Advances in Welding and Joining Technologies

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Lecture - 22
Welding and Joining of Non-Metals Part II

Good morning everybody. Today, we will discuss the remaining part of the welding and joining process for non-metallic materials. So, one of such important welding or joining process for the non-metals is the laser transmission welding.

So, laser transmission welding it is like that; this there is two component mainly it is applicable for the; plastic materials.

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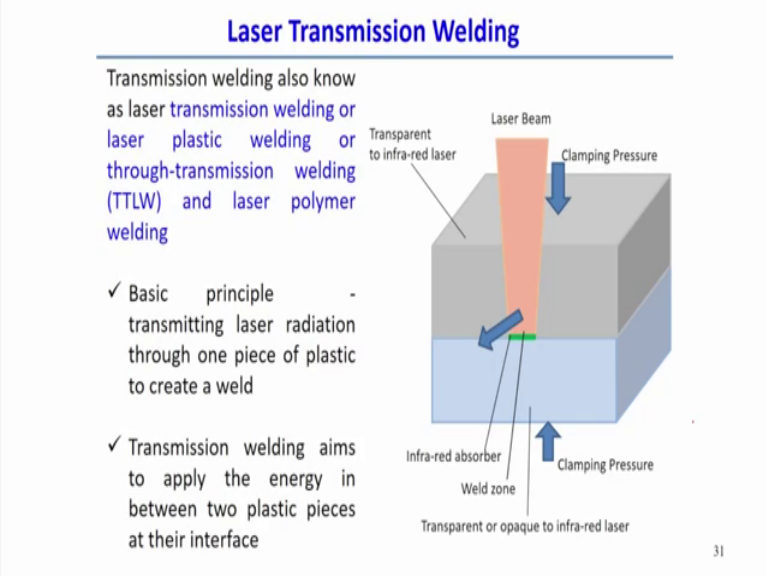

So, we can keep the upper side the transparent material through which, laser beam can passes. And at the bottom side we can put the other different carrier of plastic material such that at the interface there may be the heat generation, such that the two components can be joined here.

So, either we have to choose the material in such a way that the top materials, there is a transmission laser will occurs; that means, without any absorptions by the by the first layer, but the; whatever absorption will be occurring that will be in the second layer. So, sometimes if both are transparent material to these specific wavelengths of the laser.

So, in that case may be in between some absorbing layer can also put and that absorbing layer basically the amount of the laser energy will be absorbed at the interface and then it will melt the surrounding area and by applying the some clamping pressure or applying some forces for a specific time period, then welding of this joining can occurs after cooling down of this molten stress.

So, this is as simple this is the laser transmission welding, but sometimes this transmission welding is also known as plastic welding, laser plastic welding or through transmission welding and some laser polymer welding. So, basically this welding process has been developed in specific application for the polymeric material.

So, basic principle is that; transmitting laser radiation through one piece of plastic materials to create a weld. So, once the transmission come just through one layer, then some energy in between these two layers have to be released; such that at the interface there may be joining of between these two components can be done.

So, here if we see the figure the transparent infra laser that transparent; that laser transparent through this material, that is the it depends upon the wavelength of this specific laser, which laser is we used here and in this infrared or near infrared laser mostly transmittance happens for a different types of the polymeric materials.

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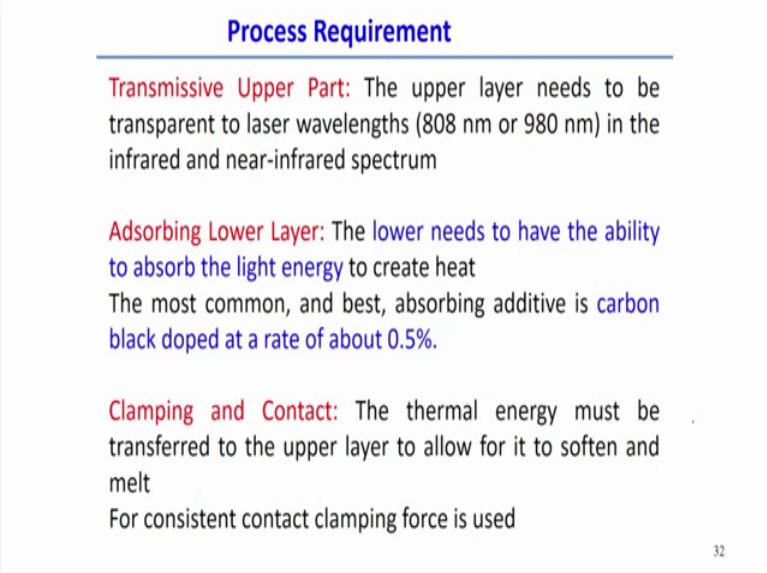

So, if you look into further the process requirement for the laser transmission welding is

that; first the transmissive upper part: the upper layer or upper components needs to be transparent to laser wavelength. So, actually the transparent transparency of the laser light depends on the wavelength of the laser specifically used for the welding process. So, normally for example, 808 nanometer or 980 nanometer these two lengths are normally we use the wavelength of the laser, in that range and that is in the infrared or near infrared spectrum. So, in that range if we use the laser and that laser is specifically applicable for the laser transmissive welding.

So, once transmissive upper part next component is be the absorbing lower layer. So, absorbing lower layer, so that we have to choose the lower layer component in such way, that the that layer will be able to absorbs the laser energy laser light energy to generate the some amount of the heat at the interface.

So, sometimes if both are polymeric both polymeric material are transmissive in nature with the specific wavelength of the laser used; so in that case sometimes some additive absorbing additive such as; carbon block, carbon black, doped at a rate of around point 0.5 percent; that means, that carbon black can be used at the interface layer, so that interface layer that carbon black actually acts basically absorb the laser energy and create some melt.

So, once the transmissive layer and then absorbing layer and after this the third process requirement here is that clumping and contact. So, contact should be is the ; so very the gap between these two components should be very low, such that once the thermal energy is released on the at the interface; that means, either in the absorbing lower layer; that means, lower component or on the interface.

So, then gradually heat will be conducted away to the upper layer. So, that amount of energy will be also at the same time it will be able to melt the upper layer, then only to make as consistent contact between these two component, there is a requirement of the application of the some amount of the pressure between these two. So, after pulling down this component, the strong weld bit or can be formed for this polymeric material through laser transmission welding.

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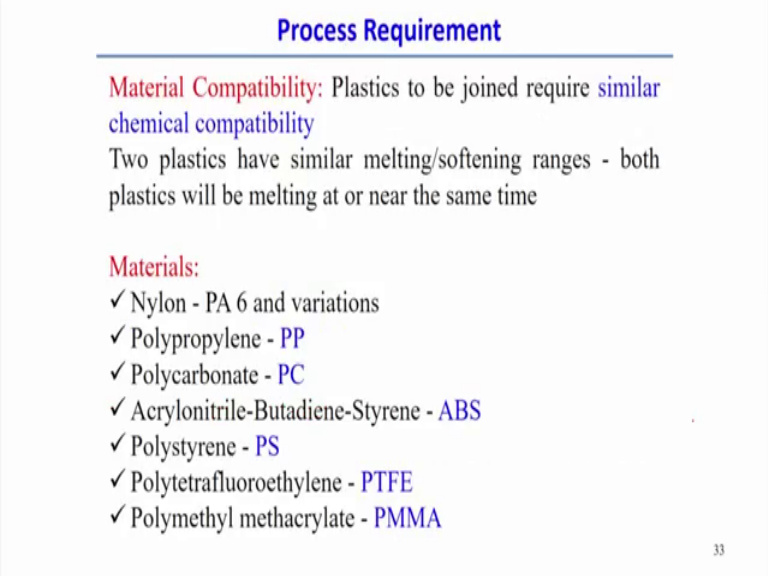

So, material compatibility you can see most of the plastics to be joined require similar chemical compatibility; that means, two components have to be chosen in such a way almost similar compatibility should exist. So, at the same time; the two materials having the melting and softening ranges and for both the plastic should be at the same time or may not be; that means, they are may not be much difference in the melting point between these two components, which is supposed to join by laser transmission welding.

