Fundamental of Welding Science and Technology

Dr. Pankaj Biswas
Department of Mechanical Engineering
Indian Institute of Technology, Guwahati

Lecture - 18
Oxy-Fuel Gas Welding

In last lecture, I was discussing about effect of different welding parameters, one well quality, especially well quality means bit shape geometry, then depth of penetration, then deposition rate in details. Today, I will start the different welding process, especially I will discuss in this course the welding process which is related to arc. So, here I will discuss especially the welding process that is arc welding process.

So, before going to arc welding process in detail first of all I will discuss oxy-fuel gas welding techniques because oxy-fuel gas welding techniques also have wide application in industry that is why first of all I will discuss about oxy-fuel welding technique, then I will go discuss about what it is called arc welding techniques. So, today's lecture is on oxy-fuel gas welding techniques.

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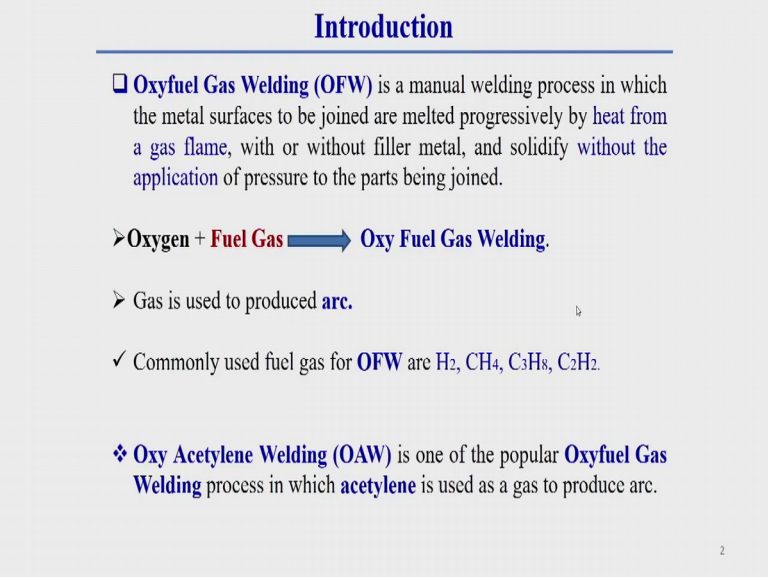

Actually oxy-fuel gas welding techniques is a manual welding process in which the metal surface to be joined are melted progressively by heat from a gas flame. So, here generally heat required to melt the work piece generally coming from a flame, gas flame. So, here sometimes flame material is used, sometimes may not require. And here weld if

we solidify without application of pressure to the part being joined. So, here application of pressure is also not require. So, it is a especially manual fusion welding process, here generally heat supply from gas flame.

Here two different gases is used, one is oxygen gas, another one is that fuel gas. This fuel gas can be different types; it can be hydrogen; it can be methane; it can be propane or it can be proprietary gas also, but the gasses that that is name is acetylene which have wide application in oxy-fuel welding techniques. So, that is why here we will discuss in details about oxy-fuel techniques, but we will concentrate more on oxy-acetylene gas welding techniques. So, here oxy acetylene welding is one of the generally popular oxy-fuel gas welding process, in which acetylene gas is used as a gas to produce the arc.

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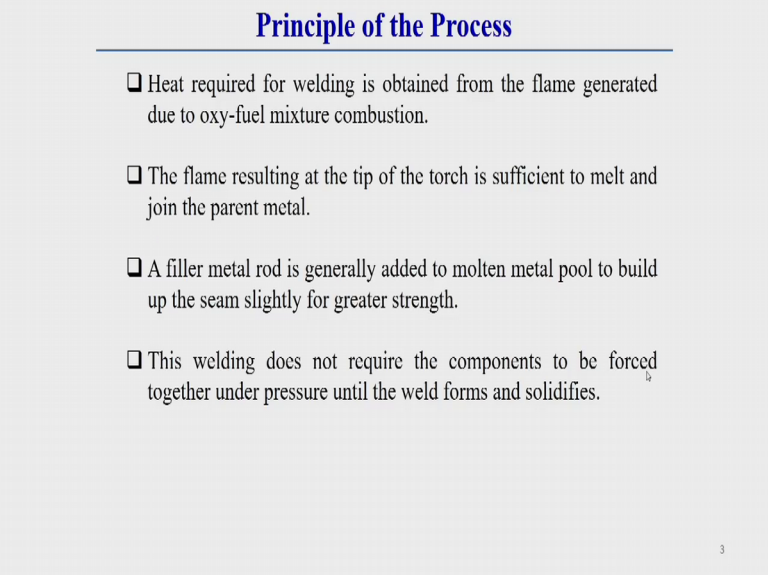

First of all we will discuss what is the principal of this welding techniques. Here the principal actually lying in the definition of welding itself that means here generally heat required for welding is obtained from the flame which is generated due to oxy-fuel mixture combustion. So, here the heat which we got for welding that is generally generated by the combustion of oxy-fuel mixture.

And that the flame resulting at the tip of the torch, here torch is used to generate the flame. This flame resulting at the tip of the torch is sufficient whatever the torch tip flame we are getting that is sufficient to melt and join the parent material. Here filler material rod is added to molten metal pool to build up the same slightly for greater

extent, sometime this filler material is used sometimes may not use. Here another things in this welding techniques is here generally pressure does not applied, so it is a non-pressure types of welding technique.

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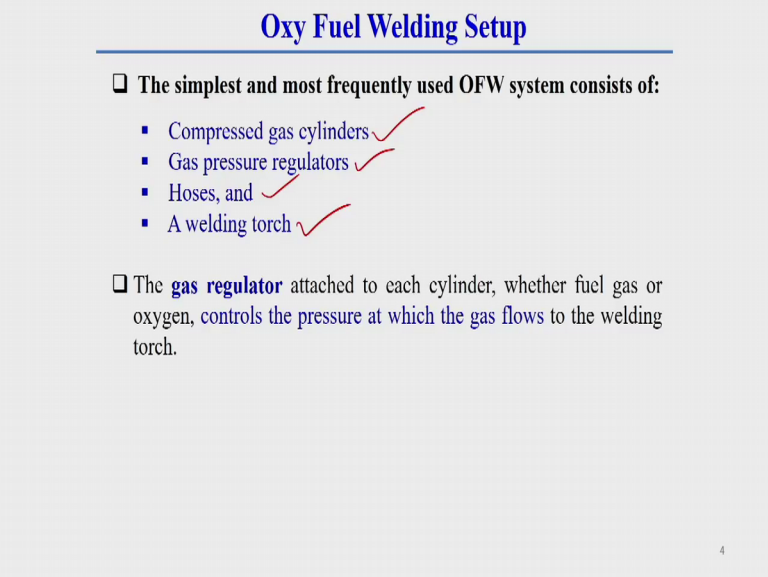

Now, here this is a generally now we will discuss about oxy-fuel welding setup. The simplest and most frequently used oxy-fuel welding system generally consists the following four different component, one is called compressed gas cylinders, why cylinders, there is generally two different cylinder is there, one is one cylinder contain oxygen gas, another cylinder contains fuel gas that is why here it is written gas cylinders. Then gas pressure regulators as there is two cylinder are there that is why here two gas regulator, gas pressure regulator are there. And there is hose, hoses means pipe actually plastic types of or rubber types pipe are there through which generally gas generally supplied to torch from cylinder, and there is a welding torch also.

So, these are the main component of oxy-fuel welding setup. Here one things we should keep it in mind the gas regulator generally attached to each cylinder, whether it is in fuel gas or in oxygen gas cylinder, it generally control the pressure at which gas flow to the welding torch. So, so the gas regulators is has the main function we can say it generally control both flow rate as well as gas pressure required to do the welding operation. Now, we will discuss one by one in details first, so, so one by one in details in the sense oxy-fuel welding setup details first of all we will discuss.

