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Theory and Practice of Non Destructive Testing

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Magnetic Particle Testing - 3

Okay so let us continue on this topic that I started in the last class last couple of classes we have been talking about this topic or magnetic particle testing. So let us continue on that but before you proceed today let us take a moment to see what we learned in the last class yeah.

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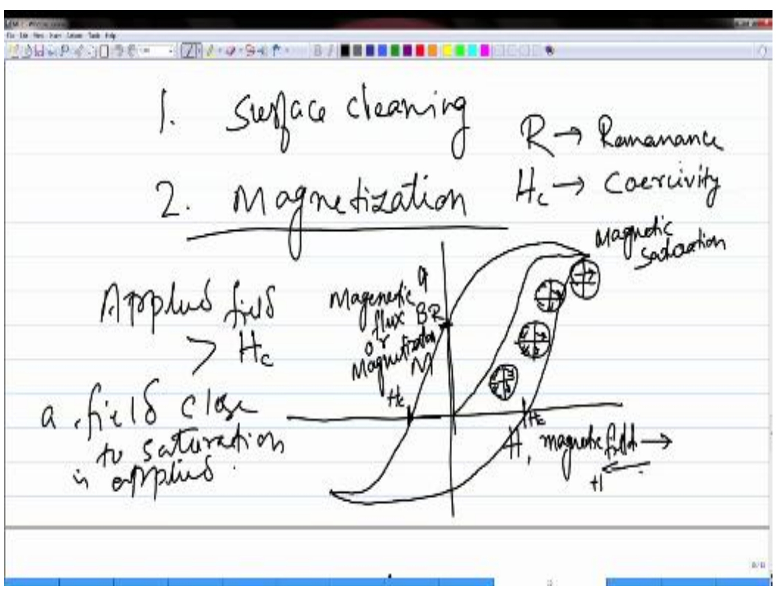

So this is what we discussed in the previous class which was about magnetizing the surface and then we saw that in terms of the magnetic field which is needed to magnetize the part you need to consider the magnetic property of the magnetic hysteresis loop of that particular material which is being tested and we saw that the applied field that should be greater than the coercivity of field HC.

And many times a field close to the saturation is applied to magnetize the part okay. So the properties of the magnetic properties of the material which play a role in this case at this the ramanance or the rittentivity and the coercivity okay. So these are the two properties which are important for magnetic particle destiny.

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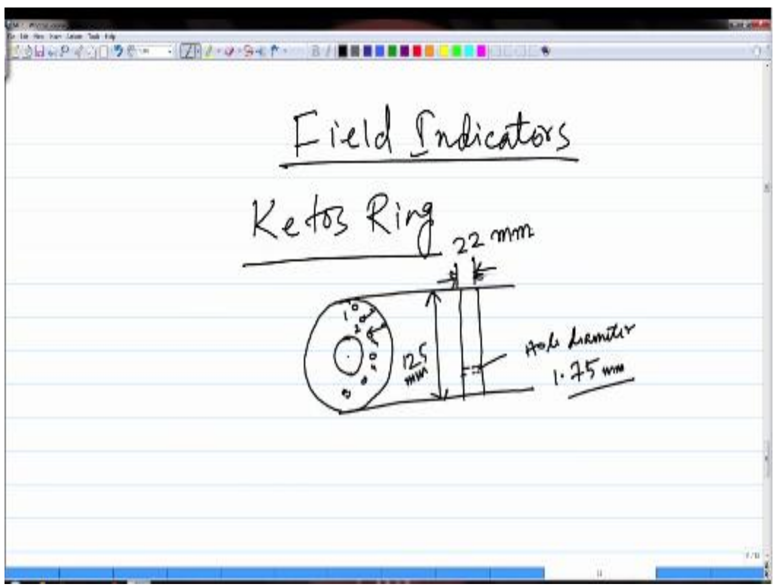

So while doing the test when you are doing it actually then you do not know what actually is the magnitude of the field which is being applied. So in that case you need some indicators which will indicate whether the field is optimum or whether the field is enough or not in a qualitative manners okay.