So, if you see the typical materials applied or weld or joined by this welding process, it is that is that nylon different that PA 6 and that different variants can be joined, then PP, then PC ABS, polystyrene; this is the short form this different polymers that can be joined well using the laser transmission welding. PTFE and that PMMA all this type of materials can be joined by using the laser transmission welding.

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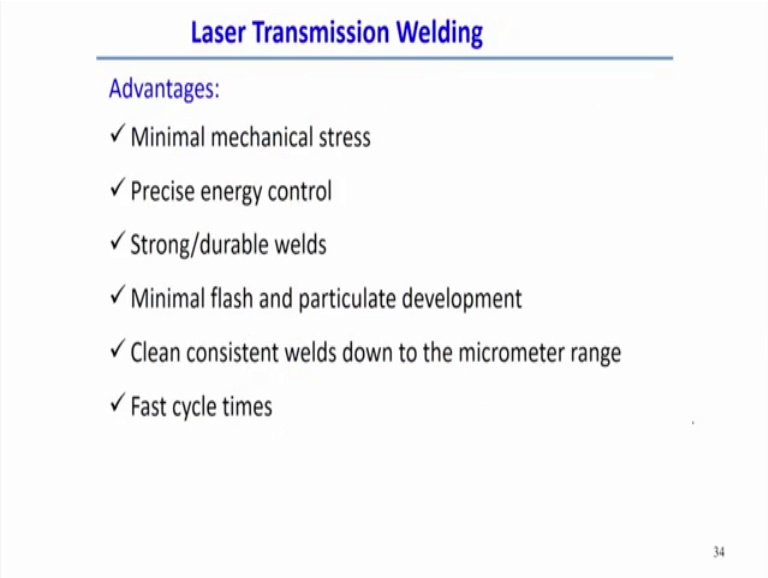

But, if we look into that the advantage; that means, with respect to the other processes here or other welding processes. So, here you can find out that, there be may some minimal mechanical stress. So, mechanical stress will be very less, because in this case there is a difference in the expense thermal expansion coefficient or maybe is the very less in between these two.

So, there is a less chance to generate, large amount of the mechanical stress. Precise energy control since we use the laser as a source, then we can very precisely focus on a specified space in the at; therefore, it is possible to control the amount of the energy release at the interface.

Then very strong and durable welds can also be done, using this process by this process. And of course, minimum flash and particulate development, which is very negligible in this process and this process is very clean process also and the weld joined; that means, heat effected zone or we can say that by this welding process can be confine very small very small space.

And finally, the it is a very first process. So, therefore, first very less welding time is required for this. So, these are the typical advantages of using the laser transmission welding for polymeric material.

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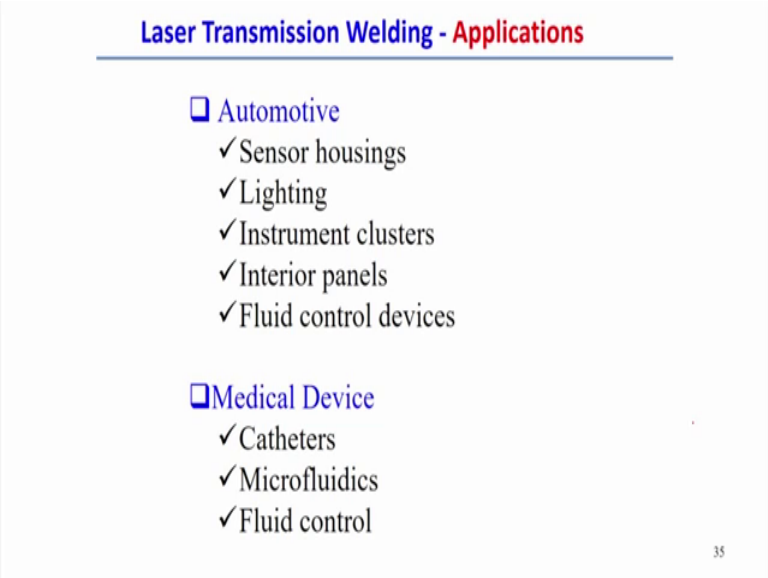

But, if you look into that other application area of laser transmission welding here see the several applications. So, automotive that sensor housing, lighting, instrument clusters, interior panels, fluid control devices, all this in or automotive sector we can find out the application of the laser transmission welding for this material for this area.

And then in medical devices there is a tip; huge application of the laser transmission welding specifically, when we try to join we use some polymeric material there microfluidic fluid control devices; that means, medical instrument or medical devices, when they will use of the plastic components, then we can use the laser transmission welding in that area.

But overall the; this process is mainly confined to laser polymeric material apart from, but other dissimilar combination of materials can also be joints. So, we will be discussing later on this. Now after laser transmission welding, we will try to look into that the glass welding.

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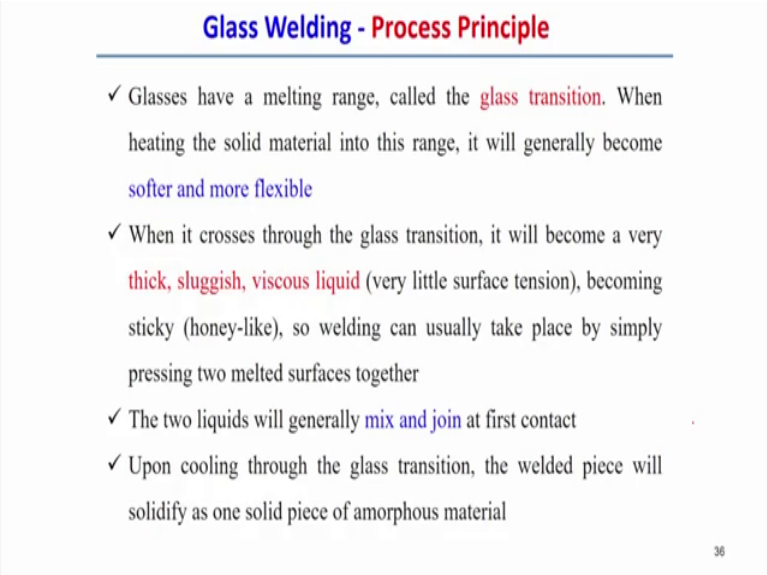

So, this is the glass we know it is a very brittle material. So, definitely the there is a some issues of welding different kind of glasses.

Let us see that what way we can; what problems; what are the methodologies can be used for welding or joining of the glass. So, definitely glass having the melting range, that is called it is a glass transition temperature. So, there is a range of temperature through; that is called the glass transition, but the heating when the heating of the solid material into this range normally glass becomes soften and becomes more flexible, and such that after bringing in this state, then it is possible to join two glass components by simply application of this small pressure, then contact then glass can be joined.

But, if you look into that it is a more precisely that; when it cross the glass transition temperature it becomes very thick sluggish kind of viscous liquid; that means, in this case it is having the very little surface tension; that means, surface tension is reduced in this with the application of the heat in the glass.

So, then after that it becomes very honey like; that means, very sticky. So, welding can be done readily by simply pressing the two melted surfaces together. And then the two liquids generally mix and join at the first contact, when they are in contact with the application of the heat. So, therefore, after when we follow the cooling figure, the through the glass transition, then the weld pieces will solidify and then one solid solidify and then it is looks like the one solid piece of the amorphous material.

So, the welding or joining of the glass process is almost similar to other conventional welding process, but the difference in that sense glass welding is that, the first the material properties are completely different from the metallic materials. So, therefore, glass whatever properties changes that is, through the glass transition temperature range. And then after it after melting it takes a it takes a kind of safe of viscous liquid, and then when they are in contact they can readily join between the two components in the glass.

So, finally, after solidification also again it go goes through the transition temperature, so properties can be change; when it is processed through the glass transition temperature. And one solid piece can form in the; as a as a amorphous material. We know that glass is an one kind of the amorphous material not the crystalline material.

Now, what are the methodology; that means, what type of the heat source can be used in case of glass welding?

