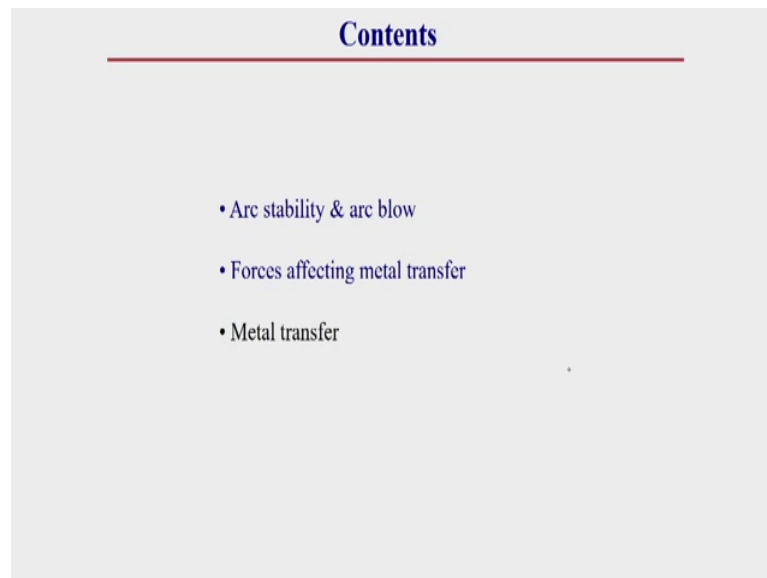


Fundamental of Welding Science and Technology
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Lecture - 12
Physics of welding-4 (Arc Stability and Arc Blow)

See, in last class I completed the arc power in details, I was also discussing about different categories of arc, welding arc, and I was also discussing about different categories of welding arc, and different mode of welding arc in details last class. And today I will start a new topic that is actually called Arc Stability and Arc Blow.

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Today, I will try to cover this arc stability and arc blow as well as forces affecting the metal transfer.

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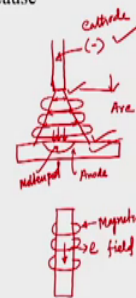
Arc stability & arc blow

So, first of all we should know what is arc stability and arc blow. So, before going to discuss about arc stability and arc blow first of all we should know what is the function of current, because what happens to know details about arc stability and arc blow first of all knowledge about current flow through the arc we should know.

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Functions of current flow

- ❑ In an arc, current density, magnetic field strength and pressure all decrease from cathode drop region towards the arc column, because arc cross-section increases rapidly in the arc column.
- ❑ The current flow through the arc gives rise to self induced magnetic field which compresses the arc plasma resulting in appreciable axial and radial pressure gradient in the arc.
- ✓ The radial pressure gradient constrict the arc (pinch effect) and raises the temperature of the arc discharge.
- ✓ Whereas axial pressure gradient give rise to **plasma streaming** which transports material and heat from electrode to the work piece.
- **Plasma streams stabilise the arc** and exert a pressure on the molten pool which helps to increase the penetration.
- ❖ **Note:** Both these effects are proportional to square of arc current.



In case of a arc welding technique what happens, let this is the electrode. I should explain and then we will go in details about arc stability in and arc blow. Here what we observe we observe that arc is arc cross section, actually we can say there is arc cross

section this gradually increasing from let this is generally for cathode and this is generally anode this is a anode. So, what we observe that the in case of arc, this is arc, this is. So, what we observe this arc is cathode means electrode arc cross section continuously varying from cathode space region towards anode space region; that means, cathode to anode region generally arc structure cross section is increases.

So, what happens if the arc structure cross section increases, then what happens? There is a chance of concentration of the electron density generally electron density corresponding to electron density, generally this current density because electron density is responsible for current density. So, if the cross section increases then the current density, then magnetic field strength and pressure all will be decrease. Because depending upon the electron density; that means, lesser the cross sectional area more will be the concentration of the electrons, more will be the current density that what I have already discuss in details why this current density increase.

Generally so, here generally due to this varying cross section that means, increasing of cross section here current density magnetic field strength and pressure all decrease the from cathode drop region generally; that means, from this region towards the arc column and towards the work piece region. Because arc cross section increase rapidly in the arc column due to this rapid variation of arc column generally current density, magnetic field strength and pressure all decrease from cathode drop region towards arc column, that idea we got.

So, as this current density magnetic field strength and pressure all decreases from cathode region towards the anode region that is why generally what happens, there is generative varying magnetic field region. That means, whatever due to this current density, what happens? We know what we know if through a conducting medium if current is flowing; that means, if electron or current is flow through the conducting medium around this medium generally what happen, there develop generally magnetic field. So, let us current is flowing through this direction. So, here generally magnetic field magnetic field that we know, due to this current flow generally magnetic field around the electrode or you can say around that conducting medium.

So, here also through the arc there is continuous flow of current is there that is why through the arc also there will generate some magnetic field. This magnetic field extend

higher near the cathode region and its gradually decreasing towards anode region and its comparatively very less in anode drop region. Actually, that we are getting also from here. So, due to this variation of this magnetic flux distribution around the arc from cathode region to work piece region, here generally develops some radial pressure gradient and axial pressure gradient. Here due to this variation of this magnetic flux distribution through that here develops some pressure gradient which is in radial direction as well as it is axial direction; that means, along the direction of current flow.

So, because there is a axial direction why this special gradient is creating? This axial because this magnetic flux density is not uniformly distributed over the arc length; it is generally varying from cathode region to anode region. Due to that things what happens? There is develop both radial pressure gradient as well as axial pressure gradient. Due to this radial pressure gradient generally this radial pressure gradient constrict the arc, whatever the radial pressure gradient it is creating along the arc that radial pressure gradient generally responsible for constrict the arc. That means, its generally prevent the arc a spreading; that means, its try to compress the arc to some confined space due to this radial pressure gradient.

