Welding Processes
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Joining Processes for Plastics - Part 01

So we will start from the new unit, the last unit of this course okay so we completed the majority welding processes be widely use for metals and alloys, so there is a special processes we use for soft material non-metals, so especially for plastics and these processes are also very important because the volume at which this process operate is also very important to understand and the principal behind this process is used for joining plastics right, so we will look at in these last units the processes that are commonly used for plastics right for both types of plastics. Okay so what are the types of plastics generally in which we classify plastics, 2 classes right.

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Okay so thermosetting polymers and then thermoplastic. What are the difference between these 2?

Student: (())(1:15).

Professor: Yes, once you process, once you melt and shaped into a given design the thermosetting polymers cannot be re-melted and then cannot rework. Examples?

Student: (())(1:29).

Professor: Backlight for example and then?

Student: (())(1:34).

Professor: So vulcanised elastomer for example tyre, rubber, vulcanised rubber so recycling can be very difficult once you make it, so generally the thermosetting polymers are difficult to joint okay so we will have to either use adhesive bonding or mechanical fastening but as in most of the application if you look at which the plastic (())(2:01) automotive applications. Can you give an example where it is used in automotive?

Student: Dashboard.

Professor: Dashboard for example, lamps okay so if you have 2 wheeler indicator lamps those are thermoplastics and we can recycle them and these thermoplastics are widely used in engineering application because you can join them easily right, so you can use simple joining method what you are going to look at in this class to really advanced joining methods. We can also use them to make part sort of these thermoplastic polymers. Can you give me example of thermoplastic polymers?

Student: (())(2:45).

Professor: Polyethylene, polypropylene…

Student: (())(2:48)

Professor: PVC Polyvinyl chloride, so these are all very commonly used thermoplastics for engineering application right, so we look at one by one.

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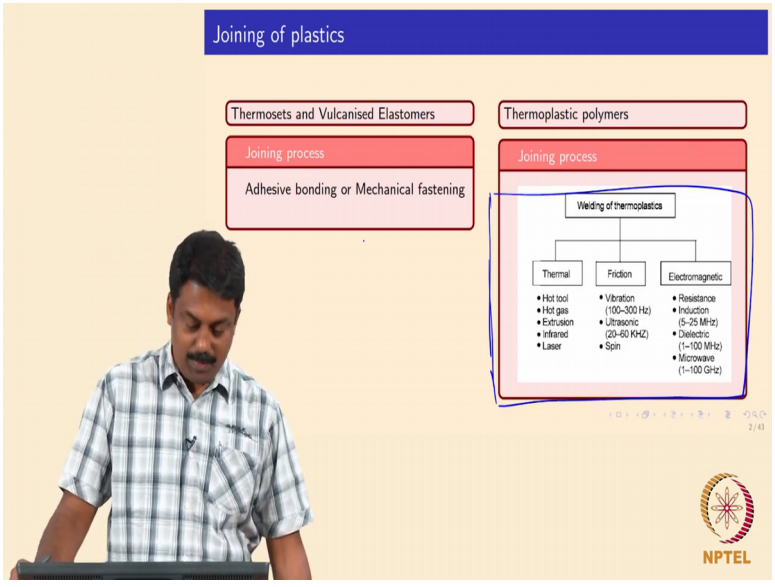

Before that the classification as I just explain so you can classify into 2 types of polymers, thermosetting and thermoplastic. Thermosetting polymers are very difficult to joint forget about it, so thermosetting polymers, so once you melt them and then cause them into a design it is very difficult to join them or you need to make engineering composite out of it and further work with that, so majority of thermosetting polymers in engineering application when you want to joint we use adhesive bonding right or mechanical fastening.

Most of the cases if you look at thermosetting polymers the components that are actually using engineering application that is the final shape, so it is almost like a net shape casting moulding is done this thermosetting polymers and then those competence are directly use in engineering application without any joining so we usually avoid because of difficulties in joining them using say for example methods we use it for thermoplastics.

So thermoplastic on the other hand they can be divided using various process that we are going to look at in this class for example we can use thermal methods like hot plates, hot gas, hot tools, extrusion process and laser-based processes, infrared optical welding processes or you can also use frictional welding like we looked at it the last class (())(4:33) process was developed mainly for polymers plastics right.

So you can use fiction to weld the polymers and ultrasonic transducer, ultrasonic welding what we use it for metals and alloys we can also be very well use for plastics right and also you can use in some induction processes electromagnetic processes resistance induction heating, microwave heating or dielectric heating right, so we look at first the welding processer, the joining processor used for thermoplastic polymers and then we look at the major joining process used for thermosets that adhesive bonding right, so first very simple process used for joining off plastic is using a hot plate okay, so I do not know how many of you have seen nowadays plumbers working with PVC pipe okay what do they use to join pipes.

Student: I was in (())(5:33) so we used to adhesive.

Professor: So they use adhesive, so the thermoplastic polymers the most easy way of joining them is to heat them up and apply some pressure and joined okay so using in hot plate.

