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Theory and Practice of Non Destructive Testing

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Magnetic Particle Testing - 3

So, let us continue on this topic that we started in the last class. Last couple of classes, we have been talking about this topic on 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.

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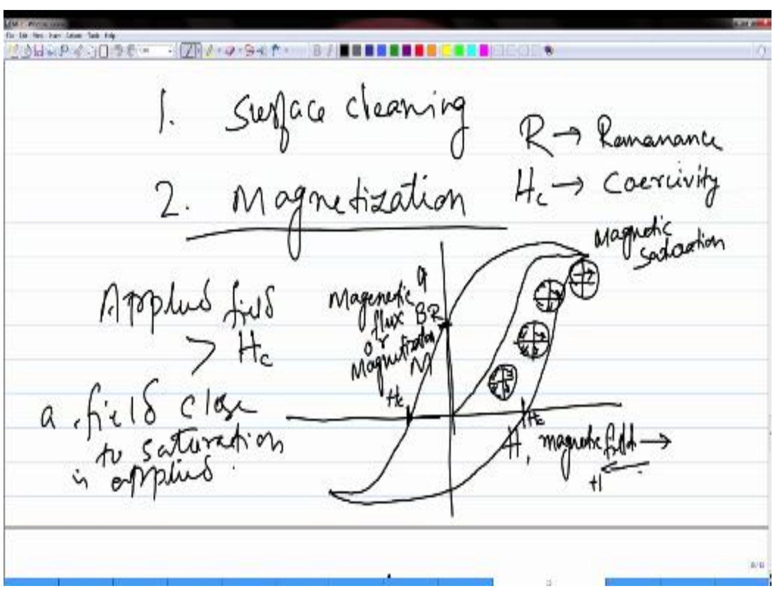

So, this is what, we discussed in the previous class, which was about magnetizing the surface and then, we saw that in terms of the magnetic field, which is needed to magnetize the part, you need to consider the magnetic property of the magnetic hysteresis loop of that particular material, which is being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

And many times, a field close to the saturation is applied to magnetize the part. So, magnetic properties of the material which play a role in this case are remanence or the retentivity and the coercivity. So, these are the two properties which are important for magnetic particle testing.

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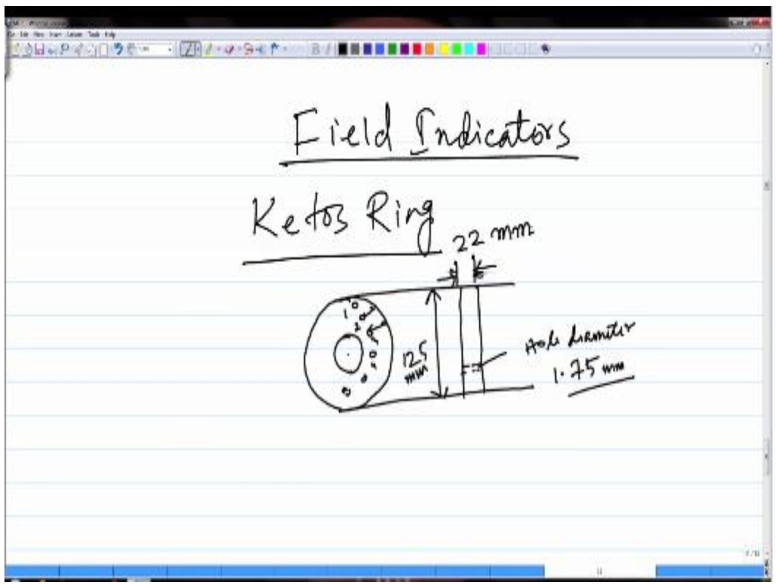

So, while doing the test, you do not know, what actually is the magnitude of the field, which is being applied? So, in that case, you need some indicators which will indicate whether the field is optimum or whether the field is enough or not, in a qualitative manners.

So, these are called field indicators and one of them, which is known as ketos ring, this 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 smaller holes, that you have along this circumference, these smaller holes, 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, you can say whether the magnetic current which is being applied is enough or not.