So, it generally compress the arc or you say you can say that its generally constrict the arc. And what happens due to this constriction the constriction of arc? Here generally there is a rise of temperature is occur, there is a rise of temperature more rise of temperature is occur also. So, the radial pressure gradient constrict the arc and rises the temperature of the arc discharge. So, radial pressure is responsible for this two. Whereas, whatever the axial pressure gradient is generating; that means, due to this variation of magnetic fields distribution through the arc length region there is develops some axial pressure gradient also.

Due to this axial pressure gradient generally what happens? This axial pressure gradient give rising to plasma streaming; so, this radial axial pressure gradient generally give rise to plasma streaming. These plasma streaming generally which transferred the material and heat from electrode to work piece. Due to this plasma streaming whatever the electrode melt or droplet is forming that droplet transferring from cathode region towards the work piece region due to this a streaming action.

So, apart from these function of axial pressure gradient it is also help to create some turbulence action over the molten pool. It is also exert some pressure on the molten pool. Due to this turbulence action of this plasma streaming and creating some pressure over the molten pool generally its helps to increase penetration that is its increase the fusion depth also. That means, this whatever the axial pressure its developing that axial pressure create some pressure where this is our molten pool, create some pressure over this molten pool, due to this plasma streaming along this axial direction its create some pressure on the molten pool due to this pressure generally its increase the fusion depth also.


So, plasma streaming function is to transfer the material from cathode to work piece as well as it also carry the heat from cathode to work piece region as well as its create some pressure over the molten pool region of that work piece due to this its increase the well penetration. Now, here one things we should keep it in mind it is generally, both this effect; that means, both this radial pressure gradient as well as axial pressure gradient is dependent on current flow. It has seen that this radial pressure gradient and axial pressure gradient is proportional to the a square of the arc current.

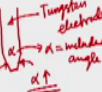
Now, we will go what is arc stability, what is arc blow, because once we know the function of current follow through the arc, then we will be able to understand this arc stability, arc blow in details very easy way, very easily.

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Arc stability

- ✓ Arc is said to be stable if it is uniform and steady.
- ✓ A stable arc will produce good weld bead & defect free nuggets.
- **The stability of a welding arc is governed by so many factors, as mentioned below:**
- ✓ Suitable matching of arc and power source characteristics, a little variation in arc length, i.e., arc voltage should not extinguish the arc.
- ✓ Continuous and proper emission of electrons from electrode (say cathode) and thermal ionization in the arc column.
- ✓ Arc length.
- ✓ Electrode tip geometry in GTAW. Higher the included angle better the arc stability.
- ✓ Presence of dampness, oil, grease etc. on the surface of workpiece increase arc instability.
- ✓ Limited practice of the welder.





Now, first of all we should know what is arc stability. Arc stability means arc is said to be a stable when it is uniform and a steady. That means, if the arc is uniform in nature and a study. If it will not varying then what happens? It will not varying with time then what happens we can say this arc is uniform and a study then this arc is said to be a stable. Here one thing, we should keep it in mind that for getting a good velvet and defect free well our arc should be that mean welding arc should be a stable enough, if the welding arc will be a stable then only we can get a good velvet as well as defect three well nugget. That means, we can get defectively nugget if our arc will be stable enough.

Generally, this stability of the welding arc is governed by so many factor which can be mentioned as below like first of all a when we can get a stable arc. That means, the whatever the arc is developing in between a electrode, electrode and the work piece means whatever the arc is developing this arc will be a stable, this arc will be a stable generally its depends on it depends on this arc will be a the a stability of this arc depends on so many factor. Like, first of all here we should know; that means, what are the different factor govern this arc a stability.

Here the first things we should know; that means, that the first point of our arc stability is that should be generally suitable matching of arc characteristics and power source characteristic, that there should be suitable matching. That means, here one things the if there will be a suitable matching of arc characteristics and power source characteristic then what happens? It will not actually it should not actually; that means, suitable matching of arc characteristics and power source characteristic mean it should not extinguish its arc with a small variation of arc length or a small variation of arc length. That means, if there will be a suitable or suitable matching of arc characteristics and power source characteristics is there, then arc voltage should not extinguish the arc if there will be a small variation of arc length that type of matching should be there.

That means, suddenly it should not actually due to a small variation it should not extinguish suddenly. This is only possible once a suitable matching of arc and power source characteristics are there. So, that is the first point; that means, to be arc a stabled first thing is its arc characteristics and power source characteristics should match properly. Then next point is once arc this characteristics is proper, then what happens? Whatever the emission and ionization occurs in arc column region that should be also

continuous and proper. If emission is continuous and proper through the arc and ionization also continuous and proper in the arc region then what happens?

Our arc will be a stable enough. It also depends on arc length it has observed that lower the arc length better the better the chance of arc stability that means, better the arc stability. And higher the arc length there is a chance of means lesser arc stability; that means, there is a chance to deflect the arc and other thing. That is why we should keep the arc length as minimum as possible, then we can get better arc stability. It is also depends on electrode tip geometry especially once we go for using non-consumable electrode like GTAW process. Generally, it depends on electrode tip geometry also

It has observed that higher the included angle better the arc a stability. What does it means? Higher the included angle means generally in case of tungsten electrode included angle means this angle is called included angle actually, alpha. Let us so this let this is tungsten electrode let this is tungsten electrode. So, included angle is called this angle alpha is called included angle.

It has observed that higher the included angle greater the arc stability. That means, if the included angle is more chances of getting more stable arc. That is generally especially this types of included angle we observe in case of non-consumable electrode like plasma arc welding techniques, GTAW techniques, this types of things we observe.

