Fundamental of Welding Science and Technology

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Module - 1
Lecture - 1
Introduction of Welding

Today, I am going to deliver a lecture on Introduction of Welding.

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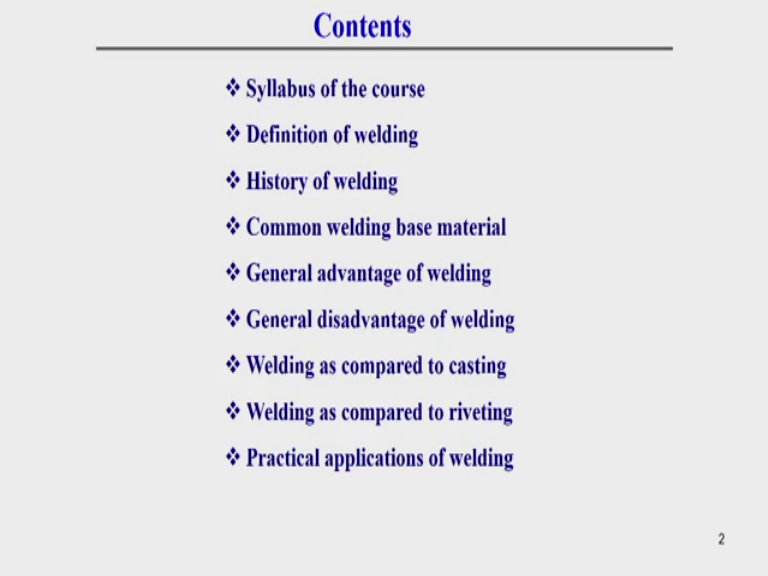

This is the overview or we can say content of this today's lecture like, I will cover the following topics. Like syllabus of the course, definition of welding, history of welding, common welding base material, general advantage of welding, general disadvantage of welding, welding as compared to casting, like other manufacturing process which is comparable with welding like; casting and welding as compared to riveting, and it is practical application in details.

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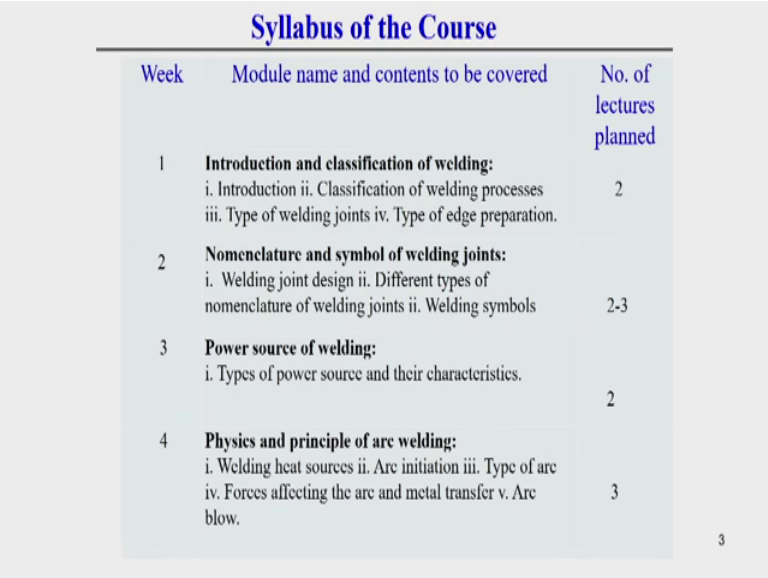

First of all I will cover the syllabus of the course. This is the week wise module name content to be covered and number of lecture planned is given. In first week I will cover the module whose name is introduction and classification of welding. Here I will cover introduction of welding, classification of welding processes, type of welding joints, type of it is preparation, it will take 2 lecture. Now, in second week the model name is nomenclature and symbol of welding joint. Here, I will cover welding joint design different types of nomenclature of welding joint, welding symbols; it will take around 2 to 3 lectures.

In the third week I will cover power source of welding. Here I will cover type of power source and their characteristics; it will take around 2 lectures. In the fourth week I will cover physics and principle involved in arc welding process. Here I will cover welding heat sources, arc initiation, type of arc, then forces affecting the arc and metal transfer, then arc blow. It will take around 3 lectures.

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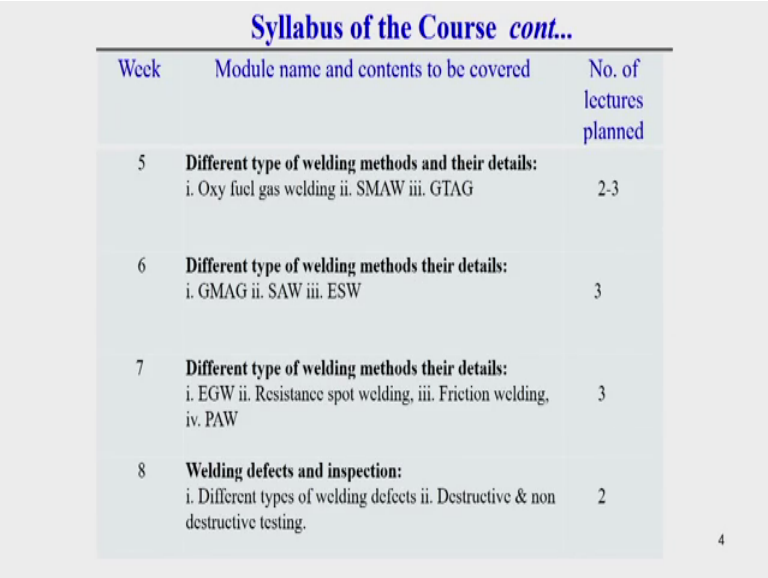

Then in fifth week I will cover different types of welding method and their details. The these different types of welding method and their details we will take another 2 weeks also. Like in 6 and 7 because I will give lecture on different types of welding method and their details. Like in fifth week there are different types of welding method and that details are oxy fuel gas welding, get shielded manual metal arc welding, then gas tungsten arc welding process. Then, in sixth week I will cover different types of welding method and their details like gash metal arc welding, sub mars arc welding then electric welding.

Then, in 7 week different types of welding method and their details I will cover electro gas welding, resistance spot welding, friction welding and plasma arc welding. These are the different welding processes, which I will cover in this 3 week which are generally widely used in traditional manufacturing industry.

In week 8, I will cover welding defects and their inspection. Here, I will cover different types of welding defect destructive and non-destructive testing. This will take around another 2 lectures. This way it will take around 20 to 24 lectures.

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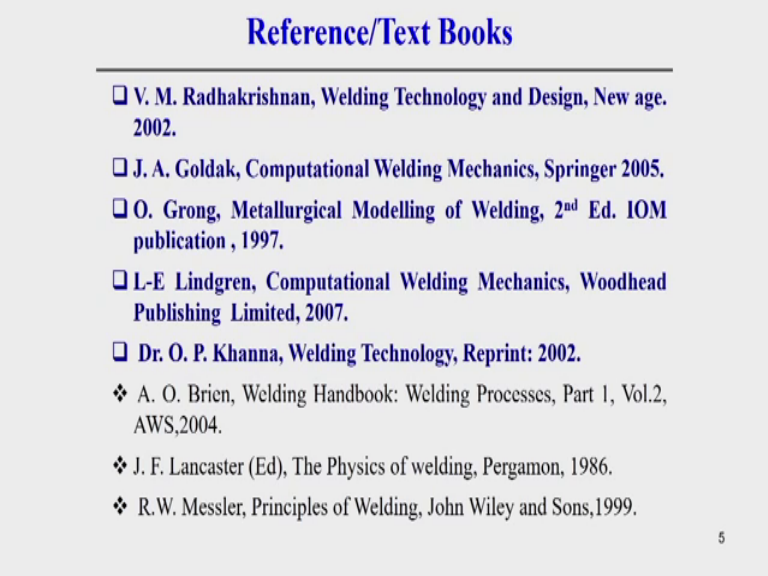

These are the reference or text books which I will follows for this course, like Welding Technology and Design by V.M. Radhakrishnan, then computational weld mechanics by J.A. Goldak, Metallurgical Modeling of Welding by O. Grong, Computational Weld Mechanics, L-E Lindgren, Lindgren L-E Lindgren Dr. O.P. Khannas book like Welding Technology. Apart from this I will follow welding handbook, then the physics of welding by J.F. Lancaster. Then principle of welding like R.W. Messler, these are the following reference or textbook generally I will follow in this course.