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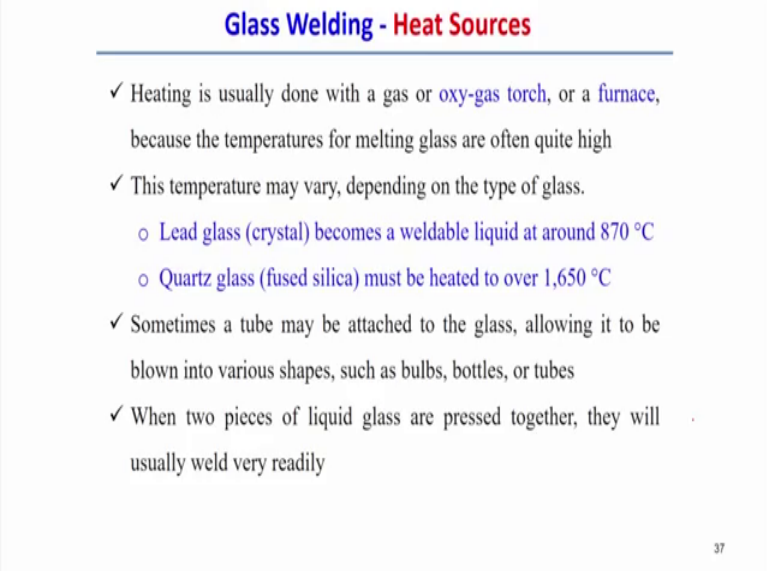

So, normally welding with gas or oxy gas torch hot oxy gas torch or using a furnace the these are the typical source of the glass and we it is easily to locally applied in certain part of the glass and then melting of the glass happens and finally, joined between these two components. But, typically the glass the melting of the glass is often quite hard quite high therefore; the furnace is one of the choices of heating the act as a heat source for the welding of the glass materials.

Let us see; let us look into that, but this range of the melting it depends on the melting point of the; that means, weldable liquid in the form of the weldable liquid are different for the different types of the glasses, if we look into that late glass; that is commonly known as crystal becomes weldable liquid around 870 degree centigrade, but if you look into the Quartz glass that is also fused silica, it can be the it can be the weldable liquid it around the 1650 degree centigrade.

So, although material the, but different types of those both are glass, but the different types of the glass there may be the use difference in the melting point temperature; such that there is a difficulty in joining the two different gates of the glass may be treated as a joining of the two dissimilar materials, since there is a huge difference of the weldable liquid between these two different types of the glasses.

Some mostly the tube sometimes tube are attached with the glass; that means, then such that this allowing to make blown into the various steps; that means, that weldable; that means, liquid weldable in the form of the weldable liquid, when it is form when the weldable liquid glass, then if we use some tube to try to make of the blow into the; then it becomes various shapes like the such like bulbs, bottles, and the tubes. These are the typical manufacturing technology using the glass.

But, when the two pieces of the liquid glass are placed together, then they usually weld as a readily, they join this readily, but definitely although there is a welding or joining of the glass technology welding of the glass or two different grade grades of the glasses are well established, but there is some limitation of the glass welding process first is that since we know that glasses very brittle material in the solid state and therefore, there is a highly chance to form the cracking during the heating cooling phase.

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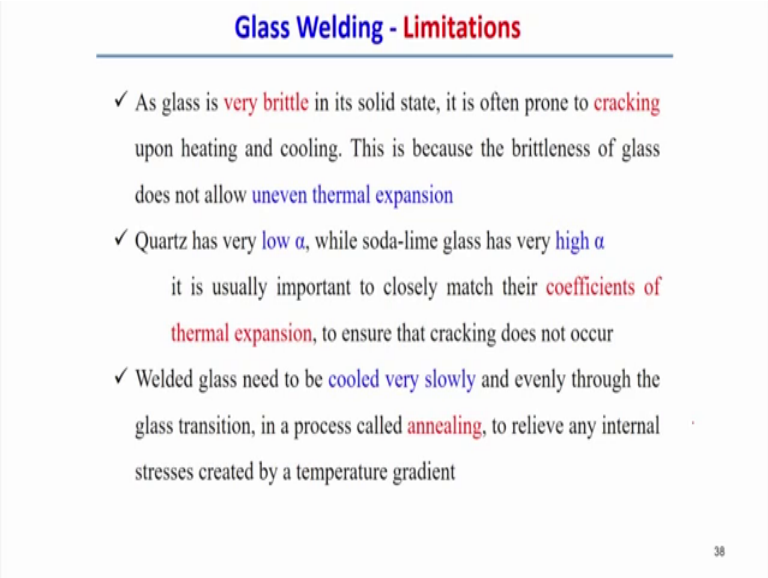

So, because cracking since glass is very brittle material. So, there is a hardly it is very difficult to absorb the uneven thermal expansion during the heating or during the cooling phase. So, there is highly chance to form of the cracking phenomena and during the processing of the glass specifically; when you try to do the welding of the glass.

So, we can take one example that quartz has a very low thermal expansion coefficient, but while the soda lime also soda lime glass having very high thermal expansion coefficients. So, it is usually in this case the joining of these two types of the glass is difficult, but therefore, it is very much important to closely match their coefficients of the thermal expansion to ensure mainly not to occur the cracking during the welding of the glass components.

So, other significant significant issues of welding or processing of the glass is that; during the cooling phase, we need to follow very slow cooling at the processing. And at the same time that; it should follow the slope slowly cool very slowly and at the same time the cool evenly through the glass transition temperature range. So, that is followed and that is basically controlled and this process is normally called as annealing process. And that annealing process is helpful to relieve any internal stresses that mainly, created by the temperature gradient.

So, therefore, the most significant component of the glass welding or maybe limitation is that; very controlled cooling is required this press and very careful in the sense that that

glass actually is very brittle material. So, even it not cannot absorb small amount of the thermal expansion. So, that is the only limitation for the welding of the glass components.

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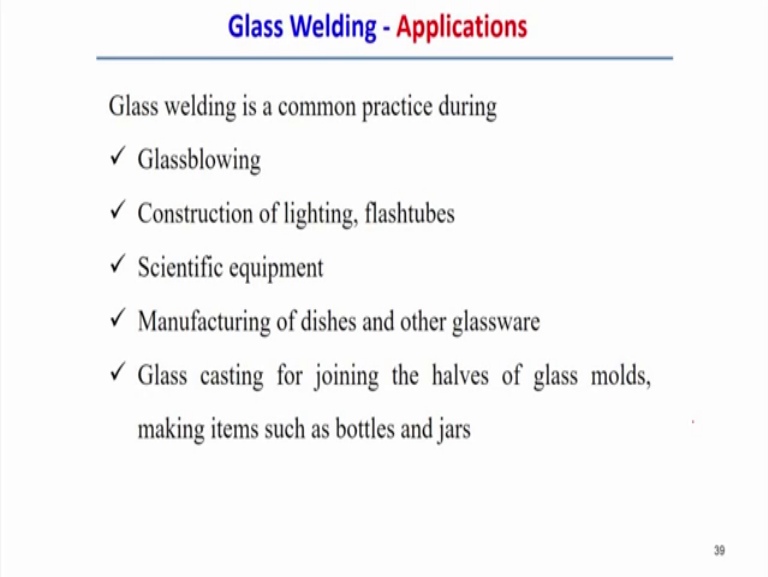

So, we can see the typical application of the glass welding that is the glassblowing. So, that glassblowing means in this case that um, but liquid at the liquid state of the glass, if you put the by using some tube, if you try to blow this one then we can make the different shapes it may be circular shape or spherical shape or may be some tubular shape or may be cylindrical shape. So, different shape can be form; that is the that is generally follow we can find out the during the processes of the glass welding.

So, therefore, construction of the lighting or flash tubes in this case also we can find out the application of the glass welding, very scientific equipment, manufacturing of the dishes, and other glasswares this the typical application of the glass welding. More over glass casting for the joining the halves of the joining of the halves of the glass molds, making it such as bottles or jars. Here also we can find out the application of the glass welding.

