

**Design of Machine Elements – I**Prof. B. MaitiDepartment of Mechanical EngineeringIIT KharagpurLecture No - 23Design of Welded Joints – I

dear student let us begin the lecture on machine design part one

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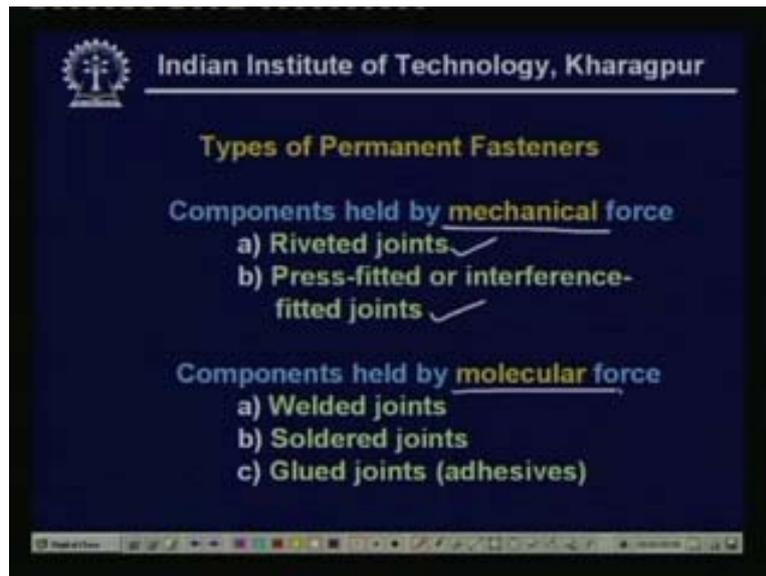


this is lecture number twenty-three and the topic is design of welded joints this will be the first part of the topic

now if you remember welded joint is a part of the joints which is normally known as permanent fasteners

let us look at the different other type of permanent fasteners [Vocalized-Noise]

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so this is the slide which was shown previously in the last lecture now i want to repeat that again

the permanent fasteners have two types they are of two types one is ah the components which are held by mechanical force [Vocalized-Noise] and there are two kinds one is the riveted joints which we had discussed earlier and the second one is the pres-fitted or interference fitted joints

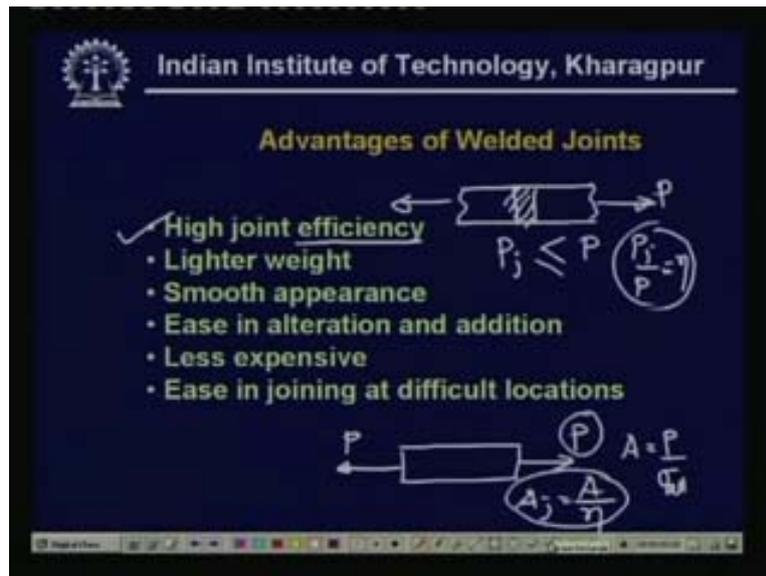
the other type is that where the components are held by the molecular force now this are the ah binding force which is responsible for the joint participations

there are three types three ah well some type three or four types one is welded joints which will be discussed today and in the next class then there may be brazing and solder joint and there are glued joints

now [Vocalized-Noise] there are very large structures for example ah the great suspension breach at Howrah or ah may be the Eiffel tower in Paris which are which is made of ah the parts which are connected by riveted joints but in spite of all that riveted joints are now losing their ground in favour of welded joints

so normally today most of the machine parts are joined by welding since there are various reasons for that let us come to those reasons one by one

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now let us look at the advantages of welded joints

here the first advantage is that high joint efficiency now we must remember what is meant by the term efficiency

now efficiency of a joint is defined as suppose the a single member it carries a load  $P$  and with the joint suppose now we introduce some joint here now with the joint the load is carried let us say  $P_j$

now definitely  $P_j$  is lesser than equal to  $P$  and  $P_j$  by  $P$  this is known as the efficiency of the joint now how efficiency is important you see that the efficiency is more means that the more the load carried load carrying capacity of the member is more

so ideally the efficiency should be one [Vocalized-Noise] but ah in many joints various joints the efficiency are ah quite small whereas in welding welded joint the efficiency could be reached very high even hundred percent efficiency is possible

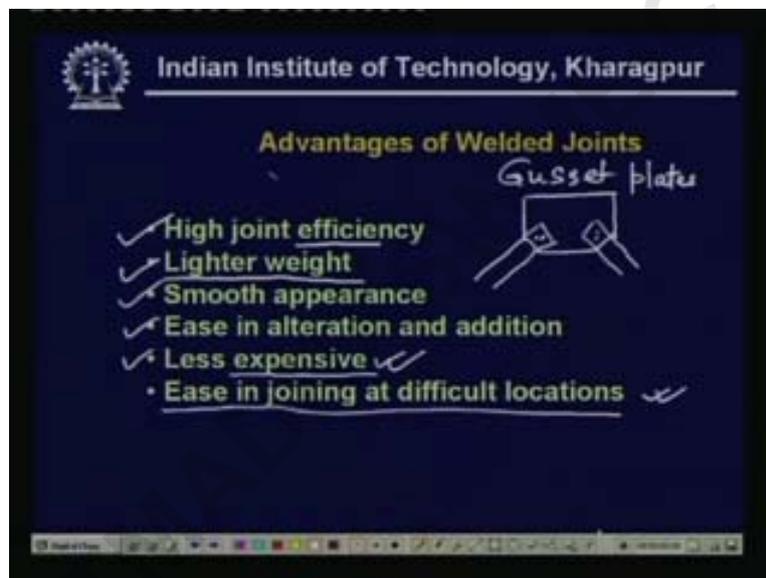
now how does the efficiency help in design that is if we design for example we want to design the ah dimension of a rod which is subjected to uni axial force  $P$  now if ah we know the strength then we can design the area of cross section as  $P$  divided by this sigma allowable now with the efficiency of course the load carrying capacity is not  $P$  but something less so therefore in order to carry the same load  $P$  the area has to be increased by some amount so the new area with the joint will be equal to  $A$  divided by efficiency

so therefore with small efficiency we have a large area of cross sections required and with large area of cross section of course what is increased is the cost or uh the weight of the structure

as i said the welding is a process where maximum efficiency could be reached because the weldings are nowadays very much standardised and we can join almost any metal to any metal even the plastics are joined ah by by welding process so welding are very standard process and we have reached such a level that hundred percent efficiency is possible therefore the welding process is very very important and very very useful in designing a joint

the second part is the the second one is the lighter weight as i said that the efficiency if decreased that is efficiency low weight will lead to larger the heavier weight of the joint in welding the joint weight is very very light why the reason is that efficiency is high and the second is that in some other joint technique for example in a rivet joint we use various other necessary components for example in rivet

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when we have want to ah join structural members we use what is known as Gusset plate now Gusset plates are used to join various members so these are the parts which are to be joined now there are rivets there so therefore this is additional component which is required this Gusset plates

similarly in bolted joint we need the uh the nuts and the washers etcetera and may be the ah locking device of the nuts all these things also in rivets we need cover plates sometimes if we use butt joint with single cover or double cover all these will lead to large the heavier weight of the joint now in welding of course the weight is lighter

then the third point is that smooth appearance because the welded joints could be ah given a machine finish may be {gra} (00:07:31) by grinding or by some machining say chipping

operations so therefore the joint appears to be very very smooth ah in modern {automo} (00:07:41) in modern fancy cars or in automobiles various types of welded joints are used the forth point is ease in alteration and additions

now suppose after making a joint we want to alter the joint to some extent or we add some joint again to this structures then of course this process becomes very easy with the welding joints

fifth is the it is less expensive it is very very important to have low expense in joining ah the other joining process is ah they are quite expensive because of ah the accessories used or may be the joining technique ah then it takes more time also it requires some other process for example {eh} (00:08:32) you might have heard the name die plate in the in connection with the joining of uh two parts by rivet joints so these are all the things required there whereas here we do not need much so therefore this is less expensive process and then ease in joining the final point ease in joining at difficult locations well this is also quit important because in joining say by rivet process we need to hold the rivet head and then apply force to the tail of the rivet

