Manufacturing Guidelines for Product Design
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Lecture-33
Vibration and Spin welding: Plastics

Namaskar friends, welcome to session 33 of our course on manufacturing guidelines for product design and currently we are in the 7th week of discussion and as you were well aware in the 6th week of our discussion our focus was on joining. And in the seventh week also we are continuing on the same focused area, now why joints are important as all of you are well aware that it is very difficult to make complex shapes using the standard manufacturing processes that are available with us.

If you talk about metals we can cast a product, we can forge a product, we can machine a product, but if we have a very complicated product design it is difficult to either cast it or machine it or forge it. So what do we do we divide, we maybe explode the product into the individual components and then these components we assemble together and get the final product, number of such examples are available with us where different joining techniques have been used to assemble the product.

And we have already seen during 3rd week of our discussion the concept of DFM and DFA, so we have to design our product so that it is easy to manufacture as well as it is easy to assemble, so therefore we need to see that how our assembly will be done. So assembly of the parts or joining of the individual parts it is an essential prerequisite which must be thought of when we are designing a product.

Because once we are designing a product suppose we want to a chair let us take an example of a chair. We know that chair must have a armrest, it must have a seat, it must have a backrest, it must have legs, it must have a central column if we want to make caster type of design for the chair or maybe in general 3 or 4 major components are there which will assemble to give us a chair.

Now we usually do not give adequate attention that how these 4 or 5 different parts that we are going to use or fabricate for assembly into a chair are going to be joined together, what type of joints will come into picture. So those joints are the key elements of design and we cannot ignore these joints why because as we have already seen that joins are the most common areas of failure in any product.

And therefore the designing of joints is very very important and with that focus area only in the first session of this week that was session number 31. And then the second session which is session number 32 what we have covered just we have a brief relook on that we have covered the induction joining or induction welding of plastics. And we have covered the ultrasonic welding of plastics and in both towards the end of the session.

We have focused on some of the joint designs, some of the joint configurations which can help us to achieve better joints, high strength joints, good quality joints, flash free joints. So all these joints will help us to assemble the plastic parts together in the form of good quality products and therefore we have seen that what are the types of joints that must be taken into account. The importance of joining also has been highlighted in session number 31 that is why it is difficult to make very large size plastic parts as a single product.

So therefore we need to make it in different parts and these parts have to be assembled together to get the final product. So therefore we need to understand, we need to highlight, we need to justify the use of joining processes for plastics. Some of you may be wondering that every session maybe 3 to 4 to 5 minutes are spent on just establishing the process or just establishing the background for the lecture.

Now this is important because this lecture maybe followed by one or the other learners or maybe by a group of learners as a standalone lecture may not have heard the previous sessions. So this if somebody is just having a view or just having interest in this particular topic only he must be able to understand that what is the relevance of this topic in the overall product design process. So, therefore we have a little introduction the little buildup a little process of building up for the discussion and then we will switch over to our final topic that is the vibration and spin welding.

So, therefore joining of plastic parts is important already highlighted in session number 31, 2 types of joint configurations for different processes already highlighted session number 31 on induction welding of plastic parts, session number 32 on ultrasonic welding of plastic parts. And today we are going to focus on session number 33 in which the target the vibration and the spin welding.

So, first we will try to understand that what is the difference between the ultrasonic welding and the vibration welding. And then we will switch over to spin welding and finally we will see some of the joint configurations that we must use when the parts or the plastic parts are joined using the vibration welding technique.