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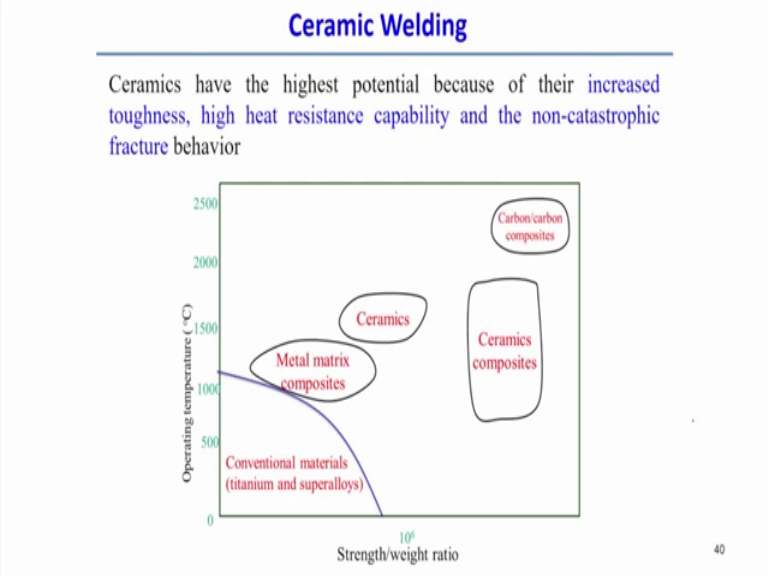

Next we will try to discuss that welding of the ceramic materials. So, definitely one of the non-metals important significant non-metals is the ceramics and there is a several developments of the different kind of the ceramic materials. So, ceramics having the high potential because of their increased toughness, mainly the high heat resistant capability and non-catastrophic failure behaviour; these are the typical driving force or for the huge application of the ceramic materials in several industry.

But, if you look into this figure; here you can see that strength to weight ratio and the operating temperature for the conventional materials mainly titanium and the super alloy that actually exist it is a narrow zone. In that sense with respect to that the processing of the ceramics require relatively at very high temperature, even for it is more than the metal matrix composites materials, processing temperature in terms of the processing temperature.

Then ceramic composites and carbon carbon composites all we can find out carbon carbon composites, here also you can find out the processing temperature is very high even as compared to the ceramics, but as compared to the common metallic materials, we can find out the processing temperature is very in case of ceramics.

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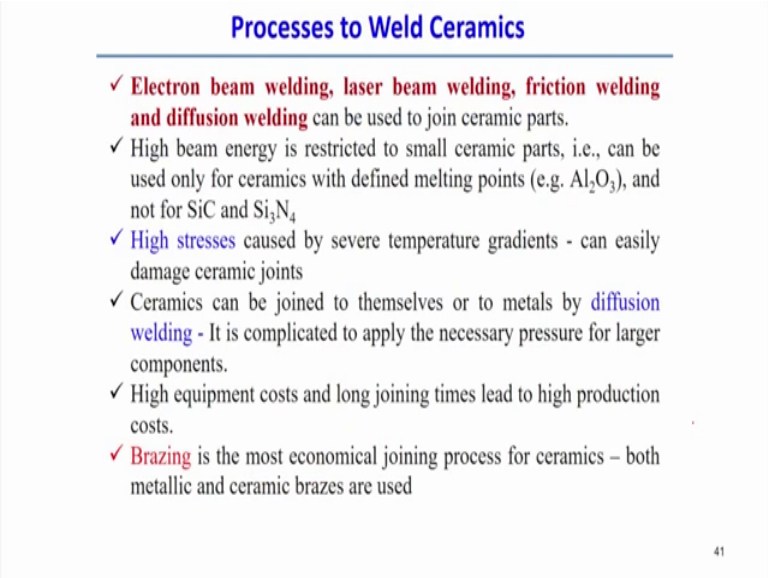

Now, what are the typical joining or welding techniques for the ceramic materials. So, here you can see that; electron beam welding, laser beam welding, friction beam welding and the diffusion welding these are the main processing main processing techniques for the for the welding of the ceramics. So, high beam energy actually restrict application of the high beam energy is basically restricted to the small components of the ceramics.

For example the that can be used with the ceramics and only for the ceramics, which is defined melting points for example, the AL 2 O 3. So, therefore, the processing of the welding or joining of the AL 2 O 3 in this case we can use the high beam energy; that means, electron beam energy or laser beam energy.

But in other cases for example, silicon carbide and silicon nitride in this cases the use of the high beam energy may not suitable for this kind of material. So, mainly high stresses cause by the severe temperature gradients can easily damage the ceramic joint. So, therefore, sort of beam very careful by choice of the material and the difference of the there mechanical properties, when you supposed to join the ceramic components.

So, other significant joining methodology for the ceramic components is the either the similar joint configuration or dissimilar configuration with the metallic materials by the; is the diffusion welding. So, in this case the in the diffusion welding, but in diffuse only the main difficulties is the due to the necessary pressure need to apply and need to apply specifically for a larger components. And there is a time requirement; so normally

diffusion welding process takes the huge time. So, high equipment quartz and long processing time, long joining times basically leads to the high production cost for the ceramic components.

Therefore most economically for the welding of the ceramic materials generally people follow the brazing process, because brazing is the most economical joining process for ceramics by simply using the braze components both ceramic braze as as well as the metallic braze are used in this case.

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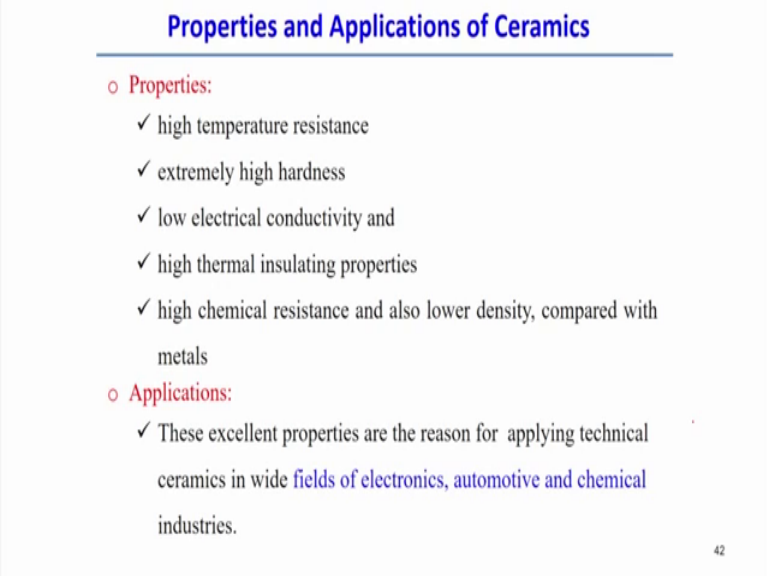

If you look into the typical properties and application of the ceramics that; definitely ceramics having the very high temperature resistance and extremely high hardness and low electrical conductivity and the high thermal insulating properties, high chemical resistance and also lower density as compared to the metal; So, all this specific advantage of using ceramics.

Therefore, nowadays we can find out there is a huge application of the ceramic materials, but in that; in that sense the development or maybe is weld ability of the ceramic materials is not up to that limit, what we found out in case of the metallic materials.

So, definitely, but still there is a development of the joining or welding of the ceramic materials also happen juts we discuss based on the different high; we generally use the high beam energy and diffusion welding and sometimes we use the brazing process also

for joining of the ceramic components either ceramic to ceramic or ceramic to metals.

But, there is huge application of area of ceramics. So, we can find we can see that excellent properties are the very main reason for applying the technical ceramics in the wide range of the fields of the electronics, automotive and the chemical industries.