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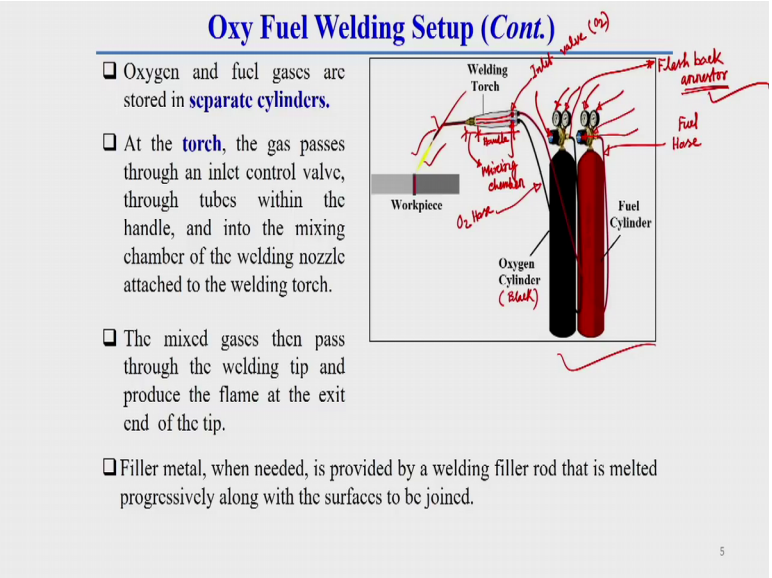

Then we will discuss subsequently its categories where, then its different types of flame, then what are the application limitation advantage safety precaution everything I will discuss in this lecture about this oxy-fuel welding techniques.

So, here this figure represent the oxy-fuel setup. Here generally to what I have already told you two cylinder is used, one cylinder generally contain oxygen gas. The oxygen cylinder colour is black in nature. And another contain fuel gas cylinder, here maroon types of colour is given which generally different fuel gas cylinder have different, different colour. To see the colour itself we can say what gases is contained by this what, what is called cylinder; that means, inside the cylinder what gases is there that we can easily guess by seeing the colour of the cylinder. This fuel cylinder whatever the colour here it is showing this colour actually the colour for this is maroon colour which is the colour for acetylene gas.

And this is generally two cylinder are there. Here this is a has torch here you see one things you can see from here. This is a gas torch. This is called gas torch. With this gas torch this is called hose, hose means actually hollow pipe actually through this, this is what types of hose, this is generally we can say fuel hose this is oxygen hose, we can write oxygen hose. So, you see through this fuel gas and oxygen gas coming to this torch, this is called welding torch. Here we you can see this is called regulator in details I will show separately what is the shape of regulator.

Here there is two indicators; there generally this is one indicator this is another indicator. So, this, this two indicator, why this two indicator, one indicator represent the cylinder pressure, another indicator shows the working pressure. Working pressure means one is representing what is the pressure inside the cylinder, then another pressure regulate what should be the outlet pressure that means, output pressure of the torch that means, that is called working pressure. Working pressure means the pressure at which a welding is done, so that pressure is called working pressure. So, for a particular types of material, particular, particular types of working pressure is required. A expert welder can easily control that working pressure.

So, this two indicator represent two different pressure, actual one is one represent the what is the pressure inside the cylinder, and what is the pressure is applied on welding torch, so that is called working pressure. So, what happens if the pressure generally is within applicable range then we can do the welding if the gas reduces then pressure inside the cylinder also reduces. By this generally what happens we can we use the gases successfully, successfully in sense we can we can use the gases as per our requirement.

Now, you see here also there is two regulator, similarly in oxygen cylinder also there is two regulator. So, this two regulator again this is also represent one is representing cylinder pressure, another is represent generally working pressure. How the working pressure is controlled, there this working pressure is controlled by using this fuel regulator, and this is called oxygen regulator. So, by controlling the by opening the fuel regulator valve or oxygen regulator valve, we can control the working pressure of welding operation.

Now, here another important thing you should remember at the generally at the connection, at the outlet actually you can say, at the outlet of the what it is called at the outlet of the regulator where the gas is coming out from cylinder to workpiece that means, after regulator once the gas is coming out then what happens here used a flashback system that is generally called flashback arrestor. Here used a flash flashback arrestor.

What is the flashback arrestor, flashback arrestor it does not allow back flow of gasses, backflow of gasses means what happens that means, it is arrest the accident. Actually what happens if the if there is a chance of sucking of backflow of the gases, then what

happens there can be chances of bursting actually chances of accident of cylinder. So, to prevent that burst of cylinder or that backflow of the fuel gases or oxygen gases, generally there is used a flashback arrestor.

The function of flashback arrestor, it generally does not allow to return back the gas inside the cylinder. Generally this is the function of that; that means, what happens once there is a chance of backflow of gases is automatically choke the flow. So, what happens gas cannot able to enter the cylinder. So, what happens there will not be chance of accident. So, this is generally called flashback arrestor this flashback arrestor used with both fuel gases as well as fuel gases [ways/hoses] hoses as well as in oxygen gas hoses. So, here is one flashback arrestor in oxygen cylinder as well as in fuel gas cylinder also there is a flashback arrestor are there.

Now, you see this is called welding torch. Here you can see in this welding torch there is two valve is there. This we will call generally inlet valve, inlet valve. This is called generally inlet valve or inert valve. This is generally called inlet valve v a l v e actually v a l v e, this is called inlet valve of oxygen that means, oxygen inlet valve and this is generally represent fuel gas inlet valve. By opening this inlet valve, we can control the flow rate, gas flow rate inside this welding torch. Here this actually about this welding torch, I will discuss in subsequent slide.

Here generally what happens in this welding torch, this portion from this inlet valve to this, this is called handle, this is generally called handle. Through this handle this pipe that means, through this gas is separately coming to gas is separately coming through separate actually two different pipe this portion this portion.

This portion have a name, this is called mixing chamber, mixing chamber that I will show in next slide in detail. So, what happens in handle region mixing is not happen. In front of this handle, there is a small region where this two separate gasses mixing is occur. So, after mixing generally it is coming out from the nozzle tip. And what happens once there is used a spark lighter, by a spark lighter, we can generate the flame. This flame generally used to do the welding operation.

So, what happens how the gas is coming this gas is coming from cylinder by controlling the working pressure by gas regulator. It is enter to the handle region by inlet valve of oxygen inlet valve, and what its call fuel inlet valve. After that generally it is come to

mixing chamber. In mixing chamber this two gas mixture is taken place. Once its mixing is taken place, after that by using a spark lighter at the tip of the nozzle generally what happens this flame is generated. So, here generally this flame then used for doing welding operation; so, this is detail setup and principle of oxy-fuel gas welding techniques. Now, I will show you what is the shape or what is the means shape of different nozzle as well as what is the welding torch in detail in next slide.

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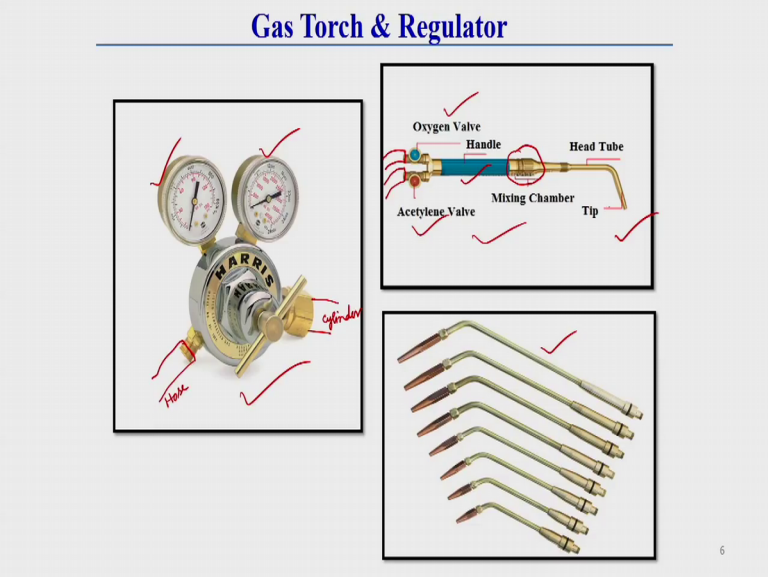

So, here one things you can see this is generally the spectacle view as you can see that this you can see once we will be in industry we will be doing oxy-fuel types of welding. There you will see there is generally use a gas torch which I have already told you. In this gas torch there is a oxygen valve, and there is an generally acetylene valve which is look like this. This is actually practical welding torch. Now, here you see this is called handle. Generally in this oxygen valve and what it is called a fuel valve this hose is connected, hose is generally connected like this/

So, by control here, generally by opening this oxygen valve acetylene valve, this, this gas is flowing through this handle. In this inside this handle, there is two different pipe which is one is connected to the oxygen valve, another one is connected to acetylene valve or we can say fuel valve. So, after that generally this two gases mixing occurs in this region. Here you see in this region mixing of these two gases this is called mix chamber. Here generally these two different pipe combinely deposits or we can say supply the gases

together and here generally mixing of gases is occur; after that generally this nozzle tip nozzle generally used for generation of arc. How this arc is generating, this arc is generated by a spark lighter. Generally here all the gas is coming out from there, if we generally a spark a light here then what happen this gas flame is generated.

