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Theory and Practice of Non Destructive Testing

Dr. Ranjit Bauri
Dept. of Metallurgical & Materials Engineering
IIT Madras, Chennai 600 036

Magnetic Particle Testing - 4

We are on this topic of magnetic particle testing. So far we have had three lectures on this particular topic and today will be the fourth lecture on this topic. So, let us continue from where we left it in the last lecture. So, if you recollect in the last class, we discussed about the types of particles, which are used and the properties of these magnetic particles that are used for magnetic particle testing.

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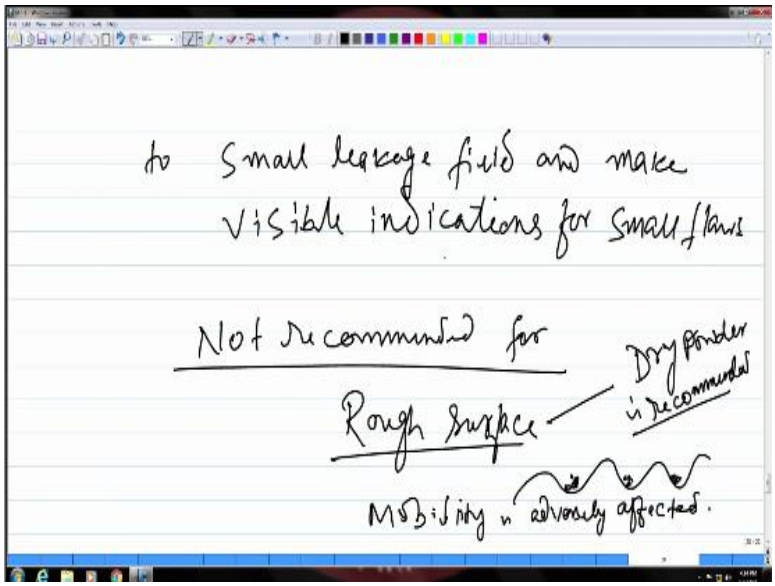

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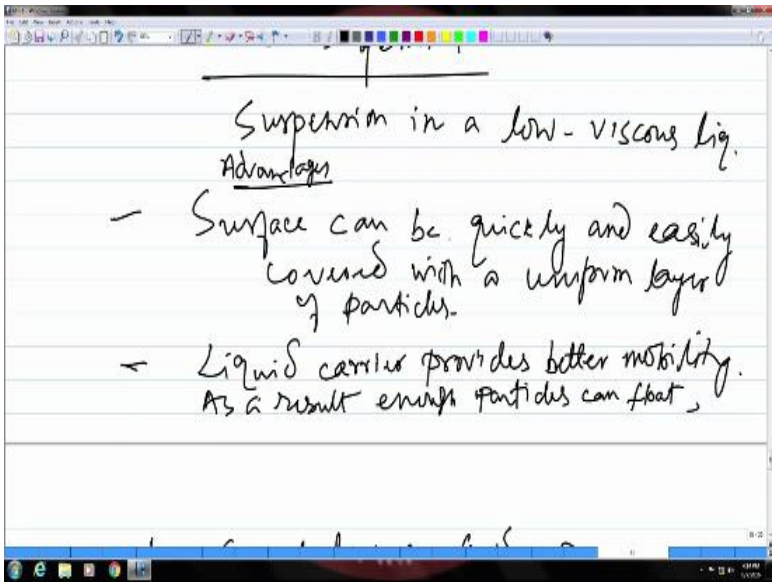