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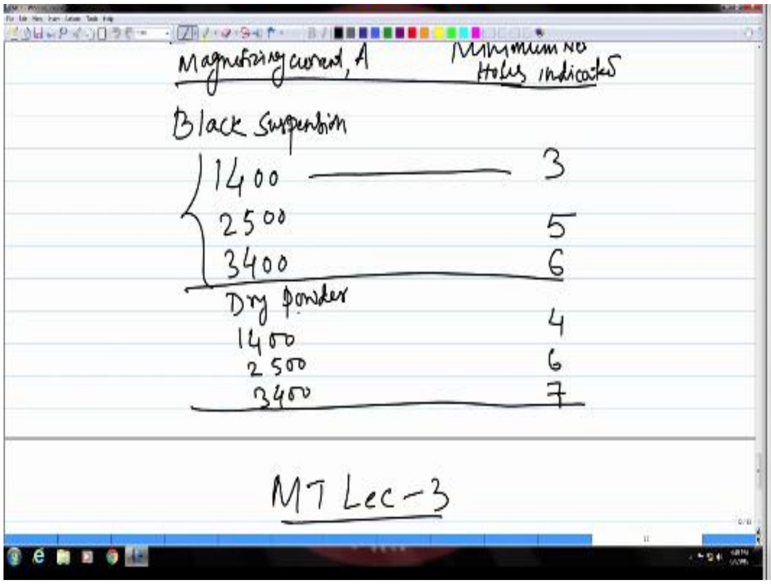

And this is how with the help of this kind of table and chart, you would be able to know, what should be the minimum number of particles; it should be indicated for a given magnetizing current. And it also depends on what types of particles are used, whether you are using a suspension or you are using dry powders.

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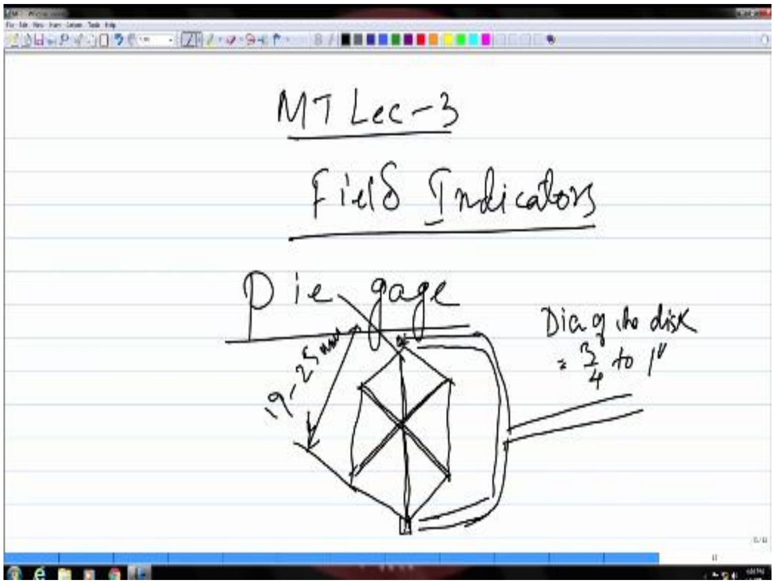

So, let us continue on that. So, one of the field indicators we have seen but we have couple of more to talk about. The next one that we have is called a pie gage and this is again a small coin, which is made of a highly permeable magnetic material and this coin can be divided into six or eight parts.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

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. 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.

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. 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 dia of this disk is around three fourth to one inch.

So, that is a typical size you have. So, now if you say that this dia is around 19 to 25 mm or three quarter to one inch.

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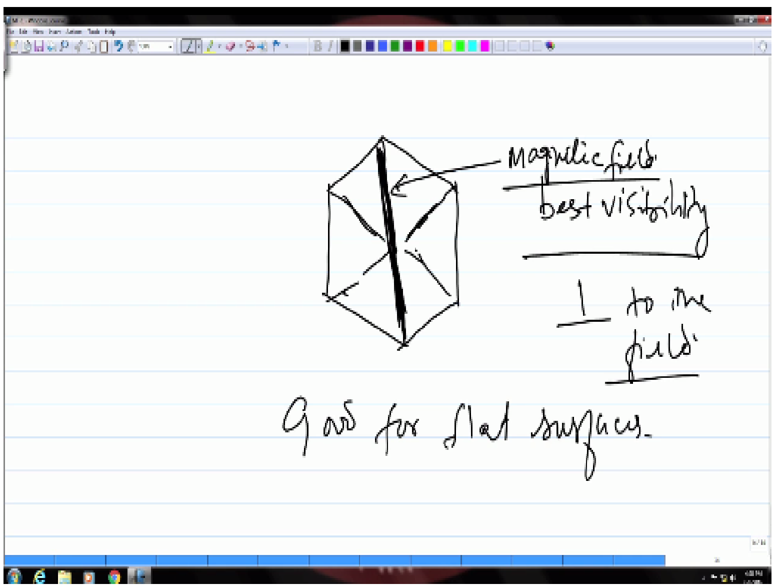

And then, these slots you have, so when you see the other surface, the other side of this, it is completely flat. So, this is what you will see on the other side of this pie gage. There is no slot or anything on this surface. So, you keep this offside down, that means a slotted side will be down and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

And you may also see that along a particular slot, more numbers of particles are being attracted compared to other slots. 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.