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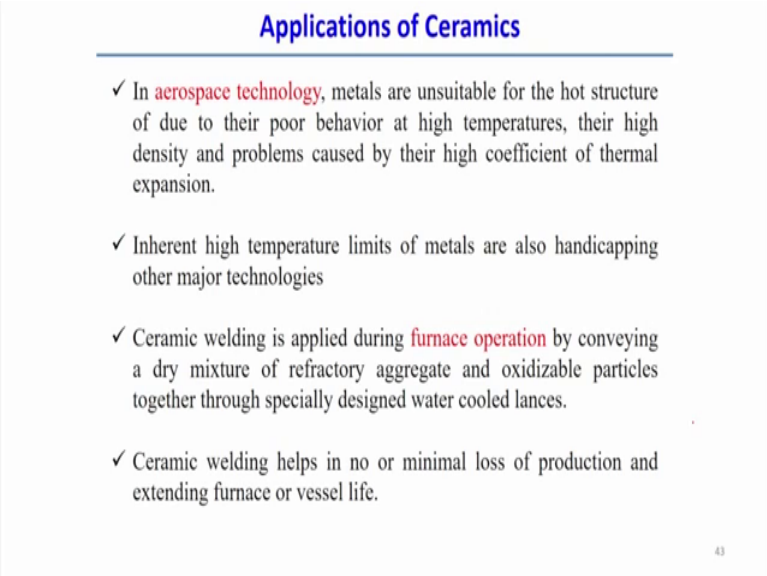

These are the areas where you can use the typical application of the ceramic materials. So, therefore, in aerospace technology, metals sometimes some components of the metals can be replaced by the ceramic component, because in the aerospace industry the it is goes through a very at that high temperature range and high density metals may not be suitable or create some problem. Therefore, in that sense the ceramic is the most alternative alternately use in that place.

So, therefore, because ceramics is having very good high heat resistance properties of course, ceramic welding is also applied during the furnace operation also simply by conveying a dry mixture of the refractory a aggregate and oxidizable particles actually kept through together, through specifically designed water and water cool lenses.

So, in that channel we can put this ceramic refractory material and then ceramic welding helps with the no minimum loss of the production and no minimal loss of the production at the same time extending the furnace or the vessel life.

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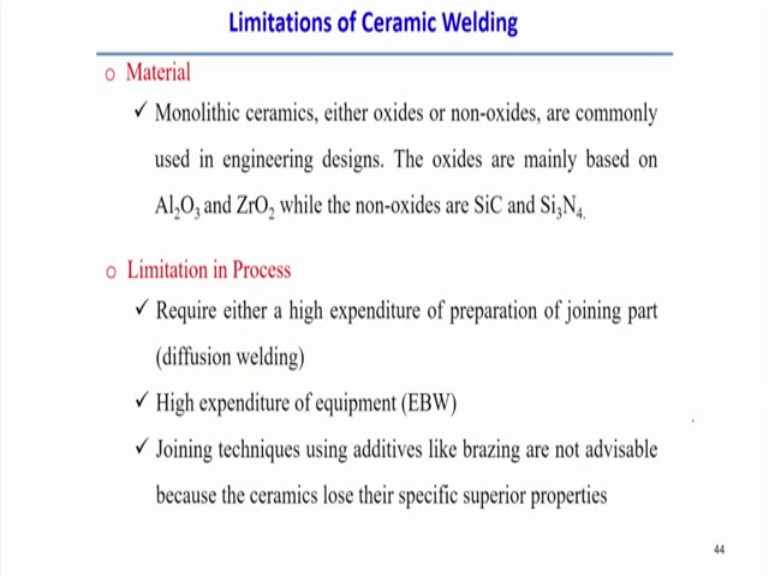

So, therefore, in the furnace operation we can find out simply welding of the by during the furnace operation, we can simply put the ceramic welding it is a it is a efficient way without loss of the production and at the same time it actually imparts the life of the furnace or vessel life.

But, if we the industrial practice normally use the materials like the monolithic ceramics; for example, either oxides or non-oxides, are mostly used in engineering design. The oxides are mainly AL 2 O 3, aluminium oxide and zirconium oxide ZrO 2, but non-oxides are mainly silicon carbide and silicon Si 3 N 4, these are the typical materials we use most of the engineering application ceramic material.

But limitation of the process is there, high expenditure of the preparation of the joining part is required specifically for the diffusion welding. And high expenditure of the equipment also, if you try to apply the electron beam welding in this case; the electron beam welding process is very costly process, but joining techniques although using the brazing is the most economical way we can find out for the for ceramic welding process, but brazing is limited are, because the ceramics loss their specific superior properties so; that means, in that case when you try to use the brazing the weld part between the two ceramic components their welded part becomes the weaker as compared to the base material.

So, therefore, very precise applications brazing may not be usable, but other sense the

brazing is the most economical way to joining of the ceramic components. Limitation, other limitation the difficult to process and the and smaller resistance to the thermal shock.

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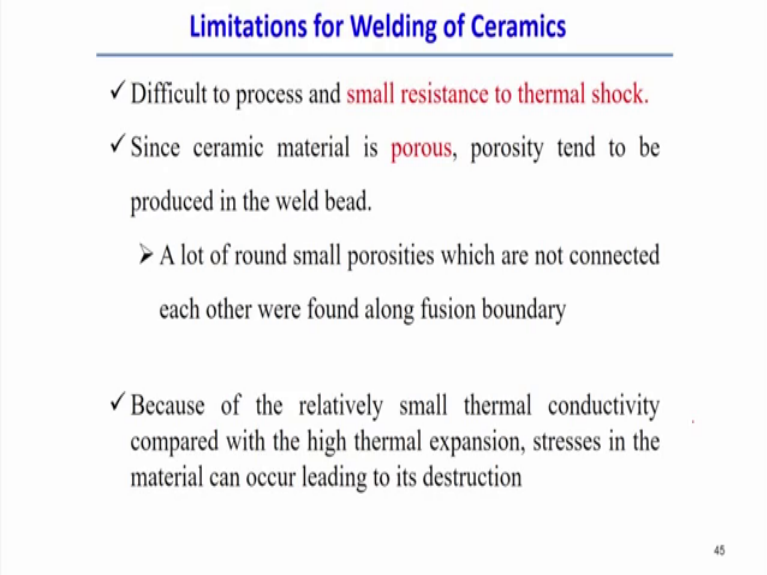

So, it is very difficult to process the ceramic materials, because most of the case we can find out the ceramic is also in brittle in nature and small resistance to the thermal shock load. So, in that sense it is difficult to process.

So, since ceramic material is porous, sometimes porosity tend to be create some problem during the welding, and we can find out some marks of the porosity or we can find the only the porosities at the weld join during the fusion welding of the ceramics.

So, since ceramics having the low thermal conductivity as compared to the; and as compared to the other material and therefore, with the high thermal expansion stresses in the material can occur and that actually leads to it is destruction. So, thermal conductivity low and high thermal expansion with this competition, there is a failure of the weld join may happen during the processing of the ceramic. So, that is the one struggle or one difficulty of the processing of the ceramics.

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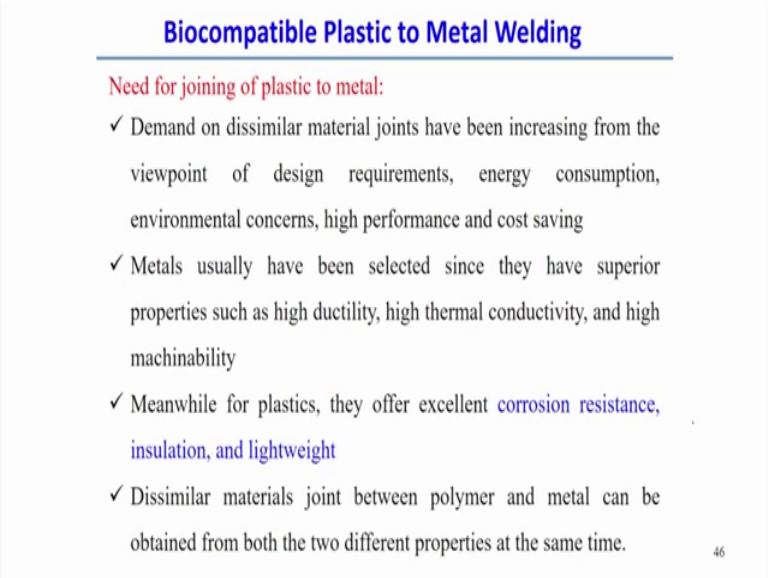

Now, there is a nowadays there is a huge application of the plastic components specifically biocompatible plastic components with the combination of the metallic materials. We can find out this some requirement in specifically in the medical instrument or medical industry. So, therefore, joining of the these two components plastic to the metal is having some significance.