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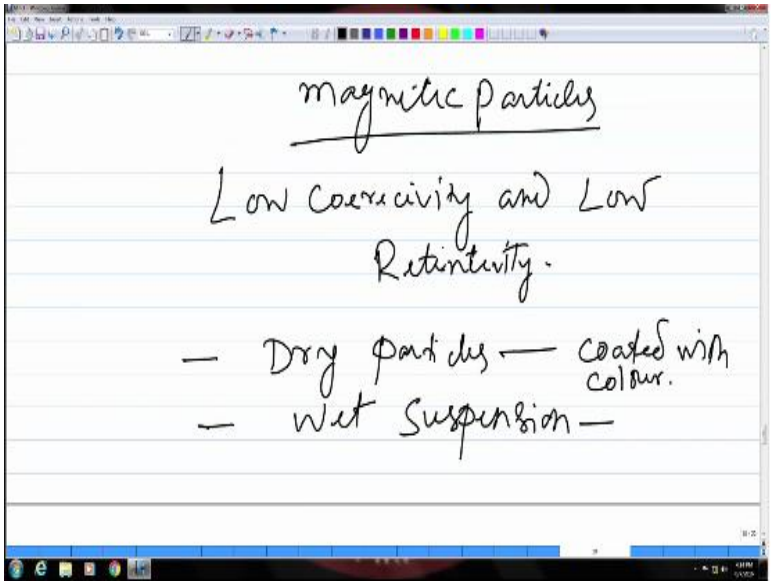

So, let us take a quick recap, as we always do, before proceeding today. So, these are the typical properties that these magnetic particles should have.

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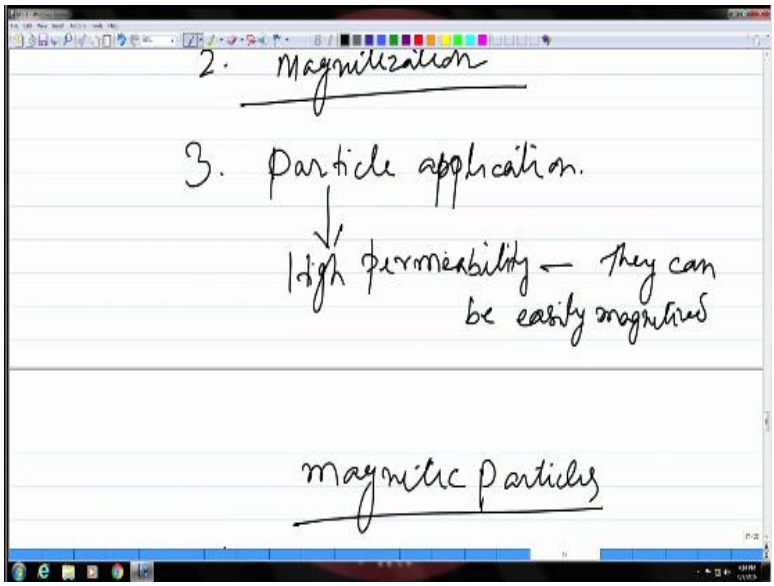

Any particle which have high magnetic permeability, like iron particle, for example, can be used for doing magnetic particle testing.

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Apart from high permeability, they should have low coerecivity and low retentivity also and the reasons behind these property requirements, we have already discussed in the last class. And

then, we saw that two types of particles are generally used, either wet suspension in some low viscous liquid or these particles can also be used as dry powders, depending on the surface condition.

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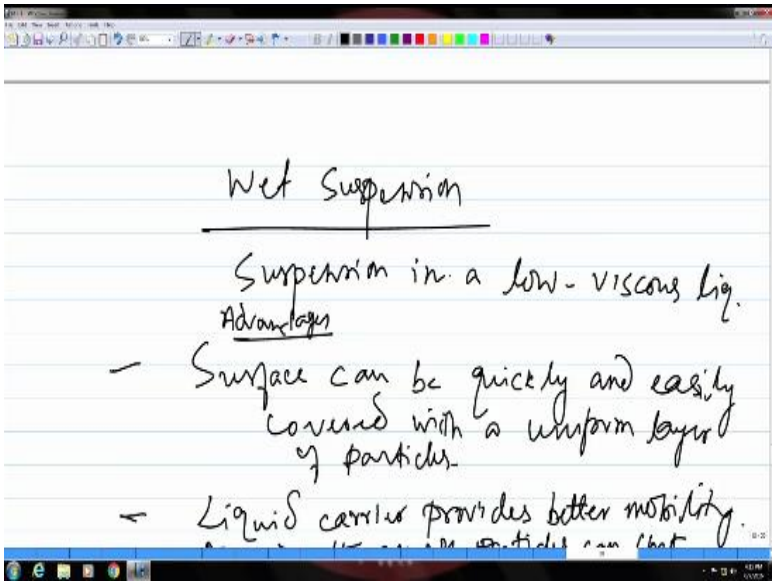

And this wet suspension has certain advantages over the dry powder and in certain cases, where the wet suspension cannot be used, like a rough surface, in those cases a dry powder is recommended.

