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# Theory and Practice of Non Destructive Testing

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## Magnetic Particle Testing - 1

Hello my name is Ranjith Bauri we are in the second week of this NPTEL course on non-destructive testing I hope you have gone through the lectures of the first day before we proceed today let me remind you if you have any question or any doubt for any of the topics that we have been discussing please feel free to clarify your doubts using either the discussion forum that you have or you can also write back to us but please make sure that you clarify your doubt okay so today as part of this course we are going to start a new topic which will be on magnetic particle inspection or magnetic particle testing.

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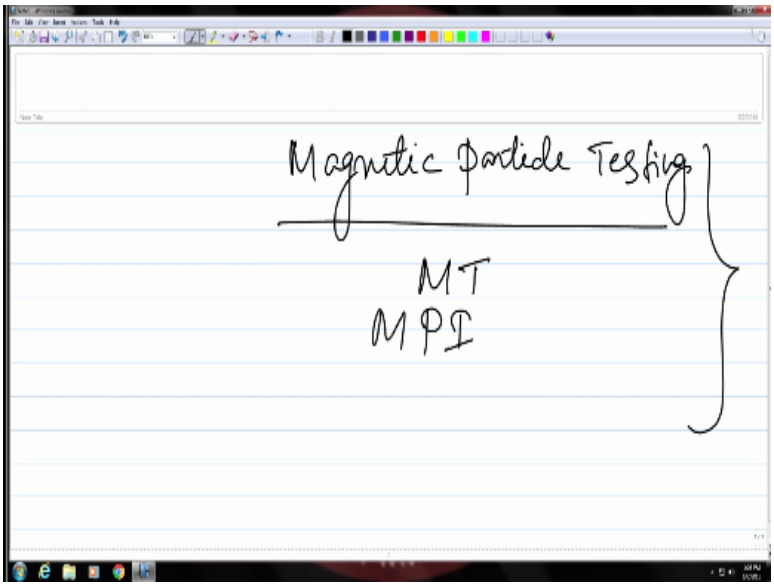


So this will be our second topic in the series so today we are going to start this new topic which will be on magnetic particle testing so this is the second topic in the series magnetic particle testing or magnetic particle inspection in short sometimes we will call this as empty and for magnetic particle inspection sometime in short it is also written as MPI okay so like I said first we are going to see what is the basic principle behind this and then we will go and see the method and the process details.

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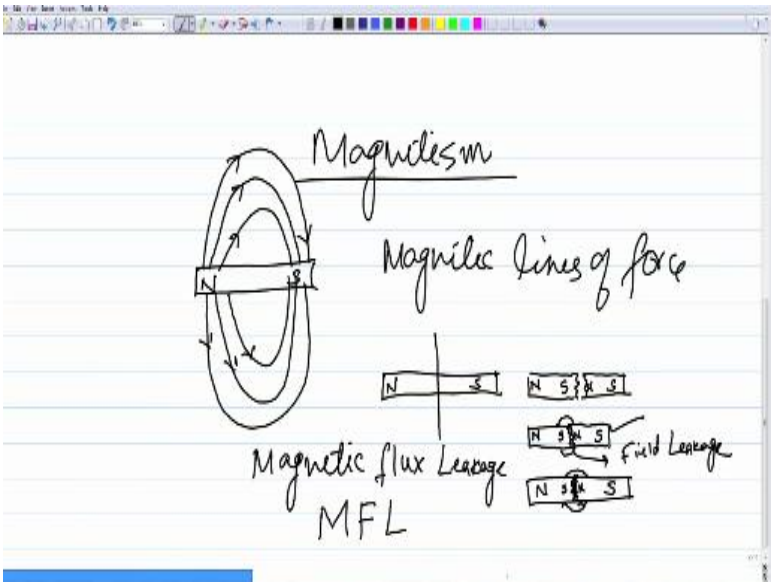


So as the name suggests this is based upon magnetism so we take the help of magnetism in this case to inspect defect and flaws so let us now see how these magnetism helps in these case to make visible integrations of surface defects and surface flaws so this is also a surface NDT method and now we are going to see how this works and what is the basic principle okay so as you all know if you have a magnet like this okay so it will have its poles north and south poles and the magnetic field will be defined by some imaginary lines like this which starts at North Pole and then enters the South Pole on both sides like this.

