Inspection and Quality Control in Manufacturing
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Lecture – 08
Magnetic Particle Inspection

Hello my friends, so now today we are going to discuss about out new lecture on magnetic particle inspection. So before going to start, first let us know what is magnetic particle inspection, so generally it's a non-destructive testing, that means that we are not going to hamper our materials just from outside we going to check whether there is any cracks or pores are present inside the materials are not, it is one kind of testing process for detecting the surface and the shallow subsurface.

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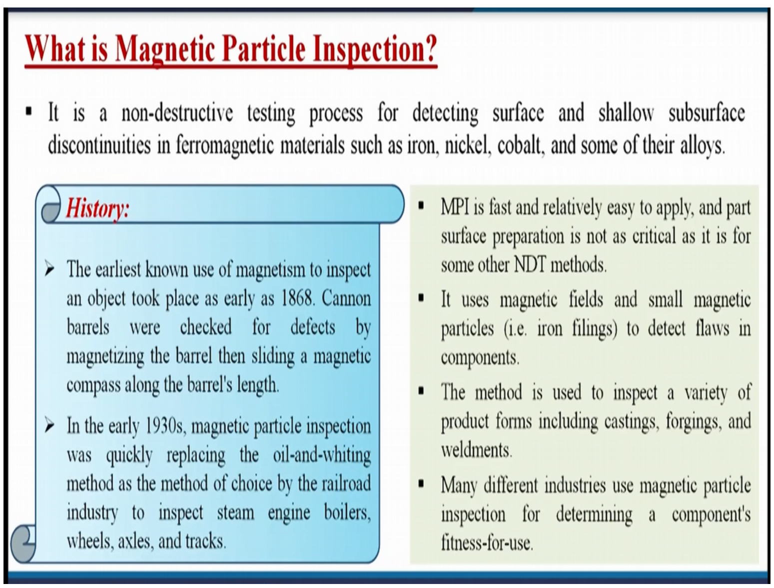

discontinuities in the ferromagnetic materials, so this is the vital point over there, so ferromagnetic, so the ferromagnetic materials such as the iron, nickel, cobalt and some of their alloys.

So, let us know about the history, In the earliest know use of magnetism to inspect an object took place as early as 1868. Cannon barrels were checked for defects by the magnetizing the barrel then sliding magnetic compass along the barrel's length. So, when there is any crack, it's simple that it generates some kind of signals, that we have to catch and we have known where the crack is it.

In the early, early 1930, magnetic particle inspection was quickly replacing the oil and whiting method as the method of choice by the railroad industry to inspect steam engine boiler wheels, axles and tracks, yes for the railways we are continuously monitoring this kind of cracks at the railway wheels or may be the railway tracks because when there is a certain change in the temperature, these tracks or may be the wheels can get certain kind of damage over there due to that this kind of defects may occur.

So Now we are calling it as an MPI magnetic particle inspection, it is very fast and relatively easy to apply and part surface preparation is not as critical as it is for some other NDT. It uses magnetic fields and small magnetic particles to detect flaws in components. The method is used to inspect a variety of product forms including castings, forgings and weldments of may be any other type of materials, so we can see the surface integrity of that particular materials. Many different industries use magnetic particle inspection for determining a components fitness for use.

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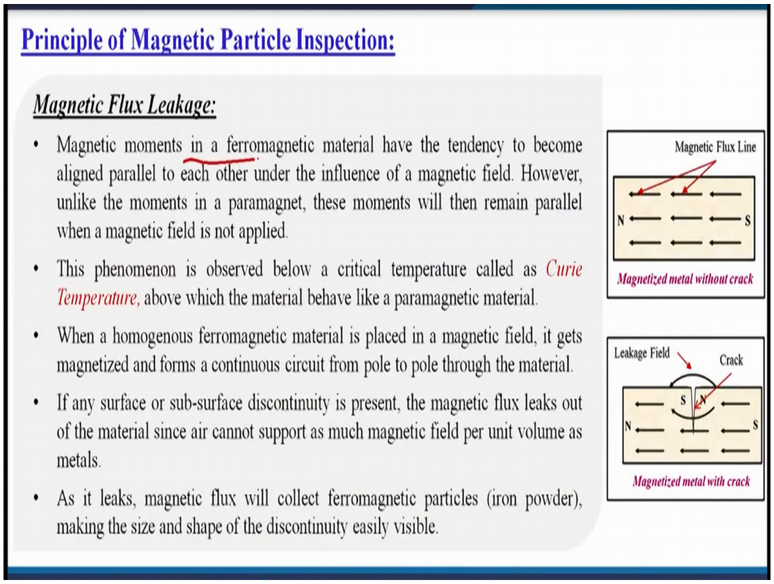

So now what are the principle behind it, first is that magnetic flux leakage that means it will give you the broader idea, that what is the logic behind it. (slide 3.13), magnetic moments in a ferromagnetic material have the tendency to become aligned parallel to each other under the influence of a magnetic field. So here, you can see the magnetic flux line, these all are the parallel to each other, so here is the magnetized metal without the crack.

However, unlike the moments in a paramagnet, these moments will then remain parallel when a magnetic field is not applied. This phenomenon is observed below a critical temperature originally called as the curie temperature. Above which the material behaves like a paramagnetic material. When a homogenous ferromagnetic material is placed in a magnetic field, it gets magnetized and forms a continuous circuit from pole to pole through the material. So that means from north pole to south pole, it will create a particular circuit.

In any surface or sub-surface discontinuity is present, the magnetic flux leaks out of the material since air cannot support as much magnetic field per unit volume as metals. In that particular case, as I told already at all the magnetic flux lines are the parallel one when there is certain cracks over there. So that in that particular flux the air has been entered into the system, so that time the magnetic field will be disturbed. As it leaks magnetic flux will collect ferromagnetic particles generally the iron powder, making the size and shape of the discontinuity easily visible.

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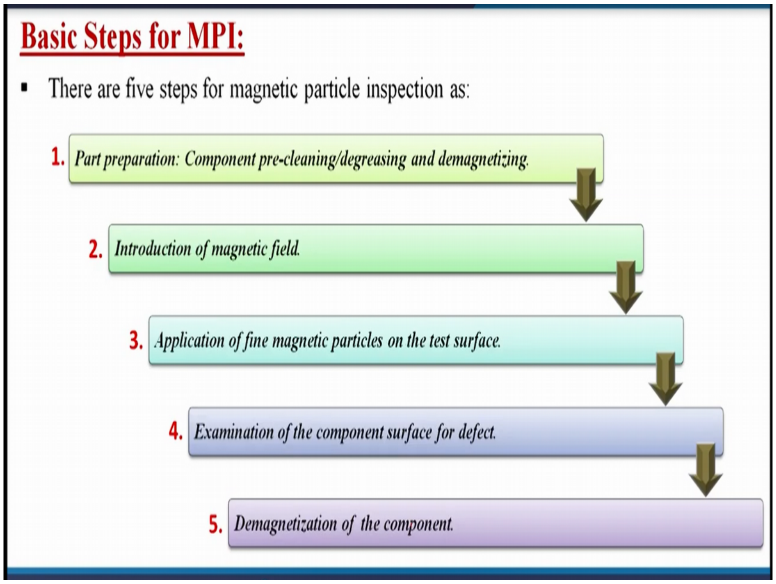

Basic steps. There are total five steps are available. The first one is the Part preparation: Component pre-cleaning/degreasing and demagnetizing, say suppose we are using that particular materials and sometimes in some applications, so maybe there is we are using some kind of oil or may be the grease or maybe we are dipping materials for kind of lubrication purpose.

So, first we have clean all those things, then suppose we are using that materials in a may be that palm or may be motors, if already any pre-magnetizations has been done that thing we have to remove and second on is the introduction of the magnetic field, third one is the application of the fine magnetic particles on the test surfaces fourth is the examination of the component surface for defect, fifth is the, because we are creating the magnetic field or may be the magnetic flux inside the materials so after examining again we have to demagnetizing the component.