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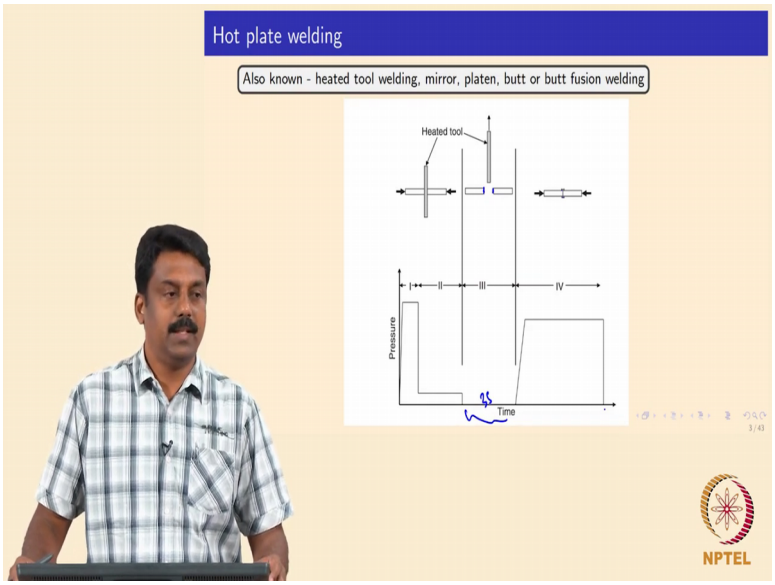

Okay it is also known as hot tool welding or mirror, platen, butt and fusion welding processes, so the method is very simple in hot plate welding so you have one heated tool or plate that goes actually inside the (())(6:05) interface to join right and then you melt the interfaces right so you have heated tool, the joints to be welded or heated up at the interface using an hot plate and subsequently apply in (())(6:25), so you also create some scene.

So this is the most commonly used joining methods used for thermoplastic hot plate or hot tool welding okay so this process is very simple, so you apply some pressure with the tool and the tool is withdrawn and this time it is very critical that is about 3 seconds not more than that, so if you leave the time interval more than critical limit the molten interface would solidify immediately is not it, so you have to make sure that the tool is heated and interface is molten and the tool is removed immediately upon removal of tool you do an upsetting, so in this process the interface is joined and you create a flash and then interface are molten and this is very simple process because thermoplastic can be molten end number of times compared to thermosetting is not it, so thermoplastic can be welded very easily using an hot plate right good.

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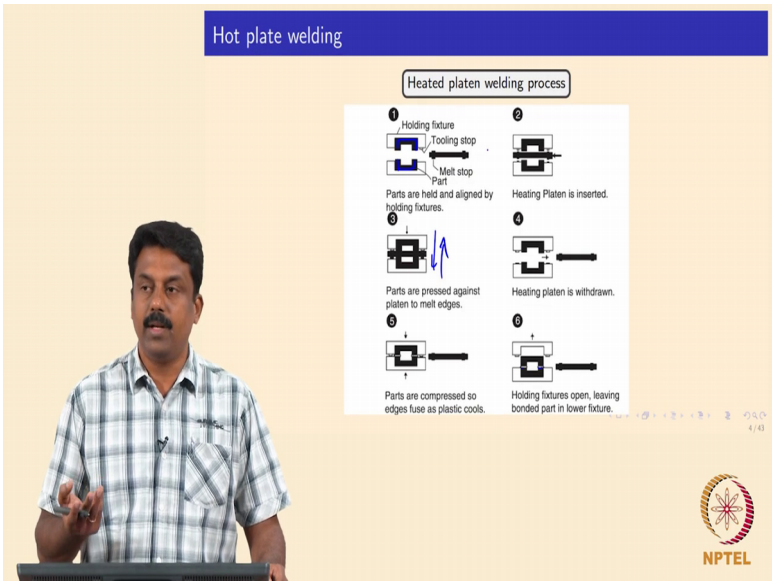

There are lot of variants of hot plate welding if you look at it, so one of the simple methods I showed you and you can also use hot plates with proper fix set and camping okay, so this is heated platen welding process where the components to be welded are held with a fixture say for example in this case we will have to weld the L clamp the L frames.

So you hold it with a proper fixture and then hard plate is inserted between the components to be welded and then the fixture are bought into (())(8:14) okay after heat plate is inserted and then you apply pressure okay the hot plate is pressed against the parts to be welded and then you melt the interface, subsequently you remove the hotplate and then you apply (())(8:32) pressure and then you have solidification of the interface forming adjoin at the interface, is not it? So it is same as the one you saw in previous slide, so in this case it is with proper camping right the hot plates welds are made using a simple molten hot tool, is it clear? Okay.

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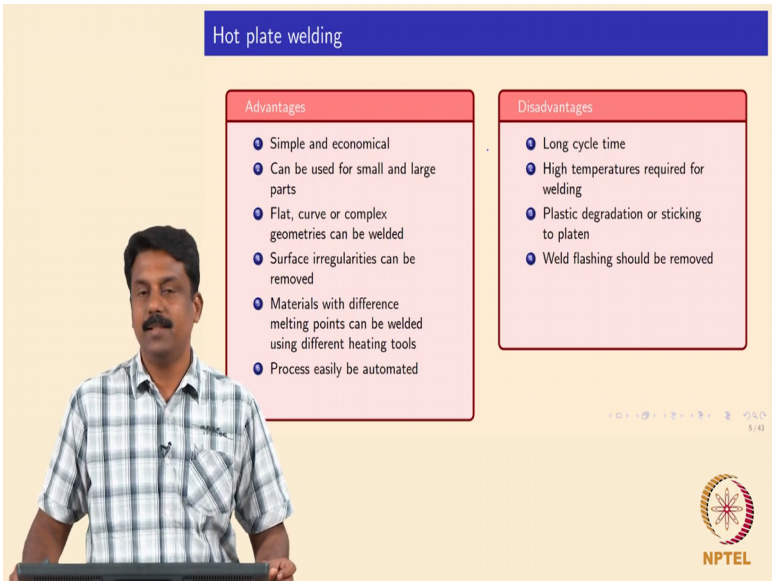

So what are the advantages this process? It is very simple and economical right so you do not need complicated heating mechanism like you see in induction welding or…it is not messy it is very simple process right, so it can be used to weld large parts of even small parts, flats, curves any complex geometry can be welded right and the other main important advantage is the surface irregularities so no need to have proper preparation of the surface. (())(9:31) preparing surface is extremely important we will have some time do (())(9:35) okay.