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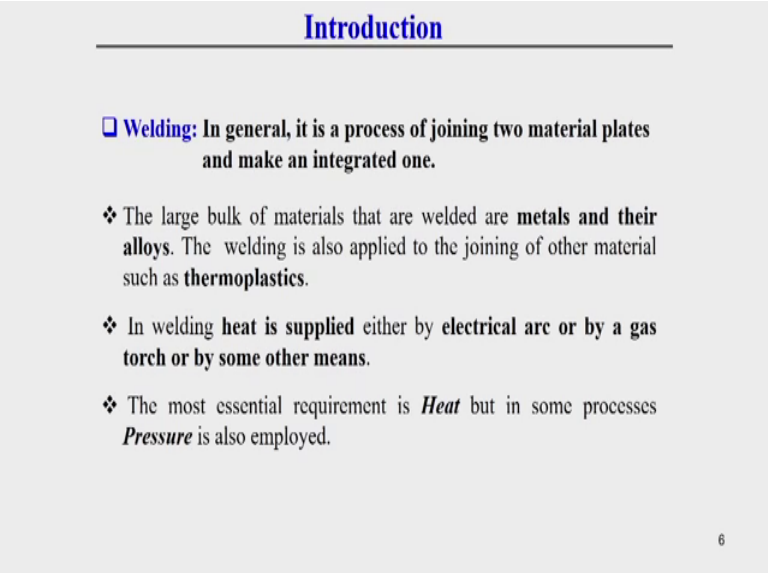

Now, the definition of welding what we can say that then definition of welding we can say in general, it is a process of joining 2 material plates and makes an integrated one. The material which generally is all the weld are metal and their alloy. That welding is sometimes applies some other types of material like thermo plastic. Actually thermo plastic is a material. Who is generally during heating it is melt and during cooling it is solidifies; that means, during heating it is plasticizes and during cooling it is solidifies.

So, this thermo plastic like the example of plastic is like PVC that means, acolytes then lilone different types of materials which can be weld able. In welding the heat is supplied I either by electric arc or by gas torch or by some other means. Like mechanical means it can be radiation energy means.

The most essential requirement is heat, but in some process pressure is also employed.

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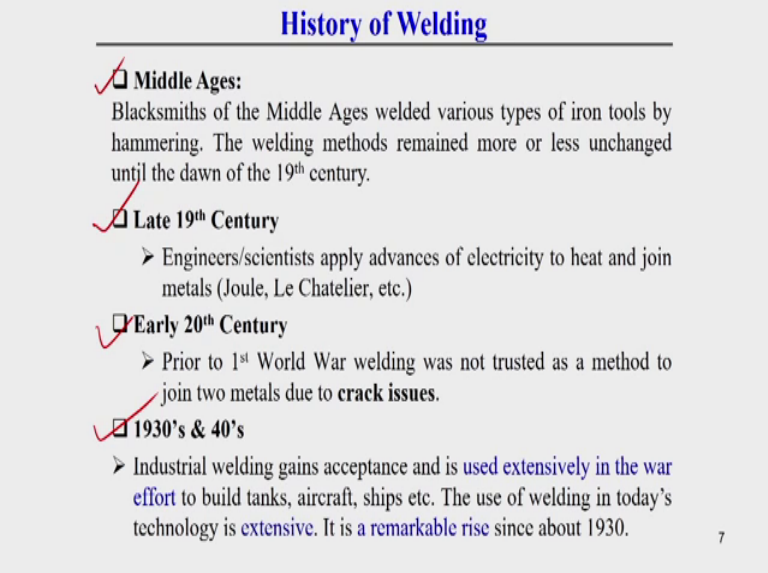

Now, in history of welding here I will cover the history of traditional welding process. Generally the conventional welding process which is widely used in industry; like in middle age Blacksmith of the middle age welded various types of iron tools by hammering. The welding method remains more or less unchanged until the dawn of 19th century. Then in late 19th century general engineer and scientist apply advantages or advances of electricity to heat and join metal. In this time they are as lot of famous researchers or scientists were there like Joule, Le Chatelier, etcetera.

Then in early 20th century prior to the 1st world war. Welding was not trusted as a method to join different metal due to crack issue. Because welding is such a process or such a technique, where we are generally intentionally create a defect in a structure. Because, whenever we will do welding in a structure then there will come some metallurgical then a structural changes. So, due to the this it creates different types of defect in a structure, that is why prior to the first order then a welding was not trusted as a method to join to metal due to this crack issues.

Then in 1930 and 40 here generally in this time industrial welding gain acceptance, and is used extensively in the war effort to build tank, aircrafts, ships etcetera. The use of welding in today's technology is very extensive, it is a remarkable rise since about 19th century.

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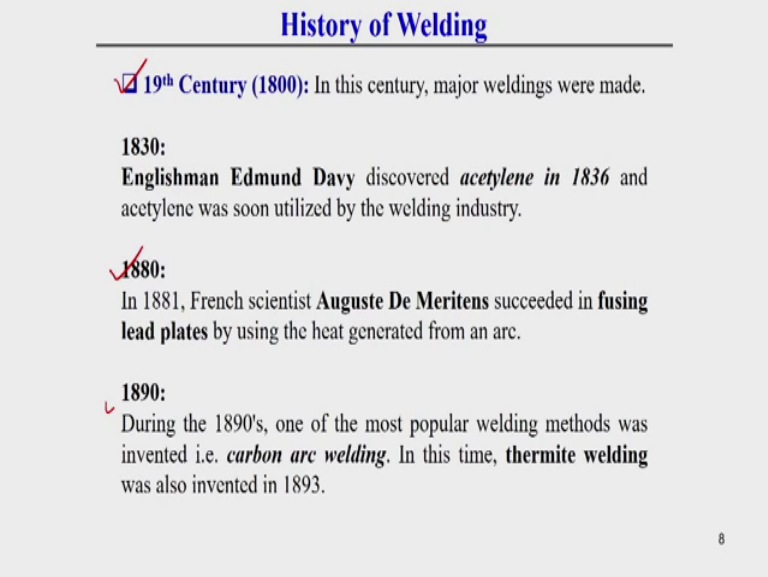

Then, the year wise the detail invention of conventional welding processes given here, like in 19th century. In this century lot of major welding techniques aws were developed. Like in year 1830 Englishman Edmund Davy discover acetylene in 1830 and acetylene was soon utilized soon after that acetylene was utilized by the welding industry.