So, this is the welding torch, this detailed welding torch. Here generally this nozzle head whatever the head or head of the nozzle is showing this there can be different, different types of nozzle. Here you see different size of nozzle. They are bending on our requirement, there we can use different size of nozzle. generally here different size of nozzle means this nozzle diameter tip diameter generally depending upon its size its varying. So, as per our requirement actually we can use different size of nozzle.

And this is called gas regulator. How the gas regulator is look like, this gas regulator one terminal is connected to cylinder, this another terminal generally connected to hose pipe, hose pipe, and this is connected to what it is called hose pipe. It has I have already told you. It has generally two regulator one regular represent what is the gas pressure is inside the cylinder, and another indicators or another regulator represent the working pressure, that means what is the pressure supplying to the torch stream that is represent generally indicator. This is the detailed view of a regulator.

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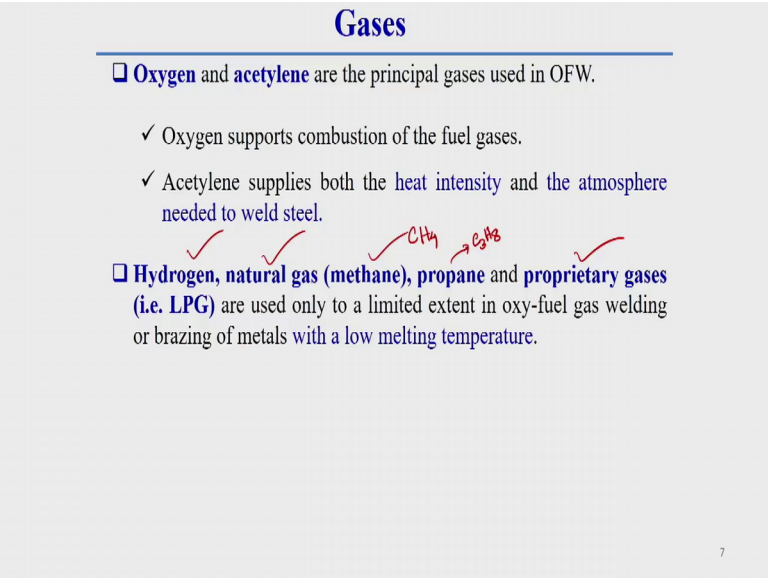

Now, we will discuss about first of all we will discuss what are the different gases generally that means fuel gases generally used. So, first of all we will discuss about what

are the different gases used in oxy-fuel welding. So, here I have already told you the main principal gas or we can say the principal gas used in oxy-fuel welding are oxygen and acetylene. Generally this is the principal gases generally which are used in oxy-fuel welding. It has wide application also. Now, here this oxygen generally used to support the combustion. And this fuel gas or you can say acetylene gas generally supply both heat intensity and the atmosphere for needed the welding operation actually.

So, what is the function of oxygen gas, oxygen gas generally support the combustion because without oxygen generally combustion very difficult. So, that is why generally for supporting the combustion oxygen gas is required. So, main function is supporting the combustion is oxygen. And the second fuel gas function is it supply the heat and intensity for doing the welding operation as well as the atmosphere needed to do the welding. Atmosphere needed to do welding means that means if this types of fuel gas will not be there, then what happens there will there can be different types of defect; that means, oxidation, carbolization, different, different actually this types of atmosphere that means, whatever the atmosphere needed for doing welding operation that also supplied by this fuel gases.

Now, another gases generally used as I have already told you in first slide itself that is has can be hydrogen gas, that that is fuel gas. These are also fuel gas actually that can be a natural gas like methane that is CH 4 generally methane, its chemical formula is CH 4. This can be propane its generally C 3 H 8. It can be proprietary gas also or LPG gas proprietary gas means generally LPG gas - liquid petroleum gas actually are also used to limited extent in oxy-fuel gas welding. It, it application have very limited because what happens this generally can supply cannot supply proper temperature or we can say proper atmosphere required for doing different, different welding.

That is why what happens it has limited application especially some low melting point temperature what is called low melting point temperature metals or and their alloys, and for doing welding operation and sometimes it is also used for brazing operation also.

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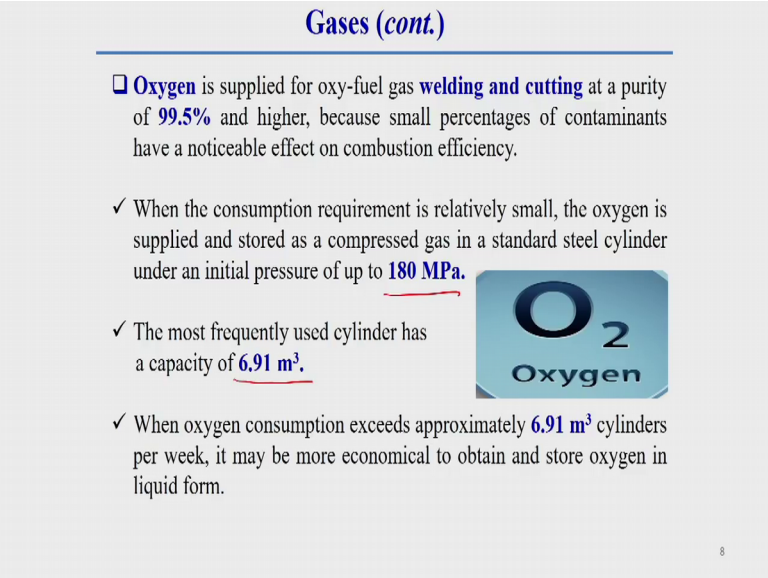

Now, one by one I will discuss in details about these gases how it is what is the function of this gases, what should be the type of this gas, what should be the safety precaution of this gas that means, and what should be the cylinder capacity and all the things, this idea we should know because we are discussing about this welding technique. So, about everything of this welding technology we should know.

So, first of all we will discuss about oxygen gas generally oxygen gas whatever oxygen gas is generally used for oxy-fuel welding techniques, it should have a purity that means, here oxygen should be 99.5 percent and it should be purity of 99 percent, 99.5 percent and higher. Because one things you should keep it in mind a small percentage of contaminants have a noticeable effect on combustion efficiency actually. If there is a small amount of contaminant is there inside the oxygen gas, then what happens its combustion efficiency generally drastically affected, that means, you can say reduce a lot the combustion efficiency reduced a lot.

And another things you should keep it in mind this oxygen you can store in cylinder either in gaseous form as well as in liquid form. If the oxygen requirement is less, then generally you can store the oxygen gas in oxygen in gas form inside the cylinder. Here one things you should keep it in mind this oxygen gas cylinder pressure should not more than 180 mega Pascal, that means, 180 MPa this you should keep it in mind. Now, cylinder volume capacity or cylinder capacity is 6.91 meter cube whatever the capacity

use, it can contain a volume of oxygen that is 6.91 meter cube. The most frequently a cylinder has a capacity of that much meter cube; that means 6.9.

Now, here one things you should keep it in mind when this oxygen uses increase that means, a oxygen consumption increase, then what happens it is better to use this oxygen in liquid form. Because what happens once we you store this in liquid form, it may be more economical to obtain, once you store this oxygen in liquid form, then it will be more economical because on the consumption of oxygen will be more, then it is better to store it in a liquid form, then it will be more economical.