So the surface has to be polished very well and then (())(9:43) minus 10 degree generally we do it in our lab as well as for adhesive bonding. So those kind of complex replacement you do not need because you have a…take a hot tool press the hot tool against the interface and the interface is molten and then subsequently remove the hot tool press it again and then you have solid joint okay.

So the materials with different melting points can be welded by using different heating tools no need to use the same tools, so you use one tool for bottom joint or bottom interface another tool for top thing and then you join together yes and you can also automate the process easily right so I mean these process are automated very commonly, most of the automated components for example indicator lamp you have an orange top and then bottom white thing right so those 2 are joint by hot plate welding okay and if you look at…how many of you use shavers for example, shavers the plastic mount they are all hot plate welded.

There are some disadvantages of the process like for example you need to have long cycle time okay then high temperature are required and sometimes you generate fumes which are

cosmogenic okay so when you melt and then you generate fumes of polymers and those fumes has to be properly cycled, recycled and captured then sent out otherwise the polymer fumes are cosmogenic right.

So sometimes the plate itself get degrades because the molten polymer can struck to the plate itself then plate has to be the regularly removed any cleaned and you always get flashing because you melt the interface and then subsequently you do (())(11:39) setting so you always have a flash forming that has to be machined off and do these process, yes is it clear? So technology wise it is very simple, you melt and heat up then press it that is it job done.

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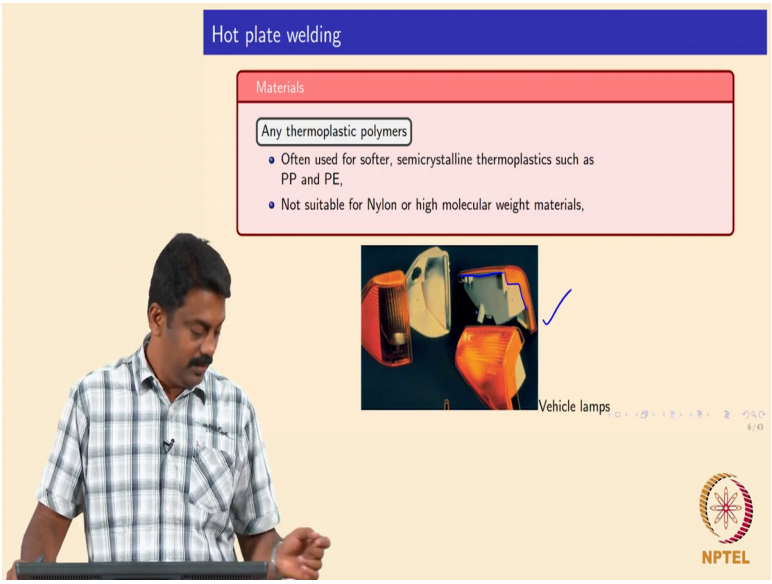

So material wise all the thermoplastic polymers can be used, so this is the one I am talking about so it is very commonly joined if you look at these 2 parts, is not it? So the vehicle lamps and those are all hot plate joint, so the bottom one and top one they are actually joined at this interface, so these 2 are the prior joining interface and you make an hot plate tool similar to the configuration what you want and then these 2 are different polymers right.

So each tool can heat up the interface to a required temperature and subsequent tool is removed and then they are pressed on the reformer flash, the flash can be removed easily right is it clear? So we can use it for any thermoplastic polymers this process, more often widely use for (())(12:54) softer because then you reduce the (())(12:57) pressure you need okay. For polypropylene or polyethylene sound suitable for nylon high-temperature high molecular materials because you need to heat up higher temperatures okay and if it softens

much easily as per the temperature and you can also not use it because the entire structure will collapse right, good. Any questions so far in this process?

Student: (())(13:28).

Professor: Semi-crystalline thermoplastic they become extremely soft and, so you need to have these component itself should have some strength otherwise how do you do in (()) (13:41) say for example the example of semi-crystalline polymers some sort of flexible rubber polymer, you cannot use that okay so collapse (())(13:52) rubber tubes. You need to have some up-setting right otherwise how do you do in up-setting force as these are already in collapsed, so if you melt and then it does not have any mechanical strength at all, so for semi-crystalline thermoplastics it has to (())(14:14) last to use have some strength okay so in this process that is why it is very commonly used for polypropylene and polyethylene okay, so nylon it is not possible because that will collapse okay.