In year 1880; that means, after 50 years of 1830 there is developed a another weld welding techniques, that is generally that was developed by French scientists Auguste De Meritens in 1881. Auguste De Meritens succeeded in fusing lead plate by using the heat generated from an arc. So, soon after that application of electric arc in welding field gain

significant interest and lot of different arc welding technology where developed after 1880.

1890 during the year 1891 of the most popular welding method was invented, that is carbon arc welding. In this time thermite welding was also invented in the year of 1893.

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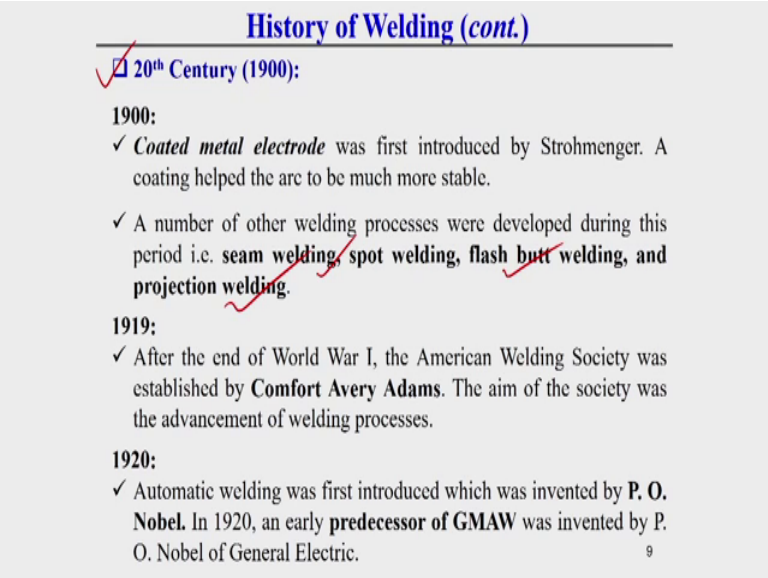

Then in 20th century there was developed lot of electric arc welding techniques apart from electric arc welding techniques here, there was developed some other welding techniques also, like solid state welding and resistance welding techniques also in this century developed. This is the most important century were lot of invention of welding was done.

Generally in 1900 years in the year of 1900 Coated metal electrode was first introduced by a Strohmenger. A coating helped the arc to much more stable. So, this is a very important development of an electric field. So, a number of other welding process are develop during this period also, that is seam welding is spot welding, flash butt welding, and projection welding. These are all generally resistance types of welding technique say solid state welding types these are all solid state welding types.

Then, after 20 years in 1991 after the 1st world war one the American welding's society has established by comfort Avery Adams the aim of this society was the advancement of welding processes. In 1920 automatic welding was first introduce which was invented by

P.O. Nobel. In 1920 and early predecessor of GMAW; that means, gas metal arc welding was invented by P.O. Nobel of general electric.

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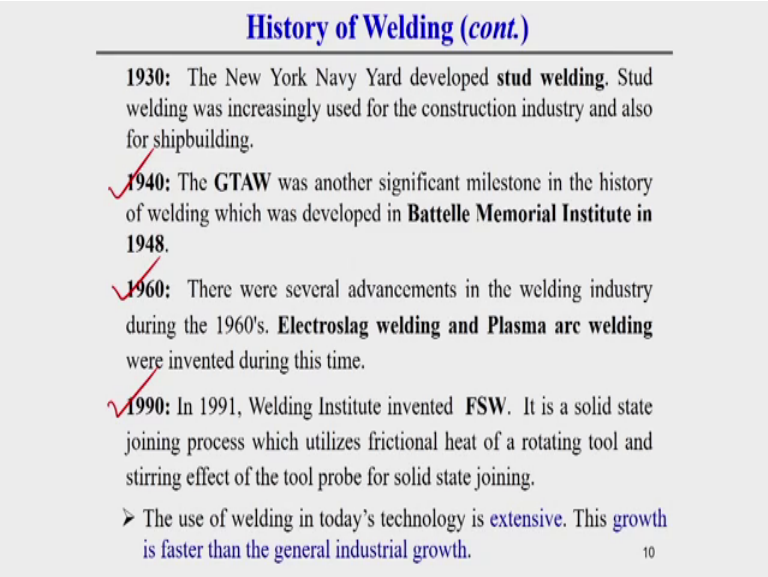

Then in 1930 the New York Navy Yard developed a stud welding. Stud welding was increasingly used for construction industry and also for shipbuilding industry. Then in the year 1940 gas tungsten arc welding was then the gas tungsten arc welding was another significant milestone in the history of welding, which was developed in Battelle memorial institute in 1948.

Then, in the year 1960 in this time there are several advancement, in the welding industry was happened; like in this time Electroslag welding Plasma arc welding were invented. Then in year 1990 welding institute generally in this time welding institute inventing friction stir welding in 1991. It is a solid state joining process who is utilize fictional heat of a rotating tool and stirring effect of tool for solid state joining. The use of welding in today's technology is very extensive the growth of welding technology is faster than the general industrial growth |.

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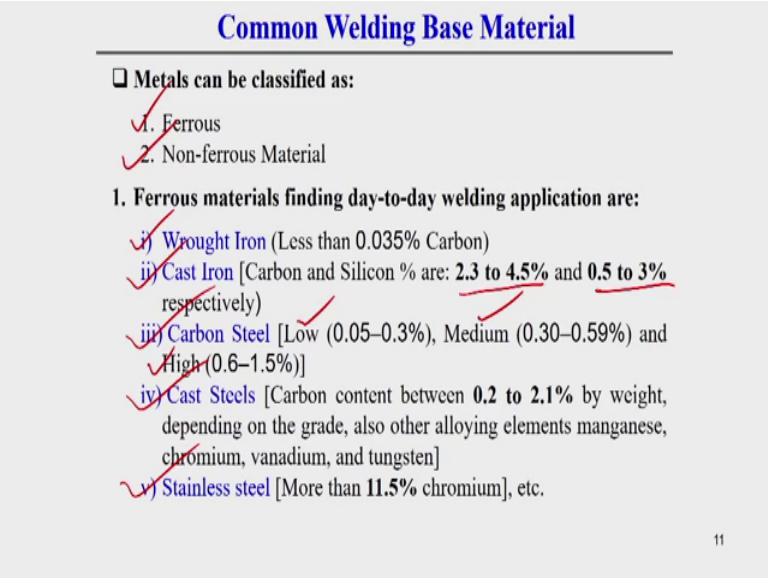

Then in common welding base material; that means, the material which is weldable can we categorize into 2 different classes one is Ferrous, and another one is Non-ferrous material. Like in ferrous material the finding day to day welding application are wrought iron, it can be cast iron, it can be carbon steel, then cast steel and stainless steel.. We will see what is wrought iron? And weldable actually which is which sort of iron is weldable.

Generally, wrought iron which as a carbon content less than 0.035 percent and rest of the things is iron. In cast iron generally here 2 major components are there that is carbon and silicon. Here generally carbon content varying from 2.3 to 4.5 percent and silicon percent is varying from 0.5 to 3 percent. Then, in case of carbon steel this carbon is steel can be categorized in 3 different categories, it can be low carbon steel, it can be medium carbon steel, or it can be high carbon steel.

Generally low carbon is steel the carbon percent is varying from 0.05 percent to 0.3 percent, in medium carbon steel carbon percent is varying from 0.3 to 0.59 percent, and for high carbon steel the carbon percentage is varying from 0.6 to 1 point. These are the cast carbon steel which can be weldable; that means, which is weld able. Then in case of cast steel so, there is a difference between carbon steel and cast steel. Like in cast steel generally here the carbon content varying between 0.2 to 2 point I 1 percent by weight, but here is some other alloying element are there. Like manganese, chromium,

vanadium, tungsten these are the different types of alloying element is there in case in cast steel.