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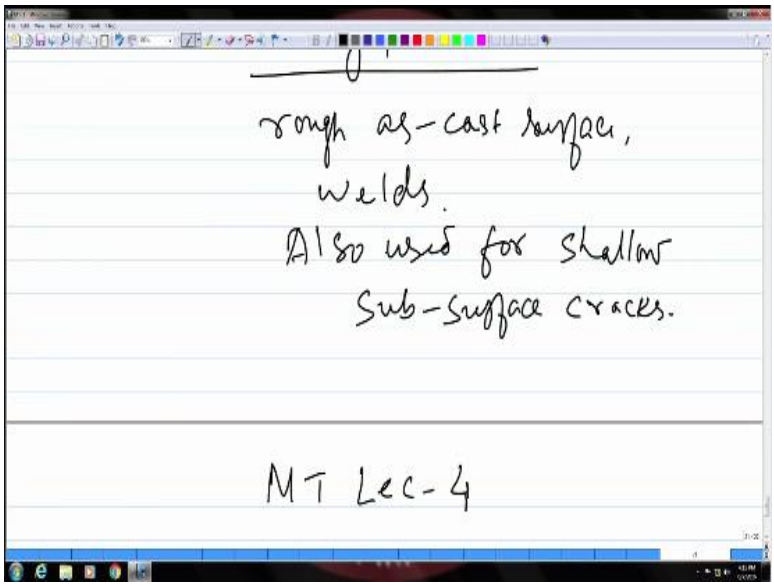

And the dry powder is also useful for doing shallow subsurface cracks, apart from the surface cracks. This dry powder can also be used for doing some subsurface inspection. So, let us continue today.

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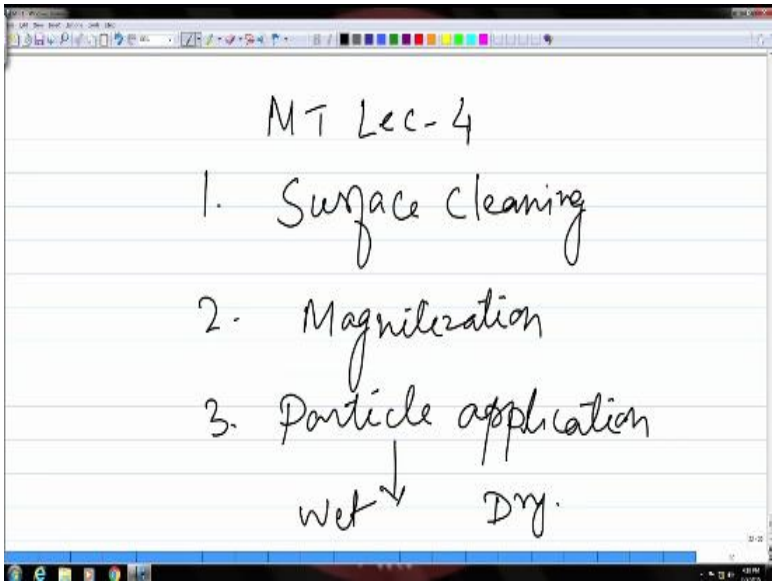

We have, so far, covered these three steps, surface cleaning, then magnetizing and once the part is magnetized, you apply the particles and in this, we saw there are two types, wet and dry, which are used depending on the surface condition.