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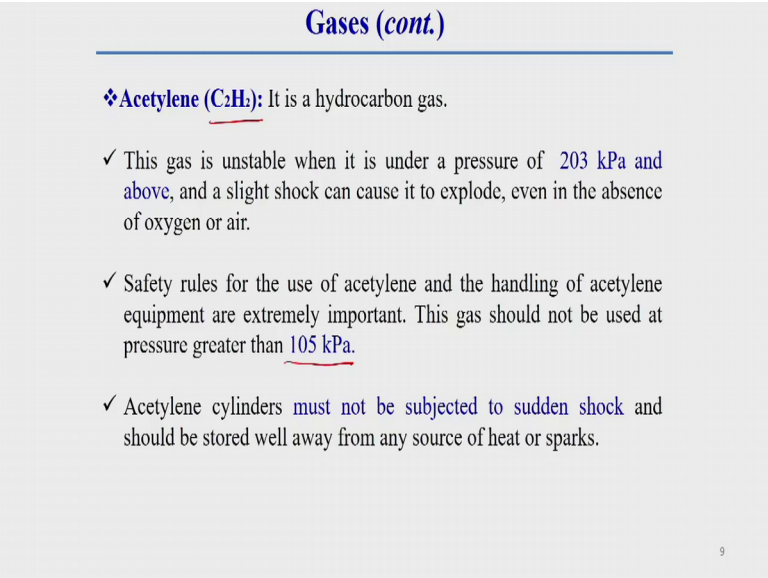

Now, we will discuss about acetylene gas. Then generally this acetylene gas is chemical formula is generally C 2 H 2, it is generally a hydrocarbon. This gas is very unstable, always keep it in mind this gas is very unstable when it is used under the pressure of 203 kPa or above that means if the acetylene gas is used above a pressure of 203 that represent 203 kilopascal and it is above, then what happens a slight shock can cause it to explode, that is why this explode can happen on its pressure is above or equal to 203 kPa this, this explode can happen without the absence of oxygen also oxygen or air also. So, that is why you should keep it in mind from safety point of view we should keep the cylinder pressure below this.

Generally safety rule for the use of acetylene and handling of the acetylene equipment are extremely important this you should keep it in mind, its safety rule is extremely

important for acetylene gas. These gas always keep it in mind this gas should not be used at a pressure greater than 105 kPa that means, 105 kilopascal. This is the main safety precaution for acetylene gas because what happens if the gas pressure is in what I have already told you that there is a chances of explode of the gas. And another things you should keep it in mind acetylene cylinder must not be subjected to sudden shock, and it should be stored well away from any source of heat and sparks this you keep it in mind, because acetylene gas is unstable types of gas. It is generally very unstable or it can be a very dangerous gas actually.

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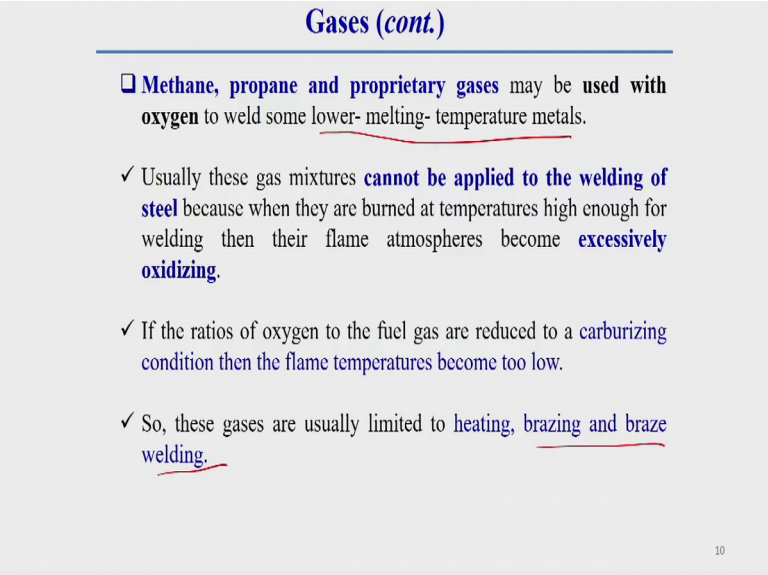

Now, we will discuss about this methane, propane and proprietary gas. This methane generally propane and proprietary gases may be used with oxygen to weld some generally this has a application for some low melting temperature metal. It is used for very low melting temperature metal especially like aluminum, manganese, then lead like bronze, this types of metal generally can be welded by this types of gaseous.

Usually this gas mixture cannot be used to welding of a steel, because burned to a temperature high enough for doing the welding of a steel then its flame temperature, flame characteristic become excessively oxidizing, that means, when the temperature goes beyond some certain limit to do the welding of a steel, then generally this flame characteristic become highly oxidizing, especially oxidizing flame is not suitable for

doing what it is called steel welding, that is why this flame cannot be applied to do steel welding.

And what happens if we go for making this oxy-fuel characteristic to reduce characteristic, then its temperature is not sufficient to do the welding of a steel. That means, for carburizing flame whatever the things we are getting by using this fuel gas that carburizing flame generally is not sufficient to do the welding a steel pipe, because its temperature is not that much high. For that reason these gases have limited application especially to heating, brazing and some extent of braze welding.

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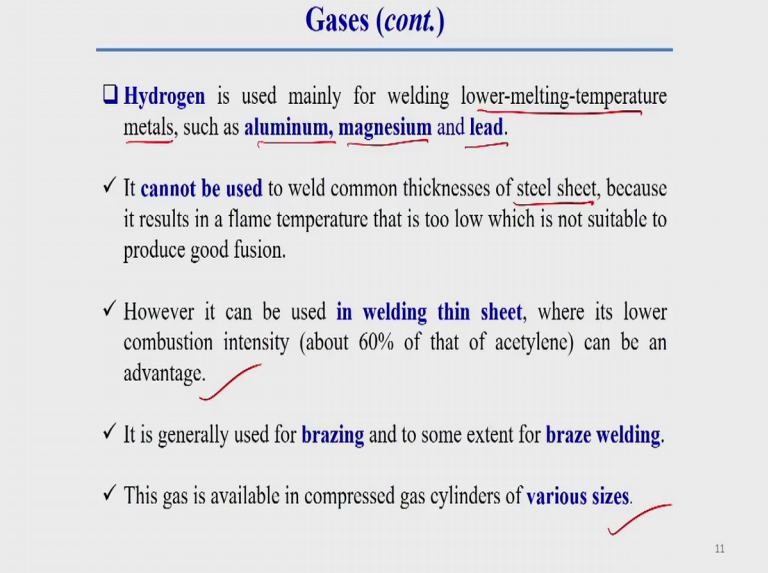

Now, generally we will discuss about hydrogen gas. Hydrogen is also another fuel gas which is generally used mainly for welding again no low melting temperature metal, especially aluminum, magnesium and lead generally this hydrogen gas is used. It cannot be used to weld common thickness of steel sheet, because it result in a flame temperature that is too low which is not suitable to produce good fusion that is why it is not used common thickness of sheet plate.

But this flame temperature we can use to join thin sheet of metal, because this generally its combustion intensity, this, this fuel combustion intensity is which is within a range of 60 percent of acetylene oxy-acetylene combustion intensity. So, this lower intensity flame which is good for lower thickness of steel plate, that is why low thickness steel plate this types of flame is advantageous.

It is generally used for brazing and some extent of braze welding actually this gas is available in compressed gas cylinder of various size. Generally, this hydrogen gas cylinder color is red in nature red types of color, generally used to see red color of the cylinder we can say what is the gas available inside this cylinder. So, it has different size also, this gas cylinder have different size also.

