Manufacturing Automation
Prof. Sounak Kumar Choudhury
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture – 18

Welcome back to the series of Manufacturing Automation lectures. So, let me remind you, in our last session we have discussed some part placing mechanisms, we have discussed some escapements. So, we said that there are some natural escapements that are activated by the parts and the work carriers, but actual escapements activate the parts and the work carrier and facilitate the parts to go to the assembly machine one by one.

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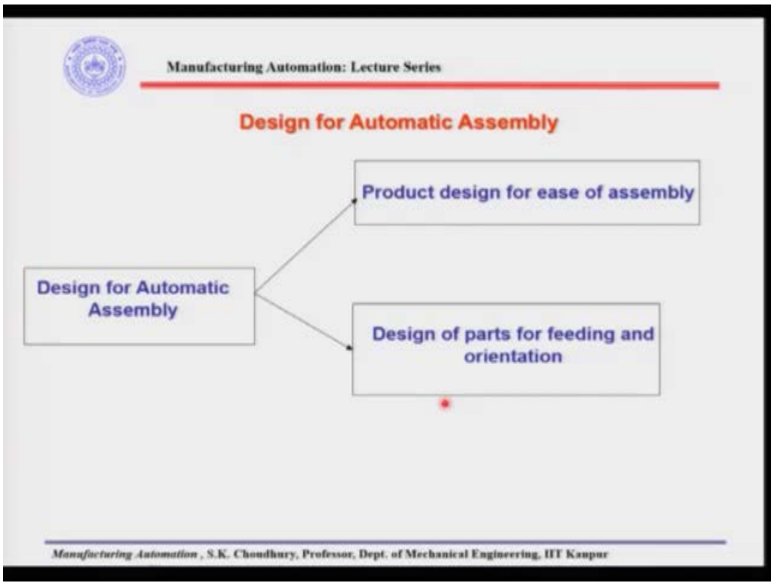

We have also discussed that the parts when they are going to the assembly or the work carrier or the assembly machine then the part may be displaced and therefore, only gravity feed track along with the escapement may not be enough for the part to get positioned in a right way or to keep the position intact.

In that case what is used is the part placing mechanisms and we have seen different types of the part placing mechanisms which are basically the robot arms, manipulators etcetera and they may take up the part from the feeder and place it to the work carrier, so that the work carrier could carry the parts to the assembly machine. Next what we said is that there are certain changes in the design that can be made so that the automatic assembly can be efficiently made and huge amount of spending can be saved by these designs. Let us see some of them.

So, we said that the design for automatic assembly has two aspects, one is the product design for the ease of assembly. I gave you some examples of chamfer, or so that two parts are not stacked together because you should understand that when the parts are fed from the bowl feeder, inside the bowl feeder the many parts are stacked together. So, they may entangle with each other, they may be stacked on one another or sticked to one another, stacked in between and so on. Next aspect is the design of parts for feeding and orientation. We will take some examples how the design can be changed so that it can be easily assembled or it can be easily fed and oriented.

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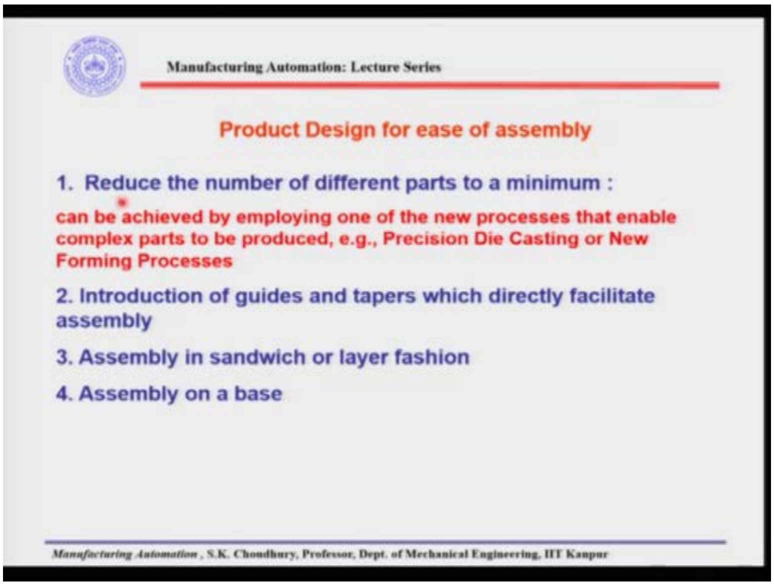