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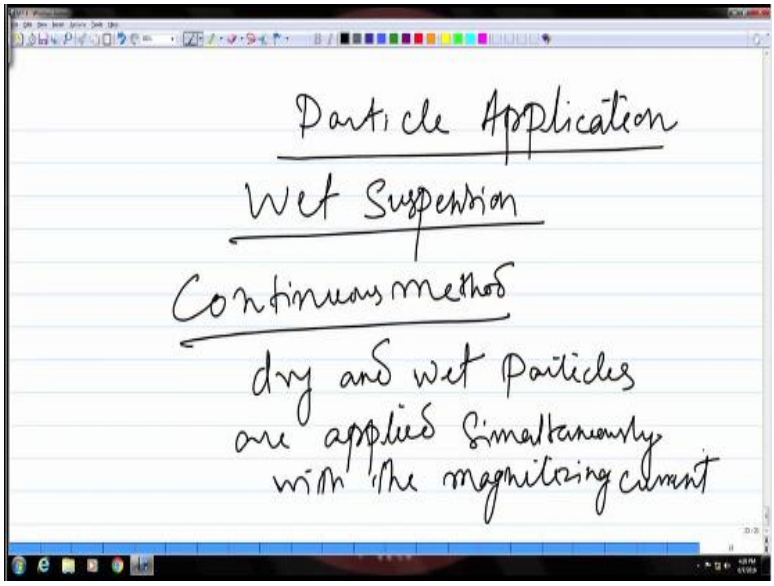

We talked about how these particles are applied during the testing. There again, you have certain methods by which you apply the particles, depending on, what is the requirement in the test or what kind of part you have and so on. When you talk about the wet suspension, there are two or three ways by which you can apply, depending on what exactly is the requirement. First is continuous method and this can be used for both dry and wet. So, dry or wet particles are applied simultaneously, when the part is being magnetized, with the magnetic field or the magnetizing current.

So, that is why this is known as continuous method because the particles are being applied continuously, when the part itself is being magnetized or when the magnetic current is on, you apply the particles, simultaneously. So, this is continuous method.

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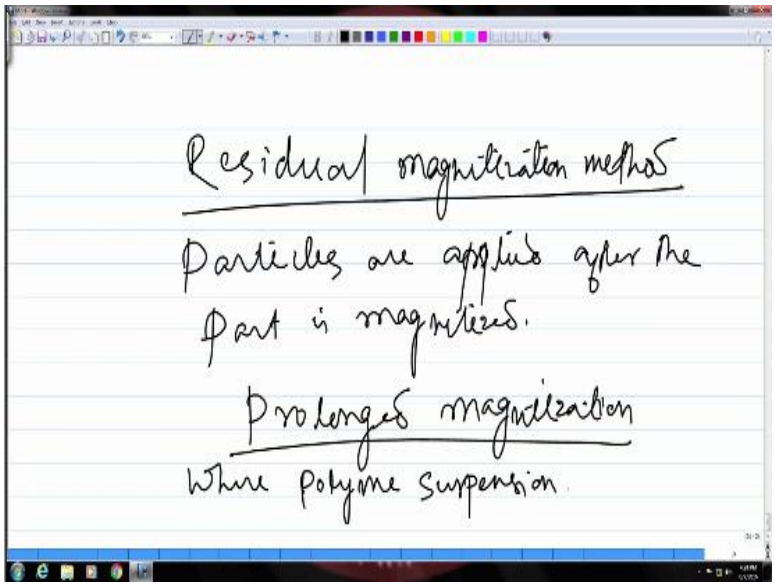

Next is the residual method. So, as the name suggests, in this case it depends on the residual magnetism, which is left behind once the magnetizing current is switched off. So, that means particles are applied after the part is magnetized. So, first you switch on the magnetizing current, which will generate the magnetic field and magnetize the part. Once the part is magnetized then, this magnetizing current is switched off and after that you apply the particles. So, that means whatever residual magnetism is remaining on the part, based on that these particles will be attracted to the surface and to the flaws.

So, in this case, particles are applied after the part is magnetized. So, these are very similar type of methods. Only difference is, in one case the magnetic current is on and in the other case, when you apply the particle, the magnetic current is not on. And then, there could be cases wherein you may have to use a different kind of suspension, which is more viscous, for example, if you want to inspect some overhead parts, in those cases you may not be able to use a low viscous liquid because it will not stay on an overhead part.