Now, arc stability also depends on generally presence of dampness, oil, grease etcetera on the surface of the workpiece generally increase the arc instability. So, we should clean the workpiece; that means, this presence of damp; that means, dampness, oil, grease everything we should clean before doing the welding operation, before a starting the welding arc. Generally, the we should cleaning then only we can get a good a stable arc.

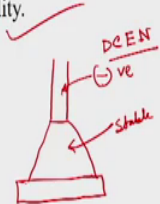
Apart from this thing it is also depends on the welder; that means, it also depends on welder why because if the welder is experienced enough then he can control this arc stability. So, what happens? Here another things we should keep it in mind limited practice of the welder also there can be arc instable. So, its that means, arc instability also depends on limited practice of the welder. So, apart from this thing arc stability highly depends on polarity that you we should know. Generally, why because, what happens, these are whatever the point I have told you that is different point apart from this thing its highly depends on polarity.

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Arc stability cont.

□ Polarity have significant effect on arc stability:

- ❖ The welding processes in which electrode is expected to emit free electrons (i.e. SMAW, GTAW, PAW) required for easy arc initiation and their stability, selection of polarity affects the arc stability.
- ✓ In consumable electrode welding i.e. in SMAW using covered electrode having low ionization potential elements provide better stable arc with DCEN than DCEP.
- However, SMA welding with DCEP gives smoother metal transfer.
- ✓ Similarly, in case of non-consumable electrode welding i.e. in GTAW welding, tungsten electrode is expected to emit electrons for providing stable arc and therefore DCEN is commonly used except in case of reactive metals e.g. Al, Mg, Ti.



Especially, the welding processes in which the electrode is expected to emit free electron like a SMAW process, GTAW process, plasma arc welding process were generally this welding processes generally here electrode is expect to emit free electron, required for easy arc initiation and arc a stability. For the requirement of; that means, for the requirement of easy arc initiation and arc a stability here selection of polarity is highly essential; that means, proper selection of polarity is required; that means, selection of polarity affect the arc stability a lot, especially in this welding process were generally electrode is expected to emit free electrons.

Here generally first of all we should now generally what types of polarity generally gives better arc stability. It has observed that both consumable as well as non-consumable types of electrode generally DCEN; that means, DCEN; that means, electrode negative polarity gives better arc stability. Generally, both this consumable electrode as well as non-consumable electrode generally we get better arc stability if we use electrode as negative. But always this negative is not good though it is good for arc stability, but sometimes DCEP also required to put there. That means, electrode positive terminal also sometimes required to put because what happens, the electrode positive have some good effect which though which though not helps the arc stability, but it has some other good effect also that also we should know. That I will tell in details here.

Electrode polarity here what I have told that to get a stable arc what are the things required this electrode should always keep negative; that means, DC direct current electrode negative polarity give more stable arc, a stable arc both in case of consumable electrode and non-consumable electrode. Like in case of consumable electrode generally like in SMAW; that means, shielded manual metal arc welding using cover electrode this cover element should have low ionization potential, and if it is connected with DCEN then generally it give it provide better stable arc, better stable arc that DCEP.

But here one things you keep in mind as in case of consume consumable electrode, electrode is carrying current as well as its transfer the molten material; that means, drop of material from electrode to work piece that is why here generally we keep it in as its the droplet is suffering from electrode to work piece. That is why for better metal transfer generally DCEP is preferable though we are getting why that I will discuss in detail in subsequent slide.

Here one things keep it in mind that better a stable arc we get in case of DCEN, but with DCEP if we generally give the smother metal transfer in case of consumable electrode. Whereas, in case of non-consumable electrode non-consumable electrode welding like GTAW welding here tungsten electrode is expected to emit electron for providing a stable arc therefore, here DCEN is commonly used. Always keep it in mind, for of non-consumable types of electrode like tungsten also there we use DCEN which generally give a stable arc. But generally for some material like reactive material like aluminium, magnesium, titanium for this type of material once we go for doing welding, there we should use DCEP because DCEP provide some good action on this types of material.

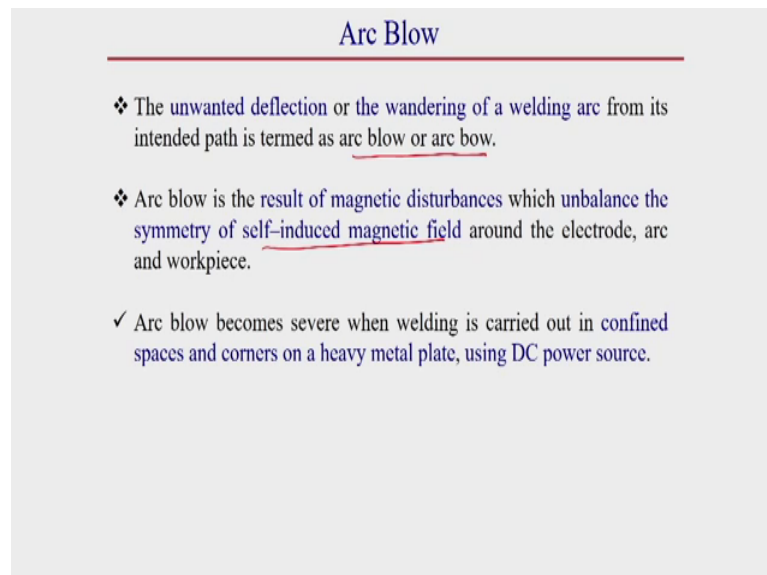
So, some exception is there. So, what we get from here? That means, once we go for consumable electrode as well as non-consumable electrode, generally direct current electrode once it connected with negative terminal; that means, DCEN polarity gives a stable arc both the for both the case, but sometime DCEP is required. Like in case of consumable electrode for a smoother metal transfer DCEP is good, similarly once we go for non-consumable electrode like GTAW gas tungsten arc welding process there generally for reactive metal especially aluminium, magnesium, titanium.