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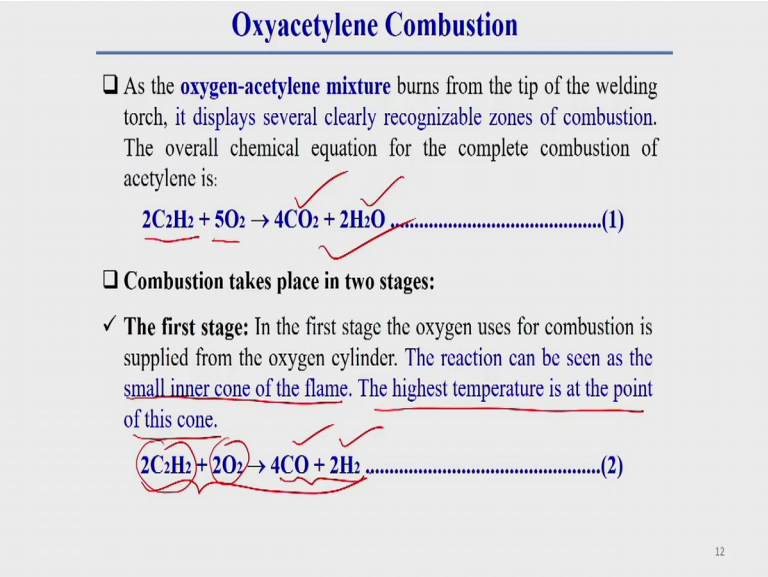

Now, we will discuss first of all combustion of oxy-acetylene gas, then we will discuss about combustion of other fuel gases. So, first of all we will discuss about combustion of oxy-acetylene gases. Here as the oxy-acetylene mixture burn from the tip of the welding torch, it display several clearly recognized zone of combustion.

So, [what/when] when the flame come out from oxy-acetylene torch that flame contain several clearly recognized zone of combustion. The overall chemical equation for complete combustion of the oxy-acetylene gas is represented in equation 1. Here what you can see, here 2 volume of acetylene gas with 5 volume of what it is call oxygen gas complete combustion required 2 volume of oxy-acetylene gas, and 5 volume of or you can say oxygen gas. And after that it produce this H 2 O and C O 2 gas carbon dioxide gas.

It is complete combustion of oxy-acetylene gas taken place in two step or you can say in two stage. So, in first stage, what happens in first stage, the oxygen used for combustion is supplied from the oxygen cylinder. Whatever the oxygen required for combustion that

is generally supplied from the oxygen cylinder that this reaction what happens, due to this generally the direction can be seen as a small inner cone of the flame, here generally the highest temperature is at the point of this cone.

So, this is the first stage of oxy-acetylene combustion, here this acetylene gas as well as this oxygen gas, which is supply from directly from the cylinder. So, here due to this here carbon monoxide, and hydrogen gas is used. This then the second stage generally the output of this first stage used in second stage.

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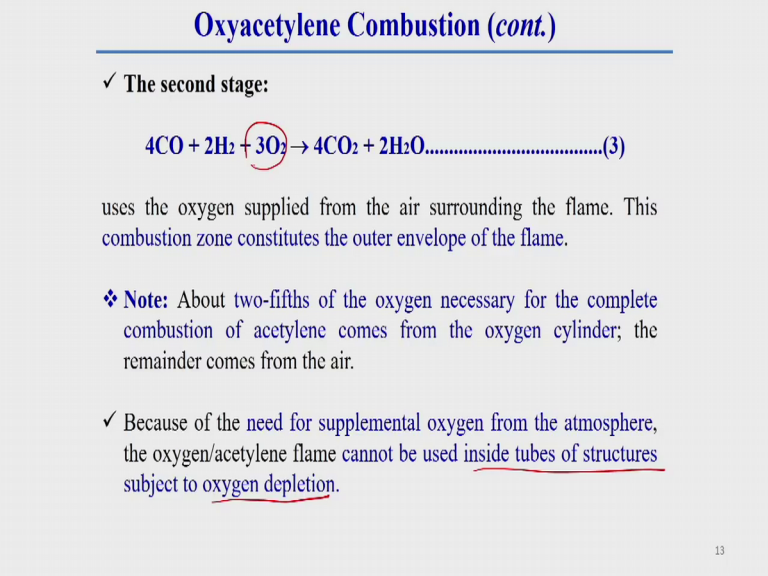

Here rest of the oxygen, whatever the rest of the oxygen are there here, this oxygen generally coming from the surrounding atmosphere. So, here in equation 5, we have seen that there is five molecules of oxygen are there, and two molecules of acetylene are there in this reaction equation.

So, among these five molecules of oxygen, two molecules of oxygen you can say or two volume two proportion of volume is coming from cylinder, rest three proportion is coming from the atmosphere that is why, here one things you should keep it in mind that means, here for complete combustion of oxy-acetylene flame here three-fifth of the total volume of oxygen coming from atmosphere that is why, here one things keep it in mind because of the need for supplementary oxygen photons from the atmosphere, the oxygen acetylene flame cannot be used inside the tube structure subjected to oxygen depletion. This you keep it in mind.

For oxy-acetylene welding generally, you should use there, where there is a less chance of oxygen depletion are there, there is sufficient oxygen are there, because for doing this welding operation generally three-fifth of the total volume of oxygen coming from atmosphere its required.

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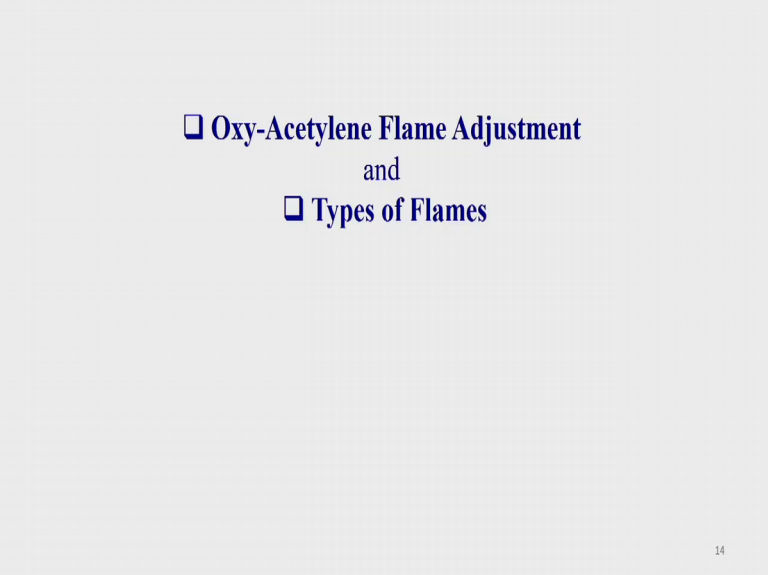

Now, we will discuss about due to this oxy-acetylene combustion, what are the different types of flame generated categories of different flame generated as well as we will discuss here how the oxy-acetylene flame adjustment is done that I will discuss. Because, what happens by adjustment of the oxy-acetylene ratio oxygen to acetylene ratio, generally here you can control the characteristics of a flame that means, what happens as per our requirement generally expert welder can generate the required flame by controlling the ratio of what it is call oxygen and acetylene ratio. How this adjustment is done that I will discuss, and I will discuss what are the different types of flame generated, what are the different types of flame, generally are there in oxy-acetylene welding technique.

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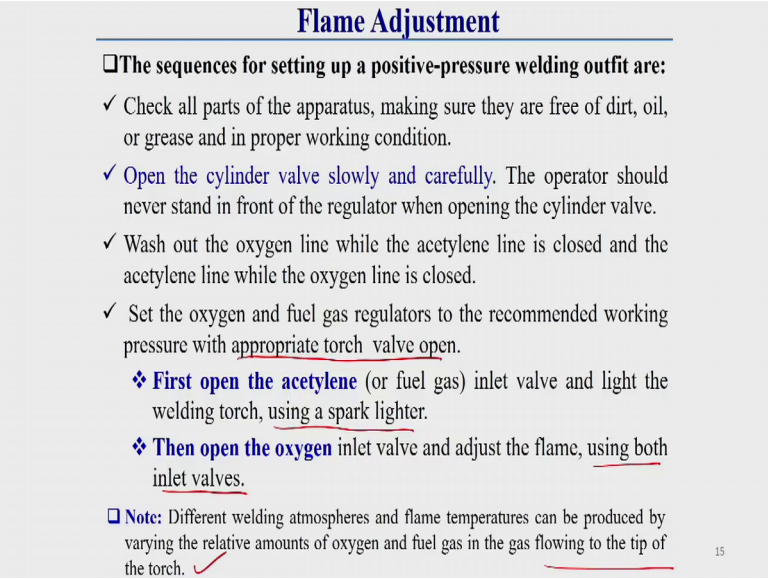

So, first of all I will discuss about oxy-acetylene flame adjustment. This is the sequence for setting up a positive-pressure welding outfit are actually. Here first of all check all the part of the apparatus that means, making sure there are free from free of dirt, oil or grease and in proper working condition. First of all we have to see that means, all the apparatus should be neat and clean, there should not be dirt, oil, grease or grease type of things over the apparatus.