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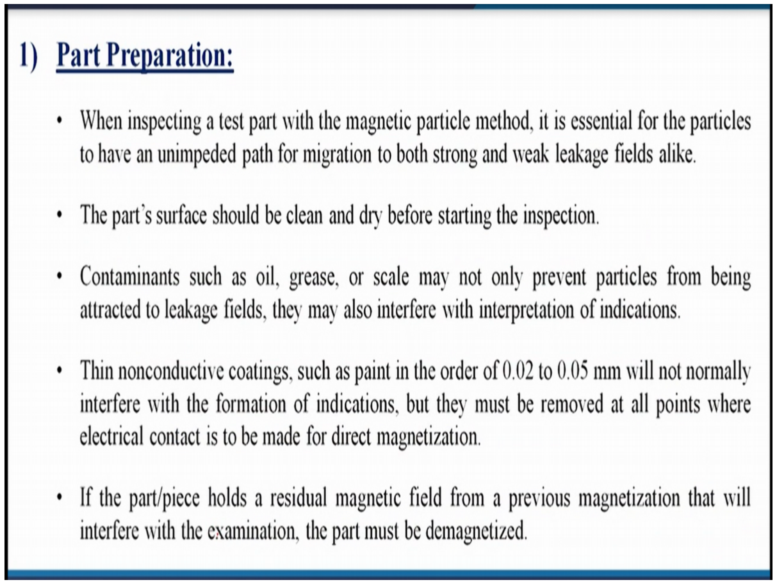

First, we will elaborately discuss about all these five points so about the part preparation when inspecting a test part with the magnetic particle method, it is essential for the particles to have an unimpeded path for migration to both strong and weak leakage fields alike. The part's surface should be clean and dry before starting the inspection as I told already.

Contaminants such as oil, grease or scale may not only prevent particles from being attracted to leakage fields, they may also interfere with interpretation of indications, because if there is any cracks or may be the pores are present into the surface, so if there is any oil or grease is present, what will happen at cavity will be filled up those material, so first initially, we have to clean the surface, so that whatever the cracks and pores that will be without any oil free or may be grease free or may be the any kind of contaminant free, then only we can perform the test and achieve the 100% result from that.

Thin nonconductive coatings, such as paint in the order of 0.02 to 0.05mm so this is the vital one, will not normally interfere with the formation of indications, because when we are talking about any parts, sometimes we need to paint it to restore or may be to save its working life, so that if the thickness is below 0.02 to 0.05, there is no need to remove otherwise we have to remove, but they must be removed at all points where electrical contacts is be made for direct magnetizations, yes of course, because the paint will act an insulator.

If the part/piece holds residual magnetic field from a previous magnetization that will interfere with the examination, the part must be demagnetized.

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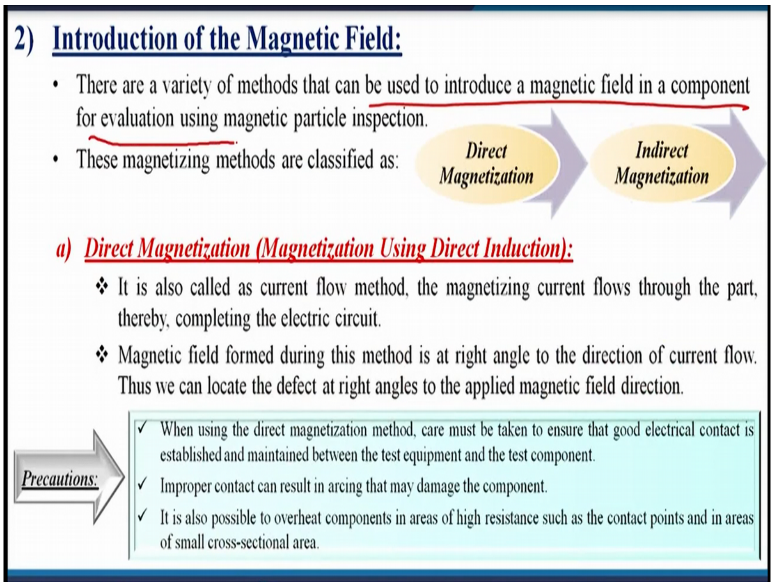

Next come to the second point, now we have to do the introductions of the magnetic field, there are a variety of methods, that can used to introduce a magnetic field in component for evaluation using magnetic particle inspection. These magnetizing methods are classified as Direct magnetization and indirect magnetization. If we talk about the direct magnetization, sometimes it is called as the magnetization used in direct inductions.

It is also called as the current flow method, the magnetizing current flows through the part thereby completing the electric circuit. Magnetic field formed during this method is at right angle to the direction of current flow. Thus, we can locate the defect at the right angles to the applied magnetic field direction. So, this is the important one, so if we flow the current in these directions, the magnetic field will be generated in these directions, so both will be exactly the 90 degree to the each other.

Now we have to take certain precautions, what are those, first is that when using the direct magnetization method, care must be taken to ensure that good electrical contact is established and maintained between the test equipment and the test component. Second, improper contact can result in arcing that may damage the component. Because, we are touching the positive and the negative terminal over there, so if it will not properly touch or maybe there will be gap, so spark will take place, that can change the shape of the particular material, it is also possible to varied components of areas of high resistance such as the contact points and in areas of small cross-sectional area.

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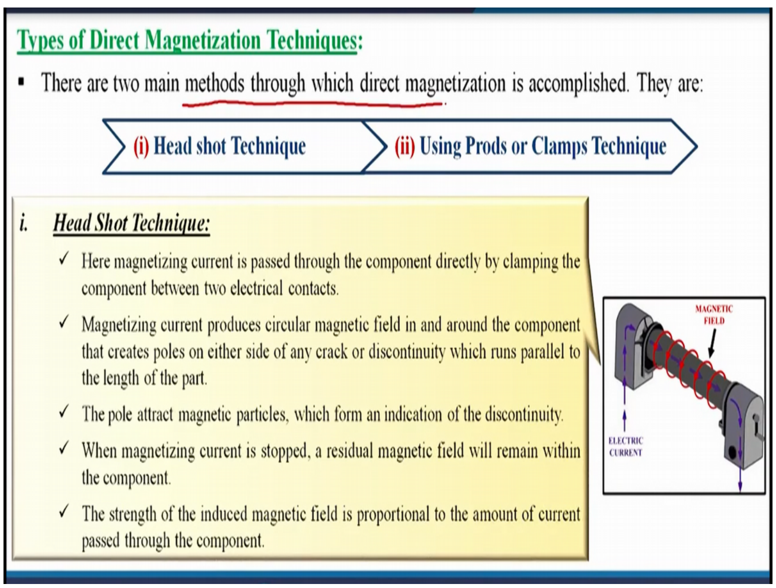

Now what are the types of the direct magnetization techniques. There are two main methods through which direct magnetization is accomplished. First one is called the Head shot technique and second one is called as the prods or clamps technique. First one is called the head shot technique. Here magnetizing current, the is passed through the component directly by clamping the component between two electrical contacts, if you can see the right-hand side image, so can see that this is our main work piece over there right.

So now we are giving two contact points over there, so directly these contact points are attached with the specimen and now we are creating the magnetic field, so this is called the head shot technique, so both the head, we are giving one positive terminal and another one is the negative terminal. Magnetization current produces circular magnetic field in and around the component that creates poles on either side of any crack or discontinuity which runs parallel to the length of the part.

Say suppose, say now the current we are giving in this direction so magnetic flux, so here suppose there is certain crack over there, so it is not there, so there is crack, either it will generate the north pole or may be the vice versa. The pole attracts magnetic particles, which form an indication of the discontinuity. When magnetizing current is stopped, a residual magnetic field will remain within the component, now again we have to do the demagnetization. The strength of the induced magnetic field is proportional to the amount of current passed through the component.

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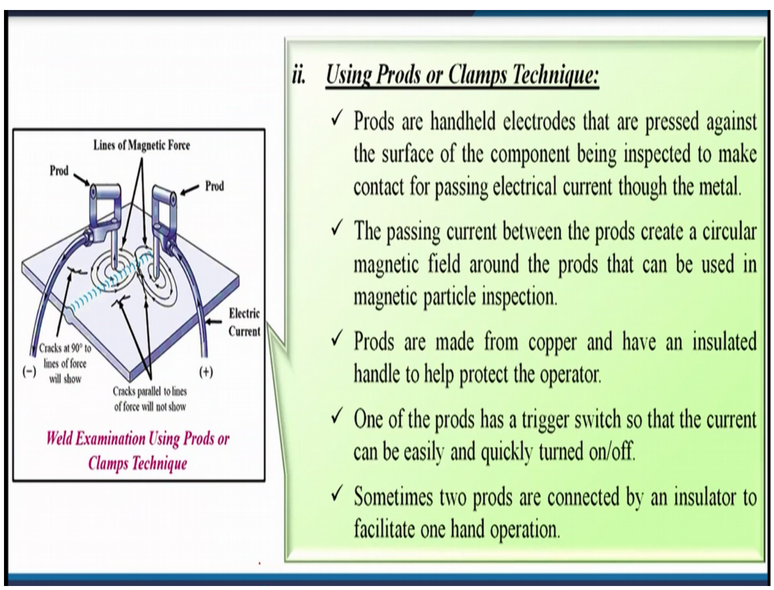

Now come to the second one, using Prods or clamps technique- Prods are handheld electrodes that are pressed against the surface of the component being inspected to make contact for passing electrical current though the metal. In this particular case you can see, it is the handheld instrument, you can easily carry it and whenever or where ever you need it, simple you can put it over there and you can do the test, these all are the prods, now you can see that we are testing it with the weld samples. We are having two parts, one you have joined it and this is the welding zone and then we are testing it.