Once you go for doing this types of material welding then what happened there we they are generally DCEP is sometimes DCEP is require because it has some good action on

this types of material, some lower quality we can get by using DCEP. But a stable arc will be generated by the DCEN. Always keep this thing in mind. Now, so we got the idea about arc stability. Now, we should know what is arc blow? It is the opposite thing; that means, whatever the stability we got if the arc blow is opposite thing. Opposite thing means here generally disturbance of arc is there that also we should know. What happens if the if there is a disturbance of arc is there, then what happens that we should know.

What are the different categories of disturbance of arc, what are the different categories of arc blow; that means, blow of arc is there that we should know.

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Arc Blow

- ❖ The unwanted deflection or the wandering of a welding arc from its intended path is termed as arc blow or arc bow.
- ❖ Arc blow is the result of magnetic disturbances which unbalance the symmetry of self-induced magnetic field around the electrode, arc and workpiece.
- ✓ Arc blow becomes severe when welding is carried out in confined spaces and corners on a heavy metal plate, using DC power source.

So, first of all the definition of arc blow we can tell the unwanted deflection or the wandering of welding arc from its intended path, from its intended path is termed as arc blow or it is sometimes called as arc bow because here arc generally deflects its intended path. So, its shape, its shape can we like curve which is generally resemble with bow that is why sometimes it is called arc bow also. Arc bow generally develop due to the flow of current through the arc, this is the main reason of arc blow always keep this thing mind when.

When this arc blow occur? Once there will this is. So, arc blow is the result of magnetic disturbance; that means, once the current is flowing there we have I already told you there generally develops cell induced magnetic field. So, what happens? Once this magnetic field is disturbed that means, this arc blow is the result of magnetic disturbance

which generally unbalance the symmetry of self-induced magnetic field. Because if there will be magnetic disturbances then what happens there will be that symmetry of the self induced magnetic field will not be there.

So, if there will there will be that means, a symmetry of magnetic field then there arc will not be able to retain its original shape or original path. Then this arc shifted to its intended path to another direction or it is generally change its shape. Due to this change of this change of its path generally what happens? This arc blow occurs in the work piece. So, arc blow is the result of magnetic disturbances which unbalance the symmetry of self-induced magnetic field. So, generally due to this asymmetry of magnetic field distribution arc blow is occur this asymmetry of magnetic field distribution is occur through the arc as well as electrode as well as work piece. Because what happens? Wherever there will be a flow of current there will create a magnetic field. So, what happens? If there will be magnetic disturbance then everywhere these magnetic self induced magnetic field also disturb. Due to this disturbance generally what happens? This magnetic arc blow is occurred.

Arc blow become severe once the welding is carrying in a confined and corner on a heavy metal plate especially once we use DC current. Why? In DC current this magnetic arc blow is severe that we should know. General what happens? In AC current that is why here in next slide I will show you why this is severe in case of DC current compared to AC current that also I will explain here.

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Arc Blow cont.

- ❖ AC arcs are less susceptible to arc blow than DC arcs.
- Because AC reverses direction which in turn, reverses the magnetic field build up, collapses and rebuilds as current reverses from +ve to -ve.
- This phenomenon does not permit the magnetic field strength to build up to a value so as to cause arc blow.
- ❖ On the other hand in DC welding, the magnetic field set up in workpiece (adjacent to the arc) continuously builds up and the arc blow occurs.


Generally, AC arc are less susceptible to arc blow than DC arc because AC reverses direction generally we know in every cycle of alternating current there is a zero crossing; that means, there is a positive flow as well as negative flow of current is there. Due to this reverse direction the reverse the magnetic field build up that means, here collapse and rebuild of magnetic field it occur as the current reverses from positive to negative direction. Due to this collapse of magnetic field and rebuilt of magnetic field here generally magnetic field cannot build up to such a high value. So, that it can create arc blow.

Because what happens due to this cyclic variation of current from positive to negative due to this alternating current here generally magnetic field cannot build up such a high value which can generally produce some arc blow. That is why in case of AC current arc blow is rarely formed. Whereas, on the other hand in DC welding the magnetic field set up in work piece continuously build up and the arc blow occurs. Here what happens? In DC current there is no such reversing is there. So, here generally continuously magnetic field build up taken place. Due to this continuously magnetic field build up what happens? Here there is a huge chance of arc blow is there.

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Factors affecting arc blow

- ✓ Magnetic fields produced in the workpiece adjacent to the welding arc, due to current flow through the arc.
- ✓ With multiple welding heads, arc at one electrode may be affected by the magnetic field of the arc at the other electrode.
- ✓ The magnetic field produced in the workpiece around the earth connection may tend to drive the arc away from the point from where this connection is made.
- This magnetic field is also produced because of current flow from the earth connection to the workpiece.



Now, we will go what are the different factors generally affecting this arc blow. Generally magnetic field produce in work piece, so what are the factors affecting the arc blow that also we should. The main factor which affect the arc blow is magnetic field distribution. Generally, this magnetic field produced in workpiece adjacent to the welding arc due to current flow through the arc what I have already told you.

So, the main factor is magnetic field distribution. So, wherever there will be a disturbance of magnetic field there will be chances of arc blow. So, that is why generally with multiple welding head where there are two different magnetic multiple weld head generally how its look, like instead of single arc generally sometimes we use continuously 2-3 arc.