Then faster then generally open the cylinder valve slowly and carefully, this you should keep in mind. And when we will go for opening the cylinder valve, then at that time the operator should never stand in front of the regulator, then for that means, all operator should stand beyond the regulator. What happens, when opening the cylinder valve that means in front of regulator, operator should not stand. Because, what happens, during opening of these valve, there is a chance of removing that regulator from the cylinder, so that can create accident that is why operator should stand beyond the regulator.

So, first of all wash out the oxygen line valve, while acetylene line is closed. And acetylene line, when oxygen line is close that we should clean that mean one by one, we should clean that holes of the our pipe of the oxygen gas supply, and another holes of the fuel gas supply. This we should clean one by one, so that means, when we clean the oxygen holes that time acetylene valve will be closed, then we clean the acetylene or fuel holes that time oxygen will be closed.

Then set the oxygen and fuel gas regulator to the recommended working pressure with appropriate torch valve open. So, by appropriate torch valve open, here one things we should kept in min. Before, starting the torch itself, where before starting the flame itself, we should control the or should generate the working pressure that means, what should be the outlet pressure of the gas from the cylinder. Then here one things keep it in mind, when the working pressure setup completed.

Then before welding, first of all we have to open the acetylene valve acetylene inlet valve. And why acetylene inlet valve, once we will open the acetylene gases, then light the welding torch using a spark lighter. So, in acetylene gas only, we have to light the gases by a spark lighter. So, at that time generally when the flame was started at that time, there is no oxygen supply from the oxygen gas.

So, when that flame started, then generally we gradually in the second that that means, in second stage, then open the oxygen inlet valve and adjust the flame using both the inlet valve. So, first flame is started without supply of oxygen from cylinder by a on level gases. Then generally what happens, then this oxygen valve gradually open by this, we can control the characteristics of the flame that mean by changing the proportion of oxygen supply to this flame, we can change the characteristics of flame.

Here this different welding atmosphere and flame temperature can be produced by varying the relative amount of oxygen and fuel gas in gas following to the tip of the torch this, you should keep it in mind. So, by controlling this ratio of this oxygen and acetylene gas, we can generate different types of temperature as well as different types of atmosphere of welding.

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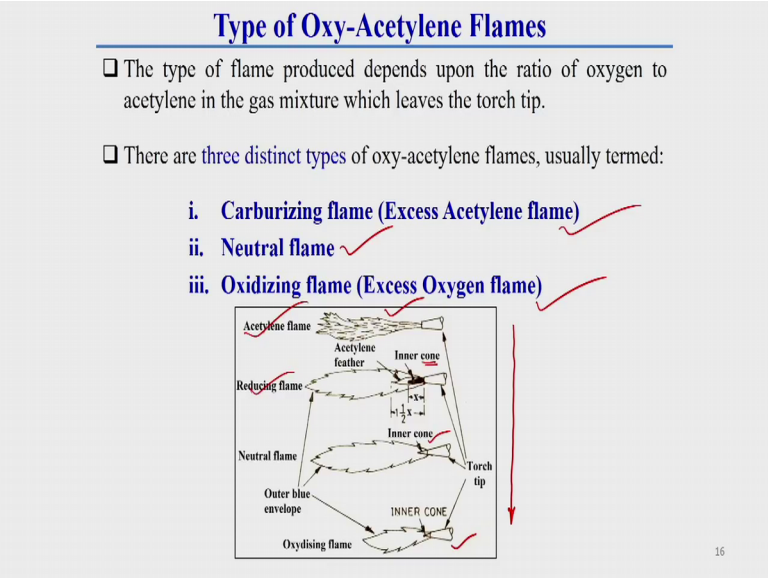

Now, we will go for categories of oxy-acetylene flame. The type of flame produce depends on what I have already discuss that means, depends upon the ratio of oxygen to acetylene in the gas mixture, which generally leaves from the torch tip that means, whatever the gas mixture is coming out from the torch tip, whatever the ratio of this oxygen and fuel gases or acetylene gases, depending upon that ratios generally.

This flame whatever generating with flame can be categorize into three main categories. So, these three main categories, what are these three main categories? One is called carburizing flame, here excess acetylene are there that is why, it is also called excess of acetylene flame. Second one is called a neutral flame, here the ratio of oxygen to acetylene is one is to one. Then third one is called oxidizing flame.

Here generally, how it is looks like? This first one is call acetylene flame. Generally, in acetylene flame, when the arc is initially started, here its look like this. Now, once we increase the means once we supply the oxygen with this acetylene gas, then this reduced to reduce flame. Reduce flame means, there is a combination of oxygen and acetylene is that, but the proportion of oxygen is lesser than acetylene gas. So, it is look like generally, it is has a outer envelope.

And there is a what are happened, there is a acetylene feather with a inner cone with a inner cone also there. There is a acetylene filler feather, and inner cone is there. Then in if we increase further the oxygen gas, then this acetylene feather vanish, and this inner

cone remains. So, this is happen in case of neutral flame, where the portion of oxygen and acetylene gas is one is to one.

And at the if we further increase the oxygen gas with this with this acetylene gas, then this inner cone generally further shorten. So, this further shorten, and it become more sharp. And this outer envelope also shorten, then what happens? It is generally converted to oxidizing flame. In this oxidizing flame, one things you should keep it in mind. In this oxidizing flame, the proportion of oxygen is more than the acetylene gas, it is ratio within 1.52 is to 1 like this types of ratio are there oxygen to acetylene ratio.

So, here one things you keep it in mind, here temperature increases with increase of oxygen concentration of over this flame that means, acetylene flame has less temperature, then reducing flame the higher temperature than acetylene flame. And in this way, this temperature increasing once the proportion of oxygen in increase with the acetylene gas that is why, among these oxidizing flame have higher temperature and among these acetylene gas has lower temperature. I will discuss one by one in details about this different types of flame.

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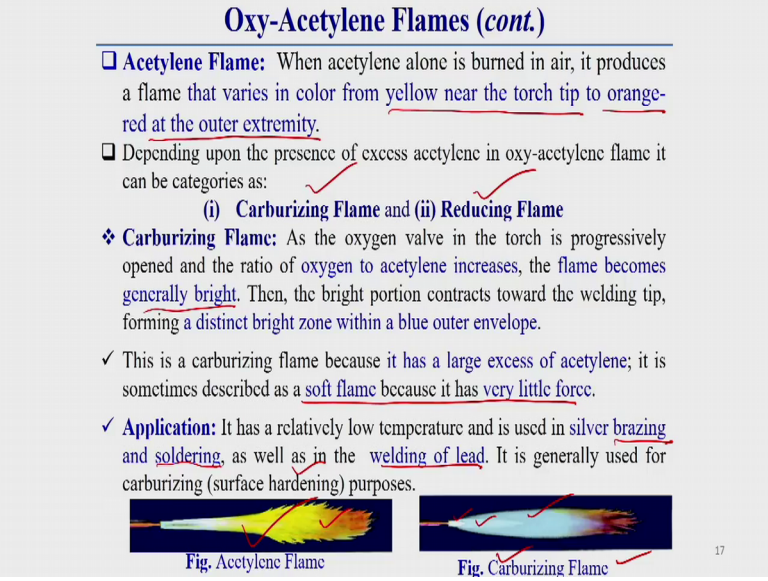

So, first of all I will discuss about acetylene flame. Generally, then acetylene flame that means in this then I will discuss about neutral flame, then I will discuss carburizing flame. So, the acetylene flame, when acetylene alone is burned in air that means, when the arc is started, it produce a flame that varies in color from yellow near the torch tip to

orange red at the outer extremity. This is here you can say at the bottom of this slide, this is actual acetylene flame, where you see you can see here orange red types of flame is there at the extremity, and near torch tip color is yellow stripe.

Now, with this acetylene flame once we supply oxygen gas, then depending upon the presence of excess of acetylene that means, in oxy-acetylene flame. This acetylene flame oxy-acetylene flame can be categorized that means, where the excess of acetylene is there, different different axis of acetylene, this flame can be two different categories. What is this two different categories, one categories is called carburizing flame, where and another categories is call reducing flame.