Product design for ease of assembly: first point is to reduce the number of different parts to a minimum. Just in the previous session I discussed that it can be achieved by employing one of the new processes that enables complex parts to be produced; for example, precision die casting or new forming processes. Let me explain it to you. If a complex part can be produced that will reduce the number of assembly processes drastically, that means, two or three parts are actually designed and combined together by casting process or by metal forming process and that way, we are reducing the number of different parts.

Second point is the introduction of guides and tapers which directly facilitate assembly. These examples we will see later that how the implementation of the taper or a chamfer could facilitate the assembly. Assembly in sandwich or layer fashion in the sense that when the assembly is made it should be made preferably on a base plate and then part should be stacked one on top of another and accessed to the sub assembly or the assembly should be from one direction as far as possible. That is what is meant by the assembly in the sandwich or layer fashion. We will see an example of assembly on a base as I said.

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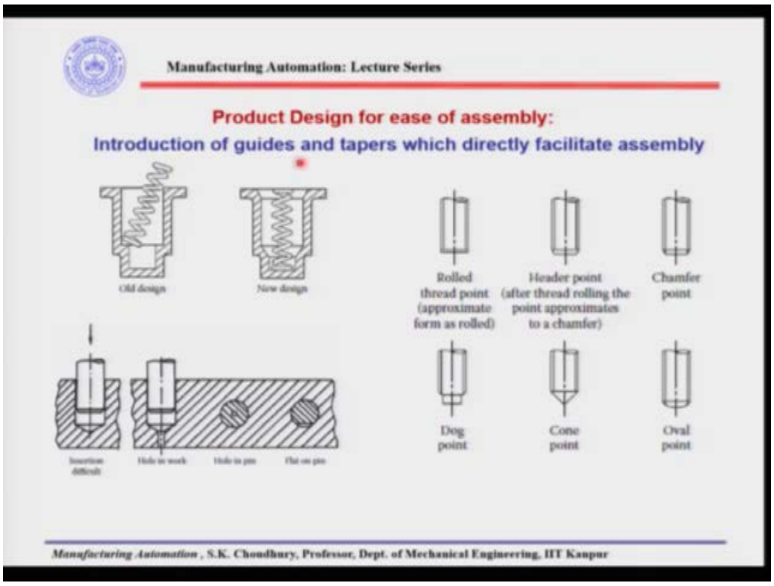

So, here are some of the examples; these examples are quite self explanatory. For example, the product design for ease of assembly: introduction of guides and tapers which directly facilitate assembly; let us take an example. Suppose we have a part like this and a spring has to be assembled; a spring has to go in. So, part placing mechanism will take the spring and put it here.

Now, because of this edge the spring actually may not go up to the end and it may get stuck here because of the design in this part, but this design can be changed by making a chamfer here. That is one aspect and a chamfer or tapering in this case, so that even if it happens like this as it is shown in the first diagram, the taper will guide the spring to the desired position. And with this chamfer and this taper the spring will never be in this position because in this case here it is also lying on that edge of this part. In this case if there is a chamfer, it will also guide the spring to come to the desired location.

There are different kinds of threaded points. For example, here there is rolled thread point this can be obtained from the cold roll. This is the headed point and here we have a chamfer. The difference between this is that this is cold rolled and this is with a chamfer. This also has a chamfer. Now, here this a dog point; this point is called the dog point. Here there is a cone point and here there is an oval point.

So, these different types of screws, now they are mostly used in practice like for example, if there is no chamfer, cold rolled, so, they are very cheap. So, they can be easily used, but when these are used in the automatic assembly to facilitate the automatic assembly, basically the cone point or the oval points should be used because the cone point and the oval point will facilitate the parts. This will to go to the threaded adjoining part for example.

So, dog point for example, can also guide the screw or the threaded part inside the threaded hole. Here there are some examples. This insertion is difficult because it is blind here and sometimes there is a small hole made, so that the insertion can be facilitated or there could be a flat here. This is the hole in the pin or flat in the pin. So, this will facilitate the assembly.

