Welding Processes
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Shielding gases for arc welding
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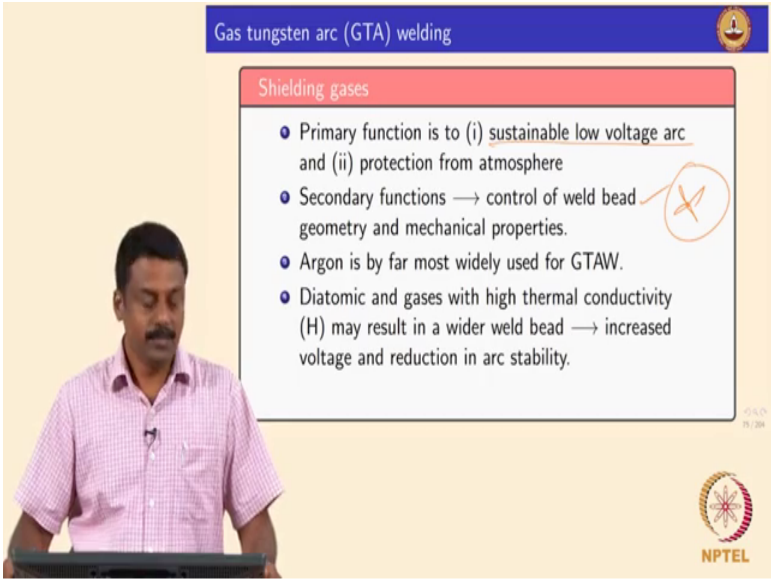

So now will move on to the shielding gases shall we right, so we looked at the heat transfer characteristics right, the conduction conversion radiation, so it is recover all the time, so the moment when you see the selection of gases whatever we learned in the heat transferred is extremely important to relate that over the correspond shielding gas okay, so the function of gas in the welding process primary function is to strike an arc is not it.

So the gas, the shielding gas what you use, the main function you use it to strike an arc and then you can use the gas to protect the weld pool okay, the shielding gas which you use is on not only use for arc, arc is primary function but secondary function again it is not only to protect the weld pool, the shielding gas influences the various aspects of welding okay.

So it of course, it protect the atmosphere but it will also can, it will also change the welding geometry, it will also change the microstructure, it can also change the pre fleet flow okay, so the all this things would be taken into consideration when you are choosing a shielding gas, so the primary function as a written over here to sustain a low voltage arc that is the primary function and then protected from the atmosphere.

Then the secondary functions the arc can also influence weld geometry and mechanical property, the one classical example is use of oxygen in a low carbon or medium carbon steel for welding, so we add some amount of oxygen with argon for example to induce oxygen inclusions okay, so the moment you induce oxygen inclusions, the oxygen inclusions that where the acicular ferrite is nucleating okay.

The acicular ferrite are nucleated at the oxide inclusions, sorry metallised the pardon me okay, so once you have the oxide inclusions, so you can nucleate acicular ferrite and acicular ferrite, so if you have a microstructure the toughness increases significantly okay, so that is one example I want to give or you can also use high conductivity gases, for example height is not helium to spread the weld pool okay.

So while spreading, so you can also increase the area you weld, so you can do wider weld geometry well, so based on your need by looking at the characteristic of shielding gas, so we can choose which shielding gas you want use for welding right, so will look at one by one looking at the characteristics.

So by for argon is very widely used for GTAW, GTAW in most of the cases is done using argon alright and sometime we mix argon with a diatomic gas, for example argon for CO_2 okay, again the CO_2 can influence the heat transfer characteristic of an arc because CO_2 is diatomic gas right, so obviously the heat transfer can be very effective you saw look it because diatomic dissociation and then re-dissociation your arc heat can be distributed much more uniformly than if you use argon alright.

Similarly if you use gases as high thermal conductivity same fundamental can also be happening, for example if you hydrogen or helium, helium is highly conductive gases, what you mean conductive, the balance of flow is very high, if you use helium or hydrogen is not it, so the heat can be transferred very effectively, so you will have end up in, you will have making very wider welds because the heat is spread right, it is clear.