So, this particular field indicator not only indicates the magnitude of the field, but it also 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. So, 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.

So, this is also helpful in identifying the direction of the field, because that is also important in magnetic particle testing. 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.

So, this one is good for flat surfaces. So, if you have a complex geometry in the part, then it may be needed to magnetize the part in multiple directions, because 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.

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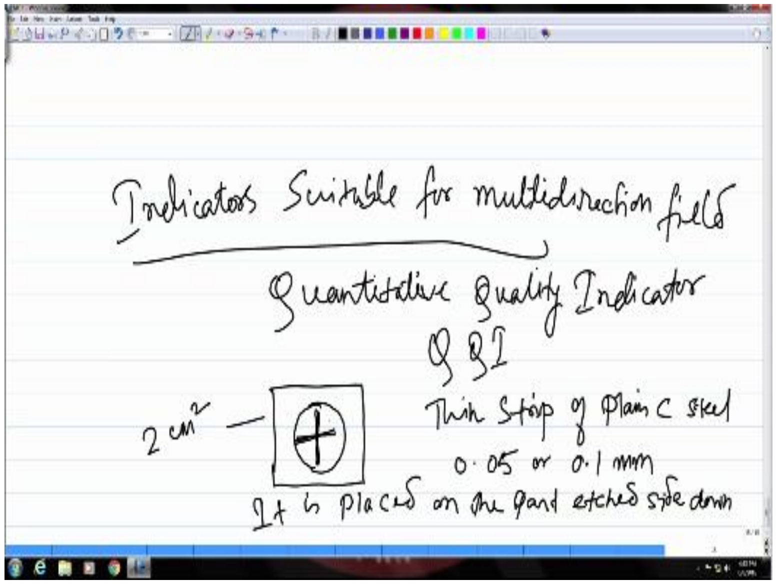

So, in those cases you need the indicators which are suitable for multiple directions or multidirectional fields. And this kind of indicators which are used for multi directional fields are also sometimes referred as quantitative quality indicators or QQI, in short. So, that means, in this case, you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

So, that means, you need to emboss some kind of pattern on the indicator, in order to do that. For example, you might have very thin strip of a permeable magnetic material, so it could be 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, etch out some kind of pattern, in order to identify the magnetic field in different directions. For example, you could emboss a pattern like this. This is one example, but you could etch out different kind of patterns, based on 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. So, this could be typically 2 cm^2 in terms of the size of the area and like the previous case, it is placed on the part etched side down. So, the flat side will be up, because 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.

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 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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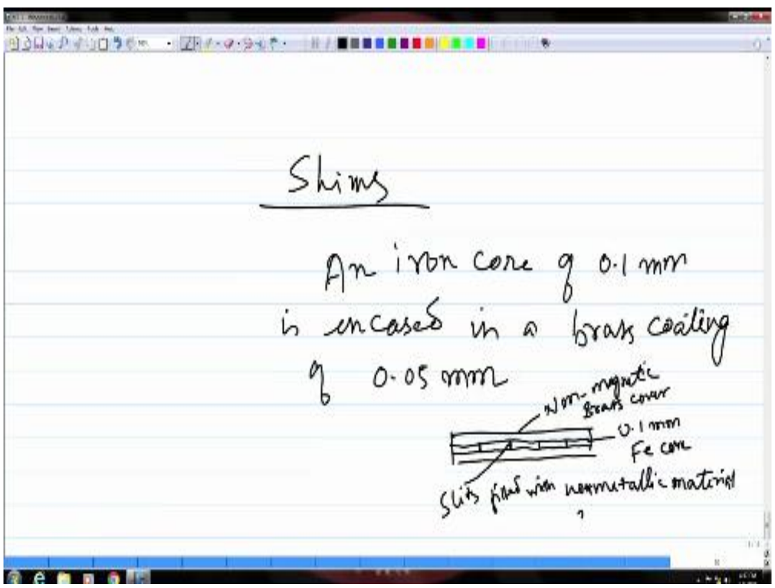

Then, you have something called, this is again part of the same similar kind of field indicators, and these are known, as shims. So, it could be like a thin strip of magnetic material again, which is covered by a non-magnetic material. For example, an iron core of 0.1mm is encased in a brass coating.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

And then, you could cut out some slots 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. So, if you see in the cross-section, it might look like this, so, inside you have this 0.1 mm iron core and outside is a non-magnetic material like brass.