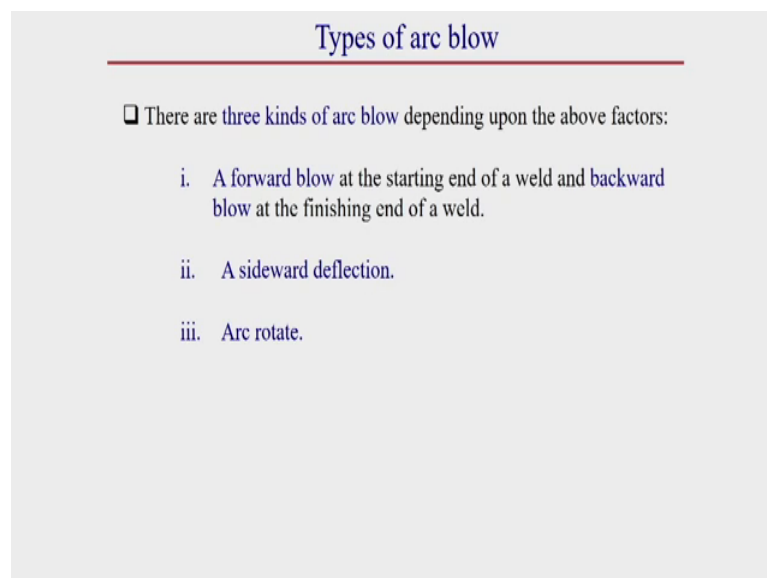
So, what happens? Along this first arc there will be a distribution of magnetic field similarly in second arc also there will be a distribution of magnetic field. So, what happens? Due to this multiple welding head arc at one; that means, arc at one head can affect the arc at other head means that means due to this distribution of magnetic field one magnetic field can disturb the other magnetic field. Due to this disturbance there can occur arc blow.

Apart from this thing the magnetic field producing the workpiece around the arc connection maintains to drive the arc away from the point where this connection is made. So, due to this earth clamp also there is a chances of arc blow also, this because what

happens? Here generally current is flowing from arc; that means, earth clamp to work piece. So, wherever there is a flow of current, so there will generate some magnetic field. This magnetic field can create arc blow once this arc is passing near the earth clamp region ok.

So, these are the generally main factor which govern the arc blow. That means, the main factor of arc blow is magnetic field disturbance. So, this magnetic field disturbance can occur in different different way that what I have told you. It can occur due to multiple welding head, it can occur due to multiple welding head as a as well as it can occur due to this arc connection. So, what happens? These are the factors generally which effect the arc blow.

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The slide is titled "Types of arc blow" in a blue serif font, underlined with a red line. Below the title, there is a bullet point with a square icon stating "There are three kinds of arc blow depending upon the above factors:". This is followed by a numbered list with Roman numerals i, ii, and iii, all in blue text. Item i describes forward and backward blows at the start and end of a weld. Item ii describes sideward deflection. Item iii describes arc rotation.

Types of arc blow

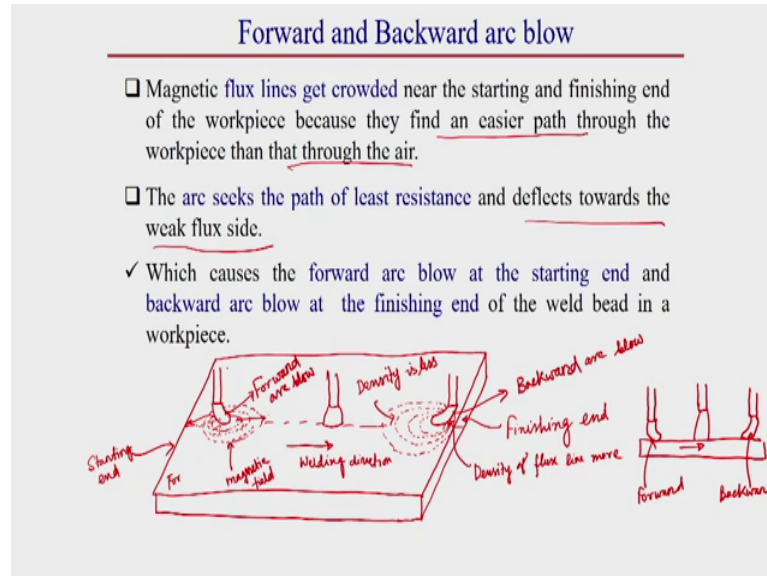
- There are three kinds of arc blow depending upon the above factors:
 - i. A forward blow at the starting end of a weld and backward blow at the finishing end of a weld.
 - ii. A sideward deflection.
 - iii. Arc rotate.

Now, we will go what are the different categories of arc blow? Depending upon the above factors this arc blow generally categorize into three different categories. So, what is the three different categories? A forward arc blow at the starting end of a weld, and a backward arc blow at the finishing end of the weld. So, this is generally; that means, forward and backward arc blow a sideward deflection is another arc blow and arc rotate is another arc.

So, these three different categories of arc blow can be there. So, forward and backward arc blow can be there, a sideward deflection or sideward arc blow can be there or arc

rotation rotate also is another kind of arc blow. Now, I will discuss in details about this forward, backward, sideward and arc rotation types of arc blow in details.

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So, first of all forward arc blow. Generally forward arc blow taken place at the starting end of the weld and backward arc blow taken place at the finishing end of the weld. Why? Because generally magnetic flux line get crowded near the starting and finishing end of the work piece, because they find an easier path generally they find an easier path through the workpiece than through the air always keep it in mind. Generally magnetic flux line pass through the work piece rather than passing through the air.

So, its crowded, instead of passing through the air it passes through the work piece because it get easier resistance in work piece rather than air generally magnetic field that we know actually. That is why the arc seek the path of least resistance and deflect toward the weak flux side. Because what happens? Due to this types of magnetic flux distribution generally concentration of magnetic flux is more at the starting end as well as at the finishing end of a weld line, because there is concentration of magnetic line will be more.