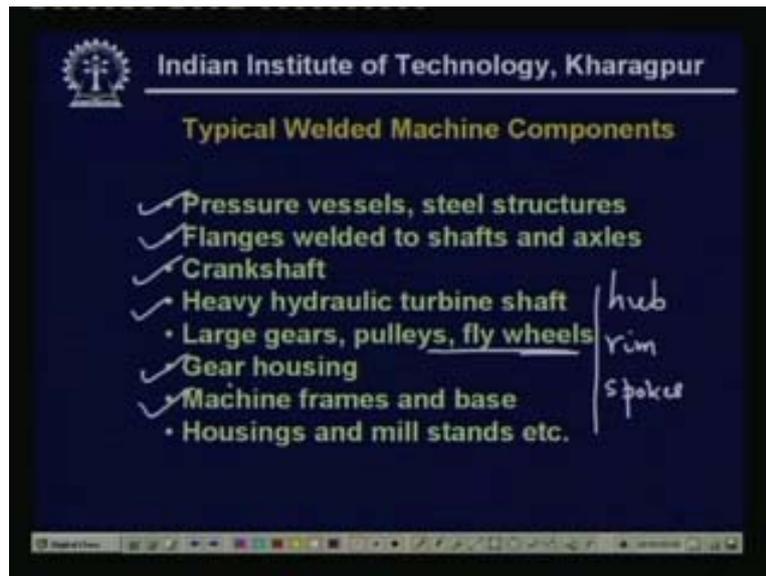
now that is ah that requires some clearance to make a riveting also in the bolted joints we need to have some clearance for the fixation of the nuts now here a less clearance is required for the welding joints

now in some cases where the ah reachability of the operator is very very difficult for the other kinds of processes in welding joints it is very much easy

now in modern world we have uh various automated welding process therefore the expense is small and then we can have enough flexibility in the welding process therefore the ease in joining at difficult locations is there

so these are the different advantages of welding {joh} (00:09:54) welded joints and therefore these welded joints are used almost extensively in today's engineering world

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now let us look at the typical welded machine components

here again we have pressure vessels steel structures now normally pressure as i ah told in the last class the pressure vessels are sometimes joined by rivets

nowadays the rivets are being replaced by welding because the welding techniques different sophisticated welding techniques have been developed and the researches are going on in the welding technology

so therefore all this has led to to ah the increase strength in joint so therefore pressure vessels are joined more or less ah usually in the ah in the industry

this steel structures for example the columns or beams or plates are joined by welding

then flanges welded to shafts and axles one kind of flanges we have already come across for example the flange coupling there are different other types of flanges used now mostly all the flanges are connected to the shaft or axles by ah welding

then crankshaft crankshaft is a um is a curious looking or a very complicated looking member but this is made of simple parts by joining them by welding so uh the crank ah crankshaft uh is made by welding

then heavy hydraulic turbine shaft when we have heavy hydraulic turbine which has ah which is used to generate very high very large power so then the turbine shaft is made of two parts and they are split into halves and those two halves are joined by welding

then large gear pulleys flywheels etcetera now gears pulleys flywheels when they are large in size they are made of several parts one is the gear hub or pulley hub or flywheels hub which is relatively thick in cross section

then ah we have of course ah what is known as rim which is the outer periphery of the large gears or pulleys or flywheels and the connection between hub and rims which is normally done by spokes or various connecting rods

now this three components are made separately and they are joined by welding processes to make a complete machine element

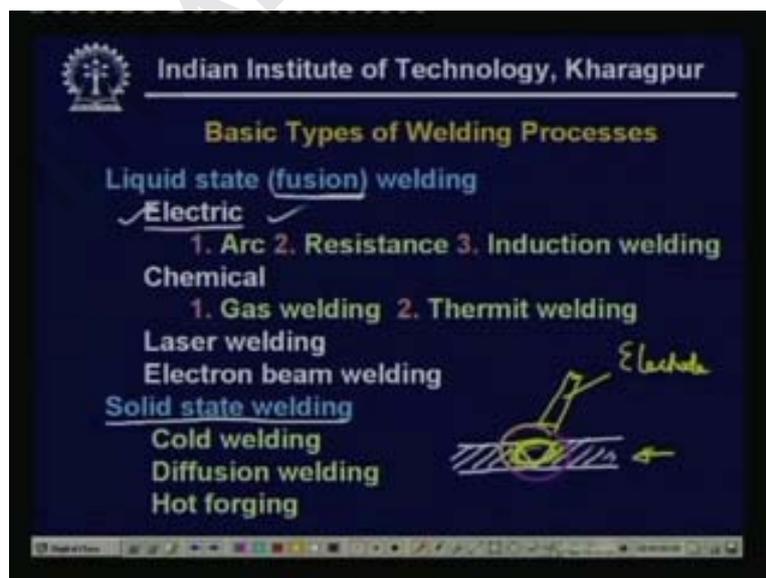
then we have gear housing now gear housing when the reducing gear train ah the gear housing box is made by joining ah different steel plates except of course few cases like the ah the boshes for the bearing mostly weldings are used

then machine frames and bases the machine frames and bases they are made by joining various structural members like beams and plates which are made of generally of steel

again housing and mill stands so when a large mill operations we have the mill stands which is {manu} (00:13:14) which is manufacture in parts and they are joined by means of welding joints

so this are the typical examples of welding of course this is not exhaustive and um various other components are made by ah welding process it is so much useful that even ah although this welding does not belong to a manufacturing process but it is ah named one of the manufacturing process because modern day manufacturing involves lots of welding so this is very very important in ah designing

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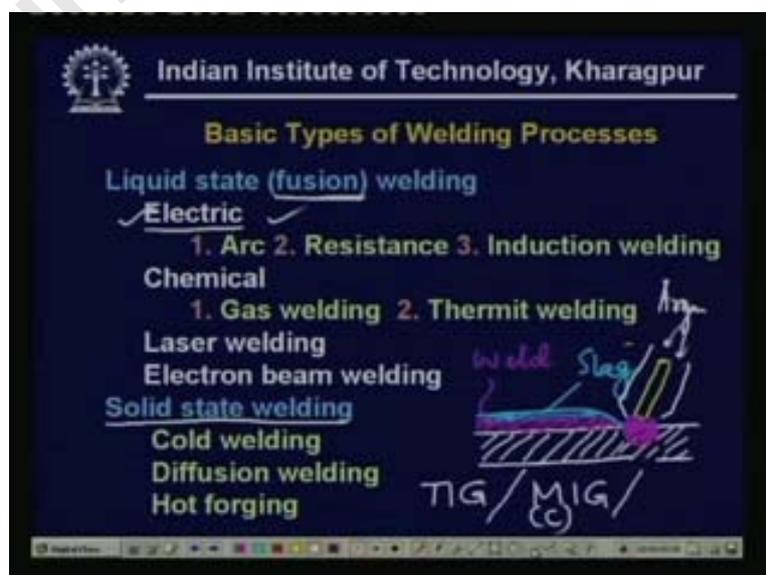
now we come to the point now what are the basic types of weldings now we have to look at the basic type of welding process

now welding process can be [Vocalized-Noise] divided broadly into two classes one is liquid state welding or what is known as fusion welding and another is the solid state welding now there are various kinds of liquid state welding or fusion welding one is the electric welding that is fusions what happens is that one of the material or the parts which are to be joined are brought to molten state to liquid state and then of course ah some added ah some metals or non metals are added to increase the strength of the joint now depending upon the source of the heat the process could be differentiated into this following kind

if the source of heat is electricity then this is the electric this process electric fusions welding now there are few ah few welding processes under the ah same heading one is arc welding now this is very very important welding process and most of the welding nowadays are arc welding process

here what happens now suppose we want to join two metals here two metals are to be joined now here this part that is [Vocalized-Noise] this part has to be melted first this part is melted now how this is done we use one arc we bring one electrode so this is electrode and we momentarily touch the electrode to the work piece and then take it away that produces because of high voltage that produces arcs and this arc are sustained by various techniques by at ah giving a coating to the ah to the electrode or ah by selecting proper electrode materials etcetera so a sustained arc is created and that gives enough heat to this work piece and it melts okay and when it melts then ah the liquid can be um while the liquid metal mixes in this region and a solid joint is formed

if you look the entire thing from this side then the structure looks something like this  
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so this is the metal looked from side this is another part of the metal

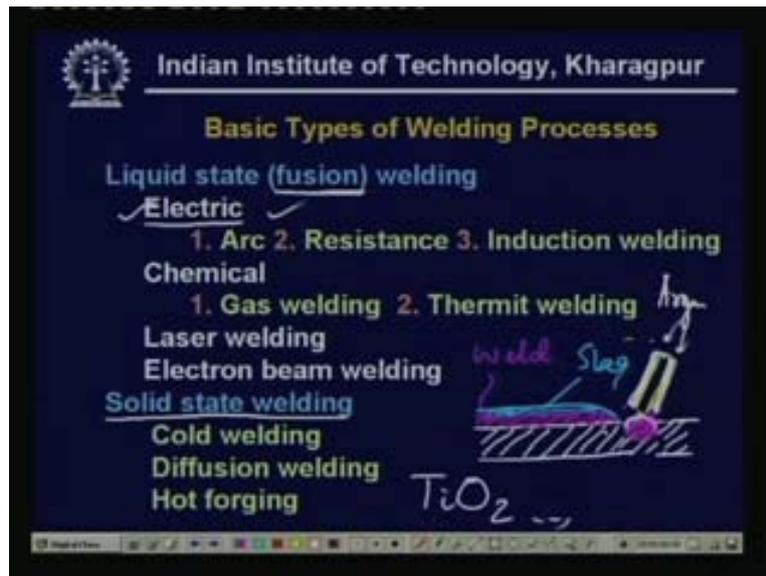
now we have electrode here we bring electrode and then because of this high voltage this arc is generated and because of the high pressure then a crater is formed {dosis} (00:17:18)

which is known as arc crater here of course the molten metal gets deposited right this is the weld weld metal and on top of it there exist another layer which is made of slag so this is the plot which is known as slag

now [Vocalized-Noise] after the welding is finished then this slag is removed by ah various process like chipping or ah grinding etcetera etcetera

here of course the main important thing is this generation of arc now this arc as i said ah this are generated by means of various electrode there are various processes one is the bear electrode arc machining here of course we have to shield this arc by ah in in some gaseous atmosphere why that is important because in the molten state the oxygen may be entrapped and that may oxidised the ah the material and therefore it leads to brittleness so therefore this oxidation has to be prevented and this is done by making this welding in inert atmosphere so this inert gas is given by by shielding this in a casing and inert gas is given mainly the argon gas is applied

now depending upon the nature of the electrode there may be of different types one is tungsten electrode that is ah which is called TIG welding tungsten inert gas welding sometimes but here the tungsten is not consumed we have metal inert gas welding MIG welding where of course metal is consumable that is consumable metal inert gas welding then we have another technique where we do not use this {ath} (00:19:34) atmosphere this uh inert gas atmosphere but what we use this shield this electrode now this shielding is done (Refer Slide Time: 00:19:56 min)



so here we give another coating to the electrode now there are various techniques of coating and this gives the shielding