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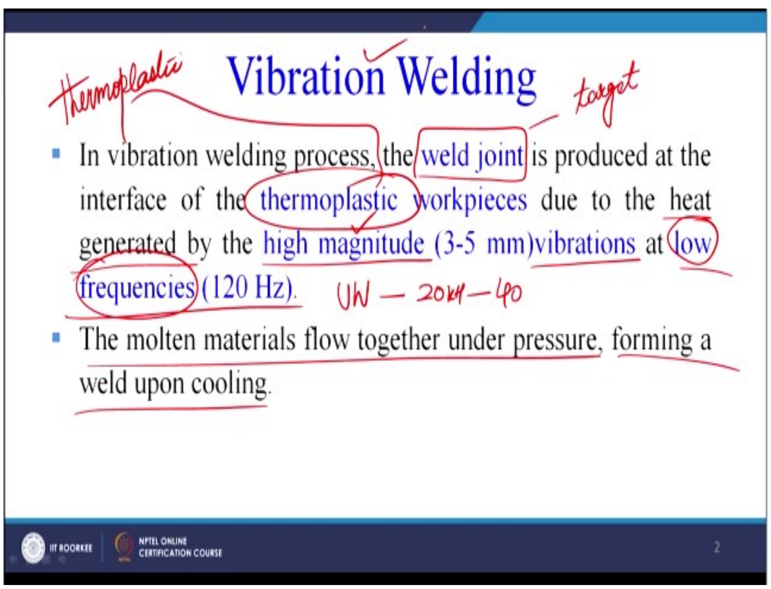

So in vibration welding we can see the vibration welding is a process in which the weld joint is produced at the interface. Now what is our target, our target is to produce the weld joint, now this is the weld joint what is our target. So we want to produce a weld joint how by the heat generated by high magnitude vibrations at low frequencies. So it clearly indicates that here the frequencies that are used are low frequencies.

But the magnitude is high whereas we have seen in ultrasonic welding technique the frequencies that were used in the range of 20 kilo hertz to 40 kilo hertz. So therefore in ultrasonic frequency range we do the ultrasonic welding and in vibration welding the frequencies are low but the magnitude is high. So that is the basic classification of categorization of the 2 joining techniques that is ultrasonic welding and the vibration welding.

So, what is the mechanism, so mechanism remains same that the frictional heat is produced between the 2 surfaces to be joined together and at the interface the localized melting of the plastics take place and then they solidify or they regroup or rejoin to form the joint. So, the molten materials flow together under pressure at the joint interface forming a weld upon cooling. So, when they cool down they form a joint between the 2 interfaces and one important thing which we are seen in the previous session also.

The material here is again a thermoplastic material which means that it is difficult to weld the thermosetting materials or thermosetting plastics using the vibration welding technique. So major application of vibration welding technique is for the joining of the thermoplastic type of materials by producing heat at the interface of the plastic surfaces how with the help of low frequency, high magnitude vibrations.

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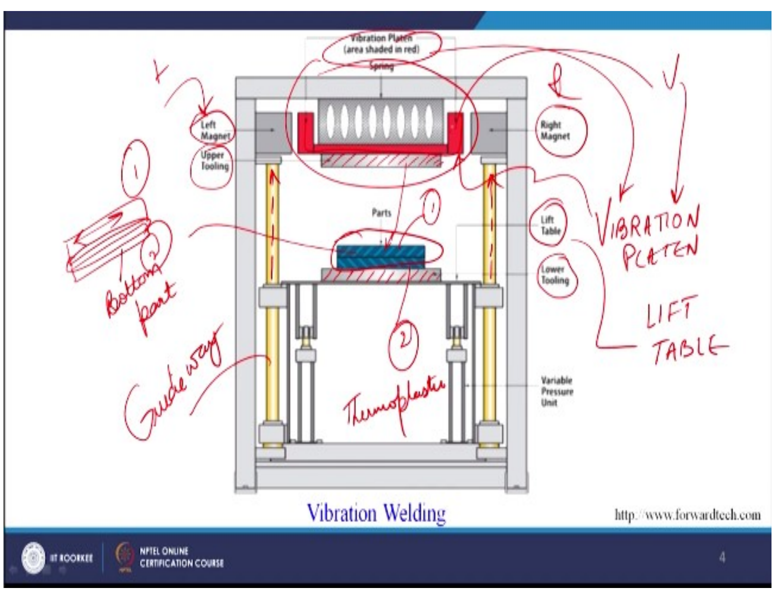

So, now let us try to understand the process of vibration welding with the help of the schematic diagram. So as you can see in the schematic diagram we can see that there is a upper tooling which we can try to understand with the help of this label that there is a upper tooling, so I will just highlight the upper tooling for you. This is the upper tooling upper part of the mold and then opposite to this is the lower tooling that we have here.