So, in cases like that, where low viscous liquid cannot be used, then you have to use a viscous liquid, which can stay on an overhead part. So, since in that case, the viscosity is high and the

mobility of the particles is low, you need to do the magnetization for a prolonged time. So, that is why that method is known as prolonged magnetization, wherein you use highly viscous suspension, like a polymeric suspension or some slurry, paint etc. are used. Since the mobility in that case is highly limited, you need to do the magnetization for a prolong time.

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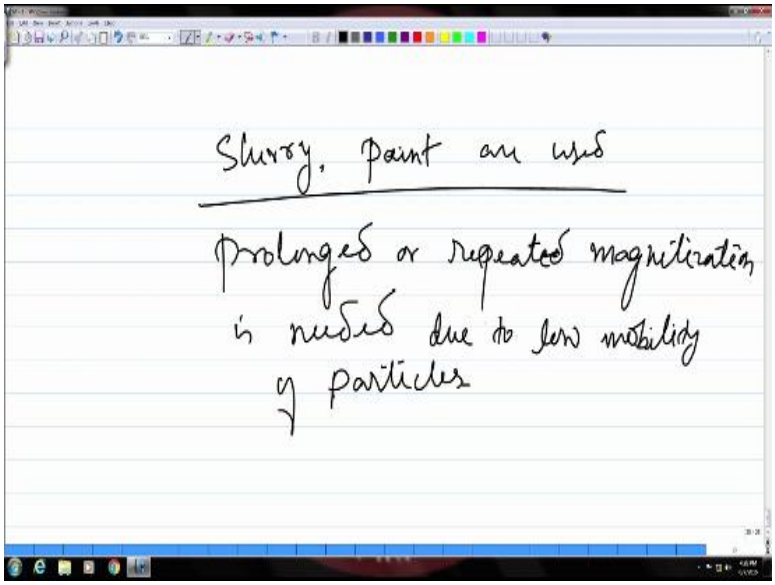

So, this is the third method that we have for wet particles and the first one, we have seen, which is the continuous method that can be used for both wet and dry.

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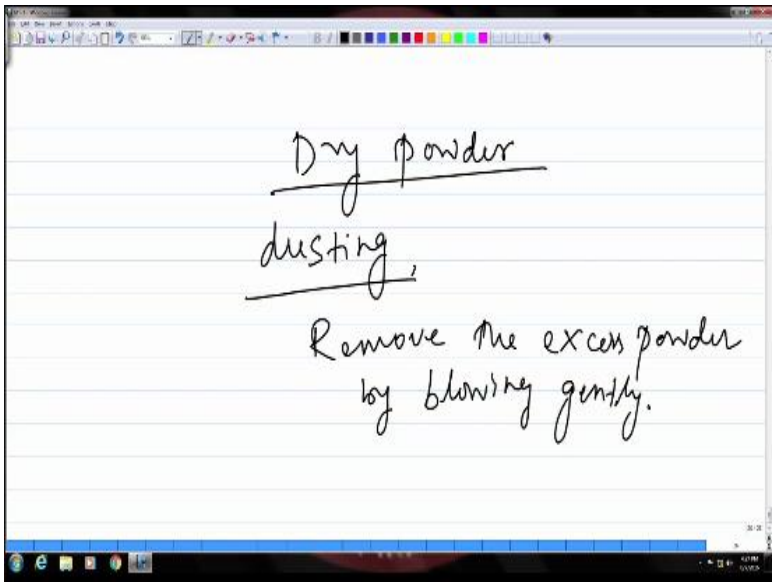

Now, if you talk about the dry particles as such, they can be applied by dusting. So, you simply take the powder and dust it over the surface and then, in this case, since you do not really have too much of control on the dusting, so, there could be excess powder on the surface. So, it is better to remove the excess powder by gently blowing it, so that you have a uniform layer of powder. So, you should remove the excess powder by blowing gently. So, you can use those small handheld blowers, wherein one side you have a small rubber pump kind of thing, which can be pressed and once you press it, you can blow it.

