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NATIONAL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING

Tutorial - 2
Materials Characterization
Quantitative metallorgraphy

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Hello everyone welcome to this material characterization online course organized by NPTEL. In the last class we have just looked at some of the basic definition of quantitative microscopy. And then I just mentioned that the parameters which are used to quantify the micro structures namely all in fraction and bring phase and etc. So I stop the tutorial, first tutorial with the definition of An ASTM grain size and also the equivalent size number.

So I will just continue that tutorial class, I will just workout some of the numerical problem to give you a feel of what, how to calculate an An ASTM grain size number using those formulas which I mentioned.

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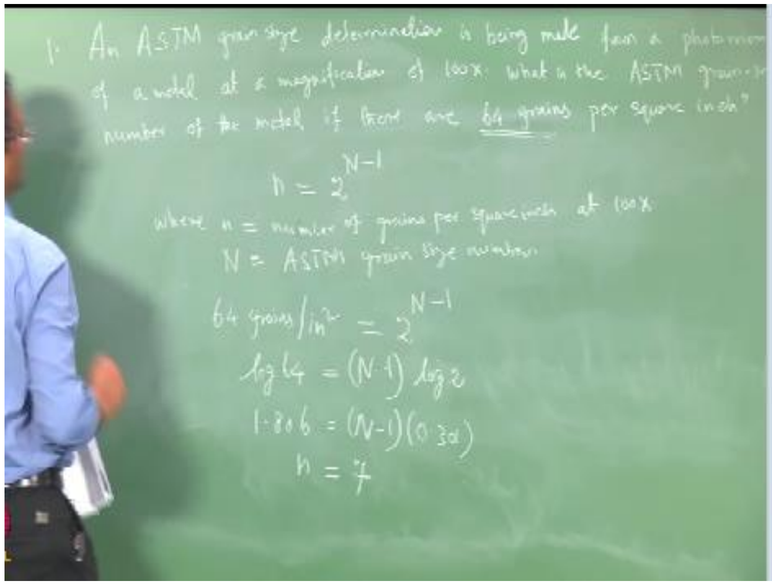

So what is this problem says, that the problem is AN ASTM grain size determination is being made on a photomicrograph of a metal at a magnification of 100 times 100X. What is the ASTM grain size number of the metal if there are 63 grains per square inch. So how to approach this problem, so let us look at the formula what we have written for the ASTM grain size, this is the formula. So where grains per square inch at 100X and N= ASTM grain size number, this is what we have stated in the last class. So now you have since 64 grains per square inch, so you have this small n available.

So that means 64 grains per inch square is equal to 2^{n-1}. Now you just solve this that is log64=(N-1)log2, so this is 1.806=(N-1)0.301 so N is approximately 7 so that is the answer. So very simple substitution you can find out easily from this formula.

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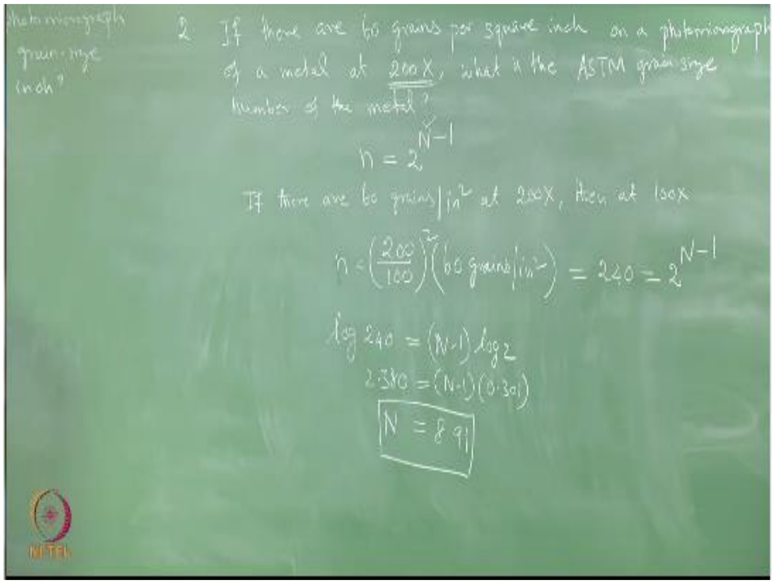