So the joint or the welding will be done between these 2 upper and the lower tooling or the upper and the lower halves of the mold. As we know that the vibration welding is a high magnitude and low frequency process which we have already seen in the previous slide. So we have to induce the vibrations, now how these vibrations will be induced that we can try to understand here we have a left magnet here and a right magnet here and the vibration platen is here.

So I will write this may not be very very clear, so this is a vibration platen I am writing it with red color and it is depicted also with the red color only. So this red portion which is depicted here is the vibration platen, so this is going to vibrate, so this is our vibration setup in majority I can see. This is our vibration setup and these are the 2 parts shown in blue color here which you want to join, now these 2 parts maybe this is the first part, this is second part and there is a gap between these 2 parts and these 2 have to be joined together at this interface.

Now we will give maybe vibration to the top part, the bottom part which is to be joined will remain stationary. So, the bottom part remains stationary we try to give a vibration like this, so when we vibrate the 2 parts together that is this is our part number 1, the bottom 1 is part number 2. So, we have to join the first and the second part with the help of the heat generated by the vibrating action of the top plate or the top part.

So when we generate this kind of a motion we will be able to join the 2 parts together, so these 2 parts have to be held together. So, here we can see how the movement will take place if you see there is another label here which is again I will write it for you which is a lift table and there are guide ways here. This is the guide way, so this guide way will help the movement of the lift table in the upper direction. So in this direction our lift table will move up and then when the upper part will come in contact with the vibration platen it will vibrate.

And it will create a relative motion between the 2 parts that have to be joined together and once the adequate amount of heat is produced between the 2 parts that have to be joined together they will form a joint. And specifically these processes as you can understand and remember is used for the thermoplastics only. So, we are majorly doing the vibration welding of thermoplastic type of polymers only.

So, just to give a brief review of this whole schematic once again I think one by one first thing is the parts that have to be joined together. So, basically we are going to focus on the thermoplastic parts that is one thing then what is a source of heat, the source of heat is the vibration platen which is written here. So, the raw material is the thermoplastic, the source of heat is the vibration, how the vibration is generated with the help of the left magnet and with the help of the right magnet.

So there is the vibration platen which is shown in red color, so this vibration platen will induce the vibrations between the 2 parts that have to be joined together to be very very specific. These 2 parts will be the thermoplastic parts and when these 2 parts will generate adequate amount of heat at their interface they will be joined under pressure. So the joint is formed between the upper part of the tooling and the lower part of the tooling which is clearly mentioned here.

So, the 2 parts of the tooling is brought together with one another with the help of the lift table and the lift table is moved over the guide ways. So, this is the basic schematic working principle of the vibration welding process. Now let us quickly go to the spin welding of plastics, so we have already understood that what is the difference between the ultrasonic welding and the vibration welding, so difference is clear.

Now we go to spin welding which is also commonly use for joining of plastics, now if you have seen there are similar welding technique for welding of metals also and I leave this as an assignment to you that you try to draw analogy between this welding and the similar process that is use for welding of metals. And I am sure that there is a process which is use for welding of metals also based on the similar principle, so in spin welding of plastics what we do.