But, in carbon steel generally these are the things is not there. Now, in stainless steel which is weldable generally a stainless steel also weldable stainless steel is that material, where generally more than 11.5 percent chromium are there. Due to this percentage of chromium generally in a stainless steel, they are developed steel layer over the surface of the steel. Due to these generally this system layer protect from the corruption and it increased the corrosion resistance of the material.

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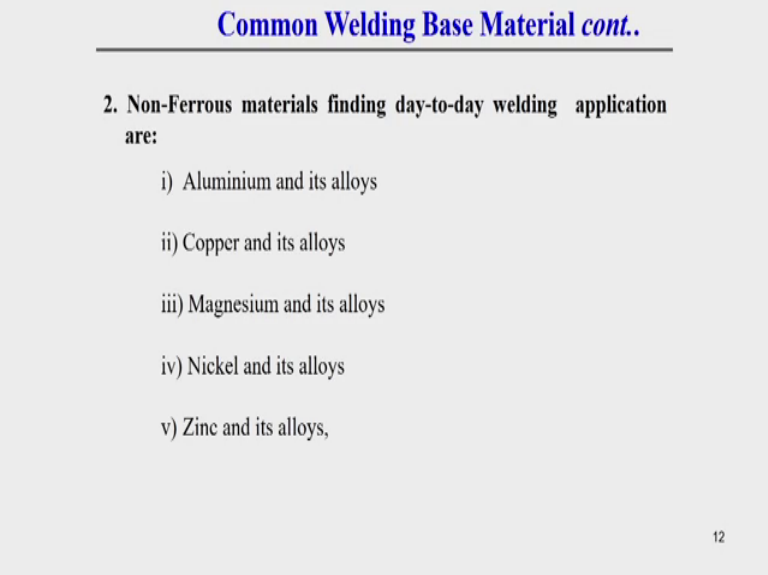

Now, in case of Non-Ferrous metal, which generally finding day to day welding application are aluminum and it is alloy, then copper and it is alloy, manganese sorry magnesium and it is alloy, the nickel and it is alloy, zinc and it is alloy. These are the generally non-ferrous materials which find day to day welding application; that means, this materials we can weld. Apart from these things lot of other material also can be well weldable like reflectory reactive material also can be weldable nowadays.

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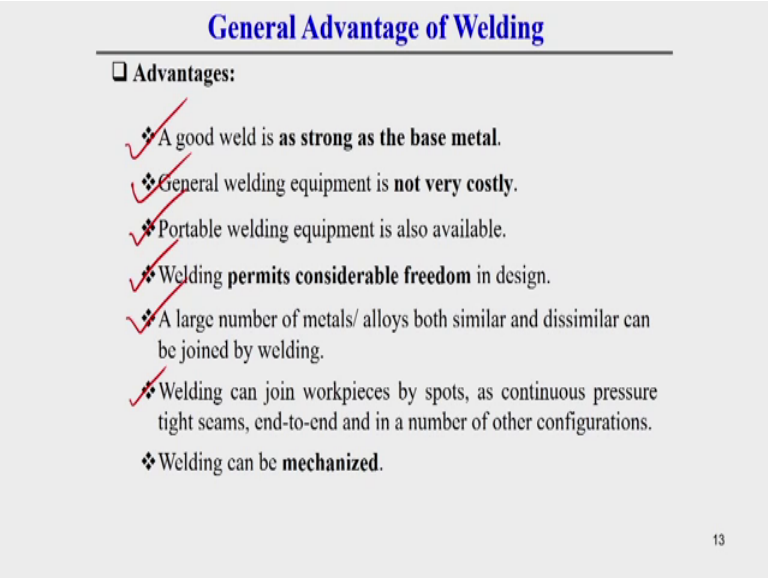

Now, these are the general advantages of welding process like a good weld is as strong as the base material; that means, in case of welding we can get a strength, which comparable with base material; that means, whatever this strength of base material is there. We can get almost similar extent in case of a welded joint.

General welding equipment is not very costly. Generally whatever the traditional welding processes we are using industry, that welding machine cost is comparatively not very costly. Portable welding equipment is also available; that means, we can take welding machine or welding equipment from one place to another place very easy way easily.

Then welding permit considerable freedom in design. This welding is such a techniques, where we can get lot of freedom in design also. A large number of metal and alloy both similar and dissimilar can be joined by welding process. Welding can join work piece by spot as continuous pressure tight end to end and in a number of other configuration also. And finally, welding can be mechanized; that means, we can do welding automatically.

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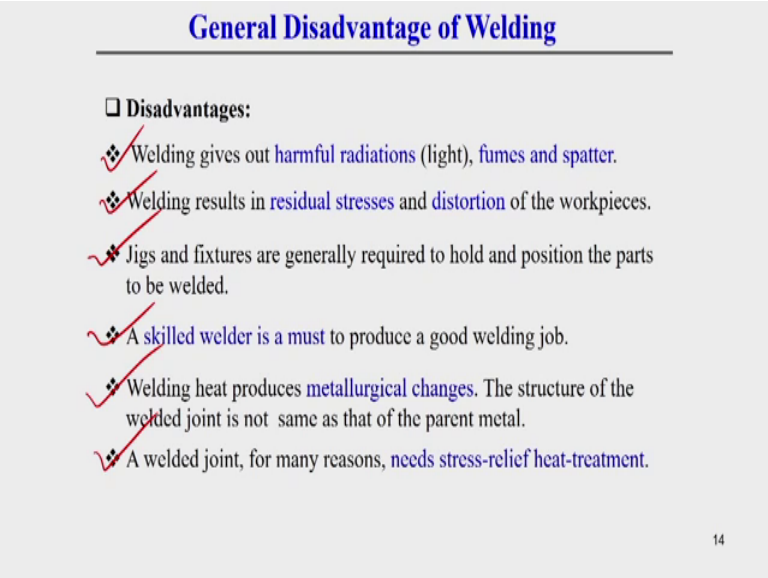

These are the general disadvantages of welding traditional welding process; like welding gives out harmful radiation, fumes and spatter, welding gives out harmful radiation fumes and spatter.

Welding result in residual stresses and distortion of work piece, this is a very vital drawback of welding process; that means; once we do the welding generally there will be the residual stresses and distortion of the structure. This residual stresses and this distortion generally tremendously deteriorate the welding structures life.

So, these are the residual stresses and distortion this residual stresses and distortion is unavoidable in case of welding process. Jigs and fixtures are generally required to hold and position the part to be welded. In case of welding generally a skilled worker or a skilled wall welder is must. Simply a non-skill welder cannot be do welding proper way. So, a skill welder is must produce a good welding job.

Welding heat produce metallurgical changes; that means, once we do the welding then there will be the metallurgical change in the structure. So, which generally break the continuity of a structure between base material and welding region? Due to these generally what happens there will come different types of changes as well as defects. The structure of the welding joint is not same as that of parent material, which is a defect or which is a disadvantage's of welding process. A welding joint for many region need a stress relief heat treatment; that means, I have already told you welding is such a process.

Generally where we are intentionally creating the defect in a structure, but due to lot of region we cannot avoid this technology, because welding we have to use in industrial application for many reasons that I will explain later on.

Now, here why welding is so important?