So these are called field indicators and one of them which is known as ketos ring these we saw in the last class so this is in the form of the ring having a central hole and when you magnetize this ring based upon how many holes how many smaller holes that you have along this circumference these smaller holes as you see which are numbered as 1, 2, 3, 4 and so on. So depending on how many holes are being indicated by the magnetic particles when you apply them on this magnetized ring.

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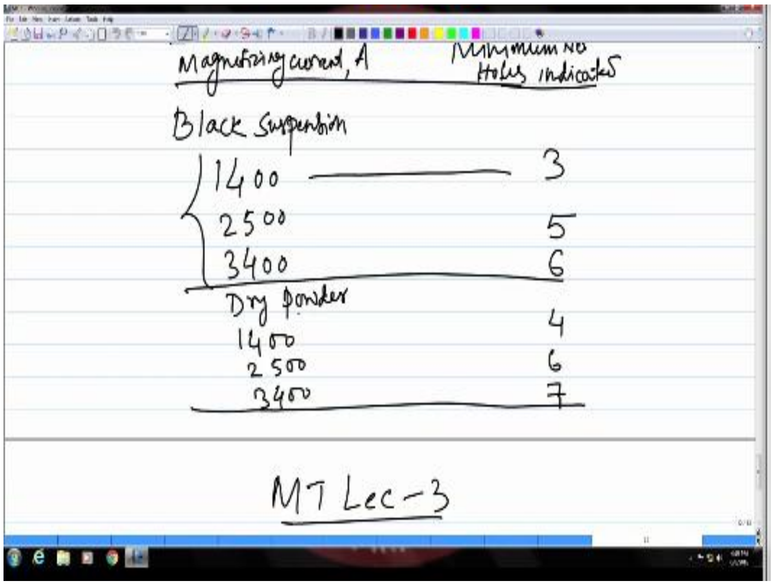

Depending on that you can say whether the magnetic current which is being applied whether that is enough or not okay. And this is how with the help of this kind of table and chart you would be able to know what should be the minimum number of particles it should be indicated for a given magnetizing current okay. And it also depends on what type of particles are used whether you are using a suspension or you are using dry powders.

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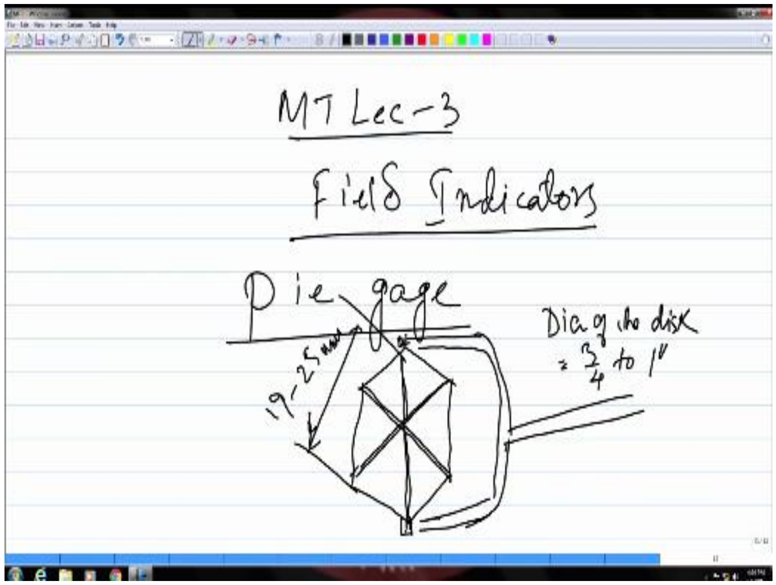

So let us continue on that so one of the field indicators we have seen but we have couple of more to talk about. The next one that we have in this is called a pie gage and this is again a small coin which is made of a highly permeable magnetic material and this coin can be divided into six or eight parts so it can be a hexagon or an octagon like this okay. So this is as big as one rupee coin made of a permeable highly permeable magnetic material okay.

And then along these diagonals some slots are cut very small slots like this and these slots are filled with some non-magnetic material. So these slots will act as artificial flaws and indicate their presence on the other side which is flat okay, so if you take this and if you see the other side of this pie gage there are no slots like that, that side is completely flat, but since the slots are there on the other side if you magnetize it then when you apply the magnetic particles on the flat surface on the flat side then you can see the indications of these slots which will act as artificial flaws as I said.