So we will look at another formula, sorry another problem just to illustrate the application of this equation. If there are 60 grains per square inch on a photo micrograph of a metal at 200x, what is the ASTM grain size number of the metal. So what is the difference between the previous problem and this problem there we had number of grains per square inches was given at 100x her it is given at 200x so how to go about it so again we will write this n = 2^{N-1} so if there are 60 grains / Square inch at 200x then at 100x we will have 200/ 100 = 240 = 2^{N-1}

So what you have to do is instead of what you have is 200x we have to convert that into 100x by this 3rd so you have this which is 240 then from there it is again a straight forward you calculate log 240 = N-1 log 2 and 2380 sorry 2. So N = 8.91 so remember here we are talking about this capital N not a small n so even the pervious problem there is a correction it is we are considering N as the ASTM grain size number because this is what we are trying to finds out so we should not confuse these things so N 8.91 so here you write.

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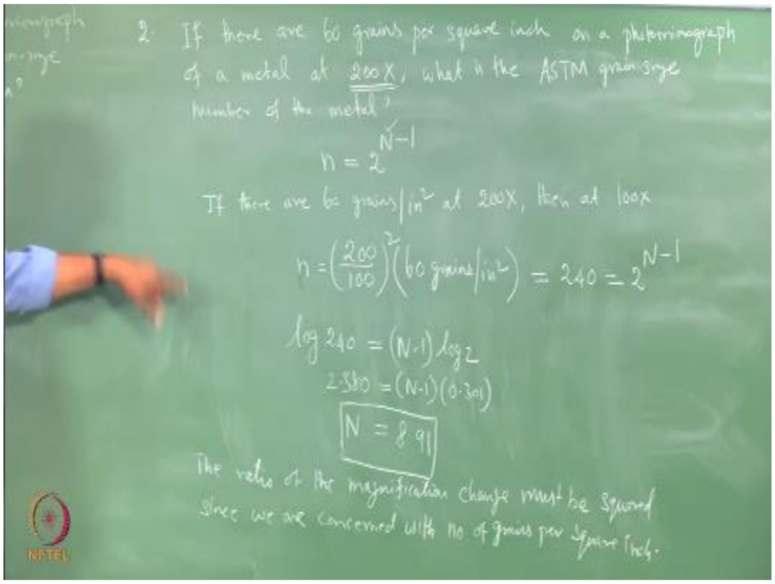

The what is that you are learning from this problem the ratio of the magnification change must be squared since we are concerned with number of grains that square inch so you may that what is that you have to learn from this problem this is the only difference we have made so the ratio of magnification must be square since we are interested in the number of grains per square inch.

So that is the only difference between the pervious problem this problem so that is how it is done so what you have to appreciate by just looking at the grain size number we can just write some general from these problems what is that we have learned we have just learned to compare the grain sizes in terms of reference called ASTM grain size.

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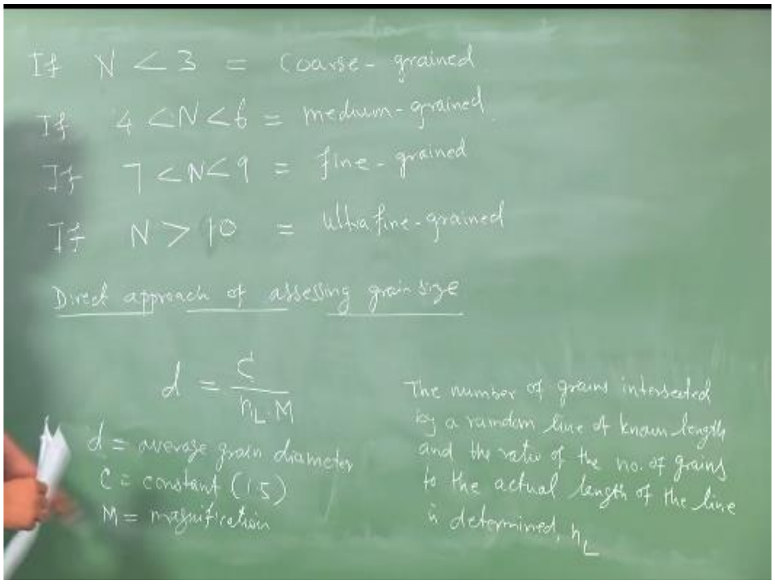