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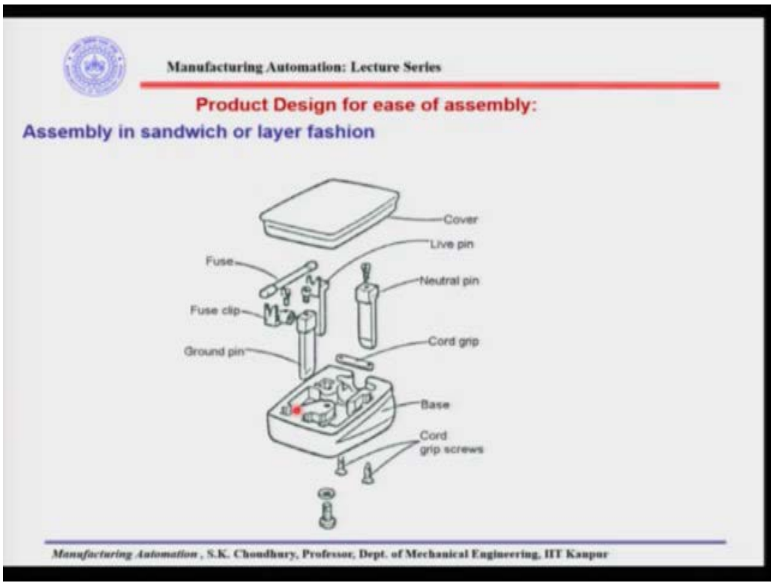

Here is an example of a plug which you understand; this is a simple 3pin plug. When we make assembly in sandwich or layered position, this is exactly what we mean, that this is a base for the plug and to the base the parts are coming from one direction preferably from the top.

This is the ground pin, this is the fuse clip coming to the ground pin, this is the fuse when these two clips are made so, then the fuse can be put in, this is the neutral pin. So, neutral pin, live pin, ground pin are placed here, then the cover can come. So, all are coming from the top. See, the access to the point to the parts, to the assembly is from one direction preferably, as far as possible. When everything goes in, after the cord grip is made with the screws, these screws will be coming from the opposite direction and the main screw to fix this base to the cover; this will also come from here.

So, as far as possible most of them will be coming from the top; sandwich or layer fashion; only thing is that the cord grip screws and the main screw have to come from the opposite direction.

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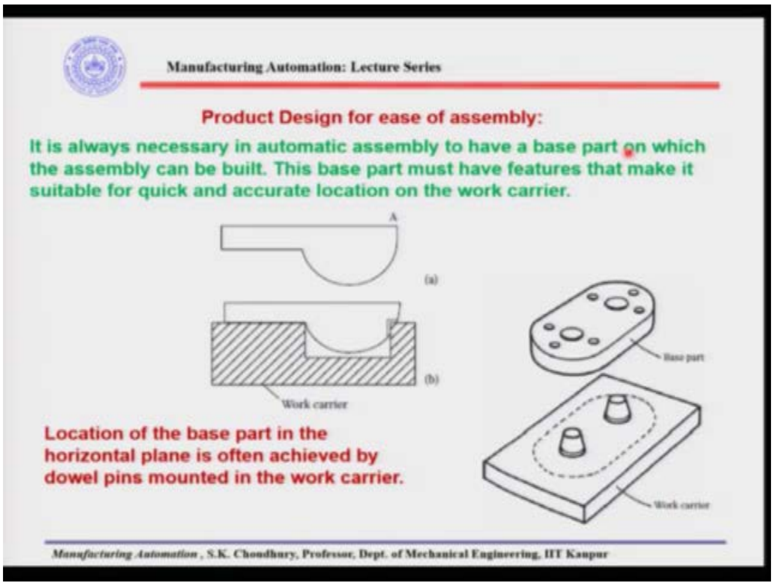

Product design for the ease of assembly, we are continuing. It is always necessary in automatic assembly to have a base part on which the assembly can be built. This base part must have features that make it suitable for quick and accurate location on the work carrier. Let us take an example of this; this is a work carrier. Now, when this work carrier, it will be coming on this on the work carrier. So, this part as a base part coming on to the work carrier, this will be unstable in here because any force which you impart at this point; this will actually rotate the part because they will be touching these two edges.