So these lines which define the extent of the magnetic field of a magnet these are known as magnetic lines of force okay like this so anything within this field if you keep a ferromagnetic material that will be attracted to the magnet so this is the magnetic field of a magnet okay now let us say if you have a magnet like that and if you fracture this into two pieces so let us say these are the fractured pieces then these two pieces will also create two magnets like this okay and even if you bring these two piece together like this so let us say you have fractured it but you again bring it together then also this magnet which is created due to this fracture is going to remain okay .

Similarly if you have a crack on a magnetized surface so let us say the surface is magnetized and you have a crack somewhere so like in this case along this fracture the magnet which is created is going to remain and it will have its own field also so in a similar manner in this case also if you have a discontinuity or crack this will also create a tiny magnet around it like this what you saw in this case okay like this so there will be a field leakage due to the presence of a discontinuity on a magnetized surface so this discontinuity could be due to a fracture like this or it could be due to presence of any flaws like cracks okay.

So if you have presence of a discontinuity on a magnetized surface this will create it is own magnetic field it will create a tiny magnet and if you now apply any magnetic particles on this surface the particles will be attracted to this crack and that is how it will make visible indications of this class okay so the main principle behind this is the magnetic flux leakage due to the presence of a discontinuity on a magnetized surface that is why sometimes this particular method is also known as MFL technique which stands for magnetic flux leakage because this whole thing is based upon this magnetic flux leakage at a discontinuity. So now we will see due to this flux leakage or creation of a small tiny magnet around the discontinuity.

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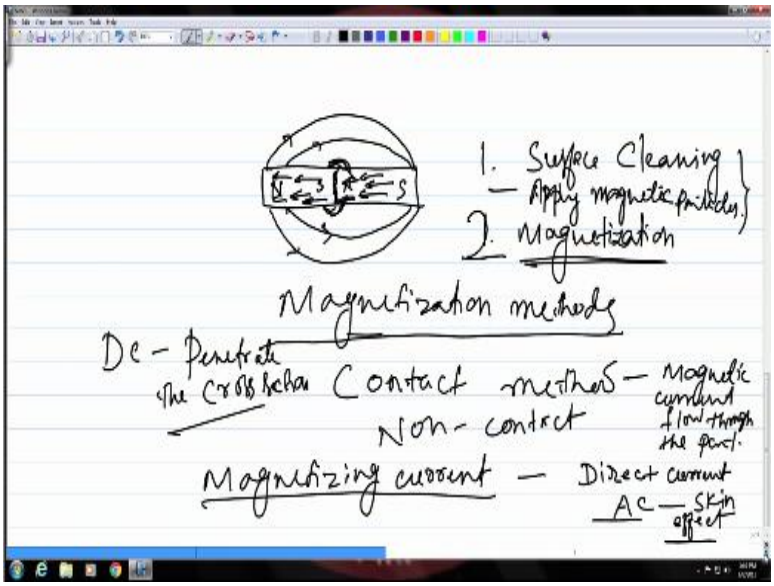

What is going to happen and how this will help us in detecting the defect so this discontinuity will also have a small magnet as I said and this will also have its own magnetic lines of force in this fashion so if the magnetic domains in the parent material are like this so around this discontinuity they will be perturbed by the magnetic field of this tiny magnet which is created due to the presence of the discontinuity so this is the phenomena of magnetic flux leakage as I say so now if you apply some magnetic particles like iron they will be attracted to this discontinuity because now it is magnetized and that is how they will accumulate along this crack and make visible indications.

So this is as simple as that due to the flux leakage at the defect a small tiny magnet is created which will attract the magnetic particles and make visible indications so when you have a part the part as such is not magnetized so the first thing that you need to do in this case is to magnetize the power but even before you magnetize it in this case also you need to clean the surface like what he saw in the last topic of dye penetrant testing surface cleaning was needed here also it is needed but in this case the purpose is different in this case what you do you apply magnetic particles on the magnetized surface.