So we can say that if ASTM grain size N < 3 and it is classified as coarse grained if N between 4 and 6 it is medium grain if it is between 7 and 9 this time grain if you have N > 10 it is called ultra time grained, so this is a general reference so which is quite handy when you look at the ASTM grain size charts, if it is less than 3 course grain if it is between 4 and 6 medium grain if it is between 7 and 9 it is fine grain if it is grater then 10 it is ultra fine grain, so that gives the very difference but then we can also look at some of the as I mentioned.

We can look at some of the direct measurement of grain size direct approach of assessing the grain size which is sometimes referred as D be C/n_LM, so you write what is d, d = average grain diameter, C you have sometimes 1.5 for typical measurements and m is magnification, so you can write here number of grains intersected random line of knowing and the ratio of number of grains to the, so this is direct approach one of the direct approach.

I will also give another method measuring directly like this, this is one of the methods where T is the average grain size and C is a constant typically 1.5 for most of the microstructures m is the magnification so the number of grains intersected by a random line of node length and the ratio of the number of grains to the actual length of the line is determined N_L then the diameter of the grain is written like this. This is about measuring the grain size and we can also look at one more simple formula or a problem one more problem we can solve before we move onto the next parameters of pree.

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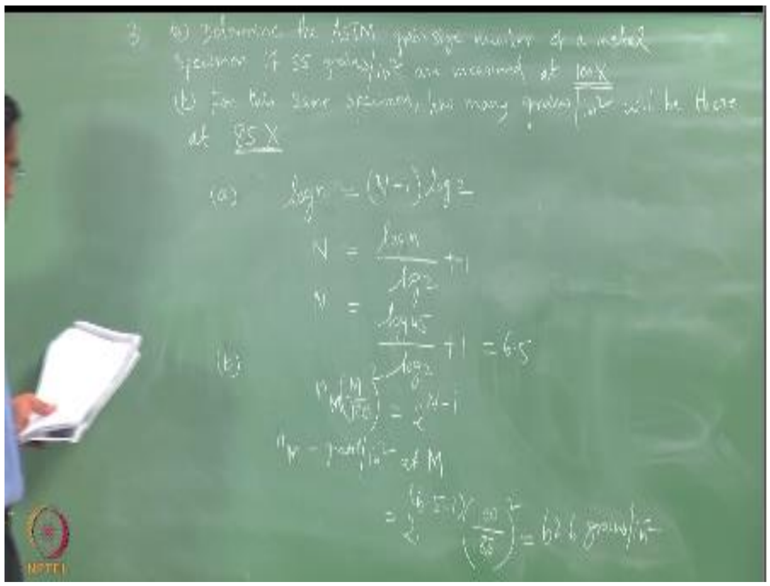

A determine ASTM brings these number, so this is a similar problem what we have solved if we seen in fact the two separated problem has been combine into the single problem but numbers are different so the I hope you can all solve by yourself let me read the problem determine the ASTM grind size number of metal specimen if 55 grains /square inch are measured at 100 magnification for the same specimen how many grains/square inch will be here at 85 magnification so you have to just follow the similar procedures like what we had done that previously I just complete this for the sake of your comfort.

So okay let us use this $(N - 1)\log_2$ and solving is equal to log n/log2 + 1 so here log5 log2 + 1 is equal to 6.5 so this is about ASTM grain size number in part b we have to just peak as the formula like $(NM/100)^2\ 2^{N-1}$ so this is how you can recall the formula for a different magnification then you simply substitute this so in this expression n_M number of grains/per square inch at M at magnification M so then now you know why we do this because we are interested in number of grains /per square inch so that is why this down comes in so now you just substitute this.