As you understand that without this ledge or without this alteration in the base part, this base part will be unstably located on the work carrier because any force which is imparted here this will actually rotate on the edges. So, there is a small change in the base part that we are doing here, small feature that has been introduced which is making the quick and accurate location of the base on the work carrier possible. So, once again this is the base part, this has to come on the work carrier and for quick and accurate location of the base part on the work carrier, there should be some specific features. So, without that feature having here, this base part on the work carrier may not be located easily or accurately, that is what we are saying.

Now, the base part is here. So, it sits on the work carrier with a dowel pin, say, these are the pins and these pins go into these holes, so that the base part can be quickly located here. Location of the base part in the horizontal plane is often achieved by dowel pins mounted in the work carrier. So, these are the dowel pins and there, as I said, they can come in. So, in that case what is happening is that base the part can be located with respect to these holes as well and that is very important because some screws or rivet may go in this. So, they have to be located properly with respect to the axis in this direction and they can be done by putting the base part on the dowel pin. These are other examples.

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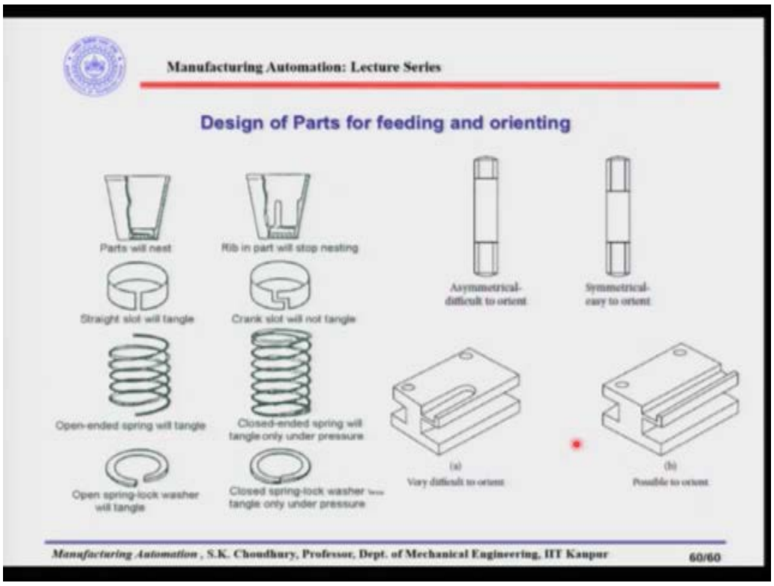

Here some of the examples given with the help of self explanatory diagrams; how the parts can be designed for feeding and orienting. For example, this kind of parts glass-type with cone or a part which is like this, there is a straight slot here. Now, here this is an open ended spring. So, here you can see the change in the design, the small feature that can be introduced, so that this parts can be fed or oriented in a proper way. For example, these parts may nest, one glass may go into another and they can stack and it will be very difficult for the parts to go out on its own. So, this feature is made that is a rib in part will stop the nesting.

Now, one thing we have to keep in mind that these are the small features which should be non functional; in the sense that these features which you are introducing, either the feature that we said here in the base plate or the feature for example here, these features should not disturb the operation of the part. So, they will be non functional. For example, here there is a straight slot. So, another of this kind of a part which are there stacked in the bowl feeder they can be actually entangled. So, if we have a crank slot here instead of having this straight slot; in this case two of those or few of them cannot entangle between each other. So, this is the advantage of changing the small feature in the design.

For example, if we have the open-ended spring. So, another spring can come in easily and they can get entangled and they will clog the exit of the bowl feeder. Now, here we can have a close-ended spring instead of the open-ended spring and in this case the springs will not be entangled with each other. Here there is an example of an open spring lock washer and that can be closed, for example.

Now, here one may ask that if this is the open spring lock washer then if we close it then this spring lock washer functioning will be affected. This will not, because still we have, you can see that, this is not exactly flat, but it will still have the springy action, so that it can still work as a spring lock washer. The only thing is that it will not be open here so that they are not entangled with each other.