So these magnetic particles should have enough mobility on the surface this would be able to freely move on the surface and for that the surface should be clean okay so the purpose of surface cleaning in this case is to provide free mobility to the particles which are applied on the surface okay so once you are clean the surface then in the second step you magnetize the part okay so let us see what are the different methods which can be used to magnetize the part primarily you can classify this like a contact method and a non-contact.

So what you do to magnetize the part is to use a magnetizing current and let this current create the magnetic field to magnetize the part okay so incase of contact method the magnetic current directly flows through the part and in case of non contact method you can use induction so you can use a coil or you can use a solenoid kind of thing through which you can induce the magnetic field into the part okay.

Now as far as this magnetic current is concerned this could be both direct current DC or it could be alternative current or AC both can be used for magnetizing apart but one thing you should remember the while selecting either direct current or alternative current is that in case of a see it will be the current will be primarily limited on the surface which is known as a skin effect okay.

Since it is primarily on the surface of the part so if you are looking to inspect subsurface that means little below the surface then an AC current is not recommended okay on the other hand if you have DC then it can penetrate the entire cross section of the part so that is the difference between AC current and DC current but both can be used depending on the requirement to magnetize the part and these are the two main categories contact method and non-contact method so let us now see how exactly it is done.

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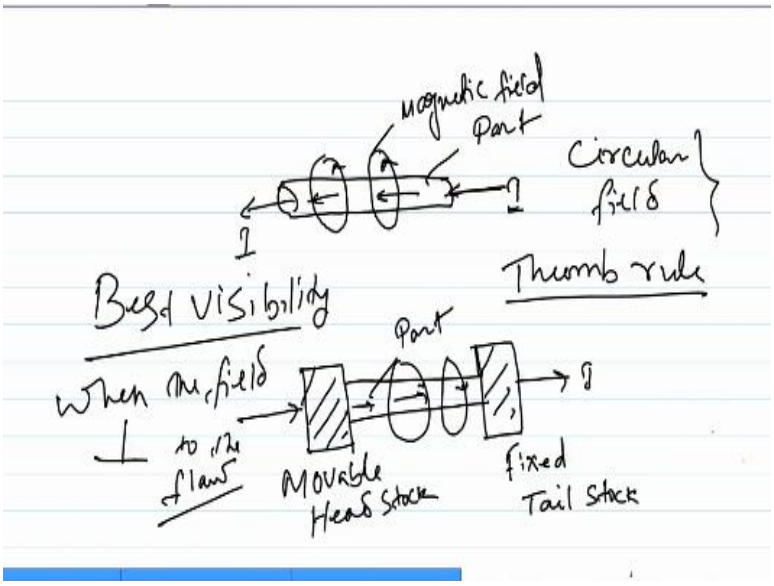


So let us say you are using a contact method so in that case as I said the current will the magnetizing current will directly pass through the part so that means you need to connect the part in between two electrodes and then switch on the magnetic current and it will magnetize the part okay so let us say you have apart like this and you are this is the current that you are passing

through it okay so in this case if you pass the current in this particular direction then the magnetic field will be like this okay.

And the direction of the magnetic field depends on the direction of the current and this you can find out from the thumb rule okay that means if your thumb is pointing towards the direction of the current the fingers will be the direction of the magnetic field this is what you see if this be the direction of the current flowing through the part and so this will be the direction of the magnetic field so when you flow a current like this on a part it produces a circular kind of magnetic field the direction of which as I said will depend on the direction of the current and using this circular field you can magnetize the part by directly flowing the current through it okay.

So this is how you use a contact method you connect this part between two electrodes and you pass the current it will create a circular magnetic field which will magnetize the part so there are different ways by which you can connect this part to the electrodes to flow the current one of them is to use two draws like this at either end of the path so let us if this be the part okay.

So this is the part of the sample to be examined and you connect it between two electrodes at either end one of them could be movable so that you can move it and push it against the part and make tight contact and another on the other side will be fixed, okay. So you can move this movable part and tighten the part against the electrodes so that there is no loose contact.

Because when you are flowing electric current loose contact is not desirable so the movable part is also sometimes called as headstock and the other electrode which is fixed is known as tail stock okay so then you flow the current from this to this, now just now we have seen that if you flow the current like this then it will create a magnetic field around this like this okay now since the field which is created has a particular direction.