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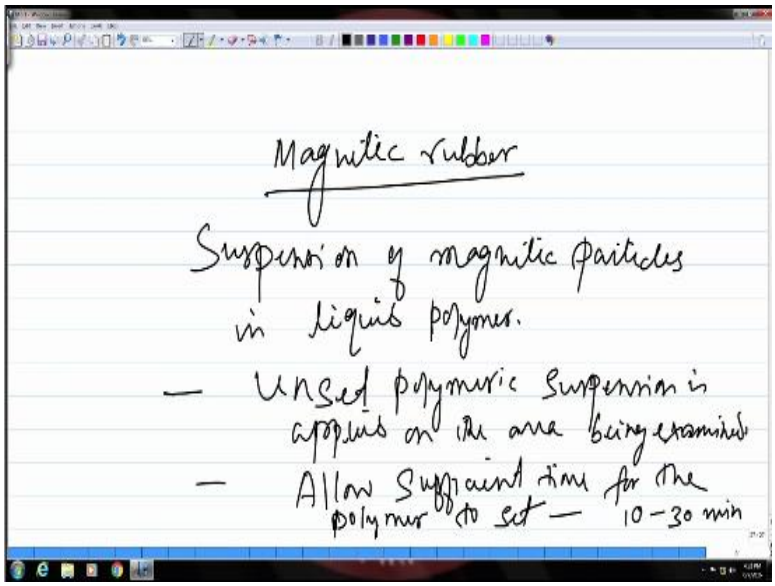

So, using that, you can blow the excess powder from the surface. There is one more thing that I should tell you here, something known as a magnetic rubber. So, just now, we talked about a thick viscous liquid, which is sometime used for parts like overhead parts. In certain other cases, wherein the inspector does not have direct physical access., to the part which is being examined., where the physical access is limited, for example, if you want to inspect the inner diameter of a bolt-hole, so, in those areas, you do not have direct physical access and hence you cannot apply the magnetic particles, like the way you do it on an external surface.

So, in those kinds of cases, you need to use a suspension, which is known as a magnetic rubber and this will help you out to inspect this kind of areas, where you do not have physical access. So, let us see how does this work and in what way it helps you in examining those kind of areas.

This is basically a suspension of magnetic particles in a liquid polymer, so, like the magnetic slurry or the magnetic paint that we talked about before. This is highly viscous slurry, highly viscous suspension, so this has liquid polymer, which contains the magnetic particles in a suspension. So, now this liquid polymer, you can apply it on the part, on the inner diameter, for

example, that you are going to examine and allow some time for this liquid polymer to cure or to set. So, unset polymer is first applied, unset polymer which contains the magnetic particles, you apply it first on the part, on the area being examined, then allow sufficient time for the polymer to cure.

So, this setting time or curing time depends on what kind of part geometry you have or what is the size of the part that is being examined and it can vary anything between 10 to 30 minutes, depending on the size of the part. Now, once you allow this time, this polymer will cure and it will make a replica of the part on which it is applied. Now, since this polymer contains the magnetic particles also, so, if there are any flaws, these particles will be attracted to those flaws. So, this replica which is formed out of this set polymer will contain the impression of those flaws, it will contain the visible indications of those flaws due to the presence of the magnetic particles in this polymer.

So, that is how it works. It makes a replica and once this liquid polymer is solidified, it will also contract and because of this contraction, it will easily separate out from the part. So, you can easily take it out and then inspect that replica instead of inspecting the part itself. So, that is how you overcome the difficulty of physical access by making this replica.