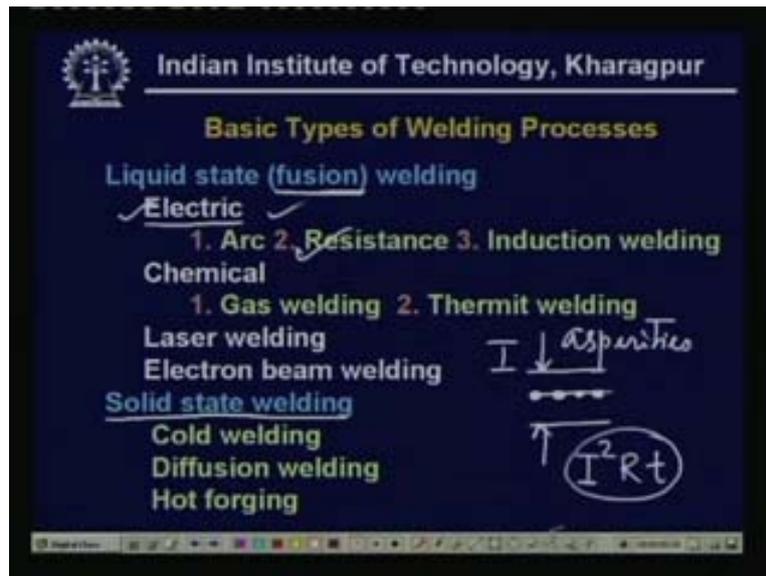
now there are various shield materials for example rutilite or ah cellulose based titanium oxide is given the or sometimes of course we have the hydrogen or base materials has that oxidations could be ah avoided but with hydrogen assisted it ah it becomes that hydrogen gets {em} (00:20:33) embedded in the or entrapped in the molten metal and that leads to embrittlement

so this is hydrogen assisted cracking or embrittlement is a severe phenomenon which should be more or less avoid so therefore we do not normally use the basic ah the hydrogen ah rich material as the coating

so there are various kinds of coatings available so this is roughly what is known as the arc welding

now we come to another type which is known as the resistance welding

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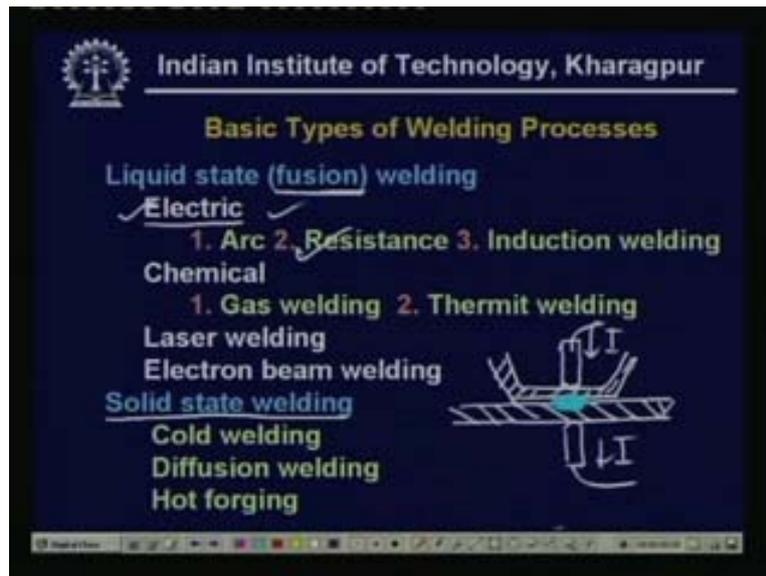


now resistance welding here the principle is that when we ah make two metals in contact then even if the contact area is very large but only a small portion gets ah practically in contact because of the asperities or unevenness in the surface

now this small area in contact when a large current is passed large current is applied then therefore a high the high resistance is developed here and this large resistance even if you do not you should not forget that there are always oxide layers present so there are impurities here

so therefore resistance is appreciable and because of the large resistance the heat generated which is given by  $I^2 R t$  so heat generated will be quite high and that melts this part okay and then they get joined so there are two kinds of resistance welding one is known as ah the spot welding where spot welding is

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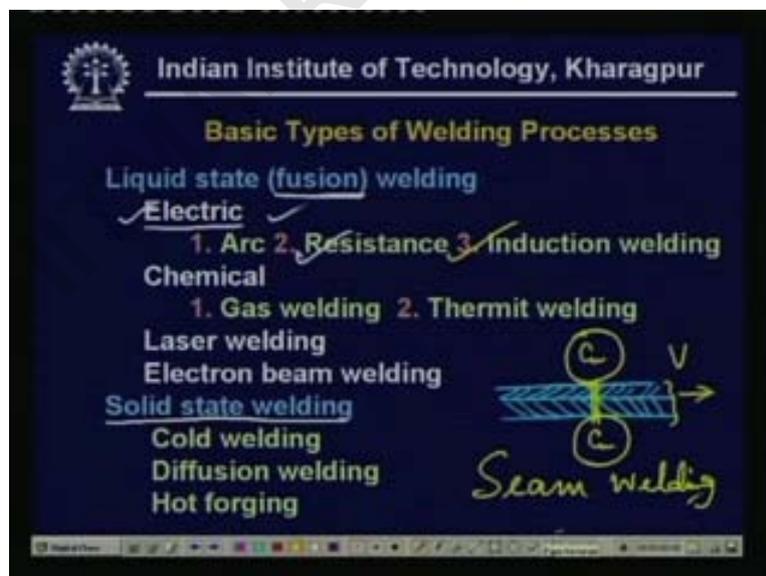


here two metal suppose this is one metal part and another metal part is here these are to be joined now we put it under two copper electrodes

so these are the copper electrodes and the current is passed okay so current is passed and therefore welding takes place here well this is the spot welding

now we have seam welding which is just a running version of this spot welding and they are what happens we have the electrodes in the form of two rollers

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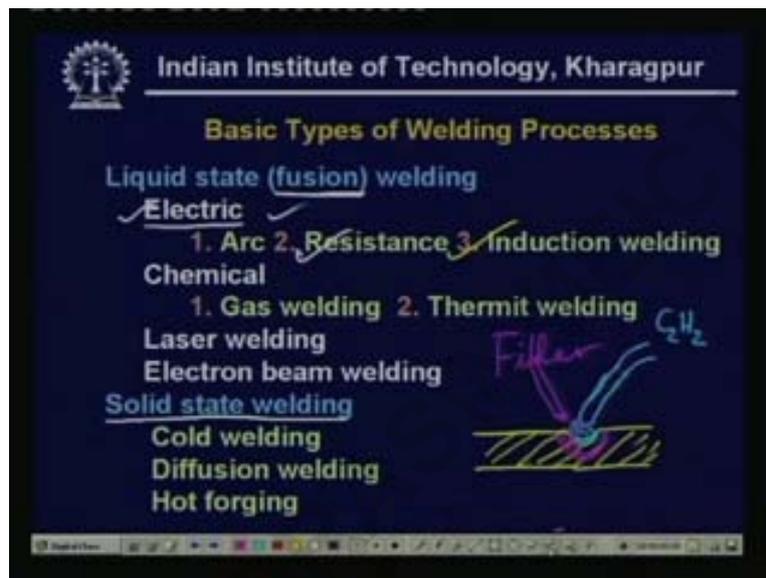


suppose we want to add this is one metal and another metal now we pass it between two rollers now this rollers are made of copper

so this is copper roller and a large current passes so then we move the whole things together right so which a velocity  $v$  is given and therefore when it moves then we see a um a line of welding and this is known as ah the seam welding

then we have another kind which is okay this is about resistance welding then ah the another type is induction welding of course which is very useful then second comes which is very important which is chemical welding here the ah the heat is generated by chemical reactions first one is the gas welding where