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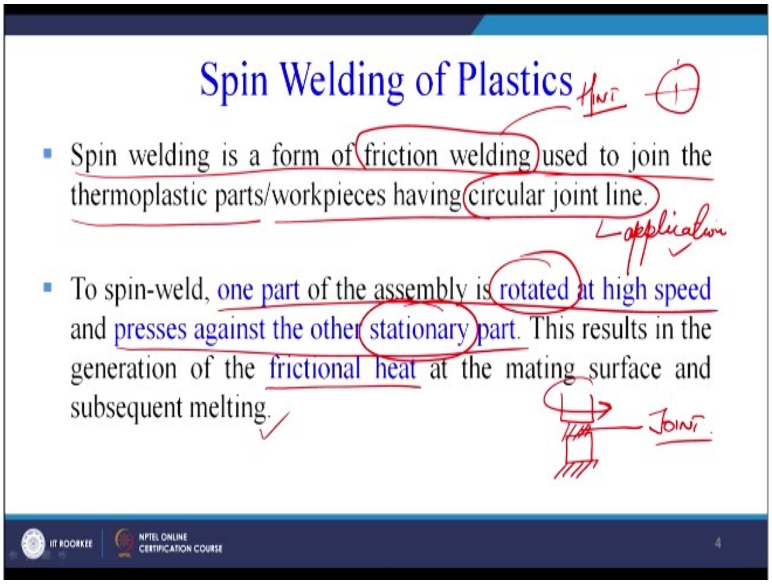

Now spin welding is a form of friction welding so already the hint is there that what is the process which is used for joining of metals. Now spin welding is a form of friction welding used to join the thermoplastic parts work pieces having circular joint line. So this is one important application area for which the spin welding of plastics can be done.

So circular joint line, so maybe when we have this type of a cross-section in that we can use another part from top can come and the spinning action between the 2, relative motion between the 2 can create a joint and that joint can be used as a maybe a joint in the design process of a product. So the spin welding is a form of friction welding used to join the thermoplastic parts or work pieces having circular cross-line.

So, which is 1 application, we will see the with the help of an example with a help of a diagram. To spin weld now what is the procedure let us try to see, to spin weld 1 part of the assembly is rotated at high speed. So, suppose the 2 parts have to be joined together 1 part will be rotated at high speed and the other one will be kept stationary and because of this relative motion between the upper and the lower part frictional heat will be created.

In ultrasonic welding the 2 pieces were rubbing against each other at ultrasonic frequency. In vibration welding we have used low frequency but high magnitude and here we are trying to produce the relative motion between the 2 plastic parts by the rotation of 1 part. So, to spin weld

1 part of the assembly is rotated at high speed and it is pressed against the other stationary part.

So, the 1 part is rotated, the other part is stationary, so we can see that if 2 parts have to be joined, so it is part number 1, part number 2. This is rotationary and this is stationary, so one is rotated another one is stationary. This results in the generation of frictional heat, where is the frictional heat generated at the mating surfaces at the mating surface and the subsequent melting and on cooling we will get a joint at this point.

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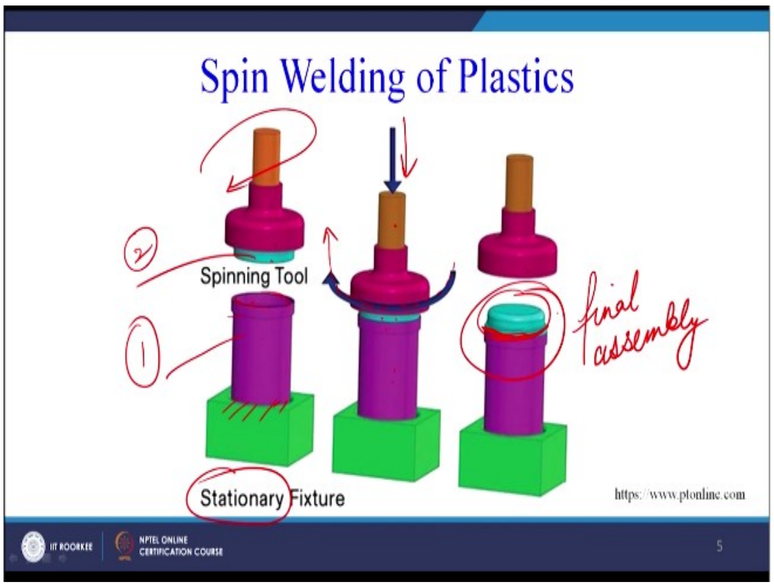

Now let us try to see the diagram, now this is the spinning tool, this is our part number 1 and you can see it is stationary here already written stationary and this is the spinning tool which is rotating. And this is the second part that we want to weld here or that we want to join here. So, this is the rotating part already the direction of rotation is clearly indicated, so you apply bring it down you apply some pressure and this part is joined to this part and this is our final assembly.