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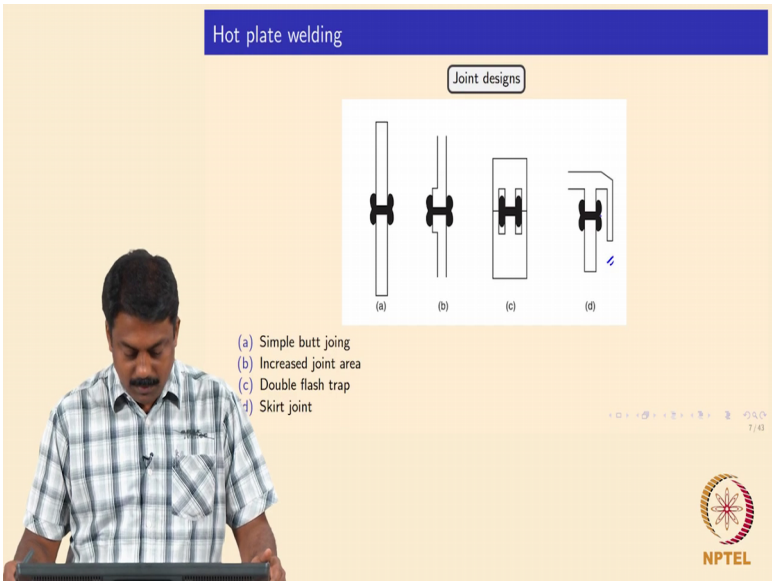

So what are joint design we commonly use for hot plates? Simple label joint and you can also increase the area okay so that the well strength and joint strength increases at that regime and you can also do double flash and skirt joint okay, so this skirt joint is also commonly used for polymers right, good so we will move on, so we will just run through.

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So this is one of the complete flash butt fusion weld, you see this is the PVC pipe okay so the PVC pipe the joint is made using a hot plate weld.

Student: So similar way another (())(15:25).

Professor: Insider will also be there.

Student: (())(15:29).

Professor: It can completely remove, so generally the tool with numerical goes inside with orbital machining especially if the pipe require… to maintain the flow of fluid at a given velocity in engineering application which are really important then you can send the orbit of machining tool go inside and then machine it off but generally this kind of PVC pipes are not used for applications which requires precise control of flow inside the material for example pumping you need plumbing application you do not need to remove flash okay.

So you can very well use flashed inside and even flashed outside also look good, is not it? Yes so the PVC pipes, now we can use hot plate to weld the joint and sometimes if you buy PVC pipe of (())(16:23) application you will see the weld but once the flash is removed it is very difficult to identify where exactly the joint is, okay so it becomes highly integral the pipe itself but if you look carefully you can see the (())(16:38). So whenever I see some structure weld is there I just go and look and stare at it. Similarly in PVC pipe for plumbing if you look at…in most of the cases you cannot buy one single seamless PVC pipe, so you may see some joint, so most of them are butt joints okay, so if you remove this flash you do not

see much of the joints. You can use the hot plate welding to join the PVC pipes as well this is also commonly done okay.

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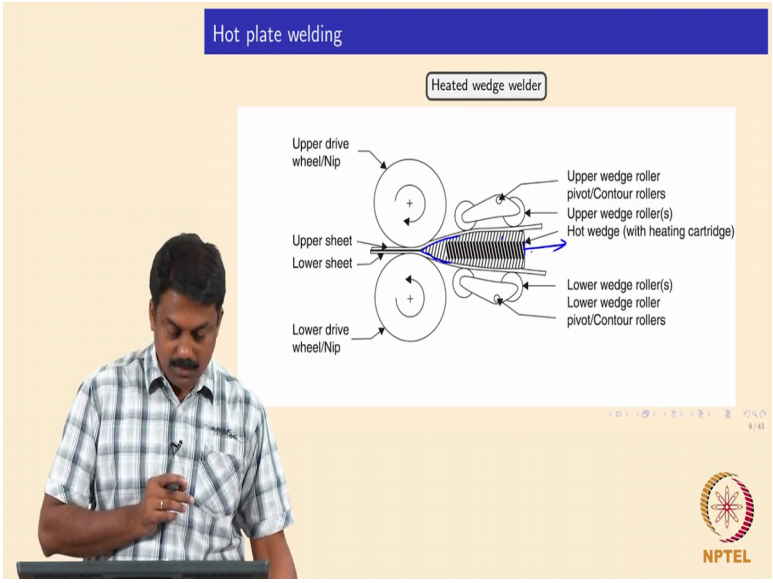

And there are some modification of the process especially the welding jointing to be done over a long seem, so we also modify the heating tool say for example in this case the wedge heater is placed at the interface between 2 joints to be made, so this is like a long seem welding, so you will have to joint 2 long plates longitudinal seem, so what you do is you place a resistant heated hot wedge at the interface you heat up the interface and subsequently the rollers roll it and this is levelling rollers okay and then this is driving rollers okay so driving rollers rolls and you heat up the interface using an assistant heated wedge and then the wedge moves subsequently the interface melts and you have a levelling rollers and then the work roller.

A work rolls just move along the interface and then the interface comes into contact (()) (18:20) there you apply the pressure by these drive holes subsequently you can make seem joints right, is it clear? This unit is also commonly use let me have a picture of that, no okay and this is commonly used to weld thermoplastic plates especially the thin section plates right so for varying application we may need the polymers for example you will have to cover a table with plastic coating so then you will have to joint with seem joints right so the principal is very simple, instead of hot plate over there here we have heated wedge, wedge travels at the interface it does heat up the interface by (())(19:12) conductive heating.

