simple supposing that I have got one this type of cylinder sort of thing. So, this is the cylinder and here you will find that. So, this is connected here one link and

here another link is connected and here you will be finding some circular group here and through this particular group another link will pass. So, this particular link will pass through this, ok.

Now, here the moment this particular the piston slides towards this in this particular direction. So, what will happen is, so these two your, the swing blocks these two swing blocks we will try to come closure to each other. So, if they come closure to each other. So, what will happen? So, it is going to grip this particular the object. And a reverse the situation, so if it is sliding towards this particular direction. So, if it is sliding towards this particular direction. So, these two swing block is going to move away from each other and consequently. So, there will be on gripping of this particular the object shown by this particular the dotted one, ok. So, this is the way actually we can grip and un-grip with the help of this type of very simple a mechanical gripper.

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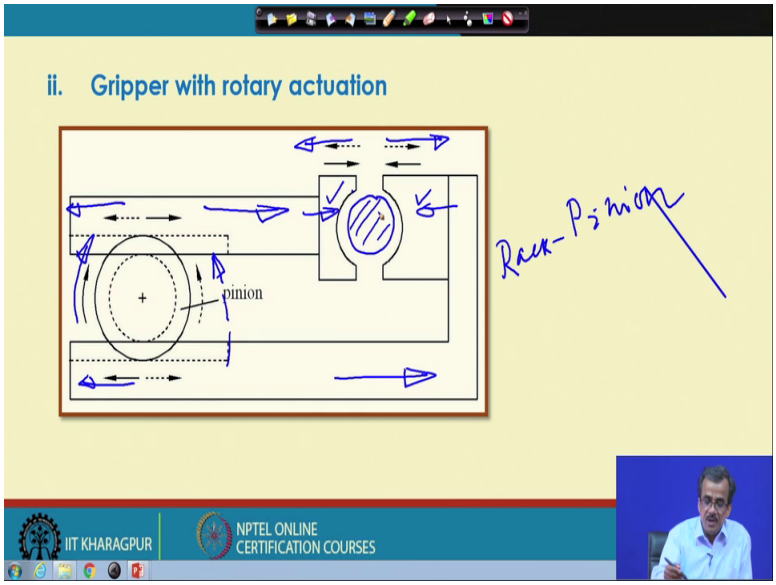

Now, I am just going to discuss the working principle of another a very simple mechanical gripper. Now, here, so this is nothing but one gripping pad, this is another gripping pad and I am just going to grip this particular objects say, ok. Now, here we have got one pinion, pinion is nothing but a small gear. So, I have got a pinion here and I have got a rack here. So, this is nothing but the rack and pinion mechanism, rack pinion mechanism.

So, a rack pinion mechanism we have. Now here, so this particular pinion it can rotate either clockwise or anticlockwise, and here so this upper part is connected to this gripping pad and the lower part is connected to the this gripping pad in this particular the fashion, ok. Now, supposing that, so this particular the pinion that is connected to your motor say. So, this is rotating in the clockwise sense. So, if it rotates in clockwise sense the upper part is going to slide something like this and the lower part is going to slide something like this; that means, it is going to move towards that and that is going to come like this and it is going to grip this particular object, ok.

And reversing the situation, so if this particular pinion is rotating in the anticlockwise sense. So, if it is rotating in the anticlockwise sense. So, this upper part is going to slide along this particular direction and this lower part is going to slide in this particular direction and consequently this is going to slide towards this, this is going to slide towards this, and it is going to un grip that particular the object. So, this is the way actually we can grip and un-grip, so this particular the object with the help of this type of very simple mechanical gripper.