So we can see very easily that by creating a relative motion between the 2 parts which are to be joined together and because of the frictional heat that is created because of the rubbing action between the 2 parts we are able to form a joint on cooling of the localized molten portion of the plastic at the joint interface. So this is the final assembly which has been created and with the colors it is very easy to understand there is a spinning tool this is a top part, this is a bottom part, it is a stationary, this is stationary.

Relative motion between the 2 parts this being stationary, this being rotating and finally a joint being formed in this area. So, therefore this is the basic principle of spin welding, now let us try to come to the major topic that we have try to understand 2 processes the working principle that is 1 is related to the vibration welding of plastics another one is into spin welding of plastics.

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Now let us quickly focus on our major area that those are that is the design guidelines for vibration and spin welding of plastics. That how the parts must be designed when we know that these parts are further going to be joined using the vibration or the spin welding techniques or what are the precautions what are the rules that we must follow when we are designing the plastic parts which have to be joined to other plastic or other non-plastic parts using the process of vibration welding.

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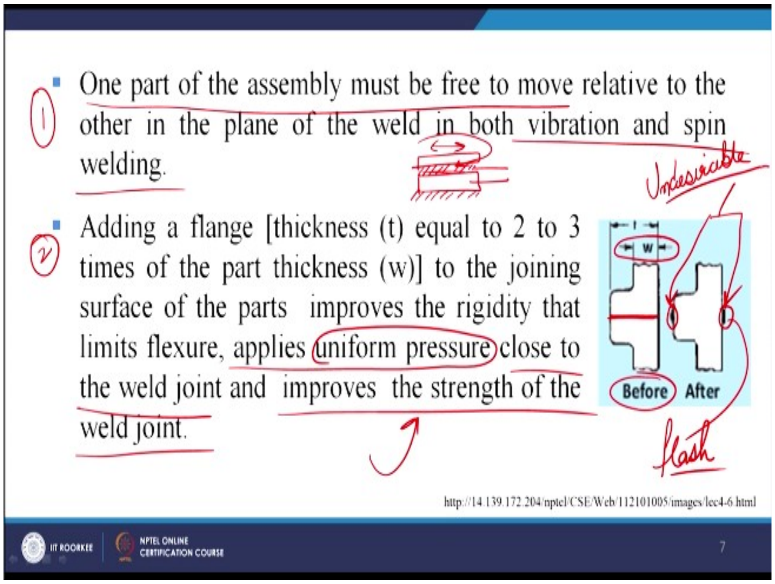

Now this is an important guideline let us see what is the first guideline here one part of the assembly must be free to move relative to the other in the plane of the weld in both vibration and spin welding. So, it is very very clear one part of the assembly must be free to move, so as we have seen one part is usually kept stationary and the other part must be able to move or it must be able to spin relative to the stationary part.

So, that we are able to create the frictional heat between the surfaces and a joint can be formed. So, one part of the assembly must be free to move relative to the other part in the plane of the weld. Now this is the plane of the weld in both vibration and spin welding, so in both cases a relative motion between the 2 parts is necessary or the 2 plastic parts is necessary which we have already understood in case of the diagrams that we have already seen.

Now the second guideline is adding a flange equal to 2 to 3 times of the part thickness, so we have seen that this is the part thickness w. So, if we add a flange which is 2 to 3 times of the part thickness to the joining surface of the parts, now this is the joining surface of the parts. So, adding a flange to the joining surface of the part improves the rigidity that limits flexure or bending under the flexural conditions applies uniform pressure close to the weld joint very very important.