Interface is molten subsequently the roller which follows the molten interface and then apply some compulsive pressure, compulsive forces on the interface and the interface quite less and from join right, is it clear? Good. Okay so these are some modifications in hot plate welding, the principles is same we always have some tool which heats up the interface and the tool geometry can be anything, the principal is use a heated plate melt the interface apply some (())(19:45) and then form a joint, is it clear?

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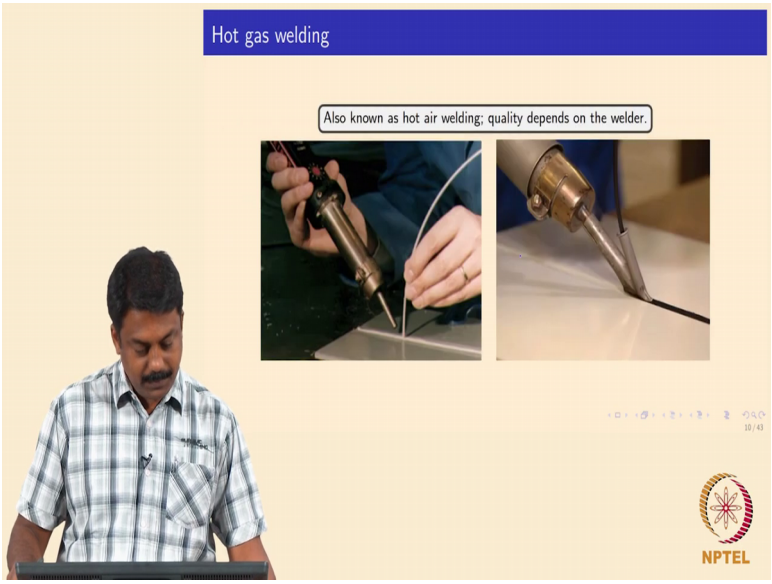

So other process we also commonly use to weld especially if the welding cavity is larger and you have to fill more volume at the interface, if the base material is thicker than we also use a process known as hot gas welding okay, so hot gas welding the principal is again the interface is heated in previous case we used plate right, so in this case we use an hot gas or hot air okay and you melt the interface and we can also simultaneously add some filler, right so this filler goes in this is the hot air tool which sends you hot and melts the filler as well as heat the interface and the molten filler subsequently deposits at the weld cavity it is like GMAW welding, is not it?

So what you do is you have a hot air, it melts the filler and deposits at the filling interface right, is it clear? And the filler can be low melting thermosetting polymers or we can also use thermoplastic polymers but thermoplastic polymers generally they have less strength than thermosetting polymers, so we can also melt and deposit the polymers and then make a joint, so what are the advantage? If you look at the process itself I may have a picture…no.

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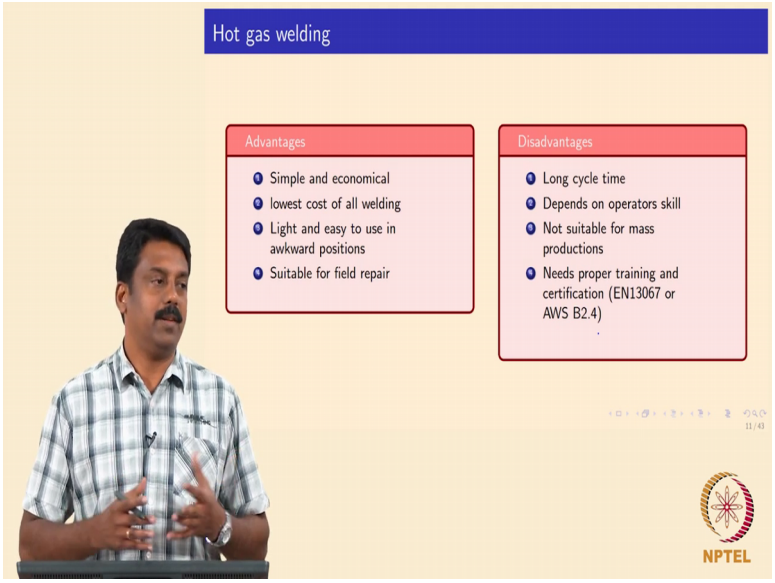

So what are the advantages compared to the other processes of hot gas welding is a simple economic like again low cost and light and easy to weld in awkward positions because you can also reach the places which are actually not reachable by hot plate welding. It is also widely use for repair, fill repair so you can use a filler and then hot gas to melt the filler and deposit at the area which is broken okay but there are some disadvantages like long cycle time and in order to do hot gas welding welder should be certified okay otherwise not everyone can do that can also use expertise from the welder to make a joint but the vendor should be certified unless certified you cannot use it. In most of the welding applications unless the welder is satisfied and you cannot use anyone else who are not certified to make a component. If the component fails and you are in (())(22:36).