But, if you look into why; the there is a need for joining of the plastic to metal. And if you look in the several points on that that this although this a dissimilar combination have increasing from the point of view the energy consumption, environmental concerns, high performance and from the point of view of the cost saving.

So, mainly metals usually have been selected since there some specific superior properties; for example, best high thermal conductivity therefore, high machinability. So, from that point metal have choice of metals having some advantage of this or based on their properties.

By at the same time plastic also having some other excellent properties like, corrosion resistance, installation and the lightweight and this all these three properties definitely comparable as compared to the metallic metal. So, metal is having some certain advantage or at the same time using the plastic also having certain advantage or having very certain properties therefore, combining these two brings a huge difference in the properties.

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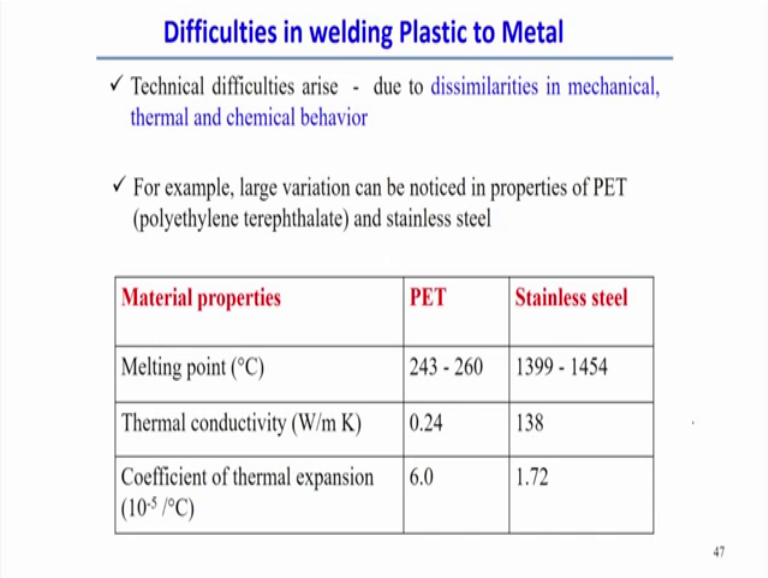

So, therefore, joining or welding of this two components metals to plastic as a huge difficulties, because there properties are completely different and not only that they are different not only the mechanical properties even thermal and chemical behaviour are also different.

So, therefore, we can we can take an example also the, if we see that there is a two material PET and stainless steel and suppose we want to join these two one is the plastic, another is the metal stainless steel. So, here we can see the there is a huge difference in the melting point temperature; one is the 243 to 260 degree centigrade, another is the around 1400 degree centigrade.

So, there is a huge difference in melting point thermal conductivity also having huge difference one is 0.24 ,one is the 138, other is the thermal expansion of the coefficients. Here you can see that one is the thermal coefficient of the thermal expansion is 6 into 10 to the power minus 5, another case is 1.72.

So, although there is a huge difference in the mechanical properties so, therefore, it brings, it is very difficult to join between these two materials.

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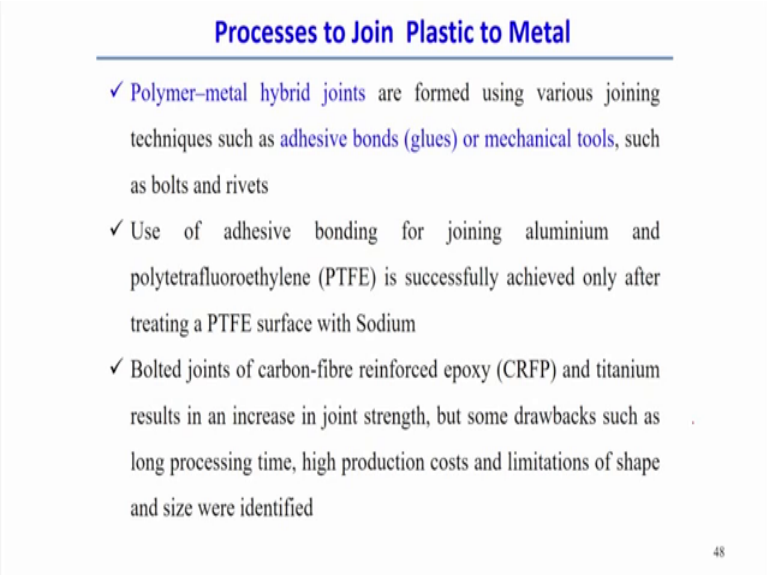

But there are several methodologies also developed for joining the plastic two metals; one is the this polymer metal hybrid joints are found using the various joining techniques simply use some adhesive bonds, simply using some glue or some mechanical tools, that is the most convenient way to join between these two components.

But use of adhesive bonding for joining aluminium and PTFE, we successfully achieved, but only after treating the very good surface treatment with the with sodium. That we absorb the using the adhesive between the joining between aluminium and PTFE; So, therefore, surface preparation is one extra requirement in this case.

Otherwise, bolted joints some using some mechanical instrument simply bolted joints of the carbon-fibre reinforced epoxy CREP and the titanium that also having results in the increased joint strength for definitely there having some drawbacks such as processing time, is low processing time high production cost limitation of the shape and size; that are the main obstacle using some means of the mechanical joining of these two components.

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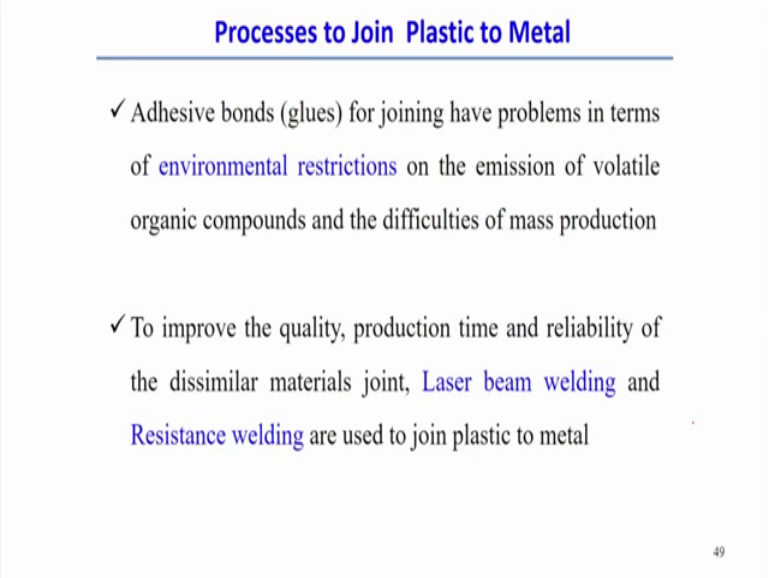

But difficulties that adhesive bonds although you can use or glue we can use more easily for joining these two components, but problem is that it is a environmental restriction is there on the emission of the volatile organic components and at the same time there is a difficulties of the mass production, using this adhesives or glues and of course, there is a some lifespan of this, so glue.

So, in that sense it is limited other way that to improve the quality, production time, because that is rate of the products and reliability of the dissimilar material combination. In this case can be used the laser beam welding and the resistance welding, these are the two mainly two welding processes can be used for the joining of the plastic to metal.