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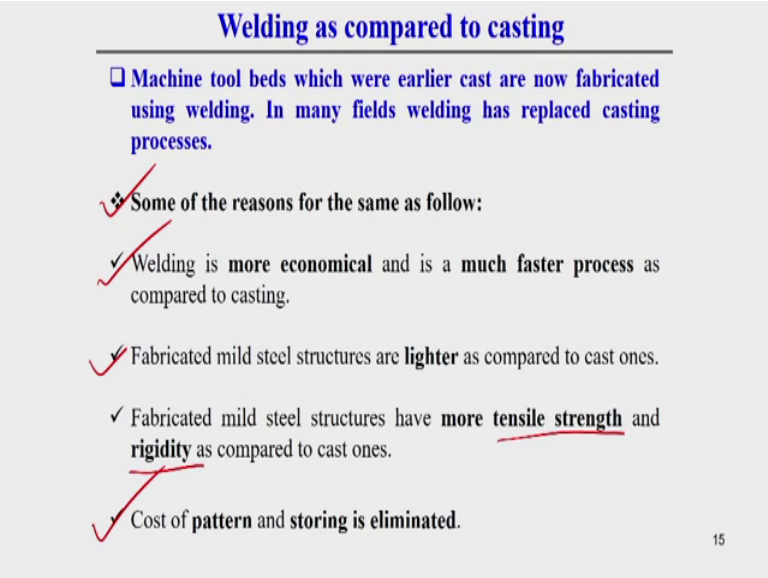

Here we are discussing welding as compared to other joining or manufacturing process, like welding as compared to casting, as well as welding as compared to rebating process. Also first we will explain welding as compared to casting. Generally machine tool bed which are earlier cast are now fabricated using welding process. In many field welding has replaced casting processes. Some of the reason for the same; that means, replacement of casting process can be a stated like first is welding is more economical and is much faster process as compared to casting process, fabricated mild steel structures are lighter as compared to cast ones.

Fabricated mild steel structure have more tensile strength and rigidity as compared to cast one; that means, once we produce a structure by casting, the whatever the strength we will get in that structure, if you do the same as a structure by welding there we can get more tensile strength and rigidity.

Cost of pattern and a storing, which is a very essential part in casting can be eliminated in case of welding process.

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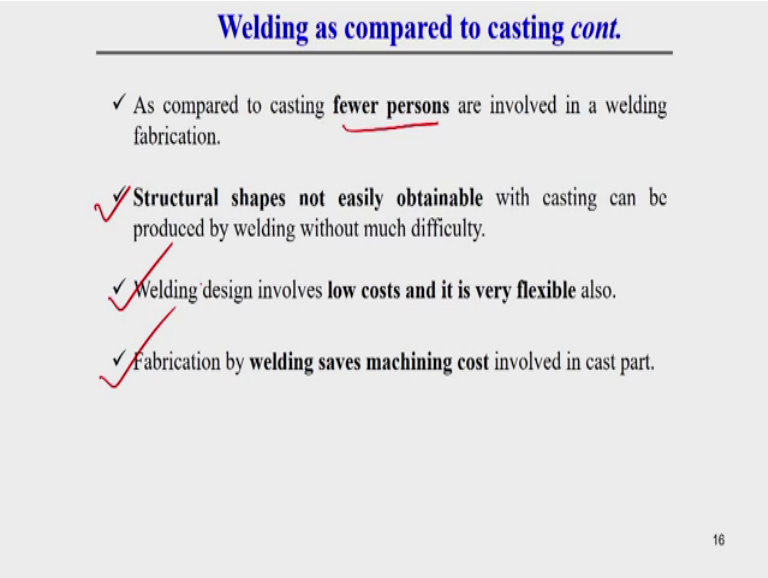

Here in case of casting more flavor or more person are required, but in case of generally welding fewer person are required to do the welding fabrication. Structural shape which is not easily obtainable with casting process, that can be produced by welding process without much difficulty; welding design involves low cost and it is a very flexible also; that means, welding is such a process where we can get lot of flexibility in design as well as in fabrication.

Now, fabrication by welding save machining cost involved in the cast part, it has seemed after casting mentioning is required to get the desire surface finish or desert quality of a structure, but in case of welding this mentioning cost we can reduce tremendously, or we can fully eliminate the mentioning part in case of welding. Now, we will go to well welding as compared to riveting.

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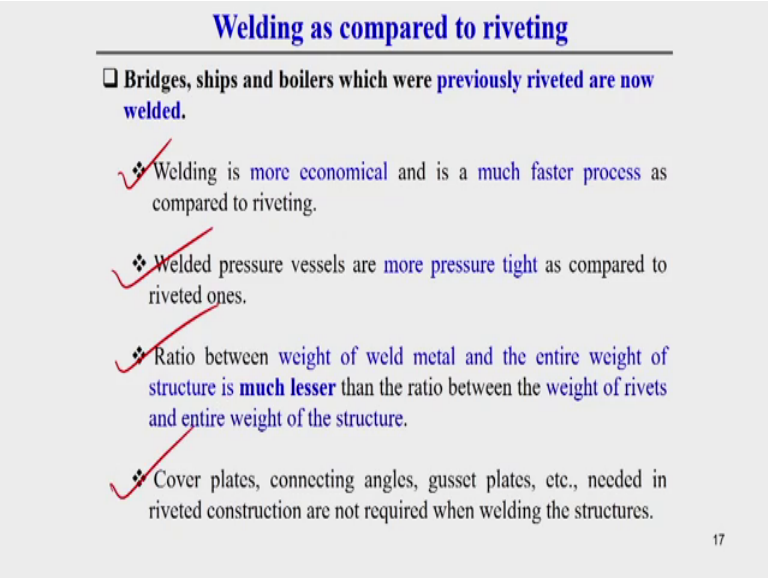

Earlier time bridges ships and boiler, which were previously reverted, are now welded; that means, earlier time generally bridge, ships, boiler, which were fabricated or manufactured by riveting, but nowadays that is replaced by welding process.

The reason behind these are welding is more economical and is a much faster process as compared to riveting, welding pressure vessels are more pressure tight as compared to riveted ones. Ratio between weight of the metal and entire weight of the structure is much lesser, than the ratio between the weight of the rivets and entire weight of the structure. Cover plates, connecting angle, gusset plates, etcetera which are needed in weld riveting construction, but this is not required in welding a structure. So, we can eliminate cover plate connecting angle gusset plate in case of welding process.

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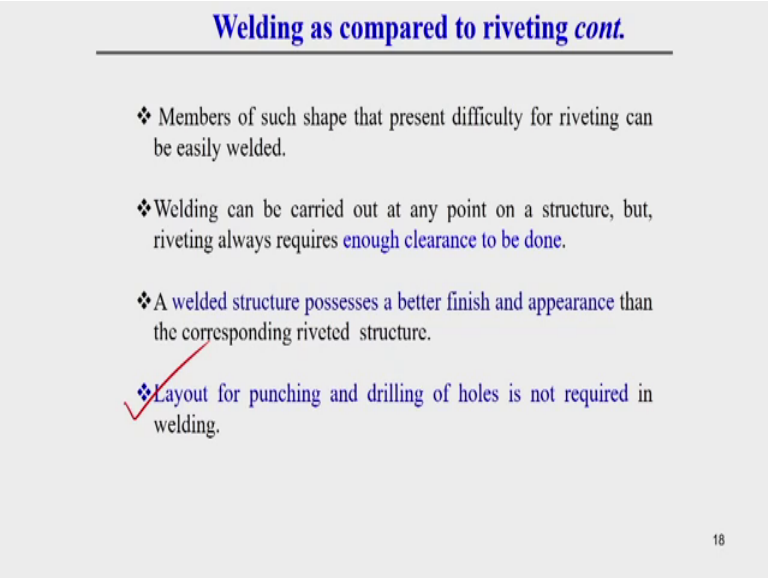

Member of such shape that present difficulty for riveting can be easily welded. Welding can be carried out at any point on a structure, but riveting always require enough clearance to be done. A welding a structure possesses a better finish and appearance than corresponding riveting a structure. Layout for passing and drilling of hole is not required in welding; this is a very important aspect in case of welding process. This is very much essential in case of riveting process. Generally once we puts some holes in a structure, then these drilling holes in the plate or in a structure break the material continuity and weakens riveted structure.