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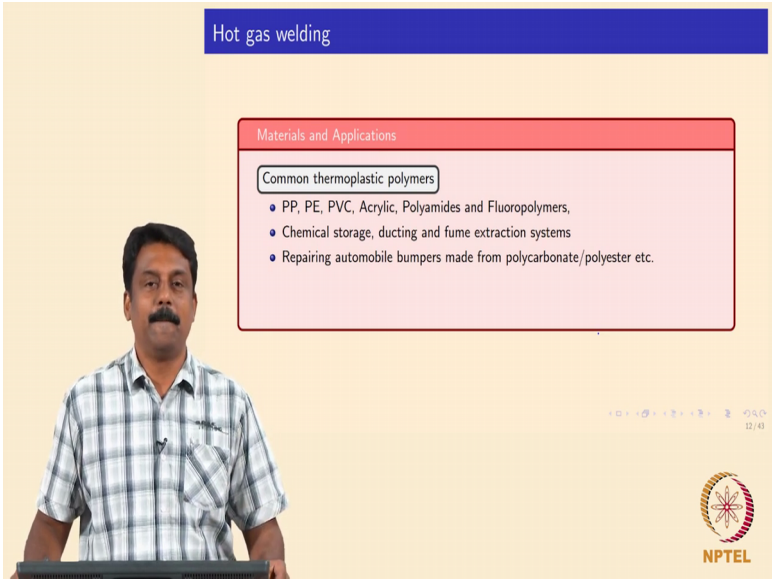

Let us move on so again hot gas welding also we can use it for polypropylene, polyethylene PVC, acrylic, polyamides and Fluoropolymers which are thermoplastic okay. So this process we commonly use for chemical storage, ducting, fume extraction system. So the repairing automatic bumpers we use it with hot gas welding, so if your car is you know if you hit someone or some tree or something like that your bumper is broken, so the bumper is repaired in most of the cases, how many of you have seen I do not know in auto shop in garage well bumper repair, so bumper repair is done majority by hot gas, hot gas welding. So you would have a hot fun with a filler and then you go and look at it I mean you break your bumper and then take so if you look at repair, bumper repair is done always with hot gas welding because you can add extra material right, good.

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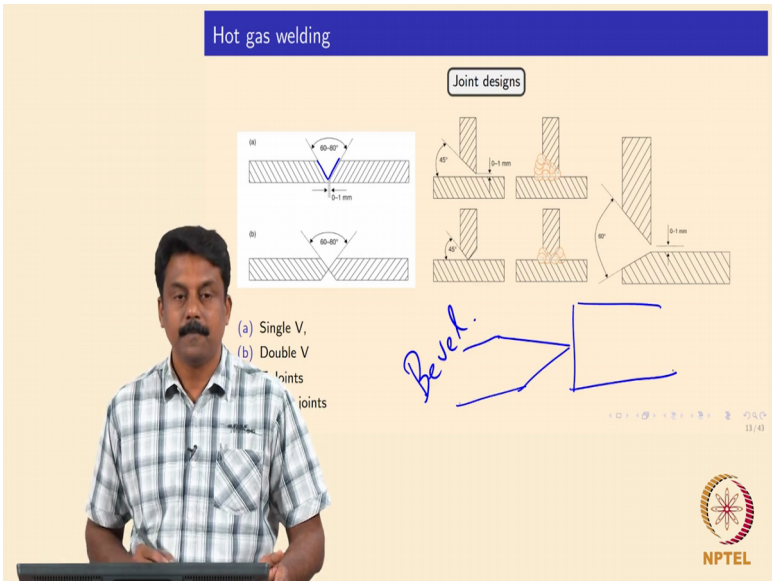

So we will move on to the joint design again so the advantage of using a filler gives us to manipulate at the joint design, so we can use the conventional bevel v group bevel or double v bevel, what is bevel? So bevel is a joint design a machine design so this is v bevel okay. We will see the next class some of these aspects in this double v bevel and you can also use the k bevel, what is k bevel? Something like this right okay we can weld t joints or corner joints we just had extra filler right, good.

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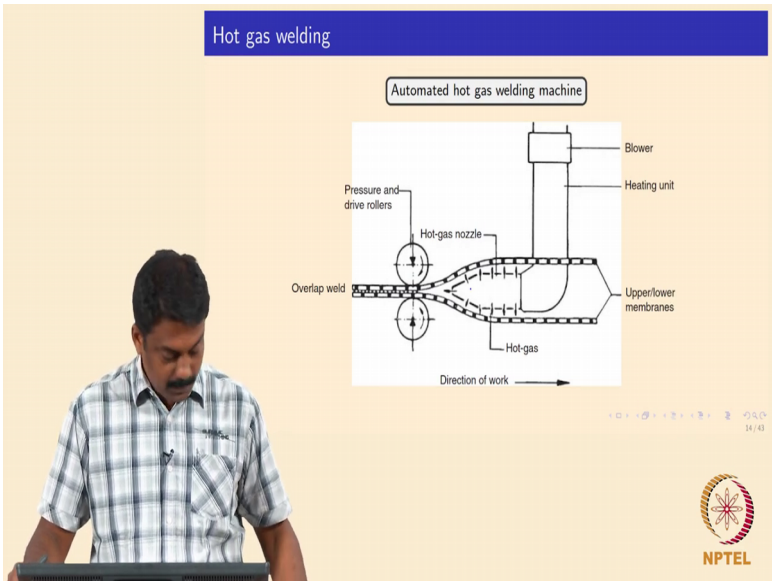

We will move on so we can also automate the process to make the longitude seen joints, again the principle is the same as we do in hot plate welding, the only thing is here we add a blower and then a filler, it can be sent to the joint subsequently can be filled the rollers can

apply pressure to get the filler joined with the interface face to be welded right, so it is no (()) (25:00) complex in terms of process itself the principal is same the blower and the heating unit, heats up the filler and melts (())(25:08) and then solidifies subsequently roller can press to make sure that the interfaces is molten and mixed with the filler okay good.