And then depending on whether these indications are clear or not you will get an idea whether the magnetic field which is being applied is enough or not okay. And for the sake of handling it you have a small hinge and handle connected here, so through this handle and because of the hinge that you have here and here you can rotate it so that you can easily handle it and keep it on the surface or on the sample which is being actually tested.

So this particular part this field indicator will be magnetized along with the sample and then you first apply the magnetic particles on this field indicator on this pie gage and then see whether these slots are being indicated properly on the flat side or not and if you see that they are being indicated properly then you can go ahead and inspect the actual part which is being tested. If you look at the dimensions of this particular indicator so the dye of this disk is around three fourth to one inch okay.

So that is a typical size you have right so now if you say the this dye it is around 19 to 25 mm or three quarter to one inch okay.

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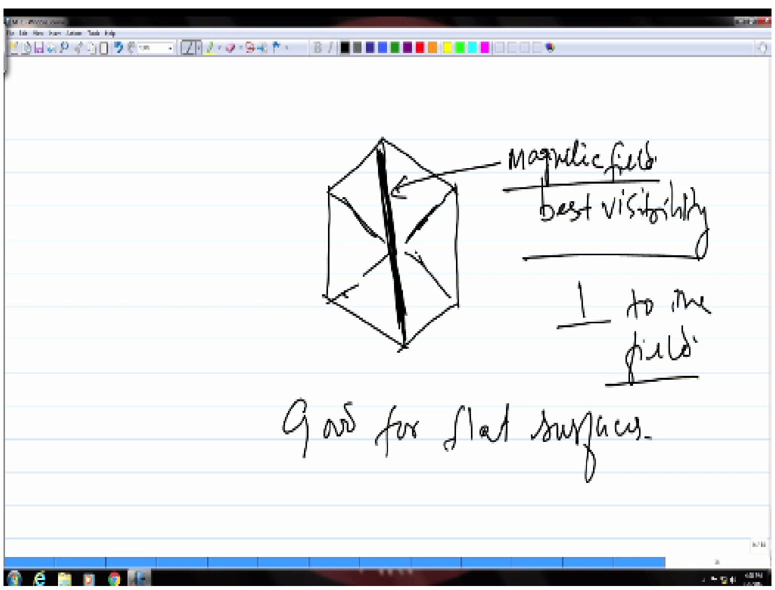

And then these slots you have so when you see the other surface the other side of this it is completely flat as I said like this. So this is what you will see on the other side of this pie gage there is no slot or anything on this surface okay. So you keep this offside down that means a slotted side will be down and then magnetize, once you magnetize and then start applying the particles you will see those some of those slots being indicated like this on the other side okay like this you would see.

And you may also see that along a particular slot more number of particles are being attracted compared to other slots which are like in other direction this direction or this direction okay. And if you remember I had said that best visibility of a discontinuity is when it is perpendicular to the direction of the magnetic field okay.

So this particular field indicators not only indicates the magnitude of the field, but it also kind of indicates the direction of the magnetic field because along the direction which is perpendicular to the magnetic field you will see most number of particles being attracted okay. So that is how for example if you see that along this particular slot maximum number of particles are being deposited or being attracted then you would know that this will be the direction of the magnetic field okay.

So this is also helpful in identifying the direction of the field, because that is also important in magnetic particle testing okay. So this is a good piece of indicator which will indicate the magnitude as well as the direction of the field, but this is a small flat coin so it is good for flat surfaces and if you have other kind of complex shapes then you may need other kind of indicators which will be more suitable for complex geometrics okay.

So this one is good for flat surfaces okay, so if you have a complex geometry in the part then it may be needed to magnetize the part in multiple directions okay because it is it may not be completely flat or linear. So it may be needed to magnetize it from different directions so that you do not miss out on any of the discontinuities which might lie in any direction okay.