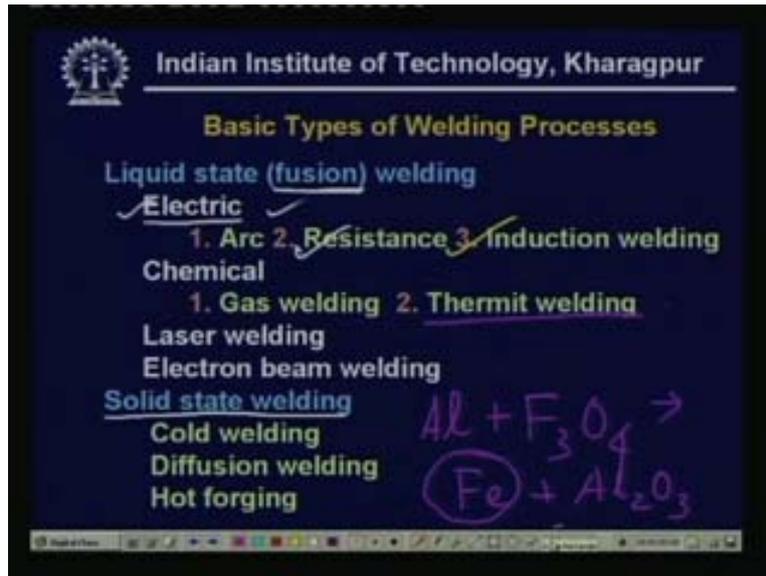
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where of course this is the metal the cross section of the joint and then a gas torch is brought here so this is connected to acetylene oxyacetylene okay and a gas burns so that gives high ah temperature here and this melts filler rod is added filler material is added somewhere there externally so this is filler material

so when the liquid melts then because of this may (( )) (00:25:50) this heat ah the filler material gets also melt and is added to this structure so a large a high strength bond is formed in the thermit welding process of course this is not very much used but it is used only in the field welding uh for example in the rails ah when we want to weld inside then we use the thermit welding here the process is that the heat is generated by chemical reactions

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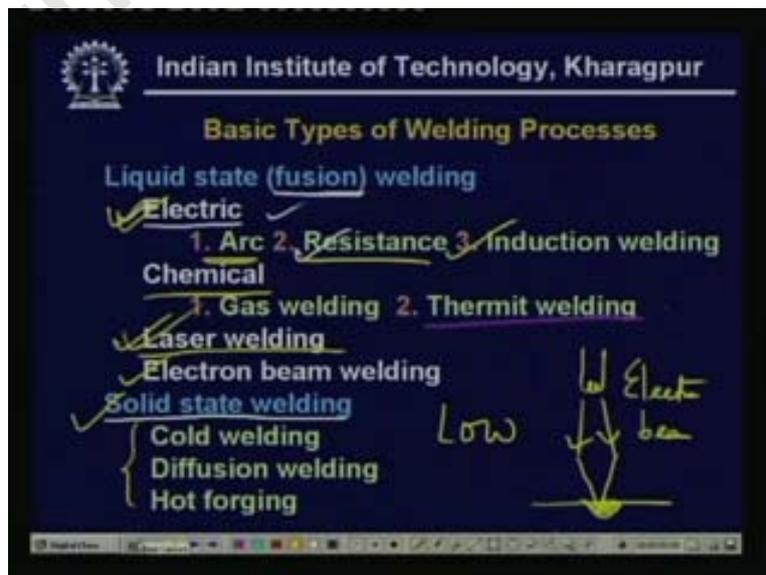


alumina and iron when added to ferric oxide will give iron and so this is the reaction now that is uh very exothermic reactions say heat is generated and that heat melts the uh base metal now here what we see this iron is added

now iron is not enough we will have to add some material because we want the steel and in the iron carbon diagram we you you we have to add to in order to melt make steel some amount of carbon and some other alloying elements because this is very important to use alloying elements so normally along with this power we use other flux materials so this is known as thermit welding process

there are other {mah} (00:27:16) advanced welding techniques like electron beam welding or laser welding let us discuss ah the electron beam welding

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here electron beam is generated and then this electron beam is focussed to the metal okay this is the base metal this is electron beam and a very focussed very large temperature large heat is generated large temperature is maintained here but within a small area but here the disadvantage is that it needs very low pressure very low ah i mean very uh low pressure that is it needs almost vacuum

so ah we need a very low pressure but this disadvantage could be avoided if we use laser welding

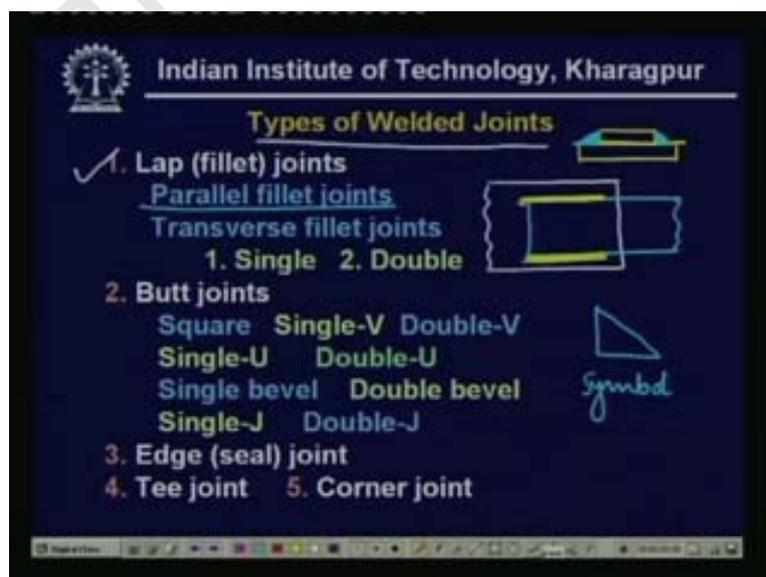
now in laser welding we have to focus the lasing material the laser now ah nowadays we have different kinds of laser and ah this is very useful nowadays and uh lots of researches ah are going on in this field but here one improvement is that a large heat is generated over a small area and the ah but here the heat is concentrated that is the heat loss is less

so therefore many other ah complications because of this heat loss can be avoided in laser welding

then there are other types which is solid state welding [Vocalized-Noise] sorry here of course in the solid state welding we have ah we do not fuse the ah metal into liquid state but we use the pressure ah in order to uh in order to deform the materials into plastic state and then by pressure and various other techniques then this two metals get joined

now from today's point of view the most important is this electric {arh} (00:29:25) arc welding or resistance welding and also chemical welding and laser welding of course to some extent

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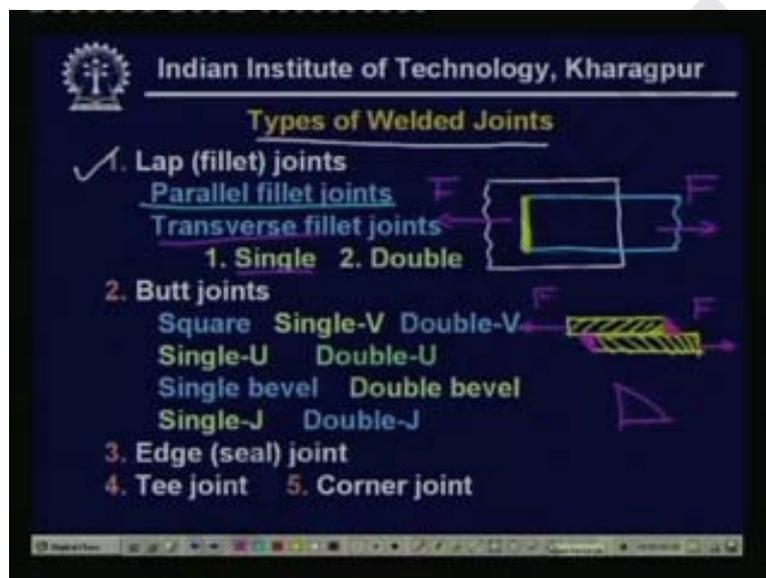
now let us come to the design part here of course we have the types of welded joints

now we have few types one is the lap or fillet joints now here the structure looks like fillet joints

suppose we want to join two metals and this is one metal which is to be joined to other metal now here two possibilities are there one is that we could apply welding in this side and in that side so if you look from the side it looks like so if you look from this side then we have welding this way so therefore this is known as parallel fillet welding parallel fillet joint

now the always with the welding we have different symbols the symbol of fillet joint is this this is the symbol associated with the fillet joint this is the symbol then of course we could have used the welding in different manner

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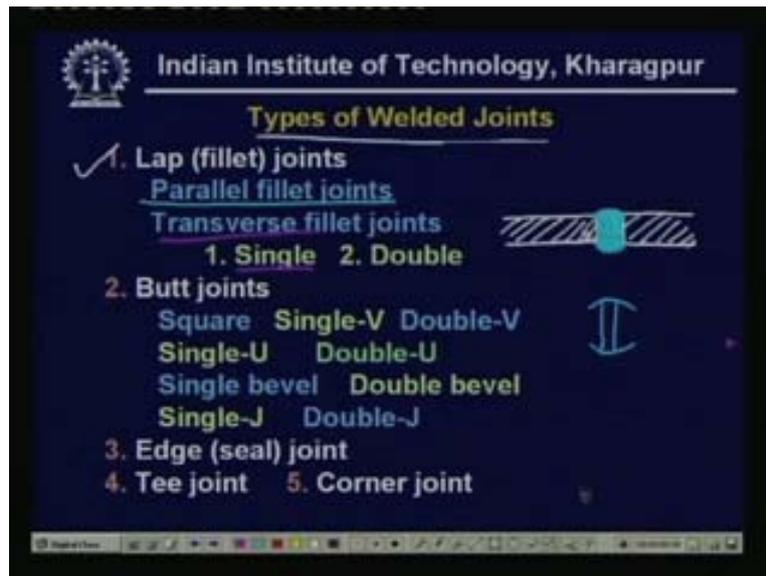
we could have used the weld metal here then of course if you look from the side it looks there is one metal and there is another

now here welding is applied here so this part is welded of course the force is given in this direction force in that directions so of course the joint has to carry some load so load is acted here so this is known as the transverse fillet joint