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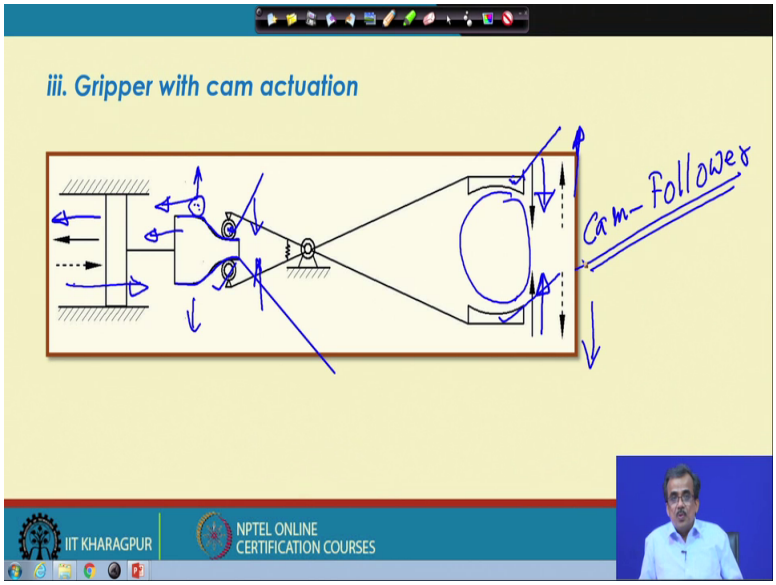

Now, then comes the working principle of another very popular mechanical gripper that is nothing but using the mechanism of cam and follower. So, using the mechanism of cam and follower, so we can design this particular the gripper. Now, let us see how.

Once again we have got the piston and cylinder arrangement and this is a one gripping pad this is another gripping pad, ok, and here we have got that particular the cam profile very complicated cam profile. So, we have got this particular the cam profile and we have got the roller follower. So, this is the roller follower. So, this is the roller follower, this is another roller follower. So, cam and follower profile, ok.

Now, supposing that. So, this particular piston is sliding towards this particular direction shown by the solid arrow. So, what will happen is your, so this is going to slide towards this. So, might be initially the roller was here are you getting my point. Now, this particular thing has will slide in this particular direction. So, ultimately the roller has come here because it has from here it has come up to this, ok. So, initially the roller was here, but after sometime due to this sliding movement. So, the roller will come here; that means, these two roller will come very close to each other.

Now, if they come closure to each other then what will happen is your. So, if it comes closure to each other. So, this is going to come, these two gripper, these two gripping pad are going to come closure to each other and it is going to grip this particular object and a reversing the situation if it slides towards this particular the dotted direction. So, if it slides along this what will happen is initially the roller was here, but after sometime the roller could be here that means, the distance between the roller is going to be increased that means, these two roller are separated out and due to that what will happen is if it is going to be separated out, ok. So, this is going to be separated out. So, it is, so these two gripping pad are also going to be separated out and it is going to un-grip that particular the object, ok.

So, this is the way this cam actuated gripper is working. These are all very simple mechanical designs of this particular the grippers.

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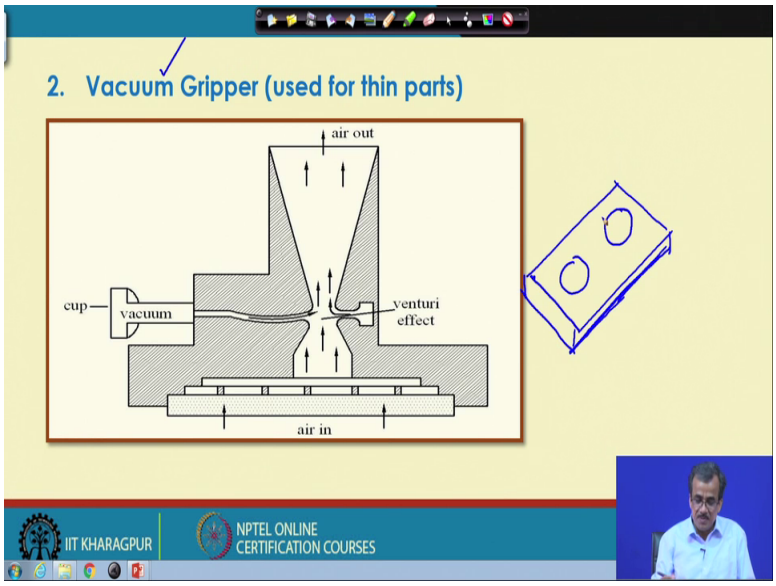

Then comes the vacuum gripper which is very frequently used nowadays ok, particularly for a handling some flat plate sort of thing. Now, let me take a very simple example. Supposing that the robot is going to do some sort of peak and place type of operation and it is going to peak one steel plate and it is going to place it to some other place, ok. Now, how to grip it?