Uniform pressure must be applied close to the weld joint and improves the strength of the weld joint. Now most important part is the joint strength, so if adding a flange which is greater than or whose length is or thickness is equal to 2 to 3 times of the part thickness. If it is able to give us enhanced improved strength of the joint we must go for it, so this is the before condition, this is the place where we want to create the weld.

And this is the final weld and you can see a little bit of flash which has been formed or left behind after the welding action. So, one of the important guidelines is here that wherever possible we must try to use the flange for forming a joint. The geometrical constraints are also given that what must be the thickness of the flange. Now special joint designs are required what are the special joint designs.

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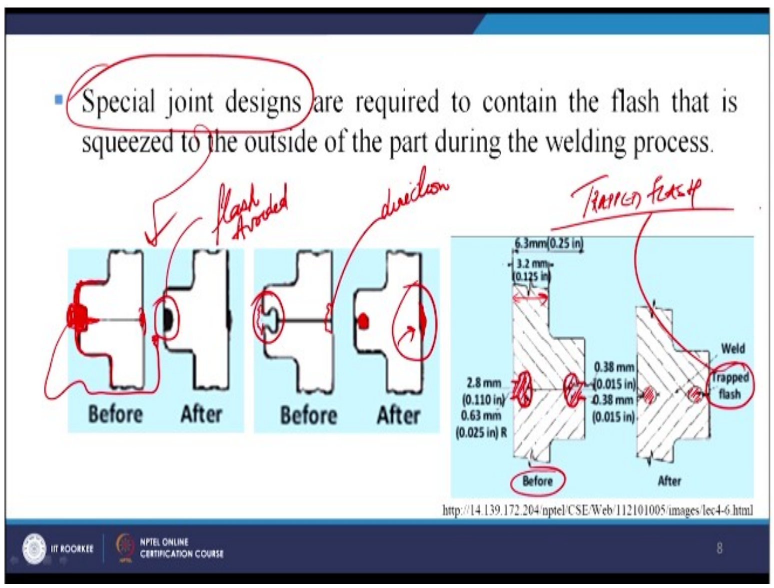

We will see with the help of diagram are required to contain the flash that is squeezed to the outside of the part during the vibration or the spin welding process. So, we have seen I will go back again to the previous slide and see that this is the area where the flash has formed. And this is completely undesirable because it adds another finishing operation once the product is ready.

Now suppose we have joined 2 plastic parts and a flash has been created at the edges, now before using you need to just maybe what do we call we can grind that in case of metals that flash can be removed by the grinding or the trimming action has to be done in order to get away from that flash or we not to remove that flash. So, additional process is added, now we must try to design our joints in such a way that the problem of flash can easily be avoided and no additional trimming or grinding is required after the process has been done.

Mostly grinding we use in case of metals and here we can go for simple trimming action, so how that can be avoided that we can see here by little modification in the joint design. So special joint designs are required which are shown here. Now this is a modification in our previous case we have seen that the joint was like this and there was flash which was formed here and flash which was formed here.

So if we modify that joint design like this, so whatever flash will be formed here can be accommodated in this area which can easily complete the surface which is shown here. So, a better product design or a better joint design in the product can help us to avoid the problem of the flash. So, here the flash has been avoided, so joint modification is useful and similar is the case here.

Here we can see there are chances that the flash may form here, so when we modify the design the flash is filled here additional molten plastic is filled here. But on this side still we are getting some flash and this can easily be avoided by modifying that joint design in this direction also. So we can modify the joint in the other direction also, so here we can see this is given with complete dimensions the modification in the joint design to mitigate or to completely eliminate the process or the problem of flash.

So, the flash will get accumulated in this area and will not get out of the at the edges of the 2 surfaces that we are joining together. So, this is 1 joint, so the thicknesses are given this thickness is 3.2 millimeter this thickness approximately 3.2 millimeter, so this is before. And it is expected that the flash must filled these vacant spaces in the joint design, so here we have seen that the flash the plastic has filled these open spaces.