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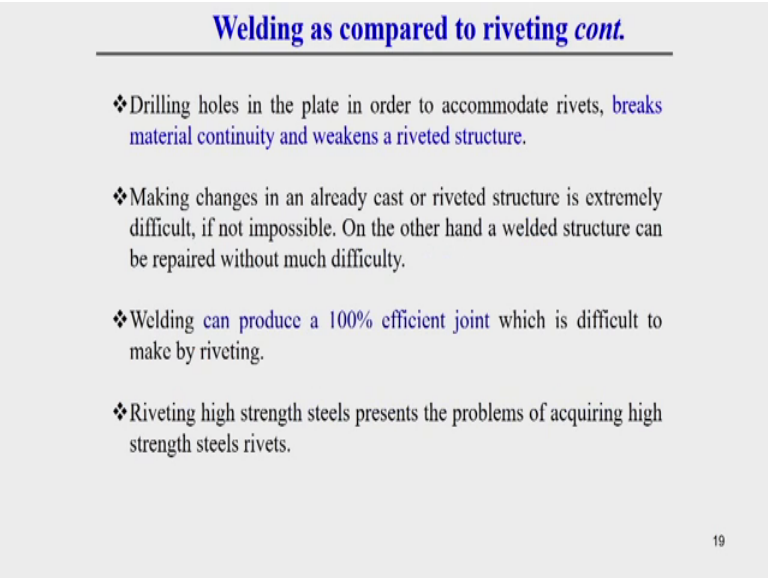

Making changes in already cast or riveted a structure is extremely difficult, if not impossible. On the other hand a welding a structure can be repaired without much difficulty. Welding can produce 100 percent efficient joint, which is very difficult to make by riveting or casting process. Riveting high strength is still present the problem of acquiring high strength is steel rivets.

Acquiring of high strength and steel rivet is problematic.

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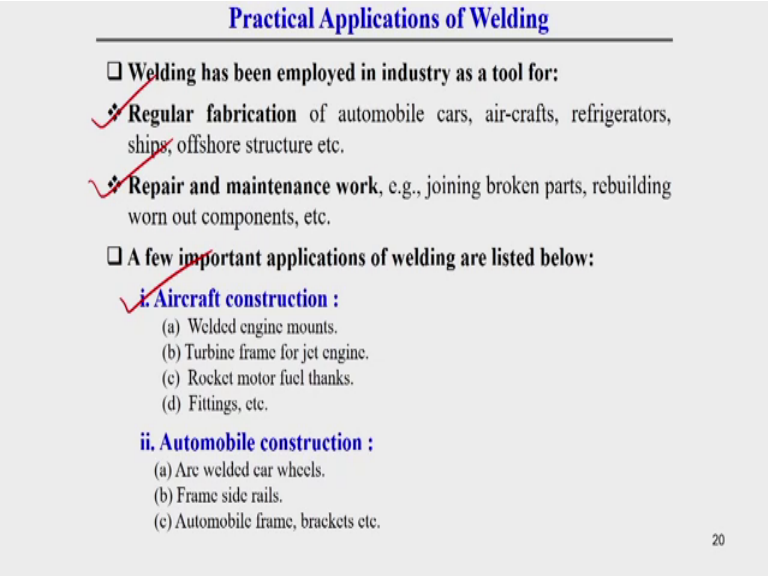

Now, we will go to practical application of welding process. Generally there is lot of practical application of welding process. Here especially I will cover the practical application of traditional welding process. Welding has been employed in industry as a tool for regular fabrication, as well as repair and maintenance work. In regular fabrication it is generally used in automobiles cars, aircrafts, refrigerators, ships, offshore structure etcetera. In repair and maintenance work we will get the application in joining of broken parts, rebuilding worn out component etcetera.

Here, I will show you a few important application of welding process. It has lot applications we have seen that welding has lot of application. Here we are showing we will show you a few important application in different industry. Like in aircraft construction, we will find the application in welded engine mount turbine frame for jet engine rocket motor fuel tank, fitting etctera.

In automobile construction also we get application like arc welded car wheels, frame side rails, automobile frame and brackets.

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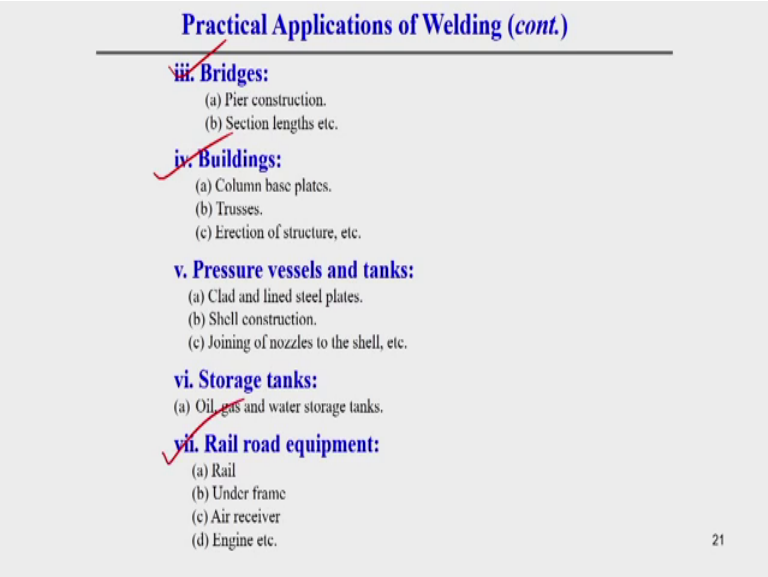

Then we get we can get the application bridges in fire construction, then selection length etcetera. In case of building also we get different types of application of welding, like column base plate, trusses, erection of a structure. In pressure vessels and tank also it has different application; like plates and lines steel plate clad and lined steel plates shell construction joining of nozzle to the shell. Like in a storage tank also oil, gas, water storage tank in railroad equipment, like rail, under frame, air receiver, engine etcetera.