So will look at one by one the all the gases what we commonly use and then what are the characteristics and then to understand the what gas you want to use for your given application, so you need to look at the physical characteristics of the gas plus the physics of arc right, it is clear, so generally diatomic gases with the gases thermal conductivity result in wider bead because of the effective heat transfer, diatomic gases the de-dissociation can transfer the heat.

Similarly the conductive gases, high thermal conductivity gases can also transfer it by effective buoyancy flow and doing this process if they are, the temperature is widened so you also increase a voltage in most of the cases because the flow is diverted, it is not going and it is diverted so obviously you end up increasing the voltage as well, system voltage okay, it is clear okay, good. Will see one by one

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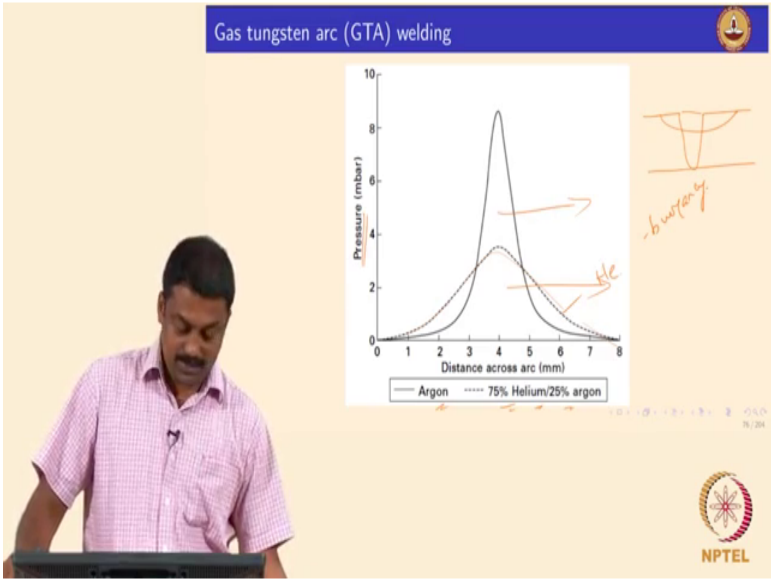

So this is the classical example of the arc pressure, measured over the distance, the diameter of the arc by using argon and helium and argon using it difference already, so helium is highly convective gas is not it, heat transfer is very effective by convection due to the buoyancy when helium or even hydrogen because of that if he is only argon, so you will have the enormous amount of keep concentrating at the arc core, the organ does not, it is an more atomic gas, it does not disassociate because it is an already atomic gas.

So the heat is not transferred effectively from the centre of the arc to the circumference is right, whereas if you mix say for example helium and 25% argon, the helium would transfer the heat effectively from the centre of the arc to the arc envelope and doing this process the pressure are in temperature would decrease significantly at the centre because it is spreading out, it is transferring.

So now if you use the same welding parameter, you just change the shielding gas which will give deep penetration, so in this case argon would give much deeper penetration because heat is concentrated is not it, suppose if we use the second mixture, your weld bead would be something like this is not it, so now you can clearly see just be changing the shielding gas, you will change the weld geometry right.

So if you use argon, so heat is concentrating at core of the arc, so it will lead to deeper penetration very narrow weld and change it to helium which convert to gas or you add argon, see what to carbon dioxide, you will see the effect already okay, so carbon dioxide which is also very effective in E transfer because of de-dissociation okay and helium and hydrogen is also very effective because of effective conductive flow, in both ways the heat can be distributed from the core to the envelop parry ferry yes, is clear and it is real.

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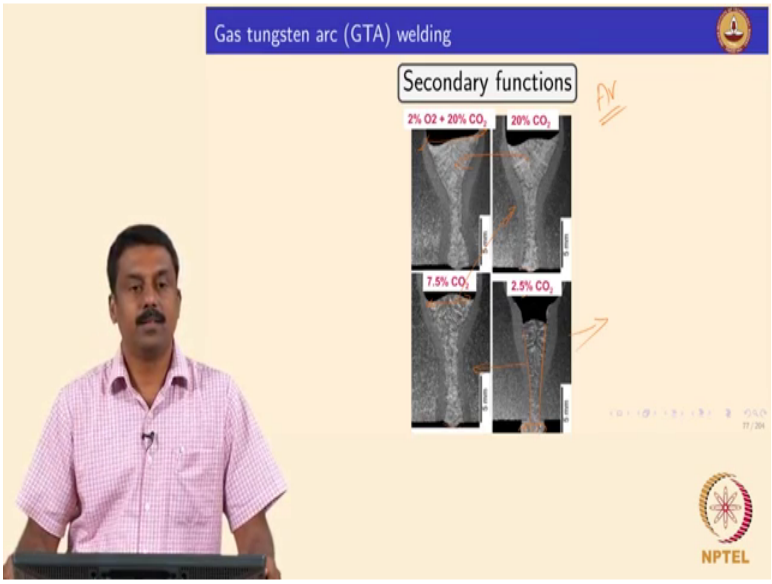