And then you can cut out some small slits like this, of different width. So, these slits that you have, these are filled with the nonmetallic material, so, these slits 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 visible 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.

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.

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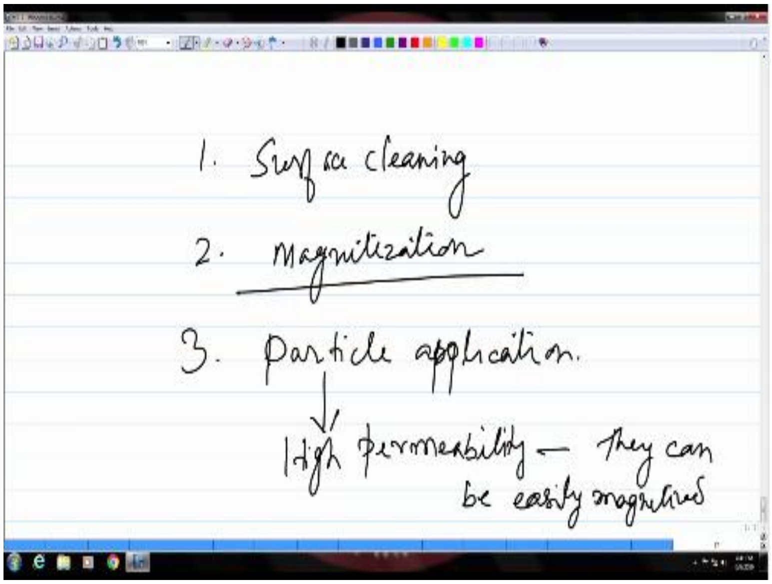

So, let us see, in what stage we are for this particular technique on magnetic particle testing. So, the first one was surface cleaning, then, magnetizing and in this magnetization, we have seen different methods and we have also learned about the theory of magnetism, which is needed in this case and 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.

So, the next step will be to now apply the magnetic particles. 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. So, you take some magnetic particles, which have high magnetic permeability.

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, so that much small magnetic field should also be enough to magnetize them, so that they can go and sit around these defects and make visible indications 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. Because if they have high retentivity, then, they will be heavily magnetized and they will tend to stick on the surface 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.

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. So, this is the other property that these magnetic particles should have, they 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 these 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 you do the inspection the visibility is better. 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. 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.

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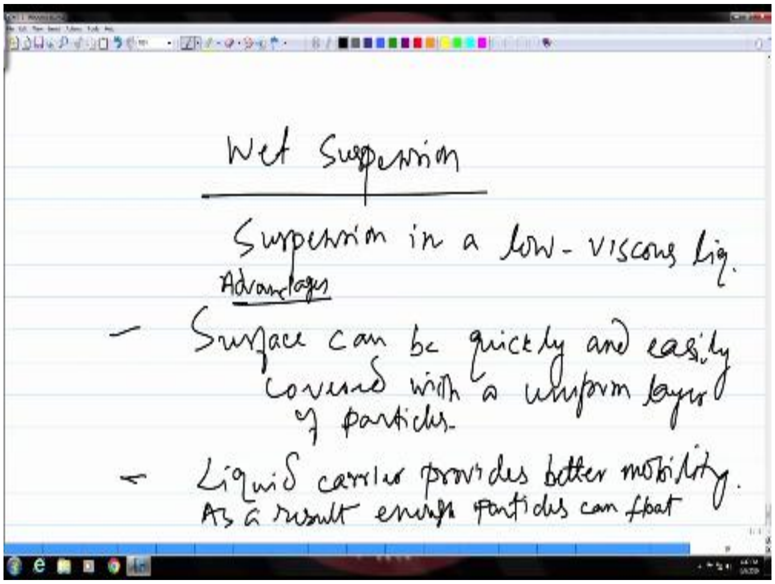

Suspension in a low viscous liquid, so, some petroleum liquid, for example, kerosene can be used because it satisfies the property requirements like low viscosity, uniformity, wetting and so on. So, that kind of petroleum liquid can be used to make the suspension and it has many advantages over dry particles, for example, if you look at the advantages; the surface can be quickly and easily covered because the liquid acts as the carrier 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 this liquid carrier provides better mobility and as a result enough particles can flow to small leakage field. 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 these particles should also be mobile enough to move to this small leakage field or to the smaller defects, can float to small leakage field and make visible indications for small flaws.