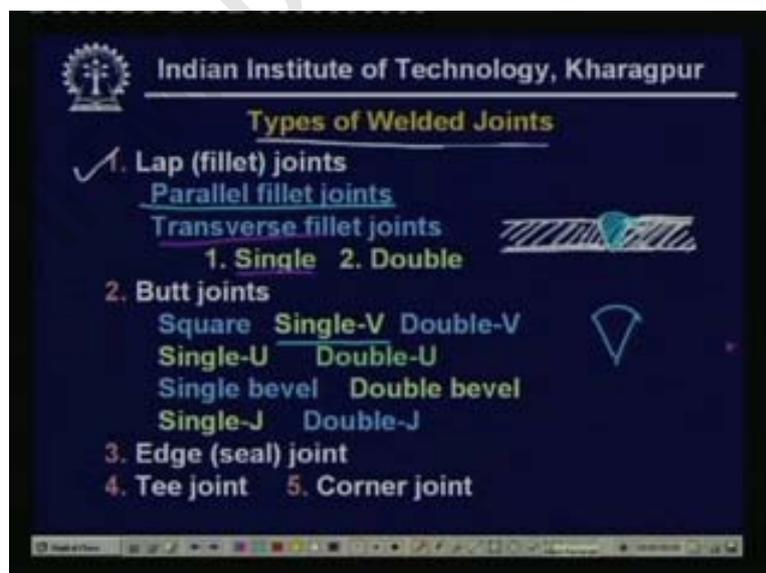
now definitely there is only one fillet ah so this is known as the single transverse fillet joint there may be also double fillet joint if you apply another fillet here then this is double fillet joint and of course the symbol as usual is this

then we come to the next type which is known as the butt joint

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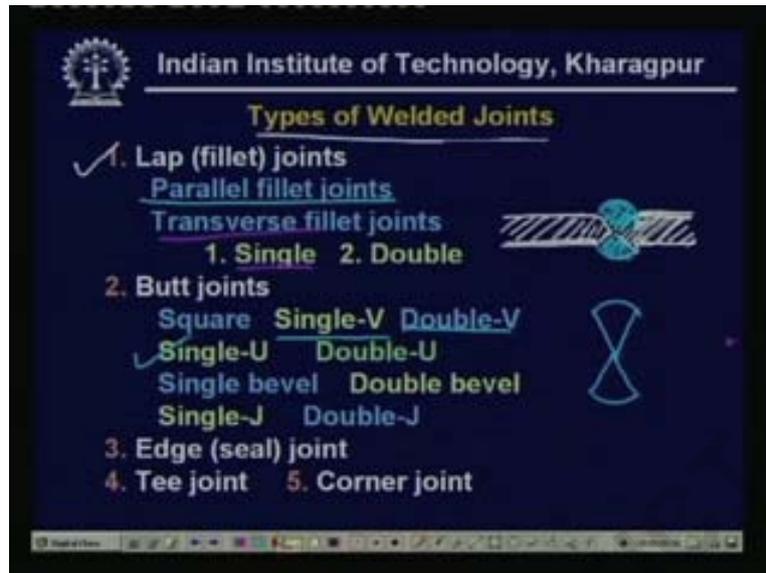
here we want to join two pieces side by side these are the two components and we want to join side by side this is butt joint then sometimes we have to prepare the face of this butt it may not be straight always so there are various possibilities if this is straight then this is known as square joint so then when you add welding welded metal weld metal here then the joint looks like so this is known as this is known as square butt joint of course here the symbol is this is the symbol of a square butt joint sometimes we use single V the next type is single V let me draw  
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here we use a single V joint here  
so is a V is formed by cutting this sides of this and then we apply weld so therefore the weld looks like this and the symbol here is so so this is the symbol of the single V butt joint

we have double V joint which looks like the following

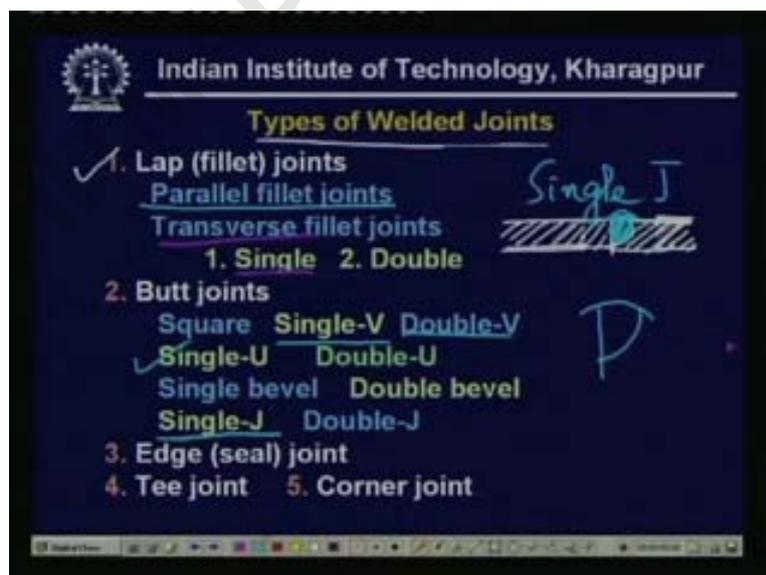
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here we cut this this is the face and similarly we make other face just like that and then we apply weld metal here of course the welding is done here and so this is known as the double V butt joint [Vocalized-Noise] and the symbol here is of course this is the symbol of double V butt joint

then we have single so this was double V then we have single U joint how does it look like

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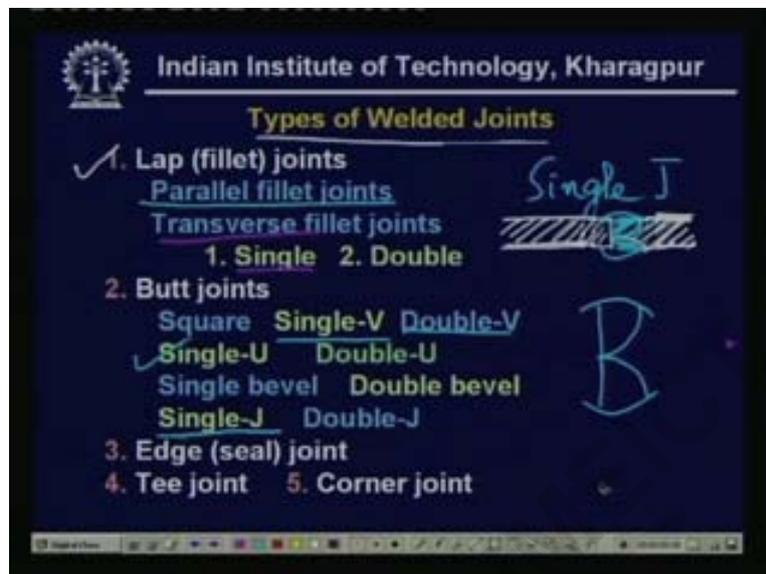


we have one is kept straight and another one is here so this is a groove is formed here and then we apply weld material so here this is the single U joint ah one small correction this is

known as single J joint rather than single U so this is single J joint because it looks like a J and the symbol here is so this is single J joint

similarly we have double J joint which looks like just very similar

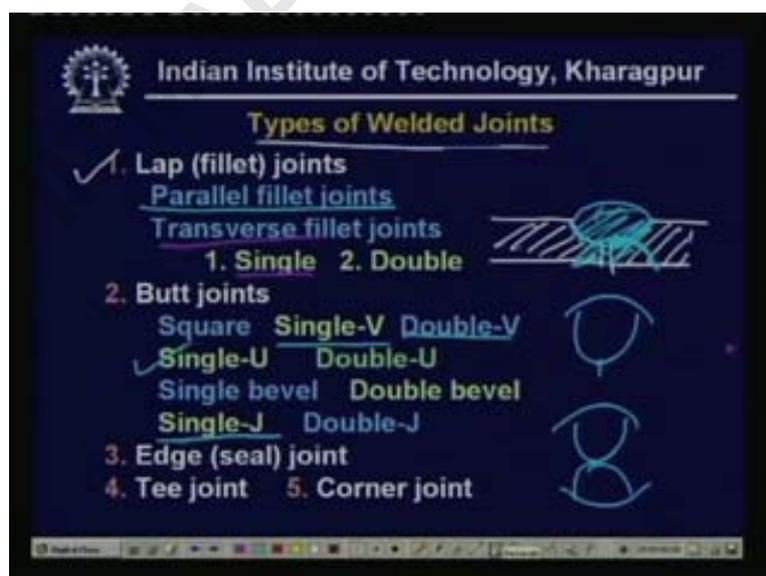
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a double J joint will be again straight and here and there again this type then the filler material is given here and then the symbol looks like double J

we have single U now we have to discuss the single U joint

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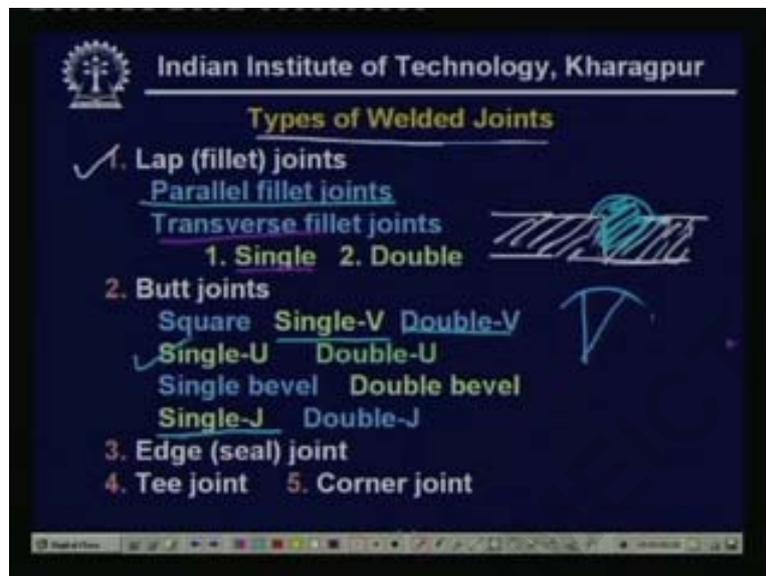