So the orientation of the cracks and the defects with respect to the direction of the field will affect the visibility of a particular defect okay because of this directionality that you have in this case so you will have best visibility when the field direction is perpendicular to the flow okay so

this is the scenario where you will have the best visibility this does not mean that other defects other cracks which are not oriented perpendicular to the flow will not be visible.

They will still be visible but the maximum indication the maximum field that will have along a discontinuity will be perpendicular to the direction of the applied field okay.

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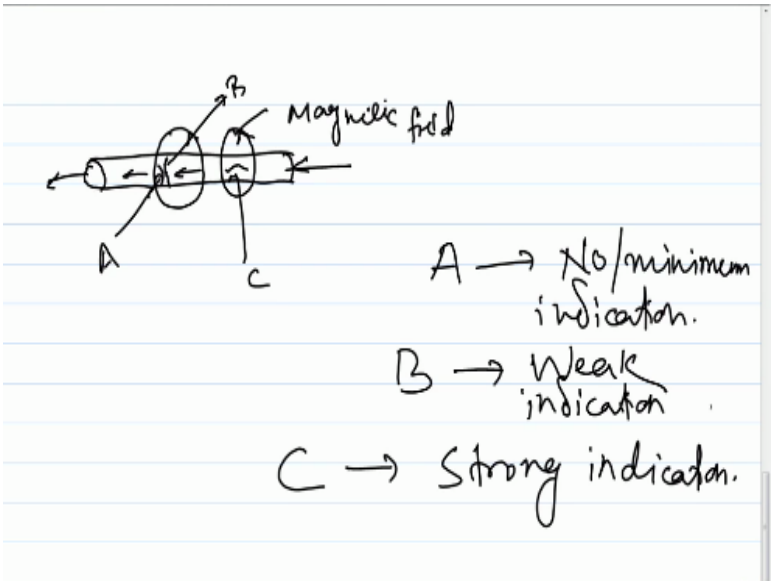


For example if you have the current and the magnetic field like this and let us say you have a very regular discontinuity like this okay which is parallel to the direction of the magnetic fields so this is your magnetic field as I showed in the previous diagram also and you have another it is not very regular the crack is licking you know uneven so let us first one let us call that as so this first one let us call that as A this one as B.

And let us say you have another crack over here okay which is perpendicular to the direction of the field okay so since a is A regular crack and it is parallel to the direction of the field you will have no or very minimum indication okay, B is parallel but it is not a regular shaped crack it is kind of little uneven so because of that although it is parallel to the field it will give some weak indication so it will there are chances that it will still be detected.

On the other hand flaws and cracks like C which are perpendicular to the field will give a strong indication so this is how the orientation of the crack with respect to the magnetic field will decide the level of integration for that particular defect.

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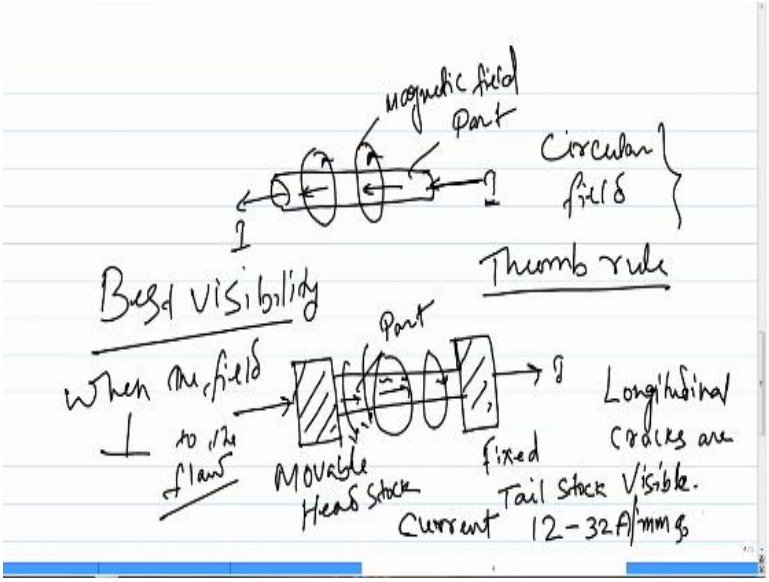


So in the first case of using this head stalk and tell stock so you could realize that in this case the best visibility because this is the direction of the field so in this case your cracks which are longitudinal or perpendicular to the field will have the best visibility okay and for this case the magnetic current levels that one has to use it depends on the size of the part in the range of 12 to 32 amps per millimeter of part diameter, okay.