The passing current between the prods create a circular magnetic field around the prods that can be used in magnetic particle inspection. Prods are made from copper and have an insulated handle to help protect the operator, so easily we can hold it. One of the prods has trigger switch so that the current can be easily and quickly turned on/off. So, in this particular case either any of that having the switch. Sometimes two prods are connected by an insulator to facilitate one hand operation. In this case you can see, it is both these parts are segregated, but sometimes it may happen that it can join with a particular metal or may be the insulating materials so that, we can do it by only single.

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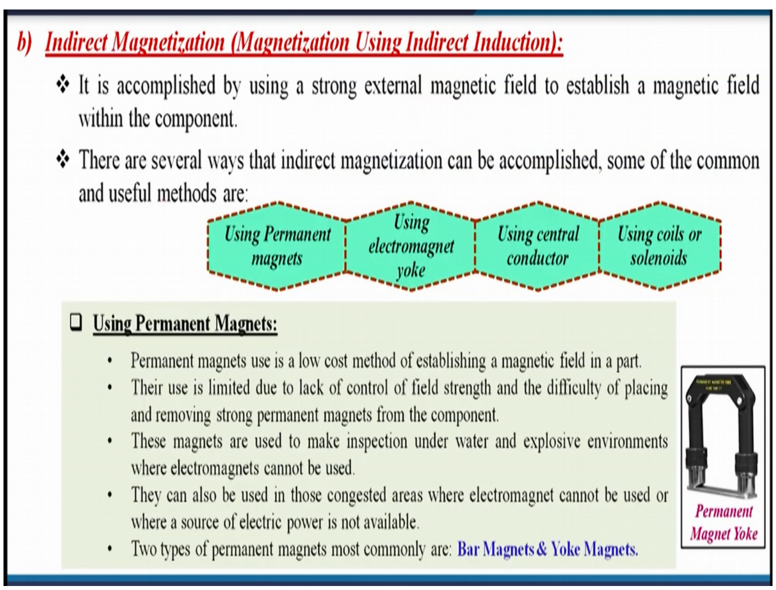

Next come to the indirect magnetization. Generally, it is called as the magnetization using indirect induction: It is accomplished by using a strong external magnetic field to establish a magnetic field within the component. In this case we are not directly using the current to the particular material to magnetize, in this case, we are creating the magnetic field just outside the component and same vice versa we are producing inside the specimen and we are doing the testing.

There are several ways that indirect magnetization can be accomplished. Some of the common methods are: Using permanent magnets, using electromagnet yoke, using central conductor, using coils or may be the solenoids. First using permanent magnets: Permanent magnets use is a low-cost method of establishing a magnetic field in a part.

Their use is limited due to lack of control of field strength and the difficulty of placing and removing strong permanent magnets from the components, so just what we are doing, we are keeping the permanent magnet just beside the sample, so that, that will affect our sample and then after that we can do the testing. These magnets are used to make inspection under water and explosive environments where electromagnets cannot be used.

They can also be used in those congested areas where electromagnet cannot be used or where a source of electric power is not available, so any remote conditions, in remote area, we can do this testing. Two types of permanent magnets most commonly are bar magnets or may be yoke magnets. So, this is the example over there, there is a permanent magnet yoke.

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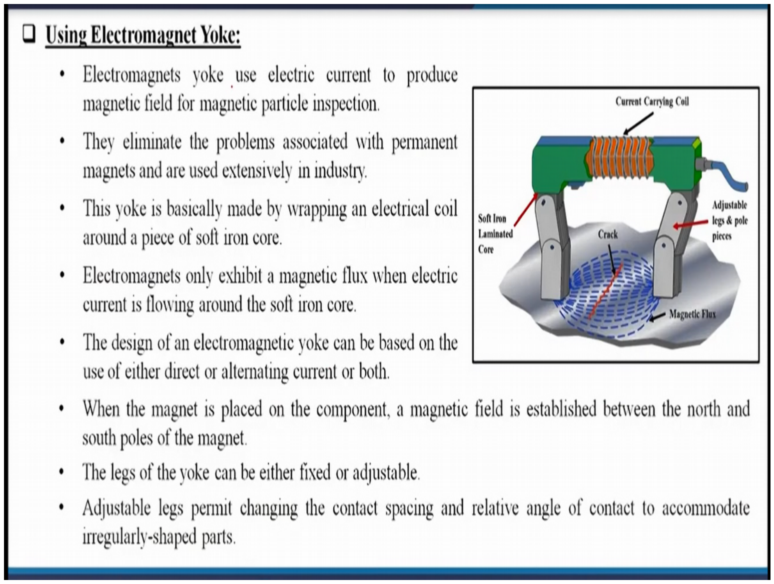

Second is that using electromagnet yoke. Electromagnets yoke use electric current to produce magnetic field for magnetic particle for inspection. They eliminate the problems associated with permanent magnets and are used extensively in industry. This is widely used. This yoke is basically made by wrapping an electrical coil around a piece of soft iron core.

So, you can see, this is known as the soft iron core, and if you cut, inside you can see, that it is having the current carrying coil. Electromagnets only exhibit a magnetic flux when electric current is flowing around the soft iron core. When we are passing the electric current over there, then that time only the electromagnetic force or may be the magnetic flux is generating at that particular point through this soft core or may be sometime we are calling it as a leak.

The design of an electromagnetic yoke can be based on the use of either direct or alternating current or both. When the magnet is placed on the component, a magnetic field is established between the north and south poles of the magnet. The legs of the yoke can be either fixed or adjustable or may be the adjustable. Nowadays, we are using the adjustable one, because it is very widely used and widely acceptable for any shape and size, we can easily do this kind of test. Adjustable legs permit changing the contact spacing and relative angle of contact to accommodate irregularly – shaped parts.

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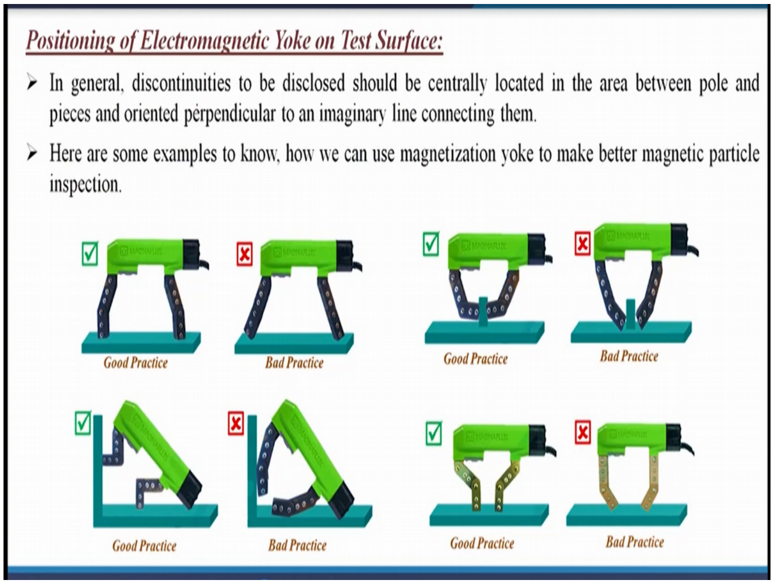

Now come to the positioning of the electromagnetic yoke on the test surface. In general, discontinuities to be disclosed should be centrally located the area between pole and pieces and oriented perpendicular to an imaginary line connecting them. Here are some examples to know, how we can use magnetization yoke to make better magnetic particle inspection.

So, you can see, we have given certain examples how you can fix this electromagnetic yoke to get the better results, whatever the green in color, the good practice or may be the right position and what are the red in color in the cross mark that are the bad practice or maybe we cannot get the proper result.