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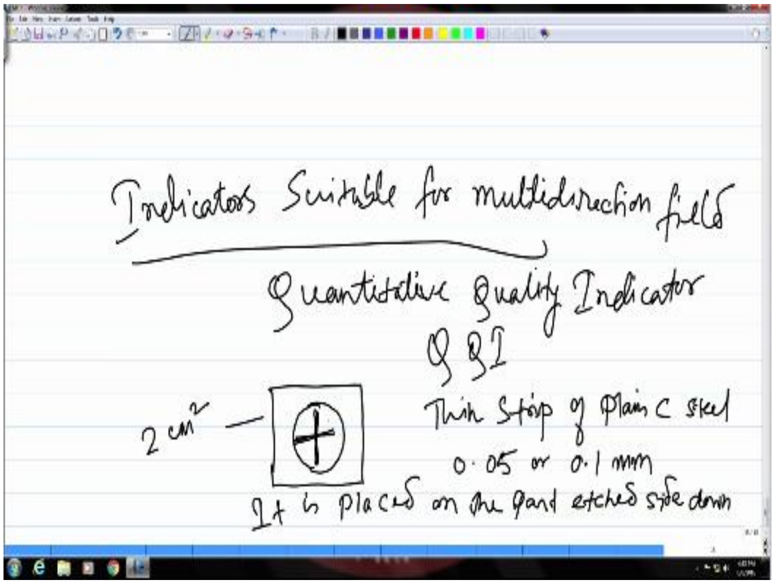

So in those cases you need the indicators which are suitable for multiple direction or multidirectional fields okay. And this kind of indicators which are used for multi directional fields are also sometimes referred as quantitative quality indicators or QQI in short okay. So that means in this case you need some feature on the indicator which can indicate the direction of the field in different directions okay.

So that means you need to emboss some kind of pattern on the indicator in order to do that okay. For example, you might have very thin strip of a permeable magnetic material like this, so it could be for example a thin strip of plain carbon steel and thickness could be in the range of 0.05 or 0.1 mm so it is very thin strip of the highly permeable magnetic material like a plain carbon steel.

And on this you have to emboss some kind of pattern H out some kind of pattern in order to identify the magnetic field in different directions. For example, you could emboss a pattern like this for example, like this okay. This is one example but you could H out different kind of patterns based on you know what kind of magnetic field you are applying or how many directions you want to apply and so on.

So depending on the requirement this pattern can be varied and different kind of patterns can be etched out on this a thin strip of metal okay. So this could be typically 2cm^2 in terms of the size of the area and like the previous case it is placed on the part 8 side down. So the flat side will be up because here also the other side of this is flat there is no pattern so the other side would indicate this pattern whatever pattern you have on this side when you magnetize it and then apply the magnetic particles okay.

So based upon that indication whether the indication is strong enough or not you would get an idea about the magnitude of the magnetic field being applied and since you have etched out some kind of pattern in different directions this will also indicate that the field you would be able to know the directions for multi-directional field also that is why I said in the beginning that these are suitable for multi-directional kind of field.

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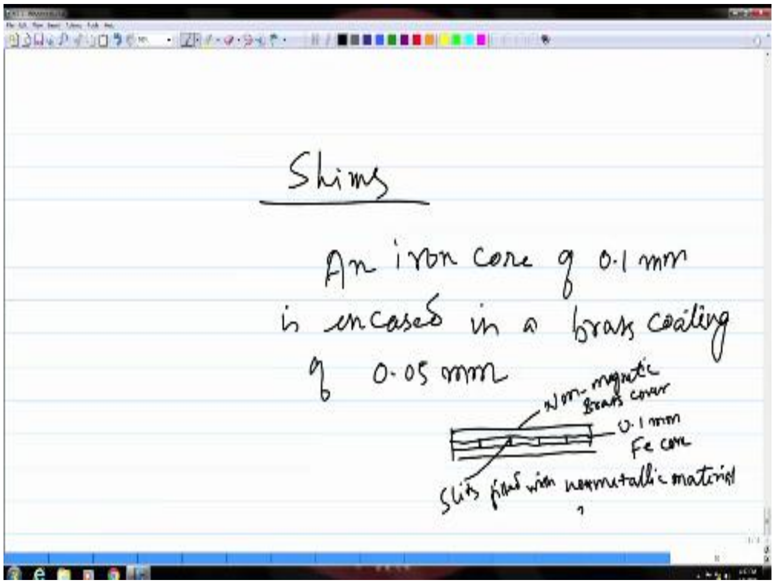

Then you have something called this is again part of the same similar kind of field indicators and these are known as shims. So it could be like a thin strip of magnetic material again which is covered by a non-magnetic material okay. For example, an iron core of 0.1mm is incased in a brass coating okay. So this ferromagnetic iron core is coated by a thin brass casing, so it is the magnetic core is quoted by a non-magnetic material like brass of around 0.05 mm thick okay.