And we have done experiments to verify that, so in this case so we use argon is the main gas and we added various gases along this argon okay, so in the first case you will start from here and this is argon only 2.5% CO2, it is close to pure form, you see that, the very deep even the weld pool is collapsed because of super heating, it is sagged, very narrow weld is not it, so if you start increasing the carbon dioxide concentration, you already see the penetration is decreasing and then it is becoming wider is not it.

So again in case in the carbon dioxide it is even wider, the penetration decreases significantly okay and from here to here we added oxygen O2, it is even increases the weld bead with the penetration decreases okay this is due to the diforma, I explained because of the change in the heat transfer of the arc right.

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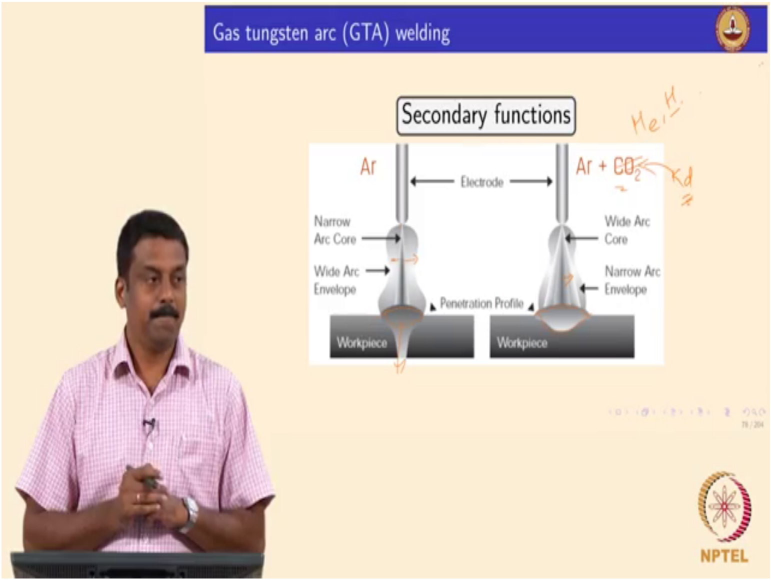

So these what happens when you have an argon Ar CO2, so the arc core is very narrow in argon case because the heat is not transferred, so there is no conductive heat transfer, there is no de-dissociation, other the conductive heat transfer by de-dissociation, so you will concentrate heat at the core the maximum when you use a pure argon right, so you will have very narrow core and leading to the deeper penetration in argon.

So you mix it CO2 okay, the arc core expands because the heat is now distributed by the de-dissociation so the KD term would influence the temperature distribution from core to the outer periphery and doing this process, so you will have to distributed the heat leading to the wider bead and then shield a penetration, same would have happens if ruthful this with helium or even hydrogen, the than instead of KD you will have a much more effective balancing flow okay, yes because they are very effective they convert to gases which have, that is where they have these Seleucid helium and hydrogen, there are very high thermal conductivity.

Okay because of the conductivity transfer, effective conductivity transfer right, it is clear, the effect of shielding gas, so you can now immediately know, think about it, now you want to reduce the penetration, you see the weld is penetrating very high so with argon okay, let us add 5% CO2 okay, so obviously the penetration will decrease, weld bead width will be increasing, you should also have significant width otherwise the load will be concentrating on a very narrow region, so the weld width will also be the aspect ratio of the weld width to the depth ratio, it is also very important alright.

So that is how we change the shielding gas in such a way that we change the weld bead geometry, so not only that the shielding gas has will also influence the microstructure generation okay, for example shall I explain the oxygen it will form of oxide inclusion and that is beneficial to nucleate acicular ferrite right.