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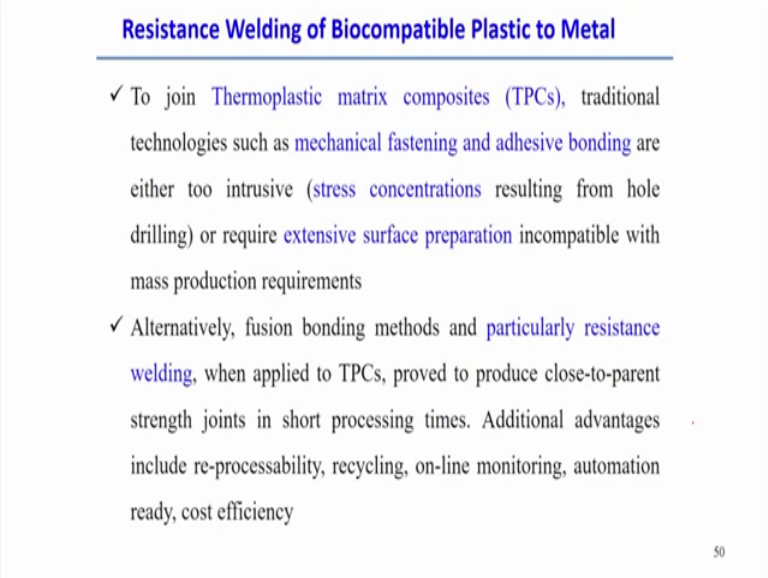

So, of course, if we look into resistance that TPC, that is the polymeric material and joining process such mechanical fastening and adhesive we can use it, but point is that, here if we use the mechanical processing, we can find out the stress concentration due to the hole drilling that is a one things and there is a extensive surface preparation also required, so that actually incompatible for the mass production requirements.

Alternately; that means, in the to avoid this situation the resistance welding can be used for joining the metal to plastic. Therefore, this when the applied to TPC proved to produce the close to parent strength joints, because when you join these things in the short processing time; using the resistance welding process we can find out that is joining strength is very much close to the parent metal may be in this among these two metals and the polymer, in which cases the strength of the base metal components it is low, if you can compare almost similar range of the weld joints strength can be achieved by joining.

At the same time additional advantages like re-processability, recycling, on-line monitoring, automation and cost efficiency all in that aspect the resistance welding of this combination metal to plastic is the better choice as compared to the other using some adhesive or using some mechanical joining.

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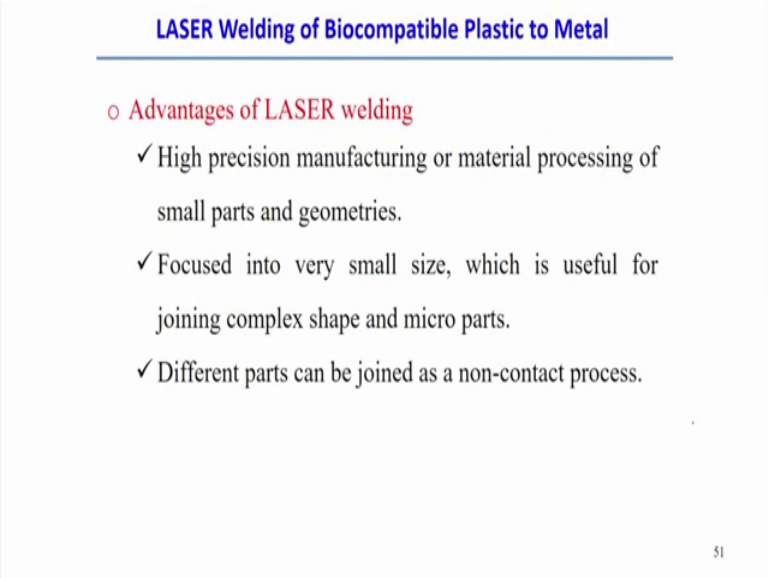

Laser advantage of the laser welding is known to us also, because laser welding it is a high precision manufacturing for the material processing for the small parts and geometries and laser can be focused into very small size, which can be used for joining of the different components and even for the micro components can also be join using some using laser. And other advantage is that laser is a noncontact process. So, therefore, this is an added advantage of; using the laser in specifically in case of the welding of the different material.

So, therefore, apart from the resistance welding laser transmission welding is the another option for the joining of the metal to plastic.

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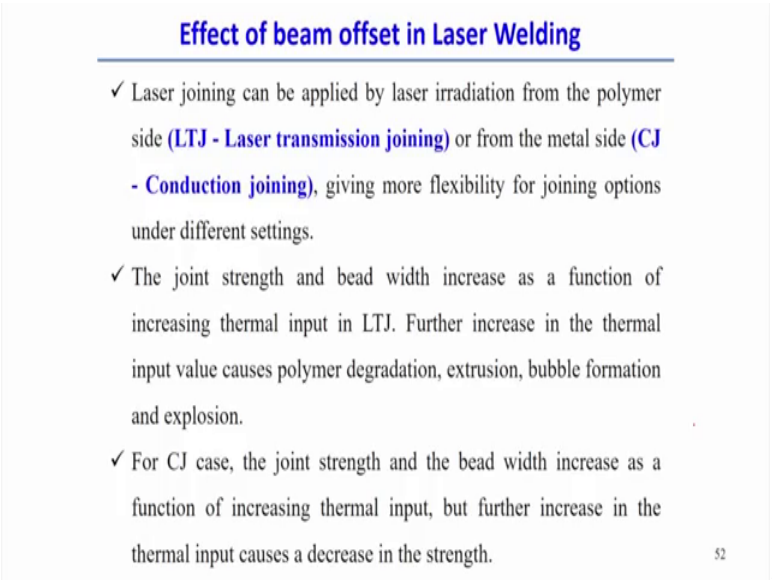

So, here we can see that already, we have discussed about the laser transmission welding or laser transmission joining in this case the polymeric materials normally we can keep on the as a transparent material on the upper side and lower side, if we put the metallic material, so then therefore, at the interface; so heat will be release on the metallic material and then we can join by the laser transmission welding specifically easy to do that in joining between metal and the plastic.

So, it is observed that joint strength and the bead width; that means, increase as a as a function of the increasing the thermal input from the in the laser transmission joining. So, therefore, if you increase the thermal input, then strength can be increased, but at the same time; if we increased too much, then there may be the degradation of the polymer and bubble formation, explosion that can also happen. So, the we need a optimum amount of the energy such that, the joints strength can be optimum between the polymer and the metal.

But in one side it is called laser transmission welding, but in other side from the; that is called the conduction welding CJ conduction welding. So, in this case the joint strength and the bead width increases as a function of the increasing thermal input as well, but further increase in the thermal input causes decrease in the strength. So, therefore, some optimum amount of the thermal input is required to get a good join between the metal and the plastic.

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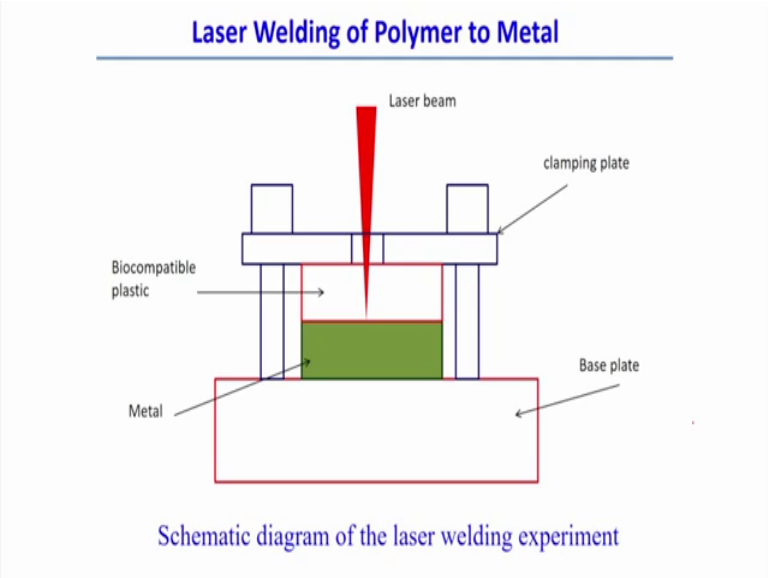

So, here you can see that joining schematic diagram in the laser welding experiment, that is the welding between the polymer to metal. It is a similar configuration to the laser transmission welding, if you see the which is biocompatible plastic normally we can put in the upper side, and in the lower side it is a biocompatible plastic and the lower side is the metal such that laser beam process through the transparent biocompatible metal plastic and heat is generally less at the interface.

And these are the clamping plate to keep on a sufficient pressure between these two contact surface and that actually after cooling then finally, join weld join is formed at the interface.