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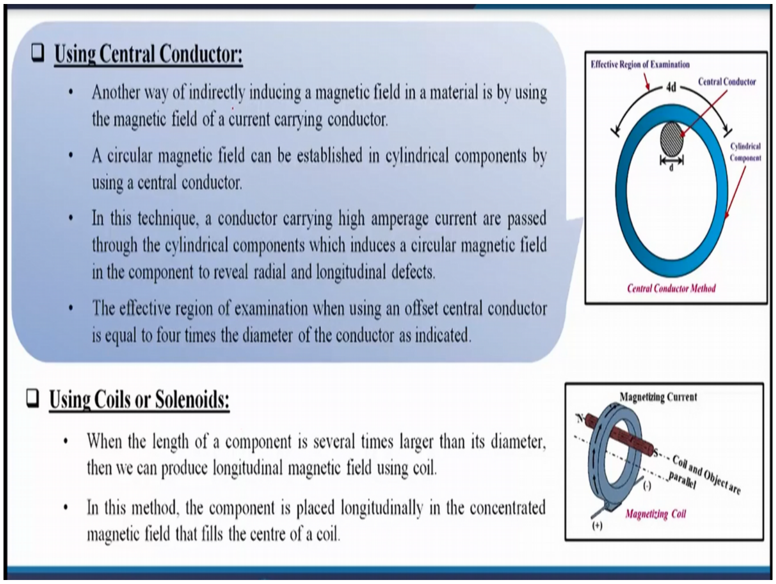

Next using the central conductor another way of indirectly inducing a magnetic field in a material is by using the magnetic field of a current carrying conductor, so that is another interesting thing. A circular magnetic field can be established in cylindrical components by using a central conductor. Say suppose I am having one cylindrical component and Now I want to test, so how I can generate the magnetic field over there or may be magnetic flux over there.

So simple, I am taking a cylindrical component over there and then inside it, I am putting my central conductor. In this technique a conductor carrying high amperage current are passed through the cylindrical components which includes a circular magnetic field in the component to reveal radial and longitudinal defects. The effective region of examination when using an offset central conductor is equal to four times the diameter of the conductor as indicated.

Next one is the using coils or solenoids, when the length of the component is several times larger than its diameter then we can produce longitudinal magnetic field using coil. In this case this is our test specimen or may be work piece, so now suppose you are having a long pipe, whether it may be solid one or may be hallow one, now you are going to test it. So generally, we are using this kind of things, in this method the component is placed longitudinal in the concentrated magnetic field that fills the centre of a coil.

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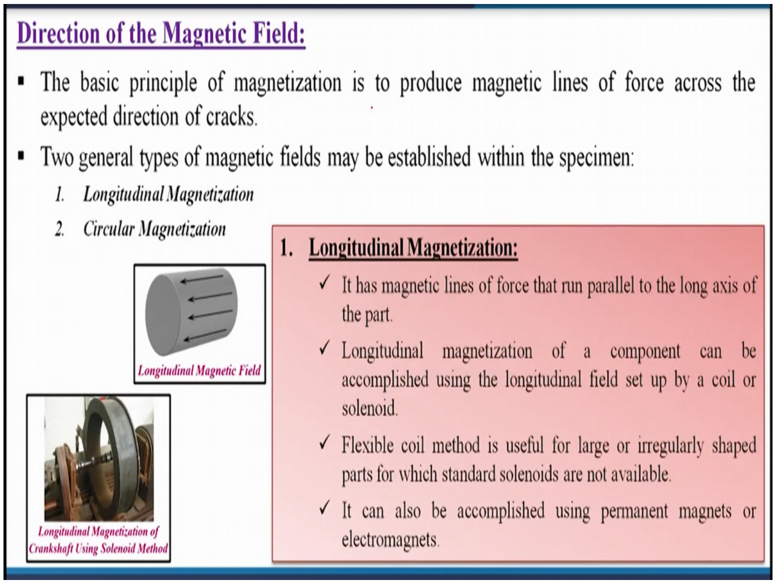

Next direction of the magnetic field. The basic principle of magnetization is to produce magnetic lines of force across the expected direction of cracks. Two general types of magnetic fields may be established within the specimen. Number one is the longitudinal magnetization and second one is called the circular magnetization, these are the examples of longitudinal magnetic field and longitudinal magnetization of crankshaft using the solenoid method.

First, we are going to discuss about the longitudinal magnetization, it has magnetic lines of force that run parallel to the long axis of the part. So, you can see here this arrow. Longitudinal magnetization of a component can be accomplished using the longitudinal field set up by coil or solenoid. Flexible coil method is useful for large or irregularly shaped parts for which standard solenoids are not available. It can also be accomplished using permanent magnets or may be the electromagnets.

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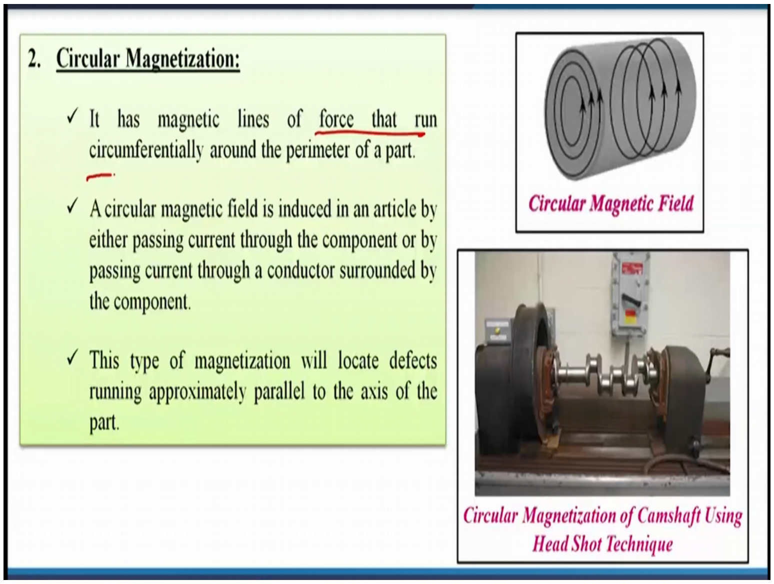

Next come to the circular magnetization. It has magnetic lines of force that run circumferentially around the perimeter of a part. In the last cases we have seen that the magnetic flux was seen in this direction, now the magnetic field was generating into the circular direction along the periphery. A circular magnetic field is induced in an article by either passing current through the component or by-passing current through a conductor surrounded by the component.

This type of magnetization will locate defects running approximately parallel to the axis of the part. This is the circular magnetic field and here and circular magnetization of camshaft using the head shot technique.

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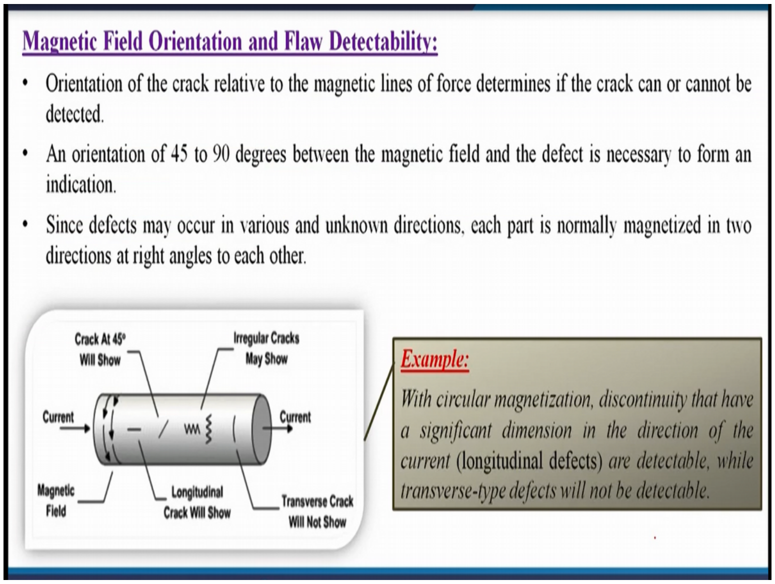

Now come to the magnetic field orientation and flaw delectability: Orientation of the crack relative to the magnetic lines of force determines if the crack can or cannot be detected. So how you are going to generate the magnetic flux. Whether it will be longitudinal or may be whether into the circumferential, that depends upon the which type of crack is generally you are expecting, so based on that you have to choose the right method.

An orientation of 45 to 90 degrees between the magnetic field and the defect is necessary to form an indication. Since defects may occur in various and unknown directions each part is normally magnetized in two directions at right angles to each other. So, in this particular case you can see that we are generating the magnetic field, so current is passing in this case, so cracks at the 45degree will show, irregular may show or may not show, longitudinal crack will show, these are the conditions.

Example With circular magnetization discontinuity that have a significant dimension in the direction of the current are detectable, while transverse-type defects will not be detectable, so this is the draw backs.