Look at this example here. This is asymmetrical here, there is a stud. So, this stud has one end with a thread which is smaller than the thread at the other end. In this case what will happen if for example, this is the ideal orientation that we want, but if the part is coming in the other orientation there will be no feature here, so that it can be reoriented. But, to avoid that problem suppose we are actually increasing the length of this thread, by this much so that it could be equal to the length of the thread made at the other side. In that case whether the part comes in this position or in other position, it will not be matter.

Now, one question that we should discuss here is that when we are increasing the length of this thread to this length, in that case we are incurring some cost of course, because we require this much length. So, it was designed like this and now you are changing the design by increasing the length of the thread for which we have to incur some cost, but it can be economically justified because otherwise what will happen is that some reorienting device has to be created for this to reorient the part if it is not coming in the right orientation. So, economically it has to be properly justified that whether we can make the change in the design in such a way that the cost incurred is justified by eliminating the reorienting device for this kind of parts.

Here there is a part shown which is very difficult to orient because of this groove here. So, this groove, since it is made, let us say half way in the design, so, this feature makes it very difficult to orient the parts. Suppose if we make it like this, in this case this functioning should not be affected that is one thing t. So, we say that any feature I repeat once again that any feature that we are introducing will be non-functional in the sense that it should not disturb the functioning of that particular part.

So, if we are extending that, in that case it will look like this diagram and here it will be very easy to orient because the orienting device can base on this surface whereas, here there is no base because it is not open; meaning that there could be something, some part here based on which this part can be transmitted. But, here it is not possible because, it is closed as you understand that. So, this feature by extending this feature in the design we are not disturbing the functioning of the part, but we are facilitating the parts to get reoriented. These are the ideas of this kind of changes in the design.

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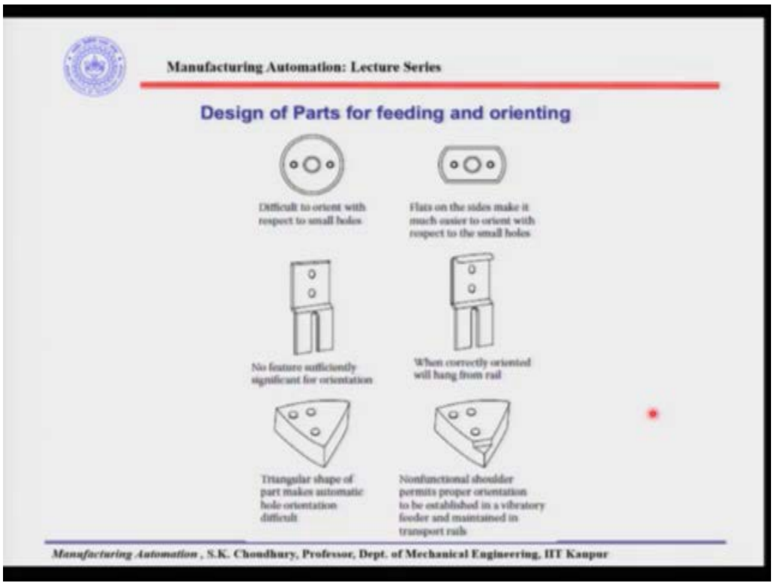

Look at these parts for example, these examples are given for parts to feed them and orient them in a better way; meaning that these changes in the design which have been shown here, will make the feeding and the orienting easier. Let us see this design, this is a disc with a center hole and two holes on the sides. Now, this disc is very difficult to orient with respect to these small holes because there is no surface here to grab, for the gripping.

So, in case we change the design in this way, we are making the flat here and flat here in this case this flat can be taken as a base for orienting this part with respect to these two holes. Otherwise what will happen is that this disc may be gripped in this way or this way or this way or this way. So, there is no way for orienting the part with respect to these two holes as you understand. Look at this part for example, if we change the part design in this way, so that there is a hook kind of a thing introduced here in the design; in that case this part can be transmitted; this part can be fed to the assembly machine when it is hanging on a wire, for example.

If this is the case for this part, for example, there is no way for the part to be fed in a direction or in the orientation like this, and otherwise what will happen suppose if we do not introduce this feature then this part can come in any orientation, but we have to use the reorienting device for example, to give this kind of an orientation to the machine to the assembly machine. Whereas, by making this small change in the design, we are facilitating the part to hang on the wire so that it can be transmitted in a proper way.