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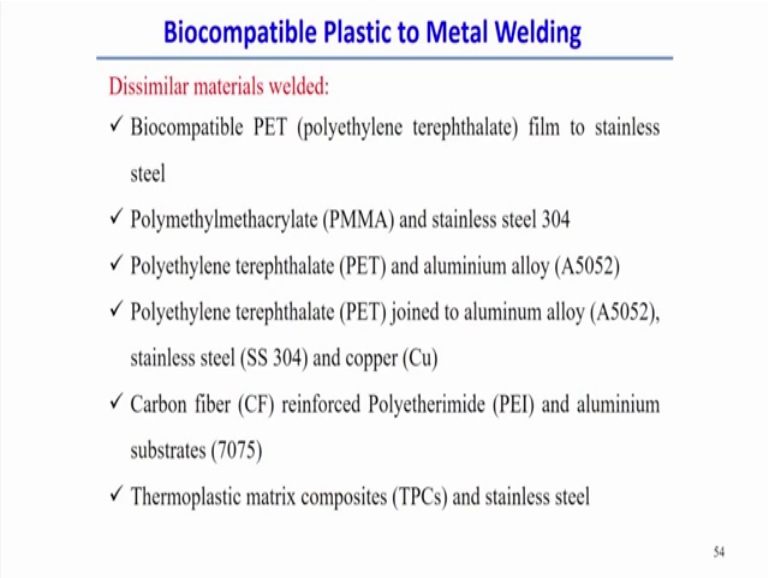

This dissimilar material there is a there are several combination of the material, normally we can found out in the literature that the biocompatible plastic to the metal here you can see that PET field to the stainless steel can be join using this material using this process. Then PMMA and stainless steel 304, PET and aluminium alloy, PET and different gate of aluminium alloy stainless steel as well as copper can be join using this process, carbon carbon fibre reinforced PEI and aluminium substrates can also be join then thermoplastic matrix composites TPC and stainless steel can also be join using this process.

So, therefore, we can find out there is a several combination of the polymeric material and the metallic material and joined by the in the mode of the laser transmission welding.

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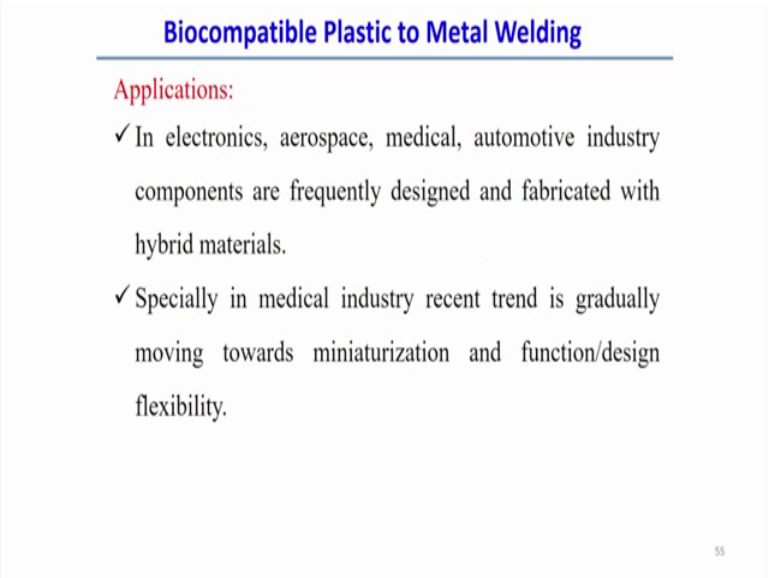

So, you can find out the typical application of the this biocompatible plastic to the metal in electronics industry, aerospace industry, medical, automotive industry and therefore, industry where, there is a requirement of the frequently there is a some components of the hybrid material fabricated with the hybrid material.

So, in that case this process is mostly suitable, but most specifically the laser transmission welding we can find out the medical industry, and that is a recent trend; then gradually moving because with the miniaturization of the components in the medical industry. So, there is a increased use of this laser transmission welding in case of medical industry.

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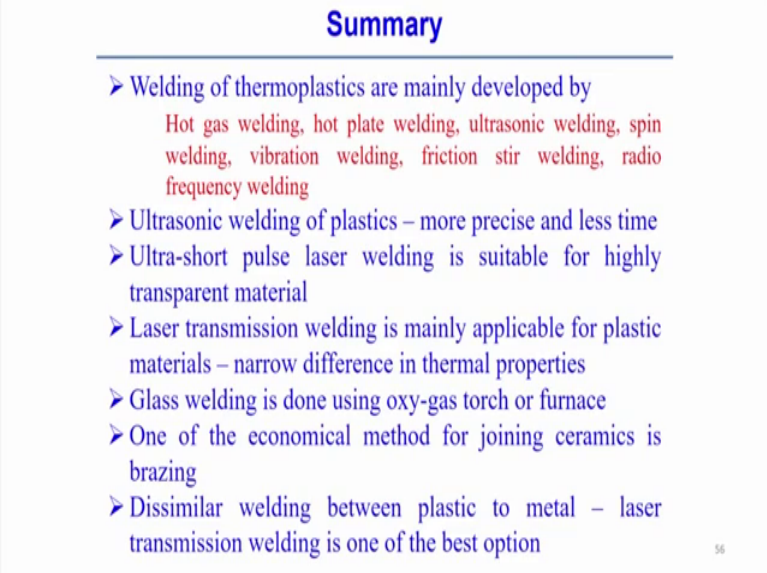

So, now up with this all these different of the although we have covered very few specific welding or joining techniques for the non-metals. And, if we summarise that for the different joining techniques or some issues in the welding and joining for the different non-metals we can find out that.

The very first we discussed that welding of the thermoplastics, and that is mainly developed by the hot gas welding, hotplate welding, ultrasonic welding, spin welding, vibration welding, friction stir welding and radio frequency welding. These are the typical methods methodology followed for the welding of the thermoplastic material.

But among that method methods welding techniques; the ultrasonic welding of the plastics that is the in this case more precisely control in the very small zone and very thin plate generally required and the weld cycle time is very less in case of the ultrasonic welding of the plastics.

Now, after that we discussed the ultrasonic welding, sorry; ultra short pulse laser welding and that ultra short pulse laser welding is very much suitable for the highly transparent material, because; if the transparent material we normally; if we transparent material we do not use any kind of conventional laser welding process. And in this case if we use the ultra short pulse laser.

So, that ultra short pulse laser when you just passes through the transparent material. So,

there may be the possibility of the absorption of the laser energy at this point. And specifically this happens in case of the ultra short pulse laser. So, that is the one typical points to be remember, when case of the application of the ultra short pulse laser.

But of course, there is a alternate of using the ultra short pulse laser that is called laser transmission welding that is also develop. And in that case also we can use the one transparent material, but if the using the specific laser at the and with the certain wavelength, if that laser passes through the both the material. So, in that case some absorbing layer can be put between these two transparent material, and then that absorb the layer some absorb the laser energy and that creates the creates the heat in at the interface and that is responsible to join the two transparent material.

So, in that way laser transmission welding is also developed and using the conventional laser process. Then glass welding although very limited welding process exist for the in case of glass welding glass welding process. So, here mainly we can use that oxy gas torch or furnace to brings the flexible or may be to brings the viscous nature of the glass, such that; when they are in contact this at this mode; when they are in contact to components, then the readily joint can be form in case of the glass, but overall we can find out the welding of the glass they are exist very limited techniques.

One of the most economical method for the joining ceramic is the brazing of course, this technique having one economic brazing is the one of the economical technique, but it is having some other limitation also, then dissimilar welding between the plastic to metal normally we can find out most of the case, we can find of the laser transmission welding is one of the good option for the joining between the dissimilar plastic to metal.

So, in this module we have discussed that different welding techniques several issues advantage disadvantage different application area for the welding and joining of the non-metals; however, there is a need for extensive review of works and till there is a; so many other techniques can also exist specifically for the joining of the non-metals, but we have covered in this very few selective techniques in this case.

Thank you very much for your kind attention.