So, due to this more concentration here the resistance will be more near the starting end as well as near the finishing end. So, what happens? Due to this more resistance generally arc deflects away from that side; that means, arc deflect away from a starting

end side as well as arc deflects away from finishing end side towards less concentration flux distribution region; that I will show you in details by drawing the thing.

That means, which causes the flow forward arc blow at the starting end and backward arc blow at the finishing end of the weld bead in the work piece. How it is that I will show now. Like here what happens? In case of welding let this is a well plate, near the starting end let this is the arc, this is the electrode, similarly this is the starting end, starting end, let this is the finishing end. So, what happens? At a starting end as well as in finishing end generally arc deflect like this.

Why this deflection is taken place? Because. So, what happens? Here generally this concentration of this here you see one things you can observe the concentration this is the magnetic field concentration, this is the welding direction actually welding is welding direction. So, here we see at the starting end; that means, near this position actually this arc should we near to here, ok. Generally, here the concentration of this magnetic field line is more because this magnetic flux lines pass through the instead of passing through the air, its try to pass through the work piece. It generally passes through the workpiece because that is why generally here crowd crowding of magnetic field line is more than this other side. So, what happens that is why here this side generally we get less resistance than this side.

So, due to this less resistance generally arc seeks the path of least resistance direction that is why in the starting end general arc deflect this arc deflect in this direction. So, whereas at the finishing end here also similar thing occurs; that means, this flux lying density generally flux lying density here also occur like this that means, concentration of this flux. So, somethings we can observe in this side also here we see; that means, flux line density is more, that flux line density is more compared to this side. This is density flux line density here density of flux line is more magnetic flux line is more and here generally density is less density is less.

So, what happens? Due to this generally arc deflect toward the less region means where the density of the once the density of the flux line is less. So, in that direction that resistance also will be less. If the density of the flux line is more there the resistance will be more due to this generally the arc seek the path of less resistance and deflects towards the weak flux or we can say less flux density side its deflect. Due to that what happens?

In case of arc welding technique at the starting end and at the finishing end we get. So, this is called forward arc blow at the starting end whatever the arc blow occurs this is called forward arc blow and this is called generally backward arc blow.

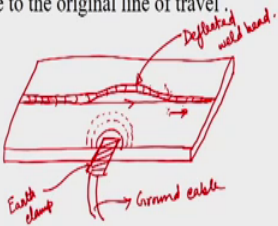
So, why it is occurred that we understand this occurs due to the crowding of magnetic flux line near the starting end and finishing end of the weld line, this, this, this two different types of arc blow occur. So, if we see the side view of these things what we observe? Generally, in middle region of this weld generally in the middle region in this middle region we will get a stable a steady arc generally. Here this middle region that means apart from a start and end region in between we get a stable arc or you can say that non-deflected arc.

So, generally if we see the side view of these things, at the starting end generally we get an arc which looks like this, at the finishing end we get an arc which looks like this, at the middle region generally we get an arc which looks like this. So, what happens? Here a starting end arc is deflected, finishing end arc is also deflected, but in between generally arc is not deflected. So, this is forward arc blow and this is generally called backward arc blow, this is the direction of welding, ok. So, we get an idea about forward and backward arc blow. Now, we will see what is sideward arc blow.

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Sideward arc blow

- ❖ It depends on workpiece earth clamp.
- ❖ As the arc comes near the arc clamp, it deflects sidewardly in a direction away from the clamp, perhaps because of the magnetic flux enacted in the workpiece by the earth clamp (i.e., ground).
- ✓ This magnetic flux is produced by the flow of the current from clamp to workpiece.
- ✓ It is also noted that as the arc crosses the earth connection, it has a tendency to come to the original line of travel.



Generally, sideward arc blow depends on work piece earth clamp; that means, we know that generally in case of welding there is an earth clamp connection. One connection

coming from earth to earth clamp connection is there to with work piece and another terminal is connected to what is called electrode that we know. So, what happens? This sideward arc blow generally occurs due to workpiece earth clamp. What happens, as the arc come near the earth clamp it defects sidewardly in a direction and from the clamp perhaps because of the magnetic flux enacted in the workplace by the earth clamp.

This magnetic flux generally is produced by the flow of current from clamped work piece, whatever the magnetic field here its producing that is produced because there is a flow of current from earth clamp to work piece. So, wherever there will be a flow of current there will be magnetic field distribution. Due to this magnetic field distribution generally what happens? When the arc come near to the near to this earth clamp position generally it deflects sidewardly in a direction away from this earth clamp.

It is also noted that as the arc process the earth connection it has a tendency to come to the original line of travel; that means, arc has a tendency to come to the original line of travel. This is how its look like that I am showing here little bit then it will be more clear to you. Let this is a weld plate, this is a let us this is a workpiece. Now, in this work piece welding is required to do let us what happens, here the earth connection is there. Let us here we put the earth clamp, these earth clamp connected with this cable.

Generally, this is this is generally called ground cable this is called earth clamp. So, generally what happens? Due to the flow of current from earth clamp to work piece here generally develop some magnetic field, here generally develop some magnetic field, here generally develop because there is a continuous flow of current from earth clamp to work piece is there. So, what happens? Due to this once this welding come near to this region it deflect like this. So, how the welding is look like? Here at the weld bead is look like here that this is the weld bead.

So, what happens on the welding? Welding arc coming to so, this is generally deflected weld bead actually. So, what we observe here? Due to this earth clamp generally here arc shifted to its intended path; that means, it is not going to through the through the a state line, instead of going through a state it deviate. That means, arc is deflected away from this earth clamp direction sidewardly, ok. Due to this generally here generally arc weld bead we get which is deflected sidewardly. But once it cross this earth clamp position then generally its return back to its original line. That what happens if it is just cross this

position its generally again its return back to its original weld line. So, these types of arc blow is called sideward arc blow, because here generally arc is deflected sidewardly due to the position of earth clamp.