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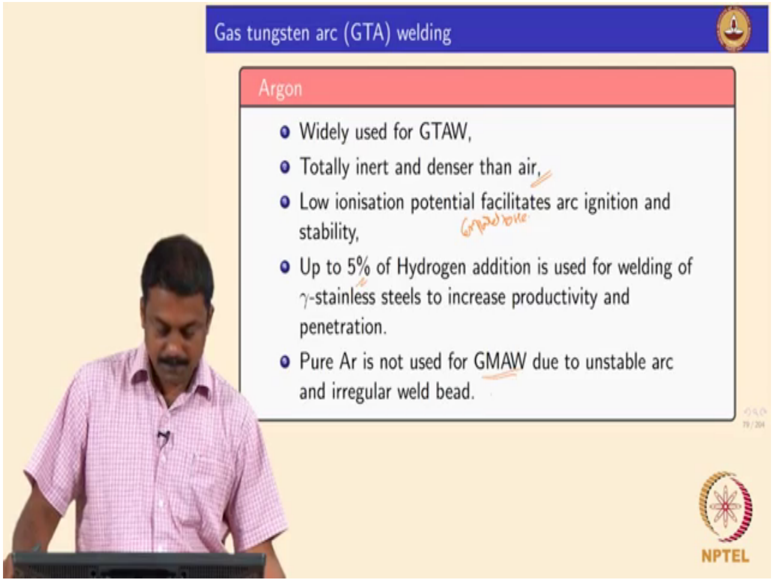

So will look at the one by one all the characteristics of the gases than we will stop okay, the first argon, so argon is widely used for GTAW, it is totally inert and denser than air, it is very important, so when you use argon shielding gas it displays the air okay, so the air is displaced effectively well-organised perched because it is denser than air, so it has very low ionisation compared to helium okay.

So therefore the ignition is easy compared to helium, so that is why when you are using the argon in GTAW, the arc ignition facilitated by the electric brake down or high-frequency ignition because if you use helium the NS energy is high, so obviously if VB which will saw it has to be even higher okay in the high-frequency ignition unit to increase the frequency or even higher than what is used for argon.

So the argon is preferred for GTAW for this very same purpose because they ignition is easy right, okay sometimes we add hydrogen mainly for stainless steels because stainless steels, so we need to spread, I would need to weld it with the wider heat the arc envelope, so if you use argons, so you will always concentrating on to very narrow region, so we add hydrogen 5% so that the heat is distributed you make a wider bead alright, it is clear, can you use hydrogen mixing for low carbon steels or steels, ferritic steels yes, so we could use.

So if you use hydrogen for welding low carbon steel and you will be fired because the weld is going to crack by (())(15:05) okay, so pure argon is generally is not used for GMAW okay, so again the heat is highly concentrating at the arc core, the melting characteristics or the filler can be ensured properly okay, so GMAW if use argon generally you know we need to melt a droplet and then transfer it than transfer characteristics is significantly affected by the arc core, the shape of the arc core.

So will see when you are looking to GMAW why is very important? So generally we do not use argon for GMAW but nowadays people use it because the control over the wire free rate, so in those days when the wire free rate is not synchronised with the power source and the waveform characteristics, the argon was not used for GMAW okay, so now we can control it but mostly we do not refer to use argon.

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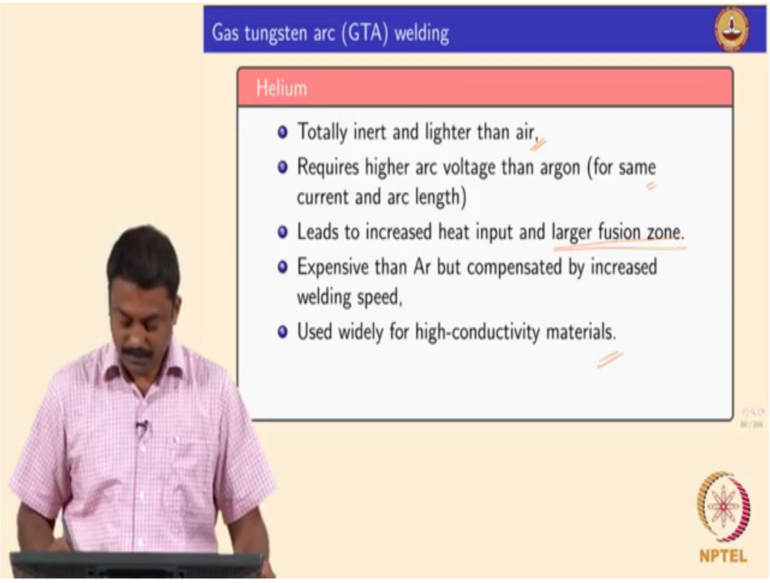