Here one things you keep it in mind. In case of carburizing flame, generally it is has a capability to carburizing operation that means, carburizing is a hardening operation. So, what happens here the acetylene proportion is higher than the reducing flame, but here proportion of acetylene for both the flame proportion of acetylene is more than the oxygen that. But, here the proportion of acetylene gas is more in case of carburizing flame, then reducing flame. Reducing flame is also a what it is called acetylene types of flame, here more acetylene are there.

Now, I will discuss one by one in about this that means, one carburizing flame, and another one is reducing flame. Carburizing flame generally as the oxygen valve in the torch is progressively opened, and the ratio of oxygen to acetylene increase, the flame become generally bright. Then the bright portion contact toward the welding tip here you see, this is carburizing flame.

So, here this bright portion, generally gradually contact towards the welding tip and forming a distinct bright zone; here you see the forming a distinct bright zone within a blue outer envelope, here within a blue outer envelope, there is create a bright inner cone you see bright inner zone. Here you see from this is different color and actual shape of carburizing flame.

This is a carburizing flame, because it has a large excess of acetylene are there, it is sometimes described as soft flame, because this types of the carburizing flame has very little force, its force is though higher than acetylene flame. But, then also its force is very little that is why, this types of flame relatively used in low temperature alloy the so it has

a relatively low temperature, and that is why it is used in silver brazing and soldering purpose as well as it is used also for welding of lead.

As it is a carburizing flame that is why, it has a wide application for carburizing purpose. Carburizing is a generally process of surface hardening process. So, for this characteristic carburizing characteristics or you can say presence of acetylene gas is more that means presence of hydrocarbon is more. So, it is produce carburizing types of flame, why it is called carburizing flame, because this flame we can use for carburizing purpose that means, surface hardening purpose, but this reducing flame cannot be used for carburizing or surface hardening purpose. Because, in reducing flame generally, the proportion of acetylene is less than carburizing flame, it cannot produce carburizing effect.

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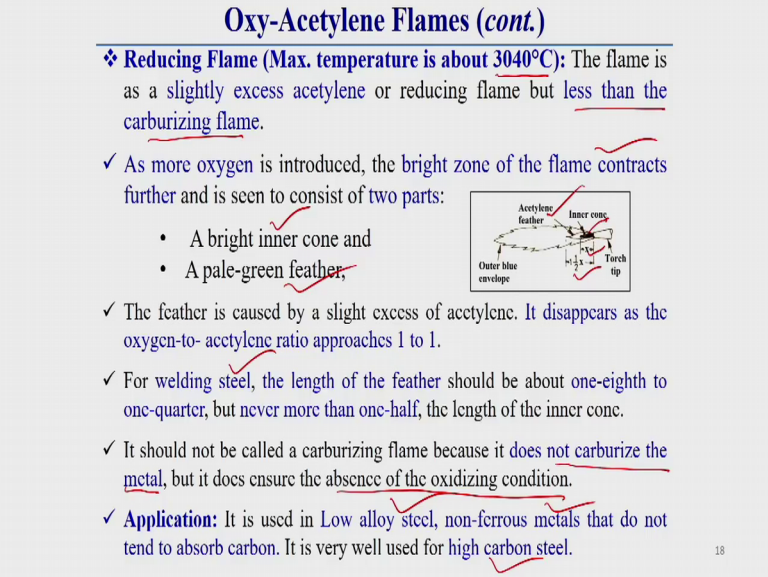

Then once I will discuss about this reduce flame, then it will be very clear to you. So, generally reducing flame means, here the flame temperature is around 3040 degree centigrade. This flame as it slightly excess acetylene or reduce flame, but less than the carburizing flame. The slightly excess acetylene is there, but generally its acetylene content is less than, what it is called carburizing flame.

Here some oxygen is introduced the bright zone, the bright zone of the flame contract further, and this seen to consist of two parts. So, as more oxygen is introduced, the bright zone of the flame contract further, and it is seen to consists of two parts. What are these

two parts, two part are, one is called bright inner cone. Here you see bright inner cone, this black here it is showing, but it is very bright colour bright inner cone. And there pale-green feather or you can say this pale green feather is called actually acetylene feather.

The feather is caused by a slight excess of acetylene. This feather disappears as the oxygen to acetylene ratio approaches to 1 is to 1, because once the once the acetylene oxygen gas further increases to this mixture, feather gradually decreases, and this vanishes once this ratio becomes 1 is to 1, and that means oxygen to acetylene ratio becomes 1 is to 1 that is why, then for welding steel, the length of the feather here one things you should keep in mind. To see this feather size, we can generate the required atmosphere for doing steel welding how, generally for welding steel, the length of the feathers should be about 1821 quarter, but never exceed more than on half the length of the inner cone that is why it is showing.

If the inner core size is x, then this acetylene feather size should not more than one and half of x. Because, once it more than one and half of x, then this will not be suitable for doing steel welding that you should this should be as much as lesser than what it is called lesser than this. If it is lesser than that means, if it is more than x, but lesser than one and half x, then what happen it is good for doing steel welding that generally a expert welder can visualize, and can control that thing during welding operation.

Here it should be it should not be called as a carburizing flame, because it does not what I have already told I told you it does not carburize the metal that mean that surface hardening, it cannot do it cannot perform. But, it does ensure the absence of oxidizing condition also, but here oxidizing condition also is not there. It is generally apply in low alloy steel, high carbon steel, and non-ferrous, especially that material which does not tends to observe carbon, so that material which generally does not tends to observe carbon. There generally this reducing flame widely used, apart from that thing it is also use low alloy steel and high carbon steel also.

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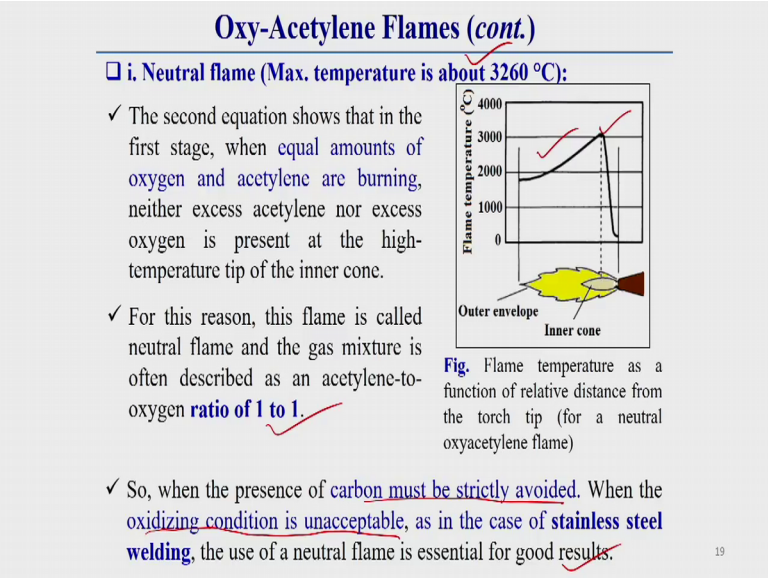

Now, neutral flame so, neutral flame further increase with this reduce flame, if we further increase the what it is called oxygen content, then what happens it approaches to 1 is to 1. So, once the ratio of oxygen and acetylene is become 1 is to 1, then this flame is called neutral flame. This neutral flame have a temperature, it is about 3260 degree centigrade.

So, these neutral flame, what I have shown in second equation during explanation of combustion of oxy-acetylene gas, there we have shown that that oxygen and acetylene in second equation that means, equal amount two molecules of oxygen and two molecule of generally acetylene gas combine, and it is produce carbon monoxide and H 2 O that equation represent the reading this combustion period, where equal amount of oxygen and acetylene are there, during that time generally this neutral gas is formed.

This neutral gas then in either excess acetylene nor excess oxygen is present. So, it has maximum temperature which is around 3260 degree centigrade, which is generally observed in inner cone of the acetylene gas. In case of neutral gas, this acetylene either vanish and here developed a bright inner cone. Here how the temperature varies in a neutral flame from tip of the torch tip to flame tip that I am showing here, how it is varying. This is relative temperature distribution.