And it is clearly written here trapped flash, so this trapped flash is not allowed to come out at the edges and therefore easily avoid the additional process of removing the material at the edges. So we can see that which little modification in the design we can very easily avoid the problem of flash. So, I think with this we can conclude the today's session we have tried to understand the various type of design modifications or what type of joints we must design in order to avoid the problem of flash.

In order to get good joint strength only we have seen that using a flange we can improve the joint strength using a special type of design or special type of joint design we can completely eliminate the problem of the flash. So all these designs will help us to get a good joint, so maybe the last type of joints that we can come here is that break away stud or socket can be incorporated into the halves or the part halves for easy assembly alignment.

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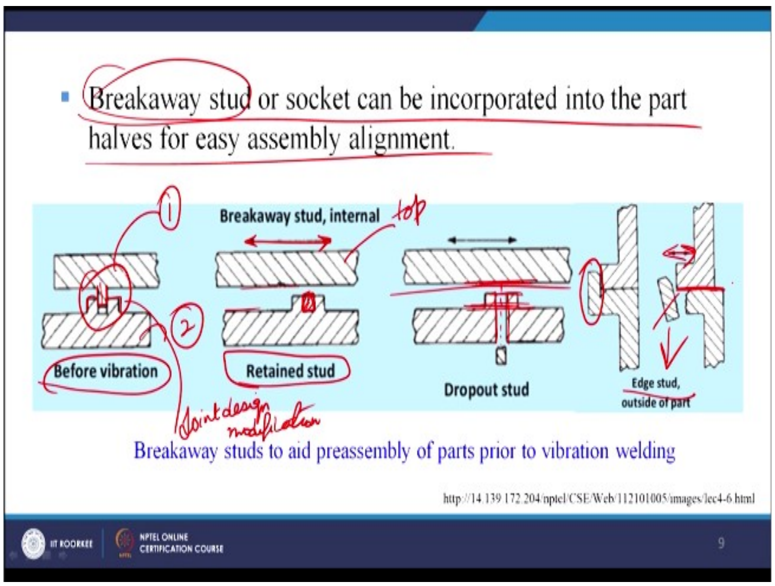

Now 2 parts have to be aligned, this is the first plastic part, second plastic part they have to be aligned. So, this type of an arrangement design modification can be done that they are aligned properly. So this is the motion or the vibration which is given to the top part which have to be welded to this part.

So when we have to join the 2 parts together such type of studs or breakaway studs can be use to ensure the alignment between the 2 part and then we can give the relative motion or the vibrations which are of low frequency and high magnitude which will help us melt the surfaces and form the joint. So, this is in this case, special case the stud is retained here, retained stud this is before vibration and this is the joint design modification.

So we have modified the joint design and here this stud is arrested here we can see and if the design is like this the stud can fall down from here and we will try to get a joint in this direction maybe this surface will join with this surface here. And we will be able to form the joint and similarly we can have a edge stud this is the edge stud and when this vibration is given the adjuster may break away and fall down and we will be able to get a joint here adjuster outside of part.

So, this is the outside the part, so we can get the joint here, so we can see that modifications in the joint design use of the breakaway studs can help us to get good joint strength, good bond line, good bonding between the 2 parts and in totality a good product which is having a number of joints which are there to join the plastic parts together. So, we when we are designing our product we must keep in mind that how the parts that are going to be assembled for making this product, how they are going to be joined together.

So first is how and second is if we know that they are going to be joined together by induction welding or by vibration welding or by ultrasonic welding how the joints must be designed in the product. So that we get a good quality joint which is free from different types of defects as well as give us good joint strength. So with this I think 3 types of processes we have covered the induction welding of plastics, the ultrasonic welding of plastics, the vibration and the spin welding of the plastic.

In our subsequent session we will focus on other advanced techniques that can be used for joining of plastics with this we conclude the today's session.
Thank you.