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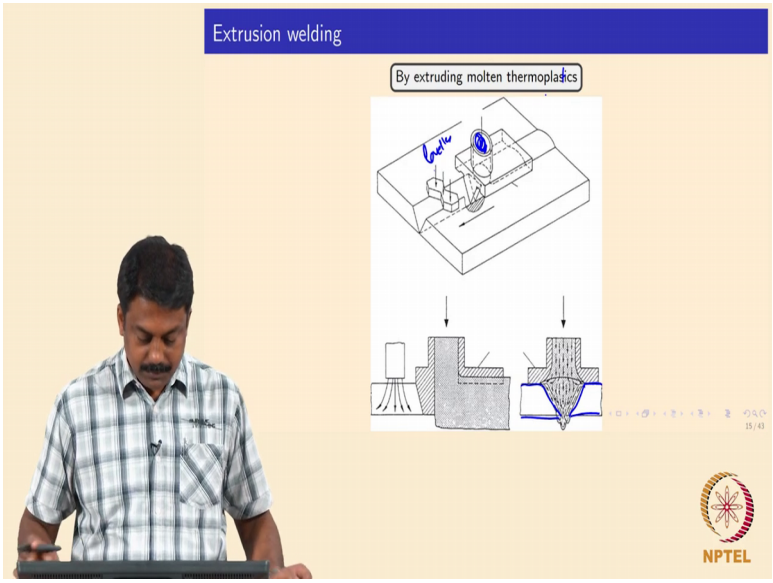

So then the next process which are commonly also used for joining plastics extrusion welding, extrusion welding is like an injection moulding okay, so the molten thermoplastics is injected or extruded into the joint right so in this case for example this is the joint to be welded, is not it? So what you do you have a tool which can extruded the molten thermoplastics into the joint and subsequently the joint can be solidify to make a joint right, so this can be similar material or de-similar material. In most of the polymer and thermoplastic polymers you can use even de-similar because they have good mixing behaviour but you can say that even if you use polyethylene or polypropylene then joins will be significantly integral okay.

So it is even de-similar filler can generally use for welding plastics and you can also use similar filler okay so in this case we can take if it is polyethylene you have a polyethylene extruder and this excludes and fills the cavity right, so you can also use a nozzle tube or the simple extrusion tool for example you can fill the filler and then can be extruded and then placed and this is leveller okay which levels the tops surface and then subsequently the entire thing can be moved either this way or this way good.

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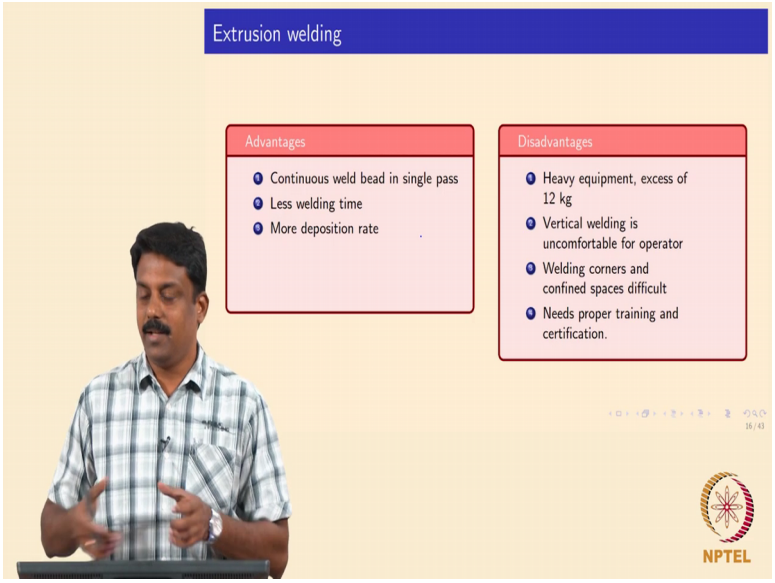

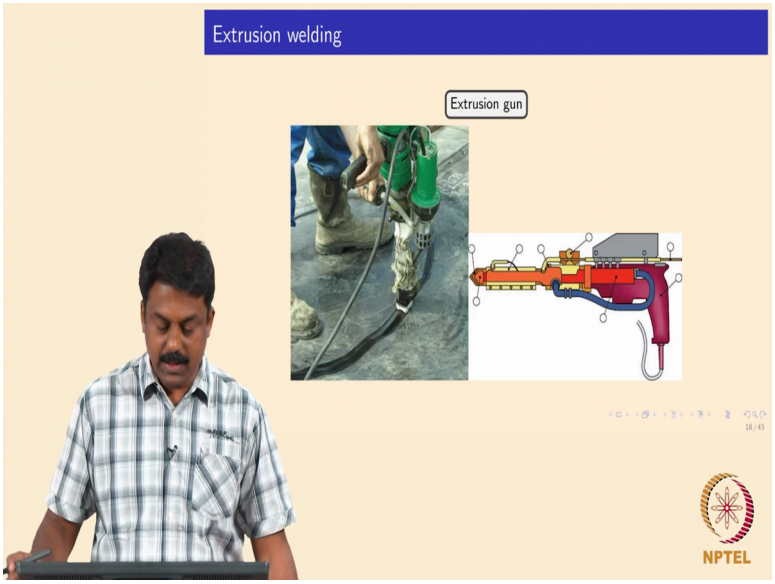

So the advantage of extrusion welding is you can do it in continuous seam in a single pass, you can fill large amount of weld cavity okay. Welding time can also be faster and you can deposit more volumes I mean thicker section can be done and this is really heavy equipment, so most of the thicker section polymers for example water tanks those are welded with extrusion welding okay, so something like this you have an extrusion gun and this is a thermoplastic.