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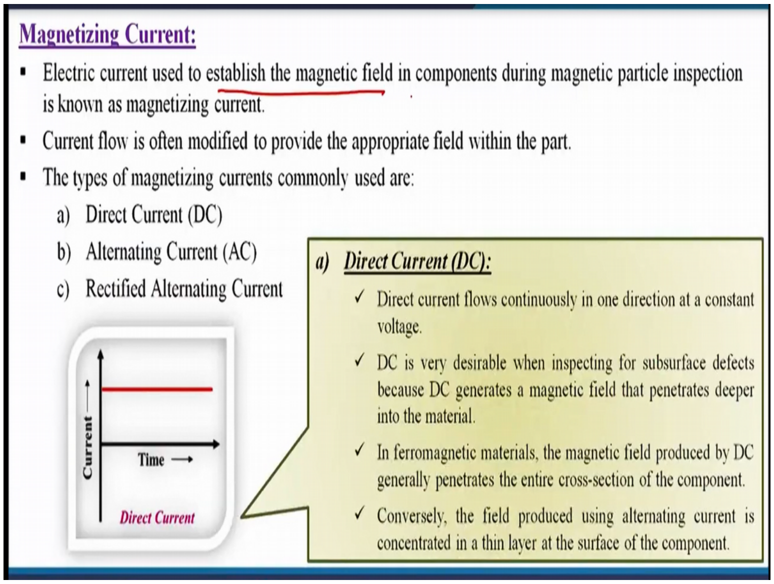

Now Magnetizing current. Electric current used to establish the magnetic field in components during magnetic particle inspection is known as magnetizing current. Current flow is often modified to provide the appropriate field within the part. There are three types of currents generally we are using. One is called the direct current. DC. Alternating current AC. And the rectified alternating current.

So, what is direct current. Direct current flows continuously in one direction at a constant voltage. So, you see, the current so constant, it is changing, DC is very desirable when inspecting for subsurface defects because DC generates a magnetic field that penetrates deeper into the material. That is the result here. In ferromagnetic materials, the magnetic field produced by the DC generally penetrates the entire cross-section of the component. Conversely, in a thin layer at the surface of the component.

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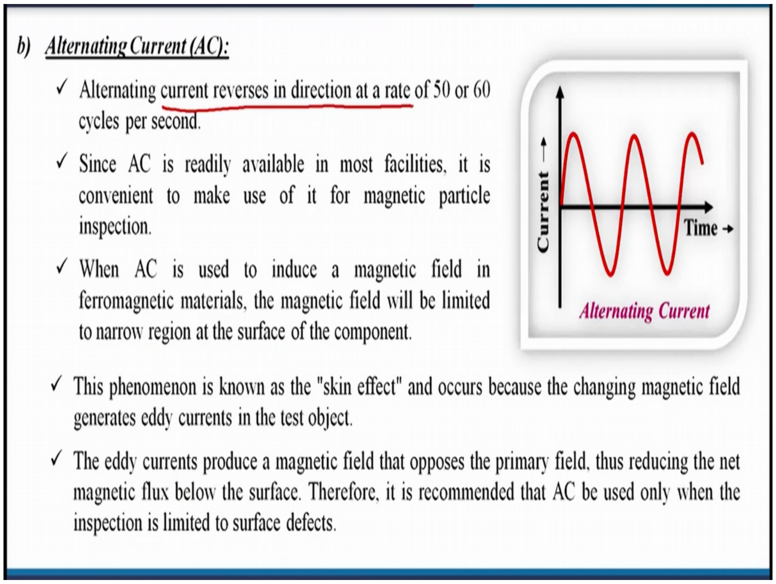

Now come to the alternating current reverses in direction at a rate of 50 or 60 cycles per second. So you can see that it is going into the positive side and then again it is coming to negative side, so it is kind of sinusoidal kind of things, this is known as the alternating current to time. Since AC is readily available in most facilities, it is convenient to make use of it for magnetic particle inspection.

Because everywhere we are using the Alternating current in our home or office, industry everywhere. When AC is used ot induce a magnetic field in ferromagnetic materials, the magnetic field will be limited to narrow region at the surface of the component. This phenomenon is known as the skin effect and occurs because the changing magnetic field generates eddy currents in the test object.

So, plus and minus. The eddy currents produce a magnetic field that opposes the primary field, thus reducing the net magnetic flux below the surface, therefore, it is recommended that AC be used only when the inspection is limited to surface defects.

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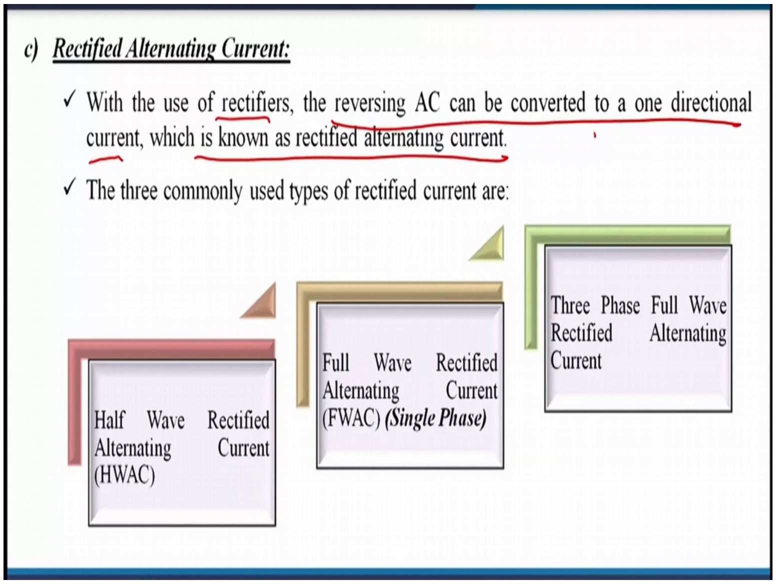

Now come to the third one. That is the rectified alternating current with the use of rectifiers, the reversing AC can be converted to a one directional current, which is known as rectified alternating current. In that case what will happen, you can get constant current over there, but still you are using the AC current.

The three commonly used types are rectified alternating currents are, half wave rectified alternating current commonly called as the HWAC, Full wave rectified alternating current (FWAC)single phase or may be the three-phase full wave rectified alternating current.

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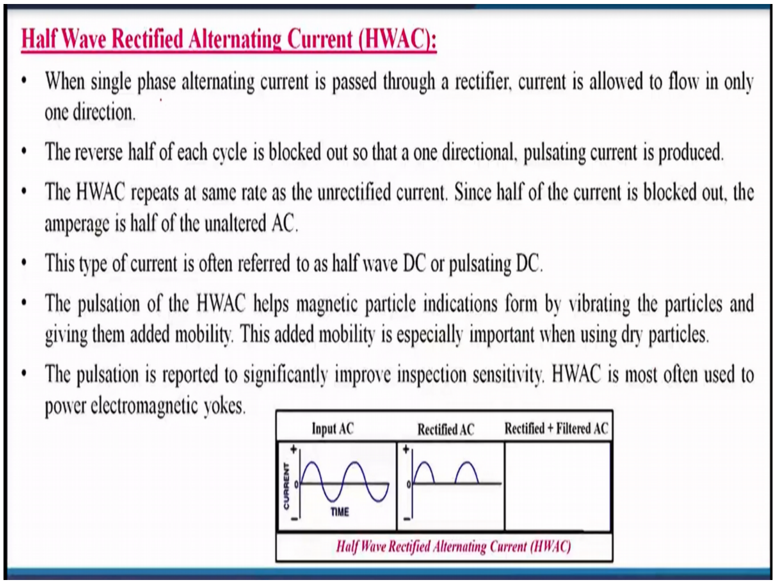

What is half wave rectified alternating current that is HWAC. When a single-phase alternating current is passed through a rectifier, current is allowed to flow in only one direction. The reverse half of each cycle is blocked out so that a one directional, pulsating current is produced in this particular case, normally input AC is that, As I told already it is having the plus and it is having the minus, when you are using the rectifier over there.

So, the thing is that it will show you only the first part or may be positive part and the negative part and it will be blocked. The HWAC repeats at same rate as the unrectified current. Since half of the current is blocked out, the amperage is half of the unaltered AC. This type of current is often referred to as half wave DC or pulsating DC.

The pulsation of the HWAC helps magnetic particle indications form by vibrating the particles and giving them added mobility. This added mobility is especially important when using dry particle. The pulsation is reported to significantly improve inspection sensitivity. HWAC is most often used to power electromagnetic yokes. If you use a rectified and filtered AC, you cannot get any signal.