So second is helium, so helium is very light, so lighter than air now we already have problem, so if you not use helium as a shielding gas, flow rate now the significant to displays the air is not it, so argon its density is that, if you send it reasonably low flow rate it would still displays the air but helium he need to have an pressure to push the air so that you fill the medium with helium, it is lighter than air, is one of the two gases which can escape from it is atmosphere, which is other one hydrogen obviously.

So helium if you send via balloon would escape okay, so I always feels someone uses helium for filling balloons and flies it because it will escape, so will a run out of helium for welding right, so I would always discourage my children using helium balloons, I needed for a welding, if all of us send helium balloons in atmosphere it will go away to space okay, so there will run out of helium, so luckily we can produce helium in the earth itself okay, so because the nuclear reactors final product this helium okay, that is very costly helium, so most of the helium comes from the volcanoes, there crust has helium okay, so we produce helium.

Obviously we also need a very high arc voltage why? The helium has very high ionisation potential right, otherwise we cannot sustain the arc ignition is not that, so it needs high arc voltage than argon and that would lead to obviously high heat generation, so the helium arc would always be hotter than argon arc because when the helium is ionised, it is ionised with very high ionised energy, so then the energy is really obviously when the electrons which are coming out of the energy is the process will also have a high energy and obviously high energy electrons are collided, you also transfer the energy much higher than when you have a low energy electrons are coming out.

So this collision will obviously lead to high temperatures, so arc temperature will always be higher than, for example if you use argon okay, all this put together will increase a heat input right and leading to larger fusion zone and that is one advantage because we can also do high-speed welding, so you can also instead of as a I am doing in slowly you already have a large amount of heat, that means you can do it slightly faster, so the welding speed can be increased compared to argon.

So the cost you spend to buy helium bottle is compensated by welding in a increase speed right but it is only a production environment, it is also widely use for high conductivity materials because the heat, the energy, the arc energy what is their it is high okay, the heat is generated in a high amount compared to the argon, so in high conductivity materials heat is dissipated so quickly, so he need to supply more heat so that he can melt is not it, so for example welding copper helium is very widely used because it is highly conductive material, so he need to supply more heat to melt the interface right, it is clear helium, good.

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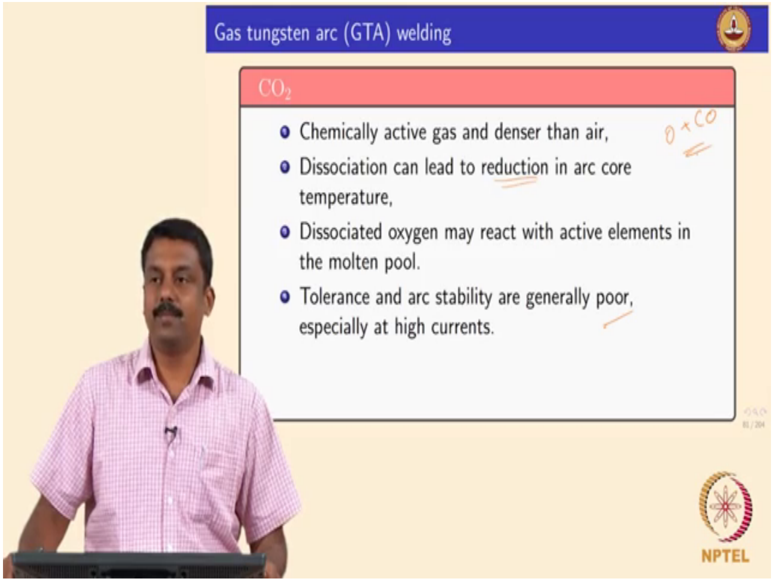

So then third commonly use is carbon dioxide okay, the carbon dioxide is very active gas right, so it also dissociates into oxygen and carbon monoxide is not it, so this dissociation lead to reduction in arc core temperature the same example I showed you, so dissociation can lead to de-dissociation elsewhere doing this process the heat can be transferred, so due to that the arc core temperature decreases because you are spreading the heat, it is not concentrated at the core, so the temperature is spread and this dissociation process also generate oxygen atom, so oxygen can react with the molten metal unfortunately it can react with aluminium, for example silicon.