Now, we will see: what is the different effect of arc blow, and what are the remedies of arc blow that also we should know. And the apart from this thing we should know what is arc rotation. Here generally in the last two cases what we have observed? Generally, arc deflected either forward direction, backward direction or side ward direction. Here instead of, here not only arc is deflected here arc is rotated also; that means, here rotation as well as a arc reflection taken place. Due to this generally what happens here, which shape is look like wavy in nature. That means is some sort of rotation as well as deflected, deflection types shape of weld bead generally here it is observed.

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Arc rotation

- ❑ Here the arc deflection as well as rotation occur.
- ❑ Arc rotation indicates that under certain conditions of arc blow, perhaps arc experiences magnetic field lines parallel to the arc axis.




Fig. Arc rotation and deflection

This arc rotation indicates that under certain condition of arc blow perhaps arc experience magnetic field line parallel to the arc axis. Generally, what happens? Here what we have observed generally magnetic flux line generally generated and transverse direction; that means, what we have observed, generally magnetic fields line generated in periphery direction; that means, what we have observed generally magnetic fields like generated in transverse direction; that means, in transverse direction.

Instead of magnetic flux line generated transverse direction, here generally these types of things can happen; that means, perhaps our experience magnetic field line here parallel

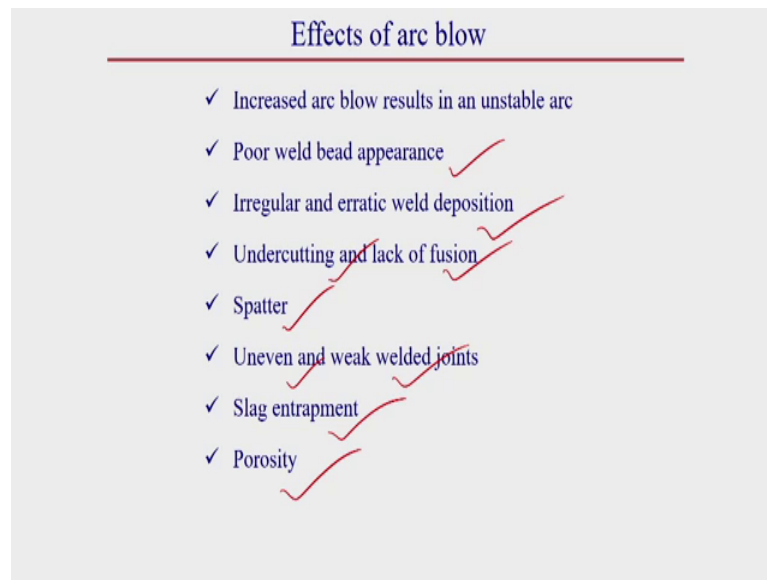
to the arc axis. Along arc axis here it is also magnetic field line, here can be generated parallel to that arc axis also. Due to this generally what happens here this types of arc rotation as well as arc deflection is occur. This is generally another third categories of arc blow. The reason of this thing I will discuss in details once I will discuss the metal transfer actually; that means, drop transfer in case of welding process in detail. Generally, the reason of this arc rotation and arc reflection is due to very high current. And what happens?

Due to this high current generally, this high heat is generated due to this high heat generally this electrode cannot return to its original a state a state shape. So, here generally electrode itself deflect and due to this high heat this electrode tip generally become plasticize and soft enough and what happens electrode tip become deflected shape. Due to this deflection of electrode generally, what happens here? Due to this deflection of electrode here generally there create asymmetry of magnetic field distribution.

Due to this wavy nature of this electrode tip as well as asymmetric distribution; that means, asymmetric distribution of magnetic flux here generally create two different types of forces. These two different types of forces, what is this two different types of forces here its created? Here generally one forces is radial forces and another forces is along its transfers direction that is called azimuthal, generally this is called azimuthal forces which is developed generally in case of arc rotation.

Due to this two different forces; that means, radial force and due to this two different forces; that means, asymmetric radial forces and azimuthal forces due to this two differences; that means, asymmetric radial force as well as azimuthal forces generally what happens here this types of arc rotation as well as deflection is taken place. This I will discuss in details also we will discuss the metal transfer. There generally this types of phenomena I will discuss in detail.

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Now, what are the different effect of arc blow? Arc blow has significant effect on weld qualities. Due to the arc blow generally they are create different types of, different types of weld defect in a welded sample. Generally, what happens? This arc blow have a very tremendous effect on quality of welding, because where there will be arc blow there will be general unstable arc blow this is the main things is there. So, once there will be unstable arc there will get poor weld bead appearance, there will get irregular and erratic weld deposition.

Because, if the weld welding arc is itself unstable then generally all the these are all different defects which arise due to this effect of arc blow. Then there can be undercut lack of fusion due to this arc blow, because here welding arc is unstable in nature, there can be spatter due to this arc blow, there can be uneven and weak welded joint there can be slag entrapment and there can be porosity. So, so these are all defects which can arise if there will be arc blow. Now, how to eliminate this arc blow or how to minimize this arc blow?

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Remedies for arc blow

□ It can be minimized by keeping the following factors in view:

- ✓ Changing the position of the earth clamp and welding away from the earth connection.
- ✓ Storing workpiece away from the magnetic sources, such as welding power sources.
- ✓ Employing ground connection more than one.
- ✓ Using a short arc.
- ✓ Lowering arc current.
- ✓ Using smaller diameter electrodes.
- ✓ Decreasing arc travel speed.
- ✓ Superimposing a counteracting externally applied longitudinal magnetic field.