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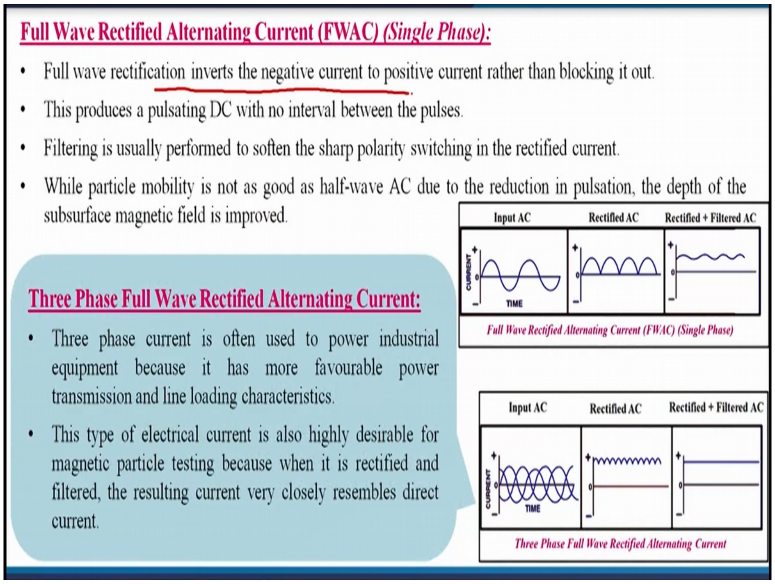

Next come to the full wave rectified alternating current, it is called the FWAC-Single phase. Full wave rectification inverts the negative current to positive current rather than blocking it out, you can see now we are getting a constant one. First the positive high speed it will come to the zero and again it will reach the high speed, like this way, so whatever is the negative just it will become the opposite way.

This produces a pulsating DC with no interval between the pulses. Filtering is usually performed to soften the sharp polarity switching in the rectified current. While particle mobility is not as good as half wave AC due to the reduction in pulsation, the depth of the subsurface magnetic field is improved.

Then come to the three-phase full wave rectified alternating current. Three phase current is often used to power industrial equipment because it has more favorable power transmission and line loading characteristics. This type of electrical current is also highly desirable for magnetic particle testing because when it is rectified and filtered the resulting current very closely resembles direct current. So, you can see when you are using the filtering and already used the rectifier almost, we are getting same like the DC current.

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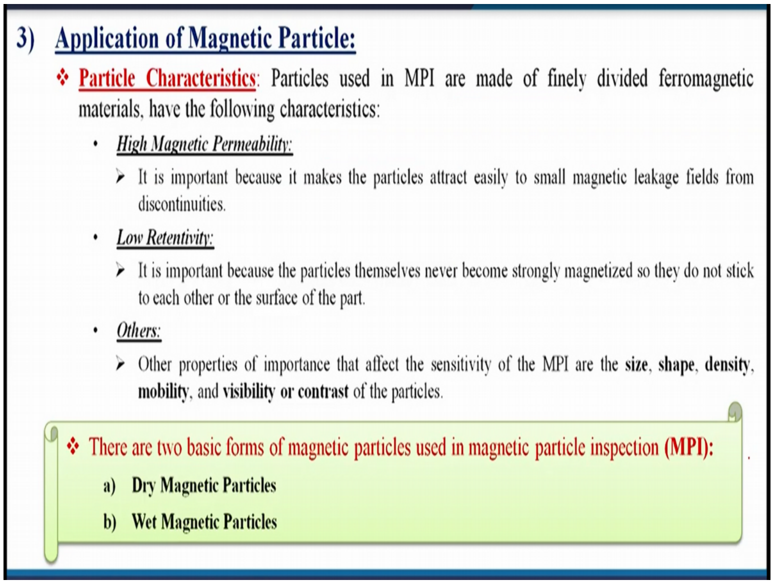

Next application of the magnetic particle. Particle characteristics. Particles used in MPI are made of finely divided ferromagnetic materials, have the following characteristics, what are those, number It should have High magnetic permeability. It is important because it makes the particles attract easily to small magnetic leakage fields from discontinuities.

Now you have created the magnetic field on top of that, you are putting some kind of ferromagnetic particles, so what will happen from the cracks itself the magnetic flux it will attract the magnetic particles, when you clean out, you can easily see the cracks over there, because that has been taken care by the ferromagnetic materials and if you put some colors in the ferromagnetic materials you can easily detect where the crack or may be any kind of pores are present onto the surface of your workpiece.

Next is Low retentivity: it is important because the particles themselves never become strongly magnetized so they do not stick to each other or the surface of the part. Others: other properties of importance that affect the sensitivity of the MPI are the size, shape, density, mobility and visibility or contrast of the particles. There are two basic forms of magnetic particles used in magnetic particle inspection, first one is called the dry magnetic particles and another one is called the wet magnetic particles.

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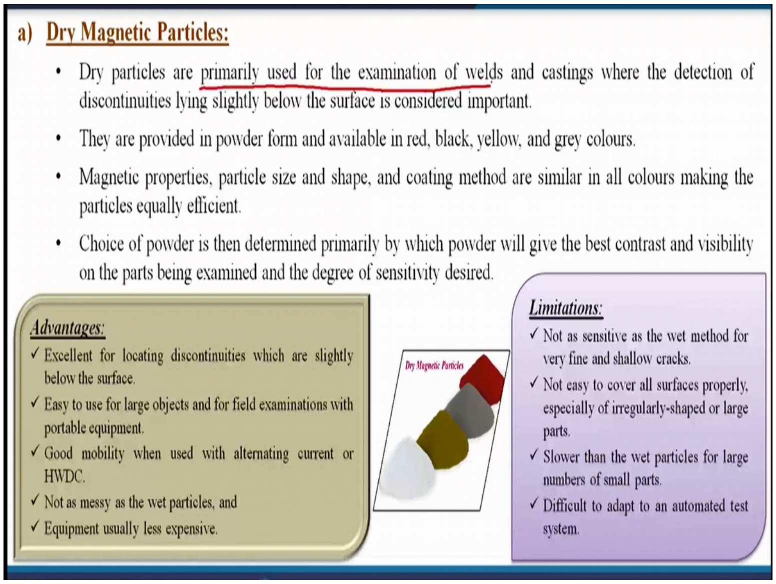

So, what is dry magnetic particles, the dry particles are used for the examination of welds and castings where the detection of discontinuities lying slightly below the surface is considered important. They are provided in powder form and available in red black, yellow and grey colors. Magnetic properties particle size and shape and coating method are similar in all colors making the particles equally efficient. Choice of powder is then determined primarily by which powder will give the best contrast and visibility on the parts being examined and the degree of sensitivity desired, depends upon the work piece color you have to choose the different color magnetic particles.

What are the advantages, Excellent for locating discontinuities which are slightly below the surface? Easy to use for large objects and for field examinations with portable equipment. Good mobility when used with alternating current or HWDC. Not as many as the wet particles and Equipment usually less expensive But of course, there are certain limitations what are those: Not as sensitive as the wet method for very fine and shallow cracks. Not easy to cover all surface properly especially of irregularly shaped or large parts. Slower than the wet particles for large number of small parts. Difficult to adapt to an automated test system.

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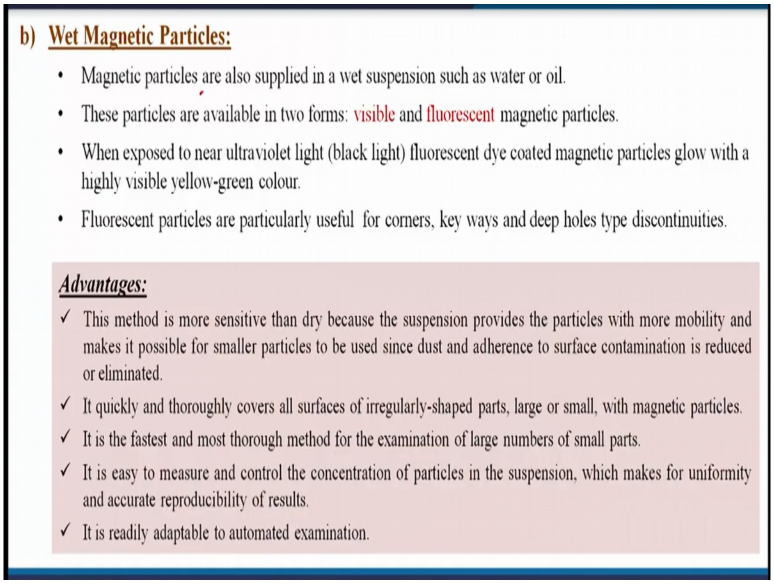

Next come to the wet magnetic particles. Magnetic particles are also supplied in a wet suspension such as water or oil. These particles are available in two forms. One is called the visible and another one is called fluorescent magnetic particles. When exposed to near ultraviolet light or may be black light fluorescent dye coated magnetic particles glow with highly visible yellow green color. Fluorescent particles are particularly useful for corners, key ways and deep holes type discontinuities.