Now, supposing that say I have got a steel plate here say this type of steel plate say let me consider that I have got a this type of steel plate. Say might be the thickness is 20 millimeter steel plate and the length could be like your 1 meter, the breadth could be 0.5 meter something like this, ok. So, this type of steel plate I am just going to grip the robot is going to grip and place it to another. How to do it?

So, what we do is we take the help of this type of vacuum gripper, ok. Now, here we put one vacuum gripper, we put another vacuum gripper here and we will be able to grip this particular the steel plate. Now, let us see the working principle of this type of the gripper. Now, here actually what we do is now, let us first see that particular picture the way it is used then once again I will be coming back.

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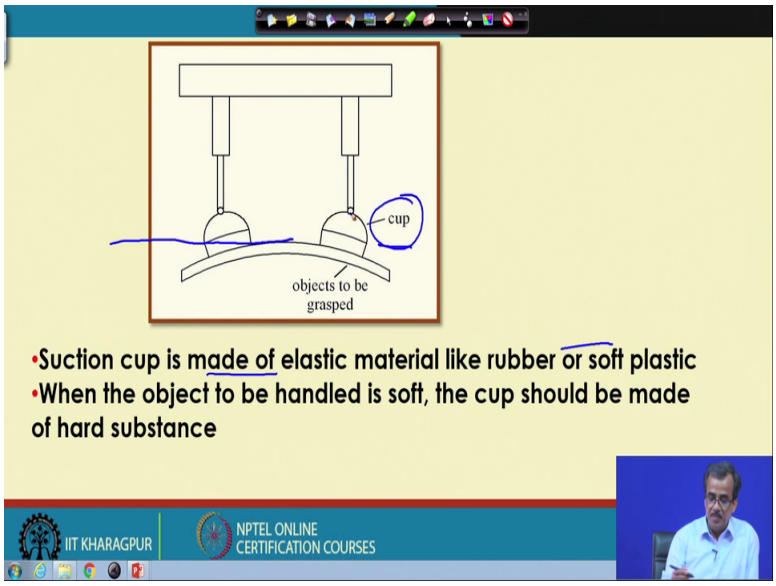

So, this is the way for example, this is the object to be gripped I am using these two vacuum gripper and this is connected to the robotic the wrist, ok.

So, this particular cup is nothing but is your the vacuum gripper, the cup is nothing but the vacuum gripper. Now, let us see how does it work. Now, to explain the working principle actually I will have to go back to this particular the design, ok. Now, here the flowing fluid is air, you can see that so air is actually air in and air out, ok. Now, we know that the air is a compressible fluid ok, but for simplicity let me assume that air is incompressible fluid that is the density row is constant. So, this is an assumption. This is an assumption because, we know that air is nothing but a compressible fluid ok, but for the purpose of analysis let me assume that the row is constant that is nothing but the in compressible fluid.

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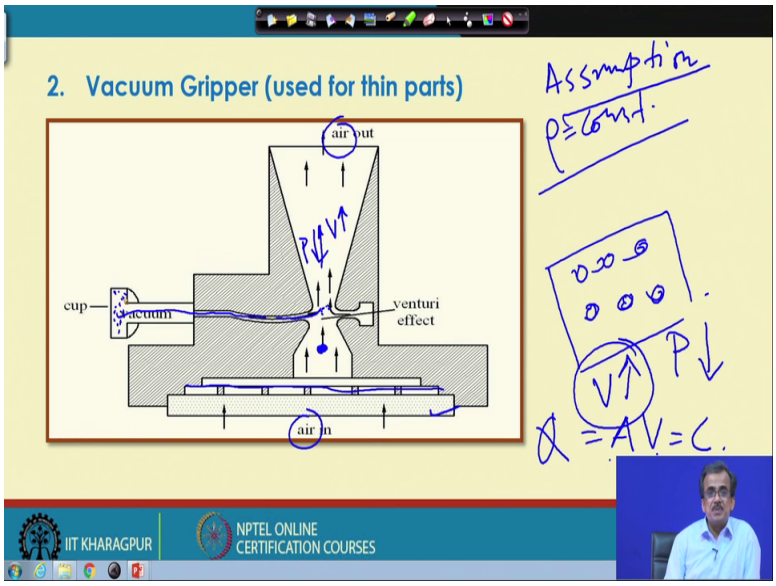

Now, here the way it works is as follows. So, here we have got a strainer. So, this is the strainer. So, it is just going to separate out the dirt particle. Now, inside we have got one plate, so this is the plate and on this particular plate. So, if this is the plate on this particular plate actually I have got some small drilled holes ok, some small opening we have and this is known as the orifice plate ok.