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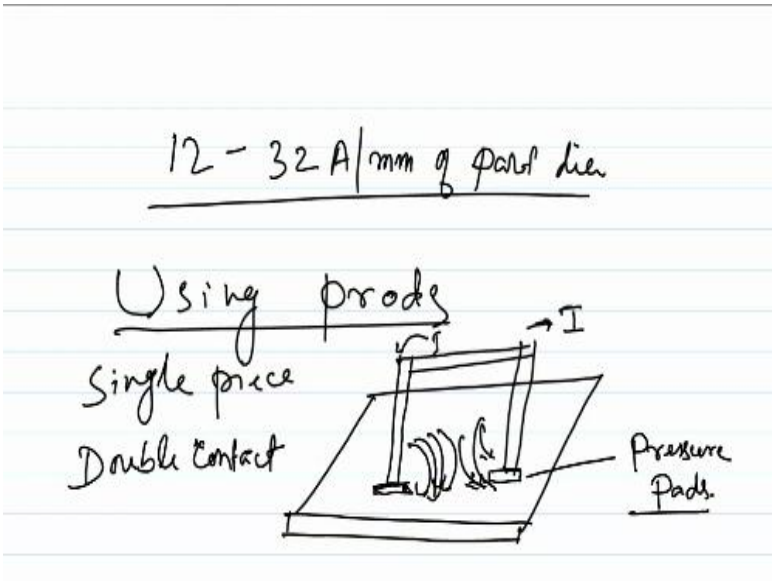


Come here, so if you are using two electrodes as headstock and tail stock then this is the level of current that you need okay then you can also use what is known as prods okay so these are primarily electrodes connected to a power source and when you make a contact of this electrode with the part being examined it will send the current through the part okay, so it could either be a single piece okay let us this is the part you have.

So it could be like this and you can send the current like this so if you want you can use two separate electrodes like this okay so if this is the current this will come and pass through the sample and Go out okay so this will create the circular type of magnetic field again around this electrode like this or in this case it is like this and anything within this field if defects and flaws are there they will be detected and the best feasibility will be for the flaws which are perpendicular to this fielder x okay.

And if you want in other case these two can also be connected so a prod can be a single piece or double so it is carrying the current and it is in contact with the part directly so you need to make sure that there is no loose contact so it should be pressurized against the part so therefore sometime this kind of pressure pads are also provided to make intimate contacts so that there is

no loose electrical contact and there are no electrical arcing do to lose contact okay. So that is one thing that you need to take care so that you do not end up with electrical arcing which is not desirable.

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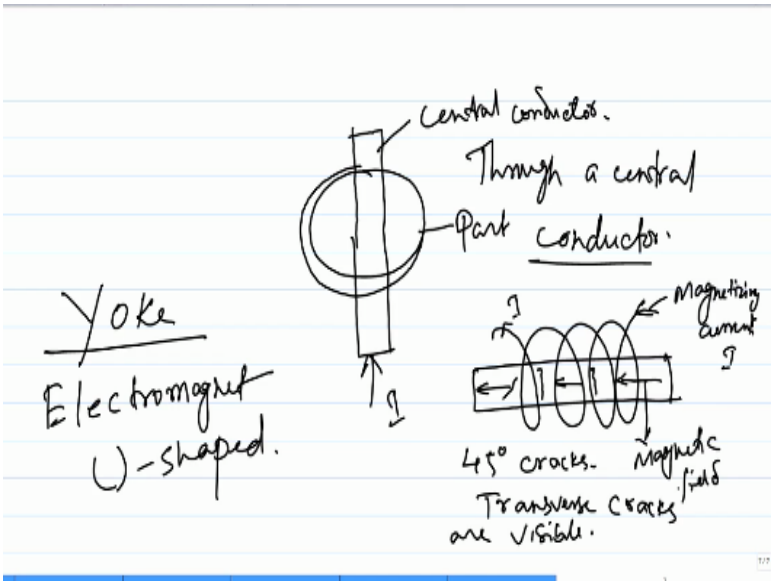


The other method is to use an induced field as I mentioned before so if you have a circular part like this you know and you need to magnetize this to inspect the circumference then what you can do you can have a central conductor carrying the current okay so you can pass the current through a central conductor, so this will carry the current and induce the field in this part get through this central conductor.