So when you using CO2 and if a steel contains aluminium the aluminium will be lost, the aluminium pickup is very low when you are using CO2 welding because the aluminium would all go away as aluminium oxide slag okay, so generally because of this phenomena the arc stability decreases because the arc core is not narrow, so it is spread and you also create the more ions and decrease the N concentration due to the dissociation and dissociation process, de-dissociation process respectively.

So then the arc stability would not be there right compared to mono atomic gases and you uses CO2, so the voltage will be higher again the same process because you are spreading like in a conductive gases, so voltage will increase therefore heat input will also increase okay but the stability will go down significantly given.

So using conductive heat transferred to increase the arc temperature, divide arc temperature will be better than using CO2 okay that will give you much more stable arc wherein in this case the stability will go down, so it is low-cost carbon dioxide okay, so argon plus CO2 mixes are very common right to spread the heat in the arc, so that you can reduce the penetration and you can wide weld bead significantly yes, it is clear.

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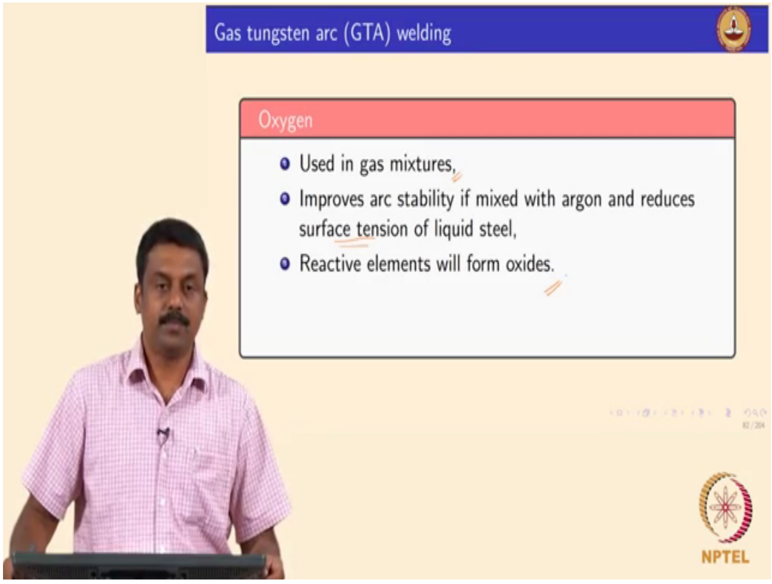

Look at two more gases and then we stop oxygen, so oxygen is always used in mixture you cannot do and welding with pure oxygen for obvious reasons, so you will have explosion right, so it is use widely to mix pure argon, mostly argon okay, so it is known to improve the arc stability right but again you have diatomic oxygen O2 would lead to de-dissociation and the spreading and it will also influence the surface tension okay.

So that is very significant affect you would see in bead geometry, will see in in the subsequent process all the surface tension of the molten metal would change the bead geometry, when the oxygen dissolves it is known to change the surface tension, so then the your flow behaviour will change, it may even change from outward flow into inward flow, where changing surface tension as function of temperature okay.

So we will see how, so these are the function of shielding gas okay, microstructure, oxygen would influence the inclusion formation, it will also influence the surface tension will change the geometry of the bead as well okay, so you would end up oxidising the, highly oxidising the high elements, you have silicon for example, aluminium, so well bead would be depleted of this elements okay.