And then you could cut out some slots in this okay and fill those slots with non-magnetic material again and like the previous case these slots will act as artificial flaws and they can be used to make indications and get an idea about the magnitude of the magnetic field which is being applied okay, so this if you see in the cross-section it might look like this so inside this you have a thin iron core like this okay, so inside you have this 0.1 mm iron core and outside is a non-magnetic material like brass, okay.

And then you can cut out some small slots like this okay, of different width so these slits that you have these are filled with the nonmetallic material so this leads we lean will act as artificial flaws and when you magnetize this whole thing they will make indications by attracting the magnetic particles and that is how they will make feasible indications and give you an idea about the magnitude of the magnetic field or the magnetizing current which is being applied to magnetize the part, okay.

So this is how with the help of different kinds of artificial flaws which are cut out or which are etched out on this field indicators you would be able to know the magnitude of the field and in some cases as you have seen you would also be able to know the direction of the field and both are important, okay.

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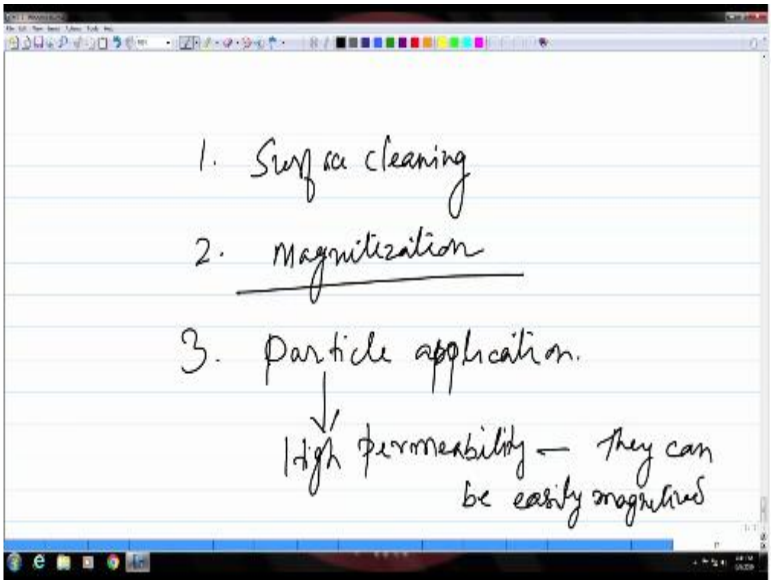

So let us see in what stage we are for this particular technique on magnetic particle testing so the first one was surface cleaning okay, then magnetizing and in this magnetization we have seen different methods and we have also learned about little bit about the theory of magnetism which is needed in this case and then you saw how a field indicator can indicate the magnitude and the direction of the field which is being applied to magnetize the part, okay.

So the next step will be to now apply the magnetic particles okay, now the part is magnetized and with the help of some kind of field indicators you have also ensured that the magnetic field is enough to magnetize it and now you can go ahead and apply the magnetic particles for them to make visible indications of flaws or defects if they are present on the surface, okay. So you take some magnetic particles which have high magnetic permeability, so particles the properties that they should have is high permeability, okay.

This is the first requirement is the first property that they should have high magnetic permeability so that they can be easily magnetized. Even if the magnetic field is small because most of the time they are supposed to be magnetized by the small leakage field around the discontinuities, okay so that much small magnetic field should also be enough to magnetize them so that they can go and sit around this defects and make visible indications, okay and that is why this would have a high permeability.

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And the other property that these magnetic particles should have is a low coercive field and also low retentivity okay, because if they have high retentivity then they will be heavily magnetized and they will tend to stick on the surface, okay and their mobility will be affected in the first place and the other adverse effect that you will have is they will stick to the surface and tend to accumulate and form some kind of unwanted pattern on the surface, okay so this is why this would also have this low retentivity property so that they will be magnetized.