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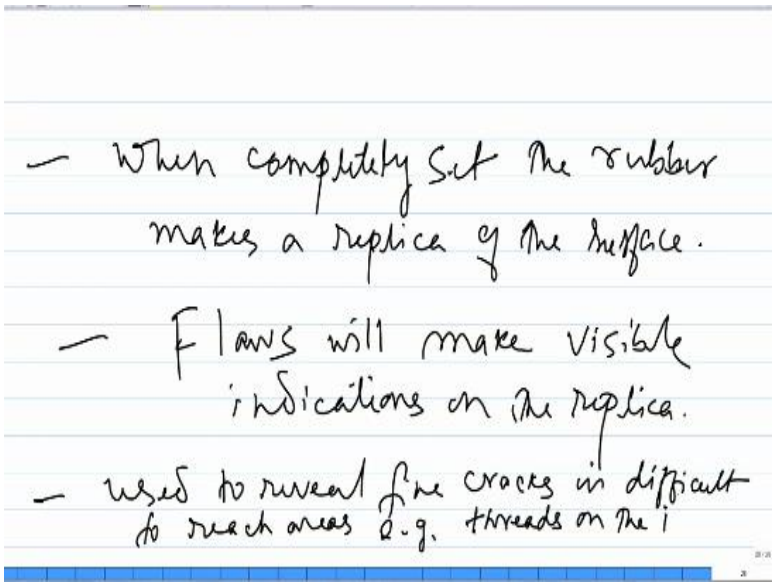

So, when completely set, the rubber or the polymer makes a replica of the Surface and flaws, if present, will make visible indications on this replica. So, this is how this magnetic rubber helps you out, in cases where the physical access is limited. So, by forming this replica, you would be able to overcome that difficulty and instead of examining the area itself, you can now examine and inspect this replica and if there are flaws they will be visibly indicated by this replica itself. So, this technique is useful for fine cracks in difficult to reach areas, like, threads on the inner dia of bolt holes.

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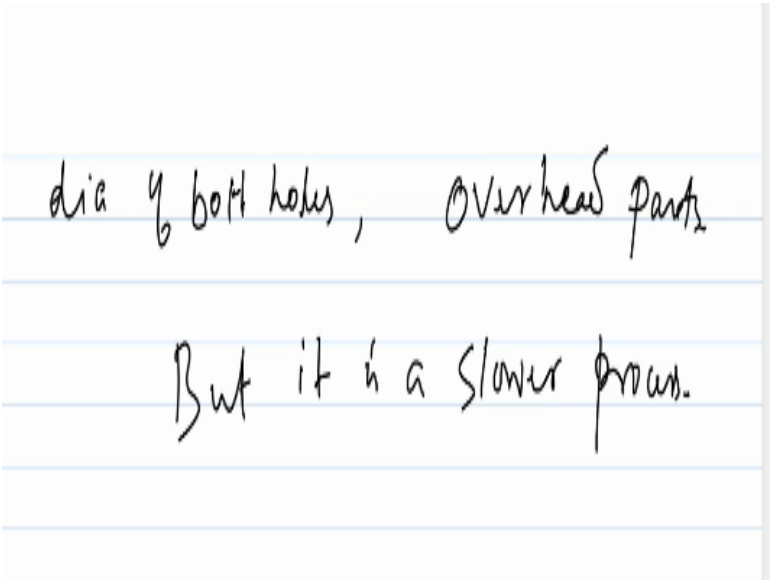

And also parts, where a normal low viscous liquid will not stay like overhead parts, there also, it is useful but this is a slower process, as you would have realized because of the presence of a highly viscous liquid and the low mobility of the particles due to that. So, that means that prolonged magnetization again comes into picture in this case as well. So, these are the different ways by which the magnetic particles can be applied and you can choose one of them depending on what kind of surface you have, what kind of parts you are talking about and what kind of areas, in terms of physical access, you want to examine and so on.

So, depending on your own requirements, one of these methods can be chosen. Now, let me show you a small video to demonstrate how this process works. So, this will again give you a practical feel of the whole process, as to how it exactly works and what is done during the process. So, this video again we have captured in our NDT lab at the department of metallurgical and materials engineering at IIT madras. So, let me show you that video.

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So, here it comes. So, if you remember, we talked about a device, an electromagnet, called yoke. So, this is a u-shaped electromagnet having two legs and in this case, you could see the legs are adjustable. So, you would be able to access the angles and the distance between them so that provides you more flexibility and there is a red switch, over here., which the examiner is pressing right now, to switch on the magnetizing current and then continuously, he is also applying the magnetic particles.

So, this is a black wet suspension, you have in this case, which is being applied.So, this is a reference block, which has some slots already, marked over it. So, this we have etched out in a particular pattern. So, this can be used to find out or this can be used as a field indicator, like what we have discussed before, to know whether the field that is being applied, whether it is enough or not and this can also indicate the direction of the field.