What are the advantage? This method is more sensitive than dry because the suspension provides the particles with more mobility and makes it possible for smaller particles to be used since dust and adherence to surface contamination is reduced or eliminated. It quickly and thoroughly covers all surfaces of irregularly shaped parts, large or small, with magnetic particles. It is the fastest and most thorough method for the examination of large numbers of small parts. It is easy to measure and control the concentration of particles in the suspension, which makes for uniformity and accurate reproducibility of results. It is readily adaptable to any kind of automated examinations.

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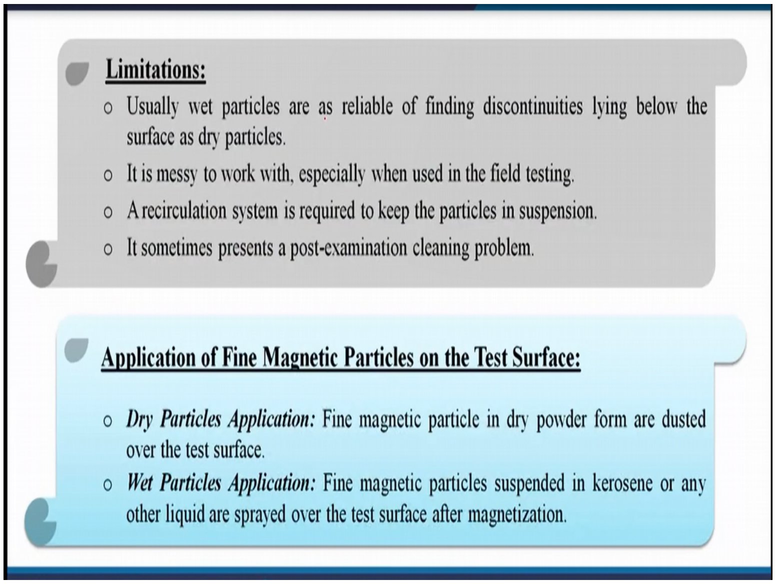

Now what are the limitations? Usually wet particles are as reliable of finding discontinuities lying below the surface as dry particles. It is messy to work with especially when used in the field testing. A recirculation system is required to keep the particles in suspension. It sometimes presents a post-examination cleaning problem. For dry particles means after doing the experiment, simple you can make it opposite and the particle will come out, but wet particles means it can adhere to the system either you have to clean it or wash out or help you may required.

Application of the fine magnetic particles on the test surface. Dry particles application: fine magnetic particle in dry powder form are dusted over the test surface. Wet particles application. Fine magnetic particles suspended in kerosene or any other liquid are sprayed over the test surface after magnetization.

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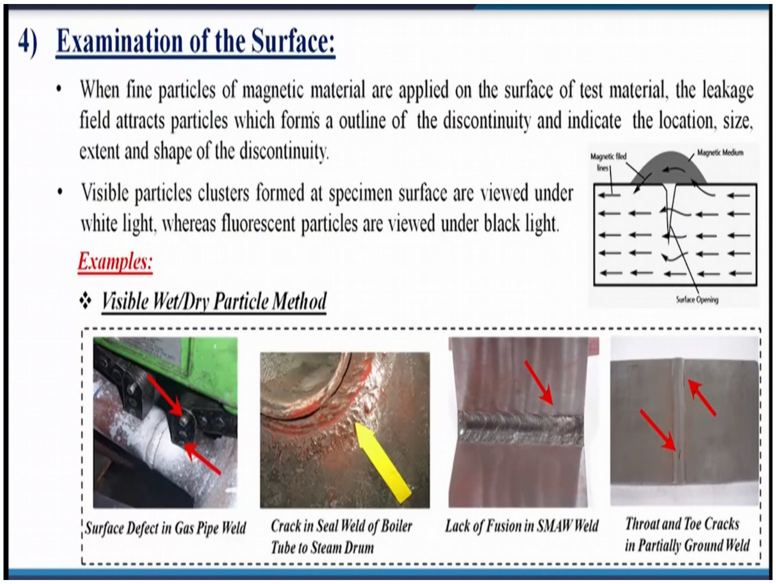

Now come to the examination of the surface: when fine particles of magnetic material are applied on the surface of test material, the leakage field attracts particles which forms a outline of the discontinuity and indicate the location. Size extent and shape of the discontinuity. Visible particles clusters formed at specimen surface are viewed under white light, whereas fluorescent particles are viewed under black light.

So, you can see, as I told already when we are generating magnetic lines inside if there is any cracks or pores and on top of that when we are putting magnetic particles over there, so only through this crack the leakage magnetic field will come and it will occur. So easily you can understand from the outside where the cracks or may be pores are present.

Come to the visible wet/dry particle method: here are some examples: Surface defects in gas pipe weld. Crack in seal weld of boiler tube to steam drum. Lack of fusion in SMAW weld. Throat and toe cracks in partially ground weld. So, you can see by this particular color.

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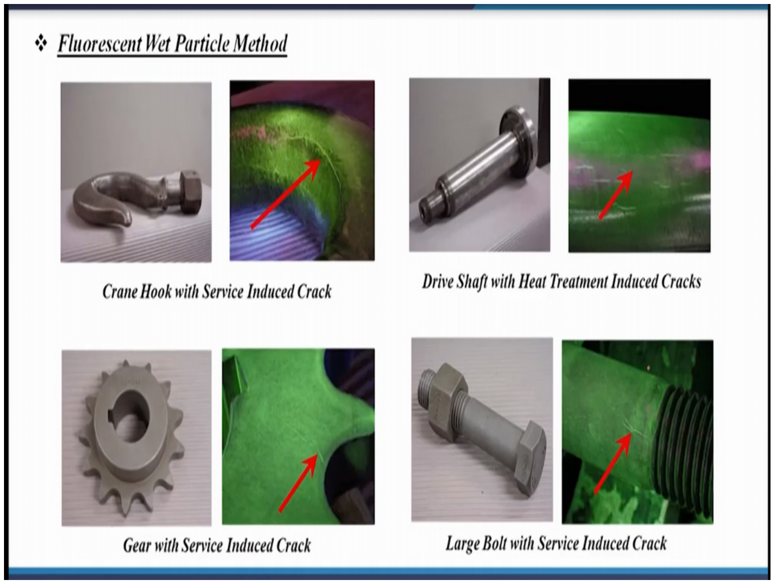

Fluorescent wet particle methods. Crane hook with service induced crack, it is showing some yellow green color. Drive shaft with heat treatment induced cracks, before testing and after testing we can see some kind of cracks over there. Gear with the service induced crack, fine a crack you can see over there, large bolt with service induced crack. These all are cracks which are easily deductible by this MPI technique.

Now come to the last one Demagnetization, As I told already, first initially we have created the magnetic flux and after that you have to destroy the magnetic flux so that you can use that particular material.

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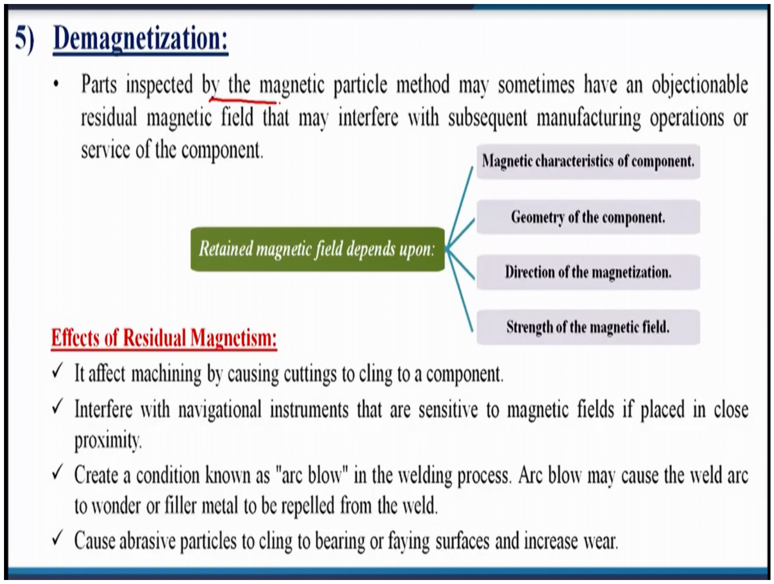

Parts inspected by the magnetic particle method may sometimes have an objectionable residual magnetic field that may interfere with subsequent manufacturing operations or service of the component. Retained magnetic field depends upon, magnetic characteristics of the component geometry of the component, direction of the magnetization, strength of the magnetic field.