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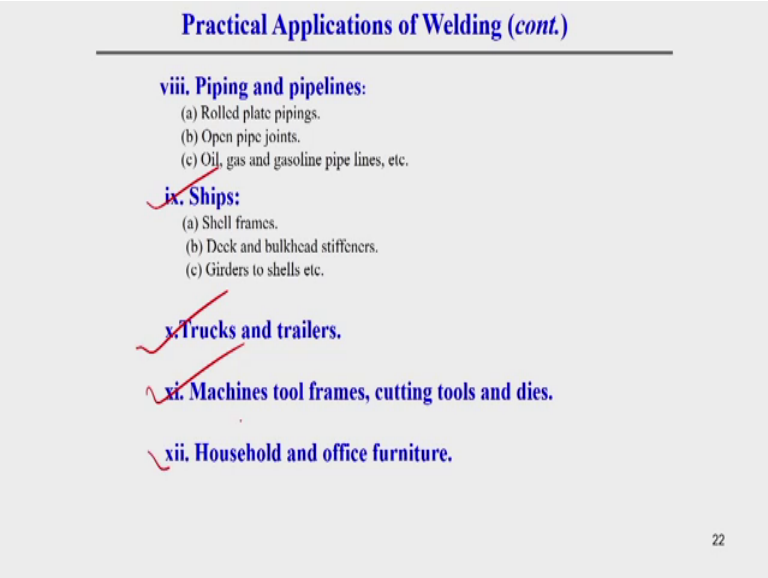

Piping and pipe lines like roller plate piping or rolled plate piping, open pipe joint, oil gas, and gasoline pipelines etcetera. In ship building industry like shell frame deck and bulkhead stiffness girders to shells etcetera truck and trailer also there is a lot of application of welding process. Then machine tool frame cutting tool and dies also it has a lot of application household and office furniture is also it lot of application.

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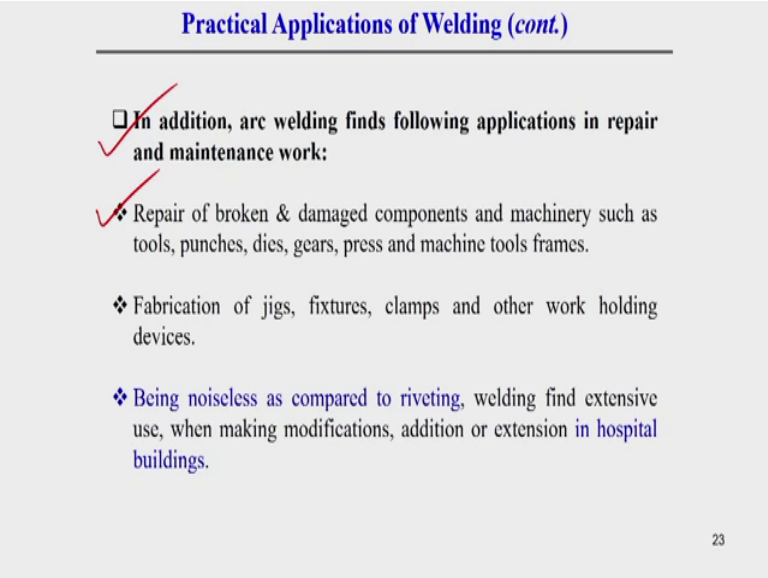

In addition to this industrial application, or fabrication application, it has also different application in repairing and maintenance purpose also. In addition arc welding finds

following application in repair and maintenance work. Like repair of broken and damaged component and machinery such as tools, punches, dies, gears, press and machine tool frame. Fabrication of jigs, fixtures, clamps, and other work holding device also, done by welding process.

Now, here is a very important aspects of welding application in hospital building especially in hospital building. Like being noise less as compared to riveting welding find extensive use when making modification addition or extension in hospital building.

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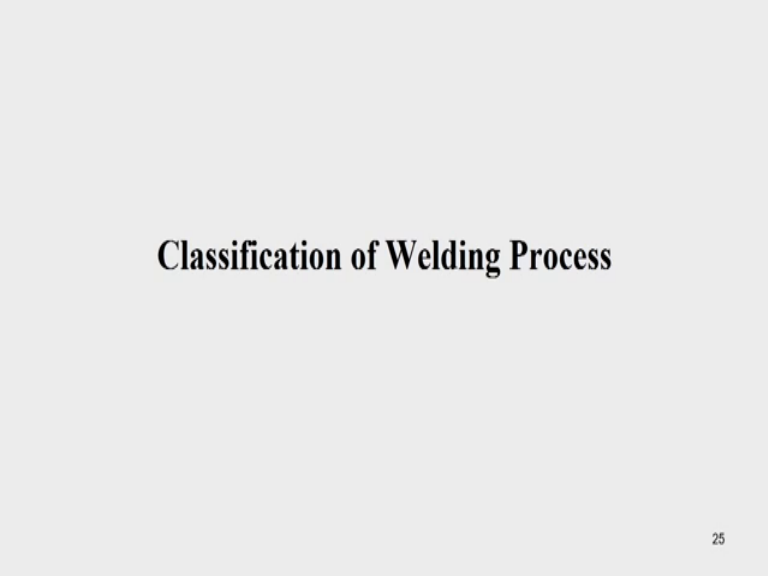

Now, classification of welding process.

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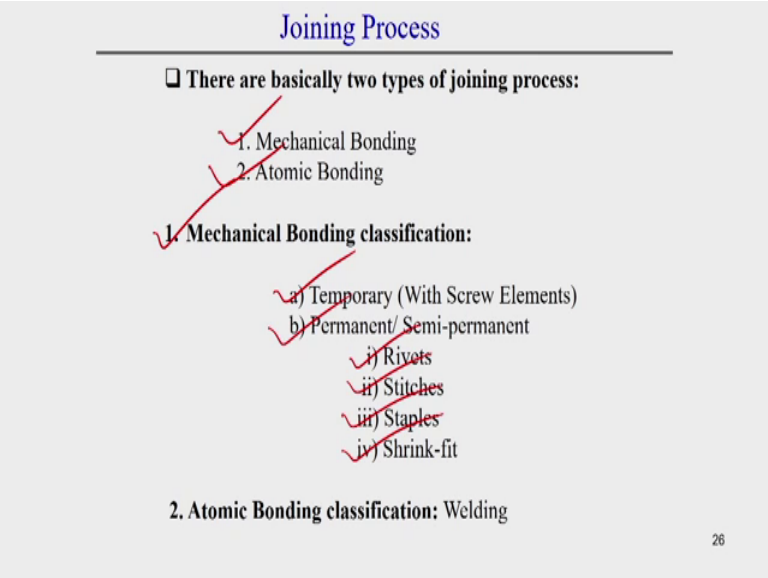

First of all joining forces classification I will explain after that we will go to classification of different welding processes.

Generally joining process are basically classified into 2 different types, which can be mechanical bonding or atomic bonding. Generally mechanical bonding in these categories, this mechanical bonding further categorized into 2 different categories; one is temporary and permanent or semi-permanent categories. In temporary category will get screw element and permanent or semi-permanent joining process can be rivets, it can be stitches, it can be staples, it can we shrink fit. And, in the categories of atomic bonding generally welding is the main categories.

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Now, classification of welding can be done based on the fall following different aspects. Here, I am showing that 6 major aspect generally followed for welding classification, which generally welding we can classify it depending upon the source of heat, it can be depending upon the application of pressure, it can be depending upon the different phases of base and filler material, it is can be depending upon the composition of joint, it can be depending upon the position of electrode and finally, it can be depending upon the mechanism. So, one by one of this class classification I will describe in detail in next slides.