Simply in this expression so you write 2 6.5 – 1 times $100/85^2$ = 62.6 grain/n^2 so what I have done this from his formula I have substitute this we are interested in this so this will go that side and then it will be like this so you get the answer 62.6 grains/n^2 so this is a this how you should be carry out this problems.

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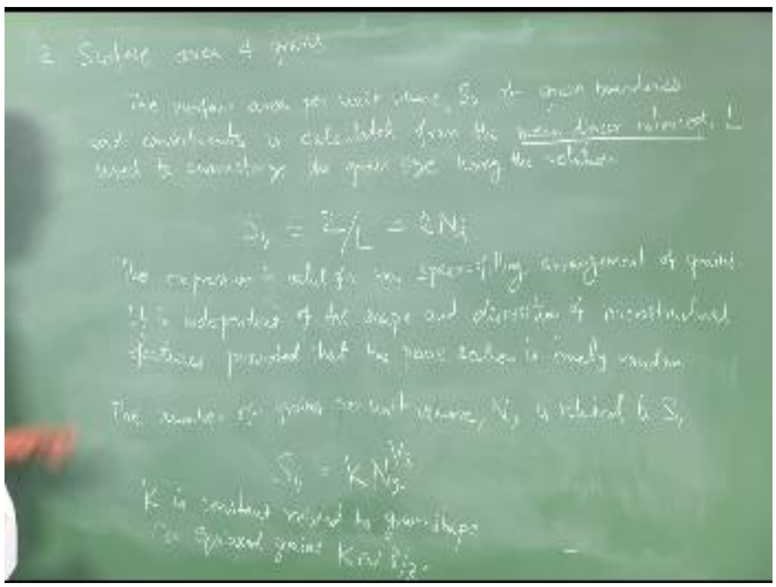

First we have seen grain size I will now talk about surface area of so what we are now talking about is surface area of length the parameter called the surface area per unit volume Sv of a grain boundaries and the constituents is calculated from the mean linear intercept L v linear intercept L which we talked about in the linear analysis which is measure of again grain size using this relation Sv=2/L or you can it is two times the number of intercepts per unit length.

So this is surface area per unit volume you have to remember Sv, so this expression is valid for any space filling arrangement of grains and it is independent of the shape disposition of micro structural features, so this expression is valid for any space filling arrangement of grains and it is independent of the shape and disposition of micro structural features provided that the plane section is truly random.

So the 2D section which we make to measure this should be a random section and then this expression is valid. So we can also relate this expression where something else the number of grains per unit volume Nv is related to Sv by $KNv^{1/3}$ K is constant related to grain shape which is for equiaxed grains K is approximately equal to 8/3. So this is the other parameters which can also be you know found out from the lineal analysis parameter what you get which is also a very powerful the parameters.

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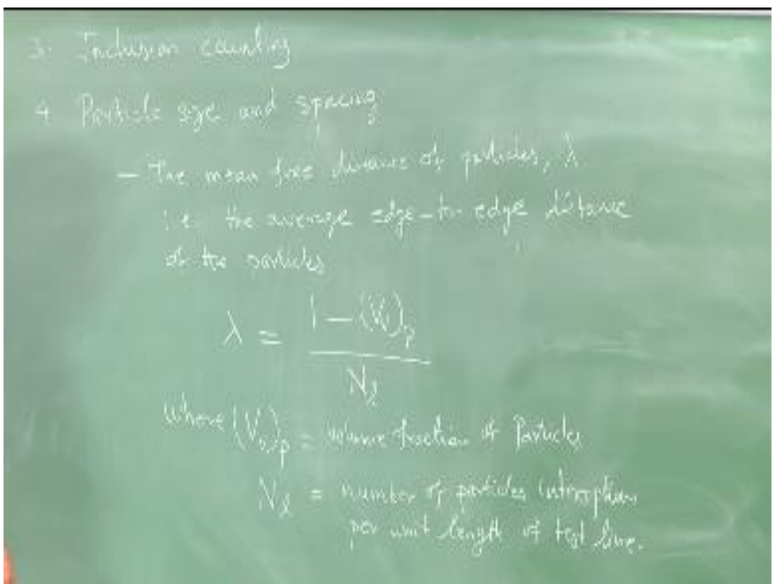