But at the same time they would still be mobile on the surface and this would be uniformly distributed over the surface and only when there is a discontinuity or crack they will go and accumulate around the discontinuities and make visible indications, okay. So this is the other property that these magnetic particles should have this would have a low coercive field and a low retentivity so that they are mobile on the surface and they do not accumulate unnecessarily on the surface.

And there are two types of particles which are in use, one is you can use dry particles and you can also use this particles in some kind of suspension and these dry particles can also be coated with some color for enhancing the visibility like they are coated with brown color or some reddish color or sometime yellow color also so that when they when you do the inspection the visibility is better okay, and in wet suspension you need to take these magnetic particles.

In some kind of low viscosity liquid which can easily flow over a surface without any difficulty and provide mobility to these particles so this liquid that you use to suspend the particles will act as a carrier for the particles for them to get distributed uniformly over the surface, okay so that is the purpose of using wet suspension because they will have certain advantage particularly in terms of the mobility of the particles and the uniformity, okay.

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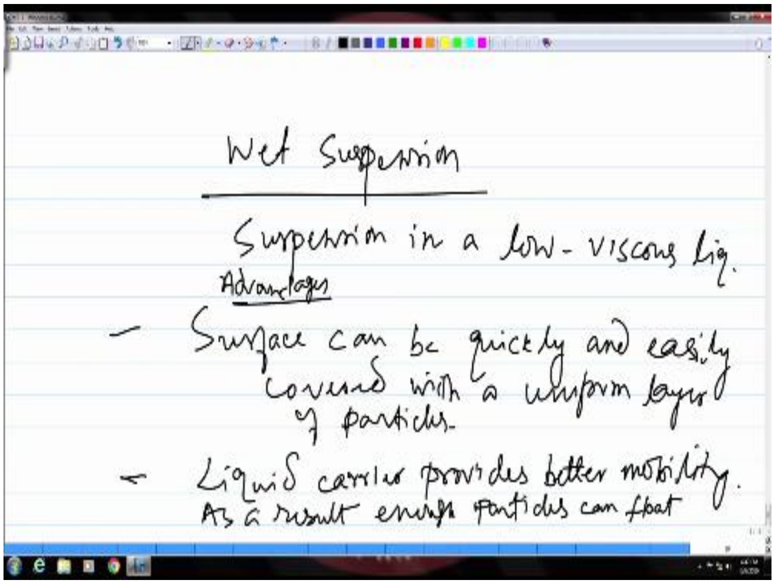

Suspension in a low viscous liquid so some petroleum liquid like for example, kerosene can be used because it satisfies the property requirements like low viscosity uniformity welding and soon, okay so that kind of petroleum liquid can be used to make the suspension and it has many advantages over dry particles as I said for example, the surface if you look at the advantages, okay, the surface can be quickly and easily covered because the liquid acts as the carrier as I said and provides mobility to the particles.

And as a result the surface can be quickly and easily covered by the particles, and it will also provide a uniform layer and as I said this liquid carrier provides better mobility and as a result enough particles can flow to small liquid-filled okay, because it is important not to miss on the smaller defects because if the defect is very small there is a chance that you might miss them so this particle should also be mobile enough to move to this small leakage field or to the smaller defects.

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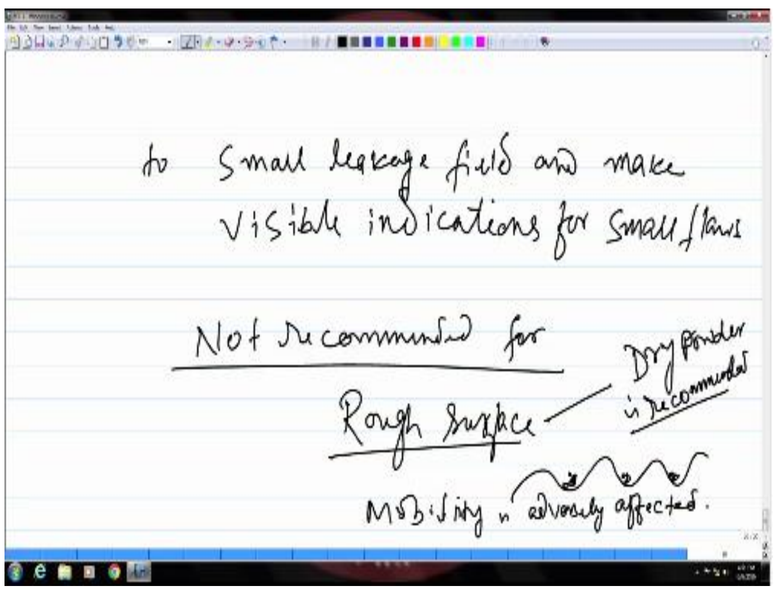