In this design for example, triangular shape of part makes automatic hole orientation difficult. Now, here is a triangular shape. So, either it can come this way or with this edge or with this edge then it will be difficult to orient the part with respect to these holes. Whereas, suppose we want the part to come in this orientation, as it is given here, if we make a small non-functional change and make a shoulder, small shoulder like this it is given here, so, this surface can be based to orient the triangular part with respect to these holes, for example.

So, as you understand that these small changes here, there is a small flat here, there is a kind of a hook here, here there is a small shoulder, they will not change the functioning ability of these parts, but these changes will actually facilitate the parts to feed and orient for the feeding and the orientation.

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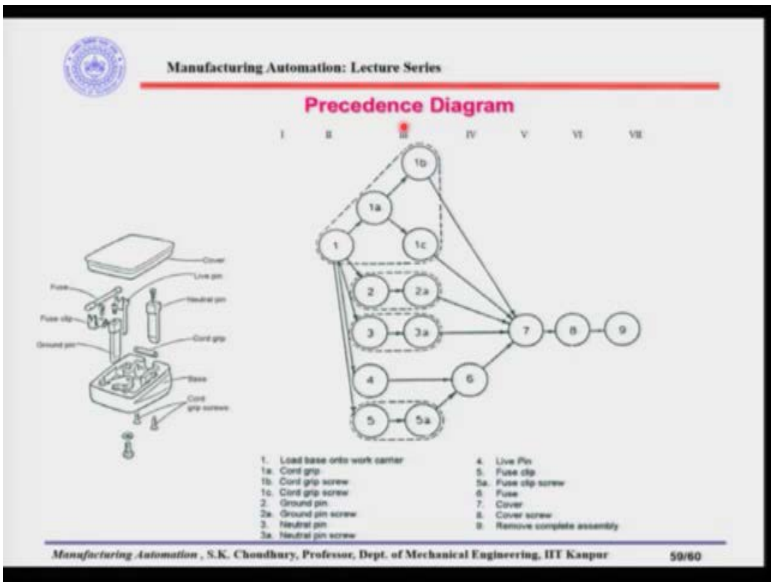

Well, next let us see what is a precedence diagram and in which way it helps us in the automatic assembly. Take an example of this plug assembly that you have seen earlier. So, here what we said are two things: one is that it has to be assembled on a base plate. This is the base and all the other parts should be coming in a sandwich manner or a layer manner from top preferably and from one direction, it should not come from different directions. What is the logic behind this? If we are having that from one direction in that case first of all it is from the top so that we can use the gravity.

And, otherwise what we have to do is we have to use some kind of assistance for the part to flow because if it is horizontal feed track as you have seen, in the horizontal position of the horizontal feed track it will be very difficult for the parts to move to the work station until unless there are other parts pushing above these parts.

So, vertical delivery feed tracks will always be advantageous because there is a gravity which is working. So, that is one reason why we should take the parts from the top and different directions will give you the positioning of the bowl feeder and the feed track in different directions, so, the space cannot be utilized properly. Because of these two reasons we are saying that assembly should be in a sandwich manner and preferably the part should be coming from one direction and preferably from the top.

Now, the precedence diagram, as it is shown here, I will explain it to you what is it. Precedence diagram tells us the number of ways an assembly can be made. To give you that example take this very simple assembly, this assembly is simple because there are only few parts, but as you understand that production machines or assemblies they can have thousands or ten thousands of parts. And, the way to make the assembly, the order of assembly, this is very important because in that case the time taken for the assembly will be minimized.

So, precedence diagram exactly tells us how many ways we can make that assembly. In this case for example, we have a base after that next we will mount the ground pin and the life pin after that we will make the fuse clip, after that we will make the screws, then the fuse on top, then the neutral pin, then this screw, then the cord grip and from here the cord grip screws, then the cover and the screws. So, this is the sequence of assembly that you can make. However, in this sequence we can have some alteration. So, what are those alterations that could be done it is shown by the precedence diagram that we will discuss in the next discussion.

Thank you very much.