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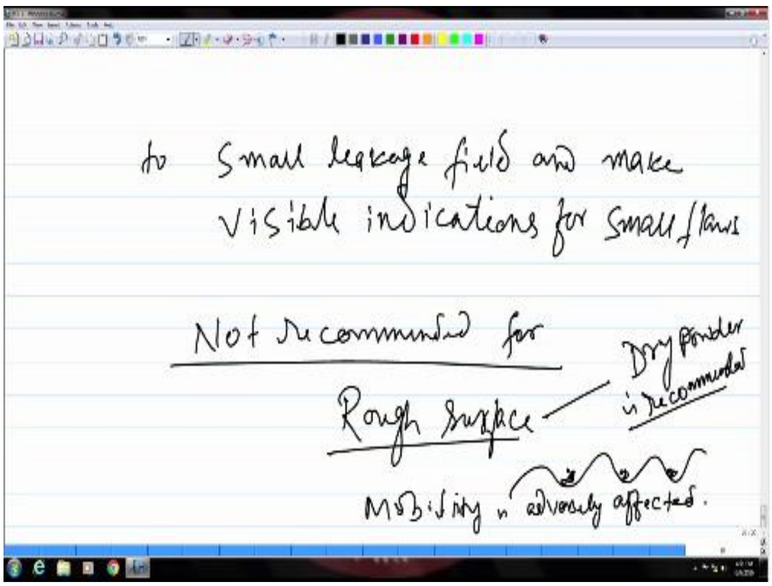

So, these are some advantages that you have, when you use a wet suspension rather than dry particles. But in case of certain scenarios, these wet suspension or wet particles are not recommended for a rough surface. So, if you have high surface roughness, like, you have lot of undulation on the surface, so then, this kind of wet particles are not recommended because in that case, in these valleys that you have, these particles will tend to segregate along these valleys.

So, their mobility will be 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. Because in that case, you do not have this problem of particles being settled down at the valleys. So, if you have a rough surface, for example, the surface of a casting, many of the parts, 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. So, in that kind of cases, in that kind of scenario, it is better to use dry particles rather than wet particles.

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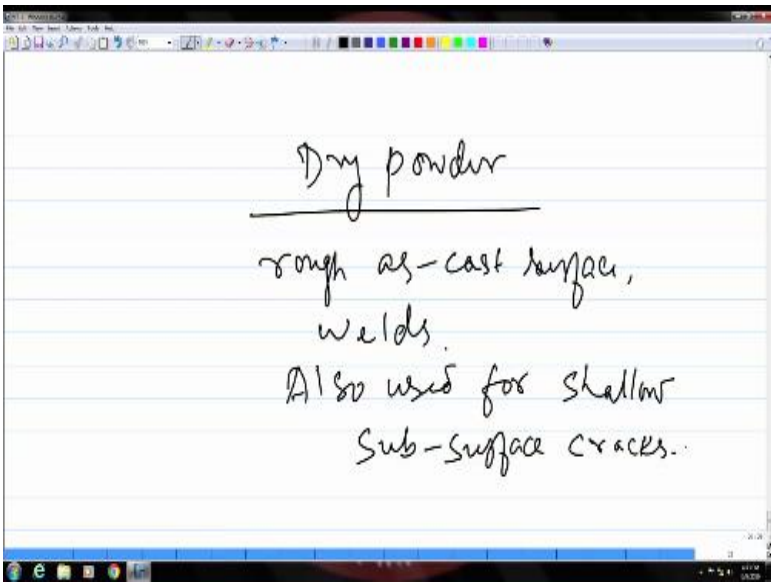

So, if you talk about the dry powder, it is good for rough surfaces, like rough as cast surface, also recommended for welds, because there again, you have a very rough surface as such on the weld itself. If you do the inspection then the weld is very rough. So, there again dry particles are useful and they are also used for shallow subsurface cracks. So, magnetic particle testing can also go little below the surface to the level of subsurface. 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, 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.

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

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