In inner core, this temperature is around more than 3000 degree centigrade which is maximum can be around 3260 degrees. And generally, it is further gradually decrease, away from this inner cone, how it is decreasing that it is showing. From this you can feel,

how the temperature is varying in a neutral flame. This flame is called neutral flame, and the gas mixture is often here, it is described as oxidant, what I have already told you oxygen to acetylene ratio of 1 to 1.

So, when the presence of carbon must be strictly avoided, you should keep it in mind. And when oxidizing condition also unacceptable, so both generally carbon must be strictly avoidable, and oxidizing condition is also avoidable. So, for these cases generally, especially this in case of stainless steel, this two condition should be strictly avoidable that means, there should not be carburizing condition or there should not be oxidizing condition. So, for doing this stainless steel, this neutral flame is generally essential for good result. So, generally for doing stainless steel, we should go for neutral flame.

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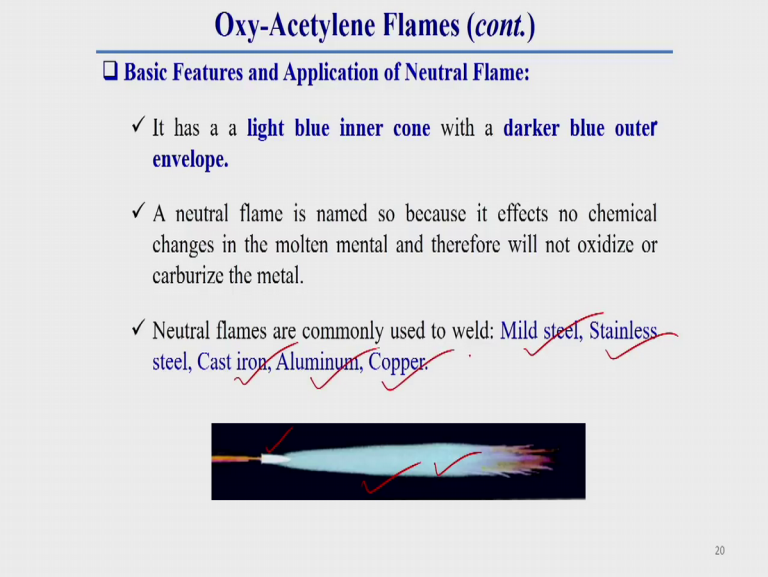

So, this is the basic feature and application of this neutral flame. It has a light generally this is a neutral flame practical neutral flame. Here one things you can say, it has blue inner cone, this is a blue inner cone with a darker blue outer envelope, you see which is the darker blue outer envelope. A neutral flame is named so because, it effects no chemicals changes in the molten metal, and therefore will not oxide or carburize the metal.

So, why it is called neutral flame, because no chemical changes in the molten flame metal is occur by using this film. Neutral flame have wide application, it is generally

used in mild steel, stainless steel, cast iron, aluminium, copper. So, it has lot of applications, we can use this neutral flame in different different matter.

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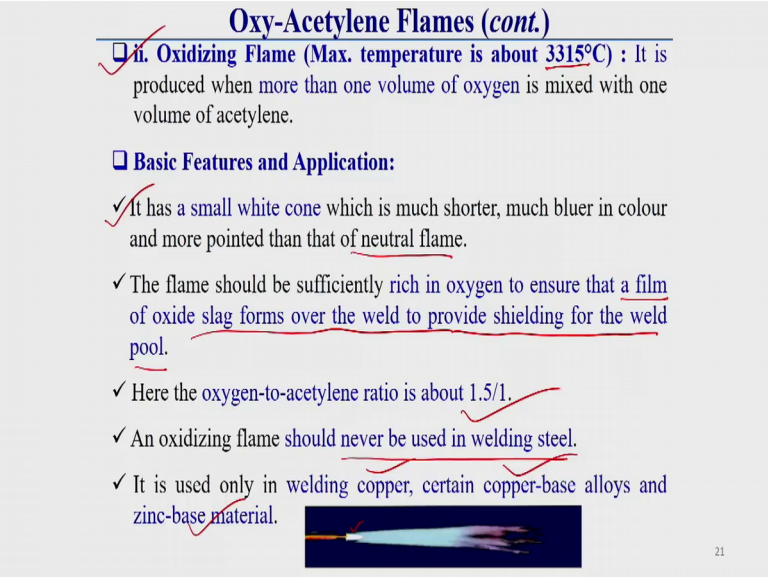

Now, the last categories of oxy-acetylene flame that is called oxidizing flame, here this is oxidizing flame. Here what I have told you, if we increase the oxygen percentage or oxygen proportion, this flame temperature gradually increase. Here the maximum temperature is more than the neutral flame that is 3315 degree centigrade. It is produced when more than one volume of oxygen is mixed with one volume of acetylene. So, here proportion of oxygen is more than the proportion of acetylene gas.

Here the basic feature of this gas, it has a small white cone due to this further increase of oxygen gas, this inner cone generally further shortened, so that is why it has a small white cone which is much shorter, much bluer in colour, and more pointed than a neutral flame. So, whatever the bright cone we are we have seen whatever the small inner cone, we have seen in case of neutral gas.

In case of oxidizing flame, this inner cone size is shorter than that. The flame should be sufficiently rich in oxygen to ensure that that a film of oxide slag form over the well to provide shielding for the weld pool. This flame also sometimes good for some types of material, because this oxide layer forming over the surface of the weld metal sometimes helpful for shielding purpose that is why, this is also applicable for some material.

So, here the oxygen to acetylene ratio is what I have already told you is about 1.5 is to 1. And oxidizing flame an oxidizing flame should never be used in welding steel that you keep it in mind. Generally, what happens once we use oxidizing flame for doing weld a steel, so there will be defective weld. So, generally it is used only in welding copper, then certain copper base alloy, and zinc base. So, it has limited application, then what to for a copper and certain copper base alloy, this oxidizing flame is giving good characteristic weld.

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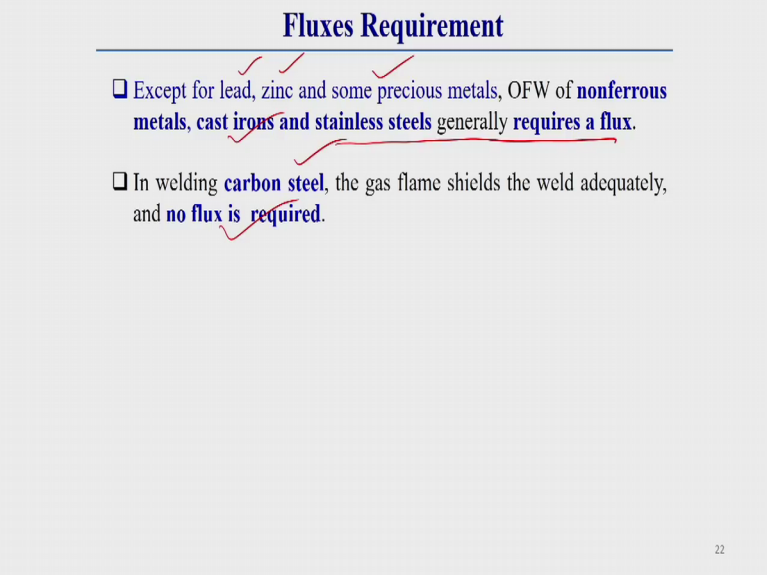

Now, the flux requirement; sometimes flux also required in case of oxy-fuel weldings, except for lead zinc and for some precious metal, oxy-fuel welding of non ferrous metal, cast iron, and stainless steel require a flux. Except for this lead zinc and some precious metal, oxy-fuel welding requires flux. Once that the sum like it can be non ferrous metal, cast iron, stainless steel, flux is required.

In welding carbon steel, the gas flame shielded the weld adequately that is why for doing carbon steel flux is not required. But, flux is required for cast iron, steel flux means, what happens which is required to protect the molten fuel from atmosphere contamination some sort of material out there that I will discuss subsequently, so (Refer Time: 51:09) used to protect the molten fuel from atmosphere contamination, so that that flux generally sometimes require in case of oxy-acetylene welding, sometimes it is not required, where it is required that I have already told.

Now, in next lecture, I will discuss combustion of other gases, what are the different combustion of other gases, then I will discuss what are the different categories of oxy-fuel welding techniques. And I will also discuss the application, why what is the advantage disadvantage or what should be the safety precaution of these welding techniques in detail.