Because you have a particular pattern and you would be able to see in each particular direction the majority of the particles are going and accumulating. So, the perpendicular direction to that will be the direction of the field. So, this is what you could see here. I could see that in some of the slots in a particular direction, majority of the particles are trying to go.

And lying beside this, over here is the pie gage, which is like a coin, which can have six or eight sides. So, as you could see and you have this kind of slots, which are cut out precisely on this surface and other side of this is completely flat So, these slots, when you magnetize this pie gage will act as artificial flaws and on the other side, you could see their indications, as we are going to show you now. We are yet to use any sample, as of now, we are just trying to establish the magnitude of the magnetic field and the direction also, by using this field indicators.

And you can see, the part is sticking, it is being attracted to the electromagnet because it is being magnetized., and now you could see, majority of the particles are going into a particular direction and now if you see on the other side, which is completely flat but still you would be able to see the same pattern that you have on the other side, once it is magnetized and you apply the particles. Now, you see the same pattern, which is etched out on the other surface, can be seen on the flat surface also.

And in this case, you could see, as I showed by that finger, that is the direction of the field and most of the particles are going in a perpendicular direction. So, that is what indicates that the best visibility you have, when the orientation of the flaw is perpendicular to the direction of the magnetic field. So here also a little bit of surface cleaning is needed, as I would have mentioned before in the beginning to ensure that the particles have good mobility on the surface.

And now, he is magnetizing this pi gage. So, this is the flat side where you do not see any slot but as you magnetize and apply the particles, you would see the indications of those slots which are cut out on the other side. So this indicates that the magnitude of the field, which is being applied through this Yoke, is enough and you could see some of the slots are filled more, compared to the other slots, in a particular direction.

So, that again indicates the direction of the field, which will be perpendicular to the particular slot, which is having majority of the particles sitting inside it. Now, I will pick up some kind of part, which we know is defective and then we will show you, how this surface flaws, surface defects, are made visible by this magnetic particle testing.

So, this is a piece of a steel plate. Some big cracks, you could already see but that is not our concern right now, because they are already visible by the naked eye. We want to see if there is something else, which is not visible by the naked eye. So, it is being magnetized right now and continuously we apply the particles also. So, this is a continuous method of particle application. So, those big cracks you can see again but apart from that, now on this closer view, you would be able to see a lot of other cracks, for example here, which was not visible by the naked eye.

And again I would like to show you the orientation of this particular crack. So, this is one leg of the Yoke and the other leg is over here and if you connect these two legs by an imaginary line, like this., so that will be the direction of the field. And now you see, this crack is perpendicular to that direction. and it is giving a very strong indication. So, that again tells you how the orientation of a crack and it is how the visibility of a crack depends on its orientation and the best visibility you have, when it is perpendicular to the direction of the field.

So, there are a lot of cracks on this particular piece and we will also magnetize it from other directions also, so that we would be able to make visible indications for cracks, which are oriented in so many other direction. So, it is always advisable that you magnetize the part from different directions, so that you do not miss out on any crack, which are differently oriented in different directions and now it could see, as we have changed the direction of the field, lot of other cracks also are coming out.

So, it is advisable to magnetize the part in different directions. You could see lot of cracks in different orientation. This is differently oriented compared to this, then you have a big one over here and then again a perpendicular crack like this and then you have cracks which are at an angle close to 45 degree like this. So, that is why it is always better that you magnetize the part from different directions. This is another small part, again the same thing you could see being magnetized and the particles are applied.

And what you could not see by naked eye, now you could see again, you could see the directionality. So, these cracks are all in this direction, which is perpendicular to the direction which is connecting these two legs. So, this is the direction of the magnetic field, a line

connecting these two legs and these cracks are all perpendicular to that direction and that is why you get very strong indications of these cracks. So, this Yoke is a very useful device to magnetize parts like this and it is very flexible and easy to use, as you would have seen. So, this is how the whole thing is done. I hope this gives you a practical feel, as to how the whole process is done. and this is what I have today. So, I will stop here today. Thank you.

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