So when you use an MMAW electrode, last week one of my student he came to me, we wanted to add aluminium in the electrode we end up getting nothing, the weld bead did not contain any aluminium, so in manual metal arc welding it is done without shielding gas because see what to generate by dissociating the flux okay, so end up making a oxygen and carbon monoxide, now oxygen what is generated by the dissociation would eat away all the aluminium and aluminium oxide would glow as a slack during welding okay and this process you also generated carbon and the carbon would also lead to, the cartoon would refuse the weld metal and the carbon concentration and also increase okay when you are using carbon dioxide okay, so the oxygen is clear.

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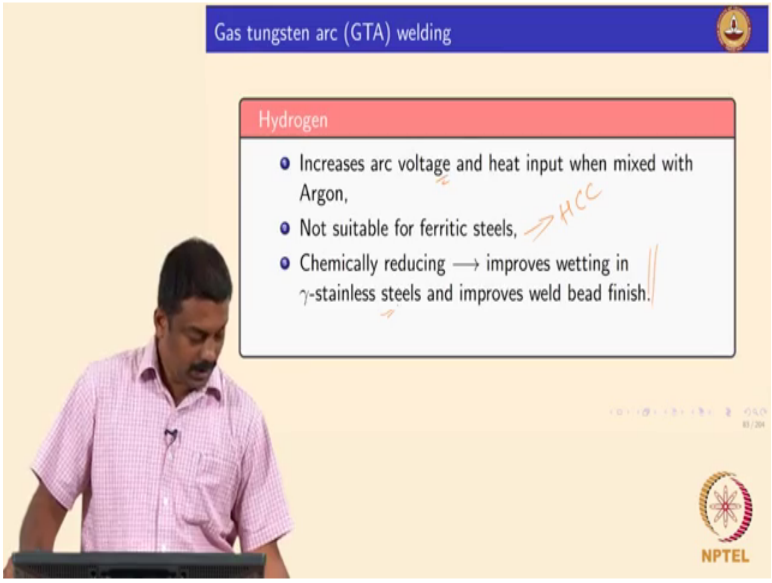

And then hydrogen, so hydrogen is also known to increase the arc voltage again because of the convective nature and not in case a heat input because hydrogen energy is also very high okay, so it is not suitable for ferritic steels for the same reasons what I will explain in the hydrogen cracking, coal cracking or hydrogen (())(25:53) so in some cases it improves wetting because it also affects the surface tension viscosity of steels no to change, so we can also use this two spread the pool effectively for argonic stainless steels is rarely used.

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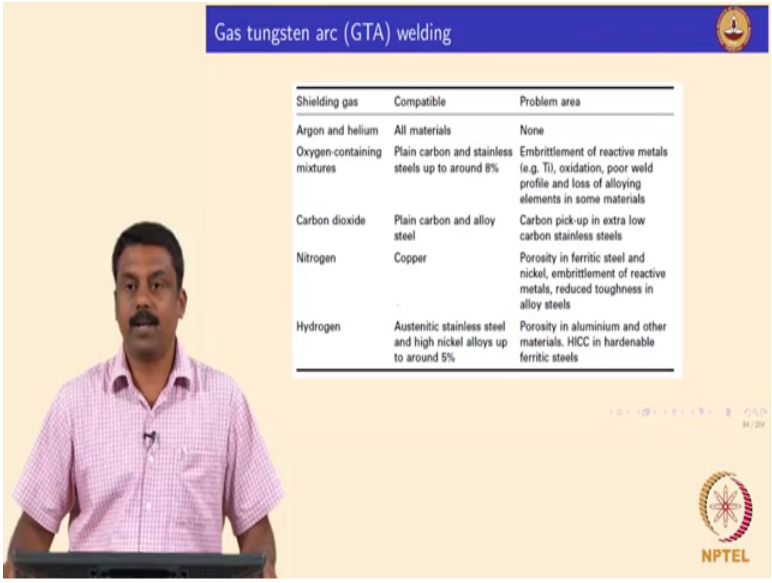

So summarised, so we can choose the shielding gases based on the material and then how good your geometry should be, the expectation should be and based on that you can choose and it will also affect your productivity because whether you have, you want to make the penetrations welds or the faster welds are if you want to weld it is slow with filler and all these things would be affecting the selection of the shielding gas because the shielding gas characteristics are determined by the heat transfer characters where you are looking at it and then the ionisation, the arc heat generation characteristics okay, so you look at this table in next class and then we will end up here okay. Thank you.