So you will have a gun which is really heavy is about 12 to 15 kilograms or so and these are the parts and you have the filler, extrusion material and it is extruded and then deposited along the weld joint, so the thickest sections welds are possible because you have more volume of materials can be extruded to the joint by using this simple gun okay, so the gun

looks like this I mean it is like you have an hydraulic cylinder which actually pushes the molten material into the tip and the subsequent tip can deposit the extruded filler onto the weld cavity right extrusion welding.

So in most of the cases the cylinder works in hydraulic principle and there are some pneumatic also that where you have hot air (())(28:42) which actually pushes the cylinder to exclude the hot polymers okay. So because of the gun itself is heavy so you need a reasonable strong man or woman to weld using the extrusion welding polymer. With this vertical welding is difficult because you will have to hold the gun and it is like shooting in the sky.

So it can be very uncomfortable so that is why the welding is generally done with down add weld, so again the welding corners can be tricky because gun itself you may assume and (()) (29:22) okay and again it needs a proper training not everyone can do that because the hydraulic pressure what it actually carries can be tricky and you will have to move along the weld seen, so you cannot do here and there right, so you will have to make sure that you track the scene and deposit along the scene right.

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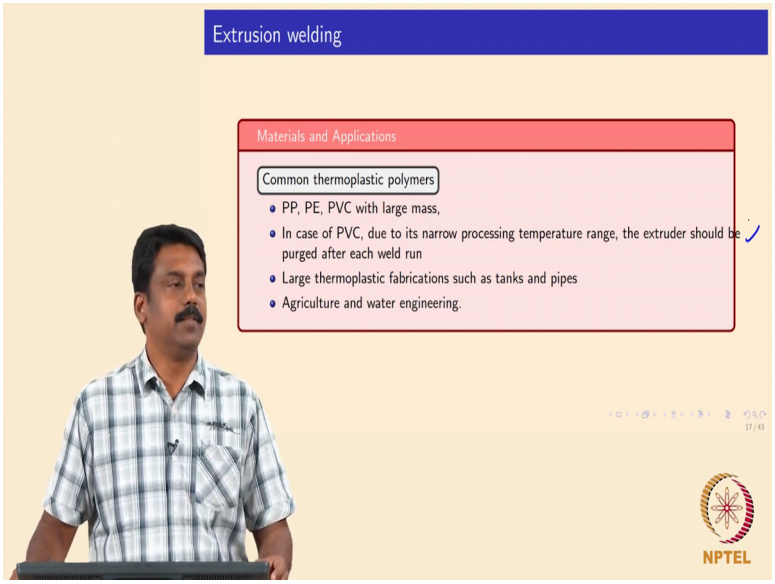

So what are the common thermoplastic polymers can be welded is again polypropylene, polyethylene, PVC with large mass okay so heavy thick sections okay so PVC has a very narrow processing temperature range although it solidify very quickly we will have to do it faster okay, so the extruder should be purged after each weld-run a device it can clog okay so the extruder can be clog with the molten PVC okay. So we can use it for large fabrication like tanks, water tanks they are all again go and look at Sintex tank the seam and you see (())

(30:27) joints, so heavy thick sections about more than 25 mm plates those are all welded with extrusion welding, so mainly used for plumbing applications, for agricultural applications, for what transportation, water storage so those are all extrusion welded okay good.

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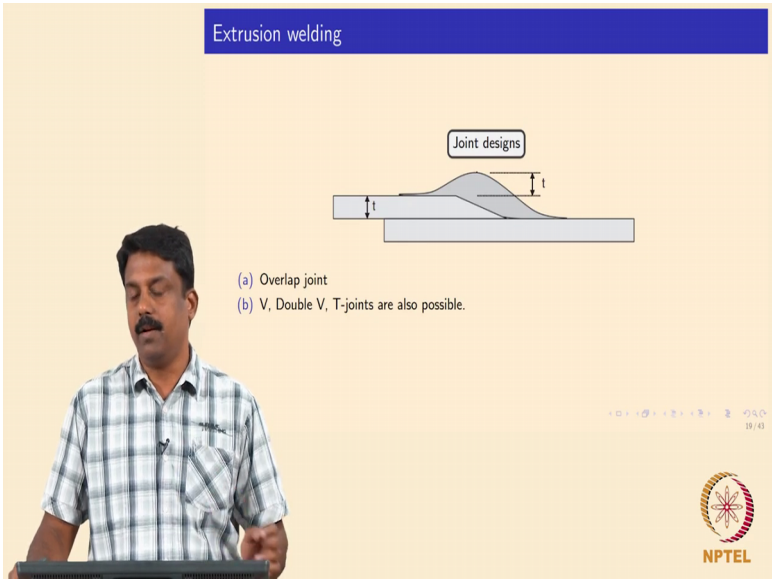

So some joined designs generally it is done in overlap configuration okay, so because you need a have some filler and then you make the filler flow along the overlap sheets okay so the butt joint is not advisable because then butt joint you filler it (())(31:11) filler than the mechanical strength of the joint is poorer than if you use overlap joint, overlap with fill it okay. So V, double V, butt joints are also possible but most of the cases this welding is done in overlap configuration, right good.