And then the another quantitative measure where the optical micrography is useful inclusion counting, so this is very specific to metallic examples especially you have the unwanted material so call dirt you can say for a people who are not aware of the or familiar with this inclusion rating or inclusion counting especially in steels is very important so this is again done using this optical micrography with some of the methods. The other one is particle size and spacing the mean free distance of particles that is the average edge to edge distance.

Distance of the particles is given by $\lambda = 1- V_{v\ P}$, were $V_{v\ P}$ all your fraction of particles. And NL number of inter, so what I have written is the main free distance of particle is λ that is an average edge distance of the particles is written as $\lambda =1-V_{v\ volume}$ fraction of the particle divided by NL. Were NL is the number of particles interceptions. So it is not intersections it is interception were unit length of the test light. So you can just we know how to calculate this we can do by point counting. And this is an obtained by sounds of number of particles intersected by random straight lines.

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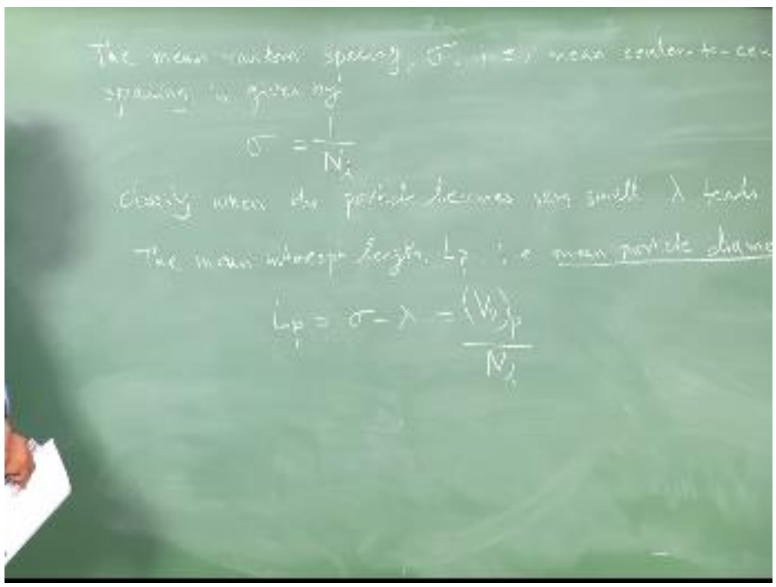

So the main spacing is given by N so clearly, so there we have seen that particle size spacing and the mean random spacing σ that is the mean center to center spacing is given by σ = 1 / NL. We know what NL is so clearly from these two expressions what you can see is when the particles become very small so the λ tends to become σ. So the, mean intercept length LP that is otherwise it is nothing but a mean particle diameter is given by LP = σ – λ. Which is nothing but volume fraction of the particle divided by the NL which is the number of particles interceptions for unit length?

So what we have time to see here is the a simple measurement from an optical micro graph or any photo micrograph a simple point count in or a line intercept count in will give you very effective and very powerful. And very effective way of measuring a quantitative parameters they are very powerful techniques so one has just to appreciate the varies list. So I will show some of this expression uses to evaluate a quantitative data from a simple optical micrographs or in CM micrograph in the coming classes.

So what I have just given is very brief and relevant quantitative microscopy. The subject is very huge and it has got lot of applications complete statics and mathematic relations are involved. But an application of optical microscopy if you are familiar with this basic or relevant relations you will be able to derive a an important quantities parameters like volume fractions or a particle size, practical spacing or grain size and so on.

So that is why I introduced these concepts in the coming two three tutorials I will just demonstrate the techniques how it is done on an actual micrograph. And you will be able to appreciate the usefulness of these expressions I will also give you some more practical exercise. For you to do at you end to get familiar with this kind of techniques thank you.

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