Effects of the residual magnetization or may be the magnetism: It affect machining by causing cuttings to cling to a component. Interfere with navigational instruments that are sensitive to magnetic fields if placed in close proximity. Create a condition known as “Arc Blow” in the welding process, Arc blow may cause the weld arc to wonder to filler metal to be repelled from the weld Cause abrasive particles to cling to bearing or faying surface and increase wear.

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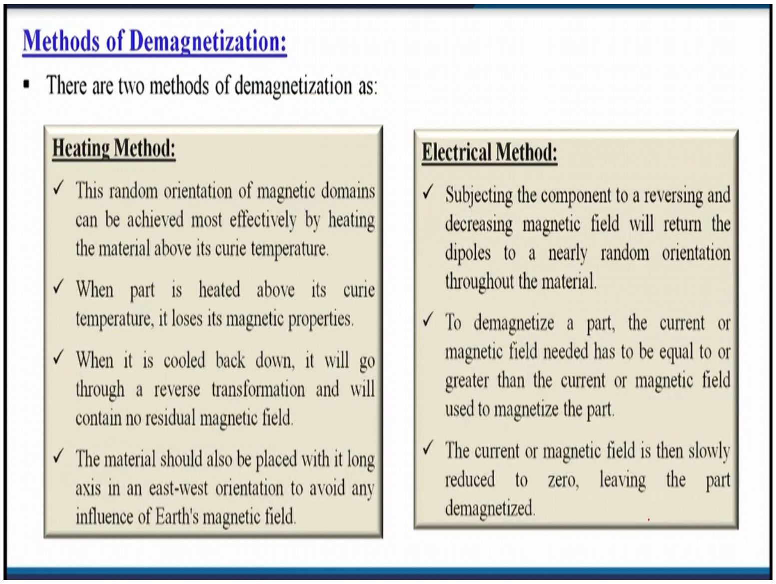

Now what are the methods of demagnetization: There are two methods of demagnetization. One is the simple the heating method and another is called the electrical method. Talking about heating method: this random orientation of magnetic domains can be achieved most effectively by heating the material above its curie temperature. When part is heated above its curie temperature a reverse transformation and will contain no residual magnetic field.

The material should also be placed with its long axis in an east west orientation to avoid any influence of earth's magnetic field. We have to keep it into the east and west direction. If we talk about the electrical method.: it is subjecting the component to a reversing and decreasing magnetic field will return the dipoles to a nearly random orientation throughout the material. To demagnetized a part the current or magnetic field needed has to be equal to or greater than the current or magnetic field used to magnetize the part.

Either it should be equal or it should be more than that. The current or magnetic field is then slowly reduced to zero, leaving the part demagnetized.

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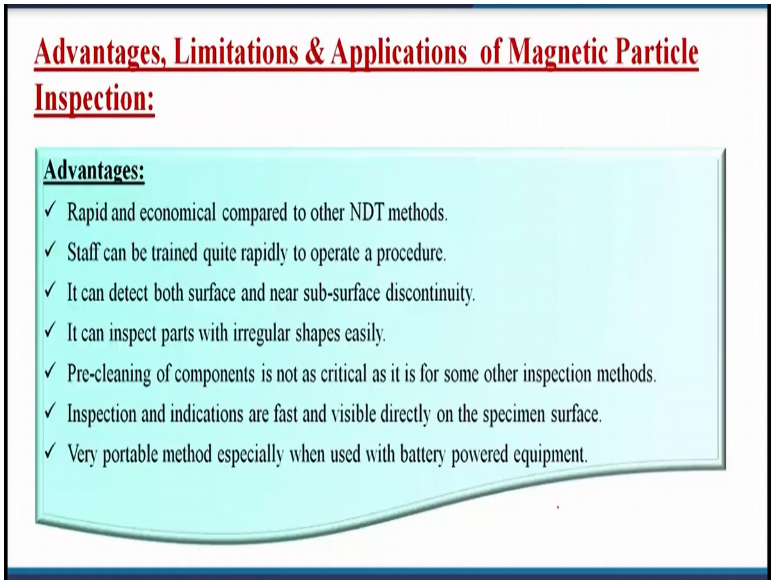

Now what are the advantages, limitations and application of magnetic particle inspection. First is the advantages. Rapid and economical compared to other NDT methods. Staff can be trained quite rapidly to operate a procedure. It can detect both surface and near sub-surface discontinuity. It can inspect part with irregular shapes easily. Pre-cleaning of components is not as critical as it is for some other inspection methods.

Inspection and indications are fast and visible directly on the specimen surface. Very portable method especially when used with battery powered equipment.

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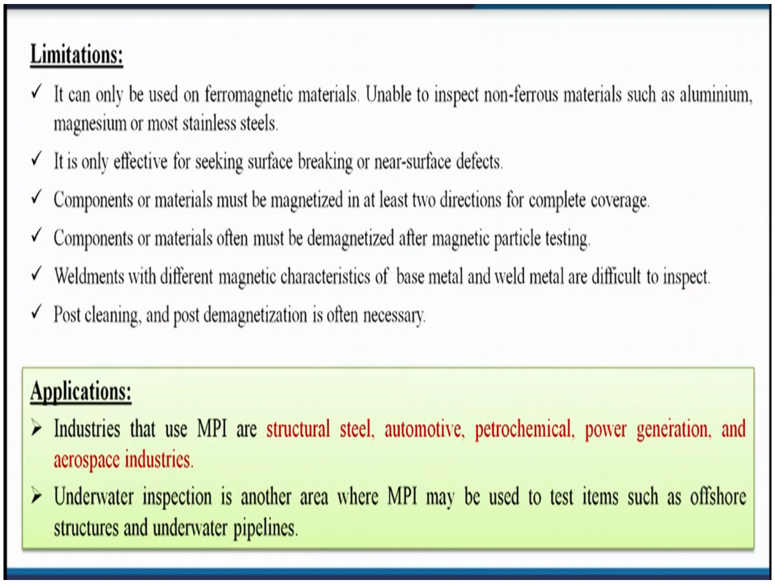

Now limitations: It can only be used on ferromagnetic materials, Unable to inspect non-ferrous materials such as aluminum, magnesium or most stainless steel. It is only effective for seeking surface breaking or near-surface defects.

Components or materials must be magnetized in at least two directions for complete coverage. Components or materials often must be demagnetized after magnetic particle testing. Weldments with different magnetic characteristics of base metal and weld metal are difficult to inspect. Post cleaning and post demagnetization is often necessary. Yes, if because you are joining two different dissimilar metals then that time it is real problem.

Applications: Industries that use MPI are structural steel, automotive, petrochemical, power generation and aerospace industries. Underwater inspection is another area where MPI may be used to test items such as offshore structures and underwater pipelines.

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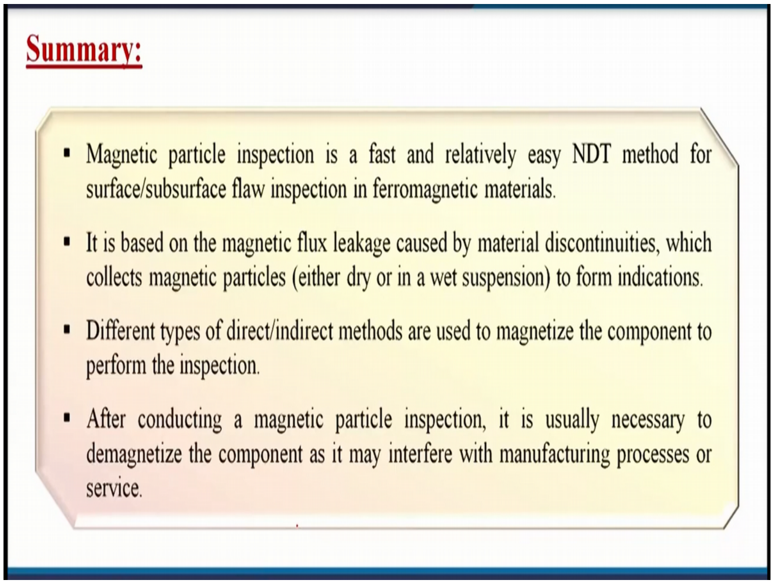

Now we have come to the last slide of this particular lecture. So now we have to summarize the whole thing. So generally, in this particular lecture we have discussed about magnetic particle inspection is a fast and relatively easy NDT method for surface/subsurface flaw inspection is ferromagnetic materials. It is based on the magnetic flux leakage caused by material discontinuities which collects magnetic particles either dry or may be the wet suspension to form indications.

Different types of direct/indirect methods are used to magnetize the component to perform the inspection. After conducting a magnetic particle inspection, it is usually necessary to demagnetize the component as it may interfere with manufacturing processes or service. So that it an again be used for the next operations or may be other things. Thank you.