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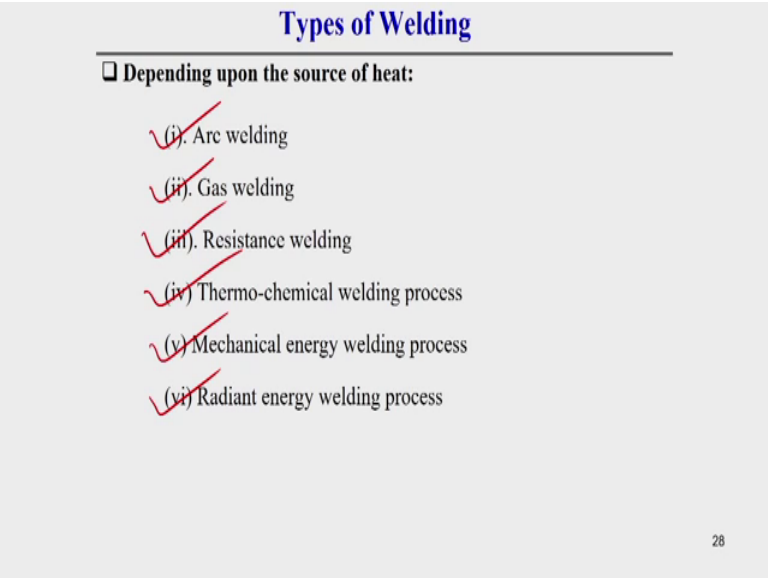

First of all depending upon the source of heat; that means, which source we are using to do welding. Depending upon this source of with this welding process can be further categorized into another 6 different categories. This source of heat either can be arc from electric arc, it can be from gas reaction, it can be from resistance, it can be from thermo chemical reaction, this heat also can be from mechanical energy, and this heat can be from radiant energy.

So, depending upon these things generally this welding can we categorized like this that mean; that means, it can be arc welding process, it can be gas welding process, it can be resistance welding process, it can be thermo chemical welding process, it can be mechanical energy welding process, or it can be radiant energy welding process.

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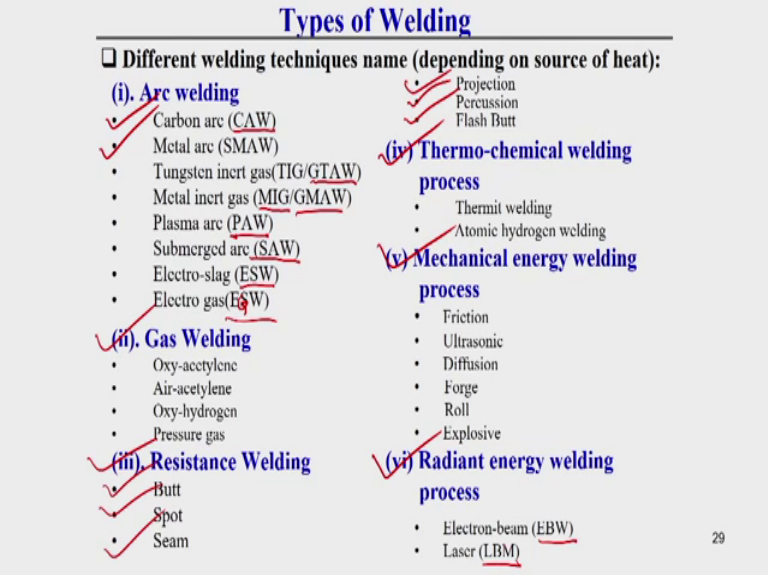

So, different welding techniques name depending upon the, is this is the most important; that means, here generally I am showing different welding techniques name, depending upon the source of heat. Like in arc welding there is around 8 to 9 different categories of welding process are there, that I will tell; that means, in arc welding that is around 8 to 9 different welding techniques is there. In gas welding there is another 4 5 different categories of welding process are there. In resistance welding; that means, were the source of heat is resistance here also we can get around 5 6 different categories of welding process. Then in thermo chemical welding process there we will get around 2

diff 2 3 different kinds of welding process, in mechanical energy welding process also we can get around 5 6 different categories of welding process.

And finally, radiant energy welding process also we can get 2 3 different types of welding process. Now, one by one I will tell in detail like based on source of heat from electric car, it can be carbon arc welding in short form generally in short form it is written like CAW; that means, carbon arc welding process. Generally this short form is widely apply in industry as or less in research articles these types of short forms generally we can find.

So, to see this short form it is we should recognize what is the name of this welding process? Like in metal arc welding; this metal arc welding what do you do it is short form is generally shielded shielded manual metal arc welding SMAW, it is represented like this.

Then tungsten inert gas I inert gas arc welding also is there, it is short form is generally TIG that is tungsten inert gas or it is more popularly used as GTAW that is gas tungsten arc welding process. Similarly, metal inert gas arc welding process, it is also represented I in terms shot in short form like MIG or GMAW process MIG means m for metal I for inert and g for gas welding process ok. Now, in GMAW it is like gas metal arc welding this short form of these things GMAW full form is gas metal arc welding process.

Then plasma arc welding process in short it is represented as PAW; that means, plasma arc welding submerged arc welding is in short form it is represented as SAW; that means, that means, submerged arc welding process. Then, electro slag welding process it is represented as ESW, electro-gas welding generally it is represented at EGW. This should be G, electro-gas welding. Generally, in case of gas welding; that means, where the source of heat is gas, this welding can be oxy acetylene welding process, it can be air acetylene welding process, it can be oxy hydrogenous welding process, it can be pressure gas welding process. That means, in case of oxy acetylene gas welding process the heat is generated due to oxy acetylene gas reaction.

Here, similarly air acetylene here heat is generated due to air acetylene reaction oxy hydrogen welding process air generally heat is generated due to oxy hydrogen reaction. Then in resistance welding there we will get different types of resistance welding, where the heat is due to resistance heating. So, here generally we will get different types of

welding process like butt welding, spot welding, seam welding, projection welding, percussion welding, flash butt welding.

So, these are the welding process generally these are all in the categories of a solid state welding process, especially in solid state welding process. Then in thermo chemical welding process, there we can get thermit welding and atomic hydrogen welding. Then in mechanical energy welding process, there we will get frictional welding process, ultrasonic welding process, diffusion welding process, forge welding process, roll welding process and explosive welding process.

And, the last category is that is radiant energy welding process, generate the generally this radiant energy welding process, we can get the energy from we can get heat from radiant energy. That is why this is called radiant energy welding process. It can be electron beam welding the short form is EBW and it can be laser beam welding; that means, laser LBW this should be W.

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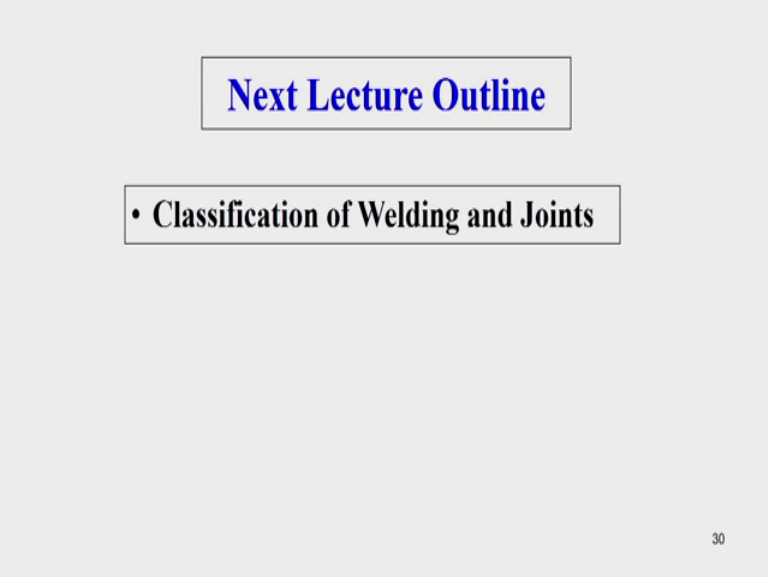

And, next lecture I will go in details about classification of welding and joints.