single U joint is both the both are they are kept here and then moulded metal is added so this is single U and this is this

we have double U if we have this kind that is ah the grooves are cut in both the face on both sides and we have this symbol so this is single U that is double U

then we have single bevel joint

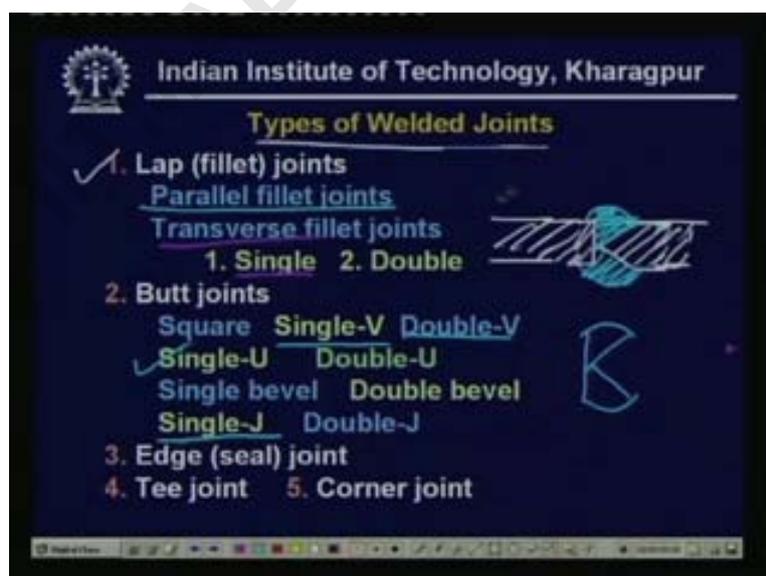
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we have single bevel joint one is kept straight another this way and then weld material is added so this is single bevel joint and the symbol is like this

we have double bevel joint may be similar

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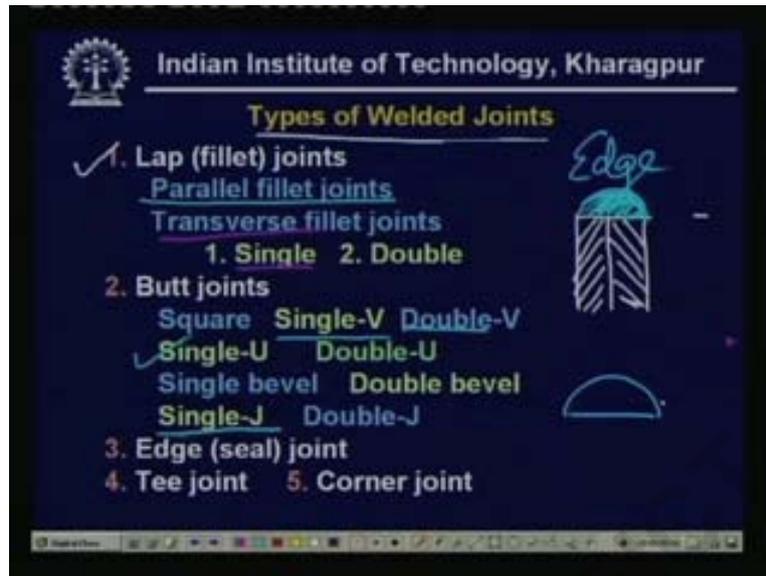


that is side as it is and here and we add metal on this so this is double bevel joint and the symbol is something like this so this are roughly the butt type joints

then we have dif another kind which is the edge joint

now here the

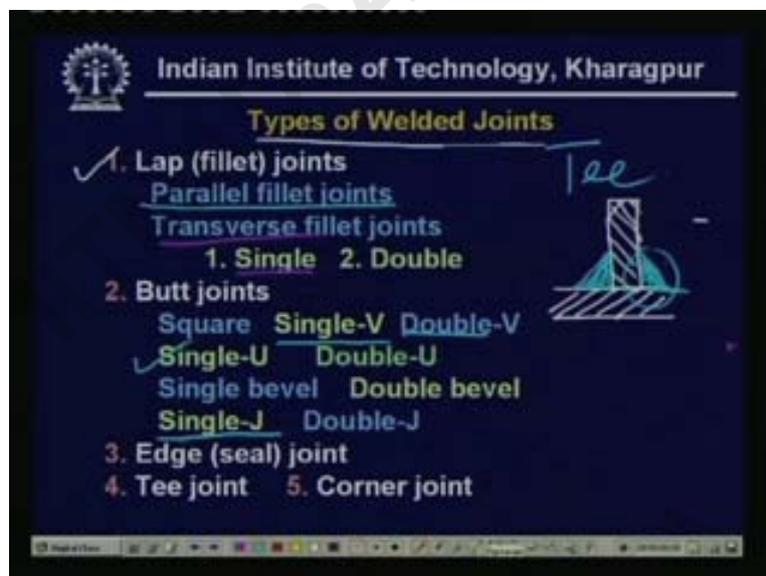
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two metals the edges of the two jointed components are brought together and then the welded material is added so this is the edge joint and the symbol is this

we have tee joint we have tee joint

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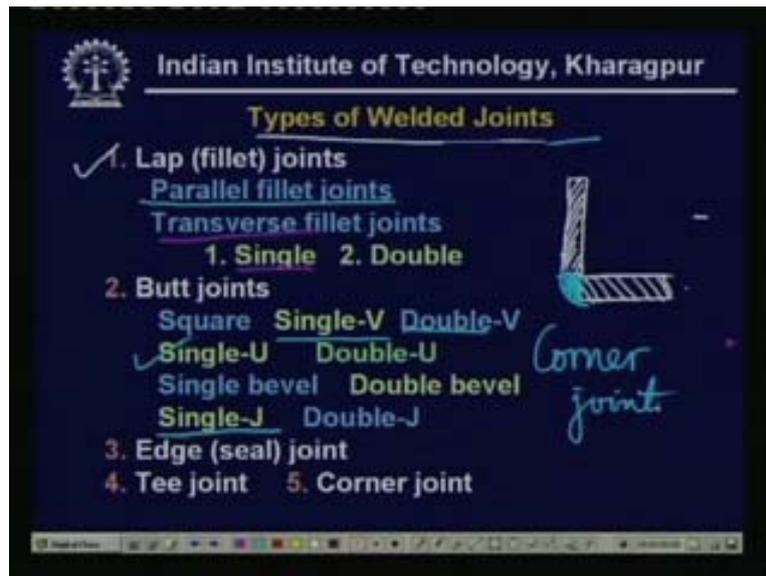


here one base metal another metal is added so this is to be jointed in form of a tee we apply over here so this is the tee joint

now you see that the fillets are used here to make a tee joint

we have also corner joint which again looks

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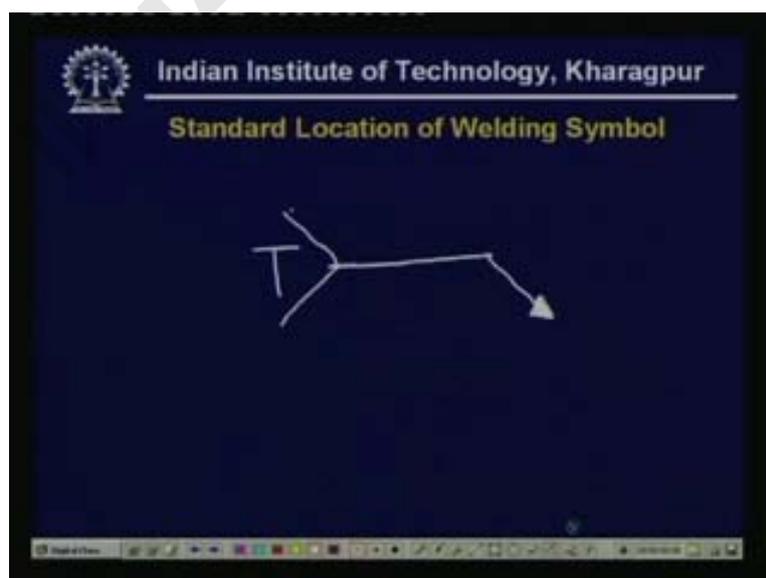


so this is one metal which is to be now joined to other and we apply weld here so this is the corner joint

so this are roughly the types of welded joints

now we have to know the standard locations of welding symbol that is very important because where if you are going to design then will have to be assessed if will have to have some understanding or some informations about the knowledge ah about the drawing of the machine components here you see the welding suppose you want to designate ah the welding