The other way of inducing current is using a shawl night so let us say you have a part like that and you use a solenoid like this so in this case what is going to happen let us say you pass the current in this direction in this case you can have instead of circular magnetic field in this particular case where you are using a coil or a or a solenoid then you will have longitudinal field like this okay.

So this is the magnetizing current in this case I which is flowing like this and in this case this will be the magnetic field which is not circular in this case it is longitudinal right so in this case the flaws and defects which are oriented like this will have the best visibility which are perpendicular to this axis of the part are perpendicular to this longitudinal direction so you will have the best visibility for those and if you have cracks at angles like let us say 45 degree angles like this.

Then also this kind of cracks would be visible, okay. So 45 degree cracks and transverse cracks which are perpendicular to this axis have good visibility in this case because the magnetic field is longitudinal so depending on how you flow the current the magnetic field direction and the type of the field would vary and as I mentioned before your best visibility for the floss would be when they are perpendicular to the direction of the field and flaws which are tangle I am not really parallel to the direction of the field will also have good visibility.

Then you have one more method which is very useful in magnetizing small parts and that is apart or an electromagnet which is known as an Yoke, so this is basically an u-shaped electromagnet which can be used to magnetize the part in this fashion, okay.

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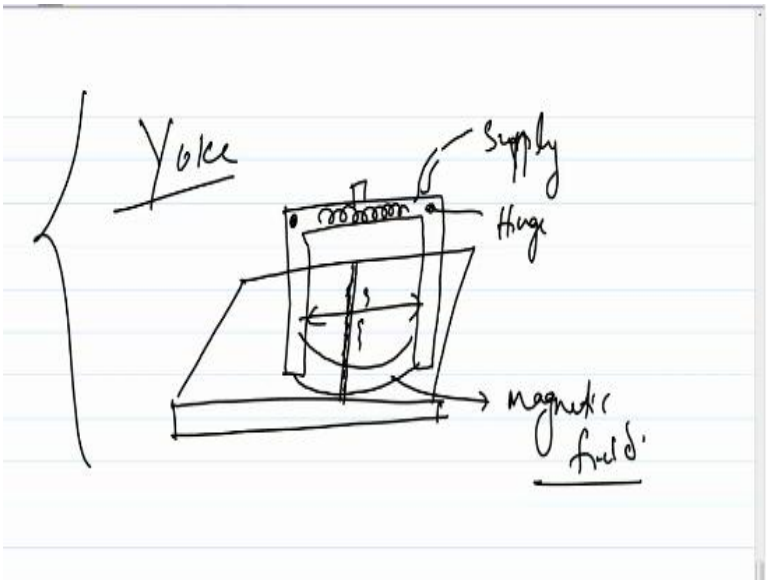

So it is like this so inside this you essentially have a coil which carries the current and then you can connect it to a power supply okay and you might have a switch to switch on the current and the moment you switch on the current it will start the magnetic current and create the magnetic field across this so let us say you want to inspect this wealth okay so these are the two plates which are welded.

So the field in these case will be along this imaginary lines if you connect these two poles okay these two ends so that is how the field will be in this case when you are using yoke so it will be like this so this will be the field direction so that means in this case the best visibility will be for cracks which are oriented to this magnetic field which is generated by this Yoke, okay. And this is very convenient to use on a laboratory or to magnetize on localized part or small parts if you want you can also provide the hinge some kind of hinges at this location.

So that this distance can be varied okay that will again help you out in magnetizing you know different distances so that is another advantage that you have these two legs can be movable so that you can adjust the distance between them and then your magnetizing distance will also where you can vary the magnetizing distance on the part so these are the different methods the most commonly used methods by which you know you can magnetize apart and once the part is magnetized then comes the other steps that we are going to discuss in the next lecture, so this is all I have for today see you next time.

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