Can float to small liquid-filled and make visible indications for small flaws, okay so these are some advantages that you have when you use a weight suspension rather than dry particles, but in case of certain scenarios these weight suspension or weight particles are not recommended for example, not recommended wet suspension is not recommended for a rough surface. So if you have high surface of ness like you have lot of undulation on the surface, okay so then this kind of weight particles are not recommended because in that case in these values that you have, okay these particles will tend to segregate along these values.

So their mobility will be affected okay, mobility is adversely affected because these particles would tend to segregate along the valleys on a rough surface. So for a rough surface dry particles are always recommended, okay. Because in that case you do not have this problem of particles being settled down at the values okay, so if you have a rough surface like for example the surface of a casting many of the parts okay, made by casting.

So as cast surface if you want to inspect then it is recommended that you use dry particles particularly when you know that the surface has roughness or it has lot of undulations okay, so in that kind of cases in that kind of scenario it is better to use dry particles rather than wet particles, okay.

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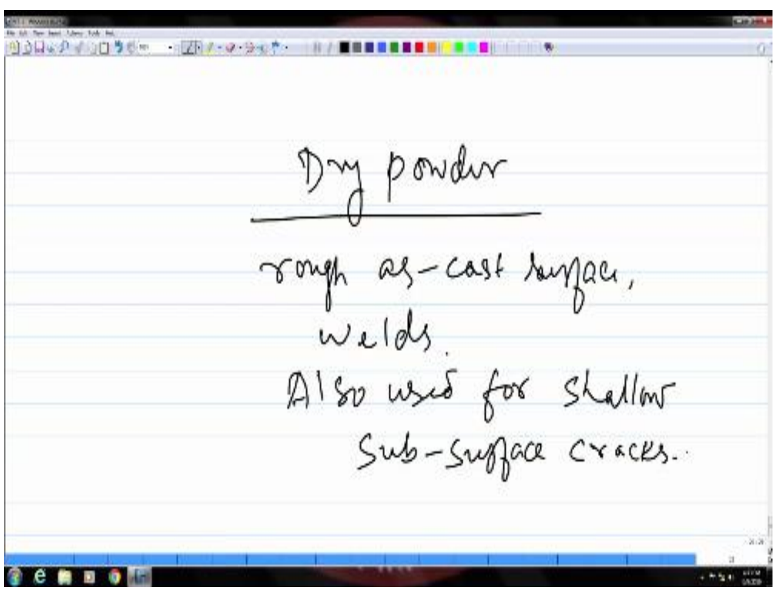

So if you talk about the dry powder it is good for rough surfaces like rough as cast surface also recommended for wells because there again you have a very rough surface as such on the weld itself if you do the inspection then the weld is very rough so there again dry particles are useful and they are also used for shallow subsurface cracks, so magnetic particle testing I should tell you at this point can also go little below the surface to the level of subsurface, okay. In case of the previous technique the dye penetrant testing we saw that it is mainly limited to the surface.

But in this case since the magnetic field can penetrate particularly when you are using a DC current it can penetrate the cross-section, so in this case you would also be able to do apart from the surface you would be also able to do some subsurface inspection also by magnetic particle testing, so this is one of the advantages that this particular technique offers over other surface NDT methods, right.

So this was about the third step which is applying the particles you could either use wet particles or dry powder and it primarily depends on whether to use dry powder or wet particle that primarily depends on the condition of the surface, okay as we just now discussed, okay and like you have different methods for magnetizing the surface there are few methods for applying the particles also which you are going to take up in the next lecture, okay. So we will see what different methods are available for applying the particles particularly the wet particles okay, so for today this is all I have I will stop here today I will see you next time.

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