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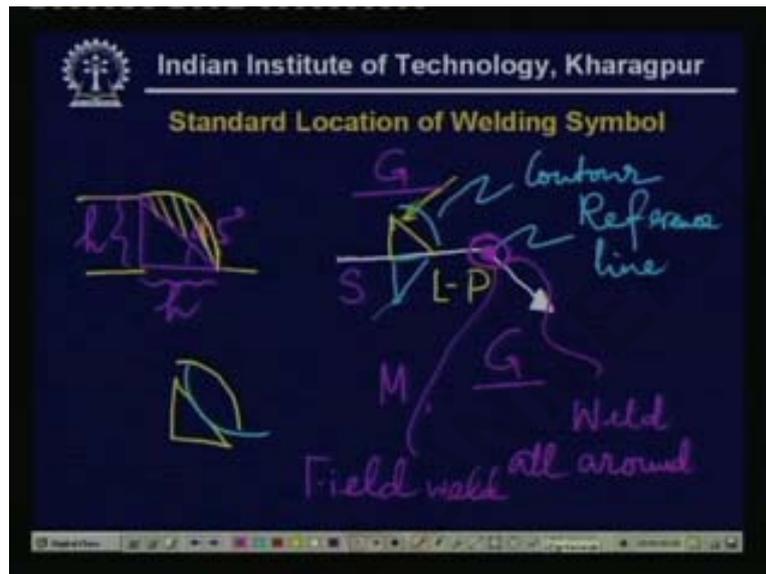


then it is given by means of a reference line and one arrow here so this arrow points to the place to the joint which where the welding has to be applied so this is the arrow and here the

first stage that if you want to describe the welding process then there is a tail of the arrow and you write down all the [Vocalized-Noise] all the process description etcetera sometimes if you do not want to describe this then you may omit this that is it is possible to not to give this one

then the important thing is that you will have to give the welding symbol that is what kind of welding is to be given

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so here there are two sides so if you if you ah specify the welding type in the in the bottom part bottom of this reference line so this is the reference line

so if you mention the welding symbols for example this is the welding symbol of a fillet joint so that means that this fillet type welding has to be used in the arrow side of the joint

now if you use so this is this side that is the uh to the arrow side of the joint this ah this kind of {joih} (00:43:29) welding has to be applied so if you want to apply the reverse side of it then you will have to give welding symbol may be you may use two different kinds of welding but proper symbols are to be given so this keeps on the other side of the ah arrow so this is a {toperh} (00:43:48) top one is the welding from the other side of the ah arrow ah of the joint pointed by this arrow

now this together both of them together mean that both sides are to be joined then we have to specify the size here we specify the size of the joint now normally in the fillet joint you might have said there are two possibilities one is that this length and that length so this two lengths may be we since this is forty-five degree angle so they are equal normally so one is enough one ah size is enough this is the height the fillet so this size has to be specified then here we

give another specifications that is we specify here of course the length of the welded and the un welded parts there may be cases where the intermittent welding is uh is given so we will have to specify exactly how much of ah how much part will be welded and how much will be left un welded so this all informations are to be provided here

{afkar} (00:45:03) after welding is done then we have to ah give the coutour (( )) (00:45:08) to the ah to the ah weld for example here this these are the two parts now here the coutour is straight coutour sometimes by machining operations we have this kind of coutour suppose we want to give this coutour

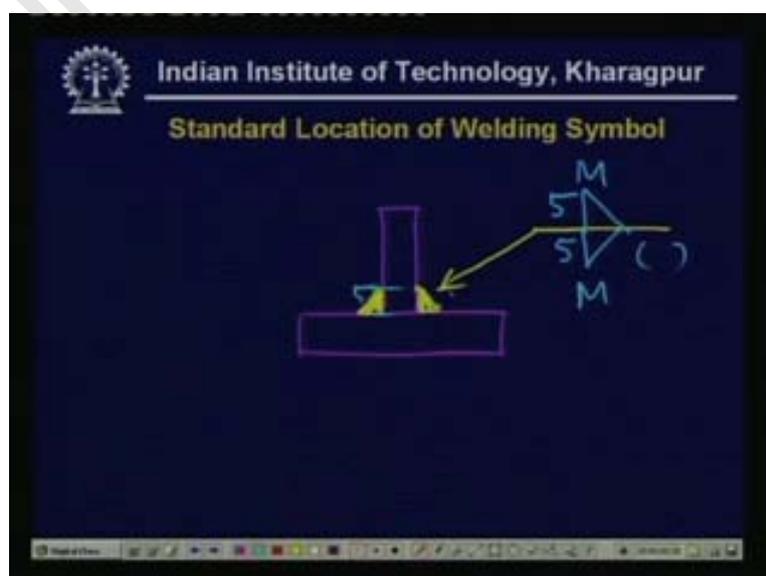
so this coutour symbol has to be given now the here the coutour symbol is here given like this so here of course the coutour symbol is given

here this part will have this one or sometimes concave coutour is given so so this is the coutour is given

then we have to have the machining the finish operations here the machining has to be done now [Vocalized-Noise] we will have to write the symbol M for machining G for grinding etcetera so if you write this then it means that a surface to be {conh} (00:46:05) convex shaped and then it is to be ground so all these informations are given in a welding in a welding symbol just an example and of course there is another thing here we have this kind a symbol that is weld throughout that is weld all around and if instead it is given this this is called the field weld so this is the symbol which is called weld all around and this one is the field weld so this are the symbols used for the welding

now let us look let us look ah at a example

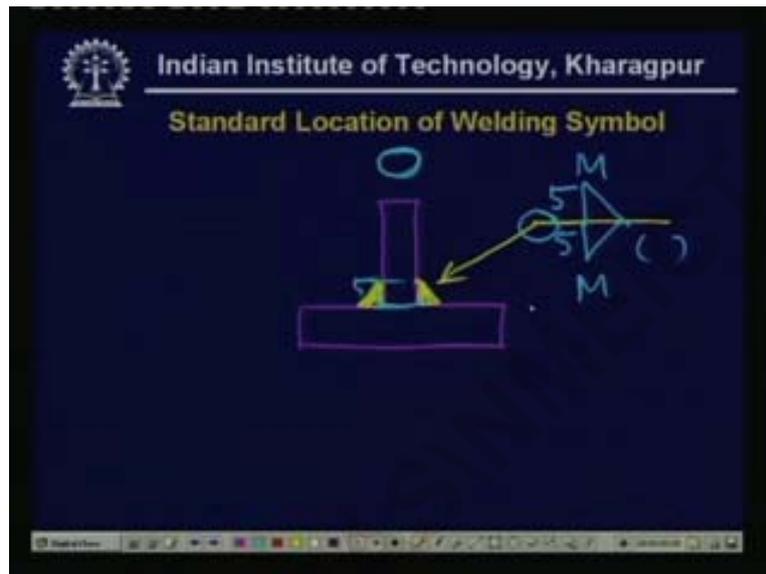
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suppose we have two parts which are welded this way

now if the arrow pointed that way that is this is the point so if you want to use this weld then what we have to do we have to write the proper welding symbol both sides let us say five millimetre if the five millimetre is this height then five and five and then it is to be machine finished machine finish this is straight edge so all this information all the informations are given ah may be you can apply the length

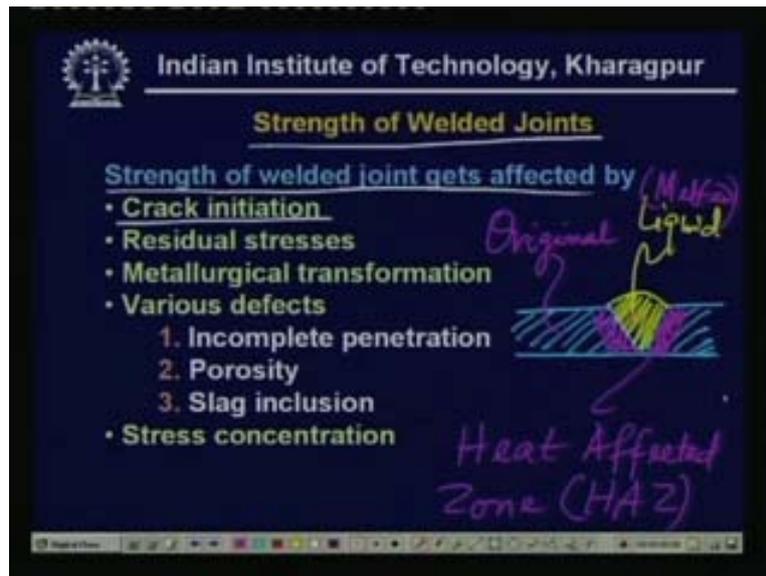
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suppose even to weld around a uh circular member then of course if we have this section circular then of course you may use this symbol such that means that all around this all around this there will be the welding okay

so this are the weld types uh welding symbols which you must know

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now we come to [Vocalized-Noise] the very important point as far as design is concerned we want to know the strength of welded joint now the welded joints they are very difficult ah to analyse in terms of stress so what we have we [Vocalized-Noise] we use the strain data by means of some experiment but first of all let us check what are the what are the ah factors which effects the strength of a welded joint one is the crack initiations