So, we should know what are the remedies for arc blow. It can be minimized by keeping the following factors in view. Generally, whatever the factors I have showing here, if you just follow this step then we can minimize or eliminate the arc blow. Like, generally what I have told you? One of the cause of this arc blow we know; that means, at a starting position and finishing position there is what it is called air gap. So, that is why this flux generally cannot instead of passing through air its generally concentrate towards the means work piece work piece region.

Due to this generally concentration of arc flux is there over this region. So, if you can provide a run on and runoff plate generally then what happens, this arc can pass that this magnetic flux can pass through this what happens then there we can get more or less uniform types of magnetic flux distribution. So, that we can at least minimize or we can some extent eliminate the forward and backward arc blow. So, by providing some run on and run of plate. That means, by which generally that magnetic flux distribution can be uniform. We can make the magnetic flux distribution more or less more uniform.

Another region of this arc blow is due to this earth clamp. So, changing the position of earth clamp and welding away from the arc connection. So, if we do this welding operation far away from this earth clamp position then what happens? There is less chance of sideward arc deflection also. So, we should put our earth clamp far away from this weld line. So, by this also and apart from this thing instead of one single earth clamp

if you provide opposite side another earth clamp there due to this what happens, due to this balance that means, effect of two different earth clamp there is a chance of less deflection of the arc. So, this is first point is changing the position of the earth clamp and welding away from the earth connection can eliminate or minimize the arc blow.

Then what are the another reason? It is storing work piece away from the magnetic source; that means, another source of arc deflection is source of magnetic field. So, what happens? If we do the welding near a magnetic source region then what happens, there is a chance of more arc deflection. So, what happens? Once we do the welding operation away from this magnetic source like one of the magnetic source in case of welding operation is magnetic power source itself. So, we should keep the power source far away from the welding region, then generally there is a less chance of what is called arc blow.

Then employing ground connection more than one, what I have told you; that means, ground connection means earth clamp more than one. Using short arc, generally I already told you generally short arc give a stable arc. So, once there will be stable arc in case of short arc the chances of deflection also less. Then lowering the arc current also, if the arc current will be less then definitely the magnetic field intensity and other things will be less. So, there is a less chance of arc deflection also will be there.

Now, thus another point is using a smaller diameter electrode if the diameter of the electrode will be a smaller than what happens there will be generally less chance of arc below. Then decrease the travel speed; that means, whatever the welding speed by which that welding is carrying out that travel speed by decreasing that thing also we can minimize the arc blow. And the last point we can say a superimposing a counteracting externally applied longitudinal magnetic field, by superimposing this thing also we can minimize the arc blow. So, these are the different factors generally if we just keep this thing in mind then we can minimize the arc blow a lot.

So, now so we have seen about arc blow as well as arc stability in details. Now, we will go metal transfer. Here what was so what we should know, before going to metal transfer first of all here what we should know? We should know what are the forces generally affecting metal transfer that we should. So, before going to details about metal transfer here one things we should know before going to first of all we should know what are the

different forces affecting the metal transfer then only we can be able to understand the metal transfer in details.

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The slide is titled "Forces affecting metal transfer" in a blue font, underlined. It contains two main bullet points, each preceded by a square icon. The first bullet point states "There are mainly two types forces affecting the drop transfer:" and lists "Aid metal transfer forces" and "Retard metal transfer forces". The second bullet point states "In general various forces involved in the phenomenon are given below:" and lists "Surface tension", "Viscosity of the liquid metal", "High velocity gas jets", "Gravity", and "Lorentz forces". Each item in the list has a red checkmark next to it.

Forces affecting metal transfer

- There are mainly two types forces affecting the drop transfer:
 - Aid metal transfer forces ✓
 - Retard metal transfer forces ✓
- In general various forces involved in the phenomenon are given below:
 - Surface tension ✓
 - Viscosity of the liquid metal ✓
 - High velocity gas jets ✓
 - Gravity ✓
 - Lorentz forces. ✓

In case of metal transfer, there are two different types of forces affecting that metal transfer or drop transfer from electrode to work piece. This is the what I am discussing here this is for consumable types of electrode that that consumable; that means, this electrode generally melt drop form and what happens there is drop transfer from electrode to work piece. This types of thing is, so consumable types of electrode cases generally I am telling because metal transfer is taken place in case of consumable electrode [FL].

So, generally there are mainly two types of forces affecting the drop transfer one is called aid metal transfer forces and other one is called retard metal transfer forces. What is aid metal transfer forces and retard metal transfer forces? Aid metal transfer forces are those forces which has to detach the droplet from electrode and which help to transfer the drop from electrode to work piece. Then generally the forces which help for detachment of that droplet from electrode as well as transfer from electrode to work piece that force is called aid forces.

That means, which help for metal detachment as well as transformation. Another forces is called retard force retard force means oppose this thing; that means, which oppose this effect; that means, which oppose this metal detachment as well as metal transfer this

forces is called retard metal transfer forces. In general, in case of a metal transfer phenomena there we got different different types of force. What are the different different forces? Like, there can be surface tension forces. In general, there can be viscosity forces there can be high velocity gas jet forces there can be gravity force there can be another force is Lorentz forces.

So, this 5-6 different types of force we observe in case of drop transfer. Generally, some of these forces is aid metal transfer force which helps the metal detachment and transfer and some of this force which generally oppose that phenomena; that means, which oppose that detachment as well as transfer of metal. So, which force is opposing and which force is detaching? That I will discussing details about these different forces in the next lecture.

So, I will discuss about all this forces apart from this thing, I will discuss about metal transfer actually which workers in case of consumable types of electrode so that I will discuss in next lecture.