So, this is actually the orifice plate and on this orifice plate we have got some small opening, ok. Now, this particular air will be force to pass through this orifice plate the moment it passes through this small area, ok. So, what will happen to its velocity? The velocity is going to increase based on the continuity equation because according to the continuity equation the volume rate of flow that is A into V area into velocity should remain constant.

Now, here the area is decreasing, so the velocity is bound to increase. Now, if velocity increases what will happen to the pressure? According to Bernoullis equation the pressure is going to be reduced, ok. So, as velocity increases the pressure is going to be reduced. So, here the velocity will be more, but pressure is going to be reduced then this particular air will pass through the venturi. Now, venturi once again there will be some change in the cross sectional area and due to this sudden change of the cross sectional area. So, what will happen? Once again the velocity is going to increase, but pressure

will further decreased and this particular region is connected to this vacuum part the this part.

So, here the pressure becomes below atmospheric. So, definitely here the pressure will be below atmospheric, ok. So, inside the cup the pressure is below atmospheric, ok. Now, if you see this particular the application the way we are using it.

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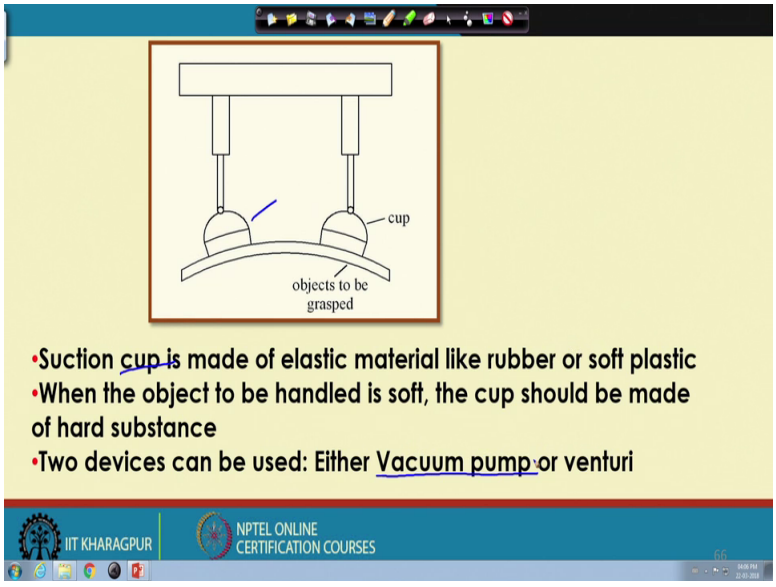

So, here inside this we have got the pressure is below atmospheric and outside we have got atmospheric pressure and due to this pressure difference so this particular elastic cup or the vacuum gripper is going to grip this particular the object ok. So, this is the way due to this pressure difference. So, it is able to grip that particular that particular the steel plate.

Now, how to un-grip? To un-grip it actually a what we will have to do is we will have to stop the air flow. Now, if you stop the air flow what will happen? So, this particular area, this is connected to air atmospheric air, inside the pressure will be atmospheric pressure, here the pressure will be atmospheric pressure, pressure will be atmospheric pressure, outside is also atmospheric pressure, there is no pressure difference and then due to the self weight so this particular your, due to the self weight so this particular steel plate is going to be un-gripped. So, this is the way actually we grip and un-grip if we use some sort of a vacuum gripper.

Now, here this vacuum gripper is developed in the form of some elastic cup. So, this is actually the elastic cup. So, this is the elastic cup. Now, this elastic cup is made of elastic material like rubber or the soft plastic. Now, if the object is hard we generally use the soft elastic material and if the object is soft we use some sort of hard material as the vacuum gripper.

Now, to generate the vacuum gripper we can use a venturi and orifice the way I discuss we can also use some sort of vacuum pump. So, using the vacuum pump also we can create that particular vacuum inside that the vacuum gripper or the elastic cup and using this we can grip and un-grip. So, this particular the object and your this particular part will be connected to the robot and the robot is going to grip and un-grip that type of the object like steel plates.

Thank you.