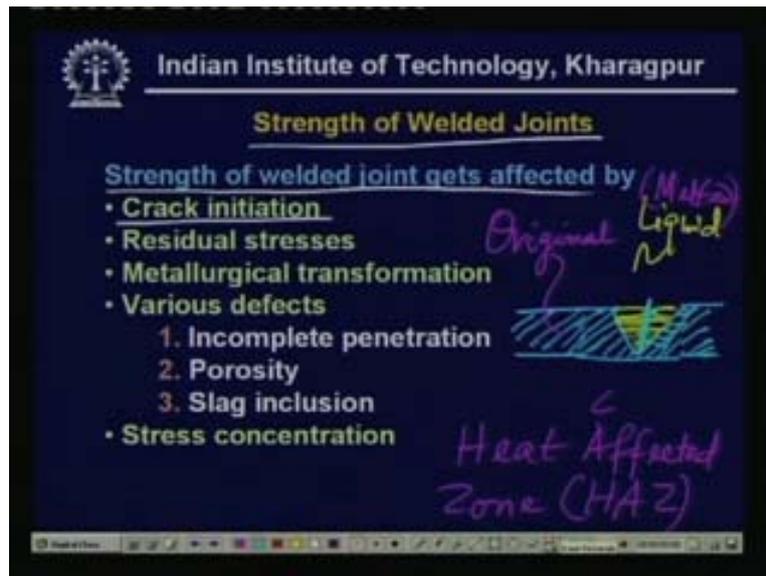
now there are various possibilities of crack initiations one is that ah if you look closely into the welding process then you see that here so this is the metal now welding is applied there weld metal is applied there so here there is a zone which which is in liquid state right and this part so this is the melted portion of this metal then there may be a part that is this part which is adjacent which is not melt but which is affected by the heat applied at ah at in this {posi} (00:49:41) position that is in the in the melt heat source so this is called heat effected zone normally HAZ

this is very important because here lots of complications occur the metallurgical transformation takes place in this in in in this locations

so this heat effected zone and this is non heat effected zone that is the original metal this is a original part and this is welded part or may be ah melted

so whenever ah it starts cooling then what happens the cooling procedure is very much ah like in a casting so all the defects of castings are present so when it starts cooling then the procedure becomes very interesting that is you see that whenever it cools

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then after cooling this kind of grains are formed and when the solidification has ended then there may be a place where a crack is formed so this is the part where crack is formed so this is due to the solidifications

there may be other causes for crack for example in this heat affected zone the crack may initiate then of course so this are the typical crack initiation process we have then the we have then the residual stress the residual stress here you see this is due to the uneven heating of the metals so the residual stress will be developed because of the uneven heating of the metals and whenever there is uneven heating so there will be a thermal stress developed you know that  $\epsilon$  is proportional to  $\Delta T$

so whenever there is a change in temperature there will be a strain and because of strain there will be stress developed and this stress causes the causes may be so high that crack may be developed so this residual stress is also very dangerous

then the metallurgical transformations

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### Strength of Welded Joints

Strength of welded joint gets affected by

- Crack initiation ✓
- Residual stresses ✓
- Metallurgical transformation
- Various defects
  1. Incomplete penetration
  2. Porosity
  3. Slag inclusion

Stress concentration  
 $\epsilon = \alpha \Delta T$

Handwritten notes: (Mukta), Original Liquid, Heat Affected Zone (HAZ)

here as i said that in the heat effecting zone the metallurgical transformations may take place normally because uh in order to have a uh high strength we have ah small grains but because of the heating the grain size gets increased so therefore the strength in this region gets down because of the heating so the grain grains are coarsened and that leads to low strength the ductility is of course increased but that is what we do not want

then there may be various defects possible one is incomplete penetration ah that is very clear that whenever we have incomplete penetration for example in a butt joint we want to we want to have the ah joint ah but the incomplete penetration takes place so it forms a sharp notch and that is a ah place where the stress concentration develops and the strength gets weakened porosity may be there so these are the defects slag inclusions these are the defects which in acts to the uh lowering of the strength

then stress concentrations now that may be due to the geometry of the weld and ah that we discussed in the next class when we study the design proper but now let us see

ah so this is about the strength of the welded joint

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**Home Work Problem**

A double riveted lap joint with zig-zag riveting is to be designed for 13 mm thick plates. Assume the safe working stresses in tension, shear and compression are 80 MPa, 60 MPa and 120 MPa, respectively. Find the efficiency of the joint.

$d = 6\sqrt{t} \text{ mm}$ ,  $(p-d)t\sigma_t = P$   
 $2 \frac{\pi}{4} d^2 \sigma_s = P_s$

now this was as far as today's lecture now let us come to the home work problem which was given in the last class

a double riveted lap joint was zigzag and thirty millimetre thick plate so thirty millimetre thick now Unwin's formula if you use then it gives root six ah six root t millimetre and this is the diameter now with the diameter we use the strength now the strength is p minus d times the thickness times the tensile strength and this is the tearing strength

now we have to use the ah the shear of this of this plate so that shearing is done again you see pie by four d square there are two because they say ah is a double riveted so this times the shearing stress so this are the allowable load in tension in the shear

now if we equate this normally they are equated so if you equate this you get the p and then once this p is known then the diametric the uh um ah the uh transverse pitch is also calculated by this formula the transverse pitch will be equal to

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**Home Work Problem**

A double riveted lap joint with zig-zag riveting is to be designed for 13 mm thick plates. Assume the safe working stresses in tension, shear and compression are 80 MPa, 60 MPa and 120 MPa, respectively. Find the efficiency of the joint.

$d = 6\sqrt{t} \text{ mm}$ ,  $p_d = \frac{p + 2d}{3}$

the diametrical pitch is calculated as  $p = p + 2d$  by three this will find in hand book then of course when the design is completed you will have to get the efficiency here you will have to calculate first the crushing strength the shearing strength and the tearing strength now the crushing strength is calculated if you use the proper cross sections

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Indian Institute of Technology, Kharagpur

**Home Work Problem**

A double riveted lap joint with zig-zag riveting is to be designed for 13 mm thick plates. Assume the safe working stresses in tension, shear and compression are 80 MPa, 60 MPa and 120 MPa, respectively. Find the efficiency of the joint.

$\eta = 67.5\%$

$d = 6\sqrt{t} \text{ mm}$ ,  $P_c = \pi d t \sigma_c$

$P_c, P_t, P_s$

that is the  $\pi d t$  of this rivet times the  $\sigma_c$  times this crushing so this gives the crushing load now you have to calculate the minimum of this  $P_c$ ,  $P_t$  and  $P_s$  and divided by the original load without any joint which is equal to  $p t$  that is the pitch times  $d t$  and the  $\sigma_t$  and if you calculate what you get is that efficiency turns out to be sixty-seven point five percent okay

so this is the result

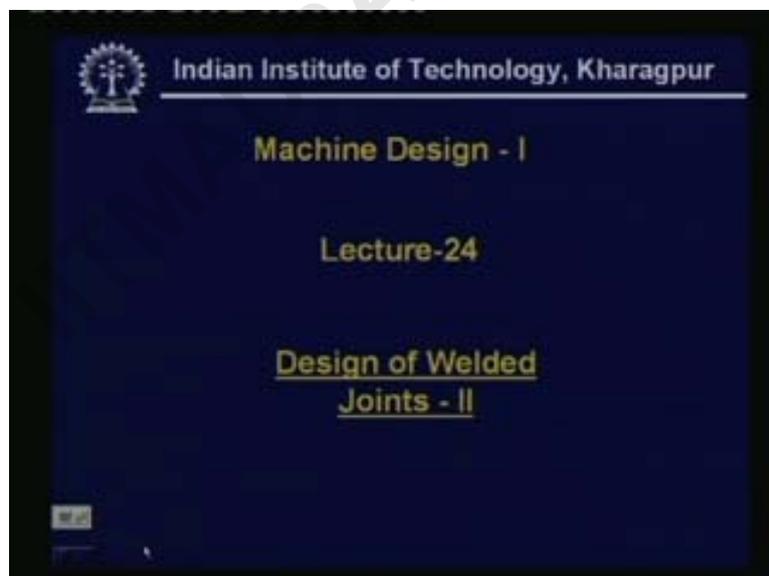
so that was the homework problem we will discuss again the welding joint welded joints in the next class thank you

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dear student let us begin the lectures on machine design part one

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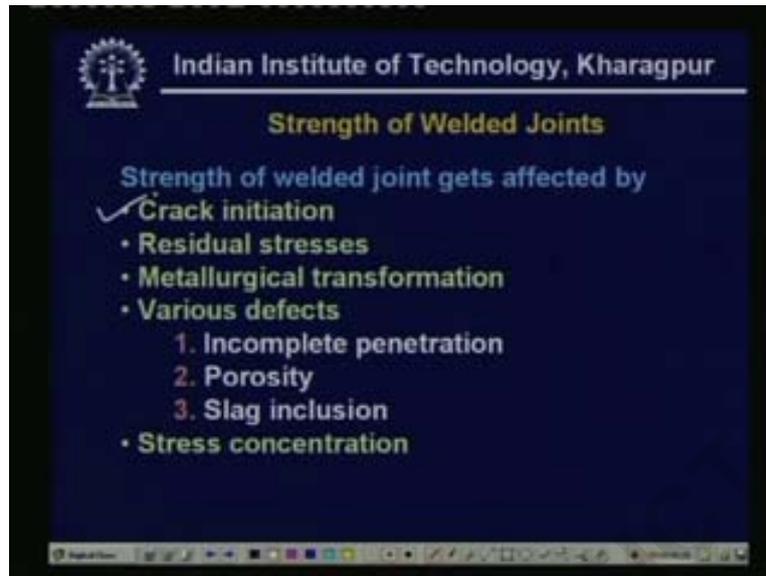


this is lecture number twenty-four and the topic is design of welded joints and this is the concluding part of the lectures on the same topic

let us recapitulate little bit what we had learned in the last class we we talked about different kinds of the welded joints different types of welding processes and towards the end we mentioned about the strength or the factors affecting the strength of this joints

now let us begin from ah the same place where we had ended in the last class

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so this was the strength of welded joints we are talking of now [Vocalized-Noise] the strength of welded joint gets affected by there are few criteria few things which effect the strength of the welded joint one is the crack initiation

now we mentioned that there are few causes of crack initiations that may be due to the incomplete the solidification contractions then there may be the cracks in the heat effected zone then there may be cracks due to the residual stress or incomplete penetrations etcetera so there are various reasons for crack initiations

then we talked of the residual stress now because of the inhomogeneous or a non-uniform hitting of the of the weld melt that is the ah the parts which are to be joined by welding because